LEHIGH UNIVERSITY.

2004-05 CATALOG

Programs and Majors

Your education at Lehigh University will help prepare you to excel by discovering and building upon your personal strengths in a campus community where active learning connects with real-world applications. Learning at Lehigh incorporates active academic research and hands-on experiences, both in and outside the classroom. As a comprehensive university, Lehigh offers students an education that integrates course work across four colleges and different fields of study in a dynamic learning experience that can be customized to individual interests.

Strong programs in business, the humanities, education, arts and sciences, and human services compliment our well-known strength in engineering. Lehigh students can choose from an array of courses and enjoy the resources and facilities of a major research university and the atmosphere and personal attention of a small college. While most of the undergraduate programs listed are offered as majors, many are also available as minors. Graduate programs are offered in many of the subjects listed as well. These are described in Section IV, Graduate Study and Research.

Arts, Humanities, and Social Sciences

Africana Studies
American Studies
Anthropology
Architecture
Art
Arts and Engineering[2]
Asian Studies
Classical Civilization
Classics
Cognitive Science
Ecology
Economics
Environmental Studies
English
French
German
History
International Relations
Journalism
Music
Music Composition
Philosophy
Political Science
Psychology
Religion Studies
Russian Studies
Science Writing
Science, Technology, and Society
Sociology and Anthropology
Sociology/Social Psychology
Spanish
Theatre
Urban Studies

Engineering, Science and Mathematics

Astronomy
Astrophysics
Applied Mathematics
Applied Science
Behavioral Neuroscience
Biochemistry
Bioengineering
Biology
Chemical Engineering
Chemistry
Civil Engineering
Civil and Environmental Sciences[2]
Computer Science
Design
Ecology
Electrical Engineering
Electrical Engineering and Engineering Physics[2]
Engineering Mechanics
Engineering Physics
Environmental Engineering
Environmental Science
Geological Sciences
Industrial Engineering
Information and Systems Engineering
Materials Science and Engineering
Mathematics
Mechanical Engineering
Molecular Biology
Optoelectronics Science and Engineering
Physics
Statistics
Structural Engineering (IBE only)

Biosciences and Bioengineering

Applied Life Science
Behavioral Neuroscience
Biochemistry
Bioengineering
Biology
Molecular Biology

Information Science and Technology

Computer Engineering
Computer Science
Computer Technology (IBE only)
Information and Systems Engineering
Optoelectronics Science and Engineering

Business and Economics

Accounting
Business Economics
Economics
Finance
Management
Marketing
Information Systems
Supply Chain Management

Education and Human Services

Counseling Psychology[1]
Counseling and Human Services[1]
Educational Leadership
Educational Technology[1]
Elementary Counseling[1]
Elementary and Secondary Education (5 year program)
School Psychology[1]
Secondary Counseling[1]
Special Education[1]

Cross-Disciplinary Programs

Africana Studies
American Studies
Arts and Engineering[2]
Asian Studies
Classical Civilization
Bioengineering
Civil Engineering/Environmental Sciences
Cognitive Science
Computer Science and Business
Electrical Engineering/Engineering Physics
Health and Biopharmaceutical Economics[1]
Integrated Business and Engineering
Pre-dental Science[3]
Pre-medical Science[3]
Pre-optometry Science[3]
Science, Technology, and Society

Special Cross-Disciplinary Programs of Study

Arts and Engineering
Computer Science and Business
Enterprise Systems Leadership
Integrated Business and Engineering
Music and Engineering/Science[4]

[1]Graduate level only

[2]Dual-degree (5-year) program

[3]Combined-degree programs only

[4]Music and Engineering/Science is not a major in itself. However, Lehigh attracts many engineering and science students who wish to continue their active involvement in music and the music department, as dual majors, minors or elective participants.

Contents

2004-2005 Academic Calendar

Fall 2004

July 1	(Thursday) - Deadline to apply for September degree
July 23	(Friday) - Last day for September Doctoral candidates to deliver approved dissertation drafts to dean
August 13	(Friday) - Last day for September masters candidates to submit unbound thesis copies to the Registrar's Office; Last day for September doctoral candidates to complete all degree requirements
August 19-20	(Thursday-Friday) - Graduate Registration
August 23	(Monday) - Classes begin; registration
August 27	(Friday) - Last day web registration; Last day to add courses without instructor's signature
September 3	(Friday) - Last day of registration; Last day to drop a course without a "W"
September 5	(Sunday) - Degree awarding date
September 6	(Monday) - Labor Day - classes held
September 10	(Friday) - Last day to select or cancel pass/fail grading
September 16	(Thursday) - Rosh Hashanna
September 21	(Tuesday) - Four o'clock quizzes
September 22	(Wednesday) - Four o'clock quizzes
September 25	(Saturday) - Yom Kippur
September 29	(Wednesday) - Four o'clock quizzes
September 30	(Thursday) – Four o'clock quizzes
October 7-10	(Thursday-Sunday) - Pacing Break - no classes
October 11	(Monday) - Classes resume; Friday classes meet
October 12	(Tuesday) - Thursday classes meet
October 13	(Wednesday) - Mid-term grades due
October 28	(Thursday) - Four o'clock quizzes
November 1	(Monday) - Applications for January degree due
November 2	(Tuesday) – Four o'clock quizzes
November 3	(Wednesday) – Four o'clock quizzes
November 4	(Thursday) – Four o'clock quizzes
November 8-19	(Monday-Friday) - Registration for Spring 2005
November 9	(Tuesday) - Last day for January doctoral candidates to deliver approved dissertation drafts to dean; Last day to withdraw from a course with a "W"
November 23	(Tuesday) - Last day for hourly exams
November 24-28	(Wednesday-Sunday) - Thanksgiving Vacation
December 3	(Friday) - Last day of classes; Last day to drop a course with a WP/WF grades; Last day for January master's degree candidates to submit unbound thesis copies to the Registrar's Office
December 4	(Saturday) - Review-consultation-study period for Tuesday classes
December 6	(Monday) - Review-consultation-study period for Monday classes
December 7	(Tuesday) - Last day for January doctoral degree candidates to complete all degree requirements
December 7	(Tuesday) - Final exams begin
December 15	(Wednesday) - Final exams end
December 20	(Monday) - Grades due

Spring 2005

January 13-14	(Thursday-Friday) - Graduate Registration
January 16	(Sunday) – Degree awarding date
January 17	(Monday) - Registration; First day of class
January 21	(Friday) - Last day web registration; Last day to add courses without instructor's permission
January 28	(Friday) - Last day for spring registration; Last day to drop a course without a "W"
February 4	(Friday) - Last day to select or cancel pass/fail
February 16	(Wednesday) - Four o'clock quizzes
February 17	(Thursday) - Four o'clock quizzes
February 22	(Tuesday) - Four o'clock quizzes
February 23	(Wednesday) - Four o'clock quizzes
March 1	(Tuesday) - Last day for filing applications for May graduation
March 4	(Friday) - Mid-term grades due
March 5-13	(Saturday-Sunday) - Spring break
March 14	(Monday) - Classes resume
March 25	(Friday) - Good Friday - classes held
March 26	(Saturday) - Passover
March 30	(Wednesday) – Four o'clock quizzes
March 31	(Thursday) – Four o'clock quizzes
April 5	(Tuesday) – Four o'clock quizzes
April 6	(Wednesday) – Four o'clock quizzes
April 8	(Friday) - Last day to withdraw from a course with a "W"
April 11-22	(Monday-Friday) Registration for Fall and Summer 2005
April 22	(Friday) - Last day for hourly exams; Last day for May doctoral candidates to deliver approved dissertation drafts to dean
April 29	(Friday) - Last day for May master's candidates to submit unbound thesis copies to the Registrar's Office; Last day for May doctoral candidates to complete all degree requirements; Last day to drop a class or withdraw with WP/WF grades; Last Class Day
April 30	(Saturday) - Review-consultation-study period for Tuesday classes
May 2	(Monday) - Review-consultation-study period for Monday classes
May 3	(Tuesday) - Final exams begin
May 9	(Wednesday) - Final exams end
May 14	(Saturday) - Grades due
May 23	(Monday) - University Commencement Day

Lehigh University defines a semester as 14 weeks and 70 individual days of instruction to be followed by 2 days of a reading-consultationand study period in preparation of 9 consecutive calendar days of final examinations with four periods per day of 3 hour exam blocks. The summer term is 12 weeks with measured sessions. The academic year consists of one summer and two regular terms.

I. Information of General Interest

This section includes information related to accreditation, admission, advanced placement, transfer students, tuition and fees, financial aid, campus life and academic regulations. Similar information for graduate students may be found in Section IV. The university's history, biographies of its presidents and descriptions of its buildings are found in Section VI.

Accreditation

Lehigh University is accredited by the Middle States Association of Colleges and Schools.

Both the undergraduate general and accounting programs and the master of business administration programs are accredited by the American Assembly of Collegiate Schools of Business. The engineering curricula are accredited by the Accreditation Board for Engineering and Technology. In addition, the computer science program offered in the College of Engineering and Applied Science is accredited by the Computer Science Accreditation Board, Inc. The Commonwealth of Pennsylvania approves for educational certification various programs within the College of Education. Programs in chemistry are approved by the American Chemical Society.

The department of theatre is accredited by the National Association of Schools of Theatre, recognized by the U.S. Department of Education as the accrediting body for the field of theatre.

Policy of Equality

Lehigh University provides equal opportunity on the basis of merit without discrimination because of race, color, religious creed, ancestry, national origin, age, handicap, sex, sexual orientation or union membership.

Admission Guidelines

The total undergraduate and graduate enrollment of Lehigh University is regulated by action of the board of trustees, with a resulting limitation in the number of candidates who can be admitted each year to the various divisions of the university.

Because of the limitations on enrollment, the Office of Admissions, under the leadership of the Dean of Admissions and Financial Aid, conducts a selective review of candidates for admission. Several criteria are used in an attempt to predict a student's ability to successfully complete four years of rigorous study at Lehigh University.

The material that follows pertains to undergraduates. Graduate students should consult Admission to Graduate Standing, Section IV.

The admission policy of the university is designed to enroll students with a variety of backgrounds. The course work or units required for admission represent the equivalent of the usual four-year college preparatory curriculum with certain specific course work being required for enrollment in certain programs within the university. Evidence of academic growth, ability to learn, and motivation are special qualities that may not be reflected in the accumulation of units. Such qualities are also considered by the admissions committee.

Minimum subject matter requirements (16 units)

English	4 units
foreign languages*	2 units
social science	2 units
laboratory science	2 units
college preparatory mathematics	3 units
elective subjects	3 units

**Only in exceptional cases, and for otherwise well-qualified candidates, will the Committee on Admissions waive the foreign language requirement for admission to any one of the three undergraduate colleges.*

Students planning on enrolling in the College of Engineering and Applied Science must have studied mathematics through trigonometry, and should have studied chemistry, physics and mathematics through pre-calculus. Calculus is recommended. Students planning to enroll in the College of Business and Economics must have completed mathematics through trigonometry, but also should strongly consider taking pre-calculus or calculus. Candidates for the College of Arts and Sciences preparing for a bachelor's of science degree must also take math through trigonometry.

Minimum course work requirements can be misleading since most students who gain admission to Lehigh University exceed the minimum course work. Strength of preparation can be difficult to assess since each individual comes from a different background. However, the Committee on Admissions will look for things such as (in no particular order):

- Rank or relative rank in class
- How the student's grades compare to those of his or her classmates at that particular school
- Evidence of improvement or deterioration in grades during the secondary school career with particular attention paid to performance in senior year courses
- The quality of performance in courses that relate to the student's anticipated area of study
- The difficulty of courses taken with special attention paid to courses recognized as being accelerated by national academic organizations
- Comments and recommendations from the principal, headmaster, guidance counselor, or other professional educators within the school system
- Performance on standardized testing
- Extra-curriculum/work experience with particular emphasis placed on demonstrated leadership
- Demonstrated interest in Lehigh University

Entrance Examinations

SAT/ACT: Each candidate for admission to the first year class is required to write either the Scholastic Assessment Test (SAT) or the American College Test (ACT). It is highly recommended that the student request that his or her scores be forwarded to Lehigh (CEEB code 2365) directly. It is not the responsibility of the high school guidance office to forward the results. If, during the evaluation process, it is discovered that the test results are missing, the student will be notified by mail or phone. Unnecessary delays in the decision-making process can result if the committee does not have the scores.

The Committee on Admissions recommends that students take the exam in the junior year and again as early in the senior year as possible. In the evaluation process, the highest score in each category will be used regardless of the test date.

SAT II Tests: SAT II tests are recommended, but not required. It is also recommended that students who plan to study a foreign language take the SAT II or Advanced Placement Test for the language they intend to study. Also, students interested in advanced placement and/or receiving college credit in chemistry, English or modern language and literature should take the SAT II tests. Please read the Advanced Placement section for specific requirements.

Test information and applications may be secured from high school guidance offices or the College Board at either of the following addresses: P.O. Box 592, Princeton, N.J. 08541, or 1947 Center St., Berkeley, C.A. 94704. Candidates writing tests outside the United States should direct their correspondence to the Princeton address.

Candidates should register for the tests early in the senior year and not later than one month prior to the test date (two months for candidates who will be tested in Europe, Asia, Africa, Central and South America and Australia).

As with other standardized testing, the candidate has the responsibility to have the results sent to Lehigh.

Recommendations

The Office of Admissions requires, as part of a candidate's file, a letter of recommendation from the guidance counselor, principal, or headmaster from the candidate's school. One teacher recommendation is also required. Such recommendations should address the candidate's other qualifications such as character, intellectual motivation, participation in school activities, and established habits of industry and dependability.

Interviews

Prospective first-year students and their parents are highly encouraged to visit Lehigh and to participate in a campus tour and to meet with a representative officer for an individual information session or a group information session. No appointment is necessary for a campus tour or group information session, but interviews must be scheduled by appointment. Visit *www.lehigh.edu/schedule* for a schedule of tours and information sessions. A call to the Office of Admissions is recommended because the schedule of tours and interviews can change several times during the year as the academic calendar changes. While visiting our campus, it is often possible to meet with faculty, coaches or other professional staff of the university. Requests for such meetings should be made prior to the actual visit so as to facilitate scheduling.

The Office of Admissions is open for interviews most weekdays beginning at 9 a.m. Tours are available several times a day during the school year. Some Saturday morning tours are available during the fall and winter.

In certain cases, an interview may be required if, in the opinion of the Dean of Admissions and Financial Aid, the additional information gained through an interview would be helpful in making the correct decision regarding admission. In such cases, the candidate will be notified of our request.

How to Apply

Students may secure applications by writing to the Office of Admissions, 27 Memorial Drive West, Lehigh University, Bethlehem, P.A. 18015, or by calling (610) 758-3100. Students may also apply on-line at *www.lehigh.edu/apply.*

Students may also use the Common Application available from school guidance counselors, or they may apply by using the Common Application on-line at *www.commonapp.org.* The Common Application is accepted as the equal of the Lehigh application. Students also are required to submit a supplemental form to the Common Application that can be obtained through the Common Application web site or the Lehigh web site.

Applications should be filed according to the following deadlines:

November 15 — Early Decision
November 15 — 7 year BA/MD Program
January 1 — Seven-year dental program with the University of Pennsylvania
January 1 — Seven-year optometry program with the SUNY State College of Optometry
January 1 — Regular Decision
January 1 — Early Decision II

Each application must be accompanied by an application fee of $60. This fee is non-refundable and does not apply towards tuition fees. Waivers of application fees are accepted when forwarded on the appropriate forms from the school guidance office. Students for whom the application fee is a hardship should consult the guidance offices at their schools.

Early Decision

Our program is a binding early decision plan, meaning that the student is expected to withdraw all applications to other schools if accepted to Lehigh. The student, his or her parents, and guidance counselor must sign an Early Decision Request form to confirm their understanding of this provision. Students applying early should be sure that Lehigh is their first choice school. Early Decision I is for students who meet the November 15 deadline. Notification will be completed around December 5. Early Decision II is for students who have met the January 1 regular application deadline and who declare their intention to apply Early Decision II by January 15. These students will be notified early February. It is understood that all early decision candidates will continue to perform at a satisfactory academic level throughout the remainder of his or her senior year.

The early decision plan is not for everyone. It is for the student who has been early and active in their college search, and is sure that he or she wants to attend Lehigh. When reviewing an early decision application, the committee will defer a decision on any candidate when there is insufficient information to make an early decision commitment. It is also possible that a student may be denied admission. The Admissions Committee will give early decision applicants some slight advantage in borderline cases because of the commitment of applying early, but the student must still present a strong record.

Early decision candidates who have filed the CSS/Financial Aid Profile application, available at *www.collegeboard.com,* and prior year tax forms, will be notified of their financial aid packages as soon as possible after the decisions on admission are made by the Office of Admissions. All other financial aid forms must be filed by the deadline indicated on each application.

Admission and Deposit

Notification of admissions decisions are made by mail. Admission is granted only through written notice by the Office of Admissions. An admitted student may secure a place in the entering class by notifying the university that he or she intends to enroll at Lehigh and by forwarding the appropriate enrollment deposit postmarked by May 1. This fee is applicable towards the fall-term bill. Students who do not attend will forfeit their deposit.

Transfer Students

Each January and August, students who have attended another college or university are admitted with advanced standing. Candidates for transfer admission must meet the high school subject matter requirements prescribed for incoming first-year students, but entrance examinations are not required if a student has completed at least one year of full-time study at another institution. Exceptions to fulfilling high school requirements will be granted following the review of a college level transcript. The academic performance at the college level is the primary focus when giving consideration to admission.

Candidates who have been dropped for poor scholarship, or who are not in good standing, or who have been released for disciplinary reasons are not eligible for admission.

Each candidate must submit an official transcript and course descriptions from each institution attended. An admissions decision cannot be made without this information. Students wishing to enter in the spring should apply no later than November 1 and applicants for the fall semester should have their application in by April 1. Applications may be obtained by writing to the Transfer Coordinator, Office of Admissions, 27 Memorial Dr. West, Lehigh University, Bethlehem, PA 18015 or by calling (610) 758-3214. The application is also available at Lehigh's web site *www.lehigh.edu/tapply*. Each application must be accompanied by an application fee of $60.

Students are encouraged to take an active role in seeing that the various components of the student's admission application have arrived at the university. Decisions are made as soon as possible after the application is complete. Students will be notified by the Registrar as to how many credits Lehigh will grant to the student in advanced standing.

Housing: Transfer students are guaranteed housing for at least their first semester provided an enrollment deposit is received by the date established within the text of the offer of admission letter. Every effort is made to accommodate transfer student housing needs. All students are guaranteed on-campus housing through the end of the sophomore year. Contact the Office of Residential Services, Rathbone Hall, Lehigh University, 63 University Drive, Bethlehem, PA 18015 or call (610) 758-3500. This office also can provide information about off campus housing. Fraternities and sororities often have room for members or boarders. Information on this option may be obtained through the Dean of Students, Coordinator of Greek Affairs, University Center, 27 Trembley Drive, Lehigh University, Bethlehem, PA 18015 or call (610) 758-4157.

Advanced Placement

The university offers capable students who have superior preparation an opportunity for advanced placement and/or college credit. Many secondary schools, in association with the College Board, offer college-level work. Students participating in these courses should write the Advanced Placement Tests offered by the College Board.

Students who achieve advanced placement are afforded three major advantages. First, they commence study at Lehigh at a level where they will be academically comfortable. Second, students who qualify for college credits may be graduated at an earlier time—with resulting savings in time and tuition outlay. Third, qualified students may, in the Lehigh senior year, enroll for a limited amount of work for graduate credit.

Entering freshmen that ask the College Board to send their advanced placement grades to Lehigh are considered for advanced placement.

Some departments noted below offer examinations during Freshman Orientation to students who studied college-level subjects in secondary school but did not write the advanced placement tests. Entering freshmen wishing to write an examination in any Lehigh course should notify the Office of Admissions in writing prior to August 1. The student should specify the number and title of the course. Students who receive credit on the basis of advanced placement grades need not write Lehigh tests to confirm the credit granted.

Current practice at Lehigh is as follows:

Art and Architecture. Six credit hours for Art 1 and Art 2 are granted to students who earn a grade of 5. Three credit hours for Art 099 Free Elective in Art History are granted for those students who earn a grade of 4. Those students who earn grades of 5 on the Advanced Placement Studio Art Examination receive three credit hours for Art 3.

Biology. Four credit hours for EES 31, Introduction to Environmental/Organismal Biology, given to those who earn grades of 4 or 5.

Chemistry. Eight credit hours for CHM 21, CHM 22, and CHM 31 are granted to students who earn a grade of 5. Those students who earn a grade of 4, or who score 750 or higher on the SAT II chemistry subject test, are granted five credit hours for CHM 21 and CHM 22 and may apply to the department for a special examination that, if completed successfully, will result in an additional three credit hours for CHM 31.

Computer Science. Students who receive a grade of 4 or 5 on the AP exam will receive 3 credits for CSE 012

Economics. Students will receive three credit hours of ECO 00 Economics Elective for a score of 4 or 5 on the microeconomics or macro economics exam. Students receiving a score of 4 or 5 on both the microeconomics and macroeconomics exams will receive 4 credits for ECO 001 and 2 credits of Economics Elective and satisfy the College of Business and Economics degree requirements.

English. Students who earn a score of 5 on one of the College Board Advanced Placement Tests in English (either in English Language and Composition or in English Literature and Composition) or who achieve a score of 750 or higher on the SAT II Subject Test in Writing receive six hours of Lehigh credit for freshman

English (and exemption from the requirement). Students who receive a score of 4 on either of the Advanced Placements Tests in English or who have a score of 700-749 on the SAT II Writing Subject Test will receive three hours of credit in freshman English; these students will complete the six-hour requirement by taking an English course suggested by the department, typically ENGL 11.

Environmental Science. Students scoring a 4 or 5 on the environmental science exam will receive 4 credits for EES 3.

Government and Politics. Four credits for POLS 1 are awarded to those students that score a 4 or 5 on the American Government test, and four credits for POLS 3 are awarded to those that score a 4 or 5 on the Comparative Politics exam

History. Students earning a grade of 4 or 5 in the American History Advanced Placement examination will receive 4 credits for HIST 41. Students earning a grade of 4 or 5 in the European History exam will receive four credits for HIST 12 Students receiving advanced placement in American history may not later enroll in History 41; students receiving advanced placement credit in European history may not later enroll in History 12.

Latin. Students receive three semester hours of credit for a grade of 4 or 5 in the Virgil examination; those who successfully write in more than one area (e.g. Virgil and lyric poetry) receive six hours of credit. Credit will be awarded for Latin 099 Latin Elective. Students receiving credit for Latin and who wish to continue their study of Latin must consult with the Director for proper placement.

Mathematics. Four semester hours of credit for Math 21, Calculus I, are granted to those who earn grades of 4 or higher on the Calculus AB examination. To those who earn a grade of 4 or higher on the Calculus BC examination, eight hours of credit are granted for Math 21 and Math 22, Calculus I and II. Credit for Math 21 and 22 or both may also be earned by passing the examination offered by the Mathematics Department during Freshman Orientation. Students regardless of whether they have taken the advanced placement examination may take this examination or not.

Modern Languages and Literature. Students receive four semester hours of credit at the intermediate level I for grades of 4, and eight hours of credit at the intermediate level I & II for grades of 5 on the advanced placement tests. Those who write the SAT II subject tests and score 600 to 699 receive four hours of credit; 700 and above receive eight hours of credit. The maximum number of credits given is eight. Those students receiving grades of 4 or higher on the French or Spanish literature examinations will receive 4 credits for French or Spanish 151.

Music. Three semester hours of credit for MUS 80 are given to those students who earn a grade of 3 or higher on the Advanced Placement test in Music, Listening/Literature of Music: Theory.

Physics. Four hours of credit are given for Physics 11, Introductory Physics I, for a grade of 5 on the Physics B examination or a grade of 4 on the mechanics section of the Physics C examination. If a student receives credit for Physics 11, four hours of credit will be given for Physics 21, Introductory Physics II, for a grade of 4 on the electricity and magnetism section of the Physics C examination. If a student wishes to be considered for credit for Physics 12 or 22, Introductory Physics Laboratory I and II, he or she should see the chairperson of the physics department with evidence of laboratory experience. A test is offered during Freshman Orientation.

Psychology. Four credit hours of PSYC 1 are granted to students who earn a grade 4 or 5.

Statistics. Student s scoring a 4 or 5 will receive 4 credits; for MATH 12 if enrolled in the College of Arts & Sciences or the College of Engineering & Applied Science, or 3 credits for ECO 145 if enrolled in the College of Business & Economics.

International Baccalaureate. Students who earn the international baccalaureate may be granted credit in higher-level or advanced subjects with scores of 5 or better or "B" or better. All students will have their credentials evaluated on an individual basis for specific course equivalency.

Estimate of Expense for Undergraduates

Principally three areas of income support the operating expense of Lehigh University: tuition and fees, endowment earnings, and gifts and grants. The university is conscious that educational costs are significant and it strives to maintain a program of high quality instruction while recognizing that there are limitations on what families can afford to pay. Costs will vary somewhat from student to student depending upon the various options chosen.

Tuition, Room, and Board

There are three major plans that cover the major expense associated with university attendance. These are as follows:

The Tuition Plan.
The university provides comprehensive academic and student services under its tuition plan. The tuition sum is inclusive of most athletic events, basic treatments in the Health Center, libraries, and laboratory services. A technology fee of $200 is charged to all full-time students. An additional $300 fee is charged to all students enrolled in the College of Engineering and Applied Science or with a declared major in natural science. The full-time tuition rate is charged to students enrolled in twelve or more credit hours per semester. For students enrolled in less than twelve credit hours, tuition is charged on a per-credit-hour basis.

The Residence Halls Plan.
A variety of living arrangements are available. The university provides housing for approximately 2,200 students on or near the campus in a wide selection of housing facilities. The housing arrangements are grouped within four basic categories, with rates associated with the category level. Upperclass students contracting for residence halls housing will be required to submit a $400 advance deposit. This deposit is credited toward the room charge for the respective semester. The deposit is either full or partially refundable based upon a published schedule.

The Board Plan.
Ten board plans are available. First-year residents are required to participate in one of the Category I Meal Plans. Upperclass students living in residence halls are required to participate in one of the Category I or II Meal Plans, with the exception that upperclass students living in the smaller houses of Warren Square may also select to participate in the category III meal plan. Subscription to special program meals is required of Taylor Residential College members. Centennial I sorority resi-

dents are required to participate in their sorority house meal plan and have the option to choose any of the Category I, II, III, IV, or V Meal Plans. Students residing in campus apartments, fraternities, or any off-campus facilities have the option to choose any of the plans offered.

Each board plan includes Dining Dollars. This pre-paid declining balance account was designed for maximum flexibility and convenience and can be used at most dining locations on campus to further increase your purchasing options.

Tuition and Fees

All charges and fees are due two weeks prior to the start of classes each semester. On a per-term basis, the expenses are charged at one-half the per-year charge. Accounts not settled by the due date are subject to a late-payment fee. All figures given are for the academic year (two semesters).

Tuition, 2004-2005	**$29,140**
Technology Fee	200
Residence Halls	
Category I (Dravo, Drinker, Richards, McClintic-Marshall, Centennial I & II, Warren Square, UMOJA, ROTC)	$4,700
Category II (Taylor College, Trembley Park Suite Singles, Brodhead House)	5,040
Category III (Sayre Park Village, Campus Square, Trembley Park Apartments)	5,420
Board	
The number of meals specified is per week.	
Category I	
The Whole Enchilada - 19 meals including $100 Dining Dollars	$ 3,530
The Square Mealer - any 14 meals including $200 Dining Dollars	3,530
The Flexible Diner - any 12 meals including $300 Dining Dollars	3,530
225 Block Plan - any 225 meals per semester including $100 Dining Dollars	3,530
Category II	
The Deluxe Diner - any 10 meals including $200 Dining Dollars	3,120
The Dynamic Diner - any 8 meals including $500 Dining Dollars	3,120
150 Block Plan - any 150 meals per semester including $300 Dining Dollars	3,120
Category III	
The Value Plus - any 75 meals per semester including $500 Dining Dollars	1,900
Category IV	
The Social Light - any 50 meals per semester including $500 Dining Dollars	1,480
Category V	
The Dining Dollars - $600 Dining Dollars	600

Based upon the above charges, most first-year students are normally billed the tuition rate and technology fee along with the Category I or II room fee and a Category I meals board plan. The total cost for the four areas would be $37,570 to $37,910 for the 2004-05 academic year.

Other Fees

(applied to prevailing circumstances)

Per credit charge for credit or audit	$1,215
Engineering and Science Fee (for specified students)	300
Application fee (for undergraduate admission consideration)	60
Late pre-registration (assigned to all full-time students who do not select their full class load during the designated period each term)	50
Late registration	50
Late application for degree	25
Examination make-up (after first scheduled make-up)	10
Late payment (after announced date)	100
Returned check fine	20
Key/lock change (lost or non-return), room door, residence halls/sorority	25
Identification card (replacement)	10

The university reserves the right at any time to amend or add charges and fees, as appropriate, to meet current requirements. Fees applicable to the 2004-05 academic year will be announced no later than February 2004.

Other Expenses

A student should plan to meet various other expenses. These expenses include the purchase of books and supplies from the Lehigh University Bookstore located in Campus Square. Necessary purchases supporting one's academic program should average approximately $1,200 per year. The Bookstore carries basic goods for students' needs. A student should also plan an allowance to handle personal and travel expenses.

Plan of Payments

An itemized statement of charges is mailed from the Bursar's Office approximately six weeks prior to the start of each semester. Payment is expected in full by the specified due date. Payment plans are available for those desiring extended payment arrangements.

Persons desiring a payment plan can elect participation in the university's educational payment plan which provides for the payment of tuition, room, and board over four months per semester. The university also offers a plan under which enrolled undergraduate students can pre-pay more than one year of tuition at current rates. Complete information is available from the Bursar's Office. Those persons desiring to use one of the plans must complete the necessary details no later than two weeks prior to the due date for payment.

Students attending the university under a provision with a state board of assistance or with financial aid from other outside agencies must provide complete information to the Bursar's Office if assistance is to be recognized on the semester statement.

Refunds of Charges

Tuition and Academic Fees

A student in good standing who formally withdraws before 50% of the semester has been completed or reduces his or her course enrollment below twelve credit hours will be eligible for a tuition refund.

The tuition refund for a student who withdraws or drops a course(s) is calculated on a weekly basis. No refunds for tuition can be made for one-week workshops after the first day of class.

The date used to calculate refunds is based on when a properly authorized withdrawal or drop/add is received by the Registrar's Office.

Academic fees are non-refundable after the first day of classes.

In the event of the death of a student, tuition will be refunded in proportion to the semester remaining.

Tuition Credit/Suspension

A student who is suspended from the university for disciplinary reasons will be eligible for a tuition credit toward the semester immediately following the period of suspension. The amount credited will be based on the regular tuition refund schedule and calculated on the tuition rate in effect during the period of suspension.

The date used to calculate the tuition credit will be the date of the incident that resulted in the suspension. Under no circumstances will a tuition refund be provided to students who are suspended for disciplinary reasons.

Summer Sessions

Students who preregister for a summer session by the end of April will receive an invoice for their tuition. Those who do not receive an invoice are expected to make payment at the time of registration. Registration will not be permitted until all charges are paid. Students in good standing who formally withdraw or reduce their course enrollment before 50% of the semester has been completed will be eligible for a tuition refund. The refund schedule for student withdrawals and course adjustments is as follows:

The tuition refund for a student who withdraws or drops a course(s) is calculated on a weekly basis. No refunds for tuition can be made for one-week workshops after the first day of class.

The date used to calculate refunds is based on when a properly authorized withdrawal or drop/add is received by the Registrar's Office.

Because of the short time involved, no refunds for tuition charged in the one-week workshops will be made after the first day of class.

In the event of the death of a student, tuition will be refunded in proportion to the fraction of the summer term remaining at the time of the death.

Residence Hall Refunds

Residence hall rooms are rented on an annual basis only. A student who signs a room contract is expected to reside in residence hall housing for both the fall and spring semesters of the specific academic year for which the contract was signed. A student who forfeits a housing reservation and who returns to the university at any time during the contracted academic year is still obligated for housing rental charges if vacancy in the residence hall facilities exists and without regard to location. An advance deposit is required to hold a room. This deposit is non-refundable to entering first-year students and either full or partially refundable to upperclass students based upon specific criteria and a published refund schedule.

Prior to registration, housing rental refunds are made in full in the event a student does not register because of illness, injury, or death; is dropped from the university due to academic reasons; attends a university-approved study abroad or co-op program; graduates; or voluntarily withdraws from the university. After registration, prorated housing rental refunds are granted based on separation from the university due to illness, injury, or death. In the event of voluntary withdrawal, a prorated refund is possible only with the provision that the lease can be transferred to another student for whom no other university accommodations exist. Prorated refunds are based upon the date the room key is returned to the Office of Residential Services. Any student suspended or expelled from the university will not be granted any housing rental refund.

Refunds for Board Plans

Board plan refunds are made in full in the event a student does not register and has not purchased any meals from the plan.

After registration, a student who purchases meals on the board plan but withdraws from the university will receive a pro-rata board plan refund based on the number of unused weeks remaining on the plan.

Any student suspended or expelled from the university will not be granted a board plan refund.

Board plans may be changed within the requirements of the living area up to the tenth day of class each semester at the Bursar's Office with charges assessed per an established pro-ration schedule.

After the tenth day of class, a student who wishes to change a board plan must petition and receive approval form the Office of Residential Services. If the change is approved, an adjustment will be processed on a pro-rata basis to the meal portion of the plan charge as of the week following the last meal purchased.

Adjustments to Financial Aid

The Office of Financial Aid is responsible for determining the appropriate redistribution of charges and refunds when students receive any financial assistance. These decisions are made on the basis of federal, state and institutional policies. Any refunds due to the Title IV programs will be refunded in the following order:

Unsubsidized Federal Stafford Loan
Subsidized Federal Stafford Loan
Federal Direct Unsubsidized Stafford Loan
Federal Direct Subsidized Stafford Loan
Federal Perkins Loan
Federal PLUS Loan
Direct PLUS Loan
Federal Pell Grant
Federal SEOG
Any other Title IV program

Financial Aid

The mission of the Office of Financial Aid is to reduce the financial barriers to a Lehigh education for those families whose resources alone would make it impossible to meet the cost of attendance. The university is deeply committed to providing need-based financial aid.

Lehigh expects each family to make every effort to pay tuition and other educational expenses. Our aid program is designed to measure the difference between our costs and the amount of money your family can be expected to contribute towards those costs. That difference is called "financial need" and represents financial aid "eligibility." The majority of Lehigh's funds are awarded on the basis of financial need. Our merit-based aid program is explained below.

The basic forms of financial aid are grants and scholarships, employment and loan assistance. Grants and scholarships are not repayable. The majority are awarded on the basis of "need" and are renewable on the basis of both continuing "need" and some stated minimum academic progress criteria. Employment provides money for books and personal expenses, and is paid through bi-weekly payroll checks based on hours submitted. Loans are repayable funds from one or more sources, repayable after the student ceases to be enrolled on at least a half-time basis.

Additional sources of aid are: state agencies, employers, and various clubs, churches, religious and fraternal organizations, and foundations. High school guidance counselors are able to provide information about local aid programs. There are also database scholarship search organizations that can be accessed via the World Wide Web. Some examples are *www.collegeboard.com, www.finaid.org* and *www.fastweb.com.* (Caution: there are many scam operations that promise great things if you send them a check. It is better to limit your efforts to the proven sites referenced above.) You are expected to apply for all possible kinds of outside financial assistance, especially the Pell Grant and state grants. You are also expected to take maximum advantage of outside sources to enable Lehigh to spread its own funds farther and to limit student borrowing.

Application Procedures for 2004-2005

The following instructions are addressed to **prospective freshmen.**

To be given proper consideration for financial aid, your application must be completed and ready for review **by February 15, 2005.** To meet that deadline, you must register **by January 15, 2005** with the **College Scholarship Service PROFILE**. Register over the web *(www.collegeboard.com).* The PROFILE service will be an exclusively on-line service, Students who do not have internet access should contact CSS at 1-800-778-6888. Complete the personalized PROFILE application as soon as possible, and be sure to complete the PROFILE to CSS by **February 1, 2005**; supplemental forms should be sent directly to Lehigh by **February 15, 2005**. Within two to four weeks CSS will report the results to Lehigh and send you an acknowledgment. You may find it necessary to use estimates in completing financial aid forms. It is better to use estimates and file on time. Late filers are at risk of not be aided. Submit complete, signed copies of your and your parent's **2004 IRS 1040 forms**, including all schedules and W2 statements by **February 15, 2005**. Finally, Lehigh University expects citizens of the United States, and eligible non-citizens, to apply for federal and state student aid. To be considered for federal student aid, including Federal Pell Grants and Federal Stafford Loans, complete the **Free Application for Federal Student Aid** (**FAFSA**) which is available at your high school or from the web at: *www.ed.gov.* Complete after January 1, 2005 but **no later than February 1, 2005**. Lehigh's federal school code is 003289.

Early Decision Candidates

For Early Decision I
To receive information on your financial aid eligibility you will be required to register with CSS by **November 1, 2004** and complete the filing process by **November 15, 2004**. We require a complete signed copy of your parent's 2003 IRS 1040 form by **November 15, 2004**. Completion of the FAFSA and submission of 2003 tax returns are the same as noted above.

For Early Decision II
To receive information on your financial Aid eligibility you will be required to register with CSS by **January 1, 2005** and complete signed copies of your parent's 2003 IRS 1040 form by **January 15, 2005**. Completion of the FASA and submission of 2004 tax returns are the same as stated above.

International students are eligible for university-funded financial aid. Opportunities are limited. Two forms are required: the Foreign Student Financial Aid Application and the Certificate of Finances. The Office of Admissions will send both forms upon receipt of a completed application for admission.

Renewal of Aid

It is necessary to reapply for financial aid for each year of study and is limited to four years, for a four year program. Extensions beyond that time period require petitions to the Committee on Undergraduate Financial Aid. Applications and filing instructions are available in January in the Office of Financial Aid, or as otherwise posted.

Returning students must file the CSS PROFILE as well as the Renewal FAFSA by April 15, 2005. The filing deadline for all forms, including signed copies of both parents' and student's 2004 federal tax return, is April 15, 2005. Your application will not be reviewed until the FAFSA, PROFILE, Lehigh application and the federal income tax forms are received.

To receive any type of aid, you must be making satisfactory academic progress. The written university policy on satisfactory academic progress is available in the Office of Financial Aid. Generally speaking, it includes 1) remaining in good standing (based on your GPA), 2) advancing a minimum of 24 new credits per academic year (minimally, 12 credits per semester) and, 3) keeping pace with your class, progressing from freshman to sophomore, etc. This is dependent upon your academic program. Recipients of Lehigh grants and scholarships are expected to achieve at least a 2.00 GPA each semester (or higher as noted on the financial aid notification). Students on academic or disciplinary probation are not normally eligible for university grant aid during any period of the probation. Students not maintaining satisfactory progress, as defined by Lehigh or the appropriate governmental agency, may be ineligible for all forms of federal aid, including loans and employment. Appeals, based on extenuating circumstances, may be submitted to the Committee on Undergraduate Financial Aid using forms provided by the Office of Financial Aid.

Sources of University Aid

Several forms of university-funded aid, based on need and merit, are available.

Lehigh University Grants

Funds budgeted from general income to provide need-based, non-repayable assistance.

Sponsored Scholarships

Individuals, foundations, and corporations provide these funds through annual contributions to the university. Lehigh has 60 such sponsored funds.

Endowed Scholarships

Income from invested gifts to the university make these scholarships possible. The university has over 800 such funds, half of which are for general, unrestricted use. Curriculum, geographic, outside interests, etc. restrict most of the others.

Dean's Scholarships

Approximately 70 scholarships, in an annual amount of $10,000 will be awarded to members of the class of 2009. Selections are made by the Office of Admissions based on academic excellence and significant extra-curricular and leadership activities. Awards are renewable over four years of undergraduate study, and require a 3.00 average and satisfactory progress toward a Lehigh degree.

Baker Gifted Arts Scholarships

Awards are valued at $2,500 per year, renewable over four years. Selections are made by the faculties of the Music and Theatre departments, and are based on taped performances and letters of recommendation.

Asa Packer Scholarships

Approximately 30 scholarships, in an annual amount of $15,00 will be awarded to entering freshmen. Selections are made by the office of Admissions based on academic excellence, extra curricular and leadership activities. Awards are renewable for four years of undergraduate study and require a 3.2 average and satisfactory progress toward a Lehigh degree.

Army ROTC Leadership Awards

In certain instances, the university may supplement an Army ROTC scholarship with a leadership award that can range from $3,000 up to the cost of room and board. These are highly competitive and require a 2.5 average for renewal.

Merit Scholarships

Lehigh is a collegiate sponsor of the National Merit Scholarship program. Scholarships ranging from $1,000 to $2,000 per year may be awarded to Merit finalists selecting Lehigh as their first-choice college, and who are not also receiving another form of National Merit scholarship.

Rodale Program in On-line Communication

Qualified students may receive a $2,500 scholarship (which may be renewed for three additional years); opportunities to intern at Rodale Press or other prominent media; and one-on-one instruction with Lehigh faculty.

Athletic Awards

Alumni Student Grants are awarded on the basis of financial need and exceptional athletic talent as evaluated by the Department of Intercollegiate Athletics. Grants are supported by annual alumni contributions. Alumni Student Grants replace the loan and employment portion of a financial aid package. Lehigh also awards NCAA grants in the sports of wrestling and men's and women's basketball.

University Tuition Loans

Lehigh uses these loan funds to supplement other types of educational loans, especially in the freshman and sophomore years when the federal Stafford loan limits are $2,625 and $3,500 respectively. Parental endorsement is required on the promissory note. Repayment begins three months after graduation or withdrawal from the university, until the loan principal and interest are repaid. The minimum monthly repayment rate is $50 plus interest, which is seven percent (7%) per annum. Interest begins to accrue after you are no longer at least a half-time student. Deferments, up to a maximum of three years can be extended for service in the military, VISTA, or Peace Corps; for those who are experiencing undue hardship; or for those who return to school on at least a half time basis. The average debt level of Lehigh students graduating in 2003 was $16,774.

Loan-Cancellation Awards

This is a unique Lehigh award that may be used as an incentive if your academic average is not sufficiently competitive for scholarship consideration. Limited to $4000, a Loan-Cancellation begins as a loan, with the same terms as our regular University Tuition Loan. This form of aid has the potential of being converted to a grant if the following conditions are met: 1) the required grade point average for the award period as shown on the award notification is achieved; 2) 12 or more credits have been passed for each award term; courses above the 12 credits may be repeated courses; 3) all outstanding X or N grades must be removed prior to the end of the following academic period. It is the responsibility of the student to notify the Office of Financial Aid when any outstanding courses have been completed. If not canceled, the loan is repayable according to the terms for university tuition loans.

President's Scholars Program

This program provides an opportunity to receive free tuition for a period of up to 12 months immediately following the awarding of the baccalaureate degree. You may be declared a President's Scholar if, upon completion of 90 Lehigh credit hours, you have a cumulative GPA of 3.75; or, if upon graduation, you are accorded Highest Honors. The Registrar is responsible for determining eligibility. For further eligibility requirement information please go to the Registrar's Office Web page at lehigh.edu.

Availability of Jobs

If you are offered work-study as part of your aid package, the Office of Financial Aid will provide you with the necessary forms and orientation to student employment. Jobs are available throughout the university and are funded through federal and university sources. Pay rates range from the federal minimum wage to $10.50 per hour. You are paid on a bi-weekly basis, as you work and submit timesheets. Your work-study earnings are not deducted from your billed expenses.

The Job Locator Development Program is designed to assist you if you do not qualify under the Federal Work-Study program to find employment off-campus or with a number of incubator companies located on the Mountaintop Campus. This program is coordinated through the Office of Career Services.

Aid from the government

Lehigh University is an eligible participant in federally funded student aid programs. Campus-based programs, where the university makes the awards based on the dollars available, include:

Federal Supplemental Educational Opportunity Grants
Federal Perkins Loans
Federal Work-Study
Direct entitlement programs (where the government directly, or through commercial lenders for loan programs, provides the necessary funds) include:
Federal Pell Grants
Federal Stafford Loans
Federal Unsubsidized Stafford Loans
Parent Loan for Undergraduate Students (PLUS)

Commercial Loan Programs

The Office of Financial Aid can provide a list of programs with current interest rates and terms and conditions of repayment.

Army ROTC Scholarships

The U.S. Army awards scholarships in varying amounts, supplemented with $480 toward course-related books and a $250 per month stipend. Lehigh University is one of a handful of universities whose ROTC recipients may receive a scholarship of $20,000 for four years. Recipients incur an obligation to serve on active duty as commissioned officers. Contact the Department of Military Science for details.

Checklist for Financial Aid

For prospective freshmen:

1. Register for the CSS PROFILE service by **January 15, 2005**, and complete the application by February 1, 2005.
2. Complete the Free Application for Federal Student Aid (FAFSA) by February 15, 2005.
3. Mail a complete, signed copy of both your parents' and your 2004 federal income tax return, including all schedules and W2 forms by **February 15, 2005**.

For students transferring from another college or university

1. Register for the CSS PROFILE service by February 15, 2005 and complete the application by March 1, 2005.
2. Complete the Free Application for Federal Student Aid (FAFSA) by March 1, 2005.
3. Mail a complete, signed copy of both your parents' and your 2004 federal income tax returns including all schedules and W2 forms to the Office of Financial Aid by March 1, 2005.
4. Complete and mail the Lehigh University Transfer Application for Financial Aid which is sent to all admission candidates by the Office of Admission.

For Returning Students

1. Register for the CSS PROFILE service by April 1, 2005, and complete the application by April 15, 2005.
2. Complete and submit the Renewal Free Application for Federal Student Aid by April 15, 2005.
3. Complete and return the Lehigh University Application for Undergraduate Financial Aid, together with complete, signed copies of your parents and your 2004 IRS 1040 forms with all schedules and W2 forms, to the Office of Financial Aid by **April 15, 2005.**

Information for all financial aid applicants

1. Check to be sure that the correct social security number is listed on all forms. If you do not have a number, apply for one and notify Lehigh as soon as it is received.
2. Photocopy all forms filed for your records.
3. Submit the appropriate state grant application, especially if a resident of Ohio, Massachusetts, Connecticut, Rhode Island, Maryland, Delaware, Vermont, or West Virginia - states from which Lehigh students have brought scholarships. Be guided by the specific instructions. The FAFSA will be the basic form for state grant consideration, although some states do require a supplemental application. The latest date for filing the FAFSA, and being assured it will be received on time, is **February 15, 2004** for prospective freshmen, and **April 15, 2005** for continuing students.

Student Rights

Students have the right to know:

- the cost of attendance;
- the refund policy for students who withdraw;
- the financial assistance available from federal, state and institutional sources;
- procedures and deadlines for submitting applications for financial aid;
- how financial aid recipients are selected;
- how eligibility was determined, including all resources the aid office considered available to the student;
- how and when funds will be disbursed;
- an explanation of each type of award received;
- for any student loan received: the interest rate, total amount to be repaid, when repayment begins, the length of the repayment period, and the cancellation or deferment provisions of the loan;
- for any Federal Work-Study or university-funded job: a description of the job, the hours to be worked, the rate of pay, and how and when the student will be paid;
- the criteria used to determine satisfactory academic progress for financial aid purposes; and
- how to appeal a decision by the Office of Financial Aid concerning any aid award.

Student Responsibilities

It is the student's responsibility to:

- read directions thoroughly, complete all application forms accurately, and to comply with any deadlines;
- provide any supplemental information or documentation required by the Office of Financial Aid or other agency if applicable;
- read, understand, and keep copies of any forms the student is required to sign;
- repay any student loans received;
- attend an entrance interview and an exit interview if federal, state or university loans are received while in attendance at Lehigh;
- notify the Office of Financial Aid of any change in enrollment status or financial status (including any scholarships or grants received from outside sources); changes of address and enrollment status must also be reported to lender(s) for any loan(s);
- satisfactorily perform the work agreed upon in a Federal Work-Study or university-funded work program; and
- know and comply with all requirements for continuation of financial aid, including satisfactory academic progress requirements.

For more information write to the Office of Financial Aid, Lehigh University, 218 W. Packer Avenue, Bethlehem, PA 18015; telephone (610) 758-3181; FAX (610) 758-6211, email *infao@lehigh.edu*

Campus Life

Approximately 70 percent of all undergraduate men and women live on campus. Campus living facilities include traditional residence halls, apartments, suites in a multi-story building, or residence in fraternity or sorority houses. Physical facilities are also described in Section VI.

Residence Halls

The offices of Residential Life and Residential Services at Lehigh University are committed to providing quality housing and educational services to its resident students. Lehigh firmly believes that living in a residence hall allows students to become members of a special community, offering the opportunity to live with and learn from a diverse group of people. Efforts are made to integrate academic and out-of-the-class learning in order to enable students to develop a balanced and realistic approach to life after they leave the university.

Approximately half of Lehigh undergraduates live in university residence halls. The university has eleven principal residence halls for undergraduate men and women. Most rooms are designed for two students, but a limited number of singles, triples, and 4-person suite and apartment units are available. Residence halls offer a wide variety of special live-in programs including: Taylor Residential College, ROTC House, Umoja House (Multicultural Living), Substance Free Housing areas, traditional dormitory-style living (in buildings with corridors), and suite/apartment-style living.

To help facilitate and maximize a student's residence experience, approximately ninety staff members of the office of residence life live in the residence halls. On every hall there is a student staff member, a Gryphon, who provides assistance in personal and academic matters, refers students to other offices where appropriate, helps mediate conflicts, and develops educational, social, and recreational programs. In addition to the student staff, six professional Residence Life Coordinators live in the residence halls thus providing additional resources for students.

In every residence hall there are also House Councils that are part of the larger Residence Hall Association. Participation in the Residence House Council provides a chance to develop leadership, programming, human relations, and budgeting skills. It is a vital and active organization, whose prime focus is to help fund residence hall programs, to assess students' opinions on issues affecting them, and to develop many service-oriented programs to aid resident students in their stay on campus.

When a candidate accepts an offer of admission to the freshman class, the candidate is sent a Room and Board Application-Contract. Those desiring accommodation in the residence halls must return this application-contract promptly. Priority for assignment is based on the date the candidate accepts admission. Normally, freshmen are informed of their room assignment and other information in early July by the Office of Residential Services.

Currently, all freshmen and sophomores are guaranteed housing on campus. Although juniors and seniors may not initially be guaranteed housing, in the past there has been sufficient space available to meet the needs of all students who desire residence hall housing. The Office of Residential Services uses a lottery to provide for fair and equitable distribution of available housing among upperclass students. The lottery is scheduled early in the spring semester. Students who are guaranteed housing pay a $400 deposit to hold the space for the following academic year.

Fraternities and Sororities

The university has a long tradition of Greek life. The continued strength of this system is due in part to the efforts of the Interfraternity Council, Panhellenic Council, the Greek Alumni Council, the Office of Residential Services and the Office of the Dean of Students to improve the quality of fraternity and sorority life through membership, leadership, social, educational, housing, and financial management training.

Greek life is an attractive alternative among the residence options at Lehigh. Each fraternity or sorority is like a close-knit community. These groups determine their own goals; organize their own houses and business affairs with the assistance of the Office of Residential Services; conduct their own social, philanthropic, and athletic activities; assist with planning their own meals; and select their own membership. Because they are largely self-governing, these organizations offer numerous opportunities for student involvement and leadership.

The twenty-three fraternities and nine sororities form a larger Greek community comprising approximately 36 percent of the undergraduate population at Lehigh. Through the Interfraternity Council (I.F.C.) and the Panhellenic Council, they determine policies and organize social, philanthropic, and educational activities for the Greek community as a whole.

There are nine sorority chapters at Lehigh. Five are housed in the Centennial I complex on the Asa Packer Campus and four are located in Sayre Park. The sororities are Alpha Chi Omega, Alpha Gamma Delta, Alpha Omicron Pi, Alpha Phi, Chi Omega, Delta Gamma, Gamma Phi Beta, Kappa Alpha Theta, Pi Beta Phi.

Twenty-two of the fraternities are located in Sayre Park on the Asa Packer Campus. One is located near the campus. The fraternities are Alpha Chi Rho, Alpha Sigma Phi, Alpha Tau Omega, Beta Theta Pi, Chi Phi, Chi Psi, Delta Phi, Delta Sigma Phi, Delta Tau Delta, Delta Upsilon, Kappa Alpha, Kappa Sigma, Lambda Chi Alpha, Phi Gamma Delta, Phi Kappa Theta, Phi Sigma Kappa, Psi Upsilon, Sigma Alpha Mu, Sigma Chi, Sigma Phi Epsilon, Theta Chi, Theta Delta Chi, and Theta Xi.

Religious Activities

The Religious Program is under the general supervision of the university chaplain. The chaplain participates in the ceremonial life of the University and conducts special university worship services throughout the year. All worship services are interdenominational, with some being inter-religious. Roman Catholic masses are held regularly. The Newman Center can be contacted for a schedule of services.

Lehigh University is non-denominational. Packer Memorial Church, dedicated in 1887 in honor of the University's Founder, Asa Packer, continues to be the center for campus worship services.

The University Chaplain works with representatives of campus religious groups of all faiths and assists students in planning religious life programming. The chaplain's office sponsors an Oxfam Fast in November, organized the original Community Service Desk that helps coordinate volunteer services on campus, and creates opportunities for discussion of moral and spiritual issues through the Chaplain's Forum. In addition to providing pastoral counseling, supporting religious groups, and helping bring speakers to campus, the chaplain seeks to provide leadership to the university on religious and ethical issues.

Over fifteen religious groups on campus provide opportunities for religious fellowship. The groups include the Newman Association for Roman Catholic students under the guidance of a resident priest; the Jewish Student Center, which sponsors various activities for Jewish students; and organizations for Hindu and Muslim students. A variety of Protestant Christian organizations are available to students, including the Lehigh Christian Fellowship, Navigators, and the Fellowship of Christian Athletes.

The chaplain's office makes information about religious life available to all students through the Chaplain's web page and can be contacted at any time for information about worship opportunities and religious activities either on campus or in the local Bethlehem community.

Student Organizations

Lehigh offers a wide variety of extracurricular activities and student organizations. The student-run campus newspaper keeps the campus informed while the student run-campus radio station and the many drama and musical organizations entertain. Additionally, the Lehigh University Student Senate recognizes over 150 student clubs ranging from academic organizations and cultural groups to competitive club sports and political organizations. Student club activities are open to everyone and many of their activities are advertised on *Lehighlive.com*, an interactive site that lists campus events, movie listings, upcoming programs, and much more!

Students are invited to view a complete list of campus organizations by going to the following URL *www.lehigh.edu/instuact/sac.html* or by visiting the Lehigh University homepage and selecting the link to clubs and organizations.

Lehigh University Theatre

In Spring, 1997, the department of theatre moved to the Zoellner Arts Center, Lehigh's impressive performing arts facility. Three theatres, scene and costume shops, a dance studio, music practice rooms, classrooms and more enhance the department's curricular activities. The department of theatre's annual production program includes four productions in the three hundred-seat Diamond Theater and multiple lab productions in the one-hundred seat Black Box Theater. The plays range from classics to world premieres and recent mainstage seasons have included *Flyin' West*, *Electra*, *A Streetcar Named Desire*, *Runaways*, *Talk Radio*, *Fools*, *Miss Julie and Macbeth*.

Shows directed and produced by students as class projects or independent work occur regularly in the Black Box Theater. Recent lab theatre productions have included *Extremeties*, *In The Blood*, A Yet-To-Be-Title Cabaret Revue (written and directed by a Lehigh 2002 graduate), *The Likeness*, *The Marriage Proposa*l, *Yesterday's Window*, *Hello From Bertha*, *Haiku*, *The Colored Museum*, *Nin the Morning* and *'Dentity Crises*. One of the preceding plays was written by a Lehigh graduate. Many events are sponsored by the Mustard and Cheese Drama Society, the country's second oldest collegiate drama club.

Auditions and production crews are open to all members of the university community. Production opportunities exist in performance, choreography, set and costume construction, properties management, lighting, sound, house management and publicity. Advanced students have opportunities to direct or design, under faculty supervision.

Outstanding work in the mainstage or lab theatre seasons may be recognized with Williams prizes and theatre department prizes in acting, directing, design, and technical production.

Professional guest artists — directors, playwrights, designers, and actors — frequently visit the Lehigh campus to work on mainstage productions, teach classes, and conduct seminars and workshops for all interested students. The department also sponsors artists-in-residence, guest lecturers, workshops, and touring performances.

Musical Organizations

The music department offers students an array of ensembles in which to perform and develop leadership skills. The choruses, bands, orchestra, and ensembles are conducted by members of the faculty and managed by elected student leaders. Nearly all performances, except Christmas Vespers, are held in Baker Hall in the Zoellner Arts Center.

Students earn one credit per semester for each ensemble or lesson course in which they are registered.

The Lehigh University Philharmonic Orchestra, Paul Chou, director. The Lehigh University Philharmonic Orchestra, a group of over seventy-five instrumentalists, makes its home in the Zoellner Arts Center. The Philharmonic performs approximately five times each year and has been featured in concerts in Washington, D.C., Florida, and Pennsylvania and on tour in Austria, the Czech Republic, China, and most recently in Brazil.

The orchestra has consistently earned standing ovations from audiences when performing, often for a full house.

The Jazz Ensemble, Bill Warfield, director, performs contemporary literature as well as the music of the more traditional bands such as Basie, Ellington, Goodman and Herman. In addition to performances on campus each semester, other concerts take place in New York City and the surrounding areas. Membership is by audition.

The **Jazz Band,** directed by Bill Warfield consists of student, faculty, and community musicians performing contemporary and traditional big band literature. Concerts are performed in the fall and spring at Lehigh as well as in the surrounding communities. Membership is by audition or invitation.

The **Jazz Combo** is an advanced combo (chamber group) for the most experienced improvisers under the direction of Dave Riekenberg. The group performs several times each semester on and off campus. Membership is by invitation only.

The **Jazz Improvisation Workshop** is a small ensemble gathered for the development of improvisational skills for students of all levels. The group participates in the fall and spring jazz concerts.

The **Marching 97** meets during the fall semester of each year and plays at each Lehigh home game, as well as several away games. Made up of students from all of the colleges at Lehigh, the band is a student-run organization dedicated to building a positive Lehigh spirit at games and off the field. Band camp is held three days during the week prior to the start of classes.

The **Symphonic Band** meets and performs only in the spring semester of each year. The ensemble consists of students, faculty and staff who are interested in playing music, and no audition is necessary.

The **Wind Ensemble** under the direction of David B. Diggs, is a select group of students dedicated to performing music for woodwinds, brass and percussion. These students represent many diverse majors. In 1999 The Wind Ensemble was honored by Downbeat Magazine, receiving the award for the most outstanding college classical symphonic band.

The **Lehigh University Choir,** directed by Steven Sametz, is an active force in campus life. The 50 mixed voices of the Choir, drawn from all majors of the University, are auditioned at the beginning of the academic year. They give three major concerts on campus and tour internationally. The Choir frequently performs with orchestra and regularly performs new music, including many works written especially for them. They have been heard five times on National Public Radio. Recent tours include Moscow, St. Petersburg, and Berlin; Florida; California; the Virgin Islands; Germany; Austria; France; and a five-city tour of Asia.

The **Lehigh University Choral Union,** composed of students, faculty, staff, and Lehigh Valley community members under the direction of Steven Sametz, performs three times a year with internationally known soloists and a full symphony orchestra. The 200 singers of the Choral Union bring major works such as Beethoven's Ninth Symphony, Mahler's Second Symphony, and the Brahms Requiem to a broad audience.

Flair and imagination characterize the **Overtones,** a small a cappella jazz group auditioned from the members of the University Choir. They frequently appear in benefit concerts and also tour with the University Choir. The Overtones' repertoire runs the gamut from Barbershop to Broadway, doo-wop to jazz.

LUVME (Lehigh University Very Modern Ensemble), directed by Paul Salerni, combines students, faculty, and professionals in performances of recent music. LUVME also sponsors concerts of music by Lehigh students.

Volunteer and Community Services

Lehigh's Community Service Office, located in the Ulrich Student Center, is a place where students, faculty, staff, and student organizations interested in volunteering in the community can get information. The Office is staffed by students who serve as Community Service Assistants, and the Community Service Coordinator, a professional staff member in the Dean of Students Office.

Students are involved in a wide range of service programs. Some of the projects include tutoring and mentoring programs with local youth through opportunities such as America Reads and America Counts, Community Work Study and The Boys and Girls Club. Many students are also active in local hospitals, with environmental groups, senior citizen centers, and shelters. The Office also provides students the opportunity to travel around the country during Spring Break to serve with Habitat for Humanity, in homeless shelters, on environmental projects and with youth programs.

Part of the Lehigh experience is getting involved. If you want to work in the community, contact the Community Service Office at (610) 758-4583 or check out our web site at *www.lehigh.edu/service/center.html!*

Guest Speakers

Students have the opportunity to hear a wide variety of notable speakers. The speeches are offered free of charge. Many of the speakers appear under the auspices of the Visiting Lecturers Committee. The VLC is made up of Lehigh University students, faculty and staff who are involved with speaker selection, booking and presentation. This committee along with others, student groups and academic departments regularly offers presentations by scholars from various disciplines. In addition to delivering a formal address, the speakers are often invited for brief residencies to provide opportunities for more informal interaction with students.

Among those to visit the campus have been former President of Poland, Lech Walesa; writer Salmon Rushdie; Maya Angelou; attorney F. Lee Bailey; Lee Iacocca; Princeton Professor Cornel West; General Colin Powell; South Africa's Bishop Desmond Tutu; and novelist John Irving. Thomas Armstrong, director of the Whitney Museum, spoke with students during a week-long residency. An Engineering Expo with speakers representing many prominent industries featured Peter Bridenbaugh, vice president of science and technology, Alcoa. From art to engineering, the campus stays in touch with current issues, trends, and movements through its many and varied speaker series.

Athletic Opportunities

Students can participate in many intercollegiate, recreation, and intramural athletic programs.

NCAA Division I intercollegiate varsity sports include the following. FALL: football, men's and women's cross-country, men's and women's soccer, women's field hockey, and women's volleyball. WINTER: men's and women's basketball, wrestling, men's and women's indoor track and field, and men's and women's swimming and diving. SPRING: baseball, men's and women's tennis, men's and women's golf, men's and women's outdoor track and field, men's and women's lacrosse, women's softball and women's crew.

Athletic facilities are located in Taylor Gymnasium and Grace Hall on the Asa Packer campus, and on the Murray H. Goodman campus, which is located one and one- half miles south of the main campus. The 500-acre Goodman athletic complex includes Stabler Arena, which seats 5,600 and hosts all Lehigh basketball games and tournament wrestling matches. The campus also contains Goodman Stadium, a 16-000-seat football stadium, and the Philip Rauch Field House, which includes a one-eighth-mile track and indoor tennis and basketball courts. The four-court Lewis Indoor Tennis Center was completed in 1994. A new dual field complex, Ronald J. Ulrich Sports Complex, features both artificial turf and natural grass fields for lacrosse, soccer and field hockey. Other facilities on the campus include a championship cross-country course, baseball and softball fields, outdoor tennis courts, the John C. Whitehead Football Practice Complex, the A. Haigh Cundey Varsity House, numerous practice fields, and an all-weather, nine-lane, outdoor 400-meter track.

Lehigh is affiliated with the National Collegiate Athletic Association (NCAA), the Patriot League and the Eastern Intercollegiate Wrestling Association (EIWA). Lehigh frequently hosts collegiate championship events in men's and women's sports and is the summer training camp facility of the Philadelphia Eagles of the National Football League.

Intramural/Club Sports

The Department of Intramural and Club Sports supervises some 40 intramural and club sports. The aim is to insure the health and physical development of students while participating in various levels of competition. ALL PARTICIPANTS ARE RESPONSIBLE TO SUPPLY THEIR OWN APPROPRIATE INSURANCE COVERAGE.

Through its program of intramural sports, the university endeavors to maintain among its students a high degree of physical fitness, to establish habits of regular and healthful exercise, to foster the development of such valuable byproducts as self-confidence, good sportsmanship, a spirit of cooperation and to provide each student with ample opportunity for acquiring an adequate degree of skill in sports of the type in which participation can be continued after graduation.

Club sports are oriented toward mutual interest and physical activity. The underlying purpose of any club is to join together those members of the student population that share a common activity interest. Club competition can range from a club varsity status (Crew or Ice Hockey), Club Competitive (Ski Team, Men's Volleyball, Lacrosse, Rugby, etc.) to Club Developmental (Soccer, Gymnastics, Tae-Kwon-Do, etc).

Good Citizenship

The university exists for the transmission of knowledge, the pursuit of truth, the development of students, and the general well-being of society. Free inquiry and free expression are indispensable to the attainment of these goals. All members of the academic community are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth.

Out of concern for individuality and respect for the privacy of all persons, the university does not impose a common morality on its members. Institutional existence, however, is a privilege granted by public trust, subject to the sanctions and responsibilities defined by the society of which the university is a part.

Furthermore, society generally provides legal canons, ethical mores, and conduct expectancies pertaining to individual and collective behavior. Thus, the university has the obligation to establish standards of conduct appropriate and applicable to the university community.

Lehigh accepts its responsibility as an institution within the broader social community. The standards of behavior expected of its members are those that the university regards as essential to its educational objectives and to community living.

Lehigh relies primarily on general principles and statements of expectation for standards of conduct, and assumes that those admitted to the university community are capable of accepting that responsibility. Specific regulations are kept to a reasonable minimum and are published in the *Lehigh Student Handbook*. Students are responsible for knowing the procedures, rules and regulations as published in the *Handbook*.

In accordance with these purposes and objectives, disciplinary action will be taken when necessary to protect the academic integrity of the university and the welfare of its members.

All members of the university community are subject to municipal, state, and federal laws. The university is not a sanctuary for persons who violate these laws. Lehigh is concerned, however, about the rights of students as citizens and will direct them to legal counsel when necessary. Off-campus misconduct may be the basis for disciplinary action.

Further, the university as a part of the community has an obligation to report serious crimes to civil authorities.

In Bethlehem, An Educational Tradition

Lehigh University shares in the historical heritage of Bethlehem, even though, having been founded in 1865, it is a relative newcomer. The fact that Lehigh was established in Bethlehem reflects the tradition of education established by the community's first settlers thirty years before the founding of the nation.

The first Moravians were among the many German religious sects that came to the New World, and especially to Pennsylvania, during the early 1700s. But unlike William Penn, who established his sylvania as a new land where he might hold his Quaker beliefs away from England's oppression, the Moravians came as missionaries with the intent of converting the Indians to Christianity. For this purpose they settled the Lehigh Valley.

The early Moravians were industrious. Their first building, the Gemein Haus (community house) was completed in 1741. This building stands today, one of thirty-nine remarkably preserved pre-Revolutionary War buildings constructed by the Moravian settlers and in continuous use ever since by the Moravian community. Many of these buildings are located on Church St., west of the City Center; industrial buildings are located in the 18th Century Industrial Area in the Monocacy Creek valley west of the business district.

The leader of the Moravians was Count Nicholas von Zinzendorf of Dresden. He arrived in the settlement in time for their observance of Christmas Eve in 1741 and gave the settlement the name Bethlehem—"house of bread".

The settlers built high-quality structures of stone, demonstrating principles of engineering that were not generally used elsewhere. They were interested in music, and established the first symphony orchestra in America. In 1748, the settlement had a fourteen-man orchestra. The community's first organ was built in 1757 by John Gottlob Klemm. The musical tradition, including the trombone choir, continues today, perhaps most visibly in the Bach Choir of Bethlehem, whose yearly Bach Festival is held in the university's Packer Memorial Church. In 1985, the 300th anniversary of the birth of Johann Sebastian Bach was observed.

Zinzendorf envisioned Bethlehem as the center for manufacturing; outlying Moravian settlements, such as Nazareth, Pa., would be primarily devoted to agriculture. On October 15, 1742, a large barn was "raised" with the help of most of the residents. Three months later a grist mill at the community spring produced the first flour. In 1758, the Sun Inn was built along Main St., a haven for travelers. Reconstruction of the picturesque inn was completed in 1982, and it now operates as a community center and restaurant.

Zinzendorf's determination that Bethlehem would be a major industrial center was assisted by the completion in 1755 of the water works, the first public utility in the New World.

The Moravian dedication to education was an extension of the philosophy of John Amos Comenius, who had written, "Everyone ought to receive a universal education." The Moravian educational institutions that continue today, including Moravian Academy and Moravian College, stem from this tradition.

The Moravians, although avowedly opposed to war, found their community pressed into service as a hospital when Washington's troops bivouacked at Valley Forge during the winter of 1777-78. Washington came to the community once, and many other Continental Army officers were visitors.

The Sun Inn was also used as a hospital during the war; among its patients was an aristocratic renegade from France, Marie Joseph Paul Ives Gilbert Motier, the Marquis de la Fayette. Lafayette had come to assist the Continental Army aboard his own ship, the "Victory." Fifty years later a college in Easton was named in his honor and it became Lehigh's traditional football rival.

The first bridge across the Lehigh River was built in 1794. It was replaced in 1816, but the latter was destroyed by a flood in 1841. In 1759, the turnpike (toll road) over South Mountain, generally along the route of the present Wyandotte St. hill, was opened. The present Hill-to-Hill Bridge was built some fifty years ago.

"Black gold." During the late 18th century, anthracite was found in the mountains north of the Lehigh Valley. In 1818, the Lehigh Coal Co. and the Lehigh Navigation Co. were formed, one to mine the anthracite on the upper Lehigh River, the other to transport it down river to metropolitan markets.

The Lehigh River was difficult to navigate. Consequently, in 1829 the Lehigh Canal was completed from Mauch Chunk (now Jim Thorpe), through Bethlehem to Easton, where it connected with the Delaware Canal. During the 1840s, iron mines were opened in the area, and several blast furnaces, fueled by coal, were in operation. Zinc ore, was found in neighboring Upper Saucon Township. In the 1850s Asa Packer built the Lehigh Valley Railroad. These origins eventually led to the heavy industry that continues in the Lehigh Valley today.

When Asa Packer founded Lehigh University in 1865, one of his objectives was to make possible broadly based education for young people of the region, combining the technical skills needed to run the flourishing industry of the Lehigh Valley with a liberal education.

In addition to its role as a steel-making center, Bethlehem today is a major tourist attraction. The Moravian community sets up an elaborate nativity scene and the entire city is decorated with lighting during the holiday period. The Moravian tradition of a single candle (now electric) in each window is widely observed.

Atop South Mountain is a steel tower known as the Star of Bethlehem. During the holiday period, the star's hundreds of bulbs create a 95-foot-high star that can be seen for many miles. The star was the gift to the community of Marion Brown Grace, wife of Eugene Gifford Grace, the steel magnate and president of the university board of trustees.

The community of Bethlehem has a population of approximately 78,000 persons with segments from a variety of nations who retain traditions of their country of origin.

There are five principal independent colleges in the Lehigh Valley besides Lehigh. They are Lafayette, DeSales University, Moravian, Muhlenberg, and Cedar Crest. A cooperative program is maintained that allows cross-registration for courses as well as shared cultural events. There are also two community colleges in the area.

In August 1984, Bethlehem held its first Musikfest, a 10-day annual festival that features a variety of musical performances and ethnic foods. An instant success, Musikfest was the brainchild of Jeffrey A. Parks, a lawyer and 1970 Lehigh graduate.

II. University Resources

A student enrolled at an institution of the size and tradition of Lehigh can draw upon many resources to enhance the educational experience. These range from classrooms and laboratories with modern equipment to expert faculty members and extensive library collections. Indeed, Lehigh University's 1,600 acres comprising its three Bethlehem campuses are a special resource, providing a beautiful environment for learning. Following are descriptions of various resources related to academic programs.

Library and Technology Services

The exponential growth and increasing sophistication of information technology offer new and exciting opportunities for enhanced teaching, learning, and research. At Lehigh University, one merged organization called Library and Technology Services (LTS)-delivers communications, computing, distance education administration, enterprise systems implementation, library, and media services to capitalize on these new opportunities. Additional information about Library and Technology Services, can be found at *www.lehigh.edu/lts*.

Libraries

Two major facilities, the Fairchild-Martindale Library and the Linderman Library, house the university collection of more than one million volumes. Both libraries provide collaborative learning spaces, wireless connectivity, and comfortable lounge areas. The Fairchild-Martindale Library contains books, journals, newspapers, audio-visual resources, and microform collections in all branches of science, engineering, mathematics, and the social sciences, including business and education. More than 12,000 print and electronic journals allow the university to compete successfully with many larger institutions in supporting scholarly research. As a government depository, the Fairchild-Martindale Library also holds more than 220,000 printed federal and Pennsylvania documents, as well as additional collections on microform of these and United Nations documents.

The historic Linderman Library with its stained glass skylight, spiral staircase, and gothic detailing evokes the classic collegiate atmosphere of the late nineteenth century. Appropriately, it houses books and journals in the humanities and Lehigh's impressive collection of rare books. Students can examine original editions of important works in science and technology such as Darwin's *Origin of Species*. New digitized collections make these resources more available on the Internet. These include: *Digital Bridges* (19^{th} century works on bridge construction), *The Problem of Planets* (works by Copernicus and Brahe), and *Lehigh Valley Geology Historical Works*. Other strengths of these Special Collections, numbering some 25,000 volumes, are travel and voyages, James John Audubon's four-volume elephant folio edition of *Birds of America,* and English and American literature. Some 30 separate archival collections focus on industrial and regional history.

The "virtual electronic library" at Lehigh is just as important as the print-based one. Lehigh has available a full range of electronic indexes, reference works, full text databases, and image databases, all accessible to Lehigh students from on and off campus. Students and faculty can move seamlessly from the Lehigh online catalog or from individual print or electronic citations to full text articles in electronic journals. Lehigh also offers an innovative "My Library" portal that organizes this wealth of information from a variety of resources into a convenient subject-based gateway. In addition, forty million books in Pennsylvania's largest academic libraries may be identified by users through a shared online catalog for quick borrowing. Students and faculty may borrow books directly from other academic libraries in the Lehigh Valley, and through interlibrary loan, from collections throughout the world.

Networking and Voice Communications

Lehigh University's campus is fully wired, increasingly wireless, and capable of providing gigabit connectivity to the desktop in several research-oriented buildings and laboratories. All this technology is tied together by a high-speed fiber optic backbone network. Residential students, including those in fraternities and sororities receive extensive networking assistance through the WIRED program described below. Most major campus buildings, three outside plazas, and commons areas in all residences are wireless. For up-to-date information on wireless locations, consult www.lehigh.edu/wireless. The new Campus Portal allows members of the Lehigh community to fully customize their access to web-based information and applications.

The World-Wide Information Resources in Every Dorm (WIRED) program is designed to assist Lehigh students with connecting their personal computers to the campus local area network (LAN) and to the Internet. WIRED staff communicate with first year students in early June to identify for them compatible hardware and software for use on the campus network. When students bring their computers to campus, WIRED staff help them get connected quickly and then provide continuing assistance with any networking problems throughout the semester. The front line WIRED consultants are well-trained students who live in the residences and can readily provide prompt, on-site support. Full-time graduate and undergraduate students who live off-campus in the local area are eligible for a free university-provided Internet Service Provider (ISP) subscription to facilitate their access to the Internet.

Through its Enterprise Systems Implementation effort, more interactive and convenient Web-based services such as Web-based course registration and online grades are offered to students. Library and Technology Services also has a state-of-the-art telephone system, with voice-mail services to the entire campus, including residence facilities.

Computing

Library and Technology Services provides computing services to all university departments and research centers, serving the needs of students, faculty, and administrative users. More than 400 microcomputers (primarily IBM-compatible and some Apple personal computers) are distributed across campus for convenient use by Lehigh students at more than 20 computing sites.

For example, there are more than one hundred microcomputers in the libraries and computing center, and another hundred in Rauch Business Center. A twenty-four hour site at Grace Hall has 30+ machines. There are also portable laptops equipped with wireless network cards available for short-term loan to students at both libraries and at the Media Center.

Local and wide area networking solutions are in place to give students and faculty access to site-licensed software applications and central file space from the campus sites or their residence facility. Each full-time student receives access to an enhanced Microsoft Professional software package for his or her own computer. In addition, LTS provides other software at public sites such as desk top publishing and graphics software, programming languages, mathematical and statistical packages, and specialized applications for engineering, scientific publishing, and creative writing.

The Fairchild-Martindale Computing Center houses a network of high-performance computers, configured as a centralized network service cluster. A separate powerful machine serves as a scientific "compute server" to support computer-intensive applications such as programming and statistical software. UNIX-based workstations, a Beowulf cluster, and a Condor grid are available for research applications. The university computing capacity and bandwidth are constantly being increased to meet the escalating demand. Lehigh also offers higher-speed connections to the research-based Internet2 network by virtue of its charter membership in that organization.

Providing technology and consulting services to support classroom teaching, laboratories, and other aspects of the academic program is a strategic priority for Lehigh University. The Technology Resource Learning Center supports faculty innovation—see the Faculty Development section of this catalog for details. Library and Technology Services provides technical support for about 100 technology enhanced classrooms with computer projection systems, VCR/DVDs, and instructor podiums. Some classrooms provide wireless connectivity and/or computers for "hands-on" instruction. In addition, portable microcomputers and portable computer projectors are available through Library and Technology Services to enable faculty or students to give computer-based presentations in any classroom.

Media Center and Services

The Instructional Technology Support Service operates three facilities to provide students with access to and instruction in a wide range of traditional and high-tech media resources: the International Multimedia Resource Center or IMRC, the Media Production Center, and the Media Center. The Media Center in Fairchild-Martindale Library offers videos and a basic production facility (scanners, color printers). Resources include audio, video, and electronic media and the equipment and viewing spaces needed for their use. More than 3,000 videos are available for viewing or short-term loan. The Center also coordinates the rental of films and videos for classroom use. A supply of laptops for short-term use by students, faculty or departments are housed there as well. The Media Center is also the location of Lehigh's Technology Resource Learning Center offering faculty the services of instructional designers and the use of a high technology demonstration classroom.

International Multimedia Resource Center (IMRC)

The IMRC is located in Maginnes Hall adjacent to the Fairchild-Martindale Library and Computing Center. In cooperation with the College of Arts and Sciences, the IMRC assists students in using multimedia resources and producing Web-based and multimedia projects. The IMRC also assists faculty in incorporating educational technology into the academic curriculum. Workshops emphasize Web-authoring and multimedia production. In addition student language and cultural learning is enhanced through the provision of interactive multimedia resources at the IMRC. The World View Room, a comfortable facility accommodating up to 40 people, can be used for viewing satellite programming, special cable programming, or video presentations.

The IMRC coordinates programming on several Lehigh channels of the campus cable network including one channel that features SCOLA, a multi-university consortium that transmits foreign news broadcasts. PBS/ALS digital downlinks are offered, as well as other international programs and university programs relating to academic, cultural and athletic life. Another channel supports programming oriented to campus residential life.

Media Production Center

The Media Production Center in Linderman Library offers students and faculty consulting assistance, instruction, and a wide range of modern and traditional technology for the creation of high quality audio, graphic, or video resources for classroom presentations, projects, and portfolios. Students can scan and edit text, photographs, and slides, and these images can be output to standard laser printers, color printers, or to computer files for transfer and manipulation. Video cameras, a small video studio, and both entry-level and professional editing equipment facilitate the production of audio and video material to support the academic program. Students can use digital cameras, a photo-quality printer, image-manipulation software, and a photography studio.

Student Services

The libraries, computing center, and most distributed computing facilities are open seven days per week and for extensive evening hours during the fall and spring semesters. For most of these hours, a help desk located at the Fairchild-Martindale Library provides general help for students and faculty on-site and for telephone inquiries relating to both library research and computing. Help desk staff refer difficult or more specialized questions to experts as needed. There are also service desks located at the Linderman Library, and the Computing Center.

Students may also take advantage of virtual help desks where they enter the questions or problems relating to library research, computing hardware or software, or telecommunications at any hour of the day or night for response at a later time, usually within one working day. Most library and computing services are available electronically; for example, requests for books to be recalled, film rental requests, and seminar registrations. "Live chat" library reference and computing help services are also available during many hours.

Each semester Library and Technology Services' Client Services Group offers an extensive program of seminars and course-based instructional sessions for students.

Attendees learn how to use software applications, the extensive print and electronic library resources, and the World Wide Web. Students learn how to create their own "home pages" as part of seminars on authoring documents for the Web. In class sessions, LTS staff work closely with faculty, to integrate library, computing and media resources into the curriculum. LTS computing, library, and instructional technology consultants have been instrumental in facilitating the use of course management software, online courses of various kinds, and course projects in a wide range of disciplines using interactive Web sites created by faculty and students.

Online and printed guides and manuals for computing and library resources are provided for students. Through seminars and policies on use of print and electronic resources, students are taught computer ethics, recommended computing practices such as frequent backup and password changes, and an understanding and respect for state and federal laws governing copyright, privacy, and destruction or vandalism of library resources or computer systems, networks, databases or software. An electronic newsletter, *LTS Digest*, with quick tips and updates is published throughout the year and is available to students who register to receive it by email.

Library and Technology Services maintains a variety of facilities for printing, copying, and duplicating within the constraints of copyright legislation. In the libraries, public photocopiers and microform printers are maintained for convenience in copying print or microform resources. The Media Production Center (described under **Media Services**) can duplicate audio and video resources. For computer printing at central and distributed sites, a network of PostScript laser printers is provided. Larger printing jobs can be routed electronically to the high-volume laser printers at the Fairchild-Martindale Computing Center.

Student Employment

Student assistants are essential for the operation of most Library and Technology Services functions. Working for LTS, students gain valuable skills and good work habits. At the job fair held each fall there are opportunities to learn in-depth about the jobs available.

Art Galleries - Museum Operation

The Lehigh University Art Galleries maintain and develop the university's permanent art collection, and present temporary exhibitions designed to make visual literacy a result of the university learning experience. More than twenty exhibitions a year in seven campus galleries introduce students and the community to current topics in art, architecture, history, science, and technology. The exhibition schedule is supplemented by lectures, films, workshops, and research opportunities in the permanent collection. The art galleries play an important role in the educational mission of the university through its exhibitions and programs. The galleries occupy exhibition, storage, office and workshop space in several campus locations. The Upper Gallery and Lower Gallery permanent exhibitions are in the Zoellner Arts Center. Maginnes Hall houses the DuBois Gallery, the Girdler Student Gallery is in the University Center, and the Siegel Gallery is in Iacocca Hall on the mountaintop campus. The Muriel and Philip Berman Sculpture Gardens are located in the courtyard of Mudd, Mart, Whitaker and Sinclair buildings; and on the mountaintop campus, and Saucon Fields on the Murray H. Goodman campus. The Ralph L. Wilson Study Gallery and Open Storage facility is located in Building J, mountaintop campus and available by appointment. LUAG offices are in the Zoellner Arts Center.

Exhibitions

Exhibitions and gallery events are planned to supplement formal classroom study in the visual arts, to create educational opportunities for the entire student body, and to enrich the cultural life of the campus and the community at large. The annual schedule includes the exhibition of works from the permanent collection, the use of borrowed objects, and traveling exhibitions on loan from major museums and cultural institutions. Experts in various fields serve as guest curators of special project exhibitions. Interdepartmental projects within the university encourage increased involvement by faculty and students. Undergraduates may take advantage of courses in museum studies including internship and independent study in the collection.

Collections

Lehigh University's permanent art collection is a work/study collection intended as a resource for students pursuing formal study in the visual arts and/or museum studies, for the faculty, and for interested members of the community. Each year, several exhibitions are prepared from the collection and works are loaned to major museums throughout the nation.

The permanent art collection consists of a variety of works by old masters and contemporary artists. Important collection groups include: the Marion B. Grace Collection of European Paintings (Gainsborough, Reynolds, Goya, Hobbema, Hoppner, and others); the Dreyfus Collection of French Paintings (Bonnard, Sisley, Vuillard, Courbet); the Ralph L. Wilson Collection of American Art (paintings by Prendergast, Sloan, Henri, Lawson, Bellows, Davies, Burchfield; prints by Whistler, Hassam, Motherwell, Johns, Rauschenberg, Calder, Warhol); the Prasse Collection of Prints (Delacroix, Matisse, Renoir, Kent, Kunyoshi, Rivera); the Philip and Muriel Berman Collection of Contemporary Sculpture (Kadishman, Unger, Tumarkin, Bertoia, Shaw).

Also, the Fearnside Collection of European Old Master Prints and Drawings; the Baker Collection of Chinese Porcelains; the Langermann Collection of Pre-Columbian and Ethnographic Sculpture; the Mr. and Mrs. Franklin H. Williams African Collection (gold weights of the Akan and West African objects); the Lehigh University Photography Collection (Fox-Talbot, Jackson, Atget, Steiner, Mendieta, Kasebier, Brandt, Siskind, Clark, Martinez-Canas, Serrano); and the Lehigh University Contemporary Prints and Drawings Collection (Bearden, Rivers, Soto, Roth, Ruscha, Tobey, Calder, Kitaj, Marca-Relli, Cruz Azaceta, Segal, Lam, Picasso, Warhol, Llinas, Golub, Jimenez, Piper, Simpson), and the Philatelic and Numismatic collection.

Faculty Development and Learning Innovations

Faculty Development connects professors with resources on teaching and learning. Teaching/learning events have included 1) faculty-led workshops on topics such as using small groups in the classroom, cooperative learning, and using course management software (Blackboard); 2) faculty-led seminars based on books about teaching, learning, and the academic life; 3) one- and two-day workshops led by nationally known consultants on specific teaching techniques; and 4) live videoconferences on teaching and learning from several sources.

Faculty Development co-sponsors events with the Teaching and Learning Technology Roundtable, and with other departments and centers. Each year Faculty Development funds faculty trips to teaching conferences such as the Lilly Conferences on College Teaching and the annual American Association of Higher Education conferences. At monthly faculty development lunches, faculty give reports from these conferences, or discuss other aspects of teaching.

Faculty Development coordinates these programs within the structure of the Lehigh Lab, a concept that the University as a whole is a laboratory in which faculty, students, and staff work and experiment together, across disciplines and departments, to advance learning. Central to the Lehigh Lab concept is the Technology Resource Learning Center (TRLC) located in the Fairchild-Martindale Library and Computing Center. A state-of-the-art technology classroom, public scanning and editing area, consulting space for instructional technology, and a Faculty Fellow office are the primary components of the TRLC. In the TRLC, support teams from Library and Technology Services bring expertise to projects proposed by faculty. The Lehigh Lab Faculty Fellow and the Faculty Development Director mentor faculty as they use technology in teaching and research. A small group of faculty serve as the Lehigh Lab Advisory Committee to the Faculty Fellow and the Director.

The Faculty Development Director provides confidential, voluntary consultation to faculty about their teaching, which may include videotaping of class sessions, and classroom observation visits. Informal mid-semester evaluations in classes may be done by the Director.

Dr. Greg Reihman, Faculty Development Director, may be contacted at 610-758-6840.

Lehigh University Press

Lehigh University Press represents a clear expression of faculty and institutional commitment to the advancement of scholarship. Philip A. Metzger, Curator of Special Collections, Lehigh University Libraries, serves as director of the press, and members of the faculty of the four colleges serve on its editorial board.

The press is interested in all fine scholarship, but places special emphasis on traditional areas of strength at Lehigh: Science, Technology and Society (STS) studies; and Eighteenth-Century studies, and the relationship of America and Asia. In linking the name of the university to a list of exemplary work by scholars across the nation, the press reinforces the value of excellence in the academic environment for faculty, graduate and undergraduate students alike, and helps to maintain intellectual contact with alumni.

A representative list of press publications, including works by our own faculty, contains: *The Trans-Alaska Pipeline Controversy*, by Peter Coates (winner of the press's first manuscript competition, and the W. Turrentine Jackson Award of the Western History Association); *Joseph Wharton: Quaker Industrial Pioneer* and *Lehigh University: A History of Education in Engineering Business, and the Human Condition,* by W. Ross Yates; *History and the History of Technology: Essays in Honor of Melvin Kranzberg,* ed. Stephen Cutcliffe and Robert Post; *Exiles in Hollywood: Major European Film Directors in America*, by Gene D. Phillips; *Science at Harvard University,* by Clark Elliot and Margaret Rossiter; *Revelation and Revolution: Basic Writings of Thomas Muntzer,* by Michael G. Baylor; *Virtue, Corruption and Self-Interest: Political Values in the Eighteenth Century,* by Richard K. Matthews; *Sentenced to Remember* (A Holocaust Memoir), by William Kornbluth; *Life on a Mexican Ranche,* ed. Dolores L. Latorre; *Maxwell on Heat and Statistical Mechanics: On Avoiding All Personal Enquiries: of Molecules*, ed. Elizabeth Garber, et al.; *Transatlantic Brethren: Rev. Samuel Jones (1735-1814) and His Friends: Baptists in Wales, Pennsylvania, and Beyond,* by Hywel M. Davies; *Toward a Dialogue of Understandings: Loren Eiseley and the Critique of Science,* by Mary Ellen Pitts; *Leonardo da Vinci's Sforza Monument Horse: The Art and the Engineering,* ed. Diane Cole Ahl; *Baptized in the Fire of Revolution: The American Social Gospel and the YMCA in China, 1919-1937,* by Jung Xing; *A World of Crisis and Progress: The American YMCA in Japan, 1890-1930*, by Jon Thares Davidann; *Sentential Probability Logic: Origins, Development, Current Status and Technical Applications*, by Theodore Hailperin; *The Life and Times of Goldsworthy Gurney: Gentleman Scientist and Inventor, 1793-1875,* by Dale H. Porter; *Separatism the Allies, and the Mafia: The Struggle for Sicilian Independence, 1943-1948,* by Monte S. Findelstein; *The Nightmare of History: The Fictions of Virginia Woolf and D.H. Lawrence,* by Helen Wussow; *'Pleasing to Our Use': David Tannenberg and the Organs of the Moravians,* ed. Carol Traupman-Carr; *Wings for an Embattled China,* by W. Langhorne Bond; *The Terror of Our Days: Four American Poets Respond to the Holocaust*, by Harriet L. Parmet; *One Woman Determined to Make a Difference: The Life of Madeleine Zabriskie Doty*, by Alice Duffy Rinehart; and *An American Musical Dynasty: A biography of the Wolle family of Bethlehem, Penasylvania*, by Paul S. Larson.

For more information, contact Dr. Philip A. Metzger, Lehigh University Press, 30 Library Drive, Lehigh University, Bethlehem, PA 18015-3067, by phone (610-758-3933); by fax (610-758-6331) or by website (http://fp1.cc.lehigh.edu/inlap/).

Resources for Students

Lehigh's administrators firmly believe that the interrelationship between students' classroom and nonclassroom activities can be fostered to become an educational avenue through which students grow, accept responsibility, and gain maturity in ways that will contribute to productive and meaningful lives. Through various services, students are assisted in becoming informed decision makers. They are also encouraged to develop greater self-awareness and self-confidence in their ability to lead the lives they choose.

Support and assistance for individual students often begins in the residential setting. Staff members in the residence halls include six live-in professional residence life coordinators, and approximately ninety undergraduate residence hall assistants, known as Gryphons. All staff members are carefully selected, extensively trained, and are available to assist resident students who may have a variety of concerns.

Students are also encouraged to seek counsel and guidance from professionals in many areas of student life. The Office of the Dean of Students serves as a central agency to help students who have questions about academic and procedural matters, personal problems, and other general concerns, both through its staff and through referral to other student affairs and academic offices. Through the programs and services provided by the Dean of Students office, students can become involved in community service, leadership skill development, multicultural opportunities, and a myriad of other activities designed to develop the well-rounded individual.

Students who need assistance with their physical well-being are referred to the university health center.

If a student has interests or concerns related to any personal or interpersonal issues, the office of University Counseling and Psychological Services offers a wide range of options, confidential and free of charge. Counseling Center staff interact with students around campus in classrooms, residence halls, and other settings. In addition, traditional services such as individual and group counseling, psychological evaluation, and crises intervention are provided by the licensed professionals in the center.

The university chaplain is available for the student with religious, moral, or personal concerns that are interfering with peace of mind and studies. A Roman Catholic chaplain also is in residence and available for counseling. A member of the faculty serves as adviser to Hillel Foundation members, who also may obtain spiritual advice from a local rabbi. The Office of Career Services offers assistance to students in identifying and developing career options that can be initiated at graduation. The office also manages an active on-campus interviewing program for graduating students.

The registrar assists students who have questions involving matters of transferred credits, graduation requirements, and allied topics.

The Office of Financial Aid consults with students who have financial concerns that are affecting their educational plans.

The Center for Writing, Math and Study Skills offers free individual tutoring in reading and study skills, mathematics, and writing.

Many members of the teaching faculty are also interested in students and student life. They serve as academic advisers, activity sponsors, group sponsors and advisers, and in friendly personal relationships with students.

In these and in other ways Lehigh University endeavors to maintain the close contacts with students that characterize the smaller institution. Services are available for all student concerns, and the student need only turn to his or her nearest Residence Life Coordinator, professor, or the *Lehigh Handbook* to learn where help can be obtained.

Alcohol and Other Drug Programs

Alcohol and Other Drug (AOD) programs, education, and services are integrated into many aspects of student life with administrative coordination of much of this work provided by the Office of Counseling and Psychological Services (610-758-3880) located in Johnson Hall. Web based (see Counseling Service Site) and direct services are provided for a wide range of issues ranging from wellness and health to matters of substance use and misuse. Because members of the Lehigh community recognize that substance abuse and chemical dependency can significantly affect student lives, educational programs are designed to encourage peak performance and avoid high-risk behavior. Confidential individual and group counseling and consultation services are available to students who find themselves having problems because of their own substance use, or related to friends and/or family members having problems with substance use. Appointments are easy to make by calling the office of Counseling and Psychological Services at 610-758-3880 or by visiting the 4th floor of Johnson Hall during office hours (8:00 a.m. to 5:00 p.m. with some additional evening hours), Monday through Friday.

Theme weeks and sponsored outreach programs such as Alcohol and Drug Awareness Week and National Alcohol Screening Day provide educational programs on a variety of AOD and peak performance topics. Peer education consultation is also available to students creating programs and planning interventions. Intervention services include training programs for Residence Life staff, peer educator groups, athletes, and students referred by the Dean of Students office, and other members of the Lehigh community. Individual and group counseling is provided by the office of Counseling and Psychological Services. Students who struggle with defining their own values regarding substance use and addiction are encouraged to clarify and process their beliefs in a safe, confidential environment. On-campus counseling may allow students to successfully enter into recovery (from alcoholism or chemical dependency) without having to disrupt their university careers. If a student cannot accomplish this on campus, referrals to in-patient or outpatient treatment programs can be made. Aftercare services can be provided once the student returns to campus, utilizing on-campus counseling or by referral to 12-step group meetings (such as A.A. and N.A). These meetings are held on campus and in the surrounding community. Referral to other treatment programs, community service programs, and programs associated with the court system can also be facilitated by various offices within Student Affairs.

Disability Support Services

In accordance with federal legislation, specifically Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act, Lehigh University recognizes the special needs of students with physical, sensory and learning disabilities. Services for students with physical disabilities are coordinated by director of Facilities Services. Academic support services for students with learning disabilities and other cognitive and sensory disorders are coordinated by the Dean of Students Office. The Dean of Students Office works in conjunction with faculty members to provide appropriate classroom accommodations for students with a diagnosed learning disability. Students requesting accommodations must present the university with a current and comprehensive psycho-educational evaluation. For more information about support services for students with disabilities, contact the Dean of Students Office (phone: 610-758-4152; University Center, room 212).

Health & Wellness Center

The university offers health services to all students at the Health Center in Johnson Hall. During the fall and spring semesters, providers are available to see patients from 8:30 a.m. to 5:00 p.m. Monday to Friday. Providers include nurse practitioners and physicians. A registered nurse is present to see patients on Saturday

10:00 a.m. to 4 p.m. with a provider on call. During breaks, hours are shortened.

The Health Center staff treats a variety of health problems, including illnesses and injuries. Gynecologic care is available by appointment. Allergy injections can be administered. Some minor surgery is performed at the Health Center. Many laboratory studies can be done at the Health Center; students are referred to local facilities for X-rays. Patients are referred to local medical and surgical specialists when indicated. More seriously ill students are sent to a general hospital.

Prior to arrival on campus, each new or transfer student must submit to the Health Center a completed health history form, and updated immunization record. A recent physical examination is required if a student plans to participate in varsity athletics.

Following enrollment, additional examinations are provided by the Health Center for students participating in intercollegiate athletic programs, and when required for graduate school or scholarship programs. The Health Center does not provide examinations for military, insurance or employment purposes, with few exceptions.

There is no charge for most of the care provided to students. Some exceptions are as follows: referrals to physicians, hospitals, or other medical facilities outside the student Health Center, and medications not carried by the Health Center which require prescriptions. A low-cost university-sponsored insurance plan is available, which complements the services of the Health Center. Expenses covered include costs for services that are not available at the Health Center, such as X-rays, laboratory studies, consultant fees, and medications not stocked by the Center. Hospital expenses are also covered. Students are urged to check with their parents regarding existing insurance coverage and to consider purchasing the university-sponsored plan if they are not adequately covered. Please consult your insurance carrier or physician if your plan is of the managed care/preferred provider type.

A health service brochure is available through the Health Center. Or consult our web page at *www.lehigh.edu/health.*

Counseling and Psychological Service

The University Counseling and Psychological Service (at 610-758-3880 is located on the fourth floor of Johnson Hall. The office is open from 8:00 - 5:00 (with some additional evening hours), Monday through Friday. Most services are free of charge. Counselors are available for 24-hour emergency consultations via campus police (610-758-4200).

I. Philosophy & Mission

The University Counseling and Psychological Service (UCPS) is dedicated to the belief that a person's college years are a time of challenge, inquiry, experimentation, productivity and change. Services are designed to help students not only manage crises, but to thrive in meaningful ways . . . to grow in self-understanding in order to make more satisfying and better use of their personal and interpersonal resources. Individual contacts, group therapy, faculty and staff consultation, and numerous outreach activities are some of the primary means by which the mission is accomplished. UCPS staff members are committed to providing assistance to all registered Lehigh students interested in personal, social, and academic growth and discovery, and to the larger campus community through consultation, teaching, research, and various other types of involvement.

II. Direct Services

To accomplish its mission, and while upholding the established state and APA (American Psychological Association) ethical principles and code of conduct for psychologists, the UCPS provides a variety of services to the Lehigh University community including:

- Crisis Intervention Services

  The UCPS provides assistance to individuals and groups in crisis. Psychologists provide 24-hour coverage via pager access (call campus police dispatcher at 758-4200) during the Fall and Spring semesters.

- Group and Individual Psychotherapy

  UCPS staff members provide group and individual counseling and psychotherapy services to both undergraduate and graduate students. A short-term treatment model is used for individual work while much of the group work is of longer duration. Referrals for psychiatric consultation are made when requested and appropriate. All counseling and therapy services within the UCPS are confidential.

- Outreach Programming

  The UCPS provides programming focused on the developmental needs of college students—designed to enhance the capacity of students to maximize their personal, social, and academic potential. These presentations occur in various settings, including living residences, classrooms, athletic sites, and meeting rooms across the university. Topics may include issues related to race, eating and body image, sexuality, drinking and other drug use, study styles, athletic performance, grieving, stress, and relationships. Some of this programming may include partnership with UCPS sponsored student peer education groups.

- Assessment and Evaluation

  Upon request and when appropriate, UCPS personnel administer and use personality and career exploration instruments. They also utilize a wide variety of assessment tools when assisting groups and individual students.

- Consultation Services

  Staff members provide consultative services to the university community with the objective of helping students, faculty and staff identify and resolve difficulties that may be exerting a negative effect on some individual, group, or system. This may include the use of referral resources within the university or in the local community.

- Training

  One component of UCPS work is to help persons such as residence life staff, peer counselors, university personnel, student leaders, and faculty more effectively advise, counsel, interact and communicate with others. A second component is to enhance the development of persons specifically interested in securing the identity and skills of a psychologist - these typically being advanced graduate students, doctoral level interns, and professional staff.

- Advocacy

  Staff of the UCPS advocate for those students and groups who struggle for understanding and respect in a society sometimes blinded by traditional norms and expectations. Through dialogue, education, programming, consultation, and direct service, the staff is committed to being engaged with issues such as racism, sexism, and other practices that destroy self and group esteem.

The Center for Writing, Math, and Study Skills: 110 Drown

Success at Lehigh depends, in part, on mastery of a number of advanced academic skills. Students must be able to write well, to study effectively, to take examinations, to communicate well, to understand advanced mathematical concepts, and to keep up with a great deal of critical reading.

The Center for Writing, Math, and Study Skills supports these vital academic abilities, providing trained consultants in writing, math, and study skills. The Center provides a variety of services such as (1) individual or small group tutoring for students enrolled in undergraduate math courses, (2) writing consultation for students and for the Lehigh community, (3) study skills strategies, and (5) seminars and presentations to Lehigh student groups on effective study skills, time management, and several other topics. Tutoring and consultations are provided by graduate students and faculty; the service is free of charge.

The Center is located in room 110 of Drown Hall. Appointments can be scheduled by calling 758-3098. Both single-session and continuous weekly appointments are available. For more information, refer to the Center website at *www.lehigh.edu/incent/incent.html.*

Career Services

One function of a college education is to foster the growth and development of the student to prepare for a meaningful and satisfying life after college. Lehigh provides career planning services for undergraduate and graduate students as an integral part of the career development process.

Career planning can best be described as an educational process through which students (1) identify and develop their abilities, aptitudes, and interests; (2) learn the relationship between their capabilities and interests, their university experiences, and professional opportunities outside the university; and (3) prepare for those opportunities.

Career Services assists students through the process of researching targeted organizations that provide the types of work desired, interviewing for specific positions through which career or professional interests can be satisfied, and then selecting from the available options the one that best meets the student's needs. This part of the process requires students to develop skills in such areas as effective resume and cover letter writing, interviewing techniques, and individual job search strategies to enhance productive interactions with employers.

The goals of this process include: to enable Lehigh students to think of themselves as educated individuals with skills and abilities of value to employers; to think in terms of functional responsibilities rather than simply linking major subjects to jobs; to acquire and develop the skills necessary to become self-reliant and informed decision-makers; to prepare for a competitive job market; and to develop the potential to become self-reliant managers of their own careers.

The Office of Career Services is committed to the preparation and education of all Lehigh students during the transition from the academic environment to the work place. Career Services offers the following resources and services to help students prepare for professional opportunities after graduation:

Career Counseling. Students may meet with professional counselors to discuss their career options and goals, individual job-search strategies, effective interviewing, and related interests. Self-assessment tools are available to assist students in identifying interests, skills and values.

Peer Educators. Peer Educators are student volunteers who have applied and interviewed to be trained to provide career assistance to their peers. Peer Educators are available throughout the semester to students who walk in with quick questions regarding resume assistance, the LUCIE system, library resources, and general job searching help.

Career Resources. Among the resources available in the Career Library are books and articles on career planning, current information on career opportunities, occupational information, graduate school resources, job-search directories, a library of employer literature, and a database of alumni contacts who have volunteered to assist students with their job search strategies. Students may obtain a free Job Search Manual that describes how to use the on-campus interviewing system, prepare for interviews and plant/office visits, write resumes and letters, and develop individual strategies.

Workshops and Special Programs. Throughout the year counselors conduct a variety of seminars and presentations in collaboration with academic departments, professional societies, living groups, and other interested campus organizations. Workshops are offered on resume writing, interviewing techniques, networking, career portfolios, job searching and internet strategies. Special programs are conducted each semester, including career panels and mini career classes.

Experiential Education. Experiential Education programs are designed to enable Lehigh students to make educated decisions about career choices. Through participation in these programs, students gain firsthand knowledge and experience in a particular career field. Experiential Education programs include: summer employment, internships, part-time positions, externships and cooperative education.

On-Campus Interviewing. Career Services works with over 200 organizations that interview on campus each year. Students utilize web-based software called LUCIE (Lehigh University Career Information Exchange) to view job openings, apply for positions using an on-line resume and sign-up electronically for specific interview times. Employers interview undergraduate and graduate candidates from all four colleges. Each year the OCI program is kicked off by a Career Fair that showcases over 100 employers interested in recruiting Lehigh students.

Lehigh Listings On-Line. Lehigh Listings On-Line is a searchable job listing database available on Career Service's Web Page as part of the LUCIE system. Job openings for part-time, summer, full-time and advanced-level positions can be searched by employer, location, job function, or major. Undergraduates and graduate students from all four colleges will find listings related to their fields of study.

Pre-professional Advising. The pre-professional advisor, along with a faculty advisory committee, provides information and guidance to candidates pursuing careers in medicine, dentistry, and other health professions, including individualized advising, special programs on health-related topics and field trips. In addition, information and assistance is provided for students interested in law school and legal careers.

The office is open throughout the year. The main phone number is (610)-758-3710.

Special Academic Programs

Distance Education

The University's distance education program provides graduate degree programs, certificate programs, individual graduate credit courses, and non-credit short courses in convenient and cost-effective format. The goal is to allow working professionals to pursue their educational goals through Lehigh University while remaining highly productive employees. Admission standards and course requirements are the same for distance and on-campus students, and distance education students receive the same degrees and diplomas. Lehigh distance education is delivered to the students by satellite (Lehigh Educational Satellite Network or LESN) or Internet (LESN-Online) with some use of videoconferencing, Internet2, CD-Rom, and videotapes.

Programs by satellite include Master's Degrees in Chemistry, Pharmaceutical Chemistry, Chemical Engineering, Manufacturing Systems Engineering, Molecular Biology, Quality Engineering, Polymer Science and Engineering, and the MBA. Satellite courses are transmitted on Ku-band digital channels and received directly at students' work sites.

LESN-Online, using the WWW, delivers programming to distance students with Internet access. Featuring both synchronous and asynchronous streaming media technology, LESN-Online allows students to see and hear their instructors while they view course materials as downloadable graphics. The following programs are now fully available online: non-credit professional and technical short courses; individual credit courses; credit/non-credit certificate programs, including Supply Chain Management, Project Management and a full Master's Degree in Pharmaceutical Chemistry.

For specific information on course offerings, admissions, registration, and technical requirements, visit the distance education website at *www.distance.lehigh.edu* or call (610) 758-4373.

Summer Studies

There has been a summer session at Lehigh for over a century and, through the years, it has developed into a significant part of the University's overall academic program. Lehigh now offers over 200 courses each summer. They range from travel programs in Europe, to field camp in the Rocky Mountains to on-campus courses that service Lehigh undergraduates and graduates, adult professionals in business and education, and students at other colleges who return to their Lehigh Valley region homes during the summer. At Lehigh, summer is a time for educational experimentation. There are many special summer offerings not available during the regular academic year, including a number of courses offered completely on-line. For more information visit the summer sessions website at *www.lehigh.edu/summersessions* or call (610) 758-3966.

Continuing Education

Lehigh University departments, research centers, and administrative agencies offer a varied selection of non-credit continuing education programs for adults. Reflecting Lehigh's traditional educational strengths, these offerings focus on professional development, organizational problem solving, and technical skills. They often carry no regular academic credit, but participants can earn some form of continuing education credential.

Lehigh continuing education programs are often designed to meet specific needs. Contents, schedules, and timing are adapted to effectively serve the audiences for which they have been developed. Apart from public programs presented on the Lehigh campus, a number of programs are available for "in-house" presentation to organizations on a contract basis. For more information about these programs, contact the appropriate department or research center.

English Language Learning Center (ELLC)

For ESL students who want to improve their ability to comprehend English on-campus and off-campus in formal and informal settings. The tutors provide language tutoring and guidance with the interactive language software.

The ESL English Language Leaning Center provides professional English language tutoring for undergraduate and graduate international students and their spouses wanting to improve their English skills in all skill areas: academic and conversational speaking, listening, reading, writing and grammar, and test preparation for TOEFL, GRE and GMAT.

The ELLC lab is located in the ESL Department Office in Coxe Hall, Room 204. Contact the ESL office for more information: (610) 758-6099 or email inesl@lehigh.edu. Also, please visit our website for online English assistance and information *www.lehigh.edu/~inesl/ELLC*

III. Undergraduate Studies

Graduation Requirements

Students are expected to maintain regular progress toward the baccalaureate degree by carrying the "normal" course load—between 12 and 18 credit hours each semester. Each student is expected to complete the baccalaureate degree by attending four consecutive years and eight semesters. They may, however, wish to accelerate the pace toward graduation by using advanced placement credits, summer session study, and receiving credit for courses through examination.

Students in good academic standing earn their degrees by meeting the requirements of their specific degree curriculum as well as general university requirements. Students should confer with their advisers on matters related to curriculum.

Students are expected to satisfy the credit-hour requirements of their chosen curriculum. Basic military science credit hours are in addition to the credit hours specified in the curricula. A maximum of six credit hours of advanced military science courses may be applied toward the baccalaureate degree.

Undergraduate Residency Requirement

To be eligible to receive a Lehigh baccalaureate degree, the candidate must have completed either a minimum of 90 credit hours in residence, or all of the last 30 credit hours at the University or in residency programs.

Five-Year, Two-Bachelor-Degree Programs

The university's five-year, two-degree programs enable a student to receive two bachelor degrees upon completion of five years of study.

The civil engineering and earth and environmental sciences program that affords two bachelor degrees, and the electrical engineering and engineering physics two-degree program are examples of programs in the College of Engineering and Applied Science.

Some five-year, two-degree programs appear in the description of courses under Arts-Engineering and Five-Year Programs in Section V. It is possible to arrange for a dual bachelor degree program even after studying at Lehigh for some time. Engineering students, for example, who decide at any stage of study that they wish to meet the requirements for both the bachelor of arts and bachelor of science degree may complete the combined requirements in five years if the decision is made before the third year.

Second degree candidates—A student entering Lehigh to obtain a second bachelor's degree, or those Lehigh students who wish to declare a second major in another college, or both a B.A. and a B.S. degree within the College of Arts and Sciences must have a minimum of 30 additional credit hours beyond the first degree credit-hour requirements in order to qualify for the second degree. All of the 30 additional credit hours must be taken at Lehigh or in Lehigh residency programs. All special second degree programs must be approved by the dean of the college in which the degree is to be offered and the Standing of Students Committee.

Advisement

Every undergraduate is assigned a faculty adviser. Undeclared majors in the College of Business and Economics are assigned to the undergraduate adviser and a student mentor. Until the major is declared, assistance is also available through the dean's office of the college in which the student is enrolled. When the major has been chosen, a faculty member from the major department will act as the academic adviser.

This adviser is one of the most valuable resources in the educational process, not only to assist in making academic selections to match the student's particular background, interests, and future objectives, but also to identify program options, to work out an academic pace, and to develop career planning strategies. The adviser will help to identify other resources and support systems available at the university, such as The Learning Center, the counseling service, and the Office of Career Services.

Guide to Academic Rules and Regulations

The university has adopted over the years numerous rules and regulations. Some of the principal rules and regulations are given here so that currently enrolled and potential undergraduates and graduate students will be apprised of what is expected of them, and what they can expect of the university.

This section concerns academic regulations. Additional regulations can be found in the Lehigh Handbook, and there is a comprehensive statement of all policy in the publication Rules and Procedures of the Faculty. All students are given a Handbook at the beginning of the fall semester; Rules and Procedures is available on Lehigh's website.

Eligibility for Degree

In order to be graduated, a candidate for a baccalaureate degree must achieve a minimum cumulative average of 2.00.

To be eligible for a degree, a student must not only have completed all of the scholastic requirements for the degree, but also must have paid all university fees, and in addition all bills for the rental of rooms in the residence halls or in other university housing facilities. Payment also must have been made for damage to university property or equipment, or for any other indebtedness for scholarship loans or for loans from trust funds administered by the university.

Responsibility for meeting academic requirements. Each student is responsible for his or her progress toward meeting specific requirements for graduation. Academic advisers and department chairs are available to assist the student. It is strongly recommended that the student specifically consult with his or her adviser prior to the senior year to ascertain eligibility for the degree for which he or she desires to qualify and to determine that all program and hours requirements are met.

The registrar's office will provide, at the student's request, a printout of a degree audit noting all program deficiencies. The degree audits are also available on the web for all undergraduate students. All students are requested to go through this process before registering for their senior year.

Final date for completion of requirements. For graduation, all requirements, scholastic and financial, must have been satisfied prior to the date stated in the university calendar.

Application for Degree

Candidates for graduation on University Day in May must file with the registrar on or before March 1 a written notice of candidacy for the degree; candidates for graduation in September file a notice of candidacy on or before July 1; candidates for graduation in January file a notice of candidacy on or before November 1.

Failure to file such notice by such dates mentioned debars the candidate from receiving the degree at the ensuing graduation exercises. If a petition for late filing is granted, a fee is assessed.

Graduating Thesis

The original of the undergraduate thesis, when required, is accompanied by drawings and diagrams whenever the subject needs such illustration. The original is kept by the university, as a part of the student's record, for future reference; but copies may be retained by students and may be published, provided permission has first been obtained from the faculty.

Undergraduate Credit and Grades

A "semester hour," used interchangeably with "credit hour," is a course unit normally involving three to four hours of student effort per week during one semester. This includes both in-class contact hours and out-of-class activities. The major parameters influencing the in-class/out-of-class division include the mode of instruction and the level of the course.

Latest date for registration. No registration is accepted later than the tenth day of instruction in any semester, or fifth day of a summer session.

Definitions of grades. Course grades are A, A–, B+, B, B–, C+, C, C–, D+, D, D–, P, F, N, X and Z. The meaning of each grade is as follows: A, A–, excellent; B+, B, and B–, good; C+ and C, competent; C–, continuation competency (the student has achieved the level of proficiency needed for the course to satisfy prerequisite requirements); D+, D, and D–, passing, but performance is not adequate to take any subsequent course which has this course as a prerequisite. The student must petition to waive a prerequisite. Upon presentation of evidence of substantially equivalent preparation and with the approval of the instructor of the course, the teaching department chair and the chair of the major department, the prerequisite will be waived. P, pass-fail grading with a grade equivalent to D– or higher; F, failing; N, incomplete; X, absent from the final examination; Z, absent from the final examination and incomplete.

Other symbols used for courses on student records are: Cr, credit allowed; W, withdrawn; WP, withdrawn with permission and with passing performance at the time of withdrawal; WF, withdrawn beyond the deadline and/or with failing performance.

Grades in the range of A through D–, P, and Cr may be credited toward baccalaureate degrees within the limits of program requirements. Grades of F, N, X, Z, W, WP, and WF cannot be credited toward the degree. Grades of W and WP do not count as hours attempted.

Courses in which grades of D+,D, D-,F, W, WF, N, X, or Z are recorded do not meet prerequisite requirements.

The grade N (grade) may be used to indicate that one or more course requirements (e.g., course report) have not been completed. It is the obligation of the student to explain to the satisfaction of the instructor that there are extenuating circumstances (e.g., illness or emergency) that justify the use of the N grade. If the instructor feels the N grade is justified, he or she assigns a grade of N supplemented by a parenthetical letter grade, (e.g., N©). In such cases, the instructor calculates the parenthetical grade by assigning an F (or zero score) for any incomplete work unless he or she has informed the class in writing at the beginning of the course of a substitute method for determining the parenthetical grade.

In each case in which an N grade is given, the course instructor shall provide written notification to the department chairperson stating the name of the student receiving the grade, the reason for the incomplete work, the work to be done for the removal of the N grade and the grade for the work already completed.

A student who incurs an N grade in any course is required to complete the work for the course by the fifth day of instruction in the next regular semester. The N grade will be converted into the parenthetical grade after the tenth day of instruction in the next regular semester following receipt of the N grade unless the instructor has previously changed the grade using the removal-of-incomplete procedure. The parenthetical grade will be dropped from the transcript after the assignment of the course grade.

In no case shall the grade N be used to report absence from a final examination when all other course requirements have been met.

N grades do not count as hours attempted and are not used in computations of cumulative averages.

The grade X (grade) is used to indicate absence from the final examination when all other course requirements have been met. The grade in parentheses is determined by including in the grade calculation an F (or zero score) for the missing final exam. The X grade may be removed by a make-up examination if the absence was for good cause (e.g., illness or other emergency). To be eligible for the make-up exam, the student must file a petition and the petition must be approved by the Committee on the Standing of Students. If the student fails to petition, or if the petition is not granted, or if the student fails to appear for the scheduled make-up examination, then the X grade will be converted into the parenthetical grade after the first scheduled make-up examination following the receipt of the X grade. If the petition is granted and the final examination is taken, the X grade will be changed by the instructor using the make-up examination procedures and the parenthetical grade will be dropped from the transcript.

Where valid reasons exist for not taking the make-up examination at the scheduled time, the student may petition for a later examination with a fee.

The notation of NR (not reported) is temporarily placed in a student record when due to circumstances, no grade was reported by the instructor by the established deadline.

The grade Z (grade) is used to indicate both absence from the final examination and incompletion of one or more course requirements. The instructor calculates the parenthetical grade using an F (or zero score) for the final examination and either an F (or zero score) or the substitute method of calculation as described above for the incomplete work.

The Z grade may be removed by the procedures presented in the previous paragraph for removing the X grade. If this results in an N grade because the course work is still incomplete, the provisional Incomplete (N grade) above shall apply, except that in no case shall the deadline for completion of the work be later than the last day of classes in the first full semester in residence (except summer) following receipt of the Z grade.

X and Z grades do not count as hours attempted and are not used in computations of cumulative averages.

Where failure to complete coursework prevents the student from taking the make-up examination at the scheduled time, the student may petition the Committee on the Standing of Students for a later examination.

A Z grade that is still outstanding after the tenth day of instruction in the next academic-year semester following receipt of the Z grade will be converted into the parenthetical grade. The parenthetical grade will be dropped from the transcript.

Scholastic Averages and Probation

Scholastic requirements for undergraduate students are expressed in terms of the cumulative grade point average (GPA)—the weighted average of all grades received in residence or at institutions specifically approved for grade transfer. The cumulative GPA is computed at the end of each semester and the second summer session. Following are the cumulative GPA requirements for good standing:

freshmen 1st semester 0 to 21 credits earned 1.70
sophomores 22 to 51 1.80
juniors and seniors more than 52 2.00

For computational purposes students who have completed 22 or fewer earned hours shall be required to achieve a 1.70 cumulative grade point average. Students who have completed 23 but fewer than 53 earned hours at the end of the most recent graded term shall be required to achieve a 1.80 cumulative grade point average. Students who have completed 53 earned hours at the end of the most recent graded term shall be required to achieve a 2.00 cumulative grade point average. Other undergraduates including all General College Division, Lehigh Valley Association of Independent College cross registered students, high school scholars and R.O.T.C. students will be required to achieve a 2.0 cumulative grade point average – the minimum average required for graduation – to remain in good academic standing.

Any undergraduate student who achieves a l.69 or lower cumulative grade point average in a given term is eligible to be reviewed by and may be placed on probation at the discretion of the Committee on the Standing of Students.

Students who do not meet the above requirements will be placed on scholastic probation. Students who, regardless of their cumulative average, have failed more than eight hours of course work in any semester are also placed on scholastic probation.

While there is no specific credit hour requirement for good standing, certain categories of students (e.g., those on financial aid and those playing intercollegiate athletics) will be expected to maintain whatever hours are required for eligibility.

Removal from probation. Students are removed from probation at such time as they meet the standard listed above, effective at the end of any semester or the second summer session.

Dropped for poor scholarship. A student who makes a 2.2 GPA or better in the probationary semester but fails to meet the standards stipulated is continued on probation for another semester. A student who makes less than a 2.2 GPA in the probationary semester and fails to meet the standards stipulated above, is dropped for poor scholarship.

If a student goes on scholastic probation for a second (although not necessarily consecutive) term, a review by the Committee on the Standing of Students will determine whether the student will continue on scholastic probation or be dropped for poor scholarship.

Withdrawal From a Course. A student dropping a course within the first ten days of the semester (five days for summer sessions) will have no record of the course on the transcript. A student dropping all courses for which he or she is registered is considered to be withdrawing from the university and the policy is noted below. A student who drops a course with the approval of his/her advisor and section instructor after the tenth day of instruction and before the end of the eleventh week of instruction will have a grade of "W" assigned to the course. A student who drops a course with the approval of his/her advisor and section instructor after the eleventh week of instruction and before the end of classes receives a "WP" or "WF" at the discretion of the instructor. A "WF" is considered to be a failing grade. An Add/Drop form signed by the student's advisor must be submitted to the registrar's office, before the deadlines noted above, to be official.

University Withdrawal. A student withdrawing from the university (dropping all courses during a given term) must submit the withdrawal form to the dean of students office. Withdrawal after registration day and during the first 11 weeks of instruction will be noted on the academic transcript by assigning a grade of "W" to all courses. A withdrawal after the eleventh week of instruction and before the end of classes will have the grade of "WP" or "WF" assigned for each course at the discretion of the instructor. The date of the withdrawal will be noted on the academic transcript for a withdrawal at any time during the term.

A student who reduces his or her course load below the minimum required for standing as a full-time student, but does not withdraw from the university, becomes a part-time student for the rest of that semester. Some areas affected by part-time status are financial aid, athletic eligibility, veterans affairs, immigration status, insurance and loan deferment.

Release of Final Grades. Grades for undergraduate students are available from the registrar as soon as possible following the deadline for reporting of grades on line using the secure access facility. Undergraduates students who would like a grade report must submit the request in writing to the Registrar's Office each term. Instructors may develop their own policies for release of unofficial reports of academic progress to individual students, or to their advisers, deans, or financial aid officers, on a need-to-know basis, including early release of unofficial final course grades. Any such policies must respect the rights of students to privacy.

Repeating of courses. If a course is repeated, the final grade received upon repetition of the course is counted in the cumulative average. The original grade and credit hours received will be dropped from the cumulative average. However, a student who fails a repeated course after receiving a passing grade the first time will have the original grade deleted from his or her average, but will retain credit for the course toward graduation.

A grade that was originally received in a course may not be changed by repeating the course under the pass-fail option.

Students repeating a course that has been graded C or better may not overload (greater than eighteen credits) during that term. For deletion of a grade from the cumulative average after repeating a course, a student must (a) file the deletion form with the registrar's Office; and (b) repeat the identical course with a final grade at Lehigh.

Pass-Fail Systems for Undergraduates

Student Option System. The pass-fail grading option is intended to encourage students to take challenging courses outside the major field that otherwise might be avoided for fear of lowering grade-point averages. Students are not permitted to take courses numbered below 100 and over 400 using the optional pass/fail grading system and should avoid wasting this option on unsuitable courses, such as courses having no college-level prerequisite or corequisite. The restrictions on the use of the system are listed below.

A student may register for no more than one course pass-fail numbered above 100 and below 400 in any one semester. Students should check the pass/fail restrictions for specific courses noted in section V of the catalog. He or she may take a maximum of six courses pass-fail per undergraduate career if the student is on a four-year program, or a maximum of eight courses per undergraduate career with a five-year, two-degree program. If a student changes a course after the first ten days of instruction from pass-fail grading to regular grading, as provided below, that course shall still count toward the maximum number of courses taken pass-fail during the student's undergraduate career.

Each college faculty shall decide under what conditions and which courses or categories of courses throughout the university may be taken for pass-fail credit by students registered in that college, except for courses designated specifically for pass-fail grading. Each college shall keep the educational policy committee advised of changes in its rules.

A student designates the course(s) to be taken pass-fail normally at preregistration but not later than the fifteenth day of instruction in a regular semester or the fifth day of instruction in any summer session. Prior to this deadline, the student may transfer from pass-fail to regular grading, or vice-versa, without penalty. The courses designated for pass-fail grading by the student require the written acknowledgment of the academic adviser.

Since the instructor giving the course is not officially notified which students are taking the course pass-fail, a regular letter grade is reported to the Registrar for the pass-fail students. The Registrar then records "P" for reported letter grades from A through D–, and "F" for a reported letter grade of F.

Under this system, the student surrenders his or her equity to letter grades of A through D–, except as specified below. A grade of P applies to the student's graduation requirements but is not used in the computation of the cumulative average; whereas an F grade is included in the cumulative grade point average.

If a student changes his or her program such that a course previously taken for pass-fail grading is not allowed for pass-fail grading in the new program, the student must submit a petition to the Committee on the Standing of Students requesting acceptance by the new program of the pass-fail grading for that course, or substitution of the original letter grade submitted by the instructor for the pass-fail grade, or the substitution of another course for the course taken pass-fail. The recommendation of the adviser must accompany the petition.

Course Auditing

A student who is in good academic standing and has not failed any courses in the previous term may be admitted as an auditor in not more than one course, which shall be outside the curriculum requirements. Application for such admission is by petition approved by the departmental chair and the Standing of Students Committee. In no case shall a student who has attended a course as an auditor be given an anticipatory examination for credit or register for the same course in the future. A student completing a course in this manner will have the course and the notation AU indicated on the permanent record. A student rostered on an audit basis may be withdrawn from the course with a grade of W for poor attendance.

Review-Consultation-Study Period

The Review-Consultation-Study (RCS) period is intended to provide a few days for informal academic work between the end of the formal instruction period and the beginning of the final examinations.

It is expected that students will use this period to consolidate their command of the material in their courses. Faculty members make themselves available to their students at announced times during this period.

No quiz or exam may be given during the last five class days before final examination period begins.

Graduation Honors

Beginning with all new degree seeking students in the Fall of 2004 or any students graduating in the Spring of 2008, degrees with honors are awarded by vote of the university faculty to those students who have attained an average of not less than 3.40 in a minimum of 90 credit hours in residence at Lehigh University or in programs approved by the faculty to have grades and credit accepted toward the undergraduate degree.

Degrees with high honors are awarded by vote of the university faculty to those students who have attained an average of not less than 3.60 in a minimum of 90 credit hours in residence at Lehigh University or in programs approved by the faculty to have grades and credit accepted toward the undergraduate degree.

Degrees with highest honors are awarded by vote of the university faculty to those students who have attained an average of not less than 3.80 in a minimum of 90 credit hours in residence at Lehigh University or in programs approved by the faculty to have grades and credit accepted toward the undergraduate degree.

For the purposes of graduation honors calculations, courses taken more than once at Lehigh will only have the most recent grade used in the calculation. Courses taken under the cross-registration policy of the LVAIC, the Washington Semester and the Urban Studies semester program will be used.

Students who spend part of their career at another institution, or are transfer admits to degree programs and have fewer than ninety hours of in residency courses, may qualify for graduation honors under the following conditions:

The student must have at least sixty credit hours of regularly graded (not pass/fail) courses that meet the residency requirement. The graduation honors category is determined by the lower of the two averages computed as follows: (1) the average of grades received at Lehigh; (2) the average of all grades received at Lehigh and grades for courses taken elsewhere for a regular grade and that are appropriate to be considered for transfer to Lehigh, or in provisionally approved study abroad programs.

Department Honors

Many departments offer honors work adapted to its curriculum for students who wish to demonstrate unusual academic ability and interest in exploring a chosen field through independent study and research. The precise nature of the program for each student is determined by the academic major department, but may include: unscheduled work or independent study, participation in graduate (400-level) courses, and an honors thesis or project.

Qualified candidates should inform their academic advisers by the end of the junior year of their intention to work for departmental honors. The adviser will give the college and the registrar names of seniors working for departmental honors in particular majors. Names of those students attaining departmental honors are published in the commencement program.

Undergraduates in the College of Arts and Sciences may apply for acceptance into the College Scholar Program, which offers unique opportunities for those qualified to develop their critical faculties and intellectual interests.

Honor Societies

There are at least 18 honor and course societies. The three best-known are:

Phi Beta Kappa. The oldest honor society in the United States invites into its membership those undergraduates from each of Lehigh's three undergraduate colleges who meet the following desired profile:

- A minimum cumulative GPA of 3.5
- A minimum of six hours each of natural sciences (including a lab); social sciences; and humanities (especially reading/critique of literature beyond freshmen English)
- Calculus or advanced mathematics that requires calculus as a prerequisite
- Foreign language roughly equivalent to second year college level
- No academic violations sufficient to warrant probation, suspension, or expulsion.

While satisfaction of this profile does not guarantee election, it ensures being considered by the council of the Beta chapter of Pennsylvania and the Alpha Gamma chapter of the United States. Any undergraduate who has questions about any of the items in this desired profile, especially about courses in the humanities that the Phi Beta Kappa Council recognizes for purposes of meeting the profile, should contact Prof. Scott Gordon, Executive Secretary of Lehigh's Phi Beta Kappa chapter. Office phone: 610-753-3320; e-mail: *spg4@lehigh.edu*

Beta Gamma Sigma. Election to membership in Beta Gamma Sigma is the highest scholastic honor that a student in business administration can achieve. Beta Gamma Sigma is the only national honorary scholarship society in the field of business administration recognized by the American Assembly of Collegiate Schools of Business.

Tau Beta Pi. Tau Beta Pi recognizes high achievement in all engineering curricula. The national Tau Beta Pi was founded at Lehigh in 1885. A bronze marker in front of Williams Hall commemorates this event.

Among course societies are the following: Alpha Pi Mu, for those in industrial engineering; Beta Alpha Psi, accounting; Chi Epsilon, civil engineering; Eta Kappa Nu, electrical engineering; Lambda Mu Sigma, marketing; Omicron Delta Epsilon, economics; Omicron Delta Kappa, leadership; Order of the Omega, leadership in Greek activities; Phi Alpha Theta, history; Phi Beta Delta, international; Phi Eta Sigma, freshman scholastic excellence; Pi Tau Sigma, mechanical engineering; Psi Chi, psychology; Sigma Tau Delta, English; and Sigma Xi, research.

College of Arts and Sciences

Anne S. Meltzer, *dean;* Hannah W. Stewart-Gambino, *associate dean*

Under the name "School of General Literature," the College of Arts and Sciences was a part of the original plan of the University. Although its aims have remained constant over the years, the means employed to achieve those aims have been adapted to the changing times. The main purpose of the undergraduate programs in the College is to prepare each student for the exercise of individual responsibility in the affairs of mature life. We seek to prepare students for life-long commitment to the public trust of a privileged education. The College faculty recognizes three distinguishing characteristics of an educated person: the ability to think and communicate in a disciplined manner, the ability and willingness to make discerning judgments, and the capacity to apply one's creative imagination. The well-educated person accepts that continuous learning is the basis for making agile adaptations in one's contributions to enterprise, family, and community in response to changing circumstances and that making such well-adapted contributions is the true path to personal growth and fulfillment. In order to achieve the College's purpose, the College faculty shares with the student facts and ideas and guides the student in transforming the raw material of facts and ideas into knowledge and understanding. Students in the College develop new habits of mind that characterize the liberal arts education, such as testing assumptions, questioning authority, respecting evidence, and probing the unknown with curiosity and an open mind. Those habits prepare our graduates to thrive in an uncertain world. We also expect students to discipline their use of time and to master the fundamentals of rational discourse and scholarly inquiry. The basic elements of the Arts and Sciences education remain what they have been for generations of liberal arts students—comprehensive study of the broad domains of knowledge and the development of expertise in one domain.

The College of Arts and Sciences offers several curricular options:

- A four-year arts and sciences curriculum leading to a bachelor of arts or bachelor of science degree in designated fields
- A five-year arts-engineering curriculum leading to a bachelor's degree from the College of Arts and Sciences and a bachelor of science degree in a specific field from the College of Engineering and Applied Science
- Double degree programs within the college and in conjunction with the other two undergraduate colleges.

Teacher preparation

- A five-year program leading to a bachelor's degree from the College of Arts and Sciences and a master's degree in Education from the College of Education

Specific requirements for many of the degree programs described in this section may be found in Section V.

Major Degree Programs in the College

Bachelor of Arts and Bachelor of Science Degree Programs

Two distinct bachelor-degree programs are offered by the College, each distinguished mainly by the proportion of courses taken in the major field. For the Bachelor of Arts degree the student takes a comparatively smaller number of courses to fulfill the major requirements plus a selection of courses in various fields outside the major. For the more professionally oriented Bachelor of Science degree, offered by the College in designated disciplines, the student takes a more extensive concentration in the major field, along with a proportionally smaller number of courses outside the major. Except for this distinction, the same basic requirements must be met for both degree programs (including the minimum number of 121 hours for graduation and the minimum average in the major of 2.0). No more than six hours of military science may be applied toward either degree.

Bachelor of Arts Degree

Humanities: architecture, art, Asian studies, classical civilization, classics, design arts, English, modern languages and literature (French, German and Spanish), music, music composition, philosophy, religion studies, Russian studies, theatre

Social Sciences: Africana studies, American studies, anthropology, cognitive science, economics, environmental studies, history, international relations, journalism, journalism/science writing, political science, psychology, STS (science, technology and society), sociology/social psychology, sociology and anthropology, urban studies

Mathematics and Natural Science: Applied life science, astronomy, behavioral neuroscience, biology, chemistry, computer science, earth and environmental science, mathematics, molecular biology, physics

BA degrees in predental science, premedical science, or preoptometry science are available to students who are admitted to certain combined degree programs (see **Health Professions Programs**).

Bachelor of Science Degree

Applied life science, astrophysics, behavioral neuroscience, biochemistry, biology, chemistry, computer science, ecology, environmental science, geological sciences, mathematics, molecular biology, physics, psychology, statistics

General Plan of Undergraduate Study

Students in the College are required to choose – usually by the end of the sophomore year – a major field and to complete a program of courses, selected in consultation with the student's adviser, to provide the breadth that is the mark of a liberal education. For most students, the credits earned for the major and those earned for the distribution requirements are not enough to meet the graduation requirement of 121, and students take free elective courses in areas of interest to earn the remaining credits. Three schemes of courses – one in the student's area of concentration (the major-field requirements), a second set drawn from certain designated disciplines (the distribution requirements representing the minimum set), and a third set without constraints – make up the educational program in the College.

Major Field of Concentration

By majoring in a specific discipline, a student establishes a foundation of knowledge in that field, learns to frame its particular kind of questions, and starts to apply its traditional body of knowledge. By submitting to increasingly challenging and complex exercises in a distinct discipline over several semesters under the guidance of mature practitioners, the student can start to feel the rewards of intellectual mastery of a subject. The student thus experiences the gratification of developing expertise and intellectual sophistication.

Along with introductory courses in the discipline, the minimum number of credits for the major is 30. The student must maintain a minimum grade-point average of 2.0 in the major field.

Standard major sequences. When a student chooses one of the standard majors, a faculty member from the department or program offering the major becomes a student's major adviser and assists the student in constructing a program of study. In all cases, the final responsibility for meeting both major and non-major requirements rests with the student.

Special interdisciplinary majors. In addition to the standard major programs, specially structured interdisciplinary major sequences between majors are possible. For example, a student interested in a professional school of urban or regional planning might wish to structure a special major consisting primarily of courses in political science and economics or in economics and social relations.

Any student may, with the aid of faculty members chosen from the disciplines involved, devise an interdisciplinary major program to include not less than thirty credits of related course work, of which at least 15 credits must consist of advanced courses. The major advisers and the dean of the college must approve the program.

Multiple majors and Double degrees. A student who wishes to fulfill the requirements for more than one major program has two options. A *double major* is a single BA degree with two majors (some students complete triple majors). A student pursues a double major by declaring both majors. Typically, double majors can be completed in four years, but sequencing of courses and time conflicts with required courses can introduce delays. No more than three courses may overlap two majors. A *double degree* program is a combined BA and BS program. The BA is in the College of Arts and Sciences, and the BS may be in any one of the three undergraduate colleges. A student pursues a double degree by declaring the first program and then petitioning the standing of students committee for permission to pursue the second degree program. The double-degree student must satisfy major and distribution requirements for both degrees and earn a minimum of 30 additional credits beyond those required for the first degree. All of the 30 additional credits must be taken at Lehigh or in Lehigh residency programs. The requirement of 30 additional credits typically makes the double degree program a five-year program. There is no limit on the number of overlapping courses between two degrees, but there must be at least 30 credits of non-overlapping coursework in each degree program. For administrative purposes, students who take two degrees or two majors must designate one as the primary major or primary degree.

Distribution Requirements

Whatever expertise in a single discipline an undergraduate may achieve, in the course of a lifetime, curiosity lures most of us beyond the confines of a single chosen specialty. Furthermore, in a swiftly changing world, careers are being rapidly redefined, and only a person of broad intellectual orientation can intelligently consider where one may be most useful to our society and find most personal gratification. Many of the basic modes of thought and work in various fields are being reformulated, often producing surprising influences in the public and private spheres. In this world—to devise for oneself a satisfying professional life and to be a responsible citizen—one needs some awareness of the concepts and methods specific not to one field only but to a variety of disciplines.

The distribution requirements are the four domains of learning in which the College faculty requires students to develop an introductory level of expertise through encountering the body of knowledge that each discipline has gathered, the kinds of phenomena it describes and manipulates, and the types of problems it addresses. Specified numbers of credits are required in each of the four domains: the mathematical sciences, the natural sciences, the social sciences, and the arts and humanities.

Distribution Requirements for the B.A. and the B.S.

A. Arts 1, Choices and Decisions — 1 credit
(first semester at Lehigh)

B. College Seminar/First-Year Class — 1-4 credits
(one course during the first year)

C. English Composition — 6 credits
(two courses during the first year)

Students and advisers should monitor closely the progress toward completion of requirements D through G. Courses taken to satisfy a major program may be used to satisfy distribution requirements in only one distribution area.

D. Mathematical Sciences — 3 credits
Chosen from mathematics or designated courses from philosophy or computer science

E. Natural Sciences — 8 credits
Chosen from those designated in: astronomy, biological anthropology, biosciences, chemistry, earth and environmental sciences, physics, and neuroscience.
At least one science course must also include the associated laboratory.

F. Social Sciences — 8 credits
Chosen from those designated in:anthropology, classics, economics, political science, history, international relations, journalism, psychology, social psychology, social relations, sociology, STS, and urban studies.

G. Arts and Humanities — 8 credits
Chosen from those designated in: architecture, art, classics, history, modern languages and literature, English, music, philosophy, religion studies, and theatre.

Total required for graduation: — 121 credits

A student's program, including the choice of distribution requirements, is not official until approved by the adviser.

Junior-Year Writing Certification

The faculty of the College of Arts and Sciences holds that writing is an essential tool for learning and that writing well is indispensable for performing responsibly in a profession and in one's life as a citizen. Beyond the two writing courses required in the first year, students in the College are encouraged to take courses that provide continued practice in writing throughout their years at Lehigh. In particular each student in the College must complete at least one "writing-intensive" course—normally during the junior year—and receive writing certification from the instructor. Some major programs require that the writing-intensive course must be taken in the major field; others, that it be taken in a specific department outside the major; still others, that it may be chosen freely from writing-intensive courses offered by any department in the College. Courses that satisfy the writing-intensive requirement may also be used to fulfill major or distribution requirements.

Foreign Language Study

Students planning to pursue graduate study toward a doctorate are reminded that most graduate schools require doctoral candidates to demonstrate a reading knowledge of one or two foreign languages. Proficiency in foreign languages is advantageous for careers in law, government, journalism, commerce, industry and other fields.

Internships

Many departments and programs offer optional internship courses, and some require an internship as part of a major program. Students should consult with the department offering the internship course for information about how the internships are arranged. The University faculty has established three important criteria that must be met by all internships: 80 hours of work are required for each credit awarded, no credit can be awarded for an internship *ex post facto*, and the student must register for the internship course during the same term that the internship work is actually conducted. Students should be sure to pre-arrange all internship experiences with the appropriate department. Internship credits cannot be awarded for work experiences without a distinct educational component. A memorandum of understanding circulated among the employer, student, and departmental internship course director helps to promote a common understanding of the educational and work objectives of the internship.

IPD and LEO

Two multidisciplinary, non-degree-granting University programs offer students special integrated learning opportunities. LEO, the Lehigh Earth Observatory, engages students and faculty from all four of Lehigh's colleges. Students from economics, political science, Earth and environmental science, civil and environmental engineering, history, art and architecture, and education are among those who have staffed LEO projects. LEO activities emphasize communication and information sharing across the disciplines. The range of projects includes water-quality monitoring on the Lehigh River, the development of a geographic information system for the Lehigh River watershed, operating a seismic station and a network of weather-monitoring stations, and collaborative work with the Nature Conservancy and the Wildlands Conservancy. The LEO program director is Prof. Stephen Cutcliffe (History) The Integrated Product, Process, and Project Development (IPD) Program integrates the three fundamental pillars of successful product design and commercialization: design arts, engineering, and business. Student teams produce technical and feasibility studies, design mock-ups, develop working prototypes, and prepare business plans for real clients. IPD emphasizes a solid grasp of engineering science, industrial design, business fundamentals, good communication skills, a superior understanding of the design and manufacturing process, and an appreciation of multidisciplinary teamwork. The IPD program director is Prof. John Ochs (Mechanical Engineering).

Minor Programs in the College

Certain departments, divisions, and programs in the College of Arts and Sciences afford an opportunity to minor in an additional field of concentration other than the major field.

A minor consists of at least 15 credits; the specific content is determined by the department, division, or program concerned. A minor is optional and, if successfully completed, will be shown on the university transcript in the same manner as the major field. A 2.0 minimum grade-point average is required for courses in the minor. Because of this requirement, no course in the minor program may be taken with Pass/Fail grading. No more than one course may be double-counted toward a major and a minor, and no more than one course may overlap between two minors.

It is the responsibility of students desiring a minor to initiate it no later than the beginning of the junior year by filing a minor program with the department, division, or program where it is offered. The student's minor adviser maintains appropriate records.

Minors in the College of Arts and Sciences departments and programs are available for degree candidates in other colleges within the university, with approval of their college adviser.

The following are established minors in the College of Arts and Sciences. Program descriptions may be found in the alphabetical listing of Section V. Some minor-program descriptions are collected within departmental descriptions, or located elsewhere, as indicated by parentheses. Students in the College of Arts and Sciences may also complete a minor in Business through the Business College or an Engineering minor through the College of Engineering.

Actuarial Science (Mathematics)
Africana Studies
American Literature (English)
Anthropology (Sociology and Anthropology)
Art (Art and Architecture)
Art/Architecture History (Art and Architecture)
Asian Studies
Astronomy
Biology (Biological Sciences)
British Literature (English)
Chemistry
Chinese (Modern Languages and Literature)
Classical Civilization (Classical Studies)
Classics (Classical Studies)
Cognitive Science
Communication (Journalism and Communication)
Computer Science (Electrical Engineering and Computer Science)
Design Arts
Earth and Environmental Sciences
Economics
Education (Education Minor, this section)
English
Environmental Studies
French (Modern Languages and Literature)
German (Modern Languages and Literature)
Graphic Communication (Art and Architecture)
Health and Human Development (Health Professions Programs, this section)
History
Humanities Minor in Ethics
Humanities Minor in Medieval Studies
International Relations
Jewish Studies
Journalism (Journalism and Communication)
Latin American Studies
Mathematics, Applied (Mathematics)
Mathematics, Pure (Mathematics)
Military Science
Molecular Biology (Biological Sciences)
Museum Studies (Art and Architecture)
Music
Philosophy
Physics
Political Science
Probability and Statistics (Mathematics)
Psychology
Public Administration (Political Science)
Public Relations (Journalism and Communication)
Religion Studies
Russian (Modern Languages and Literature)
Russian Studies
Science, Technology and Society
Science Writing (Journalism and Communication)
Social Relations (Sociology and Anthropology)
Sociology (Sociology and Anthropology)
Social Psychology (Sociology and Anthropology)
Spanish (Modern Languages and Literature)
Studio Art (Art and Architecture)
Theatre
Urban Studies
Women's Studies
Writing (English)

College Scholar Program

The Roy Eckardt College Scholar Program is intended for students who show outstanding academic promise or unusual creativity and those whose interests transcend traditional programs. It is a highly selective program, restricted to a small number of especially qualified students, some of whom are enrolled at the time of admission to the university and the rest in the following two years. Entering freshmen may join the program at the invitation of the College Scholar Advisory Council. Applications from freshmen and sophomores are evaluated by the advisory council on the basis of their academic records and written statements of educational goals, and recommendations from two faculty members.

The program allows students to devise individualized courses of study and to engage in scholarly work of an advanced nature. Participants are obliged to obtain 121 credits, including Arts 1 and the junior writing requirement, take at least one college scholar seminar, and pursue departmental or interdisciplinary majors. With the approval of the program director, they design their own academic programs. They are released from distribution requirements and, if necessary, modifications may be made in major requirements. Responsibility for the student's over-all program lies with the director who cooperates closely with the major adviser. In the final two years, the student receives up to twelve credits for work with a faculty member, leading to a senior project of substantial dimensions. This can take whatever form is appropriate to the nature of the subject. Seniors present accounts of their projects at the annual college scholar graduation dinner and are eligible for the George B. Lemmon Prize, which is presented each year to members whose academic achievements have been particularly meritorious. The award of the College Scholar graduation honors is subject to the recommendation of the program director (Prof. Ian Duffy, 340 Maginnes Hall) and the chair in the major field.

In addition to the academic privileges of the program, college scholars are offered a variety of extracurricular opportunities. These include invitations to meet visiting speakers, informal meetings with faculty members, dinners, lectures, plays, musical events, and other cultural activities in the Lehigh Valley and nearby cities. For a listing of courses and advisory council members, see College Scholar Program entry, section V.

College Seminar/First-Year Class (FYC) Program

During the fall or spring semester of the first year, every student in the College of Arts and Sciences is required to enroll in a College Seminar or First-Year Class (FYC) taught by a member of the faculty. With ten to 20 students per class, these college seminars and special classes provide an intimate and supportive environment that facilitates the transition to university life. Students begin to develop many of the skills that serve as a framework for their future scholarly work—how to read closely, think critically, write clearly, learn cooperatively, speak persuasively, and solve problems creatively.

Courses in this program are an excellent way to explore a subject that may be new, or to enter more deeply into an area of previous interest. Many of the topics are non-traditional or interdisciplinary subjects of special interest to the professor.

Whatever the topic, FYCs involve considerable effort on the part of students. Some classes emphasize reading assignments, papers, and oral presentations; others include tests, laboratory work, or fieldwork.

Pre-Law Programs

The university has a strong pre-law tradition. In keeping with the policy of the Association of American Law Schools, the university does not have a prescribed pre-law program.

Lehigh students have been successful in attaining entrance into law schools from diverse curricula in all three of the undergraduate colleges. Illustrative courses in the arts and sciences include constitutional law, civil rights, administrative law, media ethics and law, and American constitutional and legal history. Correspondingly, there are courses such as Introduction to Law and Legal Environment of Business in the College of Business and economics. That college also offers basic accounting courses that are often recommended as part of an undergraduate's pre-law preparation.

In addition to formal academic instruction, Lehigh provides other opportunities for learning about law and careers in law. The annual Tresolini Lecture series brings nationally recognized speakers to campus for extended interactions with faculty and students. Tresolini lecturers have included present and past U.S. and state Supreme Court justices and renowned legal scholars and practitioners. Lehigh also provides opportunities for gaining academic credit in several off-campus programs which provide practical experience in law and public affairs.

Counseling is available to prospective pre-law students on a continuous basis from freshman orientation through the law school application process in the senior year. The pre-professional adviser in Career Services coordinates these pre-law counseling services.

Health Professions Programs

Schools of medicine, dentistry, optometry, podiatry, and veterinary medicine stress the importance of a strong liberal arts education as well as prescribed studies in the sciences. Although most pre-health students will choose a major in a pure or applied science, as long as candidates have the essential courses in biology, chemistry, physics, and mathematics, they may major in any of the three undergraduate colleges.

A health professions advisory committee, which includes a pre-professional advisor and faculty members from the sciences, provide career and academic counseling and work closely with students from freshman orientation through the entire process of applying to professional schools. Students are urged to consult with the pre-professional adviser in Career Services as early as possible in their academic career. Students interested in other allied health fields may also obtain information to aid them in planning their courses with their academic advisers.

Combined-Degree Program in Medicine

In cooperation with Drexel University College of Medicine the university offers an accelerated program that enables selected students to earn both the bachelors of arts degree in premedical science and the M.D. degree after seven years of study at the two institutions. The program was initiated in 1974, and approximately ten students matriculate each year.

The program includes three academic years at Lehigh during which time credit hours are earned toward the 121 credits required for the baccalaureate degree. The next four years are spent in the regular program of medical education in Philadelphia. After successfully completing the one year at the medical school, students will have acquired necessary additional credit hours for the baccalaureate degree.

During the pre-professional years at Lehigh, students are expected to make satisfactory progress in academic areas as well as in the more subtle task of personal growth in those attributes ultimately needed as a physician. Drexel University College of Medicine receives student grades and monitors student progress through feedback from Lehigh. Students are expected to maintain an overall GPA of 3.45 or better (A=4.0) and a minimum GPA of 3.25 in the prerequisite sciences and receive no grades in any course less than a "C". Credentials again will be processed through the medical school's Admissions Committee prior to extending a final definitive acceptance. This program also requires that students take the Medical College Admissions Test. The results will be evaluated by the committee prior to final acceptances. It is expected that the three numbered scores be 9 or better on the 1-15 scale or a total of 30 on any given exam with no score less than a 7 or an M.

The medical college reserves the right to withdraw an offer of acceptance if academic or personal concerns cause the college to question a student's academic or personal maturation.

Application for admission to the program is made through Lehigh Office of Admissions. Criteria for admission includes SAT scores (minimum combined score of 1360 recentered scale), scholastic achievement, maturity, and motivation for medicine. SAT II scores are required in mathematics, English composition, and chemistry.

Completed applications are reviewed by the Office of Admissions, and a pool of students chosen for interview at Drexel University College of Medicine.

Interviews are not required at Lehigh, but students are encouraged to make arrangements to come to campus to have an interview and to become better acquainted with Lehigh and the special features of the program. Application deadline is December 1.

Required Science and Math Courses:
Chemistry: CHM 21, 22; CHM 31; CHM 51, 53, 52, 58
Biology: EES 31, BIOS 41, 42; BIOS 115, 116
Physics: PHY 10, 12, 13, 22
Math: MATH 21, 22 or MATH 51, 52 plus one additional approved math course

Required Non-Science Courses:
Choices and Decisions
Freshman Seminar
English Comp & Lit (two semesters)
Humanities (3 courses, 9-12 credits)
Social Sciences (3 courses, 9-12 credits)
Writing Intensive
Approved Electives: (12-16 credits)

Lehigh-Pool Scholars Premedical Education Program

Lehigh University and Lehigh Valley Hospital have established a unique premedical education program that emphasizes the link between academic and practitioner training.

Project-based, experiential learning is the driving educational philosophy behind the program. Highlights include: three years of combined biomedical research/internship experiences, guaranteed, paid summer research opportunities ($3,000 per summer) between the sophomore-junior and junior-senior years that will provide practical experience in biomedical settings to promote and accelerate skill development, joint faculty and physician advising, special courses in modern medical economics, business practices, and ethics, travel to major professional society meetings to present research and learn about state-of-the-art developments, a lecture/dinner series that will include special, individual sessions with distinguished speakers.

This is a highly competitive program open to a limited number of outstanding, strongly motivated students.

Combined-Degree Program in Dentistry

The university, in cooperation with the School of Dental Medicine at the University of Pennsylvania, offers an accelerated program that enables selected students to earn a combined baccalaureate and doctor of medicine degree after a minimum of seven years of study at the two institutions.

The program includes three academic years during which time credit hours are earned toward the baccalaureate degree. The next four years are spent in the regular program of dental education in Philadelphia.

During the first three years at Lehigh, students are expected to make satisfactory progress in the academic areas as well as in the areas of personal growth, developing those attributed ultimately needed to become a dentist. Students must maintain a minimum overall and science GPA of 3.2 throughout the three years at Lehigh and are required to take the Dental Admissions Test with a minimum of 16 in all subject areas.

The dental school reserves the right to withdraw an acceptance if academic or personal concerns cause the college to question a student's ability to function as a dentist. The dental school also reserves the right to require that students spend additional time at Lehigh if the school feels that this is necessary to insure the student's academic or personal maturation.

Application to the program occurs when a student applies to Lehigh University. The dental school takes action on the applicant in the spring of an academic year. Final decisions are forwarded to Lehigh University about March 20. The applicant is notified of joint acceptance by Lehigh University. Admission is based on SAT scores (a minimum combined score of 1270 recentered scale), scholastic achievement, maturity, and motivation for dental school. Application deadline is January 1.

Required Science and Math Courses:
Chemistry: CHM 21, 22; CHM 31; CHM 51, 53, 52, 58
Biology: EES 31; BIOS 41, 42; BIOS 115, 116; two approved BIOS electives (6 credits)
Physics: PHY 10, 12, 13, 22
Math: MATH 21 or 51; MATH 22 or 52

Required Non-Science Courses:
Choices and Decisions
Freshman Seminar
English Comp & Lit (2 semesters)
Humanities (3 courses, 9-12 credits)
Social Sciences (3 courses, 9-12 credits)
Writing Intensive
Approved Electives: (12-16 credits)

Joint Degree Program in Optometry

In cooperation with the State University of New York, State College of Optometry located in New York City, Lehigh offers a seven-year Bachelor of Arts in Behavioral Neuroscience and Doctor of Optometry (O.D.) Program. Students accepted into the joint degree program are admitted into the behavioral neuroscience major and are simultaneously admitted to candidacy in the SUNY College of Optometry's professional program of study.

Application to the program occurs when a student applies to Lehigh or while enrolled at Lehigh. Criteria for selection is based upon maturity and motivation; an interest in the basic understanding of the optometric profession; a minimum of 1180 SAT recentered score, 92 high school grade point average, and ranked in the top 10% of the high school graduating class. Or as a first- or second-year Lehigh student, a minimum overall 3.2 GPA in undergraduate coursework and in all prerequisite math and science courses completed at the time of application with no grade below a C. A committee comprised of representatives from both institutions selects the students for admission into the program.

Students will spend three years at Lehigh during which time credit hours are earned toward the baccalaureate degree. Upon maintaining a minimum 3.2 GPA in the math and science prerequisites, attaining total science scores of 320 or above on the Optometry Admissions Test (OAT), and passing reasonable personal interview standards, these students will be admitted to the SUNY College of Optometry at the completion of their third year at Lehigh. All science and math prerequisite courses must be satisfied with a C or higher. Students must submit a formal application, transcripts, and recommendations at this time. After successfully completing all first-year coursework at the college of optometry, a BA degree on behavioral neuroscience will be granted by Lehigh.

The optometry school reserves the right to withdraw an acceptance if academic or personal concerns cause the school to question a student's ability to function as an optometrist.

Application for admission to the program for incoming students is made through Lehigh Office of Admissions. Application deadline is January 1. For curriculum information, consult with the pre-professional advisor in Career Services.

Health and Human Development Minor

The minor in health and human development, located primarily within the College of Arts and Sciences, is an interdisciplinary program designed to provide insight into the social scientific aspects of health issues through the human life cycle. While this minor program is open to anyone in the three undergraduate colleges, it may be of particular interest to students preparing for careers in any aspect of health care, social work, and child or adult development.

The program is administered through the Program in Health and Human Development, an interdisciplinary group of faculty members who have research interests in this area. Current research studies cover all aspects of the life cycle, including the health dimensions of both normal and abnormal child development, reproductive health issues, adult life crises such as illness and loss, and dimensions of aging. Students are able to serve as research assistants in some of these studies.

The minor consists of a minimum of 15 credit hours chosen in consultation with the program director, Donna Kosteva, in the Office of Career Services.

Required courses (6 credit hours)

SSP 160	Medicine and Society (3) **and**
PSYC 107	Child Development (3) **or**
PSYC/SSP 109	Adulthood and Aging (3)

Elective courses (9 credit hours) chosen from three different disciplines:

ANTH 321	Anthropology of Physical and Mental Health (3)
PHIL 116	Bioethics (3)
PSYC 107	Child Development (3)
PSYC/SSP 109	Adulthood and Aging
PSYC 305	Abnormal Psychology (3)
PSYC 351	Cognitive Development in Childhood (3)
PSYC 361	Personality & Social Development in Adulthood (3)
PSYC 363	Personality and Social Development in Childhood (3)
SSP 152	Alcohol, Science & Society (3)
SSP 160	Medicine and Society (3)
SSP 162	AIDS and Society (3)
SSP 366	Sociology of Aging (3)
SSP 341/WS 341	Women and Health (3)

Education Minor

The education minor helps undergraduates explore career options in school teaching or other professional careers with elementary, secondary, or special-education students. The minor may accelerate entry into a teaching career because appropriate credits from the minor may be applied toward completion of teacher-certification credits for those admitted to Lehigh's graduate-level Teacher Intern Program.

The minor offers a systematic background of professional education experiences, coordinating practicum activities with theory courses designed to provide a foundation for future educational studies. Its focus is exploratory. No career decision is required but the minor is provided for those with a serious interest in considering the teaching profession.

The experiences of the minor are intended to enrich an individual's understanding of education as a central intellectual activity of our culture and to provide self-understanding of one's own potential as an educator.

An undergraduate may take one or all of these courses during the junior and senior years with the approval of the adviser and minimum GPA of 2.75. Completion of the minor does not assure admission to the Teacher Intern Program to become a certified professional. However, if the student passes the screening process on the basis of previous work and interviews, he or she may enter the intern program with advanced standing toward certification.

The program coordinator is Lynn Columba, Program Coordinator, College of Education, Mountaintop Campus, 111 Research Drive.

Fifteen credit hours are chosen from among the following courses for those in the education minor:

EDUC 312	Classroom Practice (1) (must be taken concurrently with EDUC 314)
EDUC 314	Intern Seminar (2) (must be taken concurrently with EDUC 312)
EDUC 394	Special Topics in Instruction and Curriculum (3)
EDUC 429	Child Development (3)
EDUC 441	Youth in Society (3)
Elective	Education course (appropriate to student's objective (3)

The Five-Year B.A. or B.S./M.A. or M.Ed. Combined Degree and Teacher Certification Program

The College of Arts and Sciences and the College of Education offer a five-year degree program that is designed to allow students to earn both a bachelor's degree and a master's degree in five years instead of the traditional six.

The combined degree program leads to either a B.A. or B.S. degree in an academic discipline, and an M.A. or M.Ed. degree in either elementary or secondary education. In addition, an Instructional I teaching certificate from the Pennsylvania Department of Education is also earned. These certification areas are:

Elementary Education

- Secondary Education:
- Biology
- Chemistry
- Earth and Space Science
- English
- French
- General Science
- German
- Mathematics
- Physics
- Social Studies
- Spanish

Freshmen are able to apply for admission into the program during their second semester. Those accepted will begin their education courses in the second semester of their sophomore year. Sophomores who wish to enter the program will complete their introductory courses in the summer between their sophomore and junior years. Accommodations can be made for transfer students.

Criteria for admission to the program include:

- A demonstrable commitment to learning and intellectual growth
- An expressed interest in teaching as a career
- Previous experience in working with young people; this can be gained in the summer between freshman and sophomore years.

Students seeking formal admission to the program after one year of study must have:

- Satisfactorily completed EDUC 312 and 314 (Note: students entering the program in their junior year will then take these courses)
- Declared a major(s) and been assigned an advisor in the College of Arts and Sciences
- Two letters of reference
- At the end of their junior year, students must have successfully completed EDUC 398.

In the last semester of their senior year, students must complete an application for advancement to graduate standing in the College of Education, including:

- A minimum cumulative 2.75 GPA
- Satisfactory experience in all field experiences
- Completion of a graduate application form
- One letter of recommendation addressing the candidates' potential as a teacher
- A master's program approval form should be completed upon admission to the graduate program

For information students should contact Professor Lynn Columba, College of Education, Mountaintop Campus, 111 Research Drive.

College of Business and Economics

Richard M. Durand, Herbert E. Ehlers dean; Joan B. DeSalvatore, associate dean, director of undergraduate programs; Kathleen A. Trexler, associate dean, director of graduate programs; Kenneth P. Sinclair, chair, department of accounting; Thomas J. Hyclak, chair, department of economics; Richard J.Kish, chair, department of finance and law; Michael G. Kolchin, chair, department of management and marketing; James A. Dearden, director, Ph.D. program; Robert J. Thornton, director, master of science in economics; John W. Paul, director, master of science in accounting.

The College of Business and Economics offers the bachelor of science degree in business and economics. In the dynamic global environment of the 21st Century, today's business students face unprecedented challenges. Lehigh's College of Business and Economics prepares them to meet these challenges and to succeed.

The College of Business and Economics consists of four departments: accounting, economics, finance and law, and management and marketing. Its programs, accredited by the AACSB International–The Association to Advance Collegiate Schools of Business–provide students with a solid foundation in business and economics principles. In addition to the traditional undergraduate majors of accounting, economics, finance, management and marketing, the College offers innovative programs and courses that respond to today's unique business requirements, including:

The Business Information Systems major that answers a recognized need in the business world. As businesses seek to make themselves more productive and competitive, they have become more reliant on information technology. Students with a good understanding of information systems can help businesses enhance their use of this technology.

The Supply Chain Management major is another response to the complex environment facing business graduates. This undergraduate major gives students solid exposure to supply management, logistics, business-to-business marketing and operations management.

The College of Business and Economics has joined with the College of Engineering to offer two cross-college programs. These programs, Integrated Business and Engineering (IBE) and Computer Science and Business (CSB) are described in full in the following "Crossing Boundaries" section.

Crossing Boundaries

A major strength of the College of Business and Economics is its ability to develop programs by partnering across academic disciplines within the College, across the colleges within the University and with the business community. Students are able to cross traditional boundaries and take advantage of all that the College of Business and Economics and other colleges of the University have to offer. The partnerships built with alumni and the business community afford students the opportunity for internships in their areas of interest.

As the needs in the marketplace change, the ingredients necessary for success must reflect these new requirements. From courses in e-commerce to supply chain management and joint degree programs, the College of Business and Economics provides today's undergraduate students with the skills necessary to become tomorrow's business leaders.

Career Placement

The undergraduate programs in the College of Business and Economics provide the students with a strong foundation in business and economic principles necessary for success in business. Upon graduation, the majority of students from the College of Business and Economics enter business in many different professional positions including accounting, investment banking, advertising, marketing, management consulting and information systems. Further professional studies in law, graduate business schools or specialized graduate education in economics, operations research, or other related fields are additional options open to graduates.

Variety of Options

While preparing students for a career in business and economics, we recognize the importance of a well-rounded individual. At Lehigh, this important exposure to science, language and the arts and humanities is accomplished by distribution requirements, within which the student has wide choice. Students have a minimum of 52 free electives, 48 of which must be taken outside the College of Business and Economics.

The bachelor of science in business and economics may also lead to admission into the master of business administration program at Lehigh or another institution after graduates have at least 2-3 years of work experience. In addition, the college also offers the following graduate degrees: doctor of philosophy, master of business administration and engineering, master of business administration and educational leadership, master of science in accounting and information analysis, master of science in economics, master of science in health and bio-pharmaceutical economics and master of science in analytical finance. These are described in Section IV.

Computer Science and Business Program

The College of Business and Economics and the Computer Science and Engineering department in the P.C. Rossin College of Engineering and Applied Science jointly offer the Computer Science and Business (CSB) program. This 135 credit hour degree integrates technology skills in software development with a solid background in business and economics. Deep immersion in both of these areas distinguishes CSB from programs offered by other universities. At the same time it is well balanced with approximately one third of the courses in liberal arts, one-third in computer science, and one-third in business.

After four years the program leads to a degree in Computer Science and in Business, which is jointly awarded by the College of Business and Economics and the P.C. Rossin College of Engineering and Applied Science. The CSB major meets the accreditation requirements for both Computer Science (CSAB) and Business (AACSB). Graduates of the program will be ideal candidates for placement within large consulting firms, small consulting teams, and startup companies. This program provides students with the background needed to become the CIO's, decision makers, and general managers of information age corporations.

While honors-like in quality and rigor, the CSB program is open to any student wishing to accept the challenges it offers. Students may matriculate at Lehigh specifically into CSB or enter the program at a later point. Transferring into CSB after freshman year, however, may require students to take additional credits to graduate.

The co-directors of the CSB program are James A. Hall, Associate Professor of Accounting and Information Systems *(jah0@lehigh.edu)* and Edwin Kay, Professor of Computer Science and Engineering *(ejk0@lehigh.edu).* For additional information see Section V of this catalog or visit the CSB web site at: *www2.lehigh.edu/page.asp?page=distinctiveprograms*

Integrated Business and Engineering Honors Program

The Integrated Business and Engineering Program (IBE) is offered jointly by the College of Business and Economics and the P. C. Rossin College of Engineering and Applied Science. This program recognizes the need for today's leaders in business and industry to have a sound foundation in both commerce and technology.

After four years and a minimum of 137 credits, students will receive a single Bachelor of Science Degree in Business and Engineering. The program meets the accreditation standards of AACSB International. Students are required to maintain a minimum GPA of 3.25 in order to remain in the program.

Students in the IBE Honors Program can major in any area of business or engineering that Lehigh offers. After freshman year, each student will elect a major in either the College of Business and Economics or the P. C. Rossin College of Engineering and Applied Science. Students wanting to major in an area of business can select from: accounting, business information systems, economics, finance, marketing, management or supply chain management.

Admission to the Integrated Business and Engineering Honors Program is highly selective, with annual admission limited to approximately 50 students. The University's Office of Admissions (610-758-3100) can explain the procedure for applying to the program.

It is possible that a small number of exceptional students may be admitted to the program following the completion of their freshman year. Admission at this point would be highly competitive and based upon freshman year GPA, faculty recommendations, and space availability.

The co-directors of the IBE Honors Program are Stephen G. Buell, Professor of Finance and Business Information Systems *(sgb2@lehigh.edu)* and Robert H. Storer, Professor of Industrial and Manufacturing Systems Engineering *(rhs2@lehigh.edu)*. For additional information, see the IBE Honors Program entry in Section V of this catalog or visit the IBE web site at *www.lehigh.edu/inibep/inibep.html.*

Centers and Institutes

The college also oversees research and scholarship in a number of centers and institutes, where graduate and undergraduate students work closely with faculty members. These include: Iacocca Institute, Martindale Center for the Study of Private Enterprise, Murray H. Goodman Center for Real Estate Studies, Philip Rauch Center for Business Communications, Value Chain Research Institute, Financial Services Laboratory, and Small Business Development Center.

Bachelor of Science in Business and Economics

For the bachelor of science degree in business and economics, 124 credit hours are required. A writing requirement, which is included within the required 124 credit hours, is also a part of the college curriculum.

Planning Courses of Study

First year

ENGL 1	Composition and Literature I (3)
ENGL 2, 4, 6, 8, 10	Composition and Literature II (3)
MATH 21	Calculus I (4) or
MATH 75/76	Calculus I – Parts A & B (2 each)
ECO 1	Principles of Economics (4)
BUS 1	Introduction to Business (3)

Excel competency must be completed before ACCT 151 and ECO 145.

Second Year

ACCT 151	Introduction to Financial Accounting (3)
ACCT 152	Introduction to Managerial Accounting (3)
BIS 111	Management Information Systems (3)
ECO 129	Money, Banking and Financial Markets (3)
ECO 145	Statistical Methods (3)
ECO 146	Applied Microeconomic Analysis (3)

Third Year

FIN 225	Business Finance (3)
LAW 201	Legal Environment of Business (3)
MKT 211	Principles of Marketing (3)
MGT 280	Management of People and Operations (4)

Fourth Year

MGT 301	Business Management Policies (3)

Major Programs (15 credits - 21 credits)

Before the end of the first semester of the junior year, students select a major consisting of sequential or related courses in one of the following major programs: accounting, business information systems, economics, finance, management, marketing and supply chain management. A GPA of 2.0 or higher in the major program is required for graduation.

Distribution Requirements (15 credits)

Students are required to take six (6) credits of humanities (HU), six (6) credits of social science (SS), and three (3) credits of science (NS) for a total of 15 credits of distribution requirements. Students should refer to the department in the catalog to determine which course offerings may be taken to satisfy these requirements.

Electives (52-58 credits) - depending on major

Students will earn 52-58 credits of "free" electives; a maximum of ten credits may be taken from other course work in the College of Business and Economics. A minimum of 48 credits are to be taken outside the College of Business and Economics.

In the College of Business and Economics, the pass-fail option is available for elective courses only. A student desiring Lehigh credit for a course taken at another institution must complete a transfer credit form and obtain approval from the appropriate Lehigh academic department in advance.

Business Minor

The purpose of the business minor program is to enable non-CBE students to pursue a course of business studies that will enable them to supplement their major studies and make them more marketable. The overall learning objective of the program is to provide non-CBE students with the knowledge and skills with which to make more informed business decisions.

Courses offered in the business minor program are not open to students currently in the CBE nor may these classes count as substitutes for CBE core classes should a student later decide to transfer into the CBE.

Program of Studies: The business minor consists of 14 credit hours. These courses are integrated across the entire program and must be taken in a locked step sequence. These 14 credit hours plus the prerequisite consist of the following courses:

Required prerequisite course:

- **ECO 1 – Principles of Economics** (4 credit hours). ECO 1 can be taken in either the freshman or sophomore year and must be completed prior to entering the business minor program.

Required courses:

- **BUS 125 – Behavioral Skills Workshop** (1 credit hour. Fall.). Prerequisite: ECO 1
- **BUS 126 – Information Analysis and Financial Decision Making I** (3 credit hours. Fall.). Co-requisite: BUS 125.
- **BUS 127 – Information Analysis and Financial Decision Making II** (3 credit hours. Spring.) Prerequisite: BUS 126.

- **BUS 225 – Developing, Producing, and Marketing Products and Services I** (3 credit hours. Fall.). Prerequisite: BUS 127.
- **BUS 226 – Developing, Producing, and Marketing Products and Services II** (3 credit hours. Spring.) Prerequisite: BUS 225.
- **BUS 326 – Business Strategy** (1 credit hour. Spring.)

Recommended courses:

- **Probability Theory and Statistics** (e.g., ECO 145, MATH 12, IE 111, PSYC 110, etc.)
- **An Integrated Learning Experience** (e.g., ME/BUS 211, MGT 311, or internship)

The courses required in the business minor program will be offered in a lock step sequence requiring completion of each course in the sequence before being able to continue with the next course. That is, students must first complete BUS 126 before taking BUS 127, BUS 127 before taking BUS 225, and BUS 225 before taking 226. BUS 125 and BUS 326 are to be taken in conjunction with BUS 126 and BUS 226, respectively.

Program admission requirements: Each spring, 80 students will be accepted into the business minor program for the following fall. Application into the program will be made by students and submitted to the program director by March 1st. An admissions committee comprised of the business minor program director, associate dean for the undergraduate CBE program, and the business minor curriculum committee will make admission decisions based on G.P.A., experience, and interest in pursuing business opportunities upon graduation from Lehigh (to be evaluated on the basis of a written essay). Students will be notified of admissions decisions prior to registration for the fall semester. Entrance into business minor classes will be controlled by restricted overrides by the director of business minor program.

College of Education

The university's College of Education offers opportunities for advanced study in the field of education. For information, see Graduate Study in Education, Section IV, or College of Education, Section V.

P.C. Rossin College of Engineering and Applied Science

Mohamed S. El-Aasser, *dean*
John P. Coulter, *associate dean for graduate studies and research*
Richard N. Weisman, *associate dean for undergraduate studies*

The P.C. Rossin College of Engineering and Applied Science offers the bachelor of science degree in 15 programs, combining a strong background in sciences and mathematics with requirements in humanities and social sciences. Students in college programs learn principles they can apply immediately in professional work; those who plan on further academic experience can design a curriculum centering on interests they will pursue in graduate school.

The Mission of the college is to prepare undergraduate and graduate students to be critical thinkers, problem solvers, innovators, leaders and life-long learners in a global society and to create an environment where students pursue cutting-edge research in engineering and engineering science.

Major Subjects

The P.C. Rossin College of Engineering and Applied Science includes seven departments and offers undergraduate and graduate degree programs at the bachelor, master, and doctor of philosophy levels.

The undergraduate degree programs leading to the bachelor of science degree are:

applied sciences
bioengineering
chemical engineering*
chemistry
civil engineering*
computer engineering*
computer science**
electrical engineering*
engineering mechanics
engineering physics
environmental engineering
industrial engineering*
information and systems engineering
materials science and engineering*
mechanical engineering*

**Accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology.*

***Accredited by the Computing Science Accreditation Board, Inc.*

Programs in chemistry and physics have been approved by the faculty program review committee in these disciplines.

Information about each of these programs may be found under alphabetical listings in Section V.

Each of the curricula includes course requirements in the physical sciences, mathematics, engineering, and the advanced engineering or science course work essential for the particular degree. In addition, each curriculum requires study in humanities and social sciences (HSS).

Declaration and Change of Curriculum

In the second semester of the freshman year, at registration for the sophomore year, students usually indicate their choice of curriculum. However, since the sophomore year programs for several curricula are very much alike, it is possible to transfer from one curriculum to another as late as the end of the sophomore year. This is done by filing a new declaration of major form. There are instances where such a transfer may require one or two courses to be taken during a summer session at Lehigh or elsewhere.

Undergraduates with interests in such topical areas as environmental biotechnology or aerospace engineering may pursue their interests through electives provided in each of the curricula. Effective preparation for graduate study in such specialties consists of basic programs in engineering and science, along with electives especially chosen for the field of interest. Such electives are chosen from among all the offerings of the university and are usually taken during the senior year.

Free Electives

The college, through its advisers, is prepared to help students to use the credit hours of "free electives" that, along with other electives in the curriculum, may be used to develop a program of personal interest. Free electives may be satisfied by taking regular course offerings or up to six credit hours from Mus 21-79, or up to six credit hours from Jour 1-8, or up to six credit hours of advanced ROTC courses.

Qualified juniors in the college planning to continue their formal education in graduate school are urged to take advantage of the flexibility in their programs and design their senior-year "free elective" opportunities in a manner that provides an effective foundation for a graduate program. Students who plan their programs in this manner can, upon recommendation of the department and petition to the Associate Dean, apply up to six hours of their total undergraduate credit hours toward graduate-level courses.

Technical Minors

Minors are offered in technical or scientific specialties that are not normally included within the standard curricula. Each minor program contains at least 15 credit hours of technical and/or scientific courses.

The student interested in a technical minor should contact the associate chair of the department in which the minor is desired for specific requirements. A student successfully completing a technical minor will receive recognition of this accomplishment on his or her transcript.

Currently, the following technical minors are offered by these departments:

Technical Minor	Department
aerospace engineering	Mechanical Engineering
biotechnology	Chemical Engineering
chemical engineering	Chemical Engineering
computer science	Computer Science & Engineering
environmental engineering	Civil & Environmental Engineering
manufacturing systems	Industrial & Systems Engineering
materials science	Materials Science & Engineering
polymer science & engineering	Center for Polymer Science & Engineering

Music Option

Music and Engineering is not a major in itself. However, Lehigh attracts many engineering and science students who wish to continue their active involvement in music and the music department. For those students who are interested in pursuing this option, music can be taken as a second degree or minor.

Cooperative Education (Co-Op)

Co-Op is a selective program available for undergraduates in the P.C. Rossin College of Engineering and Applied Science; the program provides eight months of paid, full-time work experience, bridging the gap between engineering theory and application and allowing students to graduate within a four year timeframe. Because of the rigorous academic schedule, only the top third of a given class is invited to participate in the program.

The Co-Op schedule provides for interviews and selection by the companies in the spring semester of the sophomore year. Those students selected attend Lehigh for a challenging summer schedule of junior-level coursework, then begin their first work rotation with the sponsoring company in mid-August. This rotation will last until mid-January when the student returns to Lehigh for the second semester coursework of the junior year. The Co-Op experience is completed with a second work rotation the following summer (mid-May through August). Students earn 3 free elective credits per successful work assignment for a total of 6 free elective credits.

Recommended Freshman Year In Engineering and Applied Science

A recommended outline of courses for the freshman year, which satisfies requirements for all students in the college, is shown below. For schedules of the courses required in the following three years, refer to Section V.

Freshman year, first semester (15 credits)

ENGL 1	Composition and Literature (3)
CHM 21, 22	Introductory Chemical Principles and Laboratory (5) **or**
PHY 11, 12	Introductory Physics I and Laboratory (5)
MATH 21	Calculus I (4)
ENGR 1	Engineering Computations (3) **or**
ENGR 5	Introduction to Engineering Practice (3)

Freshman year, second semester (15 credits)

ENGL 2	Composition and Literature: Fiction, Drama, Poetry (3)
PHY 11, 12	Introductory Physics I and Laboratory (5) **or**
CHM 21, 22	Introductory Chemical Principles and Lab (5)
MATH 22	Calculus II (4)
ENGR 1	Engineering Computations (3) **or**
ENGR 5	Introduction to Engineering Practice (3)

Humanities/Social Sciences (HSS)
Requirement for all Accredited Engineering Majors

Basic Requirement: English and Economics. (Three courses totaling a minimum of ten credit hours):

Students must complete English 1 or 3, English 2, 5, or 11 and Economics 1. Students with advanced placements in English I usually take English 11 to complete the English requirements.

Advanced Requirement: Breadth and Depth. 13 credits in courses designated as HU (humanities) or SS (social science), not including one-credit courses, with the following restrictions:

1. At least eight credits must be in a common discipline and from the same department or program. At least three of these credits must be a the 100-level or above, or at the intermediate level or above for a single modern foreign language.
2. At least three credits in a discipline different from, and not cross-listed with, the discipline employed to satisfy the concentration requirement above.
3. At least three credits must be designated as HU.
4. HSS Credit is not given for a first elementary-level modern foreign language course (e.g. Spanish 1) until after the second elementary-level course (e.g. Spanish 2) is completed satisfactorily.

5. None of the courses taken to satisfy the HSS requirement can be taken Pass/Fail.

Minors in Humanities/Social Sciences

For greater emphasis in a particular area, a student may choose to complete a minor in Humanities and Social Sciences (HSS). Specific requirements may be found under the heading *Minor Programs in the College.* Because students must fulfill the HSS requirements, this will result in taking as many as seven HSS courses. Therefore, a student electing a minor must use personal (free) electives. Each curriculum in the college contains a minimum of two such free electives.

Written permission to pursue a minor in HSS must be obtained from the sponsoring department, and the student's academic advisor, and filed with the registrar. A student successfully completing a HSS minor will receive recognition of this accomplishment on his or her transcript.

Minor in Engineering

The minor in engineering is available to students in the Colleges of Arts and Sciences and Business and Economics only. The courses that comprise the minor cannot be taken by students in the College of Engineering and Applied Sciences. The purpose of the minor is to educate non-engineering students concerning engineering methodology, specifically how engineers solve problems, how they design, manufacture, and analyze, and how factors such as economics, safety, environmental issues affect the process. The program will not result in an engineering education, but an education about engineering. Note that all the courses in the minor are "integrated"; none are specific to an engineering discipline.

The minor has two prerequisites, a mathematics course (Math 51 or equivalent) and a physics course (Physics 5 or equivalent). There are 2 required courses in the minor, and an additional 3 elective courses must also be taken. Contact the Associate Dean's office of the P.C. Rossin College of Engineering and Applied Science for details.

Integrated Business and Engineering Honors Program

The Integrated Business and Engineering Honors Program (IBE) is offered jointly by the P. C. Rossin College of Engineering and Applied Science and the College of Business and Economics. The program recognizes the need for today's leaders in business and industry to have a sound foundation in both commerce and technology.

After four years and a minimum of 137 credits, students will receive a single Bachelor of Science Degree in Integrated Business and Engineering. The program meets the accreditation standards of the American Assembly of Collegiate Schools of Business. Students are expected to maintain a minimum GPA of 3.25 in order to remain in the program.

A second option is the five-year dual degree program. This option allows students to obtain a second Bachelor of Science degree in engineering by completing course work in the engineering field chosen by the student as their IBE major. Students enrolled in the four year IBE Honors Program and in satisfactory standing are able to transfer to a dual-degree at any time, and stay within the honors program cohort. The additional time necessary to complete the second degree will depend on the curriculum selected, and the number of advanced placement credits. The number of additional credit hours will typically be in the range of 27 to 30.

Students in the IBE Honors Program can major in nearly any area of engineering or business that Lehigh offers. After their freshman year, each student will elect a major in either the P. C. Rossin College of Engineering and Applied Science or the College of Business and Economics.

Admission to the Integrated Business and Engineering Program is highly selective, with annual admission limited to approximately 45 students. The University's Office of Admissions can explain the procedure for applying to the program.

It is possible that a small number of exceptional students may be admitted to the program following the completion of their freshman year. Admission at this point would be highly competitive and based upon freshman year GPA, faculty recommendations, and space availability.

The Co-Directors of the IBE Honors Program are Robert H. Storer, Professor of Industrial and Systems Engineering *(rhs2@lehigh.edu)* and Stephen G. Buell, Professor of Finance *(sgb2@lehigh.edu).* For additional information, see the IBE Honors Program entry in Section V of this catalog or visit the IBE web site at *www.lehigh.edu/inibep/inibep.html.*

Centers and Institutes

Faculty and students in the college also have research and scholarship activities in a number of centers and institutes, where graduate and undergraduate students work closely with faculty members. These include: Center for Advanced Technology for Large Structural Systems, Biopharmaceutical Technology Institute, Chemical Process Modeling and Control Center, Emulsion Polymers Institute, Energy Research Center, Enterprise Systems Center, Fritz Laboratory, Institute of Thermo- Fluid Engineering and Science, Sherman Fairchild Center for Solid-State Studies, Polymer Interfaces Center, Polymer Science and Engineering Center, Structural Stability Research Council, Council on Tall Buildings and Urban Habitat, Center for Manufacturing Systems Engineering, Ben Franklin Center, Manufacturers Resource Center, Center for Advanced Materials and Nanotechnology, and Center for Optical Technologies.

Special Undergraduate Academic Opportunities

The academic programs in the colleges are supplemented by five-year, two-degree programs as well as opportunities for advanced, foreign, and experiential study.

Arts-Engineering Option

The curriculum in arts-engineering is designed for students wanting a professional education in a field of engineering and also the opportunity to study a second field.

Arts-engineers fulfill all requirements for the professional engineering degree for which they are working. However, the first three years of science and engineering courses are scheduled over four years for the arts-engineer.

During this period the arts-engineer is a student in the College of Arts and Science pursuing a bachelor of arts or bachelor of science major program.

In many instances it may be advisable to take the two degrees at the end of the fifth year. Arts-engineers working towards the bachelor of science in biology, computer science, environmental science, geological sciences, geophysics, molecular biology, and statistics are advised to pay special attention to the engineering humanities and social science requirements, which must be met in time for the student to qualify for the B.S. in engineering.

Arts-engineers have the same opportunities for multiple majors and special interdisciplinary majors as are available to students working for the baccalaureate (B.S. or B.A. degree only) in the College of Arts and Sciences. Additional information may be obtained by contacting Prof. Daniel Zeroka, 496 Seeley Mudd Building.

Bachelor/Master Degree Programs

Of increasing interest to undergraduates are the two-degree programs that may lead to both a bachelor and a master's degree in five years. Because Lehigh's well-established graduate programs are closely integrated with the undergraduate programs, it is possible to consider programs leading to the arts/master of business administration degree and the engineering/master of science in material science, among others. The fifth-year program in the School of Education enables those receiving a B.A. or B.S. degree to accomplish professional teacher training and serve as salaried interns in public schools. After the completion of one year of full-time teaching, secondary teachers can receive the master of arts and elementary teachers can receive master of education degrees.

Many other five-year, graduate-level combination programs exist, and students are advised to consult with their adviser in planning such programs.

Interdisciplinary Programs

The university's interdisciplinary programs are designed to cross the boundaries between colleges to accommodate new and developing fields as well as the interests of students. They include such programs as the following:

Africana Studies. A program offering a minor is available to students interested in exploring various aspects of the African American experience. Courses covering African American art, history, literature, music, and society are offered. The program is complemented with a lecture, film, and arts series that highlights the richness and diversity of black culture.

Applied Life Sciences. The Applied Life Sciences program offers options for talented students seeking non-traditional careers at the interface of life science and other fields. It is designed to provide a flexible curricular design for students interested in social science, humanities, and business applications of the bioscience revolution, as well as those who wish to work at the intersections among the natural sciences. The program is a Liberal Arts complement to the Bioengineering program that provides an opportunity to combine traditional Engineering disciplines with the life sciences.

Environmental Studies. The Environmental Studies program will provide broad exposure to the range of issues confronting the human condition, cultural and historical perspectives on how society has evolved to its present state, and insights into the range of possible corresponding methodological approached and solutions to the global environmental questions humanity confronts. This program complements existing Environmental Sciences as well as the program in Environmental Engineering.

Science, Technology and Society Program (STS). Faculty from all three colleges explore the interrelationships between science and technological advancement and the quality of human life in the popular STS program.

Office of International Students and Scholars

"The development of future leaders in our global society is first among Lehigh's purposes."

– Lehigh University Mission Statement

32 Sayre Drive, Coxe Hall, Bethlehem, PA, 18015-3123; (610) 758-4859. Fax (610) 758-5156. E-mail: *intnl@lehigh.edu. www.lehigh.edu/intnl/*

Lehigh fosters an environment that welcomes and encourages the international exchange of students and scholars, and that integrates their global experience into the academic and cultural community. The Office of International Students and Scholars (OISS) is a university-wide resource for students and scholars from abroad, for U.S. students studying abroad, and for U.S. students and faculty who are interested in the global focus. Its mission is to provide support services for international students and scholars to ensure maximum opportunities for them to achieve their goals; be a resource to the faculty, staff and administration on issues related to international students and scholars, cross-cultural communication and diversity; support the University's efforts to internationalize the campus; and create an environment where the Lehigh community is exposed to a multitude of cultures, traditions and viewpoints by presenting internationally-focused academic, cultural and social programming.

International Students and Scholars

Bill Hunter, Director, 32 Sayre Drive, Coxe Hall, Bethlehem, PA, 18015-3123; (610) 758-4505. Fax (610) 758-5156. E-mail: *wdh3@lehigh.edu. www.lehigh.edu/intnl/*

ISS serves the unique needs of foreign nationals who come to Lehigh as students, scholars, faculty and staff members, and their families. More than 700 people from over 65 nations currently live, work and study on our campus. ISS offers advising on immigration, visa, and personal matters. The office acts as a liaison with other offices and departments on campus, and with national and international agencies.

Services

A variety of cross-cultural programs are initiated by the OISS, including a combined undergraduate and graduate orientation, spouse conversation groups, seminars on immigration matters, international tax advising, Thanksgiving Dinner, the International Bazaar, monthly social programs, International Week, and The International Update Newsletter. Lehigh is a member institution of Phi Beta Delta, international honorary society. The Beta Pi Chapter recognizes scholarly achievement of international students and scholars, US students who have studied abroad and faculty and staff involved in international activities.

The year for international students and scholars at Lehigh begins with the International Orientation. Orientation takes place in conjunction with other programs offered by the undergraduate admissions office and/or graduate departments, starting immediately before the university-wide orientation at the beginning of each semester. Orientation is strongly recommended for all new international students and scholars. Issues discussed include filing for a social security number, opening a banking account, health insurance, and adjustment to university life at Lehigh and to the United States. International Orientation is a time to become accustomed to life in America, and to meet other foreign students. Each person will receive a Handbook for International Students and Scholars .

Additional Special Services for International Students

Career Services: Advising and special workshops for careers for international students are provided.

Food Service: For undergraduate students on the meal plan, menus meet the international dietary needs of the students. There is a stir-fry bar and balanced meals for vegetarian diets.

Health Center: Fully staffed medical personnel meet both the physical and personal needs of all students. The Counseling Center has special services for international students.

Immigration/Visa Advising: Complete service.

Learning Center: Free tutors are provided in writing, math and science.

National Clubs: Home country clubs from all regions of the world are established on campus. They form an important part of the cross-cultural dimension of the campus, providing social events, films, and international dialogue.

Phi Beta Delta, International Honor Society: Lehigh's Beta Pi chapter of Phi Beta Delta, the international honorary society with chapters across the U.S. and overseas, is an important international organization on campus. The purpose of the society is to honor those involved in high academic achievement and service in the international dimension, and to foster international exchange on campus. The honor society has three categories of membership: international students who have demonstrated high scholastic achievement at Lehigh; U.S. students who have demonstrated high scholastic achievement in the pursuit of international studies including study abroad; faculty and staff distinguished in international endeavors. Gisela M. Nansteel, Chapter Coordinator.

Religious Services: Services for all the major religions are on campus or nearby, including Muslim, Christian, Jewish, Hindu and Buddhist.

Global Union:

Bill Hunter, Director, 32 Sayre Drive, Coxe Hall, Bethlehem, PA 18015-3123, (610) 758-4505; Fax: (610) 758-5156. E-mail: *wdh3@lehigh.edu. www:lehigh.edu/inglobal/*

The Global Union is a collaboration of more than 22 student clubs and organizations that promote global awareness and cultural understanding within the Lehigh community. There are more than 600 members of the Global Union from over 30 countries, including two-thirds from the United States.

Located on the second floor of Coxe Hall, the Global Union hosts panel discussions on world issues, International Education Week, dinners and cultural festivals, musical performances, and a language exchange program. All events at the Global Union are open to the Lehigh community.

The lounge also has a TV/VCR, satellite dish, stereo, comfortable couches and a microwave, and can be used for meetings, quiet study or film presentations.

The Global Union lounge can be reserved by calling (610) 758-4505 ten business days before the proposed event.

For more information regarding the Global Union, check our website at *www.lehigh.edu/inglobal/*

Study Abroad

"Lehigh University recommends international study. We support programs that offer rigorous academic environments, immersion in host cultures, and opportunities for personal growth. Students should return to Lehigh with an enhanced ability to appreciate global concerns.

- Study Abroad Mission Statement

Erica Smith, Director; Katie McCleary, Study Abroad Advisor. Coxe Hall, 32 Sayre Drive, Bethlehem, PA 18015; (610) 758-3351; Fax (610) 758-5156; email studyabroad@lehigh.edu www.lehigh.edu/studyabroad

The Study Abroad office maintains a list of more than 60 approved semester and yearlong programs of academic study in over 40 countries The programs are regularly evaluated and monitored by faculty in order to ensure high academic quality and immersion in host cultures. Students attending these programs receive Lehigh credit.

The Study Abroad Office conducts extensive advising activities, guiding students through the process of identifying programs that fit personal and academic goals, consulting with Lehigh faculty to obtain course approval, applying, and other aspects of study abroad. Group and individual advising sessions take place every week. The Office provides mandatory pre-departure orientation meetings for all students going abroad, and continuous registration at Lehigh. A comprehensive web site with information on all aspects of participation is maintained by the Office: *www.lehigh.edu/ studyabroad.*

Lehigh University maintains formal exchange agreements with universities in Australia, Belgium, Mexico, the United Kingdom, France, Hong Kong and Japan. Students are selected through faculty interviews for these programs.

Requirements: Good standing, and a minimum GPA of at least 3.0 or a GPA of 3.0 in the last two regular full-time semesters of study at Lehigh. Any student with less than this and who believes for good reason that there are extenuating circumstances may appeal to the committee on the standing of students for an exception to this rule *before* leaving to study abroad.

Applications: Students who receive Lehigh academic credit for a study abroad program must submit an application through the Study Abroad Office. Applicants are required to consult with academic advisors, have courses approved by departments, and in some cases request recommendations by faculty.

Academic Credit: Academic credit is given for programs approved by Lehigh faculty only. Students must receive a 'C' or better for credit to transfer. Grades earned on semester and year programs do not count in the student's G.P.A.

Foreign Language: Students are encouraged to study in the language of their program country, which typically requires four semesters of college-level language study. Lehigh also has approved programs where students may learn the host language while taking other courses in English.

Fees & Financial Aid: Lehigh endeavors to make study abroad available to all students. Financial aid, as determined by the Financial Aid Office, continues when the students study abroad. Lehigh requires the payment of Lehigh's tuition, minus any financial aid, for all students who study abroad who receive Lehigh credit. Study Abroad then pays the student tuition fees to the program abroad. Students are responsible for room, board, and airfare, in most cases.

Scholarships: The Philip and Muriel Berman Center for Jewish Studies sponsors summer, semester and year programs in Israel in cooperation with Tel Aviv University and Hebrew University in Jerusalem. Contact the Center for Jewish Studies, 324 Maginnes, 9 Packer Avenue, Bethlehem, PA 18015; (610) 758-4869.

The Department of Modern Languages and Literature (MLL) offers limited merit scholarships. Contact MLL, Maginnes Hall, 9 West Packer Avenue, Bethlehem, PA 18015; (610) 758-3090.

Fulbright, Rhodes, Marshall and other applicants may seek assistance from the Office of Fellowship Advising. Director: Professor Ian Duffy; *ipd0@lehigh.edu.*

Other scholarship opportunities are available; see the Study Abroad website.

Summer Programs: Lehigh offers several faculty-led summer and winter (break) study abroad programs. The number of programs and academic offerings varies, so students are advised to consult the web: www.lehigh.edu/studyabroad. Past programs have included: Business & History in Belgium; Business in Prague; Architecture in Paris; Art History & Religion in Rome & Florence; Art & Architecture in Vicenza; Internships & Language in Shanghai; Sustainable Development in Costa Rica; French & Africana Studies in Martinique; MLL in Spain; Special Topics Seminar in Ghana; Economics & Humanities in Ireland; Archaeology in Honduras. Lehigh credit and grades are applied to a student's transcript.

Lehigh University sponsors several six-week summer language programs in Europe and Mexico through LVAIC, the Lehigh Valley Association of Independent College. Credits and grades transfer to Lehigh and are counted in the Student's GPA.

English as a Second Language

Timothy Bonner, Director,
205 Coxe Hall,
Bethlehem, PA, 18015, (610) 758-6099
www.lehigh.edu/~inesl

The English as a Second Language Program (ESL) offers academic semester and summer courses for undergraduate and graduate students and their families. In addition, academic support is provided for ESL students through the ELLC language lab, conversation groups, and language enrichment courses.

English Department (Credit) Courses. After reviewing placement test results, undergraduates accepted by the ESL program may take English 3 and English 5 (Composition and Literature for ESL Writers I and II) in substitution for required English 1 and 2. Native English speaking or near native-speaking upperclass and graduate students who are interested in the ESL field as a career can get an introduction to teaching ESL/EFL in English 310 and English 314. (Refer to the English department course listings.)

ESLP (Credit) Courses. Both undergraduate and graduate students may select from a variety of supplemental ESL credit courses in conversation, accent reduction, reading, and writing offered throughout the year. (Refer to the English as a Second Language course offerings.)

Intensive ESL (Non-credit) Program. The StepUp Program provides an intensive academic ESL experience for both enrolled Lehigh students and for other students preparing to enter a U.S. university or who need professional English skills. StepUp enhances English skills in academic reading and writing and formal academic language, and provides an orientation to American university culture. For more information, view our website at *www.lehigh.edu/~inesl/StepUp*

English Language Learning Center (ELLC). The ESL Program offers English language study through the use of interactive ESL software and tutoring. Call the ESL Office or view the ELLC program on our website.

International Multimedia Resource Center

Johanna Brams, Instructional Technology Specialist, 473 Maginnes; (610) 758-6134, 6295.

The International Multimedia Resource Center, located in Maginnes Hall, provides a diversity of services ranging from multimedia to telecommunications. Under the auspices of Information Resources, working directly with Media Production and the Media Center, in collaboration with the College of Arts and Sciences , and Modern Languages and Literature, the IMRC maintains a multimedia computing center (470 Maginnes Hall) equipped with state-of-the-art multimedia computers, a head end room (473) and the World View Room (490 Maginnes Hall) that broadcasts international, historical, and cultural events on our wide screen television. As a resource center, the IMRC supports the efforts of faculty and staff in the design , construction and application of either original or off-the-shelf multimedia presentations and projects. New CD ROM based immersive software programs enhance language learning. Student-centered web-research projects occur through partnerships with various faculty members throughout the year. Web utilization, research and design workshops are held regularly, focusing on diverse software web, desktop and design applications. An extensive collection of international audio, video and multimedia programs is maintained. Moreover, the IMRC sponsors business, university, and international broadcasting, as well as teleconferencing events through satellite and videoconferencing technologies. The IMRC also maintains the two broadcast video channels at Lehigh: the Academic Channel (Channel 21: including international news (SCOLA), student produced programming, academic programs and labs, sports and special events, etc.) and the Movie Channel (Channel 22: popular, independent, and foreign movies programmed by a student-elected committee). As a 'Window to the World,' the World View Room shows or hosts daily scheduled international and cultural programs, films and teleconferences; as well as being open for news watching all day long. Comfortably furnished, the World View Room accommodates 25 – 35 people. A new 51 inch flat screen television supports regular viewing, as well as films, satellite downlinks and newly added permanently installed DVD and VHS technologies. Newly added is our refurbished (five-meter dish) digital link, which facilitates PBS, ALS and The Business Channel teleconferencing.

Experiential Learning

The accommodation of student interest extends beyond regular departmental offerings. Hands-on experiences in learning enrich classroom instruction. Each of the three colleges offers a number of such experiences to undergraduates. Among them:

The Philadelphia Urban Semester. Undergraduates in all fields of study can earn 16 Lehigh credit hours by spending a semester studying in the nation's fourth-largest metropolis. They live, work, and study with other students from two dozen other institutions, supervised by faculty of the Great Lakes Colleges Association. This consortium of such leading Midwestern institutions as DePauw, Kenyon, Oberlin, and Wooster is a recognized leader in providing extra-mural academic programs both here and abroad.

The curriculum consists of two four-credit seminars and an eight-credit internship. All students are enrolled in a core "Seminar on the City" which introduces them to the field of urban affairs and to Philadelphia. The second seminar is elected from a half-dozen more specialized urban topics; recent choices available have included "Folklore in Philadelphia," "Art in the City" (which met each week at a different site), and "Justice." Internships involve working four days weekly in a public or private placement which tests the student's aptitude in a variety of practical ways while enhancing appreciation of city life.

The Washington Semester. Opportunity is available each year for six juniors or seniors to spend a term studying in Washington, D.C., in cooperation with American University. Lehigh University is a member with 180 other colleges and universities.

Students enroll at Lehigh but spend the semester in residence at American University with the students from other participating colleges.

The curriculum consists of national-government seminars, an internship, and a written research project. Besides the national government program, the student may choose other program offerings such as economic policy semester, journalism, public administration, foreign policy semester and justice semester.

Inspection trips. The location of the university in the center of industrial activities of various types affords unusual opportunities for visits to manufacturing plants. Inspection trips to individual plants are a required part of specific courses in various engineering curricula. Written reports may be required. These trips are generally held during the senior year and involve an average expense of $25 to $50.

Credit by Examination

Upon petition and presentation of evidence that he or she has qualified for it, a student already enrolled at Lehigh may be permitted by the standing of students committee to take a special examination for credit towards graduation. Special examinations are granted only for extraordinary reasons and upon petition. There must be adequate supporting evidence of sufficient cause accompanying each petition. There is a fee for all special examinations.

Students taking a special exam after matriculation at Lehigh will have the grade and credits assigned to their permanent Lehigh record. Special exam credit will be counted as in residence credit and the grade will be used in all grade point average calculations. No special exam will be granted in a course that the student has already taken (except senior reexaminations) for credit or on an audit basis, or in a course in which the student has already completed more advanced work at Lehigh.

Preparation for Graduate Work

Students planning to continue in graduate programs should take advantage of the flexibility in many undergraduate programs to design an upper-division curriculum that meets requirements in the anticipated graduate program.

The policies of the colleges provides as much flexibility as possible for students who wish to change to new but related fields of study after the baccalaureate degree. Students should consult with their previous program adviser and the department representative of the new field to establish an academic program that will remedy any deficiencies in background.

Guidelines for Undergraduates to Take Graduate Level Courses

1. No undergraduate student may take a 400-level course during a term where the student's total credits are greater than 18 (including audits).
2. All students receiving a graduate degree must be enrolled one full semester or summer as a regular student prior to the awarding of a graduate degree.
3. An undergraduate student may use no more than 12 credits taken as an undergraduate toward a graduate degree. These courses must be at the 300 and 400 level and beyond all undergraduate degree requirements.

4. Students should have achieved junior standing and a grade point average of 3.0 to take 400 level courses.
5. Students must petition the Graduate and Research and the Standing of Students for a possible exception to theses standards.

Apprentice Teaching

The apprentice teaching program is designed to benefit juniors and seniors who wish to learn about teaching under the guidance of an experienced teacher. Apprentices often do a limited amount of supervised lecturing or leading of discussions, assist in making up and evaluating written assignments, and are available for individual consultation with students.

To participate in the apprentice teaching program a student must:

1. Have an over-all cumulative grade point average of 2.80 or better;
2. Have a cumulative grade point average of at least 3.3 and have completed at least two courses in the major field in which apprentice teaching is done;
3. Have previously taken for credit the course or its equivalent in which the apprentice teaching will be done.

A student may register for apprentice teaching only once each semester, only once in a given course, and only twice during a college career.

To register for apprentice teaching each student-teacher partnership will submit an apprentice teaching agreement, indicating the duties and obligations for approval to the department chair and the dean of the student's college in which the course is taken. This form must be submitted to the registrar before the first day of classes in the semester. To complete the course, the apprentice teachers must submit a written report of their experience to the supervising teacher, who will forward it to the Office of the Provost.

Curricular Flexibility

Choice is a regular part of university life, and encompasses the determination of a college and major, the selection of courses each term, and the development of life goals and career options.

Many of these choices are academic in nature. The undergraduate curricula are flexible, designed to accommodate the changing interests and needs of students. Boundaries between colleges are as fluid as possible to provide many options in an educational program. For instance, students may take a bachelor of science (B.S.) degree in the College of Business and Economics or the College of Engineering and Applied Science with a minor in journalism in the College of Arts and Sciences. There are five-year programs for which degrees are awarded in two colleges.

Transfers between undergraduate colleges is permitted but only *after the freshman year.* Students considering such a transfer must confer with their advisers to begin the process.

Academic offerings of the various departments are described in Section V. To provide additional flexibility and encourage student initiative and depth of investigation, the university has developed academic alternatives including the following:

Provisional Courses. Departments may introduce provisional courses temporarily within a semester, either experimentally or as a response to a contemporary social or scientific issue. If successful, a course may become part of the regular curriculum. Such courses, identified with a 95, 96, 97 or 98 number (preceded by a 1, 2, or 3 indicating level) may sometimes take provisional courses numbered above 100 on a pass/fail basis.

Independent Study. Juniors and seniors of ability who wish to concentrate in their chosen field can substitute no more than four or six credit hours of independent, unscheduled work each semester for an equal number of credit hours of elective work required for graduation. Students, in collaboration with the major adviser, with the advice of the departmental chairperson and consent of the college dean, may structure such a project for study in any curriculum and most major study sequences.

Pass/Fail Option. Students have the opportunity to study in areas without concern for possible poor grades by electing a pass/fail option. Intended to encourage exploration at the upper division level outside the major field, this option is open to those who are sophomores and above, in good standing, who have declared a major. Courses numbered below 100 will not be eligible for pass/fail. The pass/fail option may not be used for major or minor subject credit toward graduation or for distribution requirements. Consultation with the adviser is required.

Graduate Courses. Qualified undergraduates may petition the graduate committee to register for 400-level courses if they are certified by the course instructor and the department chairperson concerned.

1. No undergraduate student may take a 400-level course during a term where the student's total credits are greater than 18 (including audits).
2. All students receiving a graduate degree must be enrolled one full semester or summer as a regular student prior to the awarding of a graduate degree.
3. An undergraduate student may use no more than 12 credits taken as an undergraduate toward a graduate degree. These courses must be at the 300 and 400 level and beyond all undergraduate degree requirements.
4. Students should have achieved junior standing and a grade point average of 3.0 to take 400 level courses.
5. Students must petition the Graduate and Research and the Standing of Students for a possible exception to theses standards.

LVAIC Cross-Registration

Currently enrolled full-time degree seeking undergraduate students in good academic standing who have achieved sophomore status may register for up to two courses per term that cannot be scheduled at the home institution at any one of the member institutions (Allentown College of St. Francis de Sales, Cedar Crest College, Lafayette College, Moravian College, and Muhlenberg College). The student must obtain the appropriate approvals of his or her own adviser and the host institution registrar. The courses must be in the normal academic load and not produce an overload. Graduate students and courses (courses numbered 400 and above) are not eligible for cross registration.

All grades of courses taken through the LVAIC cross registration process will be accepted by the home institution and entered on the permanent record, and such grades will be used in computing the grade point average. Credits taken through the cross-registration process will be calculated as in residence. The number of credit hours assigned to a course is the responsibility of the home institution registrar.

Students may not repeat a course at another LVAIC institution in which they expect to have a Lehigh cumulative grade point average adjustment.

Lehigh University students are not permitted to cross-register for courses in all January intersession programs, the evening program at Muhlenberg College, all weekend courses at Cedar Crest College, or the Access program at Allentown College. All independent study music lessons or groups and correspondence courses are prohibited from cross-registration without prior approval of the Lehigh University standing of students Committee.

Summer Session
Lehigh students must have been registered full time in the prior spring semester to be eligible to cross-register for a summer term. A maximum of two courses per session, and 12 credit hours over the course of the entire summer may be rostered. Students may not cross-register for a course being offered at Lehigh during the summer term.

The General College Division

The General College Division supplements the mission of the established undergraduate curricula. The division provides an opportunity for persons not planning to qualify for a degree to pursue work of a general or specialized nature that their preparation and interests make desirable; provides a trial period for those who wish to become candidates for baccalaureate or graduate degrees, but whose preparation does not satisfy the entrance requirements for the established curricula; and provides an opportunity for qualified students to continue their education without being committed to a restricted or specialized program of studies. Courses taken in the General College Division may not be submitted to meet the requirements for a graduate degree.

For admission to the General College Division, the student must submit a special, simplified application to the undergraduate admissions office; the application must be submitted at least one month prior to the start of the semester in which the student hopes to enroll. The applicant must show maturity, seriousness of purpose and evidence of ability to pursue with profit the program of studies he or she desires. The student must have the established prerequisites for courses in which he or she wishes to enroll, and may register for courses up to and including those at the 300-level.

There is no established curriculum for the General College Division. Each student works on a program outlined to meet his or her special needs. Each program must be approved by the registrar, director of the division. Students must obtain permission of the instructor for courses in which they want to enroll. Students in the division are not permitted to take courses using their optional pass/fail grading system, or cross register for courses in the LVAIC.

Students in the division, as non-degree candidates, do not meet the eligibility criteria for federal student aid, under Title IV, including Federal Pell Grants and Federal Stafford Student Loans. Similarly, institutional financial aid also is limited to degree candidates.

Students in the division are not candidates for degrees and must maintain a minimum 2.00 grade point average. A student may transfer to regular matriculated undergraduate status in any of the colleges only upon petition to, and with the approval of, the Committee on the Standing of Students. Transfer to the graduate school is possible only through the normal graduate admission process.

With the exception above, students in the General College Division are subject to the same rules and regulations as students of the university. They pay the tuition and fees established for regularly matriculated students.

IV. Graduate Study and Research

Graduate Study

Lehigh began awarding graduate degrees in 1882. The first recipient, T.H. Hardcastle, of the Class of 1880, wrote his thesis on Alexander Pope, entitled it The Rights of Man, and read it aloud at commencement in June 1882.

The first Ph.D. was granted in 1893 to Joseph W. Richards, Class of 1886. Richards, who had a background in metallurgy and electrochemistry, taught at Lehigh until his death in 1921.

Women were admitted to the graduate program in 1918 when the faculty and the board of trustees agreed to grant the degrees of M.A. and M.S. to women, provided they attended classes in the late afternoon and on Saturdays "so that the general character of campus life shall not be affected." Three women received graduate degrees in 1921, the first women to complete graduate work at Lehigh. In 1929, the rule was changed, and women were admitted on much the same basis as men.

In 1936, the Graduate School was established to administer the graduate program. The Ph.D., which was temporarily discontinued in 1894, was reinstated in nine departments: chemistry, chemical engineering, civil engineering, geology, history, mathematics, mechanical engineering, metallurgical engineering, and physics. Tomlinson Fort, professor of mathematics, was selected in 1938 as the first dean of the Graduate School.

In 1995, graduate programs were decentralized and are now administered by the four colleges of the university, as described below.

College of Arts and Sciences

Anne S. Meltzer, dean
Hannah Stewart-Gambino, associate dean of graduate programs

The College of Arts and Sciences offers graduate degrees in the humanities, social sciences, mathematics, and natural sciences. The master of arts, master of science, and the doctor of philosophy degrees are given in most of the traditional academic departments and in some interdisciplinary programs.

Advanced degrees may be obtained in the departments of biological sciences, chemistry, English, earth and environmental sciences, history, mathematics, physics, political science, psychology, and sociology. In addition, interdisciplinary degrees are available in American studies, photonics, and polymer science and engineering.

Although degree requirements vary from department to department, most require a combination of formal coursework and independent research. Students work closely with a faculty adviser in formulating and carrying out their research programs. Students interested in an interdisciplinary approach are admitted to a traditional department but formulate a program of study and research which draws on faculty and facilities in other areas of the college or the university.

Outstanding candidates may qualify for financial support in the form of assistantships as teaching assistants, graduate or research assistants, and scholarships or fellowships.

Information on the various degree programs appears below in section V or can be obtained from the respective Graduate Programs Office in each college.

College of Business and Economics

Richard M. Durand, Herbert E. Ehlers, dean
Kathleen A. Trexler, associate dean, director- MBA program

The College of Business and Economics offers the master of science degree in accounting and information analysis; master of science degree in economics; master of science degree in health and bio-pharmaceutical economics; master of business administration with concentrations in finance, marketing, information systems management, entrepreneurship through the vSeries program; international business and supply chain management; and the doctor of philosophy degree in business and economics. Three joint degrees are also offered. The College of Business and Economics and the P.C. Rossin College of Engineering and Applied Science offer the MBA Engineering. Students in this program will have the opportunity to concentrate in both a business area and an engineering area during their Master's studies. The College of Education and the College of Business and Economics offer a joint masters degree in MBA/Educational Leadership. This degree will develop skills in business disciplines as well as preparing educators for roles in school administration. The College of Business and Economics and the P.C. Rossin College of Engineering offer a master's degree in analytical finance. This degree provides a strong education in advanced finance and quantitative financial analysis tools. Students will be prepared to create innovative solutions for real financial problems using state of the art analytical techniques and computing technology.

There are four departments in the college: Accounting, Economics, Finance and Law, and Management and Marketing. Course descriptions can be found listed under business and economics graduate courses in Section V. More information about the various degree programs appears below. The college publishes a packet describing its graduate programs, which may be obtained by contacting the College of Business and Economics, Graduate Programs Office, Rauch Business Center, 621 Taylor Street, Bethlehem, Pa. 18015, 610-758-5280.

College of Education

Sally A. White, Dean and Professor

The College of Education was established as a School of Education in 1966, elevating it from its former departmental status under the College of Arts and Sciences. In 1985 the school was given its present status as a college, headed by a dean. The current vision statement affirms that the College of Education aspires to be a world leader in all disciplines represented in the college. It focuses on academic excellence and innovation in research and teaching, and recruits faculty and students of the highest quality. The College of Education faculty collaborates directly with school-based, human service, instructional design and technology professionals. Further, the faculty strives to solve world issues by being leaders in their fields.

Headed by a dean the College of Education is configured organizationally into a Department of Education and Human Services that encompasses six programs: Counseling Psychology, Educational Leadership, Educational Technology, School Psychology, Special Education, and Technology-based Teacher Education. Each program(s) has a coordinator who works with the faculty, while the department chair facilitates day-to-day operations of programs.

In addition, there are three other units within COE:

The Office of International Programs

The mission of the international program is to have fundamental concern for all schools in the new millennium and focus on the continual need for professional development of teachers and administrators. Life-long learning is crucial to all educators who are in the business of promoting global awareness and appreciation. The College of Education at Lehigh University is committed to providing and facilitating the exchange and transmission of knowledge.

The Center for Promoting Research to Practice

Our mission is to generate new knowledge that will truly impact the lives of individuals with disabilities. The primary objective of Center is to create a living laboratory that establishes partnerships with schools, parents and families, and community service providers to enhance the use of best practices for individuals with disabilities.

Centennial School

The College of Education operates the Centennial School, a laboratory facility for children with emotional/behavior disorders, that has both an elementary and a secondary component. Centennial School provides research opportunities as well as practical experience for advanced students in counseling, school psychology, and special education.

The College of Education offers a master of arts in education, a master of education, a master of science in education, the educational specialist, a joint master in business administration/maser of education, post-baccalaureate certificates in various concentrations, the doctor of education, and the doctor of philosophy. A total of 550 students were involved in advanced study during the 2003-2004 academic year. More information about these programs can be found on pages 211-221.

The College of Education is a graduate college offering several different alternatives for undergraduate students to become teachers. These include:

1. An intern teaching program is specifically designed for qualified persons who hold a bachelor of arts degree and who desire to enter the field of teaching. Those admitted to this program have the opportunity to accomplish their professional training and serve as interns in the public schools. After two semesters of directed full-time study, students may begin the teaching internship. Upon completion of the fifth-year program and the required semesters of intern teaching, these students ordinarily will have completed requirements for the M.A. (secondary teachers) or the M.Ed. (elementary teachers), as well as state certification.
2. Undergraduate minor in education: Upper-level undergraduates are given an opportunity to take a minor in education that combines practicum activities with theoretical work and is designed to provide a foundation for further educational studies at the graduate level.
3. Five-year Programs in Teacher Education. The College of Education operates two programs for students interested in entering the teaching profession. The B.A./M.A./M.Ed. programs require that students major in a content area within one of the three other colleges. Students begin their coursework toward their education degree as undergraduates and complete a fifth year during which they obtain a Master's degree and fulfill requirements for teacher certification in Pennsylvania. Additionally, students who major in Materials Science & Engineering (B.S.) can also enter a fifth year program that will earn them teaching certifications in physics, mathematics, general science, and possibly chemistry. These students also earn a Master's degree (M.Ed.) in education at the completion of their fifth year.

P.C. Rossin College of Engineering and Applied Science

Mohamed S. El-Aasser, dean
John P. Coulter, associate dean of graduate studies and research

There are seven academic departments within the P.C. Rossin College of Engineering and Applied Science: chemical engineering, civil and environmental engineering, computer science and engineering, electrical and computer engineering, industrial and systems engineering, materials science and engineering, and mechanical engineering and mechanics. Master of science and doctor of philosophy degrees are available in each of these departments, as well as in computational and engineering mechanics, environmental engineering, and polymer science and engineering. In addition, master of science programs are provided in analytical finance, computer engineering, photonics, quality engineering, information and systems engineering, management science, and wireless and networking engineering. Master of engineering degrees are offered in chemical engineering, civil engineering, electrical engineering, environmental engineering, industrial engineering, materials science and mechanical engineering. In co-operation with the College of Business and Economics, students can also pursue a Master of Business Administration and Engineering (MBA&E) degree. A certificate program is available in the area of nanomaterials.

Graduate study in the P.C. Rossin College of Engineering and Applied Science is most often related to the college's extensive research activity, and graduate students are expected to engage in analytical or experimental research as part of their programs of study. This activity involves students in the process of creating new knowledge under the direction of the college's distinguished faculty and brings them into contact with some of the most modern and advanced experimental techniques. Many college research programs are supported by contracts, fellowships, and grants from industry and from federal, state, and local governments. This funding not only provides financial support for outstanding students but also allows them to deal with some of the more complex and pressing problems facing our society in the 21st century.

Many faculty members and graduate students in the P.C. Rossin College of Engineering and Applied Science are associated with interdisciplinary research centers and institutes as well as with their own departments. The opportunity for interdisciplinary study allows them to cross departmental lines in specific technological areas and to work with faculty and graduate students from other departments. Centers and institutes currently carry on research in the areas of biotechnology, health sciences, thermofluids, materials, energy, environmental sciences, surfaces and coatings, solid-state studies, optical technologies, structural and geotechnical studies, high-rise habitats, emulsion polymers, fracture and solid mechanics, metal forming, robotics, computer-integrated manufacturing, and design and management innovation. Extensive research in many of these areas is also conducted within academic departments.

Further information on the graduate programs appears under the departmental listings in Chapter V and in the Interdisciplinary Graduate Study and Research section of Chapter IV. Students can also contact the Office of Graduate Studies and Research, P.C. Rossin College of Engineering and Applied Science, 19 Memorial Drive West, Bethlehem, PA 18015.

Admission to Graduate Study

A graduate of an accredited college or university may be considered for admission to graduate study. The decision to admit a student rests with the applicant's major department and stands for one year following the first semester for which admission was offered. If more than one year elapses, the prospective student's department reserves the right to reconsider the original offer. Students wishing to pursue an interdisciplinary degree may, in some cases, apply to the program directly.

Applications for admission may be obtained on-line at the university's graduate website or by writing to the department to which admission is sought, or writing to the office of the dean of the prospective college.

An applicant may enter the graduate program as a student in the following categories: regular, associate, or non-degree. Except for qualified Lehigh undergraduates, only those who have been admitted officially by the graduate program office of an appropriate college or by a department in one of the categories above may register for graduate courses or take them for credit.

Regular Graduate Students. Only regular graduate students are candidates for graduate degrees. Application for admission as a regular graduate student must be filed by July 15 for the following fall semester or by Dec. 1 for the spring semester. Regular applications for the summer sessions are accepted until April 30. **Certain departments or programs have earlier deadlines**. Applicants should consult their respective departments or their dean's office. In order to be considered for admission as a regular graduate student, the applicant must satisfy at least one of the following conditions: have an undergraduate G.P.A. of at least 2.75 out of 4.00 (note: College of Education GPA minimum is 3.0); have an average of at least 3.00 for the last two semesters of undergraduate study; have a graduate grade-point average of at least 3.00 for a minimum of twelve credit hours of graduate work completed at other institutions; or have successfully satisfied the probationary conditions as an associate graduate student discussed below). Satisfying one of these conditions is a necessary but may not be sufficient condition for admission as a regular graduate student.

Foreign graduate students are required to take the Test of English as a Foreign Language and achieve a minimum score of 550 on the paper-pencil test or 213 on the computer-scored test.

Individual departments may evaluate their candidates for admission according to higher standards and additional criteria. Students seeking admission to Professional Certification Programs may have to meet additional requirements to comply with Pennsylvania Department of Education Regulations. Departments should be consulted for information regarding required examinations for admission. For example, candidates for the M.B.A. program are required to take the Graduate Management Admissions Test (GMAT). This does not include MBA & Engineering students in the College of Engineering and Applied Science who may substitute the Graduate Record Exam if required by the Engineering Department. In some cases the GRE subjects tests are required.

Admission of a student to graduate standing is executed through the Office of Graduate Studies in each college or the respective dean's office. Credentials for admission to counseling psychology and school psychology programs and to the doctoral programs in special education are acted upon only once a year. Completed applications accompanied by requests for financial aid must be submitted by January 15 for admission in the following fall semester. Applications received after this deadline, for programs with early deadlines, will be dealt with on a space-available basis.

Associate Graduate Students. Associate graduate student status may be offered to applicants who apply but fail to qualify for regular graduate student status. Only associate student applications will be considered during the late admissions period between the end of the regular admission period and the first day of classes. Applicants for associate status may submit unofficial rather than official transcripts; letters of recommendation are not required at that time. The Registrar will require an official final transcript, however, before grades are released. Certain departments or programs have earlier deadlines and more stringent requirements. Applicants should consult their respective departments.

Associate graduate students who are admitted during the late admission period and who clearly qualify for admission as regular graduate students may petition for regular status after classes begin if all credentials are in order. There is no late application fee. Individual departments may have more stringent requirements.

Other associate graduate students must meet the following condition before they may petition for regular status: completion of the first nine credit hours of courses numbered 300 or higher with at most one grade of below B-. Students receiving a grade lower than a C will be dropped from the program. Students should note that individual departments may impose more rigorous probationary standards.

When the probationary period of nine credit hours is completed successfully, associate graduate students must petition for regular student status in order to continue. This requires the submission of regular admission documents not already on file. Courses completed during a successful probationary period may count toward a graduate degree if they are part of an approved program.

Non-Degree-Seeking Students. Students who do not wish to enter a degree program may seek admission with non-degree status. In this case, the prospective student completes an abbreviated application form (available from the appropriate college). The admissions criteria for non-degree graduate students are: 1) a bachelor's degree from an approved institution with an overall grade point average of at least 3.0; (applicants with undergraduate GPAs below 3.0 may be admitted with the approval of the department in which they wish to take courses;) **or** 2) evidence that the applicant is presently a student in good standing in an appropriate graduate program at an approved institution; **or** 3) evidence that the applicant has received an appropriate graduate or other advanced degree from an approved institution. 4) International students are required to demonstrate English language skills equal to those required of degree-seeking students. All international applicants whose native language is not English must take the TOEFL (Test of English as a Foreign Language). A minimum score of 550 (or 213 on the computer scored test) is required for admission. This TOEFL requirement may be waived if the international applicant has studied full-time in an English-speaking university for at least one year.

Admission decisions for non-degree students are made by the dean of the appropriate college or other responsible official designated by him/her for this purpose. The signature of the designated official on the application and registration forms confers admission to the non-degree graduate student status. Informal transcripts will be accepted for initial admission, but formal transcripts must be on record before the student can receive any transcript or grade report from the university or enroll for additional courses.

Non-degree students may take no more than twelve hours of graduate study at Lehigh. Any transcript or other record from the university will clearly indicate the student status as non-degree. **Students in a non-degree status are not eligible for financial aid.**

Graduate Course Auditing: With the permission of the departmental chair, graduate students can be admitted to a course as auditors. This course will not count for credit towards any graduate degree, and may not subsequently be taken for credit. In no case shall a student who has attended a course as an auditor be given an anticipatory examination for credit or register for the same course in the future A student completing a course in this manner will have the course and the notation "AU" indicated on the permanent record. A student rostered on an audit basis may be withdrawn from the course with a grade of "W" for poor attendance.

Lehigh University Undergraduates. A Lehigh undergraduate with a 3.0 cumulative grade point average who has achieved Junior standing may take any 400-level course for which he or she is qualified. The qualifications are defined by the department and are certified by the course instructor and department chairperson through petition to the graduate and research committee. For additional information on constraints on undergraduates taking graduate level courses please see Section III Curricular Flexibility.

Undergraduates at Lehigh who are within a few hours of meeting the requirements for a baccalaureate degree may, with the special approval of the graduate and research committee, enroll for 12 credit hours of study for graduate credit. Lehigh undergraduates may apply course credits taken in the undergraduate program toward a graduate degree under the following conditions: (a) the course credits are not submitted as part of the requirement for an undergraduate degree; and (b) courses for possible graduate credit are approved in advance by the course instructor, department chairperson, and the dean of the college. The student must receive a grade of B- or better.

Readmission. A student who has not been registered in a Lehigh graduate program for one year must petition for readmission. Petitions approved by the student's major department must be forwarded to the registrar's office.

International Students and Scholars. International applicants must hold an American bachelor's degree or an equivalent foreign degree requiring at least 16 years of primary, secondary, and university education. International applicants must submit all documents required for regular graduate student status, as explained above. Brochures for international applicants may be requested from individual departments.

Registration

Requirements. All graduate students using Lehigh University resources must be registered. No graduate student may register for more than 16 credits per semester. University employees may register for, at most, two courses per semester with appropriate approval. The maximum registration in a summer session is two concurrent courses and no more than 14 summer credits.

Full-time Status. In order to maintain full-time enrollment status, a graduate student must ordinarily register for a minimum of nine credits each semester. Identification as a full-time student is important for three purposes: (1) eligibility for financial aid, (2) compliance with visa requirements for international students, and (3) for university and national graduate enrollment data.

After fulfillment of degree credit-hour requirements and in some other circumstances, full-time status may be maintained with fewer than nine credits of registration, provided that the student is, in fact, continuing a program of full-time study and research. In such cases, the status must be certified on the Graduate Full Time Certification request form, first by the department and then by the appropriate college.

Registration Procedure. Registration is scheduled for a two-week period at a time designated on the university calendar. Graduate registration for new students is held during the week preceding the start of classes. Students should check with their departments for registration and semester class schedules. Graduate students may register using the on-line system after consultation with their adviser, or complete registration forms available in their departments. A course adviser will discuss course selections with students and provide the registration PIN or sign registration forms upon approval.

Late Registration Penalties. Registration after the designated period during the prior term for continuing full time graduate students or between the second and tenth day of class during the fall and spring semesters, and the second and fifth day of class during the summer sessions will require a late registration fee. Students who have not completed the registration process by the tenth day of the regular academic semester or by the fifth day of the summer session will not be permitted to attend class.

Graduate Credit and Grades

Course grades are defined as for undergraduates except that no grade lower than C may be counted toward a graduate degree and pass-fail registration is not allowed for graduate students. No regularly admitted student who receives more than four grades below a B- in courses numbered 200 or higher is allowed to continue registration as a graduate student.

The N grade is defined as for undergraduates except that graduate students have a calendar year to remove course incomplete grades unless an earlier deadline is specified by the instructor. Graduate student incomplete course grades that are not removed remain as N grades on the student's record. Thesis or research project N grades may remain beyond one year until the work is completed.

The X grade is defined as for undergraduates except that to be eligible for a make-up examination a graduate student must file a petition and the petition must be approved by the graduate and research committee.

The Z grade is defined as for undergraduates except that graduate students have a calendar year to complete coursework following a Z grade unless an earlier completion deadline is specified by the instructor. The X portion of the grade is removed as described for undergraduates. Z grades which are not removed remain on the record of graduate students. All petitions for exceptions are sent to the graduate and research committee.

Withdrawal from a Course. A student dropping a course within the first ten days of the semester (five days for summer sessions) will have no record of the course on the transcript. A student dropping all courses for which he or she is registered is considered to be withdrawing from the university and the policy is noted below. A student who drops a course after the tenth day of instruction and before the end of the eleventh week of instruction will have a grade of "W" assigned to the course. A student who drops a course after the eleventh week of instruction and before the end of classes receives a "WP" or "WF" at the discretion of the instructor. A "WF" is considered to be a failing grade. An Add/Drop form signed by the student's adviser must be submitted to the registrar's office before the deadlines noted to be official.

University Withdrawal. A student withdrawing from the university (dropping all courses during a given term) must submit the Drop/Add form signed by the adviser to the registrar's office. Withdrawal after registration day and during the first eleven weeks of instruction will be noted on the academic transcript by assigning a grade of "W" to all courses. A withdrawal after the eleventh week of instruction and before the end of classes will have the grade of "WP" or "WF" assigned for each course at the discretion of the instructor. The date of the withdrawal will be noted on the academic transcript for a withdrawal at any time during the term.

Graduate Student Scholastic Requirements. The guidelines state the requirements for all graduate students.

Associate and Non-Degree Students: will be placed on probation when they receive their first grade below a "B-" and will be dropped for poor scholarship at the end of a term when the student is assigned either two "C" OR "C+" grades or one grade "C-" or below.

If an associate student is assigned two grades below a "B-" in the same term the student is eligible to be dropped without any term on probation.

Once on probation, students remain on probation until they are granted regular status or graduate. Students who are eligible to be granted regular status but fail to apply by the regular student deadline will be evaluated according to the regular student criteria.

Regular Students: will be placed on probation at the end of the term in which they are assigned their fourth grade below a "B-" in courses numbered 200 or above;

will be dropped for poor scholarship at the end of any term in which they are assigned their fifth grade below a "B-".

Once regular students are placed on probation they will remain on probation until they receive their degrees.

Readmission: graduate students who have been dropped for poor scholarship are ineligible to enroll for the next regular term. After one term away they may petition for readmission. The department and the dean's office must approve the petition. The student will be readmitted on probation and may be dropped again with any additional grades below a "B-".

Graduation

Degree Registration. A student must be registered in the semester in which the degree is conferred. If a student is not registered for a course, he/she must register for maintenance of candidacy.

Application for Degree. Candidates for degrees to be conferred on University Day in May must file an application for degree with the registrar by March 1. Candidates for degrees to be conferred in January must file by November 1. Candidates for degrees to be conferred in September must file by July 1. Late application for a degree will incur a penalty fee of $25.

Clearance. Graduate students must receive clearance from the university prior to the awarding of the degree. The following obligations must be satisfied:

- Students must complete all coursework for incompletes they may have received.
- Theses must be cleared by the Registrar's Office.
- Dissertations must be cleared by the appropriate dean's office.
- All financial obligations must be cleared with the bursar. Tuition fees, bookstore charges, library fines, and motor or vehicle fines must be paid before graduation.
- All library books on loan must be returned.
- Students must turn in their student identification cards at the I.D. card office.

The interdepartmental clearance sheet must be completed. This form requires the signature of the student's department chairperson (except for the College of Education), and the facilities services office before it is submitted to the registrar at least three days prior to graduation.

Tuition and Fees

Tuition Payment. Graduate students who register at least six weeks prior to the start of classes will receive a tuition bill at their home address. Included with the tuition bill will be information about the various payment options that are available. Students that register less than six weeks prior to the start of classes will most likely not receive a tuition bill prior to the start of classes. To remain in good standing, tuition charges must be paid prior to the start of classes *even if the student has not received a tuition bill because of his/her late registration for classes.* Students can review their current account balance on-line at *www.lehigh.edu/inrgs/index.htm*. Additional information on payment options is available on the Bursar's Office web site at *www.lehigh.edu/inburs/* or by calling the Bursar's Office.

Tuition Refunds. A student in good standing who formally withdraws from a course before 60% of the semester has been completed is eligible for a tuition refund. Academic fees, such as the Technology Fee, are non-refundable after the first day of classes. The refund schedule for student withdrawals and course adjustments is as follows.

Tuition Refunds

The tuition refund for a student who withdraws or drops a course(s) is calculated on a daily basis according to the Federal Refund Calculation Guidelines. No refunds for tuition can be made for one-week workshops after the first day of class.

Students should note that the first calendar week begins with the first day of classes at the university.

Tuition and Fees for 2004-2005 per credit hour

College of Arts & Sciences	$950
College of Business & Economics	620
College of Education, and for full-time elementary and secondary teachers and administrators enrolled in the other three colleges	490
College of Engineering & Applied Science	950
Special Programs	
MBA & Engineering	$730
MBA/Educational Leadership	$545

Technology Fee
All full-time (9 credit hours or more, or certified full-time) graduate students are assessed the Technology Fee at $100 per semester

Audit charge per course – same as credit charge in the appropriate college

Maintenance of candidacy – same as a one-credit charge in the appropriate college

Master's candidate registration fee – same as a one-credit charge in the appropriate college

Living Accommodations. The university maintains a graduate student housing complex in the Saucon Valley that has 135 living units. This complex, Saucon Village Apartments, provides units generally on a yearly lease basis. For the 2004-2005 period beginning in September, the following are the monthly rents exclusive of utilities:

Efficiency apartment	$435
One-bedroom apartment	510
Small two-bedroom apartment	545
Two-bedroom apartment w/o AC	560
Two-bedroom apartment w/AC	575
Three-bedroom apartment	585

Other Fees

Application fee $ 50 (for graduate admission consideration)	
Non-degree application (engineering, education, business)	20
Late pre-registration (assigned to full-time graduate students who do not select their full class load during the designated period each term)	50
Late registration (for completing registration after announced day)	50
Late application for degree	25
Late payment (after announced date)	100
Returned check fine	20
Identification card (replacement)	10
Thesis, microfilming	35
Dissertation, microfilming	60

Supervision fee, College of Education (per 3 credits) Intern courses require a special supervision fee which varies from $100 to $250. Inquire at your department.

Financial Aid

Financial aid is ordinarily available only for regular, full-time graduate students. Teaching assistantships, research assistantships, graduate assistantships, fellowships, and scholarships are academic awards made by individual academic departments. Several graduate assistantships unrelated to a particular area of study can be obtained by applying to administrative offices. International students are also encouraged to apply for funding to outside sponsoring agencies and/or home governments. Finally, please note that all student loan programs, and the Federal Work-Study program, are administered by the Office of Financial Aid located at 218 W. Packer Avenue. (Please read the section, below, on loans and work-study.)

Academic Awards. Requests for fellowships, scholarships, research assistantships, teaching assistantships, and graduate assistantships to begin in the fall semester must be filed with academic departments no later than January 15. Generally, a special committee formed by department faculty selects the recipients of these awards based upon merit; students are not required to submit a financial statement.

In addition to their stipends, graduate students holding half-time teaching appointments generally receive tuition remission. Fellowship holders also receive a stipend and tuition award. Scholarship recipients are awarded tuition. Research assistants receive a stipend for research services, but their tuition is commonly paid directly by research projects.

Teaching Assistants and Graduate Assistants. Teaching assistant and graduate assistant (TA/GA) are technical terms used to describe specific types of Lehigh University graduate students. The duties of TAs and GAs are generally set by the departments or offices that appoint them, but certain conditions must be satisfied before a student can be classified as a teaching assistant or a graduate assistant. These include:

- Each TA/GA must be a regular full-time resident Lehigh graduate student, which normally requires registration for at least nine credit hours per semester.
- A TA/GA is a half-time position and each TA/GA provides services to Lehigh University of up to twenty hours per week. Quarter-time and eighth-time TA/GA appointments are possible for full-time resident graduate students, with stipends and tuition remission appropriately reduced.
- Each TA/GA must be paid a specific stipend, which is set for the academic year by the dean of the appropriate college after consultation with the Director of Budget.
- Qualified TAs/GAs receive tuition remission for at most ten credit hours in a regular semester. No TA/GA may register for more than ten credit hours. A student who is a TA/GA during the preceding academic year is entitled to at most three hours of thesis,

research, or dissertation registration (not course credit) in the following summer without payment of tuition.

- Each TA/GA is appointed by a process which begins with a formal letter of appointment issued by the appropriate department chairperson. The appointment letter specifies standard university conditions including stipend level, time of arrival, length of service, and the requirement of satisfactory academic progress and performance of duties. Each department chairperson submits written notification of TA/GA appointments to the appropriate college dean or vice president.

The graduate and research committee endorsed academic guidelines for new teaching assistants which exceed minimum admission requirements. Each TA should satisfy one of the following: have a G.P.A. of 3.0 or better in the undergraduate major field of study; have a G.P.A. of 3.5 in the senior year major field; rank in the 85th percentile or higher on the Graduate Record Exam or other standardized test; or have a G.P.A. of 3.5 in at least twelve hours of graduate work in the major field. Exceptions to these guidelines shall be made only with the approval of the appropriate dean.

In addition, each teaching assistant must make normal progress toward a graduate degree. The definition of normal progress may vary among departments, but the criteria for satisfactory progress are established by the department faculty and the graduate and research committee. Teaching assistants who fail to satisfy these criteria are ineligible for reappointment.

In addition to a minimum TOEFL score of 550 (213 CBT), Teaching Assistants whose native language is not English must have on record with the ESL Program a SPEAK score of 230+ (TSE 55+) in order to work with Lehigh undergraduates in academic settings (i.e., classrooms, recitations, labs, office hours, etc.).

Those whose SPEAK score is 200-225 may also be appointed as TAs, but they are required to attend ESL courses until their comprehensibility score is at least 230 or until they no longer have a TA position. A comprehensibility score of 195 or below eliminates an international graduate student from being appointed as a TA.

The SPEAK is given at announced times throughout the academic year. Contact the ESL Program (ext. 86099) for details and for information concerning ESL courses. The TSE is given by ETS several times each year throughout the world.

Tuition remission for qualified TAs/GAs is authorized by the appropriate dean or vice president as part of the registration process. Each college dean or appropriate vice president will be provided tuition remission accounts against which TA/GA remissions will be charged. The accounts will be budgeted at an amount equal to the nine hour TA/GA tuition rate times the approved number of TA/GA positions and will be included in the annual operating budget. The budgets shall not be exceeded. If additional TA/GA positions are desired on a temporary basis, the account executive must provide for the transfer of budget support to the remission account. These budgets are to be used exclusively for tuition remission for authorized TA/GA positions.

There are a limited number of summer TA/GA appointments. These TA/GA's employees must receive the same monthly stipend as academic year TAs/GAs and devote of up to twenty hours per week their GA/TA responsibilities. A summer TA/GA registers for a maximum of three credit hours in each summer session of appointment and receive tuition remission for that registration.

Other Graduate Assistantships. Graduate students may apply directly to administrative offices for graduate assistantships unrelated to their areas of study. The availability of these assistantships is based upon the needs of the individual departments. GAs are appointed regularly by the office of the vice provost for student affairs, the dean of students office, the university counseling service, and by career services.

Loans and Work-study Awards. Graduate students may apply for the federally funded Stafford and Perkins loans, Lehigh University Tuition Loans (UTL), and Federal Work-Study through the Office of Financial Aid located at 218 W. Packer Avenue. These funds are awarded on the basis of demonstrated need using the *Free Application for Federal Student Aid*. In addition, the University requires a university application (*Graduate Student Financial Aid Application)* and a copy of the most recent (2001) federal tax return and W-2. Applications for loans cannot be processed, and funds cannot be disbursed, until the FAFSA, and attending forms, are received and reviewed. Because Stafford loans are financed through commercial lenders, their availability is virtually assured if a student qualifies. There is, however, only limited availability of Federal Perkins loans, Work-Study, and University Tuition Loans.

Special Concerns Regarding the Processing of Federal Stafford Loans for Graduate Students. Eligibility for student loans is based on: (1) the number of credits to be taken, (2) the amount of financial aid received, and (3) the calculated financial need. Any change to the number of credits to be taken, or the amount of aid received may affect loan eligibility. To avoid problems with your loan application, it is important that you notify the Office of Financial Aid of any changes in your enrollment or in the amount of aid received. Unfortunately, students frequently change the number of rostered credit hours, or receive Graduate School aid, after their loan application has already been processed. When either of these things happen, a student's eligibility may change dramatically.

Literature on student loan programs is available through the Financial Aid office or the website (*www.Lehigh.edu*).

Degree Information

The following degrees are offered by the university: the master's degree, the doctor of philosophy, the doctor of education, and the doctor of arts.

Master's Degree

Candidates for the master's degree have six years in which to complete their programs. Students should confer with their advisers to be certain that specific department and program course requirements are met. The following requirements must be satisfied by master's candidates in all departments.

Program for the Master's Degree. A student's program must include: not less than 30 credit hours of graduate work; not less than 18 credits of 400-level coursework (research or thesis registration counts as part of the 400-level coursework requirement); not less than 18 credits of coursework in the major of which 15 credits must be at the 400 level. All coursework for the master's degree must be taken under at least two instructors and must be approved by Lehigh University. With the approval of the appropriate dean, a maximum of nine credits may be transferred to a Lehigh master's program of 30 credits. For a master's program of more than 30 credits, students should contact the associate dean of their college. A petition is submitted, with course descriptions and transcript, as well as departmental recommendation. Course grades of B or better are required.

A student must complete the form, "Program for Master's Degree," setting forth the courses proposed to satisfy the degree requirements. This form should be approved by the department and then submitted to the registrar as soon as possible after 15 credit hours toward the degree have been completed. Approval of the program by the registrar signifies that the student has formally been admitted to candidacy for the master's degree.

Thesis and Comprehensive Exam. Candidates may be required to submit a thesis or a report based on a research course of at least three credit hours, or to pass a comprehensive examination given by the major department. The department will specify which of these requirements apply and may require both. If required, the thesis or report shall not count for more than six credit hours, and thesis registration is limited to a maximum of six credit hours. University procedures must be followed if the thesis or research project involves human subjects. One unbound copy of the thesis, approved by the thesis adviser and the department chair, must be delivered to the registrar's office at least three weeks before the degree is conferred. A binding and microfilming fee must be paid to the bursar, and the bursar's receipt presented with the completed thesis. Guidelines stipulating the form of the thesis are available in the registrar's office.

A non-thesis option exists for certain programs in the Colleges. Students should check with their departments regarding that option.

Doctor of Philosophy

Time and Registration Requirements. A candidate for the doctor of philosophy degree ordinarily is expected to devote at least three academic years to graduate work. In no case is the degree awarded to someone who has spent less than two full academic years of graduate work. All post-baccalaureate work toward the doctorate must be completed within ten years. A student beginning doctoral coursework after an elapsed period of at least one semester after the master's degree has been conferred is granted seven years in which to complete the doctoral program.

Doctoral students whose graduate study is carried out entirely at Lehigh University must register for a minimum of 72 credits beyond the Bachelor's degree. However, resident students who during their entire doctoral program, including the semester of graduation, have paid full tuition continuously (normally a minimum of 9 credits per academic semester) will have satisfied the tuition requirements for the doctoral degree upon completion of all other requirements. Students who have earned a Master's degree at another university must register for a minimum of 48 credits. These requirements include registration for research or dissertation credits. Students participating in approved dual-degree doctoral programs involving external institutions may transfer up to 25% of their total required doctoral program research credits to Lehigh for work that was performed at the external partner institution. Approval of such programs is required by the dean of the relevant Lehigh college.

Full-time students working toward the doctorate normally register for a minimum of nine credits each semester. If the minimum degree registration requirement of 72 or 48 credits is attained prior to formal admission to doctoral candidacy, continued registration of at least three credits per semester is necessary. Full-time student status must be certified on the graduate registration form.

Students seeking to receive both a master's degree and a doctoral degree must complete a minimum of 72 graduate credits at Lehigh and must meet the requirements of both degrees.

After admission to doctoral candidacy, a student must maintain candidacy by registering at least two times each calendar year (in each academic semester or in one academic semester and one summer session). After completion of the minimum registration requirement plus any additional requirements of the student's department or program, registration is permitted for 'Maintenance of Candidacy.' The tuition charge is for one credit-hour. Full-time status again must be certified on the graduate registration form.

Residence. Each Ph.D. candidate must satisfy Lehigh's residence requirement. The residence requirement is intended to ensure that doctoral students spend a period of concentrated study and intellectual association with other scholars. Either two semesters of full-time graduate study or 18 credit hours of graduate study within a twelve-month period must be completed.

Individual departments may impose additional stipulations. Candidates should check with their advisers to be certain that they have satisfied their residence requirements.

Language Requirements. Language requirements for the Ph.D. are the option of and in the jurisdiction of the candidate's department. Since proficiency in a language is not a university requirement, each department decides which languages, if any, constitute part of the doctoral program.

Qualifiers. Many departments require students who wish to enroll in doctoral programs to pass qualifying examinations. Since these examinations vary among departments, students should ask their advisers or department chairpersons for more detailed information. If a qualifying examination is not used, students should find out how and when eligibility to pursue doctoral studies is determined.

Admission to Candidacy. With the help of an academic adviser, the student names the faculty members of the doctoral committee, a special committee formed to guide the student through the doctoral program. The committee is responsible for assisting the student in formulating a course of study, satisfying specific departmental requirements, submitting a suitable dissertation proposal, overseeing progress in research, and evaluating the completed dissertation. At least four faculty are appointed to the committee; one must be a member of an outside department. Committee membership must be approved by the university's graduate and research committee.

A doctoral student should apply for candidacy no later than one year after completion of the master's degree or its equivalent and after passing qualifying examinations if they are required by the major department. The prospective Ph.D. candidate must submit to the doctoral committee a written program proposal that includes a discussion of proposed dissertation research. Upon receiving approval of the proposal, the candidate submits the proposal, signed by the committee members, to the appropriate dean for action by the graduate and research committee. The dean will advise the student of the committee's decision.

If the dissertation research involves human subjects, university procedures must be followed.

General Examinations. Examinations composed and administered by the members of the student's doctoral committee are designed to test the candidate's proficiency in a particular field of study. These examinations, which may be both written and oral, should be passed at least seven months before the degree is to be conferred. If a student fails the general examination, a second examination will be scheduled not earlier than five months after the first. If the results of the second examination are unsatisfactory, no additional examination is scheduled.

Dissertation and Defense. The Ph.D. candidate is required to write a dissertation prepared under the direction of a Lehigh University professor. The dissertation must treat a topic related to the candidate's specialty in the major subject, show the results of original research, provide evidence of high scholarship, and make a significant contribution to knowledge in the field.

Upon approval of the advising professor and, if required by the department secondary readers, the final draft of the dissertation is submitted to the appropriate dean for inspection by the date posted in the academic calendar. Upon its return, the student should distribute copies of the draft to the members of the doctoral committee for review and for suggestions for revision. The candidate then schedules a dissertation defense before the doctoral committee, additional faculty members the department may add to the examining committee, and the general public. After the dissertation has been defended and revised accordingly, the student must submit the finished dissertation to the appropriate dean for review by the university's graduate and research committee no later than the date specified in the academic calendar for completion of all degree requirements. One unbound copy must be delivered to the dean's office. It must bear the original signatures of the special committee members. In addition, the candidate must pay a microfilming fee of $60 and present a bursar's receipt for the payment. Guidelines stipulating the standard form of the dissertation are available in the dean's office.

Doctor of Arts (D.A.)

The doctor of arts degree (D.A.) is offered to students preparing for careers in college teaching in the field of chemistry. The program requirements are similar to those for the Ph.D. with the following exceptions: (1) a broader distribution of graduate courses in the field, (2) a minor area of study for students interested in bidisciplinary preparation for two-year college teaching, (3) coursework and training in interpersonal awareness, (4) a supervised internship in college teaching, and (5) a research project appropriate to college teaching in the student's field of specialization.

Graduate Degrees in Business Administration and Economics

Candidates for admission to graduate study in the College of Business and Economics must provide the results obtained in either the Graduate Management Admissions Test (GMAT) for a degree in business administration, and the M.S. in Accounting and Information Analysis or the Graduate Record Examination general test (GRE) and the subject test in economics for degrees in economics. International students applying to the M.S. and Ph.D. Programs in Economics are required to take the TOEFL for admission to the program.

Master of Business Administration

The Lehigh MBA provides a rich, integrated learning experience for students. Business issues are viewed and taught from the perspective of the firm as a whole rather than along departmental lines. Lehigh's MBA curriculum is a fully integrated model which simulates a real world business environment in the classroom. The six core courses are interdisciplinary and taught by an eight-member faculty team.

In the capstone experience, students are assigned to teams based on years and types of work experience, disciplinary background and industry. These teams closely resemble interdisciplinary corporate teams where each person has a different and valuable set of knowledge, skills and experience. The teams perform a complete analysis of the assigned organization. Past projects have centered on Boeing, WalMart, merger of AOL and Time Warner, Citibank and Hershey Foods. The teams also compete in a simulation with teams from other MBA Programs.

Due to the compact and integrated core, students have increased flexibility to tailor the program to their individual needs. Students may select a concentration in finance, marketing, international business, entrepreneurship through the vSeries program, or supply chain management or pursue a broader experience by selecting courses from a variety of disciplines. Students may only have one concentration.

Effective oral and written communication skills and leadership ability have become increasingly important keys to success in business. Using case studies, group projects and a team approach to learning, Lehigh's curriculum helps students experience the dynamics of group behavior within organizations and the methods used to motivate workers and resolve conflicts.

Certificates

Students may also earn a certificate in entrepreneurship, project management, organizational leadership or supply chain management by completing 12 credit hours of coursework as defined in the certificate program.

MBA Mission Statement. To develop the knowledge, skills and abilities of managers through a comprehensive and integrated core curriculum with customized concentrated learning designed to meet the individual needs of students.

Innovative Structure. The MBA Program requires 36 credit hours. Full-time students can fulfill that requirement in 12 to 15 months. Most part-time students require three years. Students may select a concentration in finance, marketing, international business, information systems management, entrepreneurship through the vSeries program, supply chain management, or management of technology or pursue a broader experience by selecting courses in a variety of disciplines.

Prerequisites. Students should have completed undergraduate courses in computer literacy, principles of microeconomics and macroeconomics, financial accounting and statistics before entering the MBA program.

The statistics prerequisite may be fulfilled by having taken a class within the past 5 years and receiving a "B" or better, or by taking a proficiency exam. The Accounting prerequisite may be waived by taking GBUS 401, Financial Accounting for Managers and Investors at Lehigh or by taking a proficiency exam.

If a student has no previous background in financial accounting or statistics, he/she is encouraged to take a course in the subject area. If a student has previously taken coursework but has not achieved a grade of "B" or the course has exceeded the time limit, self-directed learning and a proficiency exam may be appropriate.

The prerequisites of financial accounting and statistics must be completed before enrolling in MBA 402 or MBA 403.

Core Courses

MBA 401	Introduction to the Organization and Its Environment (2)
MBA 402	Managing Financial and Physical Resources (4) Prerequisite: Financial Accounting
MBA 403	Managing Information (4) Prerequisites: Financial Accounting and Statistics
MBA 404	Managing Products and Services (4)
MBA 405	Managing People (4)
MBA 406	Integrative Experience (3)

Electives. Students will take 15 credits of electives. Students may design a concentration to best suit their career goals. Nine credit hours of approved electives are required for a concentration in information systems management, marketing, international business, and supply chain management. Concentrations in finance, and entrepreneurship require twelve credit hours of approved electives.

To increase flexibility, students may also take up to six credit hours of electives outside of the College of Business and Economics (but within Lehigh University). All elective courses must be at the 400 level.

Waiver Policy. There are no waivers for courses in the MBA Program.

GMAT Scores. All applicants are required to take the Graduate Management Admissions Test (GMAT) administered by the Educational Testing Service (ETS). The computer-based exam is given during several weeks each month. To make an appointment to take the GMAT exam call 1-800-GMAT NOW or by registering online at www.gmac.com. GMAT applications can be obtained by writing to the Educational Testing Service, P.O. Box 6103, Princeton, NJ 08541-6103.

Students taking the GMAT in the United States, must submit the application and fee to ETS at least four weeks before the testing date. If taking the test elsewhere, submit the materials at least six weeks in advance. After the test, the results will be sent to the student and to the institutions designated within four weeks.

Work Experience. Students are required to have 2 years of full-time, professional work experience.

International Students/TOEFL. International students must have 16 years of formal education, *including four years at the university level*, to be considered for admission to Lehigh's graduate programs. Applicants whose native language is not English are required to take the Test of English as a Foreign Language (TOEFL). For information, write or call the TOEFL Registration Office, P.O. Box 6154, Princeton, N.J., 08541-6154 or at *www.toefl.com*.

Flexible Class Scheduling. Most classes are scheduled Monday through Thursday in late afternoons and evenings. Seminars are offered on Fridays and Saturdays. Part-time students may complete the entire program during evenings. Many students accelerate completion of the program by taking courses during the two six-week summer sessions.

Two-day seminars provide the opportunity to explore a single topic in depth. Business ethics, virtual communities and e-commerce, anatomy of entrepreneurship, intellectual property, performing a business audit and new venture organization are examples of some seminars. Each seminar counts as one credit of elective work.

Student Profile. MBA students average seven years of professional work experience. Approximately sixty percent of the students have undergraduate degrees in engineering or science and over thirty percent have undergraduate degrees in business. The combination of work experience and diversity of background brings valuable professional perspectives to classroom discussions.

The average GPA for undergraduate work is 3.2 and over 20% of the students have graduate degrees in disciplines outside of business. The average GMAT score for students who entered the Program in Fall 2003 was 610 and average TOEFL scores exceeded 250 for international students.

There are approximately 300 part-time students and 50 full-time students currently in the MBA Program. Almost 100 of the part-time students take some or all classes by distance learning through satellite broadcast or on the internet.

An MBA Program brochure and application for admission may be obtained by contacting Mary Theresa Taglang, Director of Recruitment and Admissions - MBA Program, Lehigh University, College of Business and Economics, 621 Taylor Street, Bethlehem, PA 18015. Prospective students may call (610) 758-5280 or send e-mail to *incbe@lehigh.edu* for additional information.

Further information can be obtained from:

Office of Graduate Studies
P.C. Rossin College of Engineering & Applied Science
610-758-6310
www.lehigh.edu/engineering
or
The Graduate Programs Office
College of Business & Economics
610-758-5280
www.lehigh.edu/MBA

Certificate Programs

Certificate in Corporate Entrepreneurship

Businesses often nurture the entrepreneurial spirit by forming New Ventures groups within their organizations. The members of these groups require a special blend of education to develop the skills of discovery, innovation and leadership that starting a new enterprise requires. This certificate program prepares students to successfully evaluate business opportunities within a corporate environment. A complete series of courses prepares them for all facets of entrepreneurship including venture capital, financial forecasting, target markets, intellectual property, performing a business audit and building a business plan.

Requirements

The certificate requires 12 credit hours of coursework with six credit hours of required coursework and six credit hours of electives.

Required Courses

Anatomy of Entrepreneurship: Start-Ups and Established Companies (1 cr.)

Market Opportunity: Targeting Strategies and Selling Tactics (1 cr.)

Performing a Business Enterprise Audit: Developing an Industry Perspective (1 cr.)

The New Venture Organization: Management Design and Governance (1 cr.)

Financial Forecasting: Developing Pro Forma Financial Statements (1 cr.)

Financing Start-Ups: Seeking Outside Venture Capital (1 cr.)

Elective Courses:

Business Plan I: Strategic Considerations (2 cr.)

Business Plan II: Operating Strategies and Implementation (2 cr.)

Intellectual Property: Management and Valuation (1 cr.)

Processes and Infrastructure: Creating Production and Delivery (1 cr.)

Establishing Credit Facilities: Asset-Based and Cash Flow Forecasting (1 cr.)

Developing Exit Strategies: Concepts and Approaches (1 cr.)

Integrative Experience/New Venture Internship (1-4 cr.)

Admission Requirements:

Students admitted to the certificate program will enter as non-degree students. Applicants are required to have a 3.0 undergraduate GPA from an accredited College or University and at least 2 years of full-time professional work experience.

Certificate in Supply Chain Management

Increasingly sophisticated information technology applications and the shift toward global economic activity have shaped a competitive environment that rewards creating value for customers while reducing cost and cycle time. Through in depth study of the organizations' value chain -logistics, operations, marketing, sales and service- the certificate in supply chain management demonstrates how these activities are linked both internally and externally. Internal linkages are explored in terms of the organizational structure and information systems and integrated with enterprise-wide procurement, managerial accounting and cash flow management activities. External linkages, increasingly through e-commerce with customers and suppliers, are shown in terms of market transactions and collaborative relationships. The certificate requires 12 credit hours of coursework

Required Courses

GBUS 450	Strategic Supply Management (3)
GBUS 453	Transportation and Logistics Management (3)
GBUS 464	Business to Business Marketing (3)

Elective Courses

GBUS 447	Negotiations (3)
GBUS 459	Survey of Project Management (3)

Or choose from the following seminars:

- Price Productivity Improvement (1)
- Cost and Performance Management (2)
- Activity Based Costing (ABC) & Activity Based Management (ABM) (1)
- Integrating Suppliers and Customers Into Key Supply Chain Processes (1)
- Legal Aspects of Managing People, Products & Services (1)

Admission Requirements:

Students admitted to the certificate program will enter as non-degree students. Applicants are required to have a 3.0 undergraduate GPA from an accredited College or University and at least 2 years of full-time professional work experience.

Certificate in Project Management

A successful project is one that has been completed on time, remained at or under budget, met or exceeded its goals and satisfied the client/key stakeholders. Regardless of the size of the project or the organization, the planning and coordination of a successful project requires a specific set of skills in managing time, money, people, and materials. Good project managers are highly desirable and sought-after, particularly as intense global competition increasingly demands that projects be completed on time and within budget.

This 12 credit hour certificate will prepare students to take the Project Management Professional certification exam offered by the Project Management Institute (PMI) – the field's leading global professional association. The certificate is cohort based and is completed within 12 months through both on-line and on-campus modules.

Required Courses (12 credits):

PMGT 401	Course Framework & Project Leader Assessment (1)
PMGT 402	Skills and Abilities for Effective Leadership of Teams (1)
PMGT 403	Initiating the Project and Planning Scope and Schedule (2)
PMGT 404	Planning Resources, Communication, Quality and Risk Management (2)
PMGT 405	Project Leader Communications Expertise and Evaluating Team Performance (1)
PMGT 406	Implementing and Managing Projects (2)

PMGT 407	Controlling Performance and Assessing Outcomes (2)
PMGT 408	Problem Solving, Decision Making and Ethics (1)

Admissions:

Students may enter the Project Management Certificate program either through the College of Business & Economics or through the College of Education. Applicants must have a four year degree from an accredited college or university. Graduate students at Lehigh University may apply for the program without meeting additional requirements.

Certificate in Organizational Leadership

The 12 credit hour Certificate in Organizational Leadership is designed to develop the leadership knowledge, skills and abilities for working professionals to enable them to make better decisions, communicate more effectively, understand and strengthen their personal leadership style, lead their areas in times of crisis and change and enhance their negotiation skills.

Required Courses (6 credits)

GBUS 447	Negotiations (3)
GBUS 459	Survey of Project Management (3)

Elective Seminars (6 credits required)

Crisis Management and Communication (1)
Effective Team Leadership (1)
Ethical Decision Making (1)
Leadership Styles and Assessment (1)
Translating Vision into Strategy (1)
Cross Cultural Communication (1)
Change Management (1)
Leadership Skills Assessment and Development (1)

Admission Requirements:

Students admitted to the certificate program will enter as non-degree students. Applicants are required to have a 3.0 undergraduate GPA from an accredited College or University and at least 2 years of full-time professional work experience.

Master of Science in Accounting and Information Analysis

The Lehigh Master of Science in Accounting and Information Analysis degree program offers an outstanding opportunity to prepare for a career in today's demanding field of accounting. Accounting professionals are engaged in a variety of services, including assurance services, business valuation, information resources, and consulting. Lehigh's unique program recognizes the impact of technology on business processes and the value chain while paying respect to the time honored usefulness of accounting information.

The focus of the program is *business solutions*. Students learn how to use both information and technology to improve business processes and forge business solutions. Focal points include understanding the business framework, exposure to business subjects in complementary areas, advanced communications skills, strategic use of technology, specialized accounting knowledge, consulting skills, advanced technical information systems skills, leadership, and globalization.

Designed to meet the accreditation requirements of AACSB, the Lehigh Master of Science in Accounting and Information Analysis program also satisfies the 150-hour CPA educational requirement adopted by almost all states. The program serves as an excellent foundation for professional certification, including the CPA and CMA exams and, very importantly, provides the broad business education employers value so highly.

The Master of Science in Accounting and Information Analysis curriculum is designed to be flexible so that students may choose either a general degree or one with a specialization. The concentrations include Consulting and Business Risk Management, Financial Services, and Strategic Cost Management.

With the help of the Program Director and Lehigh Career Services, students are encouraged to obtain an internship during the summer prior to beginning the program. The internship will complement the chosen concentration and provide an excellent practical framework to enrich the academic coursework experience.

Non-Accounting Majors. High value is placed on employees who bring a broad background to their position. Recognizing this fact, the M.S. in Accounting and Information Analysis program accommodates those students who bring an undergraduate business degree to the program. A Link Program, available in the summer prior to beginning the master's degree, provides the requisite background. The courses in the Link Program include topics typically found in intermediate accounting, cost accounting, and other related accounting courses.

Mission Statement. Pursuit of excellence is the hallmark of Lehigh University's Accounting Department. The programs offered by the Department seek to instill in students such qualities as technical knowledge, business acumen, work as a virtue and vehicle for service, and the ability to approach all challenges with confidence and self-discipline. Additionally, the Accounting Department's balance of scholarly, professional and student development initiatives enhances students' command of critical career success factors, including critical thinking, effective communication and interpersonal skills.

Innovative Approach. A two semester, full-time 30 hour program, the Lehigh M.S. in Accounting and Information Analysis program provides the knowledge and skills required in a professional accounting career. With emphasis on business solutions, students learn how to use both information and technology to improve business processes.

Prerequisites. Students should have completed an undergraduate degree program in business with a major in accounting. For those business students without the accounting background, a Link Program is available in the summer prior to beginning the M.S. program.

Core Program. Six required courses of the core program accommodate students entering the assurance practice of public accounting firms, as well as those desiring to customize their program of study.

MACC 401	Professional Issues in Accounting (3)
MACC 412	Advanced Information Systems and IS Auditing (3)
MACC 413	Corporate Financial Reporting: Research, Theory and Practice (3)
MACC 420	Business Consulting: Process and Practice (3)

MACC 424	Information Quality Assurance and Business Risk (3)
MACC 427	Information Analysis for Management and Business Solutions (3)

Electives. Twelve elective credits (four courses) are required to complete the degree. Elective courses are available in the following disciplines: Accounting, Business Law, Economics, Finance, Industrial Engineering, Management, Marketing, Information Systems, and International Business.

Concentrations. Concentrations allow students to pursue one of three specialties: Consulting and Business Risk Management, Financial Services, and Strategic Cost Management.

Concentration in Consulting and Business Risk Management. Rapid technological innovation, emergence of virtual organizations, increasing global competition and higher customer expectations can lead to unexpected challenges and opportunities. The *Consulting and Business Risk Management* concentration is ideal for those students who are interested in pursuing a career with management consulting organizations, corporations with business risk management and corporate audit departments, and the consulting and assurance practices of national and regional public accounting firms. Students interested in developing their own consulting practice also benefit from this concentration.

Core courses	18 credits
Total Quality Management	3
Electives (3)	9
Total:	30 credits

Concentration in Financial Services. Financial Services is a broad field that includes investment banking, securities, corporate finance and financial institutions such as banks and insurance companies. What is common to all of these areas is a shortage in the number of professionals who have an in-depth knowledge of accounting. Consequently, the opportunities for the graduate who has both financial and accounting skills are abundant. This concentration is ideal for students with a background in either finance or accounting.

Core Courses	18 credits
Financial Statement Analysis & Interpretation	3
Investments & Portfolio Management	3
Advanced Topics in Financial Management OR Financial Markets and Institutions	3
Elective (1)	3
Total:	30 credits

Concentration in Strategic Cost Management. Industry accountants spend the majority of their time within their companies as internal consultants or business analysts. The Strategic Cost Management concentration is ideal for those students seeking a career with industrial and manufacturing firms in the areas of strategic and advanced cost management. This concentration is also designed for students pursuing a career in consulting.

Core Courses	18 credits
Advanced Cost Management	3
Strategic Supply Management	3
Electives (2)	6
Total:	30 credits

Waiver Policy. There are no waivers for courses in the M.S. in Accounting and Information Analysis Program.

GMAT Scores. All applicants are required to take the Graduate Management Admissions Test (GMAT) administered by the Educational Testing Service (ETS). Undergraduate students should take the exam in the junior year. The computer-based exam is given during several weeks each month. To make an appointment to take the GMAT exam call 1-800-GMAT-NOW or by registering online *@www.gmac.com*. GMAT applications can be obtained by writing to the Educational Testing Service, P. O. Box 6103, Princeton, NJ 08541-6103.

Students taking the GMAT in the United States must submit the application and fee to ETS at least four weeks before the testing date. If taking the test elsewhere, submit the materials at least six weeks in advance. After the test, the results will be sent to the student and to the institutions designated within four weeks.

Internships. The work experience gained from internships provides a practical framework and enhances understanding of the course material. All students are encouraged to take one or more internships prior to beginning the program. Students should meet with the Program Director prior to the summer preceding the Fall semester start of the program to arrange an internship. The internship will be taken during the summer prior to the start of the program and will complement the student's concentration, if any.

International Students/TOEFL. International students must have 16 years of formal education, *including four years at the university level*, to be considered for admission to Lehigh's graduate programs. Applicants whose native language is not English are required to take the Test of English as a Foreign Language (TOEFL). For information, contact the TOEFL Registration Office, P. O. Box 6154, Princeton, NJ 08541-6154 or at *www.toefl.org*.

Flexible Class Scheduling. Classes are scheduled Monday through Thursday during the day and evenings.

An M.S. in Accounting and Information Analysis Program brochure and application for admission may be obtained by contacting Dr. Jack W. Paul, Director–M.S. in Accounting and Information Analysis Program, Lehigh University, College of Business and Economics, 621 Taylor Street, Bethlehem, PA 18015. Prospective students may call (610) 758-5824 or send e-mail to incbe@lehigh.edu for additional information.

Master of Science in Health and Bio-Pharmaceutical Economics

The M.S. in Health and BioPharmaceutical Economics is designed for students with undergraduate life science degrees. The government, health insurers, health care providers, biotechnology firms and pharmaceutical manufacturers have become increasingly interested in the cost effectiveness of new drugs and therapies. This course of study will develop the quantitative and analytical skills that, in combination with their science training, will prepare them to carry out sophisticated studies of the benefits and costs associated with new drugs, medical therapies and diagnostic procedures and to perform critical analyses in support of strategic marketing decisions and the management of risk and uncertainty in portfolios of R&D projects.

Prerequisites

Applicants should have completed at least two calculus courses, a course in statistics, and courses in both principles and intermediate economics. Applicants lacking one or more of these background courses may still be admitted to the program but courses taken to remedy background deficiencies will not count toward minimum credit hours for the master's degree.

Required Courses (21 credits)

ECO 402	Managerial Economics (3)
ECO 412	Mathematical Economics (3)
ECO 415	Econometrics (3)
ECO 425	BioPharmaceutical Economics (3)
ECO 447	Economic analysis of Market Competition (3)
ECO 455	Health Economics (3)
ECO 457	Cost-Benefit Analysis

In addition, students must take 9 credit hours of elective courses, selected in consultation with and approved by the MS advisor. A thesis is not required.

Admission

Prospective students must have an undergraduate degree with a major in the life sciences or a related field (such as chemistry, pre-med, chemical or bio-engineering, etc.). Applicants must submit scores from either GRE and GMAT. International students must also take the TOEFL exam. Applications for regular student status are due by July 15. Associate students may be admitted up if a completed application is received prior to two weeks before the start of classes.

Master of Science in Economics

The Master of Science program in Economics is available for students wishing to pursue graduate study in the areas of economics or economics and business. The program offers considerable flexibility with respect to the selection of courses as well as the ability to concentrate in a particular area of study. Students may pursue the degree on either a full-time or part-time basis. Recent graduates of the M.S. program have accepted employment with such firms as AT&T, Pennsylvania Power and Light, and with the Federal Reserve System. Other students have pursued the master's degree as a stepping stone to the Ph.D. degree.

A minimum of 30 semester hours of course work is required.

As part of the 30 hours, the following courses must be taken:

ECO 402	Managerial Economics	(3)
ECO 412	Mathematical Economics	(3)
ECO 415	Econometrics I	(3)
ECO 417	Advanced Macroeconomic Analysis	(3)
ECO 447	Economic Analysis of Market Competition	(3)

Each student in the M.S. program is also encouraged to concentrate in one field of specialization within economics. (A listing of the fields currently offered is available through the M.S. director.) Students may also elect to write an M.S. thesis. The thesis is worth six hours of credit toward the degree and is particularly encouraged for those who may be considering the Ph.D. program.

Further information about the program may be obtained by contacting the Graduate Programs Office of the College of Business and Economics, 610-758-5280 or Dr. Robert J. Thornton, Director of the M.S. in Economics Program.

Doctor of Philosophy

The Ph.D. degree in business and economics is designed to provide advanced knowledge and the capacity to carry on independent research in various areas of business and economics. Holders of the Ph.D. are normally employed in academic positions in departments of economics or in schools of business administration, or in policy analysis and research positions in banks, business, government, and research organizations. Employment opportunities are excellent for graduates with this degree.

The Ph.D. program requires a minimum of 48 semester hours of study (including dissertation) beyond the master's degree or 72 hours of study beyond the bachelor's degree. Each student is expected to choose three major fields of specialized study. Economic theory must be included as one of the major fields. Each student must take the eight core courses in micro-economics, macroeconomics, econometrics, mathematical economics, and economic history. Students must also take written and oral comprehensive examinations in their major fields. The chairperson of the doctoral committee will help to arrange a plan of study suitable for each student's program and to prepare the student to pass the examinations.

Major fields of specialization normally available include economic theory, international economics, labor economics, managerial economics, money and banking, and public finance.

Under the guidance of a dissertation chairperson and committee formed after passing of the examinations, the candidate undertakes research culminating in an acceptable dissertation. The Ph.D. is awarded upon the successful completion of the doctoral dissertation and its oral defense.

For additional information or an application packet, please contact Dr. James Dearden, Adviser, Ph.D. Program, College of Business and Economics, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015 or call (610) 758-5280.

Graduate Degrees in Education

Lehigh's College of Education offers only graduate degree programs. Students enrolled in the College of Education should check with their advisers for a list of regulations and requirements governing degree programs.

Financial assistance. Graduate assistantships and research assistantships are available in the college and in various administrative offices on campus. In addition, graduate students may be recommended for a limited number of fellowships and endowed scholarships, which are awarded by the college.

Lehigh's Centennial School, a laboratory school for children with emotional/behavior disorders, provides employment for some Lehigh education students. Graduate students may apply for teaching internships, which pay tuition plus salaries.

Master of Education (M.Ed.)

This degree is offered in the following professional specializations: elementary education, secondary education, special education, educational leadership, counseling and human services, global educational leadership, and elementary and secondary school counseling. Degree requirements vary from program to program.

Master of Arts (M.A.)

The master of arts degree offered in the field of secondary education provides a major in education with an academic specialty. The student must take 18 credits of graduate work in education plus 12 credits of graduate work in an academic field. The academic fields that cooperate with the College of Education in offering this program include: modern languages and literature, English, mathematics, political science, sociology, and physical and natural sciences.

Master of Science (M.S.)

The master of science degree is awarded in instructional design and development and is aimed at students who are actively seeking to become designers or developers of technology-based teaching/learning materials and will work to make the transition in competence from "student" to "professional" as quickly as possible. Students pursuing this masters will be expected to work on projects throughout their program and will work outside class settings to maintain and enhance their skills.

Master in Business Administration/Master of Education (MBA/M.ED.)

The MBA and Master's of Education joint degree program offers students the opportunity to acquire a solid foundation in both business and education. Designed to increase the administrative skill required in today's educational systems, the MBA/M.Ed. provides a framework where excellent education and sound business practices can flourish. The MBA/M.Ed. will provide an additional option for students for business and students of educational leadership. The program will enhance the student's marketability in private and public sector education while providing students with an understanding of the cultures of both business and education.

Educational Specialist (Ed.S.)

Specialized post-master's degree programs for practitioners are available in school psychology.

Certification Programs and Post-baccalaureate Certificates

The college offers state certifications in various professional specialties and also offers post-baccalaureate certificate programs in Counseling in the Global School Community, Adapting Instruction for the Diverse Learner, English as a Second Language, and Global Leadership. These programs are 12 credits, focused concentrations taken by students enrolled in the international education program. In a joint program with the College of Business and Economics, students can complete a post-baccalaureate certificate in Project Management.

Doctor of Education (Ed.D.)

The doctor of education degree program provides specialized study in educational leadership and educational technology. Successful professional experience is required for admission to candidacy for this degree in most programs. The requirements for the Ed.D. degree parallel those already stated for the Ph.D. degree with the following exceptions: language examinations are not required. The residence requirement for the Ed.D. is the same as that for the Ph.D.

Doctor of Philosophy (Ph.D.)

The College of Education also offers the Ph.D. degree to students enrolled in the fields of school psychology, special education, and counseling psychology. The requirements for this degree are the same as those for the Ph.D. in the other colleges and as described in previous sections.

Graduate Studies Organizations

The Graduate and Research Committee

The graduate and research committee consists of twelve members representing the faculties of Lehigh's colleges: four from the College of Arts and Sciences; two from the College of Business and Economics; four from the P.C. Rossin College of Engineering and Applied Science; and two from the College of Education; plus the college deans, the registrar, the vice provost for research, the director of the office of research, two non-voting graduate student members, and a member of the student senate.

The committee formulates policies and regulations on graduate education, and it recommends policies and procedures for research-related activities. The committee interprets and applies faculty rules governing graduate students and degrees, including questions concerning student petitions and appeals.

Graduate Student Council

The graduate student council, comprised of one graduate student from each academic department, represents the graduate student community regarding graduate programs and graduate student life at Lehigh. It provides a forum for discussion with university officials and committees. Graduate students selected by the graduate student council are non-voting members of the graduate and research committee and the educational policy committee.

Besides functioning as a forum for discussion, the graduate student council maintains a graduate student center. The council plans social events and disseminates information in order to facilitate communication among graduate students.

Interdisciplinary Graduate Study and Research

In addition to offering graduate degrees within academic departments, Lehigh University offers interdisciplinary graduate degrees in the fields of American Studies, clinical chemistry, manufacturing systems engineering, pharmaceutical chemistry, photonics, polymer science and engineering, business administration and engineering, and business administration and educational leadership, and analytical finance.

Lehigh University also offers graduate certificate programs in certain specialized fields of study. Graduate certificates consist of a minimum of twelve credits, six of which must be at the 400-level. Students are admitted to certificate programs in the same way as to degree programs. More specific information on admission criteria and completion requirements are available from certificate program administrators.

In addition, Lehigh's interdisciplinary research centers and institutes address the research needs of government, industry, and society. Organized to recognize research efforts in interdisciplinary problem areas, they supplement the university's academic departments. Graduate students pursuing M.S. and Ph.D. degrees in academic departments as well as students enrolled in interdisciplinary degree programs may pursue research opportunities in the various centers.

A complete listing of research centers, institutes, and other research organizations appears following the section on interdisciplinary graduate programs.

Financial Assistance. Teaching assistantships and fellowships are provided by individual academic departments, while research assistantships are available through both academic departments and research centers. Students interested in research are encouraged to seek appointments with members of the faculty working in their areas of special interest, with department chairpersons, or with center or institute directors.

Graduate Certificates in Arts and Sciences

Certificate in Cognitive Science

(For details see "Cognitive Science" in Section V)

Certificate in Stereotypes, Prejudice, Discrimination, and Intergroup Relation

(For details see "Psychology" in Section V)

Interdisciplinary Graduate Programs

Several interdisciplinary programs are offered to the Lehigh graduate student.

American Studies

A Master of Arts degree in American Studies is offered jointly by English, History, and other departments in the humanities and social sciences. Candidates for the master's degree must complete at least 30 credit hours. In addition to the Theory and Method course, students must choose two courses in American history and two courses in American literature and film from those offered by the history department and the English department. Students must also take one special topics seminar. The other four courses for the master's degree will be divided between thesis or "thesis paper" credits and American Studies courses not in history or literature/film. To fulfill the thesis requirement, students will write one longer thesis or two thesis papers that are aimed at conference presentation and/or publication.

Clinical Chemistry

The M.S. program in clinical chemistry is offered by the Department of Chemistry in cooperation with local hospitals. It is directed toward training clinical laboratory scientists to be active in hospital-based and industrial laboratories in both patient sample service and new product development. The program requires fulfillment of a clinical laboratory practicum as well as a research project at the M.S. level. The core requirements for the degree are:

CHM 371	Elements of Biochemistry I (3)
CHM 372	Elements of Biochemistry II (3)
CHM 332	Analytical Chemistry (3)
CHM 336	Clinical Chemistry (3)
CHM 358	Advanced Organic Chemistry (3)
CHM 437	Pathophysiological Chemistry (3)
CHM 421	Chemistry Research (1-4)
	Clinical Laboratory Practicum

Electives or courses that may be substituted, upon an approved petition, for core requirements in clinical chemistry can be drawn from those listed in the Ph.D. programs in molecular biology or pharmaceutical chemistry (see below).

Students may be admitted into this program from undergraduate majors in chemistry, biology, medical technology, or other areas of the biochemical life sciences. One semester of undergraduate physical chemistry is required for the M.S. in clinical chemistry although in some cases this course may be taken while enrolled as a graduate student but for no graduate credit. Graduates of the program are encouraged to continue their education toward the doctorate in any one of the several biological chemistry programs offered at Lehigh.

Master of Business Administration and Engineering

In today's business environment expertise is required over a broad spectrum of skills in order to maximize performance. To meet this challenge, Lehigh has developed an interdisciplinary graduate program that provides a solid foundation in both business and engineering. The joint Master of Business Administration and Engineering (MBA&E) degree has been developed through the cooperative efforts of the P.C. Rossin College of Engineering & Applied Science and the College of Business & Economics. This program is part of Lehigh's commitment to developing the industrial leaders needed to enhance our competitiveness in the new global marketplace, and is aimed at students with an engineering or science background.

The basic 45 credit hour course sequence consists of:

MBA core courses	18 credits
Engineering core courses	12 credits
Business electives	5 credits
Engineering electives	6 credits
Free electives	3 credits
Integrated project	1 credit

Students can choose an appropriate engineering curriculum from any of the following programs – chemical engineering, civil engineering, computer engineering, electrical engineering, industrial and systems engineering, manufacturing systems engineering, materials science and engineering, mechanical engineering and mechanics.

MBA Core Courses

MBA 401	Introduction to the Organization and Its Environment (2)
MBA 402	Managing Financial and Physical Resources (4)
MBA 403	Managing Information (4)
MBA 404	Managing Products and Services (4)
MBA 405	Managing People (4)

Engineering Core Courses

Each engineering program has its own set of core courses. Course choices are intended to be as flexible as possible, and are tailored to meet the needs of individual students. Further information can be obtained from the appropriate departmental graduate coordinator, or from the Office of Graduate Studies (610-758-6310) in the P.C. Rossin College of Engineering and Applied Science.

Electives. Engineering electives are chosen from courses in the appropriate RCEAS engineering program, and the business electives are selected from course offerings in

CBE. Electives can also be chosen from joint courses that are being developed by RCEAS & CBE.

Project. A short interdisciplinary project is required of all students. Project topics, based on the specific interests of each student, will be developed by CBE and RCEAS faculty.

Admissions. Applications must be accepted by the MBA program and by the relevant department in the P.C. Rossin College of Engineering and Applied Science. When required by the engineering program, students must take the GRE. If this is not required, then the GMAT examination must be taken. Students will not be required to take both tests.

Further information can be obtained from:

Office of Graduate Studies
P.C. Rossin College of Engineering & Applied Science
610-758-6310
www.lehigh.edu/engineering
or
The Graduate Programs Office
College of Business & Economics
610-758-5280
www.lehigh.edu/mba

Master of Business Administration and Educational Leadership

The MBA & Master of Education joint degree program offers students the opportunity to acquire a solid foundation in both business and education. Designed to develop the administrative skills required in today's educational systems, the MBA/M.Ed. provides a framework where excellent education and sound business practices can flourish. The MBA/M.Ed. will provide an additional option for business students in educational leadership. The program will enhance the students' marketability in private and public sector education while providing students with an understanding of the cultures of both business and education. Core courses from both colleges will ensure that recipients of the joint degree will bring to their future positions an extraordinary medley of skills to manage human and financial resources efficiently while employing expertise in instructional supervision and training in both education and corporate settings. This program of study will enhance training and skills for those currently in the area of business and financial management in the field of education.

The Lehigh MBA/Ed. Leadership is a 45-credit joint degree program. Students earning an MBA/Ed. Leadership will be prepared for positions such as: School Superintendent, Principal, and School District Administration

Educational Leadership Core Courses

Introduction to Organizational Leadership	3
Supervision of Instruction	3
Human Resources Management	3
School Financial Management	3
School Law	3
Practicum in School Business Management	1
Research	3
Multicultural Issues	3
Electives	3

MBA Core Courses

Introduction to the Organization & Its Environment	2
Managing Financial & Physical Resources	4
Managing Information	4
Managing Products & Services	4
Practicum: Integrative Experience	1
MBA Electives	5

Electives. Educational electives are chosen from courses in the College of Education and the business electives are selected from course offerings in the College of Business and Economics.

Admission Requirements. Applications need to be approved through both the MBA Program and the Educational Leadership program. Students are required to take the GMAT. Students must have at least 2 years of professional post graduate work experience to apply for this joint degree program.

Further information about the program may be obtained by contacting C. Russell Mayo, Assistant Professor, College of Education, 610-758-3392 or crm4@lehigh.edu.

Analytical Finance

This program provides students with a strong education in advanced finance and quantitative financial analysis tools to develop graduates who can create innovative solutions for real financial problems, using state of the art analytical techniques and computing technology. Students with undergraduate degrees in computer science, economics, engineering, finance, mathematics and the hard sciences should have the quantitative background needed for success in this field.

Prerequisites

Applicants must show basic competency in the following areas: finance, corporate finance, investments, financial accounting, economics, money and banking, statistics and calculus. These courses will not count toward the masters degree.

Required Courses

The 33 credit hour program is a joint venture of the College of Business and Economics, the P.C. Rossin College of Engineering and Applied Science and the Department of Mathematics. Required courses are as follows:

GBUS 422	Derivatives and Risk Management (3) Summer
MATH 467	Financial Calculus I (3) Fall
GBUS 473	International Finance (3) Fall
IE 316	Optimization Models and Applications (3) Fall
ECO 415	Econometrics (3) Fall
IE 4YY	Financial Engineering Projects (3) Fall/Spring
MATH 468	Financial Calculus II (3) Spring
GBUS 421	Advanced Investments (3) Spring
IE 447	Stochastic Programming and Portfolio Analysis (3) Spring
ECO 424	Advanced Numerical Methods (3) Spring
STAT 410	Probability and Its Applications (3) Spring

Admissions. Students will apply through the Industrial and Systems Engineering Department in the P.C. Rossin College of Engineering and Applied Science or College of Business & Economics. Students must take the GRE or GMAT . International students must have 16 years of schooling *with four years at the University level* to be considered for admission. Applicants whose native language is not English, are required to take the Test of English as a Foreign Language (TOEFL). Since the first course, GBUS 422 – Derivatives and Risk Management, is offered during the first summer session, students are encouraged to apply to the program by May 1.

Manufacturing Systems Engineering

Lehigh's award-winning graduate program leading to the master of science degree in manufacturing systems engineering (MSE) is sponsored by all the departments in the P.C. Rossin College of Engineering and Applied Science and is administered by the Center for Manufacturing Systems Engineering. In addition, the College of Business and Economics participates in teaching accounting, business, finance, management, and marketing aspects affecting manufacturing systems.

This graduate curriculum aims to develop engineers who can design, develop, install, operate and modify manufacturing systems involving materials, processes, equipment, facilities, logistics, and people using leading edge technologies. A systems perspective is integrated by means of interdisciplinary course offerings.

Distance Education

It is possible for distance students to earn the MS in MSE degree remotely.

Major Requirements

The degree requires completion of 30 credits of graduate level work, including:

four (4) core MSE courses.

MSE 362	Logistics and Supply Chain Management (3)
MSE 421	(GBUS 481) Technology, Manufacturing & Competitive Strategy (3)
MSE 427	(IE 443) Automation and Production Systems (3)
MSE 438	Agile Organizations and Manufacturing Systems (3)

either

MSE 451	Manufacturing Systems Engineering Project (3)

or

MSE 490	Manufacturing Systems Engineering Thesis (6)

and

Elective courses (12 or 15 credits). At least one elective must be an MSE-numbered course.

Elective courses are selected in consultation with the MSE academic adviser and faculty, from technical and business areas related to manufacturing,

These areas include:

- design
- materials, manufacturing processes and quality control
- automation, control systems, and computer integration
- computer and information systems
- business, management, organization, and operations research

Admission requirements

- A bachelor's degree in engineering or an appropriate science is required.
- Candidates enroll in this program through one of the university's engineering departments, depending on individual backgrounds and interests.
- All candidates must have at least six months work experience in industry.
- All candidates must follow admission procedures and standards established by Lehigh University.

For further information contact: Carolyn Jones, MSE Program Coordinator, 200 West Packer Avenue, Bethlehem, PA 18015 (610) 758-5157, FAX (610) 758-6527, Email ccj1@Lehigh.edu or visit our web site at *www.lehigh.edu/inmse/gradprogram/*

Pharmaceutical Chemistry

The graduate program in pharmaceutical chemistry leads to the interdisciplinary professional M.S. or to the Ph.D. degree. This curriculum prepares individuals who want to pursue careers in pharmaceutical or biomedical research, teaching, administration, or in some aspect of public health.

Individuals may elect to specialize in one of the following areas: medicinal chemistry, drug development, diagnostic technologies, pharmaceutical spectroscopy, analytical methodologies, process chemistry, metabolism mechanisms, and molecular biological approaches to selected topics in pharmaceutical chemistry. The core course distribution and selection of electives may be altered to reflect the area of specialization. An internship or work experience in pharmaceutical industry is strongly encouraged and the program adviser will assist in corporate placement.

Core Courses

Students select at least six of the following core courses:

CHM 336	Clinical Chemistry (3)
CHM 350	Special Topics (1-3)
CHM 371/372	Elements of Biochemistry I and II (3 each)
CHM 423	Bio-organic Chemistry (3)
CHM 424	Medicinal and Pharmaceutical Chemistry (3)
CHM 435	Advanced Topics in Clinical Chemistry (3)
CHM 437	Pathophysiological Chemistry (3)
CHM 456	Spectral Analysis (3)
CHM 477	Topics in Biochemistry (1-3)
CHM 479	Biochemical Techniques (3)
BIOS 421	Molecular Cell Biology I (3)
BIOS 422	Molecular Cell Biology II (3)

Students, with the consent of their graduate committee members, may petition to substitute courses for some of the required ones. The substitution must be approved for the student's area of research concentration. In addition, each student selects, with the guidance of the committee, sufficient courses from the following to satisfy the requirements for the masters degree. The selection of electives from business and management areas is encouraged; the program adviser will assist in such choices.

CHM 358	Advanced Organic Chemistry (3)
CHM 421	Chemistry Research (1-6)
CHM 423	Bio-organic Chemistry (3)

CHM 424	Medicinal and Pharmaceutical Chemistry (3)
CHM 430	Chemical and Biochemical Separations (3)
CHM 441	Chemical Kinetics (3)
CHM 458	Topics in Organic Chemistry (3)
CHM 471	Eukaryotic Biochemistry (3)
CHM 480	Advanced Biochemical Preparations (1-3)
CHM 481	Chemistry Seminar (1-6)
BIOS 345	Molecular Genetics (3)
BIOS 353	Virology (3)
BIOS 405	Special Topics in Molecular Biology (1-3)
BIOS 411	Advanced Cell biology (3)
BIOS 415	Neuropharmacology (3)
BIOS 464	Molecular Biology of Eukaryotic Organisms (3)

Students admitted into this program may have majored in biology, chemistry, animal science, entomology, veterinary science, pharmacy, or some other areas of the life sciences.

All students in the Ph.D. program are required to pass a qualifying examination, a general examination, and complete a dissertation. Completion of a project is required of M.S. students.

For further information, contact Ned D. Heindel, Department of Chemistry, Lehigh University, 6 E. Packer Avenue, Bethlehem, Pa. 18015-3172.

Photonics

The Master of Science Degree in Photonics is an interdisciplinary program designed to provide students with a broad training in the various aspects of photonics, including topics in physics, electrical engineering and materials science. Admission to the program requires a B.S. or M.S. in either the physical sciences or engineering.

Applications should be directed to one of the three sponsoring departments (Electrical Engineering, Materials Science and Engineering, or Physics). Procedures and admission criteria are the same as those followed by the home department. International students must satisfy minimum university language requirements. The admissions process is under the supervision of an inter-departmental coordinating committee chaired by the program director.

Required Courses*(15 credits):

PHY 352	Modern Optics (3) [Prerequisite: Math 205, PHY 212/ ECE 202]
PHY 355/455	Lasers and Nonlinear Optics (3) [Prerequisite: PHY 31**, PHY 213/ ECE 203 or MAT 201]
ECE 348/448	Lightwave Technology (3) [Prerequisite: ECE 203]
ECE 372/472	Optical Networks (3) [Prerequisite: ECE 81]
MAT 496	Photonic Materials (3)

Selected pre-requisites for the required courses may be waived by the program director for students with equivalent background.

A minimum of three courses must be selected from the following list:

ECE 371/471	Optical Information Processing
ECE 347/447	Introduction to Integrated Optics
ECE 407	Linear and Nonlinear Optics
ECE 451	Physics of Semiconductor Devices
PHY 363	Solid State Physics
PHY 369	Quantum Mechanics
PHY 421-422	Electricity and Magnetism
MAT 302	Electronic Properties of Materials
MAT 423-427	Electron Microscopy (TEM and SEM)
MAT 430	Glass Science
PHY 312/412	Advanced Laboratory in Photonics
ECE 373/473	Optical Communications Laboratory

In order to complete the MS degree requirements of the University, candidates must submit either a Master's thesis or a report based on a research course of up to 6 credit hours. Research courses should be at the 400 level.

Polymer Science and Engineering

Lehigh has a diverse group of faculty members with strong, primary interest in polymer science and engineering. In order to provide better opportunities for courses and research in this interdisciplinary field, activities are coordinated through the Center for Polymer Science and Engineering (CPSE), and its academic Polymer Education Committee. Polymer faculty from traditional departments of chemical engineering, chemistry, materials science and engineering, physics, and mechanical engineering and mechanics, are participants of the CPSE.

There are two ways in which qualified graduate students, with degrees in the above or related fields, may participate. Students may pursue graduate studies within an appropriate department. Departmental procedures must be followed for the degree sought. The student's adviser may be in that department, or in another department, or research center, in which case, the student receives a normal departmental degree, with emphasis in polymer courses and research.

Alternatively, students may elect to pursue studies toward an interdisciplinary M.S., M.E., or Ph.D. degree in polymer science and engineering. The procedures for this latter case are summarized as follows.

Students enter through the departments and must meet each entering department's criteria. When the student is ready (must have taken/be taking at least one polymer course and be in good standing in the department), the student petitions to transfer to the Center for Polymer Science and Engineering. After entering the center degree program, his/her degree program becomes Polymer Science and Engineering, but the student remains in the home department.

M.S. in Polymer Science and Engineering. For the M.S., the student's program must include: not less than 30 credits of graduate work; not less than 18 credits of 400-level course work, and not less than 18 credits of course work in the major, of which 15 must be at the 400-level. The program must include six course credits in the student's admitting department, six research credits, and a research report or thesis to the satisfaction of the faculty advisor, to be filed with the Polymer Education Committee.

Required courses:

CHE (Chm/Mat) 388	Synthesis and Characterization Lab (3)
CHE (CHM/MAT) 393;	Physical Polymer Science (3)
CHE (CHM) 394	Organic Polymer Science (3)
	Research (6)

Three 400-level polymer courses to be selected from the following list (list may vary slightly from year to year):

CHE 428	Theology (3)
PHY 472	Polymer Physics (3)
CHE (CHM) 483	Emulsion Polymers (3)
CHE (CHM/MAT)) 482	Engineering Behavior of Polymers (3)
CHE (CHM/MAT) 485	Polymer Blends and Composites (3)
CHE 486	Polymer Processing (3)
CHM 489	Organic Polymer Science II (3)
CHM 491	Physical Chemistry of Organic Polymer Coatings (3)
CHE (CHM) 492	Topics in Polymer Science (3)
CHM 493	Organic Chemistry of Organic Polymer Coatings (3)
CHE 487	Polymer Interfaces (3)

Courses in the admitting department must include one of the following:

CHE (CHM) 400	Chemical Engineering Thermodynamics (3)
CHM (CHE) 445	Elements of Physical Chemistry (4)
MAT 401	Thermodynamics and Kinetics I (3)
ME 420	Advanced Thermodynamics
PHY 442	Statistical Mechanics

plus one other 300- or 400-level non-polymer related course from the admitting department.

M.E. in Polymer Science and Engineering. The M.E. degree requires the same course work structure as the M.S. degree above, however, instead of six hours of research credits leading to a thesis or research report, the student would take six hours of course work. The additional six hours of coursework must include two additional 300 or 400 level polymer courses, or one polymer and one non-polymer home department course. For full-time graduate students electing the M.E. degree option, the polymer course program must include Chem. Eng. (CHM.; MAT) 388, Polymer Synthesis and Characterization, a laboratory course.

Part-time and Distance Education M.S. and M.E. degree students in Polymer Science and Engineering may substitute another polymer course for Chem. Eng. (CHM; Mat) 388.

Ph.D. in Polymer Science and Engineering. For the Ph.D., the student must satisfactorily complete a qualifying examination administered by the Polymer Education Committee; satisfactorily complete graduate course work determined in consultation with the doctoral committee; pass a general examination administered by the Polymer Education Committee; and defend to the satisfaction of the doctoral committee, a dissertation in the field of polymer science and engineering. Students deficient in polymer science or related topics may be required by their committee to take remedial course work.

The doctoral committee consists of the research adviser, at least two other members of the center for polymer science and engineering, and at least one outside person. The committee's composition is subject to approval by the Polymer Education Committee and the Graduate and Research Committee of the university.

For more information, write to Dr. M.S. El-Aasser, Director, Center for Polymer Science and Engineering, Iacocca Hall, Mountaintop Campus, Lehigh University, Bethlehem, PA 18015, or Dr. L.H. Sperling, Chairman, Polymer Education Committee, Whitaker Laboratory, Lehigh University, 5 E. Packer Avenue, Bethlehem, PA 18015. Please address applications to one of the participating departments.

Certificate Programs

Cognitive Science

Stereotypes, Prejudice, Discrimination, and Intergroup Relations

Business College Certificates

Education College Certificates

Research Centers and Institutes

Lehigh has developed a number of centers and institutes to provide greater research and academic opportunities for primarily graduate students and faculty. Centers and institutes are generally interdisciplinary and complement the scholarly activities of academic departments and represent scholarship and research based on the expertise and capabilities of a group of faculty members. Frequently, centers relate to the broad-based research needs of government, industry, and the social community.

Biopharmaceutical Technology Institute

The Biopharmaceutical Technology Institute coordinates the education and research activity in the biopharmaceutical area of the chemistry and chemical engineering departments at Lehigh University. The main focus of this institute is to contribute to the creation and to the dissemination of engineering and scientific knowledge required to develop, improve and regulate biotechnology and pharmaceutical industry processes and products.

Research Activities. The research program of this institute is devoted specifically to the engineering and scientific fundamentals related to development, design, validation, cGMP (current Good Manufacture Practice) operation, safety, monitoring and control of fermentation, purification, product modification and formulation.

The research thrusts of the institute include: immunochemistry applied to clinical diagnostics; modification and use of monoclonal antibodies in radiosensitization and NMR imaging; structural analysis of glycoprotein pharmaceuticals; tumor image enhancement; medicinal chemistry; chemistry of biologically potent molecules; fundamental kinetics of microbial, mammalian and plant cell and enzyme systems; design and scale-up of bioreactor and bioseparation systems; development of instrumentation for the on-line monitoring of biological unit operations; development of novel separation and purification schemes for recovery of biologically active macromolecules, antigens, and antibodies; development of cGMP validation procedure for biopharmaceutical processes and products; and biopharmaceutical drugs research, design and delivery systems.

Specific examples of projects recently carried out within the institute are: development of Fourier transform infrared spectroscopy for the on-line monitoring of substrate, product and cell concentrations; kinetics of recombinant microbial and cell culture systems analysis of nutritional limitations and medium formulation for mammalian cell systems; use of cell cycle for enhancing mammalian cell culture productivity; fundamental studies of separation systems such as continuous chromatography, and aqueous two-phase extraction; plasmid DNA and recombinant protein purification;

fundamental studies of protein conformation in bioprocessing by 2D FT_1 HNMR; perfusive effects in chromatographic separations; effect of cross-linking on biological activity of biopharmaceuticals; kinetics and enzyme production by cellulolytic fungi/actionamycetes; bioprocessing equipments cleaning and validation.

The research is conducted in Iacocca Hall, Mountaintop Campus, where the laboratories for the Department of Biological Sciences research group, the Department of Chemical Engineering, the Emulsion Polymers Institute, and the Chemical Process Modeling and Control Research Center are located. Because of the interdisciplinary nature of the research, projects typically involve joint supervision by faculty from chemical engineering, molecular biology, and chemistry/biochemistry.

The Biopharmaceutical Technology Institute presently occupies 3600 square feet of laboratory and 2250 square feet of pilot plant space in the C wing of Iacocca Hall of the Mountaintop Campus. The institute is equipped with 30/250l of pilot-scale computer-controlled bioreactors, monitored and controlled by Leeds & Northrup MAX 1 Distributed Digital Control Unit. In addition, numerous small-scale reactors are available for batch and continuous culture work. Key emerging monitoring systems used on the pilot-scale fermentation equipment include a UTI Quadropole Mass Spectrometer, BioChem Technology Fluromeasure System, and an ASI ReactlR 1000 FTIR Spectrophotometer with steam sterilizable DiComp™ probe. Pilot scale separations capability is being developed and currently includes a Millipore Pellicon Unit, Sharples centrifuges and large-scale chromatography.

The fermentation and separations facilities are supported by analytical equipment and facilities including UV/visible spectrometer, isocratic and gradient HPLC's with refractive index and variable wavelength UV/visible detectors, gas chromatographs with FID and TCD detectors, YSI analyzer, Branson cell sonifier, incubator/shakers, laminar flow hood, microscopes, centrifuges and ultracentrifuges, scintillation and gamma counters, liquid and gas liquid chromatographs, high-field NMR, etc.

Mammalian cell cultivation is conducted in a recently constructed class 1000 laboratory equipped with CO2 incubators, vertical laminar flow hoods, a Bellco roller bottle apparatus, Millipore Milli-Q purification system, inverted microscope, etc.

Educational Opportunities. As listed in the course descriptions for the Department of Chemistry and Department of Chemical Engineering, the faculty of the Biopharmaceutical Technology Institute conduct a variety of courses as part of the graduate education curriculum in biochemcial engineering and chemistry. The typical graduate level biochemical engineering curriculum would also include core courses in chemical engineering and basic science courses in microbiology, biochemistry, and molecular biology offered through the departments of biological sciences and chemistry.

For more information, write to Dr. James T. Hsu, Director, Biopharmaceutical Technology Institute, Lehigh University, 111 Research Drive, Bethlehem, PA 18015.

Building and Architectural Technology Institute

BATI is concerned with the entire scope of the built urban environment, the social, and the cultural aspects of building technology. BATI researchers and faculty carry out border-crossing studies aimed at the development of enhanced livability of the urban environment and its structures, their suitability to the environment for which they are planned, mutations in urban function and conditions, and the concurrent architectural, urban planning, and design problems.

The institute provides a center for interdisciplinary study, research activity, information dissemination, and stimulation for the use of new information in design. BATI has as its goal both the enhancement of academic knowledge through academic research and the practical solution of current physical problems through applied research.

BATI provides a forum for faculty discussion, not only from the different disciplines on the campus as they relate to the built environment (architecture, history, sociology, psychology, business, and economics), but also for visiting fellows and professors. It also provides a contact between the academic and the business worlds.

Research Activities. The institute provides the opportunity to identify research problems, develop proposals, and seek mechanisms for their solution. This can include the traditional single-discipline approach, but typically it involves work across the disciplines within the university and with other academic and commercial entities.

Educational Opportunities. The resources of the institute, the Council on Tall Buildings and Urban Habitat, and other related centers at Lehigh University are available to interested scholars.

For more information write to Dr. Tom F. Peters, Director, Building and Architectural Technology Institute, Lehigh University, 17 Memorial Drive East, Bethlehem, PA 18015-3007.

Center for Crisis Public Relations and Litigation Studies

The mission of the Center for Crisis Public Relations and Litigation Studies is to promote the study and professional application of crisis public relations, with an emphasis on civil litigation as organizational crisis. The intercollegiate, multidisciplinary center was established to both support and to serve as a clearinghouse for cutting-edge research and "best practices" in crisis communication and litigation management. It also provides a unique environment where academic and professional experts can collaborate on research or consulting projects for clients.

Crisis used to be referred to in public relations as the "unthinkable." Today, not only is it imaginable, but also it has become a day-to-day reality for every organization, evidenced by the fact that crisis is ranked among the 10 top threats that worry companies most. By far the most prevalent forms of crises are class-action lawsuits and product recalls. Lawsuits represent nearly a third of all crisis news in the U.S. media, while recalls account for 15 percent. It is not surprising, then, that litigation public relations, crisis management and media training have become growth industries.

What is surprising is that 40 percent of Fortune 1000 industrial companies have no operational crisis plan, even though most experts agree that advance planning is the key to successfully managing most crises. The number of smaller, more vulnerable companies without plans is even greater. In addition to the need to educate managers and communicators about effective crisis planning and management, the relatively new specialty of litigation public relations also warrants careful study from strategic, legal and ethical perspectives.

Interdisciplinary Research. The center encourages a broad range of faculty, graduate and undergraduate research projects covering multiple disciplines in the social sciences, business and economics, law, education and industrial design. Particular emphasis is placed on the impact of lawsuits on organizational reputation, business practices, public opinion, public policy, government regulation, global competitiveness, and the judicial process. For example, while extensive studies have been done on the effect of pre-trial publicity on the outcome of criminal trials, research is needed on the relationship between litigation journalism (media coverage of lawsuits) and jury verdicts in high-profile lawsuits. This is only one of many research areas related to crisis and litigation that are supported by the center and pursued by its academic and professional affiliates.

Educational Opportunities. In pursuit of its mission to further the professional application of crisis planning, management and communication, the center provides professional consulting in addition to conducting workshops, executive training courses, seminars and certificate programs using both traditional and non-traditional methods of scheduling and delivery. Topics offered or planned include school and workplace violence, product liability, crisis planning and management, media training, cyber crises, risk communication, class action lawsuits, litigation journalism/litigation public relations, product recalls and withdrawals, environmental crisis, conflict resolution and consensus building, testimony at public meetings and hearings, and public participation/ citizen advisory panels, and community relationship management.

To support its educational activities, the center is affiliated with more than a dozen visiting and Lehigh faculty, as well as nationally and internationally recognized professional experts in crisis and litigation. Besides participating in workshops, courses and certificate programs, professional affiliates serve as adjunct instructors or invited speakers in classes, and as public lecturers on the Lehigh campus.

For more information, contact Carole Gorney, Director, Center for Crisis and Litigation Public Relations, Lehigh University, 29 Trembley Drive, Bethlehem, Pa. 18015; e-mail: *cmg1@lehigh.edu*; or call (610) 758-4178.

Center for Manufacturing Systems Engineering

The Center for Manufacturing Systems Engineering serves as a catalyst between the University community and industry for coordination and development of campus activities associated with manufacturing. The center was created in response to the expressed needs of industry for educational and research services which were distinctively cross-disciplinary. A primary responsibility of the center is the administration of an award winning educational program leading to a Master of Science degree in Manufacturing Systems Engineering. This world-renowned program started in January of 1984 as a result of a major initiation grant from the IBM Corporation. It now has 350 alumni who are working as managers and technical leaders in industry around the world. The center works with an Industrial Advisory Board to ensure that classroom instruction is current, and that research goals are compatible with the long-range needs of industry. The center has four major thrusts: 1) A graduate program which offers a curriculum leading to the master of science degree in MSE. 2) Research directed at solving problems of manufacturing; this also serves to maintain faculty currency and provides a vehicle for student project and thesis studies. 3) Technology transfer to sustain the free flow of knowledge from the research laboratories to industrial applications, and from leading-edge member industries back into the classrooms. 4) The provision of services by sponsoring conferences, clinics, workshops and other means for communicating and disseminating the advantages of sound manufacturing systems engineering practice.

Graduate Education. The 30-credit master's degree MSE program is cross-disciplinary, administered by the College of Engineering and Applied Science, with additional courses provided by the College of Business and Economics. Four core courses, 4-5 graduate level elective courses (at least one elective must be an MSE-numbered course) and a 3-or 6-credit research project or thesis are requirements of all candidates for the M.S. degree. Courses are offered on campus and scheduled so that part-time students can complete the degree in two years. It is possible for distance students to earn the MS in MSE degree remotely. Special activities in the program are team intensive and include in depth studies of companies, tours of industry, industry-related research and internships. Additionally, an MSE option is available in the MBA&E program.

Research Activities. Students in the MS in MSE program undertake research of interest either to their employers, or to industry in general. Research activities have included microelectronics packaging, design systems, thick film hybrids, the characterization of coatings and package interfaces, and the use of lead free solders. A microelectronics manufacturing laboratory was set up by means of grants and equipment from the AT&T Foundation and IBM Corporation. It possesses equipment for thick film hybrid manufacturing and other processes. There are investigations into activity-based costing, design management, application of financial information systems, and injection molding. There is collaboration with other centers, departments and laboratories in the preparation and planning of research proposals and programs which aim to improve the understanding of manufacturing.

For more information, contact: Keith M. Gardiner, *kg03@lehigh.edu,* Director, Center for Manufacturing Systems Engineering, H. S. Mohler Laboratory, Lehigh University, 200 W. Packer Avenue, Bethlehem, PA 18015, or call (610) 758-5157 or visit our website at *www.lehigh.edu/inmse/center/*

Center for Polymer Science and Engineering

The Center for Polymer Science and Engineering (CPSE) was formally established at Lehigh University in July 1988. The center provides a unique opportunity for faculty and students from the traditional departments of chemistry, chemical engineering, materials science and engineering, mechanical engineering and mechanics, and physics to perform interdisciplinary research in polymers. The center is an umbrella organization encompassing polymers research and graduate studies at Lehigh University. The center's primary missions are preparation of first rate scientists and engineers with proficiency in polymers, fostering cross-disciplinary polymer research, organizing and teaching continuing education short courses in areas of interest to the polymer industry; and organizing campus wide seminars.

The center's Polymer Education Committee graduate studies through the academic departments leads to the Master of Science, Master of Engineering, and Doctor of Philosophy in Polymer Science and Engineering. Students may also elect to pursue studies towards a classical degree in their respective departments with an emphasis in polymer courses and research. Both advanced undergraduate and graduate courses in polymer science and engineering are offered through the participating departments. Current course offerings include polymer synthesis and characterization laboratory, physical polymer science, organic polymer science, engineering behavior of polymers, rheology, polymer processing, emulsion polymers, polymer blends and composites, fatigue and fracture of engineering materials, colloid science, and polymer interfaces.

Research Activities. The center has a wide range of research activities covering the field of polymers. The following are the major research themes: emulsion polymerization and latex characterization, surface/interfacial aspects of polymer colloids, adhesion, polymer blends and composites, polymerization mechanisms and kinetics, polymerization reactors modeling and control, structure/property relationships of interpenetrating polymer networks, macromolecular chemistry of biopolymers and coal, polymer coatings for corrosion protection, and microelectronic packaging.

Research Facilities. The following research instrumentation is available for the Center for Polymer Science and Engineering: X-Ray Photoelectric Spectroscopy (ESCA), Scanning Auger Electron Spectroscopy, Laser Raman Spectroscopy, Mossbauer Spectroscopy, Nuclear Magnetic Resonance Spectroscopy of both solids and solutions (NMR) (3 instruments; 90 MHz, 300 MHz and 500 MHz), Fourier Transform Infrared Spectroscopy (FTIR) (both conventional and photo-acoustic), a variety of advanced transmission and scanning electron microscopes, modulated differential scanning calorimetry, hi-res-thermogravimetric analysis, instruments for rheological studies (including a Rheometrics RDA2 and Bohlin Rheometer), particle sizing instruments (Coulter N4M, Joyce-Loebl Disc Centrifuge, Capillary Hydrodynamic Fractionation, and Hydrodynamic Chromatrography), Gel Permeation and Gas Chromatography units, Electrophoretic Mobility apparatus, mechanical testing devices such as the Rheovibron Dynamic Mechanical Spectroscopy, Instron Tensile Test equipment, several computer-controlled servo-hydraulic fatigue test machines, and Polymerization Reactors, including Bottle Polymerizer, Tubular Reactor, Stirred Tank Reactors with on-line sample analysis for residual monomer and interfaced with computer for control operations.

Educational Opportunities. Programs of study for individual students are designed to meet the student's interests, the requirements of the academic department, and the student's dissertation committee. Considerable flexibility is permitted in the selection of courses and a research topic. Lehigh University has been awarding interdisciplinary M.S. and Ph.D. degrees in Polymer Science and Engineering since 1975. Graduate students conducting polymer research may also earn the M.S. and Ph.D. degrees in the classical fields of chemistry, chemical engineering, materials science and engineering, physics, or mechanical engineering and mechanics. For further information please refer to the Polymer Science and Engineering Program in the section: Interdisciplinary Graduate Programs.

For more information about the center activities, admission to graduate school, or financial aid, contact; Dr. Mohamed S. El-Aasser, Director, Center for Polymer Science and Engineering, Iacocca Hall, Room D330, Lehigh University, 111 Research Drive, Bethlehem, PA 18015; (610) 758-3590 or Dr. L. H. Sperling, Chairman, Polymer Education Committee, Lehigh University, 5 East Packer Avenue, Bethlehem, PA 18015; (610) 758-3845. Please address applications to one of the participating departments. Please visit the web site: *www.lehigh.edu/esd0/cpse/home.html* or e-mail *mse0@lehigh.edu* or *lhs0@lehigh.edu.*

Center for Social Research

The Center for Social Research is a multidisciplinary organization designed to stimulate and conduct research involving the social and behavioral sciences.

Several disciplines are involved in the activities of the center: psychology, sociology, anthropology, and education. The center also cooperates with the university's other research centers and with several science and engineering departments.

Founded in 1965 as the Center for Business and Economics, the focus of the center was later broadened, and the name changed to the Center for Business, Economics and Urban Studies. The center's early activities included research on economics and business forecasting, and on transportation problems. The change to include urban studies broadened the center's scope to encompass the disciplines of political science, sociology, and history. In 1972, the center's scope was further broadened to include behavioral science and international affairs, and the present name was selected to more accurately reflect this broadened focus.

Interdisciplinary Research. The social perspective of the center's research is interdisciplinary in nature and is relevant to the community outside the university—local, regional, national, and international. Many research activities are based on a cooperative university-community relationship through which the research goals of the center are achieved and community needs met. Interdisciplinary research activities of the center are currently being conducted in the following areas:

Health and Human Development. Members of the departments of psychology, sociology/anthropology, and education, participate in research on health and human development. The program focuses on life from early childhood to maturity. Research interests include the effect of perinatal loss on families and family members; the influence of family and community on health; management aspects of organizations that serve elderly individuals; psychological aspects of aging; and, psychological aspects of late life physical disabilities such as stroke and amputation.

Families and Children. Members of the departments of psychology, sociology/anthropology, and education participate in studies pertaining to families and children. Research interests include family dynamics and child rearing practices and the emphasis on families included under the health and human development program. Current research focuses on the effect of child rearing practices on children's development of competence.

Program Evaluation. Members of the departments of psychology, sociology/anthropology, and economics, participate in research to evaluate the effects of a variety of programs. Particular emphasis is on improving program evaluation methodology. Current research interests include evaluation of several business, science and engineering programs in the university. Research has recently been conducted on the effect of compensatory education and social service programs.

For more information, write to Diane Hyland, Director, Center for Social Research, Lehigh University, 516-520 Brodhead Ave., Bethlehem, Pa. 18015.

Chemical Process Modeling and Control Research Center

The mission of the Chemical Process Modeling and Control Research Center at Lehigh University is to collaborate with industrial partners for their benefit through the application and advancement of research in the areas of control, design, synthesis, optimization and automation of a broad range of processing systems. A key execution strategy includes incorporation of a strong graduate education program at the M.S. and incorporation of a strong graduate education program at the M.S. and Ph.D. levels grounded in work defined with industrial partners. Our commitment is the delivery of Center technologies and services that will meet or exceed the expectations of economic return while advancing the knowledge in the field of process automation.

The Chemical Process Modeling and Control Research Center was established in January 1985 through the efforts of faculty members of the chemical engineering department at Lehigh University, leading industrial processing companies, the Ben Franklin Partnership Program of the Commonwealth of Pennsylvania, coupled with the organizational and financial support of the National Science Foundation (NSF). Many of the original industrial member companies have been continuous supporters of the center.

The center provides a unique atmosphere for fundamental research, development of specific techniques, application to real industrial processes, and opportunities for advanced education in chemical process modeling and control for academics and industrial practitioners. Facilities are available for real-time testing of new algorithms in experimental process units, development of dynamic simulations of real processes, and the close collaboration with researchers in several other fields of chemical processing.

Interdisciplinary collaboration is encouraged with other research groups, centers, or institutes engaged in biotechnology, polymer processing, environmental science, applied statistics, signal processing, chemical reaction engineering, and process design.

Direct industrial benefit is realized by participation in the center by a number of companies through an industrial consortium and its advisory committee. This committee actively participates in setting the research areas; collaborates with the center faculty, students, and staff in program assessment and implementation and provides a portion of the funding for the operation of the center.

Education. An integral part of the center is the commitment to conduct an outstanding program dedicated to the education of undergraduate and graduate students. The center has and continues to attract top quality students from a large group of well-recognized international universities. In addition to these gifted students, each year several industrial companies send employees to receive advanced training and engage in research efforts for particular company technical requirements. Because of the recognition of the value of the program and the quality of the students, the center has established a worldwide reputation as an outstanding educational and research unit in this critical area of technology development and implementation. More than a dozen graduate students are engaged in the center's research efforts and are candidates for Ph.D and masters degrees in this area of specialization.

Faculty. The center brings together six faculty members and research staff from different engineering disciplines in the university engaged in the research and educational efforts of the center. Visiting faculty from other well-recognized universities supplement these researchers and provide opportunities for diversity of thinking and innovative research. All of the associated faculty members are recognized around the world as leaders in their respective fields of specialization. They are invited very frequently to present plenary lectures in international conferences, industrial company meetings, and various universities. They organize and chair national and international conferences and symposia. They also serve as consultants to a variety of industries seeking their advice on leading technological developments in process modeling and control.

Facilities. The Center is located in Iacocca Hall on the Mountaintop Campus of Lehigh University. This building represents a unique facility available to the center as well as the chemical engineering department and the Emulsion Polymers and Bioprocessing Institutes. The center has the use of several dedicated computer facilities with more than 50 PC or workstation computers continuously available to the students, faculty, and staff. In addition to the local computing network, the center's researchers have access to the Lehigh University central computing facilities and its outside links to other worldwide computing systems and data networks. The center has several laboratories with sophisticated equipment dedicated to process control research work.

Areas of Research. The research activities of the Center span a wide spectrum of problems in large complex chemical process design, dynamical analysis and control, as well micro and nanoscale complex process development, evaluation, dynamical analysis and control. The research themes emphasize a combination of new theoretical developments, new applications and translation of new theoretical developments to practical problems. The focal areas of research in the Center as summarized below:

I. Synthesis and Plant-Wide Control

During the last decade Center faculty have done pioneering work in the area of plantwide control, which has resulted in the only textbook that covers this important area. There continue to be a number of projects in this area.

(a) On-Demand Control of Processes with Multiple Products: This project studies the design and control of processes in which consecutive reversible reactions produce multiple products. The demand for these products can vary, so the process and its control system must be able to produce exactly the desired amount of each individual product. An ideal system has been studied first in which the effect of equilibrium constants and volatilities can be explored. A real chemical system is also being studied (the production of methyl amines).

(b) Design and Control of Tubular Reactors Systems: Adiabatic gas-phase exothermic reactions are often carried out in tubular reactors. There are several types of systems: a single adiabatic reactor, multiple adiabatic reactors in series with either intermediate cooling or "cold shot" cooling (mixing some cold feed with the hot reactor effluent) and a cooled tubular reactor. These alternatives are being studied in terms of both steady-state design (which has the lowest total annual cost) and dynamic controllability (which provides the tightest temperature control in the face of disturbances)

II. Dynamics and Control of Distillation

Reactive distillation is an emerging area in chemical engineering because it offers potential savings in capital and energy costs in some systems, particularly for reversible reactions. A recent project explored several reactive distillation systems: ETBE, methyl acetate, TAME, ethylene glycol and metathesis of pentene. The steady-state economic designs of these systems were studied. Then their dynamics and control were explored. Different types of chemical systems require types of control structures. These columns are sometimes operated using of an excess of one of the reactants and sometimes using exact stoichiometric amounts of the two fresh reactant feeds. Both the process design and the control scheme are different with these two scenarios.

III. Convex Optimization Techniques in Linear and Nonlinear Process Control

The last few years have seen the emergence of a new class of optimization problems that have been variously referred to as a Linear Matrix Inequalities (LMIs), semi-definite programming (SDP) problems and convex problems. We were one of the first groups to explicitly show the applicability of LMIs in process control by reformulating the model-based predictive control (MPC) algorithms as LMI problems. There are several classes of problems involving control of systems subject to constraints that are amenable to LMI formulation. These include efficient off-line MPC for fast sampling time processes, observer-based nonlinear, MPC, multi-model transition control using MPC, anti-windup, moving horizon estimation and evaluation of robustness, i.e, the impact of model uncertainty on controller performance. These new control algorithms are being tested on numerous application platforms, including continuous stirred tank reactors, continuous polymerization processes and reactive distillation.

IV. Multi-Model and Hybrid Systems Analysis and Control

Hybrid and multi-model systems are a class of systems in which there is interaction between continuous dynamical behavior of systems with discrete switching behavior. For example, systems described by piecewise linear multiple models are continuous and linear within a prescribed region and switch to a different linear model description in a different prescribed region of the state-space. Other examples include switches and overrides that switch one of a family of controllers into the closed-loop, based on the operating space and control objective.

Our research in this area has focused on two broad problems (1) control of systems described by multiple piecewise linear models; (2) formulation of saturated systems as switched/piecewise linear models and subsequent anti-windup controller design using piecewise quadratic functions. We demonstrated, through a case study, the control of a highly nonlinear solution copolymerization reactor using multi-model switching MPC. The algorithm was successful in reducing off-specification product to less than a third, when compared with a open-loop transition. We have also shown how an appropriate anti-windup controller synthesis problem can be formulated using piecewise quadratic Lyapunov functions.

V. Dynamics and Control of Micro and Nanochemical Systems

Microchemical systems are a new generation of miniature chemical systems that carry out chemical reactions and separations in precisely fabricated three dimensional microreactor configurations in the size range of a few microns to a few hundred microns. Typical microchemical systems combine fluid handling and reaction capabilities with electronic sensing and actuation, are fabricated using integrated circuit (IC) manufacturing techniques and use silicon and related IC industry materials, polymers, ceramics, glass or quartz as their material of construction.

The goal of this integrated research and education program is to study the unique dynamical properties of such integrated microchemical systems and to develop a framework for designing implementable feedback control techniques for this class of microsystems. Concepts for distributed and boundary control theory will be employed to study the model-based feedback control formulation of microchemical systems and to develop a technical framework for microsystem controller design. The Integrated Microchemical Systems Laboratory (under the direction of Professor M.V. Kothare) conducts this research as part of the Center.

For more information, contract Mayuresh V. Kothare (co-Director) or William L. Luyben (co-Director), Center for Chemical Process Modeling and Control, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem, PA 18015-4791, (610) 758 6654, fax (610) 758 5297, e-mail: mayuresh.kothare@lehigh.edu, wll0@lehigh.edu.

Emulsion Polymers Institute

The Emulsion Polymers Institute, established in 1975, provides a focus for graduate education and research in polymer colloids. Formation of the institute constituted formal recognition of an activity that had grown steadily since the late 1960s.

The institute has close ties with polymer and surface scientists in the Center for Polymer Science and Engineering, Polymer Interfaces Center, Zettlemoyer Center for Surface Studies, CAMN, Center for Chemical Process Modeling and Control, and the departments of chemical engineering, chemistry, physics, and materials science and engineering.

Polymer colloids or polymer latexes, as they are more commonly called, are finely divided polymer particles that are usually dispersed in an aqueous medium. Important products produced and utilized in latex form include synthetic rubber, latex paint, adhesives and paper coatings. The small particle size of typical latexes makes their colloidal properties as important as the polymer properties in a number of applications. Hence, the study of emulsion polymers is an interdisciplinary activity.

Research Activities. Emulsion polymers research includes a broad range of problems in the areas of preparation, modification, characterization, and application of polymer latexes. Most commercial polymer latexes contain a number of important ingredients, some in only small quantities.

Research programs at Lehigh are aimed at understanding the function of recipe components during the preparation and application of the latexes. The research projects are a blend of fundamental and applied efforts as well as a mixture of theoretical and experimental problems: emulsion polymerization kinetics, mechanisms, and morphology of core/shell latexes; colloidal, surface, and bulk properties of polymer colloids; dispersion polymerization; miniemulsion polymerization; film formation and properties; NMR studies of polymer colloids; and particle size characterization via capillary chromatography.

Significant research support for institute activities is obtained from industrial organizations through their membership in the Emulsion Polymers Liaison Program. Hence some considerable effort is made to relate the research results to industrial needs. Consequently, graduates can find excellent opportunities for employment.

Educational Opportunities. Graduate students in the Institute undertake dissertation research leading to the master of science or doctor of philosophy degree in existing science and engineering curricula or in the Center for Polymer Science and Engineering.

Programs of study for individual students are designed to meet the student's interests, the requirements of the appropriate academic department, and the student's dissertation committee. Considerable flexibility is permitted in the selection of courses and a research topic.

Faculty members of the institute are involved in teaching normal university courses and continuing education courses for industrial personnel. The annual one-week short course, Advances in Emulsion Polymerization and Latex Technology, typically attracts about 100 industrial participants and 20 Lehigh students. This course is an important mechanism for developing meaningful interactions between institute staff and students and industrial scientists and engineers. Educational and research opportunities exist for postdoctoral scholars and visiting scientists as well as resident graduate students.

For more information, write to Mohamed S. El-Aasser, Emulsion Polymers Institute, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem, Pa. 18015. Please visit our web site at *www.lehigh.edu/esd0/epi-home.html*

Energy Research Center

Energy research at Lehigh is a multidisciplinary activity, involving faculty and students from engineering, the physical sciences, life sciences, business and economics, and the social sciences. The Energy Research Center provides a structure within which faculty and students from different backgrounds can explore their specific research interests.

The center coordinates the university's energy research, helping the faculty respond to research opportunities and developments in energy. It is also the major contact between the university and industry and government for matters dealing with energy research. Originally founded in 1972 as the Task Force for Energy Research, the center was organized into its present form in 1978.

The research within the center involves a wide range of topics related to the supply and use of energy. Work in progress—supported by contracts and grants from government, industry, and private foundations—deals with fuels and energy resources, energy conversion systems, energy conservation and the environment.

The Energy Research Center has particularly close ties with industry. A number of joint research projects involve Lehigh faculty and students and research staff from industry. The center also operates the Energy Liaison Program, through which participating companies and government facilities have access to faculty consultants, make use of laboratory facilities and library services, and receive assistance on research problems, feasibility studies and other projects related to energy. Through the center's Energy Intern Program, opportunities also exist for students to receive part of their training in industry. Through this program, a graduate student involved in energy can do a research internship in industry under the joint supervision of company research staff and the student's faculty adviser.

Experimental support for energy research is provided in a number of specialized laboratories maintained by the university. These laboratories, furnished with the latest instrumentation and equipment, include the following: boiling and two-phase flow, fluidized bed, fluid mechanics, surface chemistry, chemical kinetics, GC/mass spectrometer, atomic absorption spectrometer, electron optical, mechanical testing, structural testing, welding, metal forming, fracture mechanics, ceramics, polymer, hydraulics and water resources, van de Graaff accelerator, biotechnology, aquatic biology, and microprocessor development.

All faculty members who participate in Energy Research Center activities belong to academic departments. In addition, a number of faculty and staff members affiliated with the center have close ties with other on-campus research centers and institutes, assuring broad interactions between center personnel and experts from many research specialties, including economics, social science, materials and metallurgy, marine biology, fracture and solid mechanics, metal forming, structural design, sanitary and water resources engineering, thermal science, fluid mechanics, surface chemistry, and biotechnology.

Energy Research. Research within the center falls within five major categories. Projects of interest include:

Fossil Fuels. Fluidized bed combustion of coal; heat transfer in fluidized beds, pulverized coal combustion, catalytic combustion, cyclonic combustion, coal slagging; freezing of coal, coal chemistry, microbial desulfurization of coal, kinetics of coal gasification, fluidized bed gasification, dynamic simulation of coal conversion systems, kinetics of coal liquefaction, hydrogen-enhanced crack growth in high-strength steels, organic coatings for flue gas desulfurization service, weld repair of steam turbine rotors, mechanical properties of cryogenic steels for LNG applications, toughness of pipeline steels, fracture analysis of pipelines, and mechanisms of tertiary oil recovery.

Nuclear Technology. Instrumentation for reactor safety studies; boiling heat transfer in water-cooled reactors; fracture toughness of reactor steels; static and dynamic fracture toughness of steel welds; microstructural characterization of pressure vessel welds; pressure vessel design, radioactive waste disposal; high-energy particle physics, and nuclear physics.

Environmental Impact of Energy systems. Oil pollution studies in the coastal and wetlands environment, effects of power plant operations on biological life in the New Jersey estuarine region, acid rain, trace metal contamination of aquatic ecosystems, and hazardous waste disposal and control.

Conservation and Renewable Resources. Biological conversion of cellulose to chemicals and fuels; catalysis for alcohols from biomass, energy recovery from municipal solid waste, fuel derived from waste water treatment, energy conservation in the metal-forming industries, instrumentation and analysis of industrial processes, use of computers for process control, development of microprocessors for residential load control, cooling of electric utility generators and high-capacity electric motors, design of cryogenic turbines, instrumentation for HVAC applications, and siting of wind-power applications.

Energy Economics. Dynamic analysis of energy supply-demand systems; model of an investor-owned electrical utility; and peak-load pricing of electricity and natural gas.

Educational Opportunities. The extensive involvement of faculty in energy research has created a wide range of opportunities for graduate studies in energy. Most of the departments in the College of Engineering and Applied Science, as well as several departments within the College of Arts and Sciences and the College of Business and Economics, are active in energy research and offer both masters and doctoral degree programs suitable for studies of energy-related topics.

All degrees are granted by the academic departments and graduate students interested in energy enroll in traditional graduate degree programs in departments of their choice. These students specialize in energy by complementing their programs with a selection of special energy-related courses. They pursue their graduate research in energy areas under the supervision of faculty from the Energy Research Center or from other research centers or academic departments.

Opportunities also exist for students to receive part of their training in industry through a program in which a graduate student involved in energy can do a research internship in industry under the joint supervision of company research staff and the student's faculty adviser. The Energy Intern Program is individualized: each internship is designed to meet the specific needs and interests of the student, the faculty adviser and the company.

Financial support for graduate students is available through the Energy Research Center by means of fellowships and research assistantships related to sponsored research.

Each year Lehigh faculty members offer a number of special energy-related courses at the undergraduate and graduate levels; many of them are outgrowths of current faculty research. Recent examples include courses dealing with energy economics, the international politics of oil, nuclear reactor engineering, public policy and nuclear power, air pollution, coal catalysis, coal technology, materials for modern energy systems, and solar energy.

The Energy Research Center also sponsors an annual seminar series, bringing outstanding people in the energy fields to campus to speak. Covering a range of topics from economics to energy policy to science and engineering, these seminars provide an opportunity for faculty and students to learn of new developments in energy.

For more information, write to Edward K. Levy, Director, Energy Research Center, Lehigh University, 117 ATLSS Drive, Bethlehem, Pa. 18015. Please visit our website at *www.lehigh.edu/inenr/inenr.htm*.

Engineering Research Center For Advanced Technology For Large Structural Systems (ATLSS)

The ATLSS Engineering Research Center is a national center for research and technology on structures and materials for the basic infrastructure of bridges, buildings, and ship structures. First established in May 1986 with a grant from the National Science Foundation (NSF), the center now addresses the research needs of the U.S. Navy, U.S. Department of Transportation, Commonwealth of Pennsylvania, and NSF; and collaborates with many industry groups and government agencies. About 70 people, including graduate and undergraduate students, research associates, faculty and staff members representing the disciplines important to large structural systems are active at the center.

ATLSS research topics include Innovative Structural Systems and Materials, Condition Assessment and Life Prediction, Renewal Engineering, and Seismic Behavior. Projects follow the life-cycle processes of experimentation, design, fabrication and construction, operation, and renewal and retrofit. The studies are conducted in close association with engineers and scientists from several Lehigh departments, industry, government, design and professional groups and other universities.

ATLSS has excellent research facilities and equipment, including two world-class structural testing facilities: the Fritz Engineering Laboratory and the major newer (1989) ATLSS Laboratory, in which researchers study large-scale complex connections, assemblages and structures under static, dynamic, and/or cyclic multidirectional loading with complete computer-controlled experimentation. ATLSS also has and shares outstanding resources for computing, mechanical testing, welding, metallography, and non-destructive evaluation.

Research Activities:

High-Performance Materials. Research is conducted on innovative structural forms and structural systems to promote competitive use of high performance materials, including high-performance steel and steel weldments, concrete, fiber-composites, and mixed systems for bridge, building, and ship-hull applications.

Connection Design Methodologies. Research is conducted to advance connection technology in construction. Connections for seismic resistance are emphasized.

Condition Assessment of Structures. Field and laboratory assessments are made on bridge, highway, railway and ship structures for evaluations of behavior, corrosion, and fatigue and fracture damage, with an aim to life prediction and improved design specifications. Forensic studies of damaged structures are also made.

Renewal and Retrofit Techniques. Renewal and retrofit technologies are studied for civil and marine structures, with an aim to life extension.

Educational Opportunities. The ATLSS Center facilitates programs of study and research that provide a fundamental, broad approach to the fields of structures and materials. Graduate students in the center's programs receive master of science, master of engineering, or doctor of philosophy degrees; usually in structural engineering, materials science and engineering, or mechanical engineering. They pursue course work related to a broad understanding of materials and structures while conducting research in the center.

Financial support for graduate students is available through the ATLSS Center by means of fellowships and research assistantships related to sponsored research programs.

Undergraduates participate in the center's research through summer internships and academic-year special projects.

For more information, write to Dr. Richard Sause, Director, ATLSS, Lehigh University, 117 ATLSS Drive, Bethlehem, PA 18015-4728. Or, address him at *inatl@lehigh.edu*.

Enterprise Systems Center (ESC)

The Enterprise Systems Center (ESC), an affiliate of the Industrial and Systems Engineering Department, was established in 1995. This multidisciplinary center is committed to fusing student experiential learning with industry value creation. The center also seeks to advance interdisciplinary research and scholarship relating to information technology, new process development, and integrated enterprise systems. Additional research initiatives focus on discovering new methods for collaboration among education, industry and government partners through the use of advanced technology. Emphasis is given to an entrepreneurial approach to problem-solving. Started as the Computer-Aided Manufacturing Laboratory in the mid-seventies, the CAM Lab transformed into the Computer-Integrated Manufacturing Laboratory when it became clear that improvements in plant operational efficiency would require computer-based integration of the manufacturing processes involved. Driven by industry and research needs to seek performance improvements beyond the traditional manufacturing domain, the CIM Lab expanded its mission to encompass the entire enterprise, becoming the Enterprise Systems Center. Housed in Mohler Laboratory, the ESC provides undergraduate and graduate students from a variety of university disciplines including engineering, business, education, and the arts and sciences with the opportunity to work on teams with faculty and professional engineers to solve a variety of real world industry problems. Participation in these work teams provides students with a level of work experience representative of what they will encounter following graduation. Since its inception, the ESC has completed more than 100 projects with industry and government partners that have provided more than 500 students with an integrated learning experience that develops leadership skills and sharpens entrepreneurial thinking.

Research Activities. The ESC conducts research into the development and implementation of effective strategies to put information technology to work adding value to engineering education and enterprise applications. In its applied research efforts, the Center focuses on operational improvements, enterprise resource integration, and product development and enhancement. Operational improvement research with partner companies has explored strategies for manufacturing support, the development of decision support systems, processes for work-flow analysis and facility reorganization, analysis of constraints and throughput improvement, and new solutions to supply chain management. Work in enterprise resource integration has included methodologies for business process re-engineering and for the analysis and selection of Enterprise Resource Planning (ERP) systems. Applied research in product development and enhancement has included the use of computer modeling and simulation to support integrated product development along with analysis and evaluation of existing products, and design for manufacturability and assembly support.

Involvement in these applied research activities with industry partners provides Lehigh students with hands-on learning experiences built on progressive responsibility and contribution to real-world company projects. From these activities, students gain leadership skills and valuable industry experience.

The creation of technology-enabled educational resources augments traditional learning models. Coupled with knowledge management technology, these resources create integrated learning experiences and materials to support engineering courses. The ultimate objective is to identify key components of entrepreneurial behavior and develop the educational methods necessary to transfer to students the skills and experiences that will prepare them for leadership roles in society.

Within the ESC is the Learning Collaboratory, an innovative educational environment designed to promote inquiry-based and competency-driven experiential learning that enriches the classroom lectures with practical experience through corporate partner interactions. The Collaboratory supports small-group learning, action learning, and the application of technology to augment educational resources. Collaboratory participants, including students, professors, and industry partners, can take advantage of such powerful communication methods as broadband exchanges, internet conferences, digital real-time linkages, and electronic management of information.

Educational Opportunities. The ESC provides support for courses in the analysis and design of manufacturing systems and decision support systems, computer graphics, computer-integrated manufacturing, industrial engineering techniques, and experimental projects in industrial engineering. The ISE senior project class utilizes ESC facilities and a video teleconferencing system to step beyond the traditional classroom experience in the preparation and presentation of its culminating project. These courses are offered through the Industrial and Systems Engineering department. Graduate studies leading to both masters and doctoral degrees are also available through the Industrial and Systems Engineering department.

Participation in industry partner projects is open to all Lehigh students, both undergraduate and graduate, regardless of academic major, based on an interview process. This emphasis on interdisciplinary cooperation provides the opportunity to learn and work in an environment analogous to the cross-functional teamwork structure employed in many businesses. Applied research and project work is conducted with both industry and government partners.

For more information, contact Dr. Emory W. Zimmers, Jr., Director, Enterprise Systems Center, Lehigh University, Mohler Lab, 200 West Packer Avenue, Bethlehem, PA, 18015 (*ewz0@lehigh.edu*)

Iacocca Institute

Over the years, Lehigh University has developed an impressive ability to forge university-industry-government partnerships. These partnerships are critical not only to the future of universities, but, also to improve U.S. competitiveness. It is primarily through partnerships – with companies, schools, government agencies and other universities – that the Iacocca Institute pursues its mission of preparing current and future leaders for a globally competitive marketplace. One of these partnering activities is the Global Village for Future Leaders of Business and Industry.

The Global Village provides young adults from around the world the chance to experience the type of total-immersion leadership program usually reserved for top executives. Its purpose is to provide personal and organizational change needed to thrive in the emerging global economy. During the GV these interns who share the dream of a leadership career in business and industry, focus on leadership and entrepreneurial skills, global networking relationships, and business and industry knowledge. To date over 360 interns from over 70 countries have graduated from the program and are now part of the growing list of Iacocca Institute Interns. The Global Village interns represent undergraduate students, MBA and graduate students, and managers from global corporations and family-owned businesses.

The Iacocca Institute also fulfills its mission for leadership development in two other program areas, Post Graduate Education and High School Programs. The Institute establishes and maintains the infrastructure necessary for Lehigh University to continue and grow an active program of professional education, serving leaders in business, industry, government and education. The Institute works with all the Colleges on the Lehigh campus to identify appropriate post graduation courses to serve the markets in the tri-state area of New York, New Jersey and Pennsylvania.

The Iacocca Institute has the privilege of hosting the Pennsylvania Governor's School for Global Entrepreneurship. This program is a unique learning program to educate top high school students from Pennsylvania and from around the world on global entrepreneurship. The 5-week residential program focuses on challenging students as they learn about cultural and business practices with other students, faculty, and entrepreneurs.

The Iacocca Institute is also the center for Lehigh University's Career Awareness Programs (CAP). The CAP Programs are designed for bright and talented students of color who are between their junior and senior years in high school and have an interest in further studies in Accounting/Business, Design Arts or Engineering. The one-week summer programs are open to African American, Asian American, Latino or Native American students with a minimum grade point average of 3.0. Students selected for CAP receive a full scholarship, including room and board, to the one-week in residence program at the Lehigh University campus.

The Iacocca Institute, part of the College of Business and Economics, was established in 1987 with the support of Lee A. Iacocca, former chairman and chief executive officer, Chrysler Corporation, and a member of Lehigh's Class of 1945.

For more information, contact Richard M. Brandt, Director, Iacocca Institute, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem, PA 18015.

Institute for Biomedical Engineering and Mathematical Biology

The Institute for Biomedical Engineering and Mathematical Biology was established July 1, 1988 to foster interdisciplinary research and support graduate study in the application of engineering and mathematics to medicine and biology. Faculty from several engineering departments and from mathematics and biology actively participate in the institute. Current research includes the mathematical analysis of transport and exchange in microcirculatory physiology, theoretical and experimental biomechanics, experimental biofluidmechanics, fracture and failure in skeletal units and in prostheses, shock propagation through the human body, and design for the handicapped.

The institute has established an extensive network of interaction and generated significant research collaboration with a number of major medical centers. An effective liaison program fosters interaction between the university and industry in the biomedical field.

Graduate students interested in studying biomedical engineering or mathematical biology at Lehigh enroll in one of the engineering departments or in the applied mathematics program, and satisfy the corresponding degree requirements. The institute provides the opportunity for interdisciplinary research for both the master's thesis and the Ph.D. dissertation.

For more information, write to Eric P. Salathe, Director, Institute for Biomedical Engineering and Mathematical Biology, Chandler-Ullmann Hall, Lehigh University, 17 Memorial Drive East, Bethlehem, PA 18015.

Institute for Fracture and Solid Mechanics

The institute of Fracture and Solid Mechanics was established in the fall of 1970 to enable faculty members and students within the university to participate in research relevant to fracture and solid mechanics on an interdisciplinary basis. A branch of this institute was established in the Republic of China in 1987 to carry out cooperative research activities. An area of special interest to the institute has been in fracture mechanics, which deals with the study of structural and material sensitivity to flaws. Such flaws can seriously affect the design and strength of ships, aircraft, automobiles, bridges and buildings. In the design of nuclear power plants, the incorporation of the fracture mechanics concept of safety in the presence of flaws is required. In addition, fracture mechanics is finding application in such areas as bone fracture, environmentally accelerated cracking of pavements and structural members, the fracture of rocks, and erosion of materials by solid or water particle impingement.

The activities of the institute include: expansion of research capabilities to include the application of concepts of fracture mechanics to geology (rocks), medicine (bones), and composite materials; editing books on timely subjects in fracture and solid mechanics; compilation and collection of written materials to establish and maintain a special library of fracture mechanics; planning of conferences on fracture and solid mechanics; offering short courses and seminars on special topics; and conducting liaison programs with industry and government agencies.

Research Activities. There are several research programs being conducted in solid and fracture mechanics, sponsored by industry and government agencies. They include:

Fracture mechanics. Analytical: stress analysis of engineering structure weakened by flaws.

Experimental: static and dynamic fracture toughness testing of metallic, nonmetallic and composite materials.

Solid mechanics. Analytical and numerical methods of analysis. Plates and shells.

Educational Opportunities. Students interested in fracture and solid mechanics should refer to course offerings in the departments of mechanical engineering and mechanics, materials science and engineering, civil engineering, chemistry and biology.

For more information, write to Herman F. Nied, Institute of Fracture and Solid Mechanics, Packard Laboratory, Lehigh University, 19 Memorial Drive West, Bethlehem, Pa 1805.

Institute for Metal Forming

The Institute for Metal Forming was established in 1970 to teach the principles and applications of metal forming technology to graduate and undergraduate students, to provide instructions and equipment for graduate research in metal forming processes, and to assist industry with solutions to problems in metal forming.

The main objective of the institute's research is to conduct cross-disciplinary process engineering studies to better understand and control manufacturing processes and their impact on the microstructural response of a material. Recently, classical metal forming research has been expanded to include projects in powder processing, microstructure analysis, and forming of polymers.

The study of metal forming encompasses visioplacticity (physical modeling of a forming process); simulation of microstructure response to process parameters (via reproduction of the thermo-mechanical conditions that a material experiences during deformation); and computational numerical modeling. Computer enhanced analysis of material flow also allows us to optimize tooling design in many manufacturing processes. The combined quantitative results of these techniques may then be compared with experimental data obtained from instrumented metal forming laboratories (such as those maintained at the institute), or from our research partners in industry.

Research Activities. Current research areas include: extrusion of metals, powders and polymers, sheet material formability, rolling, wire drawing, forging, semi-solid forming, light-optical and electron-optical micro-texture analysis, coatings of powders, tooling design and tooling materials, thermo-mechanical processing of metals, rapid prototyping, rapid tooling, and machinability of sintered powder materials.

Educational Opportunities. Students interested in metal forming should refer to course offerings in the departments of materials science and engineering, mechanical engineering and mechanics, and industrial and manufacturing systems engineering.

For more information contact Wojciech Z. Misiolek, Director, Institute for Metal Forming, 242 Whitaker Laboratory, Lehigh University, 5 East Packer Avenue, Bethlehem, PA 18015.

Institute of Thermo-Fluid Engineering and Science

The Institute of Thermo-Fluid Engineering and Science, established in 1978, provides a focus for research and educational activities in fluid mechanics, thermodynamics, and heat transfer.

This institute seeks to consolidate the substantial ongoing research effort in these fields, to aid in the further development of such research, and to facilitate the utilization of this interdisciplinary strength in the university's educational programs.

Currently 28 full-time faculty and staff from the departments of chemical engineering, mechanical engineering and mechanics, mathematics, and physics are among the institute members. Graduate students and undergraduates as well as part-time and visiting staff members, join in the institute's activities.

Research facilities for thermo-fluids programs are based in the College of Engineering and Applied Science. Among the facilities available are laboratories for experimental investigations of fluid mechanics, gas dynamics, turbulent structure, solid-gas fluidization, boiling heat transfer and two-phase flow, refrigeration and heat pump systems, internal combustion engines, radiation and optical measurements, unit operations, thermodynamic properties, and reaction engineering. The university's Computing Center as well as various minicomputers are available for use in analytical computations.

The institute also conducts the Thermo-Fluids Liaison Program to promote the interchange of knowledge between researchers at Lehigh and engineers and scientists in industry and government. In cooperation with companies participating in the liaison program, the institute's staff members seek to apply their specialized capabilities in thermo-fluids to current industrial and governmental engineering and scientific problems.

Research Activities. The institute's staff members are involved in three interrelated areas: fluid mechanics, heat transfer and thermal science, and applied thermodynamics and modeling.

Combining experimental investigations with theoretical analyses, the researchers seek to understand and quantify the phenomenological mechanisms governing thermo-fluid processes. This knowledge is then brought to bear on relevant engineering problems of current concern in such applications as energy conservation, power production, coal conversion, aerodynamics, weather modeling, and nuclear energy.

The institute's current research programs include more than twenty grants sponsored by industry and various governmental organizations. A wide spectrum of subjects are under investigation, including research on flow-induced vibrations, unsteady turbulent flows, coherent turbulent boundary layer structures, blade flutter in compressors and fans, stochastic optimal control, colloid size distributions by hydrodynamic chromatography, fluidized combustion of coal, heat transfer in fluidized beds, heat pump systems, two-phase flow instrumentation, boiling heat transfer and two-phase flows, and nuclear reactor thermal safety.

Educational Opportunities. Formal courses in fluid mechanics, heat transfer, and thermodynamics are offered in the College of Engineering and Applied Science. Institute staff members regularly teach both undergraduate and graduate courses in the departments of mechanical engineering and mechanics, chemical engineering, and physics. Undergraduates can select a program of study, in consultation with their advisers, with emphasis on thermo-fluid sciences by elective choices among the departmental offerings. A formal minor program in fluid mechanics is available. Graduate studies leading to the M.S. or Ph.D. with concentration in thermo-fluids are available in the three departments.

Participation by both undergraduate and graduate students in the thermo-fluids research activities is encouraged. Many undergraduates participate as individuals or as groups in term projects under the supervision of institute faculty members. This provides an opportunity for interested students to obtain first-hand experience in pioneering thermo-fluids research. The research programs directed by institute staff members also provide support for graduate research assistantships, enabling selected graduate students to pursue their education and research in thermo-fluids on either a part-time or full-time basis.

In cooperation with various academic departments, the institute sponsors seminars by both staff specialists and by invited speakers from other institutions. These seminars are open to the university community, liaison program participants, and to engineers and scientists from neighboring industries. The institute anticipates organizing topical meetings, workshops, and short courses on specialized subtopics within the over-all discipline. Meeting topics will be selected to reflect ongoing research activities of the staff members and contemporary engineering concerns.

For more information, write to John C. Chen, Director, Institute of Thermo-Fluid Engineering and Science, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem, Pa. 18015.

Lawrence Henry Gipson Institute for Eighteenth-Century Studies

The Lawrence Henry Gipson Institute for Eighteenth-Century Studies was established in 1971, to honor one of America's most distinguished scholars, who served as a long-time member of the faculty at Lehigh. Gipson's monumental life work, *The British Empire Before the American Revolution* (15 volumes) was written between 1936 and 1970. Gipson received the Pulitzer Prize in History in 1962 for Volume 10, subtitled, *The Great War For Empire*. When he died in 1971, Professor Gipson left his entire estate to Lehigh and provided the original endowment for the institute.

Research Activities. The income from the endowment of the institute is used to encourage faculty and student research in the eighteenth century by providing small grants to defray travel costs, copying, and other expenses to permit scholars to visit necessary libraries and depositories. The Gipson Institute normally awards one fellowship annually to a Ph.D. candidate enrolled at Lehigh University for dissertation research and writing in any field of eighteenth-century studies. The institute also helps provide additional resources to build the university library's research collections in eighteenth-century studies.

Educational Opportunities. The institute invites leading scholars to give occasional lectures and supports relevant programs such as interdisciplinary seminars and visiting scholars interested in the eighteenth century. Annual symposia honor Professor Gipson by bringing to campus distinguished scholars to lecture and discuss various topics. The essays generated at the symposia have been published and the institute maintains a continuing close relationship with Lehigh University Press for publishing original manuscripts on the eighteenth century.

For more information, write to either of the co-directors, Jean R. Soderlund, Department of History, Maginnes Hall, 9 W. Packer Ave., or Scott Paul Gordon, Department of English, Drown Hall, Lehigh University, 35 Sayre Drive, Bethlehem, PA 18015.

Philip and Muriel Berman Center for Jewish Studies

The Philip and Muriel Berman Center for Jewish Studies, established in 1984, develops, administers, and coordinates a comprehensive program in Jewish studies at Lehigh University. The center is directed by Laurence J. Silberstein, Philip and Muriel Berman professor of Jewish Studies.

Besides teaching on their home campuses, Berman faculty offer Jewish studies courses at DeSales University, Lafayette College, and Moravian College. In 2001, as the result of a gift from Susan Ballenzweig Beckerman, the center established the position of Writer-in-Residence in cooperation with the department of English. The center also coordinates the Richard and Susan Master Visiting Professorship in Jewish Studies at the Pontifical Gregorian University in Rome, a program initiated by Philip and Muriel Berman of Allentown, Pa.

Other activities of the center include designing and implementing new courses and seminars, an annual lecture series, scholarly colloquia, and academic conferences. The center organizes the "Lehigh in Israel" summer program taught by Lehigh faculty and provides financial awards to Lehigh undergraduates for study in Israel through the Howard Ballenzweig Memorial Fund. In addition, the center publishes a book series with New York University Press titled New Perspectives on Jewish Studies.

For more information on the Berman Center and its programs, write to Dr. Laurence J. Silberstein, Director, Philip and Muriel Berman Center for Jewish Studies, Lehigh University, 9 W. Packer Avenue, Bethlehem, PA 18015, or call 610 758-4869 (*inber@lehigh.edu*).

Martindale Center for the Study of Private Enterprise

The Martindale Center for the Study of Private Enterprise, part of the College of Business and Economics, was established in 1980 by a gift from Harry and Elizabeth Martindale. The primary purpose of the center is to contribute through scholarship to the advancement of public understanding of the structure and performance of our economic system.

Attention is focused on the private sector of the economy and on public policies as they influence the private sector. To achieve this end, the center activities include the sponsorship of lectures and conferences, support of faculty research and case studies, and administration of the visiting scholar and executive-in-residence programs. The center sponsors and administers the Martindale Students Association Program (for undergraduates) and the publication of their journal, *Perspectives on Business and Economics*. The center has established the Canadian Studies Institute which encourages scholarship dealing with the business and economic environment of Canada and with U.S./Canadian business and economic relations; and the Kalmbach Institute for the Study of Regional Political Economy which focuses attention on the business and economic environment of the Lehigh Valley and other regions throughout the U.S. The Center along with the Department of International Relations is partnering with the U.S. Department of State to establish a lecture series on Global Political Economy.

For more information, write to Dr. J. Richard Aronson, Director, Martindale Center for the Study of Private Enterprise, Rauch Business Center, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015.

Center for Advanced Materials and Nanotechnology (CAMN)

The CAMN was established in 1962 to encourage interaction among the science and engineering disciplines with an interest in materials. The mission of the CAMN is to promote interdisciplinary research and education in materials science by coordinating and administering multi-investigator projects and developing and managing world class multi-user facilities. The center also conducts the Materials Industrial Liaison Program. Founded in 1963, this program serves as an interface between industry and the intellectual resources and facilities of Lehigh University. In this capacity, the program objectives are to provide expertise on materials related issues and to facilitate industrial interactions.

Research Activities. The CAMN is currently engaged in a wide variety of research activities i.e. the processing, characterization, properties, and utilization of materials. These efforts include research programs in microstructural characterization; processing and properties of ceramics; deformation and fracture of materials; electronic materials and packaging; polymer science; thin films and coatings; joining and solidification; and computer modeling of materials processes. Major highlights include the following research projects. After approximately a year of development, the CAMN was awarded a $2 million contract through the PA Technology Investment Authority (PTIA) to work with Penn State and a local manufacturing facility in the area of microelectronic packaging. This effort has resulted in an alliance anticipated to extend beyond this initial contract. The faculty team consists of 9 members in three engineering departments. Also, the CAMN was awarded a 5 year, $4.5 million contract through PTIA in support of a collaboration with Carnegie-Mellon University and the University of Pittsburgh. This award has enabled the CAMN to successfully engage all four Colleges at Lehigh University. This award has provided us with the support of many initiatives. These include the development of the premiere Materials Science and Engineering web-based professional education program; the implementation of a needs assessment of Pennsylvania industry in the areas of advanced materials, photonics, and biomaterials; the purchase of world class instrumentation; and the support of research interactions with Pennsylvania industries.

Educational Opportunities. This center facilitates programs of study and research that cross the traditional boundaries of science and engineering curricula, providing a fundamental, broad approach to the field of materials science and technology.

Graduate students participating in the center's program usually receive master of science or doctor of philosophy degrees in the academic discipline of their choice, i.e., chemistry, physics, materials science and engineering, electrical engineering and computer science, etc.; or in an interdisciplinary program such as polymer science and engineering. However, they are expected to pursue coursework related to a broader understanding of materials and to conduct research on an interdisciplinary materials problem in one of the center's six laboratories.

Financial support for graduate students is available through the CAMN by means of research assistantships related to sponsored research programs.

For more information, write to Martin P. Harmer, Director, CAMN, Lehigh University, 5 E. Packer Avenue, Bethlehem, Pa. 18015-3194.

The Murray H. Goodman Center for Real Estate Studies

The Murray H. Goodman Center for Real Estate Studies was established in 1988 through a major gift from Murray H. Goodman, '48. The center is a self-supporting, interdisciplinary unit of the College of Business and Economics. The center provides financial support and other assistance for undergraduate courses in real estate and real estate finance, supports scholarly research in real estate, and sponsors joint activities with practitioners in the real estate field.

Educational Opportunities. The center provides resources for the teaching of undergraduate courses in real estate and real estate finance. Sponsored courses include FIN 336 – Real Estate Finance, FIN 395 – Starting, Managing and Growing a Business Enterprise, and FIN 396/397 – Senior Practicum in Real Estate. In addition, the center sponsors a continuing series of seminars and presentations by real estate executives and practitioners. The center also serves as a clearinghouse for students seeking internships with real estate firms and related companies.

Research Activities. Consistent with the university's encouragement of scholarly research, the center provides funding for faculty research in the real estate area. Funding possibilities include: summer faculty research grants; travel, telephone and administrative support; and grants for part-time graduate assistants. The center also maintains a file of sponsored research opportunities available through private foundations, government agencies and practitioner organizations and provides administrative support to faculty applying for such funding.

Practitioner Interaction. The third aspect of the center's activities is its interaction with practitioners in the real estate field. The increased emphasis on continuing education and research among real estate practitioner organizations, as well as Lehigh's proximity to major real estate markets, enable the center to engage the practitioner community in a variety of joint projects. These joint projects include: 1) sponsored research projects; 2) continuing education programs and short courses; 3) special conferences and events of national and/or regional interest; and, 4) center-sponsored databases and continuing activities of interest to the practitioner community.

For more information, write to Dr. Stephen F. Thode, Director, Murray H. Goodman Center for Real Estate Studies, Rauch Business Center, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015, or call (610) 758-4788 or email *sft0@lehigh.edu*.

Musser Center for Entrepreneurship

The Warren V. Musser Center for Entrepreneurship was established through a gift from "Pete" Musser, Lehigh class of 1949, CEO of Safeguard Scientifics, Inc., a company that leads in incubating and operating premier developing technology companies in the Internet infrastructure market.

The Musser Center for Entrepreneurship, part of the College of Business and Economics, is currently being repositioned with a focus on e-business for the entrepreneur.

For more information, write to the Dean's Office, Rauch Business Center, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015.

Polymer Interfaces Center

The Polymer Interfaces Center (PIC) is an Industry/University Cooperative Research Center that was established at Lehigh University in 1991. It is sponsored by the National Science Foundation (NSF) and is one of approximately 50 centers that have been established at universities throughout the U.S. in an effort to leverage industrial development with university science. In this arrangement, university professors, research scientists and graduate students conduct industrially-relevant fundamental research while member companies and the NSF provide operating funds and guidance on the kinds of model polymers, model substrates and goals that are of interest to them.

PIC is developing a molecular-level understanding of the structural, dynamic, kinetic and energetic characteristics of the interphase region between polymers and substrates while also developing versatile methodologies to characterize the interphase region. Center research addresses such topics as adsorption, desorption, dynamic wetting, adhesion, charge transfer, transport, miscibility, compatibility and mechanical behavior. The center's ultimate goal is to generate a scientific database to assist in designing advanced polymers for such diverse applications as lubricants, water treatment, secondary oil recovery, coatings, inks, adhesives, and engineering plastics.

Research Activities. The center is interdisciplinary and includes faculty from four academic departments; chemical engineering, chemistry, materials science and engineering, and physics. The center also has research scientists and engineers who help guide the research program. The current research effort is divided into two theme areas:

A. Polymer adsorption/characterization. Investigators are elucidating the processes of water-soluble polymer adsorption and desorption from water onto colloidal and planar surfaces such as polystyrene, TiO_2 and silica.

B. Wetting/adhesion. Using industrially important metal and plastic surfaces, researchers in this area investigate the fundamentals of wetting and adhesion and the means of varying these processes by altering the molecular structure at the interface. Another aspect of this theme is to examine the mechanical behavior of polymer interphases. Selected projects include investigations of film formation, role of mechanical interlocking on adhesion, and "toughening" mechanisms and fatigue resistance in plastics that are modified with rubbery and/or glassy inclusions.

Research Facilities. Instrumentation available to PIC includes Atomic Force Microscopy in contact, non-contact and scanning tunneling modes; X-Ray Photoelectron Spectroscopy; Scanning Auger Electron Spectroscopy; Laser Raman Spectroscopy; Fourier Transform Infrared Spectroscopy; Attenuated Total Reflectance Infrared Spectroscopy; Dynamic Light Scattering; Total Internal Reflectance Fluorescence; Ellipsometry; Surface Forces Instrument; Laser Trap; Microcalorimetry; MoireInterferometry; Scanning Electron Microscopy; Transmission Electron Microscopy; Solid-State and Liquid-State Nuclear Magnetic Resonance Spectroscopy; Column Impregnation Units; Serum Replacement Cells; and a variety of Mechanical Property Test Equipment.

Educational Opportunities. PIC supports graduate-level research for M.S. and Ph.D. degree students in subjects related to the center's goals. Students receive degrees from their respective academic departments, but they also take special courses on polymer interfaces given by the center faculty and participate in the multidisciplinary activities of the center. There are a few opportunities for research by undergraduates who have achieved senior standing in a science or engineering major.

For more information, write to Manoj K. Chaudhury, Director, Polymer Interfaces Center, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem PA 18015; or call (610) 758-3701.

Sherman Fairchild Center for Solid-State Studies

The Sherman Fairchild Laboratory was established by a major grant from the Sherman Fairchild Foundation and was opened in the fall of 1976. The laboratory houses an interdisciplinary staff consisting of faculty and students from the departments of physics, materials science and engineering, and electrical engineering and computer science. While work on various aspects of solid-state science is carried out at many locations on the Lehigh campus, the Sherman Fairchild Center provides the focal point for studies of electronic materials and devices.

Research Activities. The Sherman Fairchild Center's faculty and students have a wide range of interests that include experimental and theoretical studies of the physics of defects in non-metallic solids and of disordered materials; advanced semiconductor processing technology; and semiconductor device design, fabrication, and characterization. The materials systems of interest are equally diverse and include silicon, silicon dioxide, compound semiconductors, wide bandgap semiconductors (SiC, ZnSe, and GaN), ferroelectrics and glasses.

The Sherman Fairchild Center houses several experimental laboratories. The Microelectronics Research Laboratory provides processing facilities for the fabrication of CMOS, CCD, MNOS, bipolar devices and integrated circuits. Available technology includes low-pressure chemical vapor deposition, RF metallization, plasma chemistry, photolithography, oxidation and diffusion. A new Display Research Laboratory has been established for work on electronic devices and thin-film materials for large flat panel displays. The Compound Semiconductor Research Laboratory has facilities for processing and characterizing high speed integrated circuits. A new facility for the growth of compound semiconductor thin films by metalorganic vapor phase epitaxy is being constructed.

A 3 MeV Van de Graaff accelerator provides a radiation facility that can be used to produce high energy electrons for the generation of point defects. Individual laboratories provide instrumentation for optical excitation and luminescence, electron paramagnetic resonance (EPR), deep level transient spectroscopy (DLTS), and Fourier transform infrared spectroscopy (FTIR) for the study of defects in semi-conductors. There are also facilities for the study of transport in mesoscopic devices at milliKelvin temperatures, Raman spectroscopy, and ultrasonic attenuation. Theoretical work is facilitated by the university's extensive network of workstations.

Current research programs include work on 1) VLSI microelectronics, a study of the characterization of small-geometry solid-state devices for VLSI, with emphasis on CMOS transistors; 2) nonvolatile semiconductor memories that offer the possibility of a "semiconductor disk;" 3) SiC materials for application in power electronics at high temperature; 4) the fundamental properties of impurities and simple lattice defects in silicon and wide bandgap compound semiconductors; a variety of methods (crystal growth, diffusion, electron irradiation) are used to introduce defects which can then be studied by spectroscopic techniques that include electron paramagnetic resonance (both conventional and optically detected), deep-level transient spectroscopy, and infrared absorption spectroscopy; 5) the oxidation of $Si_{1-x}Ge_x$ alloys and SiC with emphasis on the very early stages of oxidation and impurity enhanced oxidation; 6) quantum mechanical calculations of the structural, vibrational, and electronic properties of defects in SiO_2 and wide bandgap semiconductors like GaN; 7) the fabrication of prototype active matrix displays; 8) the fabrication and characterization of high speed, compound semiconductor integrated circuits; and 9) the collective dynamics of partially ordered and disordered ferroelectrics and glasses.

Educational Opportunities. Graduate students associated with the Sherman Fairchild Center usually enroll for the master of science or doctor of philosophy degree in the traditional discipline of their choice, such as physics, materials science and engineering, electrical engineering, etc., with specific course requirements and research participation coordinated through the appropriate department chairperson. Students are financially supported by graduate fellowships provided by the Sherman Fairchild Foundation and/or by university resources. In addition, teaching assistantships are available through the departments and a number of research assistant positions are supported by research grants and contract awards obtained by the laboratory staff. All of these arrangements typically permit graduate students in the solid-state studies to take three courses per semester in addition to their teaching or research activities. There are numerous opportunities for undergraduate students to participate in the research activities of the center with the possibility of support during summer through the Fairchild Summer Scholar Program.

For more information write to Marvin H. White, Director of the Sherman Fairchild Center for Solid State Studies, Lehigh University, 16A Memorial Drive E, Bethlehem, PA 18015-3184.

Technology Studies Resource Center

The Technology Studies Resource Center, based in the College of Arts and Sciences, creates and disseminates materials and programming that will lead a wide range of people to an understanding of the mutual interaction of technology and social institutions and values. Through the center, academics from all disciplines can collaborate on research and develop educational opportunities in technology studies with academic colleagues and with nonacademic sponsors.

The Technology Studies Resource Center's activities embrace the needs of academics, pre-college and college students, and industrial, political, and public audiences, who seek information about technology as a force in contemporary society. Four principal areas of activities are the development and dissemination of resource materials, professional development programming, educational programming, and stimulation and coordination of technology studies and research projects. Specific activities include: collecting and distributing college-level course syllabi in technology studies; publishing bibliographies in specific areas of technology studies; publishing the *Science, Technology and Society Curriculum Development Newsletter*; maintenance of a data base of personnel, curricula, and materials resources in technology studies; sponsoring conferences, workshops, seminars, and institutes in technology studies; and integrating technology studies material with existing high school curricula and developing better courses in science and mathematics in cooperation with regional administrators and faculty.

For more information write to Stephen H. Cutcliffe, Director, Technology Studies Resource Center, Maginnes Hall, Lehigh University, 9 W. Packer Avenue, Bethlehem, Pa. 18015.

Other University Related Centers

Ben Franklin Technology Partners of Northeastern Pennsylvania

The Ben Franklin Technology Partners of Northeastern Pennsylvania (BFTP/NEP) is based on the Murray H. Goodman campus and is a wholly-owned subsidiary of Lehigh. The Center is part of a four-member state-funded economic development system that brings together the best of Pennsylvania's people, ideas, and technology and serves as a catalyst for advancing the state's technology economy. Ben Franklin frequently utilizes the faculty, students, and resources of Lehigh to accomplish its tasks.

BFTP/NEP fosters innovation to stimulate economic growth and prosperity. The center collaborates with educational institutions, communities, other economic development organizations, and government to help companies succeed. By providing knowledge and investment resources, Ben Franklin facilitates the creation of new products, sophisticated technologies, and fresh ideas among entrepreneurs and established companies to help them prosper. The result: the creation and retention of high quality local jobs and a strong economic climate. The goals of BFTP/NEP include helping early-stage technology-oriented businesses to form and grow, helping established manufacturers to improve productivity through the application of new technologies and practices, and promoting an innovative community-wide infrastructure that fosters a favorable business environment for high-growth companies.

Founded in 1983, the Ben Franklin Technology Partners of Northeastern Pennsylvania has:

- Created and retained over 21,900 jobs.
- Established 298 companies.
- Commercialized and implemented over 450 new products and processes.

The Ben Franklin program is structured to help companies achieve sustainable competitive advantage. BFTP/NEP is measured on the basis of the commercial success achieved by its clients as a direct result of assistance provided.

Assistance includes expertise, largely contributed in the northeast by the center's association with Lehigh University and other leading research universities, and funding, with investments ranging from $30,000 to $150,000 per year for up to three years. Faculty and students involved with Ben Franklin gain experience in solving real issues for working businesses. Technical and business assistance services are provided on a year-round basis.

The Northeast Center operates a business incubator on Lehigh's Mountaintop campus. The 12,000 square foot incubator holds up to ten start-up companies. Thirty companies have graduated from the BFTP/NEP incubator.

For the 2001 funding year, the Northeast Center received over $6.2 million from the state Department of Community and Economic Development, with nearly $11.3 million in matching funds committed from private-sector businesses, educational institutions and other sources.

For more information, contact the Ben Franklin Technology Partners of Northeastern Pennsylvania, Lehigh University, 125 Goodman Drive, Bethlehem, PA 18015-3715; 610-758-5200; www.nep.benfranklin.org. E-mail: info@nep.benfranklin.org.

Council on Tall Buildings and Urban Habitat

The Council on Tall Buildings and Urban Habitat, an international organization sponsored by engineering, architectural, planning and construction professionals, was established in 1969 to facilitate exchanges among those involved in all aspects of the planning, design, construction, and operation of tall buildings.

The Council's nine professional society sponsors are: International Association for Bridge and Structural Engineering, American Society of Civil Engineers, American Institute of Architects, American Planning Association, International Union of Architects, American Society of Interior Designers, Japan Structural Consultants Association, Urban Land Institute, and International Federation of Interior Designers. In 1974 the Council was admitted as a consulting nongovernmental organization to the United Nations Educational, Scientific and Cultural Organization.

Recognized as the source for information on tall buildings worldwide, the Council's mission is to disseminate information on healthy urban environments and tall building technology, maximize the international interaction of professionals involved in creating the built environment, and to make the latest knowledge available to professionals in a useful form.

The Council focuses on the role of tall buildings in the urban environment. Providing adequate space for life and work involves not only technological factors, but social and cultural aspects as well.

The Council hosts global conferences on the topics of tall buildings and the urban habitat and publishes the "CTBUH Review", which includes papers submitted by researchers, scholars, suppliers and practicing professionals who are engaged in the planning, design, construction and operation of tall buildings and the environment throughout the world. In addition, the Council operates the "High Rise Buildings Database" which contains date on thousands of tall buildings.

The Council is not an advocate for tall buildings, *per se,* but in those situations in which such buildings are viable, it seeks to encourage the use of the latest knowledge in their implementation.

The headquarters of the Council is at Lehigh University. Nearly 1,200 specialists, primarily engineers, architects, planners, and sociologists from 70 countries, are involved in the work of the Council, a number of whom provide advisory guidance for relevant Lehigh research projects.

For more detailed information, contact David M. Maola, Council on Tall Buildings and Urban Habitat, Lehigh University, 117 ATLSS Drive, Bethlehem, Pa. 18015; Phone: (610) 758-3515, Fax: (610) 758-4522; e-mail: *inctbuh@lehigh.edu.* Visit our website under Research Centers and Institutes on Lehigh's homepage or at *www.ctbuh.org.*

Manufacturers Resource Center

The mission of the Manufacturers Resource Center (MRC) is to help small and mid-sized manufacturers and related industries enhance their ability to compete successfully by providing them with strategic partnering, consulting and education. The MRC is a first stop, full service, highly responsive, easy-to-use resource center providing information, problem solving and funding assistance.

The MRC is one of seven statewide Industrial Resource Centers (IRCs) and one of 70 federally funded National Institute of Standards and Technology (NIST) Manufacturing Extension Partnership (MEP) centers.

Over the last twelve years, MRC has worked with approximately 500 companies on over 2,000 projects. The top six industries MRC has worked with include industrial/commercial machinery, fabricated materials, electronics, rubber/plastics, primary metals and chemicals. The top seven project types are lean manufacturing, quality management, business planning, management systems, business systems, and human resources/workforce development. The five main products groups for MRC are quality/lean manufacturing, operations (including IT), business practices, workforce development, and information technology/e-business.

The MRC serves Berks, Carbon, Lehigh, Northampton, and Schuylkill. Services are delivered through experienced staff and industry professionals, private and academic consultants, customized training programs, and Internet portals.

For further information or assistance, please contact Edith Ritter, Executive Director, at (610) 758-5599.

The Philip Rauch Center for Business Communications

The Rauch Center for Business Communications is an academic center of Lehigh University that aims to support and foster development of e-business paradigms within the College of Business and Economics. In addition, the Center focuses on the more traditional modes of business communication such as writing technique, rhetoric, and oral presentation skills. Philip Rauch, retired chairman of Parker Hannifin Corporation and a prominent member of Lehigh University's class of '33, established the Center in 1981 through a generous contribution.

The role of the Center is:

- To recognize and impart to students the communication skills needed to function in e-business today;
- To function as a faculty-friendly teaching, learning, and technology center;
- To support and develop the initiatives of affiliated CBE Centers, such as the Musser Center and the Small Business Development Center.

The Rauch Center for Business Communications is dedicated to providing students and faculty with an accessible, diversified, and up-to-date range of services, designed to most effectively meet current, and anticipate future business communication needs.

For more information, write to Robert R. Kendi, Director, The Philip Rauch Center for Business Communications, Rauch Business Center, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015-3117 or email rkk0@lehigh.edu or phone 610-758-4608.

Small Business Development Center

Established in 1978, the SBDC provides general management assistance to over 2,000 entrepreneurs and small businesses per year in the Lehigh Valley and surrounding areas. Primary funding for this program comes from major grants from the U.S. Small Business Administration and the Commonwealth of Pennsylvania.

Specialized Programs. The Management Assistance Program delivers general management consulting to existing small firms and start-up ventures. Services are offered to retail, service, wholesale, construction and manufacturing firms. Support is offered through electronic data base research. Seminars are offered on many topics of interest to growing firms.

The International Trade Development Program (ITDP) is a specialized outreach effort of the Small Business Development Center. The ITDP helps companies with exportable products to develop export marketing plans and establish direct contacts with international markets. Seminars, trade missions and research projects support the efforts of this program.

The Government Marketing Assistance Program assists potential suppliers to government in identifying and developing procedures. Clients are handled on a one-to-one basis. Trade fairs and seminars are also offered.

The Financing Assistance Program provides assistance in loan packaging and financial planning and helps clients identify appropriate financing sources. The program administers the Lehigh Valley Small Business Loan Pool and the Lehigh Valley Chapter of the Northeastern Pennsylvania Angel Network, a partnership program with the Ben Franklin Technology Partners of Northeastern PA. Contracts with the Lehigh/Northampton Revolving Loan Fund, the Lehigh Valley Economic Development Corporation and other funding agencies provide resources for this assistance.

The Lehigh Valley Export Network (LEXNET) is the regional office of the Team Pennsylvania Export Network. Throughout the year LEXNET brings PA foreign office representatives to the Lehigh Valley to meet with SBDC clients and discuss in-country export assistance needs. LEXNET also assists with export finance programs such as Market Access Grants allowing small and mid-sized manufacturing or service companies to participate in international trade events. Specialized training events and seminars are also held throughout the year.

Technology Business Development Program (TBDP) – The TBDP provides assistance to companies in the areas of technology, product development, patent searches, trademarks, copyright, Internet strategies, commercial potential, business socio-economic certifications and defense conversion. Special assistance with SBIR/STTR research funding opportunities is available. Clients are handled on a one-to-one basis. Seminars and workshops are also available.

Business Education and Training Program (BETP) – The Business Education and Training Program of the Small Business Development Center provides specialized workshops, seminars and customized training for the small business community. In addition, BETP hosts a quarterly Venture Luncheon Series, providing a networking forum for entrepreneurs and venture capitalists.

LUMAC. The Lehigh University Management Assistance Counseling program (a graded three-credit course) was established in 1972 on the initiative of undergraduate students. Through support from the SBDC, approximately 150 students per year gain practical experience by providing counseling to sixty businesses.

SCORE. The Service Corps of Retired Executives is associated with the SBDC. SCORE, which works most closely with the SBDC, is chartered by the U.S. Small Business Administration and provides business expertise to current or potential business owners.

For more information, write to Sandra Holsonback, Director, Small Business Development Center, Rauch Business Center, 621 Taylor Street, Bethlehem, PA 18015.

V. Courses, Programs and Curricula

This section includes listings of undergraduate and graduate courses offered by Lehigh University. For purposes of record, all approved courses are listed. It must be understood, however, that the offerings in any given semester are contingent upon a number of factors, including student needs as determined at the time of early registration.

All academic departments and programs are listed in alphabetical order.

Credit Hours

The number in parentheses following each course title indicates the credit value of the course in terms of semester hours ("credit hours").

Course Numbering

The course numbering system specifies which courses can be applied to the program of study as the student progresses toward the undergraduate or graduate degree. In general, the numbering series is as follows:

0-99. Courses primarily for freshmen or sophomores. Not available for graduate credit.

100-199. Intermediate-level undergraduate courses. Not open to freshmen except on petition. Not available for graduate credit.

200-299. Advanced undergraduate courses. Courses in the College of Business and Economics and specific departments as noted in the listings are open to freshmen and sophomores only on petition. Not available for graduate credit in the major field.

300-399. Advanced undergraduate courses. Same as 200-299, but available for graduate credit in major field.

400-499. Graduate-level courses, open to undergraduates only by petition.

Provisional Courses

Each instructional department is authorized to offer provisional courses, or those offered on a trial basis, as well as special opportunities courses. Such courses can become a permanent part of the university curriculum. These courses are numbered, as is appropriate, . . . 95-98 . . . 195-198, . . . 295-298, . . . 395-398, for a maximum of two semesters.

Apprentice Teaching and Cooperative Undergraduate Education

For details of these programs, see descriptions under "Apprentice Teaching" and "Cooperative Undergraduate Education," in section III.

Prerequisites

Academic preparation required for admission to courses is indicated under "prerequisites" included at the end of each course description. Prerequisites are stated in most cases for purposes of convenience in terms of Lehigh courses. Academic status required for admission, where numbering does not fully describe this status, is also indicated under "prerequisites."

A student who does not have the status (e.g., sophomore standing) or the academic preparation set forth as prerequisites must in order to be admitted to a course either obtain on line permission from the designated college or department officer or, file with the registrar at the time of registration and on a standard form provided, a waiver of prerequisites signed by the course instructor, the teaching department chair and either the chair of the student's major department or the associate dean. Academic work completed elsewhere must be attested in this manner as being substantially equivalent to prerequisites listed, unless the student's records in the Office of the Registrar show that the proper officers have so evaluated this preparation previously.

In a few cases, corequisites are indicated. In such instances the corequisite course is taken in the same semester.

Information Limits

The course descriptions are intended to guide the student in selecting appropriate courses. For reasons of space, descriptions are brief. In most cases, courses will have a significantly broader scope than the topics listed in the description. In some courses, material may change from what is described. If there is doubt concerning the appropriateness of any course for the individual's educational objectives, it is suggested that the student confer with the adviser.

Abbreviations

Whenever possible, course listings contain information indicating what requirements the course satisfies, the semester or semesters in which it is offered, and the name of the scheduled instructor or instructors.

While all information herein is subject to change, the information is included to serve as a guide in the selection of appropriate courses that best fulfill the student's academic requirements and personal goals.

The symbols following course descriptions for some College of Arts and Sciences courses include:

GC. Courses that meet the Global Citizenship program requirements.

HU. Courses that meet the Humanities distribution requirements.

NS. Courses that meet the Science distribution requirements.

SS. Courses that meet the Social Science distribution requirements.

MA. Courses that meet the Mathematical distribution requirements.

ND. Not designated to meet distribution requirements.

The symbols following course descriptions for some College of Engineering and Applied Science courses include:

ES. This code plus the following number indicates that the course satisfies a number of hours of engineering science requirements for ABET accreditation.

ED. This code plus the following number indicates that the course satisfies a number of hours of engineering design requirements for ABET accreditation.

Accounting

Professors. James A. Largay, III, Ph.D. (Cornell), *C.P.A.;* John W. Paul, Ph.D. (Lehigh), *C.P.A.;* Kenneth P. Sinclair, Ph.D. (Massachusetts), *chair, department of accounting.*

Associate professors. Karen M. Collins, Ph.D. (VPI), *C.P.A.;* Parveen P. Gupta, Ph.D. (Penn State); James A. Hall, Ph.D. (Oklahoma State); Manash R. Ray, Ph.D. (Penn State);

Assistant professor. Stephen L. Liedtka, Ph.D. (Maryland), *C.P.A.*

Professor of Practice. Paul N. Gordon, M.B.A. (University of Wisconsin at Madison), C.P.A

Adjunct professors. Daniel A. Bayak, M.B.A. (Scranton), *C.P.A., C.M.A;* Martin Rudolph, M.B.A. (Drexel), *C.P.A.*; Susan J. Toohey, M.A. (University of Northern Colorado), C.I.A., C.F.E; Kindra S. Walker, M.B.A. (New York University), C.P.A.

The Accounting Program offered through the Department of Accounting provides a variety of courses to support College of Business and Economics (CBE) core requirements and to provide an undergraduate major in accounting and a M.S. degree in accounting.

The mission of the Accounting Program is to provide rigorous professional accounting education that prepares high quality undergraduate and graduate students with diverse backgrounds for life-long learning and positions of leadership in the business community. Consistent with the missions of Lehigh University and the College of Business and Economics, the Accounting Program continuously seeks to be recognized as one of a select group of programs in the United States where an educational experience of the highest possible quality is obtainable.

Within the accounting major, there is an opportunity to explore the various career opportunities within the broad field of accounting: Public Accounting Assurance and Tax Services, Financial Services and Corporate Accounting, and Information Systems. In addition to the undergraduate program, the Master of Science in Accounting and Information Analysis degree offers an outstanding opportunity to prepare graduate students for a career in today's demanding field of accounting. Lehigh's unique program recognizes the impact of technology on business processes and the value chain while paying respect to the time honored usefulness of accounting information. The Accounting Program recognizes the learning objectives set forth by the College of Business and Economics as an integral part of the curriculum, as well as the importance of providing students with a strong foundation in liberal arts, humanities, and science as set out in the CBE core curriculum. In addition to the CBE core curriculum, the accounting curriculum is designed to foster the following learning objectives:

Skills:

- Cultivate and develop in each student, a capacity for life-long, self learning.
- Develop students' oral and written communication skills.
- Develop students' interpersonal skills, including interpersonal dynamics, leadership, teamwork, and negotiation.
- Develop students' problem-solving skills, including critical thinking and decision-making skills.

Content:

- Develop in each student an appreciation for the role of the accounting profession in the external business environment including societal, global, technological, ethical, legal, and regulatory issues.
- Provide students with a perspective of the role of the accounting professional in the internal business environment, including business strategy, organizational structure and behavior, uses of technology, ethics, diversity, and the interrelationship of business functional areas.
- Provide students with a theoretical framework and develop their ability to apply problem-solving skills in the areas of financial accounting, managerial accounting, information systems, auditing, and taxation.

To the extent that the above objectives are achieved, Accounting Program graduates will be well-prepared for positions in public accounting, industry, not-for-profit organizations, and graduate school. Although preparation for professional examinations is not a primary objective of Lehigh's Accounting Program, students successfully completing the Accounting Program will have the background to take professional examinations in accounting.

The Accounting Major

The undergraduate program in accounting is accredited by AACSB-The International Association for Management Education. This achievement places the program within a small group of schools which have satisfied a rigorous examination of the program, faculty, and students that extend beyond the accreditation standards applied to the entire College of Business and Economics undergraduate and graduate programs.

In addition to the existing sophomore prerequisites, Introduction to Financial Accounting (ACC 151) and Introduction to Managerial Accounting (ACC 152), accounting majors are required to take four junior-level, accounting core requirements (12 credits) and one concentration (9 credits):

Core Requirements (typically taken junior year)	**Credits**
Financial I and II (ACC 315 and 316)	6
Accounting Information Systems (ACC 311)	3
Cost Accounting (ACC 324)	3
	12
Concentration (typically taken senior year)– three courses, one of which is accounting	9
	21

The following three concentrations are available:

1. **Public Accounting Assurance and Tax Services**
   This concentration is suited for students interested in entering public accounting. This concentration requires the core and the following 9-credit concentration:
- Fundamentals of Federal Income Taxation (ACC 307)
- Fundamentals of Auditing (ACC 320)
- Advanced Financial Accounting (ACC 317)

2. **Financial Services and Corporate Accounting**
   This concentration may appeal to students seeking accounting positions at financial services firms and industrial corporations. For some time representatives from these companies have sought Lehigh students with a strong accounting background. External constituencies suggest that a dose of finance will strengthen these students and make them even more attractive.

Because Lehigh's finance faculty determined that two courses, Investments (FIN 323), and Corporate Financial Policy (FIN 328), are both needed to have a core understanding of finance, this second concentration requires these two courses. Also, a new course, Analysis of Financial Statements, ACC 318, is positioned at the interface of accounting and finance.

- Investments (FIN 323)
- Corporate Financial Policy (FIN 328)
- Analysis of Financial Statements (ACC 318)

3. **Information Systems**
Public accounting firms seek graduates for the rapidly growing area of global risk management (GRM). Students entering GRM will be responsible for assessing accounting system and computer risks that impact the financial statements of the organization and for evaluating internal controls in place to minimize such risks. Their findings become an important element in the conduct of the financial audit. This new career path thus requires students who possess strong systems skills and an understanding of financial accounting, management accounting, and auditing. Taxes and advanced financial accounting topics are less important in this setting. Therefore, the following courses comprise this concentration.

- Fundamentals of Auditing (ACC 320)
- Systems Analysis and Design (BIS 311)
- Electronic Commerce (BIS 331) or E-Business Systems (BIS 342) or Internship in Prague (BIS 360)

The description and requirements of the Master of Science in Accounting and Information Analysis Program are found under Graduate Study and Research.

Undergraduate Courses

ACCT 108. Fundamentals of Accounting (3)
A one-semester survey of accounting principles and practices designed for those students which includes an introduction to industrial cost systems designed for those non-CBE students planning to take only one accounting course. Other students should take the Acct 151-152 sequence.

ACCT 151. Introduction to Financial Accounting (3)
The organization, measurement and interpretation of economic information. Introduction to accounting theory, concepts and principles, the accounting cycle, information processing, and financial statements. Exposure to controversial issues concerning income determination and valuation. Prerequisite: sophomore standing and successful completion of Excel competency exam.

ACCT 152. Introduction to Managerial Accounting (3)
An introduction to internal accounting information for all levels of management. Topics include cost flow in a manufacturing operation; planning, evaluating and controlling through budgeting and standard costing; and decision-making using cost-volume-profit analysis, direct costing, and relevant costs. Prerequisite: Acct 151.

For Advanced Undergraduates and Graduate Students

Courses numbered 200 and above in the College of Business and Economics are open to sophomores only on petition.

ACCT 307. Fundamentals of Federal Income Taxation (3)
An introductory study of the principles and concepts of federal income taxation of individuals, corporations, partnerships, and fiduciaries; and federal gift and estate taxes. Determination of tax liabilities and opportunities for planning are emphasized. Problem-solving using the source materials of tax law and tax research are important components of the course. Prerequisite: Acct 151.

ACCT 309. Advanced Federal Income Taxation (3)
An advanced study of the taxation of business organizations, estates, trust, and wealth transfer taxes. Planning and research are the basic components of the course. Problem-solving and written research are emphasized. Prerequisite: Acct 307.

ACCT 311. Accounting Information Systems (3)
An introduction to the concepts underlying information systems as they relate to organizational structure, managerial decision making and accounting. The course acquaints students with the reports and documents generated by information systems, as well as procedures and controls employed in a variety of business applications. Students apply these concepts, techniques and procedures to the planning, analysis and design of manual and computer-based information systems. Prerequisite: Acct 152 and BIS 111.

ACCT 315. Financial Accounting I (3)
Intensive study of the basic concepts and principles of financial accounting, emphasizing the problems of fair presentation of an entity's financial position and operating results. Consideration of the conceptual framework of accounting, review of the accounting process, and measurement and valuation of current assets, current liabilities, plant assets, intangibles, investments, and long-term debt. Problem-solving skills and critical analysis are stressed. Prerequisite: Acct 152.

ACCT 316. Financial Accounting II (3)
The sequel to Accounting 315, this course continues with intensive study of such topics as stockholders' equity, valuation and disclosure of leases and pensions, income tax allocation, changing prices, revenue issues, earnings per share, and complexities related to the statement of changes in financial position. Analysis and interpretation of financial statements and problem-solving skills are integral parts of the course. Prerequisite: Acct 315.

ACCT 317. Advanced Financial Accounting (3)
A study of specialized topics in financial accounting, including partnership accounting, business combinations and consolidated financial statements, segment and interim reporting, foreign currency transactions and translation, and accounting and reporting for governmental and other nonprofit organizations. Involves considerable problem-solving and critical evaluation of controversial theoretical issues. Prerequisite: Acct 315 or 316.

ACCT 318. Analysis of Financial Statements (3)
This course uses financial statement information to analyze companies' profitability and risk. Understanding the form, content and relationships among the financial statements is integrated with the use of ratios and analytic adjustments to augment the information in published financial reports. Current developments, business strategies and off-balance-sheet financing are linked to assessments of companies, performance. Case studies, team projects and presentations involve actual compa-

nies, financial statements. Prerequisite: Acct 316 (may be taken concurrently); open only to graduating seniors.

ACCT 320. Fundamentals of Auditing (3)
An introduction to auditing theory, objectives, and practices related largely to the responsibilities of independent professional accountants. The auditing environment, generally accepted auditing standards, internal control theory, and reporting alternatives are considered. Exposure to operational auditing is provided. Prerequisites: Acct 311 and 315.

ACCT 324. Cost Accounting (3)
An in-depth study of cost concepts appropriate for product costing in a manufacturing operation, planning and controlling routine operations, and nonroutine decision-making. Topics include job order and process costing, joint and by-products, cost allocation, budgeting, standard costing, direct costing, cost-volume-profit analysis, and relevant costs for decisions. Prerequisite: Acct 152.

ACCT 371. Directed Readings (1-3)
Readings and research in various fields of accounting; designed for superior students who have a special interest in some topic or topics not covered by the regularly rostered courses. Written term paper(s) required. Prerequisite: preparation acceptable to the department chair.

ACCT 372. Special Topics (1-3)
Special problems and issues in accounting for which no regularly scheduled course work exists. When offered as group study, coverage varies according to interests of the instructor and students. Prerequisite: preparation in accounting acceptable to the program coordinator.

Course descriptions for the College of Business and Economics graduate courses can be found in this section (Section V) under the heading of *Business and Economics Graduate Courses.*

Africana Studies

Professors. William R. Scott, Ph.D. (Princeton), *Professor of History, program director;* Elizabeth N. Fifer, Ph.D. (Michigan), *Professor of English;* Jean R. Soderlund, Ph.D. (Temple), *Professor of History.*

Associate professors. Berrisford W. Boothe, M.F.A (Maryland Institute College of Art), *Associate Professor of Art and Architecture.*

Assistant professors. Seth Moglen, Ph.D. (UC Berkeley), *Assistant Professor of English;* Heather Johnson, Ph.D. (Northeastern University); *Assistant Professor of Sociology and Anthropology;* Kashi Johnson, MFA (University of Pittsburgh)

Adjunct professors. Mildred Rivera- Martinez, Ph.D. (Stanford University); Sharon Levy, Ed.D. (Lehigh); Jeffrey B. Fleisher, Ph.D. (University of Virginia).

The purpose of the Africana Studies Program is to engender in Lehigh students an intellectual appreciation of the life and culture of people of African descent worldwide, especially in the United States, thereby enriching the Lehigh curriculum and increasing the relevance of a Lehigh education to a culturally diverse society and world. In the best tradition of a liberal arts education, Africana Studies expands all Lehigh students' critical understanding of their own heritage in interaction with other cultures.

The major and minor in Africana Studies constitute an interdepartmental and comparative program of study for undergraduates who wish to integrate the insights and methods of several disciplines to understand the history, culture, social, and political experience of people of African descent globally. The Africana Studies curriculum encompasses two intended lines of inquiry: (1) the diverse influences in Africa and the African diaspora that have shaped African American culture, and (2) the variety of ways that the African American experience has shaped and been shaped by American culture.

The Major

The major in Africana Studies consists of a minimum of ten (10) courses, constituting at least 30 credit hours and no less than four (4) upper level courses. It entails training across disciplinary lines as well as concentrated study in a single discipline:

Introductory Course	(1)
Humanities	(3)
Social Sciences	(3)
Disciplinary Concentration	(3)

In addition, students are encouraged to pursue independent study opportunities to enhance their knowledge of specific aspects of Africana Studies.

The Minor

The minor consists of a minimum of five (5) courses, constituting at least 15 hours of study that includes the introductory course and no less than two upper level courses in the field.

Core Courses:

Core courses concentrate on subject material directly relevant to the study of past and present experiences of people of African descent.

AAS 3. Introduction to Africana Studies (4)
An interdisciplinary examination of the roots, culture, and politics of the modern black world through study of classic works in Africana Studies with emphasis on the continuities among African peoples worldwide and the social forces that have shaped contemporary black life in Africa and the Americas. Scott. (SS)

AAS 5. (HIST 5) African Civilization (4)
Sub-Saharan Africa through the millennia of the ancient world to the present. Human origins, state and non-state systems, the external slave trade; colonialism, resistance to European rule; independence movements; neocolonialism. Scott. (SS)

AAS 38. (ENGL 38) Introduction to African Literature (3)
Sub-Saharan African literary themes and styles, historical and social contexts, African folk tales, oral poetry, colonial protest literature, postcolonial writing, films on contemporary Africa. Staff. (HU)

AAS 64. (ECO 64, HIST 64) Plantation to Ghetto (2)
Examination of topics in the economic history of African Americans from the 1500s to the present. Explores the slave trade, slavery, post-Civil War South, the black family, migration, urbanization, and race and poverty. O'Brien, Scott. (SS)

AAS 103. (SSP 103) Race and Ethnicity (4) fall
Examines race and ethnicity from a sociological perspective. Focus on the role of the major racial and ethnic communities in modern American society. Explores the

roles of race and ethnicity in identity, social relations, and social inequality. Topics include racial and ethnic communities, minority/majority groups, assimilation, prejudice/discrimination, identity and the social construction of the concept of "race." H. Johnson. (SS)

AAS 129. (HIST 129) Black Political Thought in America (4)
Black leadership, organizations, and philosophy in America from Reconstruction to the Civil Rights Era; ideas and programs of Booker T. Washington, W.E.B. DuBois, Marcus Garvey, Malcolm X and Martin Luther King, Jr. Scott. (SS)

AAS 130. (HIST 130) African American History (4)
Blacks in America from the first importation of Africans to the implementation of civil rights laws. West African origins, slave trade, slavery, free blacks and emancipation and study of Reconstruction, segregation, urbanization, and the struggle for racial equality. Staff. (SS)

AAS 138. Introduction to African American Literature (4)
Survey of African American prose narrative and poetry from the 18th century to the present. Features writers from the Harlem Renaissance, the Black Arts Movement, and the post-Black Power era. Levy. (HU)

AAS 140. (THTR 140) African American Theatre (4)
Foundations of African American theater: historical, literary, and practical. K.Johnson. (HU)

AAS 142.(PSYC 142) The Psychology of African Americans (4)
Exploration of scholarship on the attitudes and actions of black Americans stressing the psychological dynamics, popular culture and behavior of contemporary African Americans. Staff. (SS)

AAS 145. (WS 145) African American Women Writers (4)
Literature by African American women writers with a focus on the experiences and images of black women in the U.S. Explores the written portraits and voices of 20th century black female novelists and poets, including Hurston, Petry, Morrison, Angelou, and Walker. Levy. (HU)

AAS 148. Cultural Diversity in the Caribbean (4)
Cultural diversity in the Caribbean islands and the Guyanas, with emphasis on the African, Amerindian, and Indian influences. The sociological and cultural implications of the region's diversity, with special emphasis on ethnicity, slavery and indenture, emancipation and independence, modernization, immigration, the impact of tourism and the development of Creole cultures. Lecture and discussion. Rivera-Martinez. (SS)

AAS 150. (ART 150) Africans in the New World (3)
African American art, architecture, and craft from precolonial Africa to the present. Early primitivism, neo-classicism, the Harlem renaissance, modernism, and contemporary directions. Guest lecturers, open dialogue, gallery visits, and media presentations. Writing Intensive. Staff. (HU)

AAS 166. (SSP 166) Wealth and Poverty in the United States (4)
Examines the sociology of wealth and poverty — affluence and disadvantage, "rags and riches" — in American Society. Focus is a critical analysis of the wealth gap, its causes, consequences and social context. We will consider the roles of wealth and poverty in determining life chances and structuring opportunity, as well as their roles in the perpetuation of social inequality across generations. We will address contemporary debates surrounding public policy, tax laws, anti-poverty programs and other reform efforts aimed at decreasing the gap between the "Haves" and the "Have-Nots." H. Johnson (SS)

AAS 263. Caribbean Artistic and Cultural Traditions (4)
Representation of contemporary popular culture in the Caribbean in literature, music, painting and other artistic expressions. Major attention is devoted to the influences on tradition, folklore and religion in modern Caribbean life. Martinez-Rivera. (HU)

AAS 310. (SSP 310, WS 310) Gender, Race and Sexuality: The Social Construction of Differences (4)
This course will provide the student with an opportunity to engage current debates about the meaning and use of racial and sexual classification systems in society. Using a multidisciplinary and critical approach, we will examine the historical and sociological contexts in which specific theories of racial and sexual differences emerged in the U S. Prerequisite: SSP 103, or department permission. Staff. (SS)

AAS 331. (HIST 331) United States and Africa (4)
Reciprocal relationships between North America and the African continent from the slave trade in the seventeenth century to the twentieth century Afrocentric movement; impact of Americans on shaping of modern Africa, Pan-African relations; influence of African Americans on U.S. policies toward Africa. Scott. (SS)

AAS 332. (HIST 332) Slavery and the American South (4)
The emergence and demise of the "peculiar institution" of African American slavery in British North America and the Old South. African background, colonial beginnings, 19th century slave community, the ruling race and proslavery ideology, the death of slavery and its aftermath, slavery and freedom in a comparative context. Staff (SS)

AAS 359. (HIST 359) History of South Africa (4)
South Africa's history from its earliest human settlement to its emergence as a racist political order and transition to a non-racial democratic state. Includes comparisons with political thought and practices in the U.S. Scott. (SS)

AAS 371, 372. Independent Study (1-3)
Independent study in advanced areas of Africana Studies. Independent research with an individual faculty member in the Africana Studies program. Consent of director. (ND)

AAS 379. (SSP 379) Race and Class in America (4)
The ways in which race and class intersect in the social, economic, and political structures of American society. Through sociological literature, fiction, non-fiction, film, and other media we will explore the place of race and class in American society. We will examine how race and class operate on a personal, "micro" level, while at the same time operating on a large-scale, "macro" level. H. Johnson. (SS)

AAS 381. Special Topics. (ND)

AAS 382. Seminar on a topic in Africana Studies. (ND)

Collateral Courses

ANTH 12	Human Evolution and Prehistory
HIST 334	American City in the 20^{th} Century
POLS 330	Movements and Legacies of the 1960s
POLS 352	Civil Rights
POLS 322	Politics of Developing Nations

American Studies

American Studies Faculty. John Pettegrew, Ph.D. (Wisconsin), *associate professor of history, Director of the American Studies Program*; David Amidon, Jr., M.A. (Penn State), *professor of urban studies;* Peter G. Beidler, Ph.D. (Lehigh), *Lucy G. Moses Distinguished Professor of English*; Gail A. Cooper, Ph.D. (UC., Santa Barbara), associate professor of history; Berrisford Booth, M.F.A. *associate professor* (Maryland Institute College of Art); Stephen H. Cutcliffe, Ph.D. (Lehigh), *associate professor of history;* Alex Doty, Ph.D. (Illinois), *professor of English*; Edward J. Gallagher, Ph.D. (Notre Dame), *professor of English*; Norman J. Girardot, Ph.D. (Chicago), *professor of religion studies*; Heather Johnson, PhD (Northeastern), *assistant professor of sociology;* Dawn Keetley, Ph.D. (Wisconsin), *assistant professor of English*; Judith N. Lasker, Ph.D. (Harvard), *professor of sociology*; Alexander Levine, Ph.D. (U.C., San Diego), *associate professor of philosophy*; Jack Lule, Ph.D. (Georgia), *professor of journalism*; James R. McIntosh, Ph.D. (Syracuse), *professor of sociology*; Richard K. Mathews, Ph.D. (Toronto), *distinguished professor of political science*; Seth Moglen, Ph.D. (U.C., Berkeley), *assistant professor of English*; Edward T. Morgan, Ph.D. (Brandeis), *professor of political science*; Monica Najar, Ph.D. (Wisconsin), *assistant professor of history;* Kathy Olson, Ph.D. (North Carolina), *assistant professor of journalism;* Michael L. Raposa, Ph.D. (Pennsylvania), *professor of religion studies*; William R. Scott, Ph.D. (Princeton), *professor of history*; Roger D. Simon, Ph.D. (Wisconsin), *professor of history;* John K. Smith, Ph.D. (Delaware), *associate professor of history;* Jean R. Soderlund, Ph.D. (Temple), *professor of history*; Albert Wurth, Ph.D. (North Carolina), *associate professor of political science*.

American Studies is the interdisciplinary study of American thought, literature, and culture–both past and present. Born in the early years of the Cold War and with an implied commitment to American exceptionalism, American Studies has since transformed itself into a multi-faceted critical examination of United States society. Comparative frameworks along with close attention to applying cultural and literary theory to such matters as violence, citizenship, democracy, community, poverty and prosperity, politics, race, and gender in the United States make American Studies an intellectually sophisticated yet practical course of undergraduate study.

American Studies is an excellent major for those seeking a general education in the liberal arts and social sciences. Students have found it a particularly good major for careers in journalism, law, and teaching.

Lehigh in New York Summer Program

The American Studies Program hosts a six-week summer academic session in New York City. Several professors of History, Sociology and Anthropology, Art and Architecture, English, and other departments contribute their teaching and research expertise on New York City to the program.

Lehigh in New York combines course work on New York culture, art, and history with experiential learning in the city itself. Walking tours, theatre, art museums, and just hanging out deepen students' classroom study of one of the world's great cities.

Students stay in a New York University dormitory in Greenwich Village and attend classes within easy walking distance. The program cost includes eight Lehigh University undergraduate credits, dormitory room, meal plan, and special events.

Each student selects two courses out of three or four that are normally offered. Courses offered usually include The History of New York City's Built Environment (HIST 96) and TV in New York and Beyond (COMM/HIST/SSP 197).

Requirements for the major:

The American Studies major consists of a minimum of 35 credit hours, normally ten courses. The major must complete the following three groups of courses:

I. Four Required Courses

AMST 101	Introduction to American Studies (4)
AMST 372	Special Topics Seminar in American Studies (4)
AMST 391	Senior Thesis or Project (2)
AMST 392	Senior Thesis or Project (4)

II. Three Courses Split between the Departments of English and History (a minimum of nine credits)–at least one course must be at the 200 level or higher

III. Three Further Courses on a Topical or Chronological Focus (a minimum of nine credits), one of which must be outside English and History. At least one course must be at the 200-level or higher.

In close consultation with his/her adviser, majors will select a topical focus (e.g., ethnicity and race, film and electronic media, art and literature, popular culture, gender, cross-cultural studies, legal and political thought) or a chronological focus (e.g., antebellum America, the twentieth century), which they will explore in at least three courses plus their senior thesis or project.

Core American Studies Courses:

AAS 138	Introduction to African American Literature
AAS 140	African American Theater
AAS 145	African American Writers
AAS 150	Africans in the New World
ARCH 107	History of American Art
ART 150	Africans in the New World
ENGL 123	American Literature I
ENGL 124	American Literature II
ENGL 163	Topics in Film Studies
ENGL 316	Native American Literature
ENGL 376	Early American Literature
ENGL 377	American Romanticism
ENGL 378	American Realism
ENGL 379	Twentieth-Century American Literature
ENGL 380	Contemporary American Literature
ENGL 387	Film History, Theory and Criticism
HIST 41	United States to 1865
HIST 42	United States, 1865-1941
HIST 43	United States Since 1939
HIST 64	Plantation to Ghetto
HIST 124	Women in America

HIST 129	Black Political Thought in America
HIST 130	African American History
HIST 315	American Environmental History
HIST 323	American Cultural History Since 1900
HIST 325	History of Sexuality and the Family in the U.S.
HIST 328	American Intellectual History since 1900
HIST 331	United States and Africa
HIST 332	Slavery and the American South
HIST 360	American Legal History
PHIL 239	Figures/Themes in Contemporary Philosophy
POLS 227	Socialization and the Political System
POLS 229	Propaganda, media, and American Politics
POLS 230	Movements and Legacies of the 1960s
POLS 251	Constitutional Law
POLS 252	Civil Rights and Civil Liberties
POLS 267	American Political Thought
POLS 271	U.S. Politics and the Environment
REL 152	American Judaism
REL 180	Religion and the American Experience
SSP 103	Sociological Perspectives on Racial and Ethnic Communities
SSP 310	Gender, Race, and Sexuality: The Social Construction of Differences
SSP 379	Race and Class in America
SSP 394	Historical Sociology: Identity and the Social Problems of Generations

This is not a comprehensive list. New courses may be offered each semester. Students should check with the director for an updated list.

Courses:

AMST 101. Introduction to American Studies (4)
An introduction to the methods, concerns, and practices of American Studies through the examination of a critical decade of cultural transformation (e.g. the 1770s, 1850s, 1890s, 1930s or 1970s). Will draw on literature , philosophy, painting, architecture, landscape design, social thought and cultural criticism, crime, reform movements, sports, and popular culture to explore such topics as responses to economic change, ideas of nature and culture, the meaning of work and leisure, law and politics, race, construction of gender, family structure, population dynamics, science and technology, sexuality, class, urban experience, and the American polity.

AMST 372. Special Topics in American Studies (4)
Focused interdisciplinary study of one particular subject area in American culture.

AMST 391. Senior Thesis or Project (2)
Independent work with an individual faculty member on a research thesis or other project approved by faculty member and adviser.

AMST 392. Senior Thesis or Project (4)
Continuation of AMST 391.

Graduate Work in American Studies

A Master of Arts degree in American Studies is offered jointly by the departments of English and History. Candidates for the master's degree must complete at least 30 credit hours. In addition to the Theory and Method course, students must choose two courses in American history and two courses in American literature and film from those offered by the history department and the English department. Students must also take one special topics seminar. The other four courses for the master's degree will be divided between thesis or "thesis paper" credits and American Studies courses not in history or literature/film. To fulfill the thesis requirement, students will write one longer thesis or two thesis papers that are aimed at conference presentation and/or publication.

Courses:

AMST. 400. American Studies: Theory and Method
An introduction to the theoretical orientations and methodological strategies of American Studies. Seminar involves extensive reading as well as application of theory and method to students' research.

AMST. 401. Special Topics in American Studies
Graduate seminar focused on one particular subject area in American Culture.

Anthropology

See listings under Sociology and Anthropology.

Applied Mathematics and Statistics

Professors. Bennett Eisenberg, Ph.D. (M.I.T.); B. K. Ghosh, Ph.D. (London); Wei-Min Huang, Ph.D. (Rochester); Eric P. Salathe, Ph.D. (Brown); Joseph E. Yukich, Ph.D. (M.I.T.).

Associate professors. Garth Isaak, Ph.D. (Rutgers); Ramamirthan Venkataraman, Ph.D. (Brown).

The Division of Applied Mathematics and Statistics was established within the Department of Mathematics to promote and administer undergraduate and graduate education in applied mathematics and statistics, and to foster interdisciplinary research in the mathematical sciences at Lehigh. Courses and programs offered by the division may be found under the departmental listing.

Applied Sciences

Director, associate dean of the P.C. Rossin College of Engineering and Applied Science

The Applied Science Program enables students to create interdisciplinary specialties that prepare them for careers in a world that increasingly bridges academic disciplines. Students pursue subject-area concentrations that represent academic interests they wish to integrate into a meaningful program. The core offers students the intellectual tools to identify connections between the concentrations and engage in interdisciplinary problem-solving and critical thinking.

The program leads to the Bachelor of Science in Applied Science. Each student's curriculum combines a general engineering education with a carefully customized concentration in engineering and/or science as well as another area of emphasis, which may include courses taken inside the PC Rossin College of Engineering & Applied Science *and may also include* courses taken in one or more of the other three Colleges within the University.

In order to ensure the success of this individualized approach to education, Applied Science places primary emphasis on advisement. Each student is teamed with an advisor who helps the student plan the course of study and who supervises independent study and internships. The advisor remains the student's advisor throughout his or her undergraduate career.

Unlike students in the traditional college programs, students in the Applied Science program of individualized study do not declare a major in a particular academic department. Instead, they develop a concentration that may combine study in several areas. Students are encouraged by their advisor to develop the concentration in such a way that the student will be well prepared for further study in graduate school or for pursuing a particular career path.While the chosen concentration can be highly customized in consultation with the advisor, examples of concentrations include: Technical Communications, Digital Media, Entertainment Science, Technology/Science and Education, Technology/Science and Pre-law, Technology/Science and Pre-Medicine, Technology Management, Technology Marketing, and Engineering and Architecture. Many other combinations are possible.

The College of Engineering & Applied Science requirements in math and basic sciences, as well as the humanities and social science requirements must also be satisfied.

Recommended Sequence of Courses

first engineering year (see Section III)

sophomore year, first semester (15 credits)

EES 31	Introduction to Environmental and Organic Biology (4) or
EES 21	Introduction to Earth Materials and Processes and Laboratory (4)
CHM 51, 53	Organic Chemistry and Laboratory (4)
MATH 23	Analytic Geometry and Calculus III (4)
ECO 1	Principles of Economics (4)

sophomore year, second semester (17 credits)

	major subject (3)
	approved elective (3)
MATH 205	Linear Methods (3)
PHYS 21, 22	Introductory Physics II and Laboratory (5)
	HSS elective (3)

junior year, first semester (16 credit hours)

EES 21	Introduction to Earth Materials and Processes and Laboratory (4) or
EES 31, 32	Introduction to Environmental/ Organismal Biology and Laboratory (4)
PSYC 1	Introduction to Psychology (4)
MATH 231	Probability and Statistics (3)
	major (3)
	HSS elective (3)

junior year, second semester (15 credit hours)

	approved electives (6)
	major (6)
	elective (3)

senior year, first semester (18 credit hours)

	approved electives (6)
	major (6)
	HSS elective (3)
	free elective (3)

senior year, second semester (18 credits)

PHIL 128:	Philosophy of Science (3)
	approved elective (3)
	major (6)
	HSS elective (3)
	free elective (3)

Apprentice Teaching

300. Apprentice Teaching (1-4)
Supervised participation in various aspects of the teaching of a course. Transcript will identify department in which apprentice teaching was performed. Prerequisite: consent of department chairperson. The transcript will reflect the subject area in which the teaching was done.

Art and Architecture

Professors. Lucy Gans, M.F.A. (Pratt); Tom F. Peters, M.ARCH (ETH Zurich dipl.ARCH.ETH) and Dr.sc. (techn.) ETH Zurich, director, Building and Architectural Technology Institute; Ricardo Viera, M.F.A. (R.I.S.D.), director of Lehigh University Art Galleries; Ivan Zaknic, M. ARCH. and Urban Planning (Princeton).

Associate professors. Berrisford W. Boothe, M.F.A. (Maryland Institute College of Art); Amy Forsyth, M.ARCH (Princeton University); Bruce Thomas, Ph.D. (University of Calif., Berkeley), Anthony Viscardi, M.ARCH (Georgia Institute of Technology).

Professor's of Practice. Douglas Mason, B.F.A. (R.I.S.D), Christine Ussler, M.ARCH (Columbia University).

Lecturer. Ann Priester, Ph.D. (Princeton).

The department of art and architecture offers two major programs:

The **architecture major** is a multidisciplinary major based in a department that draws on the resources of all Lehigh's colleges. Although architectural design is the primary concern of this major, other courses in architectural history, art studio and technology are also required. A special track is available within the architecture major for students interested in architectural history.

The architecture major leads to the liberal arts B.A. (Bachelor of Arts), a pre-professional four-year degree. This degree is satisfactory for admission to graduate study in architecture and candidacy for the M.ARCH. professional degree.

In recent years students have gone on to graduate study in architecture at Yale, Harvard, Columbia, University of Pennsylvania, Maryland and Washington University, among other schools, or to entry-level employment in the profession.

The Arts/Engineering five-year degree, in which the student earns both B.A. (architecture) and B.S. (civil engineering), is available for those interested in both fields.

A **major in art** introduces the student to the basic media of art such as drawing, sculpture, printmaking, painting, and photography. For those interested in becoming creative artists, intensive study at Lehigh as well as the other Lehigh Valley colleges is recommended; such students can expect to take more than the required number of credits for the major. Cooperation with Moravian College allows students to register for art courses not offered at Lehigh, such as ceramics. A major in art may also focus on museum studies, graphic design, or product and industrial design.

A major in art may also be combined with a series of linked, interdisciplinary courses known as Integrated Product Development (IPD), focusing on industrial products.

A major in art can also be combined with psychology for those who seek a career in art therapy. It may also be combined with theater for those interested in costume design or with architecture and theater for those interested in set design. A major in art and minor in education is available for students interested in becoming public school art teachers. A special track is available within the art major for students interested in art history.

The resources of the Lehigh University art collection and the Zoellner Art Center are made available to many students taking classes in art. Prints, photographs, and paintings are often brought into the classroom and visits to art exhibitions on campus and elsewhere in the Lehigh Valley are a common part of art instruction.

The Lehigh University Art Galleries maintain and develop the university's permanent art collection. LUAG presents temporary exhibitions, designed to provide visual literacy as part of the university learning experience. Exhibitions and gallery events supplement formal classroom study across the disciplines and create educational opportunities for the student body, enriching the cultural life of the campus and community at large. The university's public collection of outdoor sculpture, in a variety of sizes and materials such as steel, aluminum, bronze, slate and wood, can be found on all three campuses.

Approximately 20 exhibitions a year introduce contemporary topics in art and culture. The exhibition schedule includes gallery talks, lectures and workshops, as well as opportunities for research in the permanent collection. Experts in various fields serve as guest curators of special projects.

In addition to these two major programs, individually structured programs may be planned, such as art or architecture with an emphasis in history, art history with an emphasis on museum training, and architecture with an emphasis on planning, urban studies, graphic design, or government. Minor programs are available in art, with an emphasis on studio art, art/architectural history, graphic communication, and museum studies. Course requirements are specified, and a list of courses acceptable for the minor is available in the department.

Note: A student must achieve a 2.0 or higher in each major course.

Departmental Honors:

Exceptional students in art or architecture may apply for departmental honors at the end of their junior year or beginning of their senior year. To be eligible, a student must have attained a 3.5 GPA in her/his major program and a minimum overall GPA of 3.0. Candidates should submit to the department chair a written proposal, prepared in consultation with a faculty advisor. The project could result in a research paper, design project, or exhibition, accompanied by an oral presentation. Successful completion of the project and presentation would result in the "Departmental Honors" designation being affixed to the student's transcript.

Art Major

Forty-three credit hours are required.

Required courses (22 credit hours)

ART 1 or ARCH 1	Art History 1 or Architectural History I (3)
ART 2	Art History II (3)
ART 3/DES 3	Design Foundations I (3)
ART 4/DES 4	Design Foundations II (3)
ART 13	Sculpture I (3)
ART 15	Figure I (3)
ART 120	20th-Century Art (4)

plus one of the following (3 credit hours)

ART 22/REL 22	Visions of God: 2000 Years of Christian History and Art (4)
ART 121/WS 121	Women in Art (4)
ART 150/AAS 150	Africans in the New World (3)
ART 175	Introduction to Museum Work (3)
ART 206/ARCH 206	Medieval Art and Architecture (3)
ART 207/ARCH 207	Renaissance Art and Architecture (3)
ARCH 210	20th-Century Architecture (3)
ART 222	Seminar in Contemporary Art (3)

plus six studio major courses (18 credit hours)

Art studio; six courses, two at the advanced level

Students who desire an art history concentration are required to take ART 1 or ARCH 1 and ART 2, ART 3, ART 4, ART 120 plus one other studio. At least six courses in the history or philosophy of art and/or architecture must be selected in consultation with the instructor.

Architecture Major

Fifty-two credit hours are required.

Design Sequence (22 credit hours)

ARCH 43	Architectural Design I (4)
ARCH 143	Architectural Design II (6)
ARCH 243	Architectural Design III (6)
ARCH 343	Architectural Design IV (6)

Art Studio (12 credit hours)

ART 3/DES 3	Design Foundations I (3)
ART 4/DES 4	Design Foundations II (3)

plus two other studios (various choices) (6)

Architectural History (9 credit hours)

ART 1 or ARCH 1	Art History 1 or Architectural History 1 (3)
ARCH 2	Architectural History II (3)
ARCH 210	20th Century Architecture (3)

Materials and Building Systems (3 credit hours)

ARCH 147	Building Materials and Methods (3)

Architecture and its intellectual context (6 credit hours) (including Architecture and Technology courses)

ARCH 107	History of American Architecture (3)
ARCH 204/CLSS	Ancient City and Society (3)
ARCH 206/ART 206	Medieval Art and Architecture (3)
ARCH 207/ART 207	Renaissance Art and Architecture (3)
ARCH 209	Architecture and Ideas (3)
ARCH 213	The City (3)

ARCH 2	The Architecture of Carlos Scarpa/Theory and Practice (3)
ARCH 253	Paris, The Planning of a Metropolis (3)
ARCH 254	Modern Architecture in France: New Directions (3)
ARCH 342	Theory of Architecture (3)
ARCH 367	Modernism to Post-Modernism (3)
ANTH 335	Religion, Symbolism and Cosmology (4)
ECO 311	Environmental Economics (3)
ECO 312	Urban Economics (3)
HIST 334	American Urban History (4)
PHIL 123	Aesthetics (3)
PSYC 373	Sensation and Perception (4)
US 62	Contemporary Urban Issues (4)
US 363	Philadelphia: Development of a Metropolis (4)
Architecture and Technology	
ARCH 10/CEE 10	Engineering/Architectural Graphics and Design (3)
ARCH 361/HIST 361	Evolution of Highrise Building Construction(3)
ARCH 363/HIST 363	Evolution of Long-span Bridge Building (3)
ARCH 365/HIST 365	Evolution of the Modern Building Techniques (3)

For the architecture major, students must fulfill the mathematics requirement with MATH 21 & 22 or MATH 51 & 52 or MATH 75/76 *and* MATH 22 or MATH 52; the physical science requirement must be filled with PHYS 10 or 11 *and* 12.

ARCH 5 Introduction to Architecture (2) and ARCH 6 Introduction to Architectural Drawing (2) are recommended for first-year students. A typical first semester schedule might include ART /ARCH 1, ART /Architectural History I [required for major], ART 3/DES 3 Design Foundations I [required for major] and ARCH 5 Introduction to Architecture [recommended for major]. A typical second semester schedule might include ARCH 2 Architectural History II [required for major], and ART 4/DES 4 Design Foundations II [required for major].

For students contemplating graduate studies in architecture, MECH 2 is recommended.

Undergraduate Courses in Art

ART 1. Art History: Ancient and Medieval (3) fall
Survey of major monuments of art and architecture from the prehistoric caves of Lascaux and Altamira through the Gothic cathedrals of Chartres and Notre-Dame of Paris, along with highlights of art and architecture of the non-Western civilizations of Africa, India, and China. Work seen in the context of cultural, historical, and technological developments. Priester. (HU)

ART 2. Art History: Renaissance to Present (3) spring
Survey of Western painting and sculpture from Renaissance to present. Priester. (HU)

ART 3 (DES 3). Design Foundations I (3)
An introduction to the basic elements and principles of design. Course involves use of various materials to solve 2-D design problems in studio and computer lab. Required for all majors in department. Staff (HU)

ART 4 (DES 4). Design Foundations II (3)
An introduction to the basic elements and principles of design. Course involves use of various materials to solve 3-D design problems in studio and computer lab. Problem solving in variety of materials for 3-D design including assemblages, models, constructions, and conceptual forms. Required for all majors in department. Staff (HU)

ART 11. Drawing I (3)
Concepts and practice of drawing, both traditional and contemporary. Includes drawing from life and an introduction to materials and techniques. Staff. (HU)

ART 13. Sculpture I (3)
Projects directed toward developing design in sculpture. Exploration of materials and their application. Emphasis on sculptural form as it relates to techniques. Gans. (HU)

ART 15. Figure I (3)
Drawing and modeling in clay from direct observation of the human figure. Fundamental principles of drawing, and two- and three- dimensional design through analysis of the human form. In-class exercises cover basic scale, proportion, structure, drawing media and techniques, and clay modeling. Emphasis on personal expression, the human figure as vehicle for narrative, abstract or formal drawings or sculpture. Gans. (HU)

ART 22 (REL 22). Visions of God: 2000 Years of Christian History and Art (4)
An interdisciplinary course that combines art history and the history of Christianity. From the beginnings of their tradition, Christians have represented their theologies and religious sentiments in visual arts and architecture, and for the same two millennia, a myriad of Christians have learned their Christianity through visual representations. Provides a one-semester survey of the history of Christianity as expressed in the visual arts. Priester/Wright (HU)

ART 35. Painting I (3)
Painting in oil beginning with color mixing and basic layering techniques. Students learn the basic mechanisms for creative expression. Emphasis on understanding the physical nature of the materials. Studio prerequisite: ART 3, 4, 11 or consent of instructor. Boothe. (HU)

ART 37. Survey of Printmaking I (3) fall
Introduction to various techniques in relief and intaglio printing: monoprints, woodcuts, linocuts, drypoint, etching grounds, aquatint, and other intaglio techniques. Includes an historical survey through slides and actual examples. Viera. (HU)

ART 38. Survey of Printmaking II (3) spring
Introduction to the fundamentals of stone and metal lithography and the basics of screen printing as a fine art print medium: various screen stencils, blockouts, and color transparencies; drawing methods and transfer. Includes an historical survey through slides and actual examples. Viera (HU)

ART 53 (DES 53). Graphic Design I (3) fall and spring
Design principles are explored with emphasis on visual communication. Students learn basic concepts for design and typography including the vocabulary and historical precedence of graphic design and computer graphics. Introduction to professional-level formal exercises contributes to the development of visual thinking and original ideas. Prerequisite: ART 3/DES 3. Staff (HU)

ART 68 (DES 68). Color Theory (3)
Application of color in design. Color in graphics, product, digital imaging, and all related fields of design. (HU)

ART 73. Introductory Studio Practice (1-3)
An introduction to the methods and techniques of studio art. Designed to acquaint the student with general studio practice, covering topics not covered in other specific studio course listings. May be repeated for credit. Staff (ND)

ART 77. Photography I (3)
Introduction to photography as a fine art. Emphasis on interaction of technique, perception and communication in making and responding to photographic image. Lectures, demonstrations, critiques. Students must provide own hand camera. Mason. (HU)

ART 111. Drawing II (3)
Projects in creative drawing designed to build on concepts and practices initiated in basic drawing and life drawing. Prerequisite: ART 11. Staff. (HU)

ART 113. Sculpture II (3)
Development of principles and techniques in Sculpture I. Modeling, casting, fabrication and carving. Emphasizes an approach to sculptural form and an exploration of the evolution of modern sculpture. Prerequisite: ART 13. Gans. (HU)

ART 115. Figure II (3)
Projects in figure modeling and drawing from direct observation of the human figure, designed to build on concepts and practices initiated in Figure I. Students may elect to concentrate in one particular medium, although the primary investigation of form will always incorporate both two- and three-dimensional work. Prerequisite: ART 15. Gans. (HU)

ART 120. 20^{th}-Century Art (4)
A survey of the major movements of 20^{th} century art including Cubism, Expressionism, Surrealism, Abstract Expressionism, Pop, Minimalism, Conceptual Art, Feminism and Post-Modernism. Priester. (HU)

ART 121. (WS 121) Women in Art (4)
Women artists from Renaissance to present. Attitudes toward women artists and their work; changing role of women in the art world. Visits to museums and artists' studios. May be repeated for credit as topic varies. Gans. (HU)

ART 135. Painting II (3)
A sustained exploration of paint media. Students concentrate on developing a body of related images using various media and approaches. Prerequisite: ART 35. Boothe. (HU)

ART 144 (REL 144). Raw Vision: Creativity and Ecstasy in the Work of Shamans, Mystics, and Artist Outsiders (4)
Comparative exploration of the nature and meaning of religious and artistic experience as reflected in shamanism (both prehistoric and tribal), mystic traditions (especially Taoism and Christianity), and contemporary self-taught artistic visionaries (e.g. Jean Dubuffet, Howard Finster, Mr. Imagination, Lonnie Holley, Norbert Kox). Various disciplinary perspectives will be employed including comparative religions, anthropology, art history, and psychology. Girardot. (HU)

ART 148. (DES 148). Furniture Design 1 (3)
Design methodology, fabrication techniques, and methods of design presentation. Prerequisite: ART/DES 4. Forsyth. (HU)

ART 150. (AAS 150) Africans in the New World (3) spring
African American art, architecture, and craft from precolonial Africa to the present. Early primitivism, neo-classicism, the Harlem renaissance, modernism, and contemporary directions. Guest lecturers, open dialogue, gallery visits, and media presentations. Writing intensive. Boothe. (HU)

ART 153 (DES 153). Graphic Design II (3) spring
Aspects of design are inter-related in function, concept or planning processes. Students focus on the poster in order to solve a variety of contemporary design problems. Professional-level formal team exercises include a series of informative posters, identity systems, publication, and advertising design. Computer graphics and Macintosh lab are employed as integral design tools in graphic design. Prerequisite: ART 53/DES 53. Staff. (HU)

ART 169. Special Topics in Art History (1-3)
Directed projects for students in the history of art or architecture. Prerequisites: consent of instructor. May be repeated for credit. Staff. (HU)

ART 174. (ARCH 174, CLSS 174, ANTH 174) Greek Archaeology (3)
Ancient Greek cultures from the neolithic to hellenistic periods. Reconstructions of Greek social dynamics from study of artifacts. Small. (SS)

ART 176. (ARCH 176, CLSS 176, ANTH 176) Roman Archaeology (3)
Cultures of the Roman Empire. Reconstructions of social, political, and economic dynamics of the imperial system from study of artifacts. Small. (SS)

ART 177. Photography II (3)
Intensive work in photography as fine art. Advanced study of problems of the photographic images. Lectures, demonstrations, critiques. Students must provide own hand camera. Prerequisite: ART 77. Mason. (HU)

ART 179. History of Photography (1)
Photography as fine art from earliest images to present day. Problems in contemporary photography. Mason. (HU)

ART 206. (ARCH 206) Medieval Art and Architecture (3)
Focus on art and architecture in Western Europe from 313 A.D. until ca. 1500 A.D. Topics include: the emergence of Christian art and architecture; the art of barbarian migrations; the Carolingian Renaissance; monasticism, pilgrimage and the Romanesque; the Gothic cathedral; and medieval manuscript illumination. Priester. (HU)

ART 207. (ARCH 207) Renaissance Art and Architecture (3)
Survey of the art and architecture of the Italian Renaissance from its beginnings in 13^{th} and 14^{th} century Tuscany and its first flowering in 15^{th} century Florence through the brilliant achievements of the masters of the High Renaissance and later 16^{th} century. Priester. (HU)

ART 211. Drawing III (3)
Projects in traditional and contemporary drawing. Oriented toward developing an individual portfolio. Drawing as a vehicle for ideas, creative expression, and image making. Students investigate a broad range of materials, forms and traditions. Prerequisite: ART 111. Boothe or Gans. (HU)

ART 213. Sculpture III (4)
Development of principles and techniques in Sculpture II for advanced students. Modeling, casting, fabrication and carving. Prerequisite: ART 113. Gans. (HU)

ART 215. Figure III (3)
Further exploration of the human figure as the subject of art. More advanced students may elect to concentrate in either two- or three- dimensional representations in any media. The emphasis will be on personal interpretation and independent work with the instructor. Prerequisite: ART 115. Gans. (HU)

ART 222. Seminar in Contemporary Art (3)
Recent aspects, developments in contemporary art. Exploring ideas and consequences of today's image-making. Studio workshops, readings, discussions and museum visits. Prerequisite: ART 2. Staff. (HU)

ART 235. Painting III (3)
Emphasis on identifying an individual creative style or direction with the media. Students are encouraged to develop a body of painted work ready for professional exhibitions. Outside critics invited to final reviews. Prerequisite: ART 135 or consent of instructor. May be repeated for credit. Staff. (HU)

ART 248. (DES 248). Furniture Design II (3)
Advanced fabrication. Contemporary art issues and furniture history. Prerequisite: ART/DES 148. Forsyth. (HU)

ART 253. (DES 253). Graphic Design III (3) fall
A combination workshop/seminar course in which the student, as part of a design team, through classroom and individual discussion with the instructor and respective non-profit clients, develops and produces a minimum of two major design projects. Readings and classroom discussions of contemporary graphic design history and current trends form an essential part of the course. Prerequisite: ART/DES 153. Staff (HU)

ART 269. Special Topics in Art History (1-3)
Directed projects for advanced students in the history of art or architecture. Prerequisite: consent of instructor. May be repeated for credit. Staff. (ND)

ART 273. Special Topics in Studio Practice (1-4)
Individually directed projects for advanced students capable of undertaking independent creative work in studio art. Prerequisite: consent of instructor. May be repeated for credit. Staff. (ND)

ART 277. Special Topics in Photography (1-4)
Individually directed projects in photography for advanced students capable of undertaking creative work in photography. Prerequisites: ART 177 and consent of instructor. May be repeated for credit. Mason. (ND)

ART 311. Art Portfolio (1-4)
The concept, layout, and preparation of a portfolio for graduate school application or employment search, including graphic techniques and reproduction method. Student must contact sponsoring professor. Prerequisite: ART 111 or consent of instructor. (ND)

ART 337. Multimedia Workshop (3)
A workshop emphasizing individual instruction and allowing students to explore all art mediums and/or combinations while developing a relationship between ideas and materials. May be repeated for credit. Prerequisite: consent of professor. Viera. (HU)

ART 350. Special Topics in Graphic Design and Theory Seminar (1-4)
Current topics in graphic communication theory and practice. Course will cover preparation, production, and formulation of individual portfolio. Selected readings and discussions in professional ethics as well as legal issues in the field will be covered. May be repeated for credit. Prerequisites: ART/DES 253. Staff (ND)

ART 352. Advanced Studio Practice (1-4)
Advanced studio for art or architecture majors under guidance of faculty. Oral and written critiques. Variable media. May be repeated for credit. Prerequisites: Third-level (200-numbered) course of a studio art discipline and permission of instructor. Staff (HU)

ART 353. Graphic Design Internship (1-4)
Practical in-field experience in a communication design field. Preapproved a semester in advance by instructor and host organization. A minimum of 15 hours per week. Prerequisite: Art/Des 253. Staff. (ND)

ART 373. Studio Art Internship (1-4)
Practical in-field experience in an artist's studio or art-related apprenticeship opportunity. Requires approval a semester in advance by instructor and host organization. Staff. (ND)

Museum Studies

ART 175. Introduction to Museum Work (3) fall
Introduction to the methods and procedures of research and interpretation of art objects, historical material sites, documents, specimens, and living entities. The nature of museum work in its practical aspects. Field trips and workshops. Each student completes several interactive projects. Viera. (ND)

ART 275. Museography and Museology (4) fall-spring
Theory and practice in contemporary museums and galleries. Practicum in the L.U.A.G. Museum operation, dealing with collection management, exhibition, and interpretation issues. Student completes a research report or equivalent. Recommend that concentration/minors repeat this course. Prerequisite: ART 175. Viera. (ND)

ART 370. Special Topics in Museum Studies (1-4)
Special project and/or internship for graduate and advanced undergraduates in the museum studies. Prerequisite: Art 275 or equivalent course in Anthropology or History. Viera (ND)

ART 375. Museum Internship (3) fall-spring
Internship under professional supervision in one or more of the following areas: education/interpretation, collection management, curatorial, exhibition/installation, and development/PR, administration; in one of the following regional organizations: Allentown Art Museum, Lehigh County Historical Society, Bethlehem Historical Partnership, Hugh Moore Park, Canal Museum. Prerequisite: ART 275. Viera. (ND)

Undergraduate Courses in Architecture

ARCH 1. Architectural History I (3) fall
Survey of architecture from earliest building to the Renaissance, examined in the context of culture formation, design concepts, and the built environment. Thomas. (HU)

ARCH 2. Architectural History II (3) spring
Survey of architecture from the Renaissance to the present, examined in the context of culture formation, design concepts, and the built environment. Thomas. (HU)

ARCH 5. Introduction to Architecture (2) fall
An introduction to the discipline of architecture for first-year probable architecture majors. Covers basic principles, aspects of the profession, how to understand building, etc. Staff. Freshman Year Class. (HU; FYC)

ARCH 6. Introduction to Architectural Drawing (2) spring
An introduction to basic architectural drawing skills for first-year probable architecture majors. Covers sketching techniques, orthographic drawing, axonometric, etc. Staff (ND)

ARCH 10 (CEE 10) Engineering/Architectural Graphics and Design (3)
Graphical communication of civil engineering or architectural projects using manual techniques and commercial state-of-the-art computer software. Topics include visualization and sketching; orthographic, isometric and other drawings; points, lines and planes in descriptive geometry; site design; overview of geographical information systems and 3-D applications. Teamwork on design projects with oral and graphical presentations. Open to a limited number of architecture, design arts or other students with project roles consistent with students' background. Not available to students who have taken MECH 10.

ARCH. 43. Architectural Design I (4)
Fundamental design studio for architecture majors. Composition, spatial concepts; precedent; materials and detail; light and color in architecture. Instruction in basic communication techniques. Prerequisite: ART/DES 3 and ART/DES 4. Reserved for declared Architecture majors. Viscardi or Ussler. (ND)

ARCH 107. History of American Architecture (3) spring
Survey of American building from European colonization to the present. Prerequisite: ART/ARCH 1 and ARCH 2 or permission of instructor. Thomas. (HU)

ARCH 143. Architectural Design II (6)
Studio format, introductory course in architectural design which introduces students to new ways of thinking about architecture and the perception of space, three-dimensional composition, drawing, and model-making. Previous or concurrent courses in studio art and/or architectural history are recommended. Prerequisite: ARCH 43. Zaknic. (ND)

ARCH 147. Building Materials and Methods (3)
The primary structural material block, wood, steel and reinforced concrete are examined in their relationship to architectural design. Peters. Prerequisite: ARCH 43 or consent of professor. (ND)

ARCH 161. (THTR 161) Theatre Design and Technology (4)
Theatre environments, equipment systems and acoustics. Functions and ethics. (HU)

ARCH 171. Special Topics in Architecture (1-4)
Directed projects for students in architecture. Student must initiate contact with sponsoring professor. Prerequisite: Major standing in department and/or permission of instructor. Staff (ND)

ARCH 174. (ART 174, CLSS 174, ANTH 174) Greek Archaeology (3)
Ancient Greek cultures from the neolithic to hellenistic periods. Reconstructions of Greek social dynamics from study of artifacts. Small. (SS)

ARCH 176. (ART 176, CLSS 176, ANTH 176) Roman Archaeology (3)
Cultures of the Roman Empire. Reconstructions of social, political, and economic dynamics of the imperial system from study of artifacts. Small. (SS)

ARCH 204. (CLSS 204) Ancient City and Society (3)
Ancient theories of city and city planning; attitudes to life in the city; rise of urban civilization from Neolithic prototypes through the Near East, Egypt, Greece, Rome, and New World; insights applicable to current urban problems. (SS)

ARCH 206. (ART 206) Medieval Art and Architecture (3)
Focus on art and architecture in Western Europe from 313 A.D. until ca. 1500 A.D. Topics include: the emergence of Christian art and architecture; the art of barbarian migrations; the Carolingian Renaissance; monasticism, pilgrimage and the Romanesque; the Gothic cathedral; and medieval manuscript illumination. Priester. (HU)

ARCH 207. (ART 207) Renaissance Art and Architecture (3)
Survey of the art and architecture of the Italian Renaissance from its beginnings in 13th and 14th century Tuscany and its first flowering in 15th century Florence through the brilliant achievements of the masters of the High Renaissance and later 16th century. Priester. (HU)

ARCH 209. Architecture and Ideas (3)
Examination of philosophical, technological, and cultural forces shaping Western architecture and urbanism. Prerequisites: ART/ARCH 1 and ARCH 2 or permission of instructor. Writing intensive. Thomas. (HU)

ARCH 210. 20th-Century Architecture (3)
History and theory of modern architecture. Analysis of buildings and architects, theories and manifestoes, from industrial revolution to avant-garde movements. Prerequisite: Art 1 or ARCH 1 and another course in architectural history is recommended. Zaknic. (HU)

ARCH 211. Architectural Drawing/Analysis and Expressions (3) alternate summers in Italy
This studio course is part of the Lehigh in Italy summer program and will utilize several different architectural drawing techniques to study aspects of architecture from analysis of a piazza to architecture in detail. It will employ pencil sketching, charcoal drawing, and watercolor. These drawings will act as a way of seeing the Italian urban landscape and supplement the study and analysis

of the Italian architects' contemporary work. Fulfills an art studio elective requirement. Viscardi. (ND)

ARCH 212. The Architecture of Carlos Scarpa/Theory and Practice (3) alternate summers in Italy
This course which is part of the Lehigh in Italy summer program will survey several of the Venetian architect's most famous works. Meet with architects who worked with Scarpa and completed his unfinished projects. Explore thematic principles behind Scarpa's work, their origin and roll in his unique process of design. Viscardi. (HU)

ARCH 213. The City (3)
Historical development of the modern city. Philosophical, technological, and cultural forces shaping urban experience. Western culture beginning with the Enlightenment. Prerequisites: Art 1 or ARCH 1 and ARCH 2 or permission of instructor. Thomas. (HU)

ARCH 243. Architectural Design III (6)
Continuation of ARCH 143. Design principles of space and form stressed in earlier studios to issues of "materiality," "structure," "modes of representation" and the "process of making." Prerequisites: ARCH 1, 143 and one art studio. Viscardi. (ND)

ARCH 253. Paris, the Planning of a Metropolis (3) alternate summers in Paris
The splendor of modern Paris is due in large part to bold, large-scale modernization and changes in the city's patterns during the 19th century. This course, which is part of the Lehigh in Paris summer program, will cover a century of change and focus on the major accomplishments of its visionary planners. Zaknic (HU)

ARCH 254. Modern Architecture in France: New Directions (3) alternate summers in Paris
The course, which is part of the Lehigh in Paris summer program, will cover the most important contributions to modern architecture in the Paris region including Centre Pompidou, Musee d'Orsay, Le Grand Louvre, Parc de la Villette, La Defense, and the new satellite towns around Paris. Zaknic (HU)

ARCH 271. Special Topics in Architecture (1-4)
Directed projects for advanced students in architecture or architectural criticism. Prerequisites: ARCH 1 and 143. Major standing in the department or consent of instructor. Student must contact sponsoring professor and complete a contract sheet at pre-registration. May be repeated for credit. Staff. (ND)

ARCH 311. Portfolio (1)
The concept, layout, and preparation of a portfolio for graduate school application or employment search, including graphic techniques and reproduction method. Student must contact sponsoring professor. Prerequisite: ARCH 243. Staff. (ND)

ARCH 321. Architectural Internship (1-3)
Supervised internship in architectural firm, planning or preservation office. Internship plan must be approved in writing before it is pursued. Staff. (ND)

ARCH 328. Architectural Representation (3)
Studio format, instruction in rendering media such as graphite, charcoal, color pencil, water color and pastel and a variety of three-dimensional drawing techniques. Intended for architectural students who have mastered orthographic drawing (plan, elevation, section). The origin, history, and theory of three-dimensional drawing techniques will also be studied. Prerequisite: ARCH 243. Ussler. (ND)

ARCH 342. Theory of Architecture (3)
Study of the genesis of form, its representation and its interrelationship to related artistic disciplines. Formal notions will be studied, compared and manipulated through the role of time, scale, perceptual analysis and material transformation. Permission of instructor required. Viscardi. (ND)

ARCH 343. Architectural Design IV (6)
Continuation of ARCH 243. The design of buildings and building groups, with the emphasis on urban design and the city. Prerequisite: ARCH 1/ART 1, 210, 243 and one art studio. Ussler. (ND)

ARCH 345. Architectural Design V (3)
Undergraduate thesis. An individual design project exploring, with faculty approval, some aspect of architecture of interest to the student. Prerequisite: Architectural Design I-IV; all other courses required for major, previously or concurrently. Staff. (ND)

ARCH 346. Construction, Materials and Design (3)
The influence of construction, structure, and material choice on the design of a small building. The studio also deals with the relationship between different scales of design concern. Pre-requisite: ARCH 147 and ARCH 243. Peters. (ND)

ARCH 361. (HIST 361) Evolution of Highrise Building Construction (3)
The new materials iron and concrete led to new ways of thinking about building. The Industrial Revolution initiated the development of our modern culture of building and our current urban society. Peters. (HU)

ARCH 363. (HIST 363) Evolution of Long-span Bridge Building (3)
New materials, forms of education and technology contributed to advance structural understanding. Specialization and the rise of technological thinking led to new bridge types and increasing span size. Peters. (HU)

ARCH 365. (HIST 365) Evolution of the Modern Building Process (3)
The criteria of trade—time and money—entered the world of building in the 19th century. The unplanned interlude between the design and the inauguration of a building became a new professional field: the building process. Peters. (HU)

ARCH 367. Modernism to Postmodernism (3)
Re-examine the central issues facing the great masters of twentieth-century architecture: how they formulated their principles, how they applied them, and how those who inherited the legacy have interpreted it. The major attention will focus on either the great master builders such as Le Corbusier, Mies vander Rohe, Frank Lloyd Wright and Walter Gropius, or on second generation including the transitional figures such as Philip Johnson and other groups: The Whites, Greys, High-Tech, etc. Prerequisite: Art I/ARCH I or Art 2/ARCH 2 and ARCH 210. Zaknic. (HU)

ARCH 388. Advanced Architectural Design (3) spring
Intensive design projects under a sequence of visiting design instructors. Prerequisites: ARCH 210, 243 and consent of the instructor. Zaknic. (**ND**)

Arts and Sciences

ARTS 1-9. Choices and Decisions (1)
Introduction to decision making with emphasis on curriculum, career planning, and social options. Techniques for using values, family history, and social norms as guidelines for decision-making processes. Pass-fail grading.

ARTS 251. Fieldwork (1)
Structured fieldwork for students who have previously taken Arts 250 without the fieldwork component. Students will be required to provide some regular written and oral reports of activity and then write a detailed analysis/assessment report of particular issues and lessons learned. Prerequisite: 3 credits of Arts 250 (without fieldwork component) and instructor's consent. (**ND**)

ARTS 250. Communications, Cultures, Behaviors and Attitudes (4)
Writing-intensive experiential focus on communications, development of social roles and life skills required for effective functioning in a diverse society in America and globally. Models of group processes; small group projects; communications; critical thinking and its application to course content; cognitive processes in handling individual differences in race, gender, class, religion, disabilities, sexual harassment, religions of the world, sexual orientation, and culture; synthesis of class experiences with readings and discussions; and social role implications on choices. The application of lessons learned in the course to real life situations such as structured fieldwork will be required in addition to in class work. As part of the fieldwork experience, students will be required to provide some regular written and oral reports of activity and then write a detailed analysis/assessment report of particular issues and lessons learned. Students may not receive credit for both Arts 250 and Comm 65. (**ND**)

Arts-Engineering

The Arts-Engineering program provides the student with an opportunity to experience the breadth of an arts education and simultaneously follow the more focused curriculum of an engineering major. This is a five-year, dual-degree program administered by the College of Arts and Sciences. An Arts-Engineering graduate is awarded two bachelors degrees, one from the College of Arts and Sciences and another from the College of Engineering and Applied Science.

A typical freshman year class schedule for an Arts-Engineer is shown below. Note that the Arts-Bioengineering program has a different freshman year class schedule.

freshman year, first semester (15-17 credit hours)

ARTS 2	Choices & Decisions	1
ENGL 1	Composition/Literature I	3
MATH 21	Calculus I	4
PHY 11	Intro Physics I	4
PHY 12	Intro Physics Lab I	1
(Dept) 90	College Seminar or FYC	2-4

freshman year, second semester (18 credit hours)

ENGL 2	Composition/Literature II	3
MATH 22	Calculus II	4
CHM 21	Intro Chemical Principles	4
CHM 22	Chemical Principles Lab	1
ENGR 1	Engineering Computations	3
ENGR 5	First-Year Design Experience	3

Selection of a major in the College of Engineering and Applied Science occurs prior to beginning the sophomore year. A major leading to a degree in the College of Arts and Sciences should be chosen prior to beginning the junior year.

Basic Arts-Engineering programs leading to a bachelor of arts degree from the College of Arts and Sciences and a Bachelor of Science degree in an area of engineering are suggested below. The listed courses may be taken in any order if prerequisites are met. Arts-Engineering candidates should recognize that pursuit of a bachelor of science degree (e.g., biology, chemistry, biochemistry, earth and environmental sciences, mathematics, and physics) or a bachelor of arts program with larger than average credit requirements (e.g., art, architecture, physical sciences, cognitive science, international careers, among others) will severely restrict choices of free electives. For these students, very careful planning of the academic program is necessary to guarantee completion of all major, distribution and total credit requirements for the two degrees in five years.

The designation AS-courses/electives refers to those courses which meet the major and distribution requirements for the degree in the College of Arts and Sciences while other types of electives meet major requirements in the College of Engineering. When selected properly, courses which meet distribution requirements in the College of Arts and Sciences will also satisfy most distribution requirements of the College of Engineering and Applied Science. *Note that the bookkeeping used to arrive at the total credits for each dual degree program assumes 33 credit hours were earned in the freshman year.*

Arts-Bioengineering

A total of 164-5 credit hours is needed for the bachelor of arts and the bachelor of science degrees depending on the bioengineering track selected.

freshman year, first semester (17 credit hours)

ARTS 2	Choices & Decisions	1
BIOE 1	Intro to Bioengr I	1
ENGR 1	Engineering Computations	3
ENGL 1	Composition/Literature	3
MATH 21	Calculus I	4
CHM 21	Intro Chemical Principles	4
CHM 22	Chemical Principles Lab	1

freshman year, second semester (17 credit hours)

BIOE 2	Intro to Bioengr II	1
ENGL	to be selected	3
MATH 22	Calculus II	4
PHY 11	Intro Physics I	4
PHY 12	Intro Physics Lab I	1
BIOS 41	Biology Core I: Cellular and Molecular	3
BIOS 42	Biology Core I: Cellular and Molecular Lab	1

sophomore-fifth year (130-131 credit hours)
Please read the section of the catalog referring to B.S. in Bioengineering. Then contact either Professor Ou-Yang

or Professor White for further advice on which of the 3 tracks to select and the courses that should be taken.

Arts-Chemical Engineering

A total of 163 credit hours is needed for the bachelor of arts and the bachelor of science degrees.

See electives (1) through (5) for the chemical engineering program in Section III. Careful planning is required so that these may be scheduled during the senior year and fifth year of the program. Any order that does not violate prerequisites is acceptable.

sophomore year, first semester (17 credit hours)

CHE 31	Material and Energy Balances of Chemical Processes (3)
CHM 31	Chemical Equilibria in Aqueous Solutions (3)
MATH 23	Calculus III (4)
ECO 1	Principles of Economics (4)
	AS course/elective (3)

sophomore year, second semester (18 credit hours)

CHE 44	Fluid Mechanics (4)
PHY 21	Introductory Physics II (4)
PHY 22	Introductory Physics Lab II (1)
BIOS 41	Biology Core I: Cell and Molecular Biology (3)
MATH 205	Linear Methods (3)
	AS courses/electives (3)

junior year, first semester (17 credit hours)

CHE 151	Introduction to Heat Transfer (3)
CHM 51	Organic Chemistry I (3)
CHM 53	Organic Chemistry Laboratory I (1)
CHM 192	Physical Chemistry Laboratory (2)
	AS courses/electives (8)

junior year, second semester (17 credit hours)

CHE 244	Mass Transfer and Separation Processes (3)
CHE 210	Chemical Engineering Thermodynamics (4)
CHE 179	Professional Development (1)
CHM 52	Organic Chemistry II (3)
	AS courses/electives (6)

senior year, first semester (15 credit hours)

CHE 201	Methods of Analysis in Chemical Engineering (3)
CHM 189	Physical Chemistry II (3)
	electives for engineering major* (6)
	AS courses/electives (3)

senior year, second semester (15 credit hours)

CHE 211	Chemical Reactor Design (3)
CHE 242	Introduction to Process Control and Simulation (3)
	electives for engineering major* (6)
	AS courses/electives (3)

fifth year (31 credit hours)

See program description for senior year of Chemical Engineering.

**These electives are chosen with the chemical engineering adviser.*

Arts-Civil Engineering

A total of 160 credit hours is needed for the bachelor of arts and the bachelor of science degrees. This total may differ depending on selection of electives that satisfy requirements for both degrees.

sophomore year, first semester (16 credit hours)

MATH 23	Calculus III (4)
MECH 2	Elementary Engineering Mechanics (3)
CEE 10	Engineering/Architectural Graphics and Design (3)
	AS courses/electives (6)

sophomore year, second semester (18 credit hours)

MATH 205	Linear Methods (3)
MECH 12	Strength of Materials (3)
PHY 21	Introductory Physics II (4)
PHY 22	Introductory Physics Lab II (1)
CEE 170	Introduction to Environmental Engineering (4)
	AS course/elective (3)

junior year, first semester (16 credit hours)

MAT 33	Engineering Materials and Processes (3)
CEE 123	Civil Engineering Materials (1)
CEE 11	Surveying (1)
CEE 12	Civil Engineering Statistics (2)
CEE 121	Mechanics of Fluids (3)
	Engineering Science Elective* (3)
	AS course/elective (3)

junior year, second semester (15 credit hours)

CEE 117	Numerical Methods in Civil Engineering (2)
CEE 222	Hydraulic Engineering (3)
ECO 1	Principles of Economics (4)
	AS courses/electives (6)

senior year, first semester (15 credit hours)

CEE 142	Fundamentals of Soil Mechanics (3)
CEE 159	Structural Analysis I (4)
	AS courses/electives (8)

senior year, second semester (15 credit hours)

CEE 262	Fundamentals of Steel Structural Design (3)
or CEE 264	Fundamentals of Concrete Structural Design (3)
CEE 242	Principles and Practice of Geotechnical Engineering (3)
	Civil Engineering electives** (3)
	AS courses/electives (6)

fifth year, first semester (17 credit hours)

CEE 202	Civil Engineering Planning and Engineering Economics (3)
CEE 203	Professional Development (2)
	Civil Engineering electives** (6)
	AS courses/electives (6)

fifth year, second semester (15 credit hours)

CEE 290	Civil Engineering Capstone Design (3)
	Civil Engineering elective** (6)
	AS courses/electives (6)

***Of seventeen CEE elective credits, three credits are satisfied by a 300 level course in the major AS department; the other fifteen approved by the CEE department chairperson; see list on department web site.*

Arts-Computer Engineering

A total of 166 credit hours is needed for the bachelor of arts and bachelor of science degrees.

sophomore year, first semester (16 credit hours)

MATH 23	Calculus III (4)
PHY 21	Introductory Physics (4)

PHY 22	Introductory Physics Lab (1)	
ECE 33	Introduction to Computer Engineering (4)	
	AS course/elective (3)	

sophomore year, second semester (17 credit hours)

CSE 17	Structured Programming and Data Structures (4)
MATH 205	Linear Methods (3)
ECO 1	Principles of Economics (4)
	AS courses/electives (6)

junior year, first semester (16 credit hours)

ECE 81	Principles of Electrical Engineering (4)
MATH 231	Probability and Statistics (3) **or**
MATH 309	Theory of Probability (3)
	AS courses/electives (9)

junior year, second semester (16 credit hours)

ECE 82	Sophomore Laboratory (1)
ECE 108	Signals and Systems (4)
	AS courses/electives (11)

senior year, first semester (16 credit hours)

ECE 121	Electronic Circuits Laboratory (2)
ECE 123	Electronic Circuits (3)
CSE 109	Systems Programming (3)
	approved technical elective* (3)
	AS courses/electives (5)

senior year, second semester (16 credit hours)

ECE 138	Digital Systems Laboratory (2)
ECE 201	Computer Architecture (3)
CSC 216	Software Engineering (3)
CSC 261	Discrete Structures (3)
	AS courses/electives (5)

fifth year (36 credit hours)

See program description for senior year of computer engineering.

**Approved technical electives, chosen with the advisor's consent, are subjects in the area of science and technology. They are not restricted to offerings in the department of computer science and electrical engineering. One elective must be an engineering science elective from another department.*

Arts-Computer Science

A total of 164 credit hours is needed for the bachelor of arts and the bachelor of science degrees.

sophomore year, first semester (16 credit hours)

MATH 23	Calculus III (4)
PHY 21	Introductory Physics II (4)
PHY 22	Introductory Physics Lab II (1)
CSE 17	Structured Programming and Data Structures (4)
	AS course/ special elective* (3)

sophomore year, second semester (16 credit hours)

MATH 205	Linear Methods (3)
CSE 109	Systems Programming (3)
ECO 1	Principles of Economics (4)
	AS courses/ special electives* (6)

junior year, first semester (16 credit hours)

CSE 261	Discrete Structures (3)
ECE 33	Introduction to Computer Engineering (4)
MATH 231	Probability and Statistics (3) **or**
MATH 309	Theory and Probability (3)
	AS courses/special electives* (6)

junior year, second semester (18 credit hours)

CSE 216	Software Engineering (3)
CSE 262	Programming Languages (3)
CSE 340	Design and Analysis of Algorithms (3)
	AS courses/special electives* (9)

senior year, first semester (18 credit hours)

CSE 318	Automatic and Formal Grammars (3)
MATH 230	Numerical Methods (3)
	AS courses/special electives* (12)

senior year, second semester (15 credit hours)

ECE 201	Computer Architecture (3)
CSE 252	Computers, the Internet, and Society (3)
	AS courses /special electives* (9)

fifth year, first semester (17 credit hours)

CSE 303	Operating System Design (3)
CSE 379	Senior Project (3)
	AS courses/special electives* (11)

fifth year, second semester (15 credit hours)

CSE 302	Compiler Design (3)
	AS courses/special electives* (12)

**Special electives [technical electives (15 credit hours) and professional electives (6 credit hours), with one of the electives being a hardware-oriented course] are required and are chosen with the approval of the major advisor. See the catalog listing for B.S. in Computer Science in the P. C. Rossin College of Engineering for further details.*

Arts-Electrical Engineering

A total of 165 credit hours is needed for the bachelor of arts and bachelor of science degrees.

sophomore year, first semester (15 credit hours)

MATH 23	Calculus III (4)
PHY 21	Introductory Physics II (4)
PHY 22	Introductory Physics Lab II (1)
	AS courses/electives (6)

sophomore year, second semester (15 credit hours)

MATH 205	Linear Methods (3)
	approved elective* (3)
	AS courses/electives (9)

junior year, first semester (16 credit hours)

ECE 33	Introduction to Computer Engineering (4)
ECE 81	Principles of Electrical Engineering (4)
MATH 208	Complex Variables (3)
	AS courses/electives (5)

junior year, second semester (16 credit hours)

ECE 82	Sophomore Laboratory (1)
ECE 108	Signals and Systems (4)
ECE 126	Fundamentals of Semiconductor Devices (3)
MATH 231	Probability and Statistics (3)
	AS courses/electives (5)

senior year, first semester (18 credit hours)

ECE 121	Electronic Circuits Laboratory (2)
ECE 123	Electronic Circuits (3)
ECE 202	Introduction to Electromagnetics (3)
ECO 1	Principles of Economics (4)
	approved elective* (3)
	AS courses/electives (3)

senior year, second semester (16 credit hours)

ECE 125	Circuits and Systems (3)
ECE 138	Digital Systems Laboratory (2)
ECE 203	Introduction to Electromagnetic Waves (3)
	approved technical elective* (3)
	AS courses/elective (5)

fifth year (36 credit hours)

See program description for senior year of electrical engineering, under Electrical Engineering.

**Approved technical electives are subjects in the areas of science and technology. Students must select a minimum of four courses from the ECE or CSC course listings, with a minimum of two courses in one of the technical areas described in the following list. Students must also choose at least one engineering elective in either materials, mechanics, thermodynamics, fluid mechanics or physical chemistry, and at least one science elective in physics, chemistry or biology. For students interested in solid state electronics, quantum mechanics is recommended for the science elective.*

Arts-Engineering Physics

A total of 161 credit hours is needed for the bachelor of arts and bachelor of science degrees.

sophomore year, first semester (17 credit hours)

PHY 21	Introductory Physics II (4)
PHY 22	Introductory Physics Lab II (1)
MATH 23	Calculus III (4)
ECO 1	Principles of Economics (4)
ECE 81	Principles of Electrical Engineering (4)

sophomore year, second semester (16 credit hours)

PHY 31	Introduction to Quantum Mechanics (3)
PHY 190	Electronics (3)
MATH 205	Linear Methods (3)
MATH 208	Complex Variables (3)
ECE 108	Signals and Systems (4)

The student must choose either the Solid State Electronics or the Optical Sciences concentration, listed below.

Solid State Electronics Concentration

junior year, first semester (16 credit hours)

PHY 212	Electricity and Magnetism I (3)
ECE 33	Introduction to Computer Engineering (4)
ECE 123	Electronic Circuits (3)
MATH 322	Methods of Applied Analysis I (3)
	AS courses/electives (3)

junior year, second semester (18 credit hours)

PHY 213	Electricity and Magnetism II (3)
PHY 262	Advanced Laboratory (2)
PHY 215	Classical Mechanics I (4)
ECE 126	Fundamentals of Semiconductors Devices (3)
	AS courses/electives (6)

senior year, first semester (15 credit hours)

PHY 362	Atomic and Molecular Structure (3)
PHY 363	Physics of Solids (3)
	SSE Elective* (3)
	SSE Elective* or AS courses/ electives (3)
	AS courses/electives (3)

senior year, second semester (15 credit hours)

	SSE Electives* (5)
	AS courses/elective or SSE elective (3)
	AS courses/electives (7)

fifth year, first semester (15 credit hours)

PHY 340	Thermal Physics (3) **or**
ME 104	Thermodynamics I (3)
	SSE Elective* (3)
	AS courses/electives (9)

fifth year, second semester (16 credit hours)

AS courses/electives (16)

**The 14 credit hours of SSE electives must include ECE 251 or 252 or PHY 273 (must be a design project with an engineer co-advisor). Advisor has list of approved SSE electives. Must include at least 30 credits taught by engineers and sufficient engineering design and engineering science credits to satisfy ABET guidelines.*

Optical Sciences Concentration

junior year, first semester (15 credit hours)

PHY 212	Electricity and Magnetism I (3)
PHY 362	Atomic and Molecular Structure (3)
MATH 322	Methods of Applied Analysis I (3)
	OE Elective** (3)
	AS courses/electives (3)

junior year, second semester (18 credit hours)

PHY 213	Electricity and Magnetism II (3)
PHY 262	Advanced Laboratory (2)
PHY 215	Classical Mechanics (4)
	OE Elective** (3)
	AS courses/electives (6)

senior year, first semester (17 credit hours)

PHY 352	Modern Optics (3)
	OE Elective** (9)
	AS courses/electives (5)

senior year, second semester (15 credit hours)

PHY 355	Lasers and Non-linear Optics (3)
	OE Elective** (6)
	AS courses/electives (6)

fifth year, first semester (15 credit hours)

PHY 340	Thermal Physics (3) **or**
ME 104	Thermodynamics I (3)
	AS courses/electives (12)

fifth year, second semester (15 credit hours)

AS courses/electives (15)

***The 18 credit hours of Optical Engineering electives must include ECE 257 or 258 or PHY 273 (must be a design project with an engineer co-advisor). Must include at least two of ECE 347, 348, 371, and 372. Advisor has list of approved OE electives. Must include at least 30 credits taught by engineers and sufficient engineering design and engineering science credits to satisfy ABET guidelines.*

Arts-Environmental Engineering

A total of 160 credit hours is needed for the bachelor of arts and the bachelor of science degrees. This total may differ depending on the selection of electives that satisfy the requirements for both degrees, Some CAS requirements may be satisfied by taking courses such as CEE/EES cross-listed courses that can reduce this total.

sophomore year, first semester (17 credit hours)

MATH 23	Calculus III (4)
MECH 2	Elementary Engineering Mechanics (3)

CHM 51	Organic CHEM I (3)
CHM 53	Organic CHEM Lab I (1)
	AS courses/electives* (6)

sophomore year, second semester (17 credit hours)

MATH 205	Linear Methods (3)
PHY 21	Introductory Physics II (4)
PHY 22	Introductory Physics Lab II (1)
CEE 170	Introduction to Environmental Engineering (4)
CEE 272	Environmental Risk Assessment (2)
	AS course/elective* (3)

junior year, first semester (17 credit hours)

CEE 12	Civil Engineering Statistics (2)
CEE 121	Mechanics of Fluids (3)
CEE 276	Env. Engineering Processes (3)
CHE 31	MAT. & Energy Bal. Of CHE Process (3)
	AS course/elective* (6)

junior year, second semester (17 credit hours)

CEE 222	Hydraulic Engineering (3)
CEE 274	Environmental Water Chemistry (3)
CHE 60	Unit Ops Survey (3)
ECO 1	Principles of Economics (4)
	AS courses/electives* (4)

senior year, first semester (16 credit hours)

CEE 142	Fundamentals of Soil Mechanics (3)
CEE 378	Solid & Haz. Waste Management (3)
EES 31	Intro. Env./Organismal Biology (4)
	AS courses/electives* (6)

senior year, second semester (14 credit hours)

CEE 275	Enviro-Geo-Hydraulics Lab (2)
EES 21	Intro. Planet Earth (4)
	Technical electives** (3)
	AS courses/electives* (5)

fifth year, first semester (14 credit hours)

CEE 202	Planning and ENGR. Economics (3)
CEE 203	Professional Development (2)
CEE/EES 379	Env. Case Studies (3)
	Technical electives** (3)
	AS courses/electives* (3)

fifth year, second semester (15 credit hours)

CEE 377	Environmental Engineering Design*** (3)
	Technical elective** (3)
	AS courses/electives* (6)
	Free elective (3)

**AS courses must include POLS 111.*

*** 9 technical (approved) elective credits approved by the academic advisor to satisfy proficiency in three focus areas of water supply and resources, environmental chemistry, and hazardous waste management; approved list available from CEE department.*

****CE 290 acceptable substitute when offered as a multidisciplinary course that includes environmental engineering as a major focus*

Arts-Industrial Engineering

A total of 163 credit hours is needed for the bachelor of arts and bachelor of science degrees.

sophomore year, first semester (17 credit hours)

MATH 23	Calculus III (4)
PHY 21	Introductory Physics II (4)
PHY 22	Introductory Physics Lab II (1)
IE 111	Engineering Probability and Statistics (3)
IE 112	Computer Graphics (1)
ECO 1	Principles of Economics (4)

sophomore year, second semester (16 credit hours)

IE 121	Applied Engineering Statistics (3)
IE 131	Work Systems and Facilities Planning (3)
IE 132	Work Systems and Facilities Planning Lab (1)
ACCT 108	Fundamentals of Accounting (3)
	AS courses/electives (6)

junior year, first semester (15 credit hours)

MATH 205	Linear Methods (3)
MAT 33	Engineering Materials and Processes (3)
	AS courses/electives (9)

junior year, second semester (17 credit hours)

IE 122	Software Tools (1)
IE 220	Introduction to Operations Research (3)
ECE 81	Principles of Electrical Engineering (4)
IE 224	Information Systems Analysis and Design (3)
	AS courses/electives (6)

senior year, first semester (16 credit hours)

IE 215	Fundamentals of Modern Manufacturing (3)
IE 216	Manufacturing Laboratory (1)
MECH 2	Elementary Engineering Mechanics (3)
	AS courses/electives (9)

senior year, second semester (15 credit hours)

IE 226	Engineering Economy and Decision Analysis (3)
ME 104	Thermodynamics I (3)
IE Elective	(See IE Program for Possible Electives) (3)
	AS courses/electives (6)

summer

IE 100	Industrial Employment (0)

fifth year (34 credit hours)

See program description for senior year of Industrial Engineering.

Arts-Information and Systems Engineering

A total of 160 credit hours is needed for the bachelor of arts and bachelor of science degrees.

sophomore year, first semester (17 credit hours)

IE 111	Engineering Probability and Statistics (3)
MATH 23	Calculus III (4)
CSC 17	Structured Programming and Data Structures (4)
	AS courses /electives (6)

sophomore year, second semester (17 credit hours)

IE 121	Applied Engineering Statistics (3)
MATH 205	Linear Methods (3)
ACCT 108	Fundamentals of Accounting (3)
PHY 21, 22	Introductory Physics II and Laboratory (5)
	AS course /elective (3)

junior year, first semester (16 credit hours)

IE 122	Software Tools (1)
IE 220	Introduction to Operations Research (3)
BIS 211	Management Information Systems (3)
MECH 2, ME 104	Elementary Engineering Mechanics (3), Thermodynamics I (3), **or**

MAT 33 Engineering Materials and Processes (3)
AS courses /electives (6)

junior year, second semester (17 credit hours)
IE 170 Algorithms in Systems Engineering (3)
IE 171 Algorithms in Systems Engineering Laboratory (1)
IE 275 Fundamentals of Web Applications (3)
ECE 81 Principles of Electrical Engineering (4)
AS courses /electives (6)

senior year, first semester (16 credit hours)
IE 224 Information Systems Analysis and Design (3)
IE 345 Manufacturing Information Systems (3)
ECO 1 Principles of Economics (4)
TE Technical Elective (3)*
AS course /elective (3)

senior year, second semester (16 credit hours)
IE 226 Engineering Economy (3)
IE 305 Simulation (3)
IE 339 Stochastic Models (3)
TE Technical Elective (3)*
AS courses /electives (4)

summer
IE 100 Industrial Employment (0)

fifth year, first semester (15 credit hours)
IE 316 Advanced Operations Research Techniques (3)
IE 372 Systems Engineering Design (3)
TE Technical Elective (3)*
AS courses /electives (6)

fifth year, second semester (15 credit hours)
IE 154 Senior Project (3)
IE 341 Data Communication Systems Analysis and Design (3)
TE Technical Elective (3)*
AS courses /electives (6)

**Technical Electives from approved list*

Arts-Materials Science and Engineering

A total of 165 credit hours is needed for the bachelor of arts and bachelor of science degrees.

sophomore year, first semester (16 credit hours)
MAT 33 Engineering Materials and Processes (3)
MATH 23 Calculus III (4)
PHY 21 Introductory Physics II (4)
PHY 22 Introductory Physics Lab II (1)
MAT 10 Materials Laboratory (1)
AS courses/elective (3)

sophomore year, second semester (17 credit hours)
MECH 2 Elementary Engineering Mechanics (3)
MATH 205 Linear Methods (3)
MAT 20 Computational Methods in Materials Science (2)
MAT 203 Structure and Characterization of Materials (3)
MAT 205 Thermodynamics and Phase Diagrams (3)
AS courses/electives (3)

junior year, first semester (15 credit hours)
MAT 201 Physical Properties of Materials (3)
MAT 216 Diffusion and Phase Transformations (3)
MAT 218 Mechanical Behavior of Materials (3)
ECO 1 Principles of Economics (4)
MAT 101 Professional Development (2)

junior year, second semester (15 credit hours)
ENGR 211 Integrated Product Development Projects I (3)
MAT 204 Processing and Properties of Polymeric Materials (3)
MAT 206 Processing and Properties of Metals (3)
MAT. 210 Macro Materials Processing Lab (2)
MAT 214 Processing and Properties of Ceramic Materials (3)
MAT 226 Materials Selection in Design (1)

senior year, first semester (17 credit hours)
ENGR 212 Integrated Product Development Projects II (2)
AS courses/electives (15)

senior year, second semester (15 credit hours)
CHE 60 Unit Operations Survey (3)
AS courses/electives (12)

fifth year (34 credit hours)
See program description for senior year of Materials Science and Engineering, except replace ENGR 212 (2) with AS course (3) and CHE 60 (3) with AS course (3).

Note: Students interested in the industrial or research options should consult with the department chairperson prior to their fourth year. Students selecting the research option should elect MAT 240, Research Techniques, in the first semester of the senior year. Students selecting the industrial option should elect MAT 327 & MAT 329, Industrial Project.

Arts-Mechanical Engineering

A total of 163 credit hours is needed for the bachelor of arts and the bachelor of science degrees.

sophomore year, first semester (16 credit hours)
PHY 21 Introductory Physics II (4)
PHY 22 Introductory Physics Lab II (1)
MATH 23 Calculus III (4)
ME 10 Graphics for Engineering Design (3)
ME 111 Professional Development (1)
AS courses/electives (3)

sophomore year, second semester (18 credit hours)
MECH 2 Elementary Engineering Mechanics (3)
ME 104 Thermodynamics I (3)
MATH 205 Linear Methods (3)
AS courses/electives (9)

junior year, first semester (17 credit hours)
MECH 12 Strength of Materials (3)
ECE 81 Principles of Electrical Engineering (4)
ECO 1 Economics (4)
AS courses/electives (6)

junior year, second semester (15 credit hours)
MECH 102 Dynamics (3)
ME 21 Mechanical Engineering Laboratory I (1)
ME 231 Fluid Mechanics (3)
ECE 162 Electrical Laboratory (1)
AS courses/electives (7)

senior year, first semester (15 credit hours)
MAT 33 Engineering Materials and Processes (3)
ME 215 Engineering Reliability (3) **or**
MATH 208 Complex Variables (3) **or**

MATH 230	Numerical Methods (3) **or**
MATH 231	Probability and Statistics (3)
ME 252	Mechanical Elements (3)
	AS courses/electives (6)

senior year, second semester (16 credit hours)

ME 211	Mechanical Engineering Design I (3)
ME 242	Mechanical Engineering Systems (3)
ME 240	Manufacturing (3)
ME 121	Mechanical Engineering Laboratory II (1)
	AS courses/electives (6)

fifth year (33 credit hours)
See program description for senior year of Mechanical Engineering & Mechanics. One of the courses is an AS course/elective (3).

Asian Studies

Professors. John Gatewood, Ph.D. (Illinois), *Sociology and Anthropology*; Norman Girardot, Ph.D. (Chicago), *Religion Studies;* Kenneth Kraft, Ph.D. (Princeton), *Religion Studies;* Michael Notis, Ph.D. (Lehigh), *Materials Science and Engineering;* David Pankenier, Ph.D. (Stanford), *Modern Languages and Literature;* Nicola Tannenbaum, Ph.D. (Iowa), Program Director, *Sociology and Anthropology;* Raymond Wylie, Ph.D. (London, England), *International Relations.*

Associate professors. Constance Cook, Ph.D. (U.C., Berkeley), *Modern Languages and Literature;* Gail Cooper, Ph.D. (U.C., Santa Barbara), *History*; Alexander Levine, Ph.D. (San Diego), *Philosophy*; Michael Mendelson Ph.D. (San Diego), *Philosophy*; Kiri Lee, Ph.D. (Harvard), *Modern Languages and Literature.*

Assistant professors. Amardeep Singh, Ph.D. (Duke), *English*; Robert Rozehnal, Ph.D. (Duke), *Religion Studies;* Elizabeth Vann, Ph.D. (Virginia), *Sociology and Anthropology*.

The Asian Studies program provides undergraduates in any college within Lehigh an opportunity to acquire a systematic knowledge of Asia, specifically East Asia, Southeast Asia, and the Pacific. The program focuses on the rich historical and cultural heritage of the countries of Asia, as well as their growing importance in world affairs and their critical relationship to the national interests of the United States.

Courses offered at other LVAIC institutions and may be taken for credit by Lehigh students. Students are encouraged to participate in a variety of extracurricular activities that are offered in Asian Studies, such as special lectures and seminars, films, performances, and exhibits.

The overall program is administered by the Asian Studies Committee, an interdisciplinary body of faculty with a special interest in the region. This committee oversees both the formal academic work within the program as well as the extracurricular activities sponsored at the university. It also cooperates with the Asian Cultural Society and other campus organizations involved in aspects of Asian Studies.

The courses listed are regularly offered in the program and new ones are currently under development in a number of subject areas. (Consult the Registrar's Schedule of Classes for specific offerings in any particular semester.)

For further information, interested students should consult Dr. Constance Cook, Director, Asian Studies Program, Maginnes Hall, 9 W. Packer Ave, 758-3091 (cac8), or any of the Asian Studies faculty listed above *(www.lehigh.edu/~inasp/).*

Major in Asian Studies

The Asian Studies major is designed to accomplish three goals: to ground the student in a regional language and culture (Chinese or Japanese), to survey various disciplines in Asian Studies more broadly, and to provide advanced research opportunities in the upperclass years. The program, when successfully completed, prepares the student for further graduate work, professional education, or employment in the public or private sector. There is an increasing demand for graduates who combine a major in a disciplinary field (e.g., business, economics, international relations) with a second major (or minor) in Asian Studies, including Chinese or Japanese language competence.

The major in Asian Studies may have a Chinese studies or a Japanese studies concentration, each requiring a minimum of 9 courses (36 credits). The distribution of the credits is as follows, subject to the guidance of the academic advisor, Dr. Constance Cook, Director, Asian Studies Program, Maginnes Hall, 9 W. Packer Ave, 758-3091 (cac8). Students may also request an advisor from among the Asian Studies faculty above.

Minor in Asian Studies

The minor in Asian Studies is intended to complement a student's major field of study and it is flexible according to individual needs. Students are free to survey the field broadly or concentrate in a special area such as Chinese or Japanese studies. The minor is composed of a minimum of 4 courses (16 credits) in Asian studies, chosen from an approved list in consultation with the minor advisor, Dr. Constance Cook, Director, Asian Studies Program, Maginnes Hall, 9 W. Packer Ave, 758-3091 (cac8).

While students minoring in Asian Studies are encouraged to study languages, only 8 credits of language study count towards the Asian Studies minor. Students interested only in language study are encouraged to minor in Chinese or Japanese (see MLL).

Study Abroad Programs

Students are encouraged to spend a summer, semester, or year in an approved study program in China, Japan, Korea, Southeast Asia, South Asia or the Pacific. Students who wish to study abroad, and who wish to have the academic work taken in that program count toward a Lehigh degree, must have a GPA of 2.7 or higher. Any student with a lower GPA may petition the Committee on the Standing of Students for an exception to this rule before applying to an approved study abroad program. These programs are open to all LVAIC students subject to the regulations of their home institutions. For details on all programs, consult Erica Smith, Director, Study Abroad Office, Coxe Hall, 32 Sayre Dr, 610-758-3351, (ers5) *(www.lehigh.edu/studyabroad).*

I. Core Requirements

A. Language and Culture: Chinese or Japanese or other approved Asian languages to intermediate level (2 years); or 4 courses (16 credits), based on placement, chosen from the following *:

ASIA 91. Elementary Asian Language and Culture Abroad (1-8)
Elementary Language and culture abroad other than Chinese or Japanese. (HU)

ASIA 191. Intermediate Asian Language and Culture Abroad (1-8)
Intermediate language and culture other than Chinese and Japanese. (HU)

CHIN, JPNS 91. Language and Culture Abroad I (1-8)
Intensive study of conversation in the language of the country; reading, development of writing skills and selected aspects of the culture. (HU)

CHIN, JPNS 191. Language and Culture Abroad II (1-8)
Intensive study of conversation in the language of the country; rapid review of basic grammar, the reading and analysis of moderately difficult texts, development of rudimentary writing skills, supplemented study of selected aspects of contemporary civilization. Prerequisites: consent of chair and proficiency examination in the target country. (HU)

CHIN 001. Beginning Chinese Reading & Writing I (2)
Introduction to the Chinese writing system and beginning character acquisition; reading practice with pinyin transcription system. (Fall) Co-requisite: Chin 003 or permission of the instructor. Staff. (HU)

CHIN 002. Beginning Chinese Reading & Writing II (2)
Continuation of Chin 001: continued character acquisition, reading practice in pinyin and simple character texts. (Spring) Prerequisites: Chin 003, Chin 004 or permission of the instructor. Staff. (HU)

CHIN 003. Beginning Spoken Chinese I (2)
Introduction to Mandarin Chinese pronunciation, the pinyin transcription system, and modern colloquial Chinese; emphasis on oral proficiency. Not open to native speakers. (Fall) Co-requisite: Chin 001 or permission of the instructor. Staff. (HU)

CHIN 004. Beginning Spoken Chinese II (2)
Continuation of Chin 003: further practice with text-based dialogues in modern colloquial Chinese; emphasis on oral proficiency. Not open to native speakers. (Spring) Prerequisite: Chin 002 or permission of the instructor. Staff. (HU)

CHIN 011. Intermediate Chinese Reading & Writing I (2)
Continued focus on vocabulary/character acquisition and text-based reading and writing exercises using Chinese characters. (Fall) Prerequisites: Chin 013 or permission of the instructor. Staff. (HU)

CHIN 012. Intermediate Chinese Reading & Writing II (2)
Continuation of Chin 011: vocabulary/character acquisition and text-based reading and writing exercises using Chinese characters. (Spring). Prerequisites: Chin 013, Chin 014, or permission of the instructor. Staff. (HU)

CHIN 013. Intermediate Spoken Chinese I (2)
Further development of communicative skills in Chinese using situational dialogues and class discussion; emphasis on oral proficiency. Not open to native speakers. (Fall) Prerequisite: Chin 004, Chin 011, or permission of the instructor. Staff. (HU)

CHIN 014. Intermediate Spoken Chinese II (2)
Continuation of Chin 013: further development of communicative skills in Chinese using situational dialogues and class discussion; emphasis on oral proficiency. Not open to native speakers. (Fall) Prerequisite: Chin 012, Chin 013, or permission of the instructor. Staff. (HU)

CHIN 111. Advanced Chinese Reading & Writing I (2)
Reading, translation, and writing practice using text-based exercises, short stories, essays, and other selected materials. (Fall). Prerequisites: Chin 014, Chin 113 or permission of the instructor. Staff. (HU)

CHIN 112. Advanced Chinese Reading & Writing II (2)
Continuation of Chin 111: reading, translation, writing exercises using text-based exercises, short stories, essays, and other selected materials. (Spring). Prerequisites: Chin 111, Chin 113, or permission of the instructor. Staff. (HU)

CHIN 113. Advanced Spoken Chinese I (2)
Topical discussions and oral presentations in Chinese. (Fall) Prerequisite: Chin 014, Chin 111, or permission of the instructor. Staff. (HU)

CHIN 114. Advanced Spoken Chinese II (2)
Continuation of Chin 113: topical discussions and oral presentations in Chinese. (Fall) Prerequisite: Chin 112, Chin 113, or permission of the instructor. Staff. (HU)

JPNS 1. Elementary Japanese I (4) fall
Introduction to the oral and written language with emphasis on spoken Japanese and syllabaries. Language laboratory. (HU)

JPNS 2. Elementary Japanese II (4) spring
Continuation of Japanese 1. Prerequisite: Japanese 1 or equivalent. (HU)

JPNS 11. Intermediate Japanese I (4) fall
Continuation of Japanese 2. Structural patterns in both spoken and written languages. 150 kanji (Chinese characters). Prerequisite: JPNS 2 or equivalent. (HU)

JPNS 12. Intermediate Japanese II (4) spring
Continuation of Japanese 11. Prerequisite: Japanese 11 or equivalent. (HU)

JPNS 141. Advanced Japanese I (4) fall
Advanced reading and oral comprehension. Conversation and writing practice. Prerequisite: JPNS 12 or equivalent. (HU)

JPNS 142. Advanced Japanese II (4) spring
Continuation of JPNS 141. Prerequisite: JPNS 141 or equivalent. (HU)

**Note 1. Students with prior knowledge of Chinese or Japanese will be placed on the basis of a competence test. Native speakers placing out of the language requirement in part or in whole will be required to take additional Asian studies courses to make up a minimum of 36 credit hours.*

B. Humanities and Social Science: 3 courses (minimum 10 credits) chosen from the following:

ASIA 61. (IR 61) Pacific Asian International Relations (4)
Introduction to Pacific Asian international relations, with emphasis on post-1945 period: historical background; Cold War conflicts; China's rise to power; Japan's growing role; Korea and the NIC's; Southeast Asia; U.S. and Russian policies; current and future issues. Wylie (SS)

ASIA 60. (REL 60) Religions of South Asia (4)
A thematic introduction to the foundational religious traditions of South Asia: Hinduism, Jainism, Buddhism, Sikhism and Islam. Students explore the social and spiritual dimensions of these religious worlds through scripture, ritual practices, narrative and teaching traditions, music and art. Rozehnal. (HU)

ASIA 62. (REL 62) Religions of India (4)
Origin, development and meaning of the major forms of Indian religious traditions. Attention to elite and popular forms of Hinduism, Yoga, early Buddhism. (HU)

ASIA 64. (REL 64) Religions of China (4)
History and meaning of the major forms of Chinese religion- especially Confucianism and Neo-Confucianism, Taoist mysticism, Buddhism (Ch'an/Zen), and popular religion. Girardot. (HU)

ASIA 65. (REL 65) Religions of Japan (4)
A survey of Japan's diverse religious heritage and its impact on contemporary culture. Japanese approaches to the self, the world, and the sacred are considered in comparative perspective. Topics covered include: Shinto, Buddhism, Zen, Confucianism, the way of the warrior, folklore, and postwar movements. Kraft. (HU)

ASIA 67. (REL 67) Japanese Civilization (4)
The history and culture of Japan from its origins to the present. Special consideration will be given to the rise and fall of the warrior class, developments in art and religion, the dynamics of family life, and Japan's "economic miracle." Kraft. (H/S)

ASIA 68. (MLL 68) Japanese Language: Past and Present (4)
Historical and contemporary aspects of the Japanese language, including the origins of Japanese in relation to Korean, the influence of Chinese, syntactic features which reflect the hierarchical character of Japanese society, differences in female and male speech, and use of foreign loan words. Prerequisite JPNS 1. Lee (HU)

ASIA 73. (MLL73, WS 73) Film, Fiction, and Gender in Modern China (4)
Study of the struggle for an individual "modern" identity out of traditionally defined roles for men and women as depicted by Chinese writers and filmmakers. Class, texts, and films in English. Students interested in setting up a corollary Chinese language component may discuss this possibility with the professor. Cook (HU)

ASIA 74. (MLL 74) Chinese Cultural Program (1-8)
A summer program in China, taught in English. (HU)

ASIA 75. (HIST 75, MLL 75) Chinese Civilization (4)
The development of traditional Chinese thought, beliefs, technology, and institutions from a historical perspective, from earliest times to China's encounter with the West. Pankenier (H/S)

ASIA 76. (HIST 76, MLL 76) Understanding Contemporary China (4)
An overview of recent history, politics, economy, religion, problems of modernization, popular culture, and attitudes. Contemporary Chinese society viewed against the backdrop of tradition and the tumultuous history of twentieth-century China. Pankenier (SS)

ASIA 77. (REL 77) The Islamic Tradition (4)
A thematic introduction to Islamic history, doctrine and practice. Topics include: Qur'an; prophecy and sacred history; ritual practices; community life; legal interpretation; art and aesthetics; mysticism; politics and polemics. Rozehnal. (HU)

MLL 78. (ASIA 78) Asian-American Studies (4)
A survey of issues concerning Asians living in the United States from the perspectives of history, language, literature, and film. (HU)

ASIA 100. Seminar in Asian Studies (1-4)
Topics in Asian Studies. May be repeated for credit. **(HU/SS depending on topic)**

ASIA 125. (MLL 125) Immortal Images: Traditional Chinese Literature in Translation (4)
Explore age-old themes in literature as diverse as premodern novels, ghost stories, poetry, divination manuals, and medical texts. Cook **(HU)**

ASIA 140. (PHIL 140) Eastern Philosophy (4)
Survey of selected texts and issues in the eastern philosophical traditions. Attention will be given to the development and interrelations of these traditions as well as a comparison of western and eastern treatments of selected issues. Areas of focus may include Confucianism, Taoism, and Zen Buddhism. (HU)

ASIA 141. (STS 141) Science and Technology in East Asia (4)
The development of science and technology in East Asia with emphasis on Japan and China. (SS)

ASIA 145. (REL 145) Islam and the Modern World (4)
Examines how numerous Muslim thinkers-religious scholars, modernists, and Islamists-have responded to the changes and challenges of the colonial and post-colonial eras. Special emphasis is placed on the public debates over Islamic authority and authenticity in contemporary South Asia. Rozehnal. (HU)

ASIA 146. (REL 146) Islam in South Asia (4)
A survey of the dynamic encounter between Islamic and Indic civilizations. Topics include: Islamic identity, piety and practice; art and aesthetic traditions; inter-communal exchange and conflict; the colonial legacy; and the politics of contemporary religious nationalism. Rozehnal. (HU)

ASIA 160. (REL 160) The Taoist Tradition (4)
Consideration of the religious and cultural significance of Taoism in its various historical forms. Primary attention will be given to a close reading of some of the most important texts of the early philosophical tradition (e.g. *Tao Te Ching, Chuang Tzu*) and of the later religious tradition (*e.g. Pao P'u Tzu* and other selections from the *Tao Tsang*). Contemporary implications of Taoist thought will also be considered (e.g. "The Tao of Physics", "a Taoist on Wall Street", and "the Tao of Japanese Management"). Girardot. (HU)

ASIA 161. (IR 161) China in World Affairs (4)
China in world affairs, emphasizing role in Pacific Rim: historical background; domestic politics; foreign and security policies; relations with regional and global powers; policies toward Asia and Third World; current and future issues. Wylie. (SS)

ASIA 162. (REL 162) Zen Buddhism (4)
History, doctrines, and practices of Zen Buddhism in China, Japan, and the West. Monastic life, notable Zen masters, Zen's cultural impact, and enlightenment. Current aspects of the Zen tradition. (Optional meditation workshop.) Kraft. (HU)

ASIA 163. (IR 163) Japan in World Affairs (4)
Japan in world affairs, emphasizing role in Pacific Rim: historical background; domestic politics; foreign and security policies; relations with regional and global powers; policies toward Asia and Third World; current and future issues. Wylie. (SS)

ASIA 164. (IR 164, REL 164) Japan's Response to the West (4)
A survey of Japanese history and culture from 1500 to the present, following the theme of Japan's contact with the West. What enabled Japan to modernize and Westernize so successfully? Topics covered include: the expulsion of Christianity, the first samurai mission to the U.S., the postwar American occupation, and contemporary issues. Readings include Japanese novels and short stories (in translation). Kraft. (SS)

ASIA 164. (REL 164, IR 164) Japan's Response to the West (4)
A survey of Japanese history and culture from 1500 to the present, following the theme of Japan's contact with the West. What enabled Japan to modernize and Westernize so successfully? Topics covered include: the expulsion of Christianity, the first samurai mission to the U.S., the postwar American occupation, and contemporary issues. Readings include Japanese novels and short stories (in translation). Kraft. (H/S)

ASIA 167. (REL 167) Engaged Buddhism (4)
Examines a contemporary international movement that applies Buddhist teachings and practices to social, political, and environmental issues. Topics include: important thinkers, forms of engagement, and areas of controversy. Kraft. (HU)

ASIA 168. (REL 168) Buddhism in the Modern World (4)
Explores contemporary Buddhism in Asia, America, and Europe. Topics include the plight of Tibet, Buddhist environmentalism, and the emergence of a socially engaged Buddhism. How are Westerners adapting this ancient tradition to address present-day concerns? Kraft. (HU)

ASIA 169. (REL 169) Classics of Asian Religion (4)
Sacred scriptures of Asia and an introduction to the religions they represent. What do these texts teach about reality, humanity, divinity, and society? How is the path of spiritual practice presented in the different traditions? Prerequisite: one prior course in Religion or Asian Studies. Kraft, Girardot. (HU)

ASIA 177. (HIST 177, MLL 177) China Enters the Modern Age (4)
The collapse of the imperial order and China's agonizing transformation into a modern nation-state over the past 150 years. The impact of imperialism, war, radical social change, and protracted revolution on Chinese traditions, values, and institutions. Pankenier (H/S)

ANTH 184. (Asian Studies 184) Cultures of the Pacific (4)
Cultures of the Pacific Islanders prior to substantial disruption by European influences. Culture histories, language families, social organizations, and religions of Australian, Melanesian, Polynesian, and Micronesian peoples. Gatewood. (SS)

ANTH 187. (Asian Studies 187) Peoples of Southeast Asia (4)
Peoples and cultures of Burma, Laos, Cambodia, Thailand, Malaysia, Singapore, Indonesia, and the Philippines. World view, religion, economy, politics, and social organization. Tannenbaum. (SS)

II. Advanced Electives

Two courses (7 or 8 credits) chosen from the following, 1 course (4 credits) of which must be at the 300 level:

A. Language and Culture:

CHIN 251. Special Topics (1-4)
Literary and linguistics topics not covered in regular courses. May be repeated for credit. Prerequisite: consent of the instructor. (HU)

JPNS 290. Special Topics (1-4)
Literary or linguistics topics not covered in regular courses. May be repeated for credit. Prerequisite: consent of instructor. (HU)

ASIA 291. Advanced Asian Language and Culture Abroad (1-8)
Advanced language and culture abroad other than Chinese and Japanese. (HU)

CHIN, JPNS 291. Language and Culture Abroad III (1-8)
Intensive practice of speaking and writing in the language of the country aimed at providing the student with extensive proficiency of expression and the ability to discriminate linguistic usage. Idiomatic expressions and an introduction to stylistics. Reading and analysis of more difficult texts, supplemented by in-depth study of selected aspects of contemporary civilization. Prerequisites: consent of MLL chair and proficiency examination in the target country.(HU)

CHIN 371. Special Topics (1-4)
Directed study of an author, genre, or period not covered in regular courses. May be repeated once for credit. Prerequisite: consent of the instructor. (HU)

B. Humanities and Social Sciences:

ASIA 221. (REL 221) Topics in Asian Religions (4)
Selected thematic and comparative issues in different Asian religious traditions. May include Buddhism and Christianity, religion and martial arts, Asian religions in America, Taoist meditation, Zen and Japanese business, Buddhist ethics. May be repeated for credit. Girardot, Kraft. (H/S)

ASIA 247. (REL 247) Islamic Mysticism (4)
Sufism, the inner or 'mystical' dimension of Islam, has deep historical roots and diverse expressions throughout the Muslim world. Students examine Sufi doctrine and ritual, the master-disciple relationship, and the tradition's impact on art and music, poetry and prose. Rozehnal. (HU)

ASIA 254. (REL 254) Buddhism and Ecology (4)
Buddhism's intellectual, ethical, and spiritual resources are reexamined in light of contemporary environmental problems. Is Buddhism the most green of the major world religions? What are the moral implications of actions that affect the environment? Prerequisite: One prior course in religion, environmental studies, or Asian studies. Kraft. (HU)

ASIA 240 .(PHIL 240) Figures/Themes in Eastern Philosophy (4)
This seminar course will involve in-depth focus upon a major figure in Eastern thought or upon the Eastern treatment of a particular theme or set of themes. Content varies. May be repeated for credit. (HU)

ASIA 340. (HIST 340) History of Japanese Industrialization Since 1800 (3-4)
He late Tokugawa economic development, rise of an entrepreneurial class, importation of western technology, and the rise of social, political and economic which support industrial growth. Cooper. (SS)

ASIA 361. Internship in Asian Studies (1-4)
Internship in public or private agency involved in some aspect of Asian studies. Individual faculty mentor. Written report required. May be repeated for credit. Program permission required. (**HU/SS depending on topic**)

ASIA 364. (IR 364) International Relations of Pacific Asia (4)
Research-oriented seminar on contemporary international relations of Pacific Asia. Special emphasis on China, Japan and regional and global powers. Substantial research paper on topic of student's own choice is required. Prerequisite: IR 61 or 161 or 163 or 164. Wylie. (SS)

ASIA 371. Advanced Readings in Asian Studies (1-4)
Directed course of reading and writing in advanced topic not covered in regular Asian Studies course offerings. May be repeated for credit. Program permission required. (**HU/SS depending on topic**)

ASIA 381. Special Topics in Asian Studies (1-4)
Advanced study of aspects of Asian studies not covered in regular course offerings. Individual faculty supervision. Research paper required. May be repeated for credit. Program permission required. (**HU/SS depending on topic**)

ASIA 391. Senior Seminar in Asian Studies (1-4)
Advanced seminar focusing on discussion and research on specialized subjects in Asian studies. Variable subject matter. Offered by faculty on rotating basis. May be repeated for credit. Program permission required. (**HU/SS depending on topic**)

ASIA 399. Senior Thesis in Asian Studies (1-4)
Advanced, individual research project on topic agreed between faculty and student. Research paper and oral defense required. May be repeated for credit. Open to Asian studies majors only. Program permission required. (**HU/SS depending on topic**)

C. Other suitable courses at LVAIC or other approved institutions in the United States.

D. Other suitable courses in approved study abroad programs in Asia.

Astronomy and Astrophysics

Professors. George E. McCluskey, Jr., Ph.D. (Pennsylvania), head; Gary G. DeLeo, Ph.D.(Connecticut).

Astronomy and Astrophysics are offered in the department of Physics.

Astrophysicists apply physics and mathematics to the study of planets, stars, galaxies, pulsars, black holes, quasars and the universe, among many other fascinating objects in order to understand their origin, evolution and ultimate fate. Students who major in astronomy or astrophysics usually have very inquisitive minds and a good aptitude for physics and mathematics. The bachelor degree programs in astronomy and astrophysics provide the student with a solid background in laboratory and theoretical astrophysics as well as in the fundamentals of physics and mathematics. Research opportunities are available to supplement classroom instruction.

The bachelor of science degree in astrophysics is designed for students who wish to go on to graduate studies in astrophysics with the goal of becoming professional astronomers. Professional astronomers generally find positions at colleges, and universities, national labs, NASA or its contractors and in various space industries. This degree also prepares you for many jobs in related fields such as computer science, mathematics or physics.

The bachelor of arts degree in astronomy is intended for students who desire a broad background in astronomy, mathematics and physics but do not plan to do graduate work in astrophysics. With this broad background, the student is well prepared in many fields of endeavor, including planetarium and museum work, teaching astronomy at colleges and universities, secondary education, science writing, or, in fact, in many professions in which the ability to learn is critical.

Both of these degrees can be profitably combined with physics, mathematics, and other sciences producing excellent double majors or double degrees.

A minor program in astronomy is also available for students who wish to enlarge their potential for a career choice or who may be eager to learn more about astrophysics than an introductory course can provide.

Astronomy and Astrophysics Degree Programs

Requirements for the **Bachelor of Arts** degree in astronomy:

Mathematics	
MATH 21, 22, 23, and 205	[15]
Basic and Intermediate-Level Science	
ASTR 7/8	(4)
PHY 11/12 or 10/12	(5)
PHY 21/22 or 13/14	(4-5)
PHY 31, 262	(5)
CHM 21/22 or 75/76	(5-8)
EES 21	(4)
EES 113 or 2-4 cr. hr. at 100 level or above	(2-4)
	[29-35]
Intermediate - Advanced Astronomy/Astrophysics	
ASTR/PHY/EES 105	(4)
ASTR/PHY 110	(1)
ASTR/PHY 201 or 202	(4)
	[9]

Approved Electives

Two additional physics/astronomy courses at the 200 level or above	(6)
Two additional science or mathematics courses at the 200 level or above	(6)
	[12]

Approved Electives are subject to the approval of the student's advisor, and should be chosen to provide a coherent program.

Recommended courses are MATH 12, PHY 212, EES 31, BIOS 31.

Requirements for the **Bachelor of Science** degree in Astrophysics

Mathematics

MATH 21, 22, 23, 205, (320 or 332)	[18]

Basic and Intermediate-Level Science

PHY 11/12 or 10/12	(5)
PHY 21/22 or 13/14	(4-5)
PHY 31, 212, 215, (262 or 352)	(12-13)
CHM 21/22 or 75/76	(5-8)
EES 21	(4)
EES 113 or 2-4 cr. hr. at 100 level or above	(2-4)
	[32-39]

Intermediate - Advanced Astronomy/Astrophysics

ASTR/PHY/EES 105	(4)
ASTR/PHY 110	(1)
ASTR/PHY 201, 202	(8)
ASTR/PHY (332 or 342 or 350)	(3)
	[16]

Approved Electives

Three additional physics/astronomy courses at the 200 level or above	(9)
One additional science course (not physics or astronomy) at the 100 level or above	(3)
	[12]

Recommended sequence of courses for the first two years:

B.A. Astronomy		**B.S. Astrophysics**	
Fall	Spring	Fall	Spring
Freshman year			
ENGL 1 (3)	ENGL 2,4 (3)	ENGL 1 (3)	ENGL 2, 4... (3)
EES 21 (4)	PHY 11(4)	PHY 11 (4)	EES 21 (4)
MATH 21 (4)	PHY 12 (1)	PHY 12 (1)	MATH 22 (4)
ASTR 7/8 (4)	MATH 22 (4)	MATH 21 (4)	Col Sem and/or Dist Req (3-6)
Coll Ment (1)	Col Sem (3-4)	Col Sem or Dist req(1) (3-4)	Coll Ment (1)
[16]	[15-16]	[16-17]	[14-17]
Sophomore Year			
PHY 21 (4)	PHY 31 (3)	PHY 21 (4)	PHY 31 (3)
PHY 22 (1)	MATH 205 (3)	PHY 22 (1)	MATH 205 (3)
MATH 23 (4)	ASTR 110 (1)	MATH 23 (4)	ASTR 110 (1)
ASTR 105 (4)	CHM 21 (4)	ASTR 105 (4)	CHM 21 (4)
Dist req(2) (3-4)	CHM22 (1)	Dist reg(2) (3-4)	CHM 22 (1)
Dist req(2) (3-4)	Dist req(2) (3-4)		
[16-17]	[15-16]	[16-17]	[15-16]

(1) If the College Seminar is deferred until spring, students may choose to select ASTR 7 by deferring a distribution requirement.

(2) Students may wish to select EES 113 or another course that satisfies this EES requirement by deferring a distribution requirement.

	College of Arts & Sciences				**College of Engineering**	
	Concentration in:					
	Physics		Astronomy			
	B.A.	B.S.	B.A.	B.S.	Solid-State Electronics	Optical Sciences
Frshmn English	6	6	6	6	6	6
Coll. Ment. & Sem	4	4	4	4		
Distrb. Courses	*16	*16	*16	16	17	17
Required Prelim & major courses	56	66	53	66	85	78
Apprvd Electives	16	17	12	12	11	18
Electives	23	15	30	20	12	12
Total	121	124	121	124	131	131

Departmental Honors in Astronomy or Astrophysics. Students receiving a BA in Astronomy or a BS in Astrophysics may earn Departmental Honors by satisfying the following requirements:

1. *Academic Performance:* Minimum grade point average of 3.50 in astronomy and physics courses used to satisfy the major degree requirements.
2. *Research or Project-Based/Creative Activity:* completion of approved* special topics courses in astronomy that include written reports, ***or***
   completion of 6 credits of PHY 273 (research) or equivalent, ***or***
   completion of a summer research project with written report and oral presentation
3. *Additional Course Work:* Completion of at least one approved* 300-level course in either physics or astronomy beyond those required in the student's degree program. This course may ***not*** be selected from special topics or research courses such as ASTR/PHY 350 or PHY 372.

specific approvals are granted by the Program Director

The minor program in Astronomy. The requirements for a minor in astronomy are:

PHY 11/12 and 21/22
ASTR 105, 201, and 202
One ASTR course at the 300 level
Two courses (minimum of 6 credit hours) selected from the following: Any ASTR course (except ASTR 7 or 8) CSC 17, MATH 208, 231, PHY 31, 213, 215, 348, 362.

The minor program must be designed in consultation with the program director.

Undergraduate Courses in Astronomy/Astrophysics

ASTR 7. (PHY 7) Introduction to Astronomy (3) fall

Introduction to planetary, stellar, galactic, and extragalactic astronomy. An examination of the surface characteristics, atmospheres, and motions of planets and other bodies in our solar system. Properties of the sun, stars, and galaxies, including the birth and death of stars, stellar explosions, and the formation of stellar remnants such as white dwarfs, neutron stars, pulsars, and black holes. Quasars, cosmology, and the evolution of the universe. May not be taken by students who have previously completed ASTR/PHY 105, 201, or 202. (**NS**)

ASTR 8. (PHY 8) Introduction to Astronomy Laboratory (1) fall
Laboratory to accompany ASTR/PHY 7. (NS)

ASTR 105. (PHY 105, EES 105) Planetary Astronomy (4) fall
Structure and dynamics of planetary interiors, surfaces, and atmospheres. Models for the formation of the solar system and planetary evolution. Internal structure, surface topology, and composition of planets and other bodies in our solar system. Comparative study of planetary atmospheres. Organic materials in the solar system. Properties of the interplanetary medium, including dust and meteoroids. Orbital dynamics. Extrasolar planetary systems.

ASTR 110. (PHY 110) Methods of Observational Astronomy (1)
Techniques of astronomical observation, data reduction, and analysis. Photometry, spectroscopy, CCD imaging, and interferometry. Computational analysis. Examination of ground-based and spacecraft instrumentation, and data transmission, reduction, and analysis. (NS)

For Advanced Undergraduates and Graduate Students

ASTR 201. (PHY 201) Modern Astrophysics I (4) fall
Physics of stellar atmospheres and interiors, and the formation, evolution, and death of stars. Variable stars. The evolution of binary star systems. Novae, supernovae, white dwarfs, neutron stars, pulsars, and black holes. Stellar spectra, chemical compositions, and thermodynamic processes. Thermonuclear reactions. Interstellar medium. Prerequisites: PHY10 and 13, or PHY 11 and 21, MATH 22 or 52. (NS)

ASTR 202. (PHY 302) Modern Astrophysics II (4) spring
The Milky Way Galaxy, galactic morphology, and evolutionary processes. Active galaxies and quasars. Observed properties of the universe. Relativistic cosmology, and the origin, evolution and fate of the universe. Elements of General Relativity and associated phenomena. Prerequisites: PHY 10 and 13, or PHY 11 and 21, MATH 22 or 52. (NS)

ASTR 332. (PHY 332) High-Energy Astrophysics (3) spring, odd-numbered years
Observation and theory of X-ray and gamma-ray sources, quasars, pulsars, radio galaxies, neutron stars, black holes. Results from ultraviolet, X-ray and gamma ray satellites. Prerequisites: MATH 23 or 33 previously or concurrently, and PHYS 21. McCluskey. (NS)

ASTR 342. (PHY 342) Relativity and Cosmology (3) spring, even-numbered years
Special and general relativity. Schwarzschild and Kerr black holes. Supermassive stars. Relativistic theories of the origin and evolution of the universe. Prerequisites: MATH 23 or 33 previously or concurrently, and PHY 21. McCluskey. (NS)

ASTR 350. Topics in Astrophysics (3) fall-spring
For science or engineering majors who desire to study an active area of research in astrophysics. Individual supervision. Prerequisites: ASTR 201, and MATH 23 or 33 and PHY 21. May be repeated for credit with the consent of the program director. (NS)

Biochemistry

An interdepartmental B.S. biochemistry major is offered in the College of Arts and Sciences. The B.S. in biochemistry degree is managed by an interdepartmental committee composed of biochemists, bioorganic chemists, and molecular/cellular biologists. The committee administers the degree, monitors the academic program, provides research possibilities, and advises student majors. The director of the program is currently Linda J. Lowe-Krentz. Faculty in both Biological Sciences (Lowe-Krentz and Iovine) and Chemistry (Schray) serve as advisors. Majors should be declared in Biological Sciences.

Bachelor of Science Degree in Biochemistry

I. College and University Requirements (26)

a. ENGL 1, 2 (6)
b. ARTS 1 (1)
c. First Year Seminar (3)
d. Non-science electives: 16 hours to be broadly distributed in fields of thought other than natural science and mathematics, including at least 8 hours each in humanities and social sciences.

II. Collateral Science Requirements at least (24)

a. Physics 10, 12, 13, 22 (or 11, 12, 21, 22) (9 or 10)
b. Mathematics 51,52,43 (or 21, 22, 23) and a statistics course (at least 12)
c. Survey of Computer Science 12 or Engineering 1 (3)

III. Required Chemistry Courses (25 to 26)

a. Introductory Chemistry 75, 76 (8*)
b. Organic Chemistry 51, 52, 53, 58 (8)
c. Inorganic Chemistry 205 or 307 (2 or 3)
d. Physical Chemistry 187 or 194 (3)
e. Analytical Chemistry 332 (3)

**The Chemistry 21/22/31 sequence may be substituted.*

IV. Required Biological Science courses (24)

a. Biology Core I: Cellular and Molecular and Laboratory 41, 42 (4)
b. Biology Core II: Genetics 115 (3)
c. Biochemistry 371, 372, 377 (9)
d. Advanced Laboratory (4)
e. Electives in Biological Sciences (3 hours minimum*)
f. Technical Writing (2 hours minimum)

**The three credit hours of biological sciences electives are chosen with the approval of the adviser.*

Model Pattern Roster

freshman year

CHM 75,76	Concepts, Models, and Experiments I and II (8)
BIOS 41,42	Biology Core I: Cell and Molecular and Laboratory (4)
MATH 51,52	Survey of Calculus I and II (7) or
MATH 21,22	Calculus I and II (8)
Dept 90	College Seminar (3)
ARTS 1	Choices & Decisions (1)
ENGL 1,2	Composition and Literature (6)
PHY 10,12	General Physics I and Laboratory (5) or
PHY 11, 12	Introductory Physics I and Laboratory (5)

sophomore year

CHM 51, 52, 53, 58	Organic Chemistry and Laboratory (8)
PHY 13, 22	General Physics II and Laboratory (4)
or	
PHY 21, 22	Introductory Phys. II and Laboratory
MATH 43	Linear Algebra (3) or
MATH 23	Calculus III
BIOS 130	BioStatistics**
CHM 187	Physical Chemistry I (3)*
BIOS 115	Biology Core II: Genetics

**Alternatively, if CHM 194 is elected, it would be taken fall of junior year*

***A statistics course from the MATH department could also fulfill the statistics requirement*

junior year

CHM 332	Analytical Chemistry (3)
BIOS 371,372	Elem. of Biochemistry I and II (6)
BIOS 377	Biochem. Lab (3)
CHM 205	Main Group Elements (2)*
CSE 12	Survey of Computer Science (3)
	Technical Writing (2)

**If CHM 194 is taken in the junior year, CHM 205 would be displaced to senior year. If CHM 307 is elected in place of CHM 205, it would be taken in the senior year.*

senior year

BIOS	Advanced laboratory course(s)
BIOS	elective

Biological Sciences

Professors. Neal Simon, Ph.D. (Rutgers), chair; Barry Bean, Ph.D. (Rockefeller); Michael J. Behe, Ph.D. (Pennsylvania); David Cundall, Ph.D. (Arkansas); Murray Itzkowitz, Ph.D. (Maryland); Steven Krawiec, Ph.D. (Yale); Linda J. Lowe-Krentz, Ph.D. (Northwestern); John Nyby, Ph.D. (Texas); Jeffrey A. Sands, Ph.D. (Penn State).

Associate professors. Lynne Cassimeris, Ph.D. (North Carolina); Michael R. Kuchka, Ph.D. (Carnegie Mellon); Jill Schneider, Ph.D. (Wesleyan); Jennifer Swann, Ph.D. (Northwestern); Vassie C. Ware, Ph.D. (Yale).

Assistant professors. Maria Bykhovskaia, Ph.D. (Russian Academy of Sciences); Matthias Falk, Ph.D. (Heidelberg); Mary Kathryn Iovine, Ph.D. (Washington); Stefan Maas, Ph.D. (Heidelberg); Tamra Mendelson (Duke); Robert V. Skibbens, Ph.D. (North Carolina); Colin J. Saldanha, Ph.D. (Columbia)

Adjunct professors. Martin L. Richter, Ph.D. (Indiana)

The biological sciences include the study of living systems at levels ranging from the structure and function of molecules to the behavior and evolution of communities of organisms. The department offers four different routes to mastering skills and knowledge in this broad area. The B.A. and B.S. programs in biology provide a broad introduction to biology with opportunities for students to create a program of study suited to their specific interests. Programs of study focused on particular aspects of biology are the B.A. and B.S. degree in the areas of behavioral neuroscience and molecular biology and the interdepartmental B.S. degree in biochemistry managed in conjunction with the chemistry department. For programs in ecology and environmental biology, see the Department of Earth and Environmental Sciences listing.

The requirements for the B.A. and B.S. in biology, behavioral neuroscience, and molecular biology are listed below. Research interests of the faculty and instrumentation are described in the section on graduate education.

B.A. with Major in Biology

College and university requirements for all majors (26 credit hours)

ENGL l, 2	Composition and Literature (6)
ARTS 1	Choices and Decisions (1)
	First Year Seminar (3)
	Social Sciences (8)
	Humanities (8)

Major Program (50-51 credit hours)

Biology (30 credit hours)

BIOS 41	Biology Core I: Cellular and Molecular (3)
BIOS 42	Biology Core I: Cellular and Molecular Laboratory (1)
BIOS 115	Biology Core II: Genetics (3)
BIOS 116	Biology Core II: Genetics Laboratory (1)
BIOS 120	Biology Core III: Integrative and Comparative (4)
Electives *	Biology electives

**Approved electives (18 credit hours, no more than 3 cr. from the following courses: 161, 261, 262, 391,393, College scholar project, not BIOS 130 and no more than 1 course from the following courses: EES 253, EES 255, EES 259, EES 265, EES 351).*

Mathematics (7-8 credit hours)

MATH 51	Survey of Calculus I (4)
MATH 52	Survey of Calculus II (3) or
MATH 12	Basic Statistics (4) or
BIOS 130	BioStatistics (4)

Collateral Sciences (13 credit hours)

CHM 21	Introductory Chemical Principles (4)
CHM 22	Chemical Principles Laboratory (1)
CHM 51,53	Organic Chemistry I and lab (3,1)
CHM 52,58	Organic Chemistry II and lab (3,1)

The B.S. in Biology

The bachelor of science in biology offers broad scientific preparation in biology to facilitate advanced work in the life sciences. Progression through the program is best served through early commitment.

Requirements for the B.S. in Biology

College and university requirements as above (26 credit hours)

Major Program (76 credit hours)

Biology (37 credit hours)

BIOS 41	Biology Core I: Cellular and Molecular (3)
BIOS 42	Biology Core I: Cellular and Molecular Lab (1)
BIOS 115	Biology Core II: Genetics (3)
BIOS 116	Biology Core II: Genetics Laboratory (1)
BIOS 120	Biology Core III: Integrative and Comparative (4)
BIOS 317	Evolution (3)
Electives*	Biology electives (22)

**Biology electives must include one course from list A, one course from list B and at least four credits of laboratory* *experience (e.g. two 2 credit laboratory courses and may include no more than one course from the following courses: EES 253, EES 255, EES 259, EES 265, EES 351). These will be chosen in consultation with the major advisor.*

List A

BIOS 276	Behavioral Neuroscience II (3)
BIOS 313	Vertebrate Histology (4)
BIOS 314	Vertebrate Development (3)
BIOS 335	Animal Behavior (3)
BIOS 337	Behavioral Ecology (3)
BIOS 382	Endocrinology of Behavior (3)

List B

BIOS 324	Bacteriology (3)
BIOS 345	Molecular Genetics (3)
BIOS 353	Virology (3)
BIOS 356	Human Genetics and Reproduction (3)
BIOS 367	Cell Biology (3)
BIOS 371	Elements of Biochemistry I (3)

Mathematics (14 credit hours minimum)

either

MATH 51, 52, 43	Survey of Calculus I, II and Linear Algebra (10)

or

MATH 21, 22, 23	Analytic Geometry and Calculus I, II, III (12)

and

BIOS 130	BioStatistics (4)

Collateral Sciences (25 credit hours)

CHM 75,76	Concepts, Models and Experiments I and II (8) **or**
CHM 21, 22, 31	
CHM 51, 52	Organic Chemistry I and II (6)
CHM 53, 58	Organic Chemistry Laboratory I and II (2)
PHY 10	General Physics I (4) **or**
PHY 11	Introductory Physics I (4)
PHY 12	Introductory Physics Laboratory I (1)
PHY 13	General Physics II (3)
PHY 22	Physics Lab II (1)

Recommended B.S. Biology Sequence

freshman year

BIOS 41	Biology Core I: Cellular and Molecular (3)
BIOS 42	Biology Core I: Cellular and Molecular Laboratory (1)
MATH 51, 52	Survey of Calculus I and II (7)
CHM 75, 76	Concepts, Models and Experiments I and II (8)
Dept 90	First Year Seminar (3)
ARTS 1	Choices & Decisions (1)

sophomore year

BIOS 115	Biology Core II: Genetics (3)
BIOS 116	Biology Core II: Genetics Laboratory (1)
CHM 51, 52, 53, 58	Organic Chemistry and Laboratory (8)
MATH 43	Survey of Linear Algebra
BIOS 120	Biology Core III: Integrative and Comparative(4)
BIOS 130	BioStatistics (4)

junior year

PHY 10, 12	General Physics I and Laboratory (5)
PHY 13, 22	General Physics II and Laboratory (4)

Approved biology electives including one from list A and one from list B (9-12)

senior year

BIOS 317	Evolution (3)
elective	Biology electives including at least 4 credits of laboratory (10-14)

Minor in Biology

A minor in biology may be achieved by completing the following requirements (18 credits):

BIOS 41, 42	Biology Core I: Cellular and Molecular and Laboratory (4)
BIOS 115, 116	Biology Core II: Genetics and Laboratory (4)
BIOS 120	Biology Core III: Integrative and Comparative (4) **or**
BIOS 177	Behavioral Neuroscience I (3)
CHM 51	Organic Chemistry (3)
Elective	Biology electives at the 200 or 300 level (3 **or** 4)

B.A. with major in Behavioral Neuroscience

The B.A. in Behavioral Neuroscience is a natural science major for B.A. distribution purposes.

Required Major Courses

BIOS 41	Biology Core I: Cellular and Molecular (3)
BIOS 42	Biology Core I: Cellular and Molecular Laboratory (1)
BIOS 115	Biology Core II: Genetics (3)
BIOS 116	Biology Core II: Genetics Laboratory (1)
BIOS 120	Biology Core III: Integrative and Comparative (4)
BIOS 130	BioStatistics (4)
BIOS 177	Behavioral Neuroscience I (3)
BIOS 276	Behavioral Neuroscience II (3)
BIOS 277	Experimental Neuroscience Laboratory (1)
BIOS 382	Endocrinology of Behavior (3)

Major Electives (6 credits)

BIOS 234	Comparative Vertebrate Anatomy (4)
BIOS 313	Vertebrate Histology (4)
BIOS 314	Vertebrate Development (3)
BIOS 317	Evolution (3)
BIOS 324	Bacteriology (3)
BIOS 328	Immunology (3)
BIOS 335	Animal Behavior (3)
BIOS 337	Behavioral Ecology (3)
BIOS 345	Molecular Genetics (3)
BIOS 353	Virology (3)
BIOS 356	Human Genetics and Reproduction (3)
BIOS 367	Cell Biology (3)
BIOS 368	Cell Biology Laboratory (2)
BIOS 371	Elements of Biochemistry I (3)
BIOS 372	Elements of Biochemistry II (3)
BIOS 377	Biochemistry Laboratory (3)

CHM 31	Chemical Equilibria in Aqueous Systems (3)
PSYC 117	Cognitive Psychology (3)
PSYC 153	Personality (4)
PSYC 154	Introduction to Clinical Psychology (3)
PSYC 176	Mind and Brain (4)
PSYC 305	Abnormal Psychology (4)
PSYC 307	Seminar in Cognition (4)

Required Collateral Courses

MATH 51, 52	Survey of Calculus I and II (7) **or**
MATH 21, 22	Calculus I and II (8)
CHM 21	Introductory Chemical Principles (4)
CHM 22	Chemical Principles Laboratory (1)
CHM 51, 52	Organic Chemistry (6)
CHM 53, 58	Organic Chemistry Laboratory I and II (2)
PSYC 1	Introduction to Psychology (4)

Other Options

The B.A. in Behavioral Neuroscience is a traditional liberal arts degree that can be structured for a wide variety of possibilities (see listing of recommended elective courses). By using free electives to take additional science, the B.A. also can serve as a preprofessional degree for many graduate and professional schools. Students interested in a particular career-based program should consult their advisor or the program director, Professor John Nyby.

B.S. in Behavioral Neuroscience

B.S. majors are required to take the core courses of the B.A. program and to fulfill the elective requirements of the B.A. program. An early commitment to the B.S. is desirable to meet all the requirements of this program. Additional requirements are shown below.

Math and Science Requirements for the B.S.

MATH 51, 52, 43	Survey of Calculus I, II and Linear Algebra (10)
CHM 21, 22	Introductory Chemical Principles & Lab (5)
CHM 51, 52	Organic Chemistry I and II (6)
CHM 53, 58	Organic Chemistry Laboratory (2)
BIOS 234	Comparative Vertebrate Anatomy (4)
BIOS 371, 372	Elements of Biochemistry I & II (6)
BIOS 377	Biochemistry Laboratory (3) **or**
BIOS 368	Cell Biology Laboratory (2). If this course is elected, Cell Biology BIOS 367 must be taken as an elective
PHY 10, 12	General Physics I and Laboratory (5) **or**
PHY 11, 12	Introductory Physics I and Laboratory (5)
PHY 13, 22	General Physics II and Laboratory (4)
or	
PHY 21, 22	Introductory Physics II and Laboratory (5)
PSYC 1	Introduction Psychology (4)

B.A. with major in Molecular Biology

Requirements for the B.A. in Molecular Biology

College and university requirements (see above).

Biology (30 credit hours)

BIOS 41, 42	Biology Core I: Cellular and Molecular (3) and Lab (1)
BIOS 115, 116	Biology Core II: Genetics (3) and Lab (1)
BIOS 120	Biology Core III: Integrative and Comparative (4)
BIOS 324	Bacteriology (3) **or**
BIOS 328	Immunology **or**
BIOS 353	Virology
BIOS 325	Bacteriology Lab (2) **or**
BIOS 368	Cell Biology Lab (2) **or**
BIOS 377	Biochemistry Lab (3)
BIOS 371	Elements of Biochemistry I (3)
BIOS 345, 346	Molecular Genetics (3) and Lab (2)
BIOS 367	Cell Biology (3)
BIOS	approved electives (6 credit hours)

Mathematics (8-10 credit hours)

MATH 21 and 22	Calculus I & II (8) **or**
MATH 51, 52, & 43	Survey of Calculus I & II, and Linear Algebra (10)

Chemistry (16 credit hours)

CHM 21, 22	Introductory Chemical Principles (4) and Lab (1)
CHM 31	Chemical Equilibria in Aqueous Systems (3)
CHM 51, 52, 53, 58	Organic Chemistry I, II and Lab I & II (8)

Physics (9 credit hours)

PHY 10, 12	General Physics I and Lab I (5) **or**
PHY 11, 12	Introductory Physics I and Lab (5)
PHY 13, 22	General Physics II and Lab (4)

The B.S. in Molecular Biology

Requirements for the B.S. in Molecular Biology

Major Program (93 credit hours)

Mathematics (12 credit hours)

MATH 21, 22, 23 Calculus I, II and III (12 credit total) **or**

MATH 51, 52, 43 and one of MATH 12, or 231 or BIOS 130 (13-14, credit total)

Chemistry (16 credit hours)

CHM 21	Introductory Chemical Principles (4)
CHM 22	Chemical Principles Laboratory (1)
CHM 51, 52	Organic Chemistry I and II (6)
CHM 53, 58	Organic Chemistry Laboratory (2)
CHM 31	Chemical Equilibria in Aqueous Systems (3)

Physics (9-10 credit hours)

PHY 10 (**or** 11)	General Physics I (4)
PHY 12	Introductory Physics Laboratory I (1)
PHY 13 (**or** 21)	General Physics II (3 or 4)
PHY 22	Physics Lab II (1)

Molecular Biology (37-39 credit hours)

BIOS 41	Biology Core I: Cellular and Molecular (3)
BIOS 42	Biology Core I: Cellular and Molecular Lab (1)
BIOS 115	Biology Core II: Genetics (3)
BIOS 116	Biology Core II: Genetics Laboratory (1)
BIOS 120	Biology Core III: Integrative and Comparative (4)
BIOS 324	Bacteriology (3) **or**
BIOS 328	Immunology (3) **or**
BIOS 353	Virology (3)

BIOS 325	Bacteriology Laboratory (2) **or**
BIOS 368	Cell Biology Laboratory (2) **or**
BIOS 377	Biochemistry Laboratory (3)
BIOS 345	Molecular Genetics (3)
BIOS 346	Molecular Genetics Laboratory (2)
BIOS 367	Cell Biology (3)
BIOS 371	Elements of Biochemistry I (3)
BIOS 372	Elements of Biochemistry II (3)
BIOS 381	Physical Biochemistry (3)
Approved Molecular Biology Electives (12)	

Recommended sequence for the B.S. in Molecular Biology

freshman year

BIOS 41	Biology Core I: Cellular and Molecular (3)
BIOS 42	Biology Core I: Cellular and Molecular Laboratory (1)
MATH 21, 22	Calculus I and II (8)
CHM 21, 22	Introductory Chemical Principles and Lab (5)
CHM 31	Chemical Equilibria in Aqueous Systems (3)

sophomore year

BIOS 115	Biology Core II: Genetics (3)
BIOS 116	Biology Core II: Genetics Laboratory (1)
BIOS 120	Biology Core III: Integrative and Comparative (4)
MATH 23	Calculus III (4)
CHM 51, 52	Organic Chemistry (6)
CHM 53, 58	Organic Chemistry Laboratory (2)
PHY 10, 12	General Physics I and Lab (5)
PHY 13, 22	General Physics II and Laboratory (4)

junior year and senior year

BIOS 324	Bacteriology (3) **or**
BIOS 328	Immunology (3) **or**
BIOS 353	Virology (3)
BIOS 325	Bacteriology Laboratory (2) **or**
BIOS 368	Cell Biology Laboratory (2) **or**
BIOS 377	Biochemistry Laboratory (3)
BIOS 345	Molecular Genetics (3)
BIOS 346	Molecular Genetics Laboratory (2)
BIOS 371, 372	Elements of Biochemistry I and II (6)
BIOS 367	Cell Biology (3)
BIOS 381	Physical Biochemistry (3)
Approved Molecular Biology Electives (12)	

Molecular Biology Minor

The molecular biology minor program consists of BIOS 41 (3), 42 (1), 115 (3), 116 (1), 345 (3), 346 (2), and a minimum of 4 additional credits of BIOS coursework at the 200 or 300 level. Collateral coursework must include: MATH 51 or 21 (4 credit hours), CHM 21 (4), CHM 22 (1), and CHM 51 (3).

Departmental Honors

A student may apply for admission to the departmental honors program through a potential thesis advisor. Requirements for Departmental Honors include a major GPA of 3.25 and at least 2 semesters of research for a minimum of 6 cr. The student must write a research proposal for their project and a thesis at the conclusion of their research. This work must be presented in a symposium at the end of the project. Students must meet regularly to discuss their research progress either in BIOS 387 and BIOS 388 or with their advisor and research group to facilitate progress in the research project.

Undergraduate Courses in Biological Sciences

Courses with numbers below 010 are intended for non-majors and may not be used to satisfy any life science major or minor requirement.

BIOS 1. Biology for Non-Majors (3 or 4)
Basic and applied biology for non-science majors. May not be used in satisfaction of life science major or minor programs. Focus of topics at the discretion of the instructor. May be taught with (4 credits) or without (3 credits) a laboratory. (NS)

BIOS 7. Human Reproduction (3)
Basic and applied human reproductive biology for non-science majors. May not be used in life science major or minor programs. (NS)

BIOS 8. Drugs and Behavior (3)
Basic principles of drug action in the central nervous system. Effects of stimulants, depressants, intoxicants and drug abuse on behavioral function. Clinical use of drugs in the treatment of various psychological and psychiatric disorders. (NS)

BIOS 9. Anatomy and Physiology (4)
Introduction to the structure and function of the major systems of the body. (NS)

BIOS 41. Biology Core I: Cellular and Molecular (3)
Basic building blocks and higher-order structures required for cellular processes. Topics include the character of membranes, the molecular/cellular basis of energy production, cell cycle progression, DNA replication, gene expression, signal transduction, and cell division. Pre- or co-requisite: CHEM 21 or 75. (NS)

BIOS 42. Biology Core I: Cellular and Molecular Lab (3)
Experiments, observations, and discussions related to the principal topics covered in BIOS 41. Corequisite: BIOS 41.

BIOS 115. Biology Core II: Genetics (3)
The structure, function, and continuity of hereditary information. Classical genetic analysis. Molecular biology of genes and genomes. Population genetics and evolution. Genetics of complex traits. Prerequisites: BIOS 41. (NS)

BIOS 116. Biology Core II: Genetics Laboratory (1)
Laboratory work that demonstrates major principles of genetics: included are experiments on microorganisms and the common fruit fly, Drosophila melanogaster. Prerequisite: BIOS 115, preferably concurrently.

BIOS 120 Biology Core III: Integrative and Comparative (4)
Experimental and historical approaches to the analysis of structural and functional properties in organisms. Use of scientific method to study species diversity. Introduction to the analysis of organismal attributes that explain behavioral repertoire and ecological relationships. Prerequisites: BIOS 115, 116 (NS).

BIOS 130. BioStatistics (4)
Elements of statistics and probability theory with emphasis on biological applications. Statistical analysis of experimental and observational data. Prerequisite: BIOS 41 (ND)

BIOS 152. (EES 152) Ecology (4)
Basic principles and applications of ecological interrelationships. Examination of ecological phenomena at the individual, population, community, and ecosystem levels. Impact of human activities on global ecosystems. Prerequisite: EES 31. (NS)

BIOS 161. Supervised Research (1-3) fall-spring
Apprenticeship in ongoing faculty research program. Literature review, experimental design, data collection and analysis, and professional writing under faculty sponsor supervision. May be repeated but only 3 credits can be counted toward any life science major. Prerequisite: Consent of department. (ND)

BIOS 177. Behavioral Neuroscience I (3)
Nervous system functioning with varying emphasis on neurophysiology, neuroanatomy, behavior genetics, information transmission, research techniques, sensory and motor functions. Prerequisite: BIOS 41. (NS)

BIOS 202. Biomedical Externship (1-3)
Analysis of individualized experiences at external biomedical clinical or research sites. Limited enrollment. May not be taken for pass-fail grading. May be taken only once and may not be used to satisfy any life science major or minor requirement. Prerequisite: Consent of department chair required. (NS)

BIOS 233. Invertebrate Zoology (4)
Survey of representative invertebrates. Structure and behavior of selected types and concepts of evolutionary relationships among the major groups. Two lectures and two laboratory periods. Prerequisite: BIOS 120. (NS)

BIOS 234. Comparative Vertebrate Anatomy (4)
A course in vertebrate zoology with emphasis on the study of homologous body structures in the various vertebrate classes and their relationship to the functional demands of habit and environment in each class. Detailed dissections of representative vertebrates are made in the laboratory. Two lectures and two laboratory periods. Prerequisite: Consent of department. (NS)

BIOS 241. Vertebrate Natural History (4)
An introduction to the ecology, behavior, distribution and evolution of vertebrates, with emphasis on the North American fauna. Two lectures, one tutorial and one laboratory and field trip. This course may be used to fulfill junior writing requirements with the permission of the instructor. Prerequisite: BIOS 115. (NS)

BIOS 251. Writing and Biological Sciences (3)
A course designed to acquaint students with some of the intellectual foundations of science, with attention to the distinctiveness of molecular biology. Format includes readings, intensive writing, extemporaneous speaking, and discussion. Prerequisite: Consent of department. (NS)

BIOS 261. Special Topics in Biological Sciences (1-3)
Research, conferences and reports on selected topics not covered in the general undergraduate offerings. May be taken more than once for credit. Prerequisite: Consent of the department chair. (NS)

BIOS 262. Research Proposal (3)
Literature and methods of research in area of department faculty expertise. Requires development of detailed proposal for research to be performed in senior year. Prerequisites: Major in any biological sciences degree program; junior standing; GPA of 3.0 in major; and consent of the department chair. (NS)

BIOS 276. Behavioral Neuroscience II (3)
Neuronanatomy and neurophysiology of animal and human behavior. Feeding, thirst, sleep, emotions, learning, and psychopathology. Prerequisite: BIOS 177. (ND)

BIOS 277. Experimental Neuroscience Laboratory (1)
This laboratory course examines the specialized properties of the neuron which shape its function within neural networks, the development and structure of the nervous system, and the preparation of neural tissue for microscopic examination. Included are experiments and demonstrations utilizing important biochemical, cellular and molecular techniques used in modern neurobiology. Prerequisites: BIOS 177 and consent of department chair. (NS)

For Advanced Undergraduates and Graduate Students

BIOS 313. Vertebrate Histology (3)
Microstructural and ultrastructural properties of vertebrate cells and tissues. Techniques of tissue preparation. One lecture and two labs. Prerequisite: BIOS 234. (ND)

BIOS 314. Vertebrate Development (3)
Germ cell formation, fertilization, early development, and the origin of the principal organ systems. Location, structure, and regulation of information from molecular to organismal levels of organization. Prerequisite: BIOS 115 and BIOS 234. (NS)

BIOS 317. Evolution (3)
Mechanisms of evolution, emphasizing genetic structure and variation of populations, and isolation. Origin of species and higher taxa. Rates of evolution, extinction. Prerequisite: BIOS 115. (NS)

BIOS 324. Bacteriology (3)
The structure, physiology, growth, genetics and taxonomy of prokaryotes. Prerequisites: CHM 51 and BIOS 115. Corequisite: BIOS 325. (NS)

BIOS 325. Bacteriology Laboratory (2)
Standard procedures and metabolic tests used in determinative bacteriology; aseptic technique, sterilization, enumeration, and control of bacterial growth; other selected topics. Corequisite: BIOS 324.

BIOS 328. Immunology (3)
Distinction of "self" and "non-self" through humoral and cellular mechanisms. Antigens; biochemical structures, cellular mechanisms, genetic control and processing, phylogenetic distribution, diseased states. Prerequisite: BIOS 115. (NS)

BIOS 329. Herpetology (3)
Biology of amphibians and reptiles. Two lectures, one laboratory or field trip per week. Prerequisite: Consent of department. (ND)

BIOS 335. (PSYCH 335) Animal Behavior (3)
Discussion of the behavior of invertebrates and vertebrates and analysis of the physiological mechanisms

responsible for behavioral stimuli, and adaptive value of specific behavior patterns. Prerequisite: BIOS 115. (NS)

BIOS 336. Animal Behavior Laboratory (2)
Experiments and field observations illustrating principles discussed in BIOS 335. Emphasis on observing animals, performing experiments, collecting and analyzing data, and individual research. Six hours of laboratory per week. Corequisites: BIOS 335 or 337.

BIOS 337. Behavioral Ecology (3)
Social systems of vertebrate and invertebrate groups. Emphasis on ecological and evolutionary factors that influence social behavior. Prerequisites: BIOS 115. (NS)

BIOS 345. Molecular Genetics (3)
The organization and replication of genetic material; mutagenesis; mechanisms of regulation; mechanisms of gene transmission involving prokaryotes and eukaryotes and their viruses; techniques for intervention into genetic organization and expression. Prerequisite: BIOS 115. (NS)

BIOS 346. Molecular Genetics Laboratory (2)
Laboratory experiments related to the topics covered in BIOS 345. Emphasis is on molecular characterization of DNA and the principles of gene isolation and transfer. Corequisite: BIOS 345.

BIOS 347. Advanced Topics in Genetics (3)
Lectures and student projects on selected aspects of genetics such as the genetics and evolution of particular organisms, regulation of gene expression and transmission, human genetics, gene therapy, etc. Prerequisites: BIOS 345 or consent of department chair. (NS)

BIOS 353. Virology (3)
Structure and replication of viruses. Emphasis on the organization, replication, and regulation of expression of viral genomes; the mechanisms of virus assembly and release; and on virus-host interactions. Special attention given to human pathogenic viruses. Prerequisite: BIOS 115 and CHM 52. (NS)

BIOS 356. Human Genetics and Reproduction (3)
Processes and mechanisms of human heredity. Emphasis at the cellular and molecular levels. Analysis, organization, expression, and evolution of human genome. Genetic aspects of reproduction and development, mapping human chromosomes, cell hybridation, molecular analysis of gene structure and function, behavior and intelligence, primate origins and evolution, immunogenetics, cancer and oncogenes, genetic technologies. Prerequisite: BIOS 115. (NS)

BIOS 367. Cell Biology (3)
Molecular aspects of cell biology. Emphasis on membrane structure and function, organelle biogenesis, cell motility, the cytoskeleton, and extracellular matrix. Prerequisite: BIOS 115. (NS)

BIOS 368. Cell Biology Laboratory (2)
Basic methods used in cell biology laboratories around the world and the opportunity to carry out an independent research project. Techniques include histology and microscopy (both white and fluorescent light), tissue culture and sterile procedures, cellular fractionation, nuclear import assays, and immunological probing. Co- or pre-requisite Bios 367. Departmental permission required. (NS)

BIOS 369. Comparative Physiology of Vertebrate Systems (4)
Functional analysis of energy balance in vertebrate animal models. Digestion, respiration, circulation, and excretion, across aquatic and terrestrial vertebrates. Homeostatic mechanisms of salt, water, and gas exchange. Ionotropic and metabetropic signal transduction. Hormonal and electrical cellular communication among muscles, glands, and neurons. Sensory systems, movement and reproduction. Physiological adaptations to extreme environments. Includes one laboratory meeting per week. Prerequisite: BIOS 120. (NS)

BIOS 370. Plant Molecular Biology (3)
Molecular aspects of photosynthesis; chloroplast biogenesis; plant gene expression; plant development; plant-microbe interactions; genetic engineering in plant systems. Prerequisite: BIOS 345. (NS)

BIOS 371. (CHM 371) Elements of Biochemistry I (3) fall
A general study of carbohydrates, proteins, lipids, nucleic acids and other biological substances and their importance in life processes. Protein and enzyme chemistry are emphasized. Prerequisite: one year of organic chemistry. (NS)

BIOS 372. (CHM 372) Elements of Biochemistry II (3) spring
Dynamic aspects of biochemistry; enzyme reactions including energetics, kinetics and mechanisms; metabolism of carbohydrates, lipids, proteins and nucleic acids; photosynthesis, electron transport mechanisms, coupled reactions, phosphorylations, and the synthesis of biological macromolecules. Prerequisite: BIOS 371 and BIOS 41 or consent of the instructor. (NS)

BIOS 376. Classical & Molecular Embryology (3)
Differentiation of multicellular organisms from a single cell. Axis determination; gradients; induction and pattern formation viewed through modern analysis of regulated gene expression. Prerequisite: BIOS 345 (previously or concurrently). (NS)

BIOS 377 (CHM 377). Biochemistry Laboratory (3) fall
Laboratory studies of the properties of chemicals of biological origin and the influence of chemical and physical factors on these properties. Laboratory techniques used for the isolation and identification of biochemicals. Prerequisite: BIOS/CHM 371 previously or concurrently. (ND)

BIOS 378 (CHM 378). Biochemical Preparations (1-3) spring
A laboratory course involving the preparation or isolation, purification and identification of chemicals of biological origin. Prerequisites: BIOS/CHM 377 and 372, previously or concurrently. (ND)

BIOS 381 Physical Biochemistry (3)
Topics include: thermodynamics of biological systems; Forces acting on and between biological molecules; Principles of macromolecular structure; Physical methods used to characterize biomolecules; and other topics to be determined. Prerequisite BIOS/CHM 371 and BIOS 41. (NS)

BIOS 382. (PSYCH 382) Endocrinology of Behavior (3)
Hormonal effects upon animal and human behavior. Emphasis on neuroendocrinology of steroid hormone involvement in reproductive behaviors. Prerequisite: BIOS 177. **(NS)**

BIOS 383. Biological Sciences Colloquia (1)
Analysis of weekly colloquia in molecular biology. For senior biology and molecular biology majors. May be taken twice for credit. **(ND)**

BIOS 384 Eukaryotic Signal Transduction (3)
Signal transduction between cells of multi-cellular eukaryotic organisms examined in the context of specialized functions that include: nutrition, hormones and neurotransmitters, vision, muscle contraction, adhesion, and the immune system. The evolution of cancer based on mutations in these signaling systems. Prerequisite BIOS 367 or 372.

BIOS 385. Neurophysiology and Memory (3)
Lectures and seminars on mechanisms of neuronal communication, the ability of neuronal networks to store and retrieve information, cellular basis for memory. Prerequisite: BIOS 177 and PHY 13, or consent of the instructor. **(NS)**

BIOS 387. Biological Sciences Honors Seminar (1)
Development, presentation and implementation of research proposals, and discussions of research. Required for senior biology and molecular biology majors pursuing departmental honors. Departmental permission required. **(ND)**

BIOS 388. Biological Sciences Honors Seminar (1)
Continuation and extension of BIOS 387. Departmental permission required. **(ND)**

BIOS 391. Undergraduate Research (1-3)
Laboratory research under tutorial with a faculty member. May be taken more than once for credit. Prerequisites: junior standing, and consent of instructor. **(ND)**

BIOS 393. Thesis (3)
Literature review and design of project in selected area, execution of the project, final report and presentation. Departmental permission. Intended for senior majors in BIOS only. May be repeated one time for additional credit. **(ND)**

Special Health Professions Programs

Students may apply for admission to an accelerated B.A.-Doctor of Medicine program and a B.A.-Doctor of Medical Dentistry program. A six-year B.A.-M.D. program is offered in conjunction with Drexel University College of Medicine, and a seven-year B.A.-D.M.D. program is offered in conjunction with the University of Pennsylvania School of Dental Medicine. Students in these programs receive a B.A. from Lehigh and a graduate degree from the designated professional school within a six- or seven-year period. For details concerning admission to these programs, see Health Professions, Section III. Undergraduate courses, please see listings for BIOS and EES.

Graduate Study in the Biological Sciences

Rigorous, research-oriented graduate programs leading to a Doctor of Philosophy are offered in three divisions of the Department of Biological Sciences: biochemistry, integrative biology, and molecular biology. To complete the program students must successfully complete core courses, pass a qualifying exam, prepare, submit, and successfully defend a written research proposal, complete the research described in the proposal, and submit a written dissertation and defend the completed research to the department.

Once students enter the department, their progress is monitored by the graduate committee until they are admitted to candidacy. Members of the committee meet with the student each semester to assess the student's progress towards the degree and to assist students in choosing the appropriate courses to provide a solid scientific foundation and an up-to-date understanding of the discipline. This will be assessed by the qualifying exam.

The qualifying exam generally should be taken after the third semester and no later than the fourth semester of course work. It will be prepared, administered and graded by the faculty associated with the specific graduate program in which the student is enrolled. It consists of a two-day written exam and an oral examination. The exam can be repeated once. Admission to candidacy is granted after successful completion of the qualifying exam and the thesis proposal. The proposal is a written description of an original research project developed under the guidance of a faculty member chosen by the student to be his/her advisor. The proposal will be presented orally to the thesis committee, typically after the fifth semester. Following the presentation of the proposal, an oral examination will take place in which the thesis committee will question the student about general science related to the project. This will constitute the general examination.

Core requirements for each division are listed below. The graduate school requires students to register for at least 72-post baccalaureate credits to earn the Ph.D. In addition, all students must take BIOS 408 (0 credits) *Responsible Conduct of Science* within their first year of graduate study. All students must also attend departmental seminars and enroll in BIOS 406 (1 credit) *Biological Sciences Seminar* at least twice in the first four semesters. A minimum of 24 course credits may be chosen from upper level courses in biochemistry, molecular biology, cell biology, behavioral biology and evolutionary biology, and neuroscience. At least 12 of these credits must be at the 400 level.

In the biochemistry program, research areas include DNA structure and function, regulation of protein synthesis, and signal transduction. Students admitted to graduate study in biochemistry will typically have an undergraduate degree in chemistry or biochemistry. Students with an undergraduate degree in a related discipline will be expected to have the following undergraduate preparation for graduate study beyond introductory chemistry and a year of organic chemistry: at least one semester of analytical chemistry and one semester of physical chemistry - thermodynamics and kinetics, with appropriate math. Students without that background will be expected to take courses to fulfill those requirements as part of their graduate study. Required courses: BIOS 371, 372 Elements of Biochemistry I and II, BIOS 469, 470 Biochemical Problem Solving I and II, CHM 423 Bio-Organic Chemistry, BIOS 345 Molecular Genetics, and a seminar course. BIOS 408 or CHM 400 must also be completed before beginning research.

The graduate program in integrative biology is designed to train students in advanced organismal biology with the emphasis on behavioral ecology, evolution, functional morphology, endocrinology, and neurobiology of animals. The mission of the program is to create students who are broadly trained and uniquely capable of asking questions and solving problems at the interface of these traditionally defined fields. Students admitted to the program should have a basic knowledge of evolution, anatomy, physiology, behavioral neuroscience, and/or behavioral ecology. Students will begin by taking core courses providing a broad foundation in integrative biology at the graduate level and work toward a Ph.D. with a concentration in either behavioral neuroscience or behavioral and evolutionary biology. Regardless of concentration, all students in the program develop an appreciation for the fact that all aspects of biology, whether cellular, physiological, anatomical, behavioral, environmental , or social, are inextricably linked and cannot be fully understood as separate, parallel systems of knowledge. All students must take 4 courses, with at least one from each of the three core areas: (1) Behavior/ Evolution- BIOS 439 Advanced Behavioral Ecology, BIOS 409 Evolutionary and Functional Morphology; (2) Neurobiology I- BIOS 453 General Neuroanatomy, BIOS 457 Advanced Behavioral Neuroendocrinology; (3) Neurobiology II- BIOS 416 Neurophysiology and Memory, BIOS 450 Developmental Neurobiology. All core courses will be offered at least every second year. In addition, one year of graduate level statistics is required- either PSYC 421 and 422 Statistical Analysis of Psychological Data or EDUC 410 and 411 Univariate and Multivariate Statistics, as well as BIOS 406 Biological Sciences Seminar, BIOS 408 Responsible Conduct of Science, and BIOS 401 Professional Graduate Skills (strongly recommended to be taken in the first two years of the program). Two additional elective courses are required and may be chosen from core courses not used to fulfill core requirements or BIOS 429 Advances in Herpetology, BIOS 455 Systematics and Evolution, BIOS 411 Advanced Cell Biology, BIOS 421 Molecular Cell Biology I (prerequisite is BIOS 345), BIOS 371 Elements of Biochemistry I, BIOS 372 Elements of Biochemistry II (prerequisite is BIOS 371), or BIOS 471 Elements of Eukaryotic Biochemistry (prerequisite is BIOS 372 or BIOS 411 or permission of instructor).

In the molecular biology program, research areas include microbial evolution and genetics, plant and animal molecular genetics, eukaryotic cell biology, and regulation of gene expression. Required core courses include BIOS 345 Molecular Genetics, BIOS 371 Elements of Biochemistry I, BIOS 372 Elements of Biochemistry II, BIOS 411 Advanced Cell Biology, BIOS 421 Molecular Cell Biology I, and BIOS 422 Molecular Cell Biology II. Additional courses to reach 24 credits are chosen from upper level electives in molecular biology, cell biology, and biochemistry.

Facilities available for research in the biological sciences include core facilities with equipment (for example, for DNA synthesis, confocal microscopy, digital imaging, chromatography, cell culture, centrifugation, controlled environments, gamma and scintillation counting, flow cytometry, and rodent surgery). Individual research laboratories and advanced teaching laboratories contain a variety of additional equipment. Ongoing interactions with a variety of private companies contribute additional opportunities for student experiences.

Graduate Courses in the Biological Sciences

BIOS 401. Professional Skills for Biological Sciences Graduate Students (3)
Students learn expectations and fundamental skills related to success in the biological sciences. The course is designed to help students make the most out of their graduate education. Students learn the principles underlying fundable, publishable research, and how these general principles can be applied to their specific research area. They learn to write and review manuscripts and grant proposals by serving on a mock editorial board and scientific review panel. They gain experience in giving oral presentations. Readings are from texts on scientific writing and research styles, and from original journal articles and grant proposals written by the faculty. No prerequisites. Required of all Integrative Biology graduate students.

BIOS 404. (PSYC 404) Behavioral Neuroscience (3)
Theoretical and empirical issues in biopsychology. Prerequisite: Graduate standing or consent of instructor.

BIOS 405. Special Topics in Molecular Biology (1-3)
Research, conferences, and reports on selected topics not covered in the general graduate offerings. May be taken more than once for credit.

BIOS 406. Biological Sciences Seminar (1)
An advanced seminar in current developments including departmental research. Required for candidates for graduate degrees in molecular biology. May be taken more than once for credit.

BIOS 407. Research in Biological Science (1-9)
Laboratory investigations in one of the department's research areas.

BIOS 408. Responsible Conduct of Science (0)
Responsible practice in research. Training in general laboratory methods; human subjects concerns; radiation safety; chemical hazards; aseptic technique; physical, mechanical, biological, and fire hazards; animal welfare. Occupational and workplace considerations. Recombinant DNA guidelines; patent and proprietary rights; controversies over applications of science. Appropriate aspects required of investigators in all departmental research projects.

BIOS 409. Evolutionary and Functional Morphology (3)
Readings in the current literature, demonstrations and laboratory exercises exploring the applications of comparative methods to the analysis of evolutionary patterns at a range of morphological levels (molecular and macroscopic). Students will also learn experimental approaches to testing relationships between form and function in vertebrates. Emphasis will be on the musculoskeletal and nervous systems. Prerequisite BIOS 234 Comparative Vertebrate Anatomy, BIOS 317 Evolution, or permission of instructor.

BIOS 410. Special Topics in Behavioral and Evolutionary Bioscience (1-3)
Readings and discussions on selected topics not covered in the general graduate offerings. May be taken more than once for credit.

BIOS 411. Advanced Cell Biology (3)
Cell structure and biochemistry, as related to specialized cell functions.

BIOS 412. Metabolic Influences on Behavior (3)
Sensory systems that detect metabolic energy availability and affect the behavior of humans and other animals: food intake and body weight regulation, sexual and parental behavior, aggression, learning, and body temperature regulation. Prerequisite: BIOS 404 and consent of instructor.

BIOS 414. Sexual Differentiation (3)
Genetic and hormonal events mediating the development and expression of sexual dimorphisms in physiology and behavior. Current theoretical models; emphasis on biochemical, neuroanatomical and molecular biological considerations. Prerequisite: BIOS 404 and consent of instructor.

BIOS 415. Neuropharmacology (3)
Mechanism of drug action in the central nervous system, including cell surface receptors and second messenger systems. Drug use/abuse and cellular changes mediating behavioral effects. Drug use in clinical therapy. Prerequisite: BIOS 404 and consent of instructor.

BIOS 416. Neurophysiology and Memory (3)
Lectures and seminars on mechanisms of neuronal communication, the ability of neuronal networks to store and retrieve information, cellular basis for memory. Prerequisites: Background in neuroscience and undergraduate physics or consent of instructor.

BIOS 418. Analysis of Reproduction and Mating Systems (3)
Study of reproduction and sexuality in plants and animals with emphasis on current hypotheses as reported in the literature. Topics include hermaphroditism, neoteny, larval forms, parental investment, complex life cycles, population structure. Readings from primary source material and review articles. One review paper and one research proposal are required, and together with readings forms the basis for discussion sections and examinations. Prerequisite: Consent of the department chair.

BIOS 419. Bacterial Genetics (3)
Structure and function of genetic information in prokaryotes. Composition, size, and organization of chromosomes and accessory elements; mechanisms of replication, recombination, transmission, and mutation; variation within and among strains.

BIOS 420. Pheromonal Communication (3)
Mechanisms of pheromone synthesis, biochemistry, sensory transduction, neuroanatomy/neuroendocrinology, and adaptive significance. Prerequisite: BIOS 404 and consent of instructor.

BIOS 421. Molecular Cell Biology I (3)
Molecular aspects of cell structure, cell motility, intracellular transport; and biomembrane dynamics. Prerequisite: BIOS 411 or equivalent.

BIOS 422. Molecular Cell Biology II (3)
Molecular aspects of gene expression, including genome structure and replication, RNA synthesis/processing, and protein synthesis. Prerequisite: BIOS 345 or equivalent.

BIOS 425. Male Reproductive Biology (2 or 3)
Molecular, cellular, and genetic aspects of the mammalian male reproductive system. Prerequisite: BIOS 367 or equivalent.

BIOS 427. Techniques in Cell and Molecular Biology (3)
Laboratory experiences in three or more cell and molecular biological techniques: gel electrophoresis of nucleic acids/proteins; polymerase chain reaction; DNA/RNA sequencing; molecular hybridization techniques; fluorescence microscopy; confocal microscopy; flow cytometry; electron microscopy tissue preparation; immunological detection methods; molecular cloning techniques; oocyte microinjection techniques; tissue culture methods; and autoradiography.

BIOS 429. Advances in Herpetology (3)
Lectures and readings from the primary literature on current research in amphibian and reptilian biology. Two lectures, one discussion session and one laboratory or field trip. Not open to students who have received credit for BIOS 329.

BIOS 431. Advanced Topics in Cell Biology (3)
Current research problems in cell biology. May be repeated when a different topic is offered. Prerequisite: BIOS 367 or equivalent.

BIOS 432. Advanced Topics in Molecular Genetics (3)
Current research in molecular genetics. May be repeated when a different topic is offered. Prerequisite: BIOS 345 or equivalent.

BIOS 433. Advanced Topics in Developmental Biology (3)
Current research problems in developmental biology. May be repeated when a different topic is offered. Prerequisite: BIOS 345 or equivalent.

BIOS 437. (CHM 437) Pathophysiological Chemistry (3)
Biochemical basis of human diseases involving abnormal metabolism of proteins, nucleic acids, carbohydrates, and lipids. Emphasis on the correlation of the clinical presentation of disease processes seen as physiological dysfunctions with clinical laboratory methods. Lectures, student presentations, and clinical case discussions. Prerequisite: consent of the department chair.

BIOS 439. Advanced Behavioral Ecology (3)
Critical evaluation of the theoretical foundation in sociobiology. Emphasis placed on kinship, altruism, mate choice, parental investment, parent-offspring conflict, etc. Lectures and seminars. Prerequisite: BIOS 317 Evolution or equivalent. Not open to students who have taken BIOS 337.

BIOS 445. Systematics and Evolution (3)
Theoretical, philosophical and methodological foundations of the classification of eukaryotic organisms and the manner in which systematic theory and method relate to evolutionary theory. Two lectures and one lab-recitation-discussion session. Prerequisite: BIOS 317.

BIOS 450. Developmental Neurobiology (3)
Fundamental mechanisms underlying neural development. Early events leading to the induction of the neuroectoderm and the reorganization of the vertebrate central nervous system during adulthood and aging. Major developmental events such as phenotype commitment, cell migration, differentiation and growth cone guidance. Emphasis on the interplay between concepts emerging from organismal and molecular levels of analyses.

BIOS 453. General Neuroanatomy (3)
Graduate level study of the neuroanatomy and neurochemistry of systems that underlie behavior in vertebrates. Emphasis will be on the traditional and novel methodologies used to reveal neuroanatomical pathways as well as the function of these pathways. Prerequisites: BIOS 177 Introduction to Behavioral Neuroscience and BIOS 375 Neuroanatomy of Behavior or permission of instructor.

BIOS 457. Advanced Behavioral Neuroendocrinology. (3)
A seminar course that covers current primary literature on the hormone-nervous system interactions that underlie physiology and behavior. The course covers the neuroendocrinology of reproduction, sex behavior, parental behavior, social behavior, agonistic and territorial behavior, learning and memory, homeostasis (caloric, nutritional, water and salt balance, temperature regulation), circadian rhythms and seasonality in a variety of vertebrates. Prerequisite: BIOS 382 or permission of instructor.

BIOS 463. Advances in Plant Molecular Biology (3)
Gene expression and molecular biology of plants. Biochemistry of photosynthesis and chloroplast development; higher plant developmental genetics; plant/microbe interactions; plant viruses; advances in genetic engineering in plants. Prerequisite: BIOS 345 or equivalent.

BIOS 464. Molecular Biology of Eukaryotic Organisms (3)
Comparative analysis of several eukaryotes as model systems in cell biology, developmental biology, genetics, and molecular biology. Prerequisite: BIOS 345 or equivalent.

BIOS 466. Structure and Function of RNAs and Ribonucleoprotein Complexes (3)
Biochemistry and function of small nuclear RNPs, RNase P, ribosomes, self-splicing introns, signal recognition particle, RNA viruses. Functions of RNA in DNA replication, in regulation, as an enzyme, and as a repressor. Prerequisite: BIOS 345 or equivalent.

BIOS 467. (CHM 467) Principles of Nucleic Acid Structure (3)
alternate years
An examination of the principles underlying nucleic acid structure including stereochemistry, electrostatics, hydration, torsional constraints, sequence specific effects, and interaction with nuclear proteins. Special emphasis will be placed on DNA structure. Prerequisites: one year of biochemistry and one year of physical chemistry or permission of the department chair.

BIOS 468. (CHM 468) Principles of Protein Structure (3)
alternate years
An examination of the principles underlying protein structure including stereochemistry, preferred tertiary structures, protein homology, excluded volume effects, time dependent structural fluctuations, and prediction of protein structure from sequence information. Prerequisites: one year of biochemistry and one year of physical chemistry or permission of the department chair.

BIOS 469. (CHM 469) Biochemical Problem Solving I (1) fall
Applications of material covered in BIOS/CHM 371 including techniques used in research. Prerequisite: BIOS/CHM 371 previously or concurrently.

BIOS 470. (CHM 470) Biochemical Problem Solving II (1) spring
Applications of concepts covered in BIOS/CHM 372 including techniques used in research. Prerequisite: BIOS/CHM 372 previously or concurrently.

BIOS 471. (CHM 471) Eukaryotic Biochemistry (3)
alternate years
Biochemistry of selected eukaryotic processes including hormone chemistry, blood clotting, immunochemistry, vision chemistry, muscle chemistry and photosynthesis. The second part of the course will involve presentation and discussion of the current literature by class participants. Prerequisite: BIOS/CHM 372 or consent of department chair.

BIOS 472. (CHM 472) Lipids and Membranes (3) alternate years
Structure, physical properties and functions of lipids and their biological aggregates. Techniques for studying lipid assemblies, enzymes which act on lipids, membrane proteins and lipoproteins will also be discussed. Prerequisite: BIOS/CHM 372 or consent of department chair.

BIOS 473. (CHM 473) Biochemistry of Complex Carbohydrates (3)
alternate years
Consideration of the structure, function and metabolism of complex carbohydrates (glycolipids, glycoproteins and proteoglycans) with particular emphasis on glycoproteins. The first part of the course will consist of lectures to familiarize the student with basic terms, concepts and processes. The second part will involve critical readings, presentation and discussion of the current primary research literature by class participants.

BIOS 477. (CHM 477) Topics in Biochemistry (1-3)
Selected areas of biochemistry; such as mechanisms of enzyme action, new developments in the chemistry of lipids, nucleic acids, carbohydrates and proteins. May be repeated for credit when different topics are offered. Prerequisite: consent of the department chair.

BIOS 479. (CHM 479) Biochemical Techniques (3)
Laboratory studies of the techniques and principles involved in the isolation, identification, and biochemical transformation of carbohydrates, lipids, nucleic acids and proteins. Prerequisite: BIOS 371 or its equivalent previously or concurrently.

BIOS 480. (CHM 480) Advanced Biochemical Preparations (1-3)
An advanced laboratory course in the preparation, isolation, purification, and identification of biochemically produced materials. Emphasis is placed on materials and procedures of current interest in biochemistry. Prerequisite: consent of the department chair.

BIOS 483. Special Topics in Behavioral Neuroscience (3)
Examination of the biological substrates of behavior. Topics may include animal communication, sociobiology, behavioral endocrinology, or behavior genetics. May be repeated for credit. Prerequisite: BIOS 404 or consent of department.

BIOS 488. Seminar in Neuroscience, Behavior, and Evolution (1)
Advanced seminar in current research developments. May be taken more than once for credit.

Biology

Biology, life science, and related courses at Lehigh University are offered in a variety of settings that reflect the various levels of organization in life science and different orientations relating to areas of application. The College of Arts and Sciences offers degree programs in Applied Life Science, Behavioral Neuroscience, Biochemistry, Biology, Earth and Environmental Science, Ecology, Environmental Science, and Molecular Biology. The P. C. Rossin College of Engineering and Applied Science offers degree programs in Bioengineering. Refer to the catalog entries below for complete descriptions.

Major and minor programs	Catalog entry
Applied Life Science (BA or BS)	Bioscience and Biotechnology
Behavioral Neuroscience (BA or BS)	Biological Sciences
Biochemistry (BS only)	Biochemistry
Bioengineering (BS only)	Bioscience and Biotechnology
Biology (BA or BS)	Biological Sciences
Earth and Environmental Science (BA only)	Earth and Environmental Sciences
Ecology (BS only)	Earth and Environmental Sciences
Environmental Science (BS only)	Earth and Environmental Sciences
Molecular Biology (BA or BS)	Biological Sciences

Courses related to life science interest can be found under the catalog entries above as well as in other departments, including Chemical Engineering, Chemistry, Mathematics, Physics, Psychology, and Sociology and Anthropology.

Bioscience and Biotechnology Program

For additional information, students should contact Professor Neal G. Simon, Chair,
Department of Biological Sciences at 610-758-3620 or ngs0@lehigh.edu or

Professor Anand Jagota,
Department of Chemical Engineering at 610-758-4396 or anj6@lehigh.edu

Core Professors. Maria Bykhovskaia, Ph.D. (Russian Academy of Sciences), *Biological Sciences*; Lynne Cassimeris, Ph.D. (North Carolina), *Biological Sciences*; Manoj Chaudhury, Ph.D. (SUNY Buffalo), *Chemical Engineering*; Volkmar Dierolf, Ph.D. (Utah), *Physics;* James D. Gunton, Ph.D. (Stanford), *Physics*; Mitiadis Hatalis, Ph.D. (Carnegie Mellon), *Electrical Engineering*; Ned Heindel, Ph.D. (University of Delaware), *Chemistry*; James T. Hsu, Ph.D. (Northwestern), *Chemical Engineering*; Mary Katherine Iovine, Ph.D. (Washington, St. Louis), *Biological Sciences*; Himanshu Jain, Eng.Sc.D. (Columbia), *Materials Science and Engineering*; Linda Lowe-Krentz, Ph.D. (Northwestern) *Biological Sciences*; Sudhakar Neti, Ph.D. (Kentucky), *Mechanical Engineering and Mechanics*; Karl Norian, Ph.D. (Imperial College, London), *Electrical Engineering*; H. Daniel Ou-Yang, Ph.D. (UCLA) *Physics*; Theodore K. Ralphs, Ph.D. (Cornell); *Industrial and Systems Engineering*; Eric P. Salathe, Ph.D. (Brown), *Mathematics;* Jill Schneider, Ph.D. (Wesleyan), *Biological Sciences*; Neal G. Simon, Ph.D. (Rutgers), *Biological Sciences*; Robert V. Skibbens Ph.D. (North Carolina), *Biological Sciences*; Svetlana Tatic-Lucic, Ph.D. (California Institute of Technology), *Electrical and Computer Engineering*; Richard P. Vinci, Ph.D. (Stanford), *Materials Science and Engineering*; Arkady S. Voloshin, Ph.D. (Tel-Aviv University, Israel), *Experimental Mechanics*; Marvin H. White, Ph.D. (Ohio State) *Electrical Engineering*.

The Bioscience and Biotechnology program is designed to meet the goals of students seeking educational opportunities at the interface of life science with engineering, humanities, business, social science, or other natural sciences. Two degree programs are offered: **Applied Life Science** in the College of Arts & Sciences and **Bioengineering** in the P.C. Rossin College of Engineering and Applied Science. The programs were developed jointly by faculty from both Colleges and were motivated by the anticipated societal impact of the human genome and proteome projects. They share several common courses, lab facilities, faculty participation, and opportunities for undergraduate research while retaining distinct identities and educational goals. Degrees available to students are: Bachelor of Arts or Bachelor of Science in Applied Life Science (Arts & Sciences) or Bachelor of Science in Bioengineering (Engineering and Applied Science).

Applied Life Science

The Applied Life Science program provides a flexible curriculum in the liberal arts tradition for students interested in bridging life science with disciplines such as mathematics, economics, political science, philosophy, international relations, information management, chemistry, communications, or business. The educational goals of the program include the development of critical analytical capabilities, strong communication skills, a core understanding of bioscience and biotechnology, and the capacity to bring an integrative, multidisciplinary perspective to the analysis of issues emanating from advances in life science. These goals are achieved through a learning environment that features integrative practices on four levels: uniting traditionally separate academic disciplines, bridging theory and practice through classroom and project-based experiential learning, working in research environments that foster team-based problem solving and professional responsibility, and partnerships and research opportunities with faculty, clinicians and the private and public sectors.

The B.A. and B.S. programs will provide students with preparation for a range of careers based primarily on the field that is hybridized with the life science core. Potential career paths including law (particularly intellectual property), management in biotechnology- related industries, ethics, journalism, policy analysis, finance, information management, or medicine as well as graduate and professional school are among the many possibilities open to Applied Life Science majors.

For additional information, students should contact Professor Neal G. Simon, Chair, Department of Biological Sciences at 610-758-3620 or *ngs0@lehigh.edu.*

BA in Applied Life Science

The B.A. in Applied Life Science is intended to provide a technical concentration in a liberal arts context. It is well-suited for students who are interested in the broad impact of the life science revolution on society including the economic, social, political, and legal implications. The program provides sufficient flexibility for the student to explore a range of interests and to pursue a double major or minor. Students can prepare for graduate school but are advised to seek guidance early to insure appropriate preparation.

University and College requirements (24 to 27 credits)
ENGL 001 and 002 (6 credits)
Choices and Decisions (1 credit)
College seminar (1 to 4 credits)
Social Sciences (at least 8 credits of designated coursework)
Humanities (at least 8 credits of designated coursework)

Collateral requirements (16 to 17 credits)
MATH 021 (4 credits)
CHM 021 and 022 or CHM 075 (4 or 5 credits)
BIOS 41, 42, 115, and 116 (8 credits)

Major requirements (at least 36 credits)
1. Core
BIOE 110 (3 credits)

Applied Bioscience or Bioengineering Physiology or MATH/CHE 207 (3 credits)

2. Concentration
   a. At the time of declaring the major, the student will meet with an adviser in the Applied Life Science program and design a group of courses to suit the student's interests. The courses selected must form a cogent grouping to the adviser's satisfaction. The student's individualized program must be drawn up and approved by the adviser before the 10th day of classes in the student's fifth college semester (i.e., with at least three semesters remaining to be rostered).
   b. The concentration must include at least 30 credits of natural science, mathematics, and engineering beyond the 6 credits required for the core. At least 20 credits of the concentration must be at the 100 level or above, and at least 8 credits of the concentration must be at the 300 level.
   c. No more than 3 BIOS courses after 115/116 may be included in the major.
   d. CHM 031 (or CHM 076) is strongly recommended.
   e. The concentration must also include at least one of the designated Advanced Applied Life Science seminar courses, which counts toward the credits required at the 300 level.
   f. Up to 4 credits of adviser–preapproved independent work may be included in the major.

Free electives
Sufficient coursework to bring the total to at least 121 credits. Students are advised to include courses in ethics, history and philosophy of science, and economics among their electives.

BS in Applied Life Science

The B.S. in Applied Life Science follows the same philosophy as the B.A., but requires a larger number of core courses and a greater focus on major requirements. While there is lesser flexibility compared to the B.A. program, a B.S. student can complete minors, participate in a faculty research project, or prepare for graduate study in a different field (e.g., economics, journalism, ethics).

University and College Requirements (24 to 27 credits)
ENGL 001 and 002 (6 credits)
Choices and Decisions (1 credit)
College seminar (1 to 4 credits)
Social Sciences (at least 8 credits of designated coursework)
Humanities (at least 8 credits of designated coursework)

Collateral Requirements (41 credits)
MATH 012, 021 and 022 (12 credits)
PHY 011, 012 (5 credits)
CHM 075 and 076 (or 021, 022, and 031) (8 credits)
CHM 051, 053, 052, and 058 (8 credits)
BIOS 41, 42, 115, 116 (8 credits)

Major Requirements (at least 42 credits)
1. Core
BIOE 110 (3 credits)
Applied Bioscience or Bioengineering
Physiology or MATH/CHE 207 (3 credits)
2. Concentration
   a. 3 courses from A (life science specialization; see below) (at least 9 credits)
   b. 5 courses from B (complementary specialization; see below) (at least 15 credits)
   c. 3 courses selected from A and B (selection must be approved by the adviser and constitute a cogent grouping) (at least 9 credits)
   d. 1 senior seminar (at least 3 credits)
   e. Up to 4 credits of adviser–preapproved independent work may be included and count towards either A or B.
   f. No more than 3 BIOS courses after 115/116 may be included in the major.
   g. The concentration must also include at least one of the designated advanced Applied Life Science seminar courses, which counts toward the credits required at the 300 level.
3. Practicum
   The student must complete an experience preapproved by the adviser and relating to the practical application of methods in applied life science. Laboratory or independent work courses or an internship or other work experience may satisfy all or part of the practicum. The practicum need not entail academic credit but must be the equivalent of at least 4 credits of effort (at least 8 weeks of full–time employment in a suitable activity). Detailed information is available from the adviser.

Free electives
At least 12 credits to bring the total to at least 121 credits

The concentration

A. Life Science specialization
The biological basis for the student's concentration, provided by advanced courses in Bioengineering, Biological Sciences, or kindred disciplines (e.g., ecology, biochemistry).

B. Complementary specialization
The complementary coursework for the student's concentration, provided by courses outside the life sciences.

Concentrations (*denotes required course for the concentration)

1. Biophysics concentration
   - A. Life Science specialization
     BIOE 120/121, Applied Bioscience, Biomedical Instrumentation and Sensors, Integrated Bioelectronics/Biophotonics Lab, Photonics for Biomedical Applications, BIOS 345, BIOS 353, BIOS 367, BIOS 371, BIOS 372, BIOS 381, BIOS 384
   - B. Complementary specialization
     CHE 044, ECE 081, ECE 108, ECE 123, ECE 125, ECE 212, MATH 023*, MATH 205*, MATH 242, MATH 320, MATH 322, MATH 323, MECH 002, BIOE 120/121, PHY 021/022*, PHY 091, PHY 190, PHY 212, PHY 213, PHY 352, PHY 355, PHY 380
2. Mathematical and Computational Life Science concentration
   - A. Life Science specialization
     Applied Bioscience, Bioengineering Physiology, BIOS/EES 152, BIOS 317, BIOS 324, BIOS 328, BIOS 337, BIOS 345, BIOS/EES 351, BIOS 353, BIOS 356
   - B. Complementary specialization
     CHE/MATH 207, CSE 010/014 (or ENG 001), CSE 017, CSE/MATH 261, CSE/MATH 340, CSE 347, MATH 023*, MATH 205*, MATH 208, MATH 230*, MATH 231, MATH 242, MATH 243, MATH 301, MATH 302, MATH 309, MATH 310, MATH 312, MATH 320, MATH 322, MATH 323, MATH 334, MATH 338, MATH 341, PHY 380
3. Chemical Biology
   - A. Life Science specialization
     Applied Bioscience, Biotechnology Practice, Bioengineering Physiology, BIOS 177, BIOS 324, BIOS 328, BIOS 345, BIOS 346, BIOS 367, BIOS 368, BIOS 371, BIOS 372, BIOS 377, BIOS 381, BIOS 382, BIOS 384
   - B. Complementary specialization
     CHE 281, CHE 282, CHE 283, CHM 194*, CHM 332, CHM 336, CHM 338, CHM 339, CHM 341, CHM 353, CHM 358, MATH 023, MATH 205
4. Decision–Making in Applied Life Science
   - A. Life Science specialization
     Applied Bioscience, Biotechnology Practice, BIOS 177, BIOS 276, BIOS 317, BIOS 328, BIOS 345, BIOS 356, BIOS 367, BIOS 371, BIOS 372, BIOS 382, BIOS 384
   - B. Complementary specialization
     ECO 001, ECO 105 or 146, ECO 145 or MATH 012, ECO 231*, ECO 234, ECO 246, ECO 315, ECO 323, ECO 333, ECO 357, ECO/IE 358, ECO 368, PHIL 105, PHIL/REL 116*, PHIL 126, PHIL 128, PHIL 137, SSP 160, SSP 162, SSP 341, SSP 367, STS 011*, STS/JOUR 124, STS/HIST 145

Bioengineering

The Bioengineering program provides a structured curriculum for students interested in working at the interface between engineering and life science. The BS in Bioengineering degree is comprised of three tracks. **Biopharmaceutical Engineering** is for students whose interests lie in genomics, proteomics, bioinformatics, recombinant DNA, protein engineering, bioprocessing, drug synthesis and delivery. The **Bioelectronics/photonics** track covers education and research dealing with signal processing, biosensors, MEMs, biochips for DNA sequencing, laser and fiber based optical technology for biomedical applications. **Cell and Tissue Engineering** encompasses biomaterials and biomechanics, from cells and tissue to organs and systems.

An integral part of the BS in Bioengineering program is Longitudinally Integrated Experiential Learning (LIEL). LIEL facilitates research and direct interaction with industry and clinical partners. It is intended to teach the value of a team approach to problem solving. LIEL projects continue form the sophomore to the senior year with two summers of internships. Bioengineering students will intern at relevant sites, including regional hospitals and corporate research laboratories. As part of the curriculum, students also have the option to participate in Lehigh's Integrated Product Development (IPD) program.

The educational goals of the bioengineering program include:

- learning how biological systems work
- developing analytical skills
- using advanced tools in experimentation, modeling, and simulation of problems at the interface of biological and non-biological systems.
- applying these skills in the design, synthesis, manufacturing, or other engineering-related aspects of the health career industry

The B.S. in bioengineering will prepare students for careers in established and emerging fields that require combining engineering principles with the life sciences. Potential paths open to students include the health care, biomedical, pharmaceutical, biomaterials, and other biotechnology-related industries through careers in medicine or graduate studies.

The courses listed are offered in the program and new ones are currently under development in a number of subject areas. (Consult the Registrar's Schedule of classes for specific offerings in any particular semester.)

For further information, interested students should contact the program co-directors.

BS in Bioengineering Degree Requirements

General Requirements (26 credits)

ENGL 1 & 2	(6) credits
PHIL 116	Bioethics (4)
SSP 135	Human Communication (4)
ENGR 1	Engineering Computations (3)
ECO 1	Principles of Economics (4)
	Free Electives (6) credits

Mathematics (18 credits)

MATH 21	Calculus I (4)
MATH 22	Calculus II (4)
MATH 23	Calculus III (4)
MATH 205	Linear Methods (3)
MATH 231	Probability and Statistics (3)

Chemistry (15 credits)

CHM 21, 22	Intro. Chemical Principles and Laboratory (5)
CHM 31	Chemical Equilibria in Aqueous Systems (3)
CHM 51, 53	Organic Chemistry I and Lab (4)
CHM 187	Physical Chemistry I (3)

Physics (10 credits)

PHY 11, 12	Intro. Physics I and Lab (5)
PHY 21, 22	Intro. Physics II and Lab (5)

Biological Sciences (8 credits)

BIOS 41, 51	Biology Core I: Cellular and Molecular and Lab (4)
BIOS 115, 116	Biology Core II: Genetics and Lab (4)

Engineering (19-21 credits)

CHE 31	Material and Energy Balance (4)
ECE 81	Principles of Electrical Engineering (4)
ME 231	Fluid Mechanics (3) or
CHE 44	Fluid Mechanics (4) or
CE 121	Mechanics of Fluids (3) or
MAT 33	Materials (3)
MECH 2	Mechanics (3)
CHE 210	Chemical Engineering Thermodynamics (4) or
MAT 205	Thermodynamics and Phase Diagrams (3) or
ME 104	Thermodynamics I (3) or
PHY 340	Thermal Physics (3)

Integrated Bioengineering

Required by all Three Tracks

BIOE 110	Elements of Bioengineering (3)
BIOE 225	Introduction to Bioengineering Design (3)
BIOE 210	Bioengineering Physiology (2)

Required Courses for **Biopharmaceutical Engineering** Track

CHEM 52	Organic Chemistry II (3)
BIOE 243	Integrated Biotechnology lab (2)

Recommended electives (minimum of two from list)

BIOS 371	Elements of Biochemistry (same as CHM 371) (3)
CHE 341	Biotechnology I (3)
CHE 342	Biotechnology II (3)
BIOS 345-346	Molecular Genetics and Lab (5)
BIOE 2XY	Applied Bioscience (3)
BIOE 2XZ	Biotechnology Practice (3)

Required Courses for **Biolectronics/Biophotonics** Track

ECE 108	Signals and Systems (4)
BIOE 231	IntegratedBioelectronics/Biophotonics Lab (2)

Recommended electives (minimum of two from list)

ECE 123	Electronic Circuits (3)
ECE 202	Introduction to Electromagnetics (3)
PHY 212	Electricity and Magnetism I (3)
ECE 333	Medical Electronics (3)
PHY 352	Modern Optics (3)
BIOE 2XX	Biomedical Instrumentation and Sensors (3)
BIOE 3XX	Photonics for Biomedical Applications (3)

Required Courses for **Cell and Tissue Engineering** Track

BIOE 120,121	Biomechanics and Laboratory (4)
BIOE 257	Integrated Biostructural and Mechanical Lab (2)

Recommended electives (minimum of two from list)

BIOS 177	Intro. Behavioral Neuroscience (3)
BIOS 277	Experimental Neuroscience Laboratory (4)
CHE 388	Polymer Synthesis and Characterization Laboratory (Same as CHM 388, MAT 388)
CHE 391	Colloid and Surface Chemistry (3) (Same as CHM 391)
BIOS 367	Cell Biology (3)
BIOS 371	Elements of Biochemistry (same as CHM 271) (3)
BIOE 2ZX	Cell and Tissue Engineering (3)
BIOE 2ZY	Biophysics (3)

Longitudinally Integrated Experiential Learning (11 credits)

BIOE 1	Freshman Seminar I, Introduction to Bioengineering I: Philosophy to Practice (1)
BIOE 2	Freshman Seminar 2, Introduction to Bioengineering II: Current Topics (1)
BIOE 10	Sophomore Seminar I, Literature Research (1)
BIOE 20	Sophomore Seminar 2, Research Proposal (1)
BIOE XX*	Summer Internship 1 (0)
BIOE 132	Junior Research 1, Teamwork Project (2)
BIOE 142	Junior Research 2, Teamwork Project (2)
BIOE YY*	Summer Internship 2 (0)
BIOE 1XZ	Senior Research Teamwork Project (2)
BIOE 1ZZ	Seminar, Thesis Presentation (1)

**Summer Internships not required. Enrollments are limited. Selection will be based on fellowships available and quality of research proposal.*

Total needed for BS in Bioengineering: 133-137 credits

Typical Four-Year Course Schedule for BS in Bioengineering

A. Biopharmaceutical Engineering Track
B. Bioelectronic/Biophotonics Track
C. Cell and Tissue Engineering Track

First Year – Fall Semester

BIOE 1	Seminar I - Introduction to Bioengineering (1)
MATH 21	Calculus I (4)

CHM 21,22	Intro. Chemical Principles and Laboratory (5)
ENGL 1	Composition and Literature (3)
ENGR 1	Engineering Computations (3) or
PHY 11, 12	Introductory Physics I and Lab (5)
	(16-18 Credits)

First Year – Spring Semester

BIOE II	Seminar II – Introduction to Bioengineering (1)
BIOS 41,42	Biology Core I: Cellular and Molecular and Lab (4)
MATH 22	Calculus II (4)
ENGL 2	Composition and Literature II (3)
ENGR 1	Engineering Computations (4) or
PHY 11, 12	Introductory Physics I and Lab (5)
	(15-17 Credits)

Sophomore – Fall Semester

BIOE 10	Bioengineering II – Introduction to Bioengineering (1)
BIOS 115, 116	Biology Core II: Genetics and Lab (4)
MATH 23	Calculus III (4)
CHM 31	Chemical Equilibria in Aqueous Systems (3)
CHE 31	Material and Energy Balances of Chemical Processes (3) A track
CHM 51,53	Organic Chemistry I and Lab (4) A track
MECH 2	Elementary Engineering Mechanics (3) B & C tracks
MAT 33	Engineering Materials and Processes (3) B & C tracks
	(18-19 Credits)

Sophomore – Spring Semester

BIOE 20	Bioengineering Sophomore Seminar II (1)
BIOE 110	Elements of Bioengineering (3)
PHY 21,22	Intro. Physics II and Lab (5)
CHM 52	Organic Chemistry II (3) A track
ECE 81	Principles of Electrical Engineering (4) B track
BIOE 120,121	Biomechanics and Biomechanics Lab (4) C track
ECO 1	Principles of Economics (4) (A & B track)
SSP 135	Human Communication (4) C track
	(16-17 Credits)

Junior – Fall Semester

BIOE 132	Junior Research I, Team Project (2)
MATH 205	Linear Methods (3)
BIOE 225	Design (3)
MECH 2	Elementary Engineering Mechanics (3) A track
CHM 51, 53	Organic Chemistry I and lab (4) B & C track
ECE 81	Principles of Electrical Engineering (4) A track
CHE 31	Material and Energy Balances of Chemical Processes (3) B track
ME 104	Thermodynamics I (3) C track
SSP 135	Human Communication (4) A & B tracks
ECO 1	Principles of Economics (4) C track
	(18-19 Credits)

Junior – Spring Semester

BIOE 142	Junior Research 1, Teamwork Project (2)
MATH 231	Probability and Statistics (3)
CHM 187	Physical Chemistry (3)
BIOE 210	Physiology (3)
MAT 33	Engineering Materials and Processes (3) A track
ECE 108	Signals and Systems (4) B track
BIOE	Elective (3) C track
CHE 44	Fluid Mechanics (4) A track
ME 104	Thermodynamics (3) B track
ECE 81	Principles of Electrical Mechanics (4) C track
	(18 Credits)

Senior – Fall Semester

BIOE 1XZ	Senior Research 3, Teamwork Project (2)
BIOE	Elective (3) A & B tracks
BIOE 231	Integrated Bioelectronics/ Biophotonics Lab (2) B track
BIOE 257	Integrated Biostructural Mechanical Lab (2) C track
CHE 210	Chemical Engineering Thermodynamics (4) A track
CHE 31	Material and Energy Balances of Chemical Processes (3) C track
PHIL 116	Bioethics (4)
HSS	Free Elective (3)
ME 231	Fluid Mechanics (3) B & C tracks
	(16-17 Credits)

Senior – Spring Semester

BIOE 1ZZ	Seminar, Thesis Presentation (1)
BIOE 243	Integrated Biotechnology Lab (2) A track
BIOE	Elective (3)
HSS	Free Electives (9)
	(13-15 Credits)

BIOE 1. Freshman Seminar 1, Introduction to Bioengineering I: Philosophy to Practice (1) fall
Overview of the bioengineering field, the advancements of related topics in sciences, technology, engineering and applications for health care and medicine. Humanity and ethical issues.

BIOE 2. Freshman Seminar 2, Introduction to Bioengineering II: Current Topics (1) spring
Overview of a broad spectrum of current topical areas in biotechnology and bioengineering and their applications in health care and medicine.

BIOE 10. Bioengineering Sophomore Seminar I: Literature Research (1) fall
Literature research on current bioengineering and biotechnology topics to assemble information for producing a written research proposal.

BIOE 20. Bioengineering Sophomore Seminar II: Research Proposal (1) spring
Prepare written research proposals for research projects. Define research topics, objectives of the research, specific goals, methodology, research plans and expected impact of the research.

BIOE 110. Elements of Bioengineering (3) spring
An introduction to the fields of biotechnology and biomedical engineering. The areas include biomechanics, biomaterials, bioinstrumentation, medical imaging, rehabilitation engineering, biosensors, biotechnology and tissue engineering.

BIOE 120/121. Biomechanics and Biomechanics Laboratory (3/1) spring
Applications of the mechanics to study mechanical behavior of anatomical structures, biological tissues and systems of the musculoskeletal system. Specific topics include: structure and function of biological tissues, mechanical properties of biological tissues, and analysis of specific tissues (i.e., bone, muscle, and soft connective tissues). Co- or prerequisite: MECH 2.
Biology courses at Lehigh University are offered in two departments. The Department of Biological Sciences offers molecular, cellular, and organismal biology as well as biochemistry and neuroscience, while the Department of Earth and Environmental Sciences offers courses in ecology and environmental biology. See separate catalogue entries for course listings and more information.

Business

The designation of "business" refers to general business courses.

Undergraduate Courses

BUS 1. Introduction to Business (3)
An introduction to business, emphasizing critical issues impacting the business world, such as globalization, technology, ethics, and diversity. Provides an overview of the various functional areas of business and how they fit together. Stresses experiential learning and develops team-building skills. Strengthens written and oral communications skills. Provides an introduction to career opportunities and curriculum choices in business and economics. Course is offered only in the fall and is open only to College of Business and Economics freshmen.

BUS 211. Integrated Product Development (IPD) 1 (3) spring
Business, engineering and design art students work in cross-disciplinary teams of 4-6 students on conceptual design including marketing, financial and economic planning, economic and technical feasibility of new product concepts. Teams work on industrial projects with faculty advisors. Oral presentations and written reports. Prerequisite: Junior standing in business, economics, arts or engineering.

BUS 212. Integrated Product Development (IPD) 2 (2) fall
Business, engineering, and design arts students work in cross disciplinary teams of 4-6 students on the detailed design including fabrication and testing of a prototype of the new product designed in IPD course 1. Additional deliverables include a detailed production plan, marketing plan, detailed base-case financial models, project and product portfolio. Teams work on industrial projects with faculty advisors. Oral presentations and written reports. Prerequisite: Bus 211/ENGR 211.

Business Minor

The purpose of the business minor program is to enable non-CBE students to pursue a course of business studies that will enable them to supplement their major studies and make them more marketable. The overall learning objective of the program is to provide non-CBE students with the knowledge and skills with which to make more informed business decisions. Courses offered in the business minor program are not open to students currently in the CBE nor may these classes count as substitutes for CBE core classes should a student later decide to transfer into the CBE.

Program of Studies: The business minor consists of 14 credit hours. These courses are integrated across the entire program and must be taken in a locked step sequence. These 14 credit hours plus the prerequisite consist of the following courses:

Required prerequisite course:

ECO 1 – Principles of Economics (4 credit hours). ECO 1 can be taken in either the freshman or sophomore year and must be completed prior to entering the business minor program.

Required courses:

- **BUS 125 – Behavioral Skills Workshop** (1 credit hour. Fall.). Prerequisite: ECO 1
- **BUS 126 – Information Analysis and Financial Decision Making I** (3 credit hours. Fall.). Co-requisite: BUS 125.
- **BUS 127 – Information Analysis and Financial Decision Making II** (3 credit hours. Spring.) Prerequisite: BUS 126.
- **BUS 225 – Developing, Producing, and Marketing Products and Services I** (3 credit hours. Fall.). Prerequisite: BUS 127.
- **BUS 226 – Developing, Producing, and Marketing Products and Services II** (3 credit hours. Spring.) Prerequisite: BUS 225.
- **BUS 326 – Business Strategy** (1 credit hour. Spring.)

Recommended courses:

- **Probability Theory and Statistics** (e.g., ECO 145, MATH 12, IE 111, PSYC 110, etc.)
- **An Integrated Learning Experience** (e.g., ME/BUS 211, MGT 311, or internship)

The courses required in the business minor program will be offered in a lock step sequence requiring completion of each course in the sequence before being able to continue with the next course. That is, students must first complete BUS 126 before taking BUS 127, BUS 127 before taking BUS 225, and BUS 225 before taking 226. BUS 125 and BUS 326 are to be taken in conjunction with BUS 126 and BUS 226, respectively.

Program admission requirements: Each spring, 80 students will be accepted into the business minor program for the following fall. Application into the program will be made by students and submitted to the program director by March 1st. An admissions committee comprised of the business minor program director, associate dean for the undergraduate CBE program, and the business minor curriculum committee will make admission decisions based on G.P.A., experience, and interest in pursuing business opportunities upon graduation from Lehigh (to be evaluated on the basis of a written essay). Students will be notified of admissions decisions prior to registration for the fall semester. Entrance into business minor classes will be controlled by restricted overrides by the director of business minor program.

Business Information Systems

Professor. Susan A. Sherer, Ph.D. (Pennsylvania), *BIS program director and Kenan Professor of Information Technology Management.*

Associate professor. *James A. Hall, Ph.D. (Oklahoma State)*

Assistant professors. Catherine M. Ridings, Ph.D. (Drexel); Yuliang. Yao, Ph.D. (Maryland)

Lecturer. Chitra Nayar, M.B.A. (Univ. of Iowa)

The Business Information Systems program offered through the College of Business and Economics provides an opportunity to prepare students to work with information technology in today's business environment. As businesses seek to make themselves more productive and competitive, they have become more reliant on information technology. Students who have a good understanding of information systems can help businesses enhance their use of this technology. The information systems program is designed to provide requisite technical skills along with a strong business foundation, developing students' abilities to apply information technology to business problems. Career opportunities include systems analyst/designer, information systems manager, information systems consultant, and computer auditor.

The information systems major requires four courses and two electives beyond the core requirements of the College of Business and Economics. Students are required to take BIS 111, Management Information Systems, as part of the business and economics core. Other courses are as follows:

Required Courses (4):

BIS 120	Business Applications in Java (4)
or CSE 17	Structured Programming and Data Structures (4)
CSE 241	Database Systems (3)
or IE 224	Information Systems Analysis and Design (3)
BIS 311	Managing Information Systems Development (3)
MGT 311	LUMAC Management Assistance Counseling (3)
or BIS 360	Business Information Systems Practicum (3)
or BIS 373	Business Information Systems Internship (1-3)

Elective Courses (**Choose 2**):

ACCT 311	Accounting Information Systems (3)
CSE 216	Software Engineering (3)
CSE 262	Programming Languages (3)
CSE 330	Advanced Software Engineering Tools (3)
IE 341	Data Communication Systems Analysis and Design (3)
MGT 302	Quantitative Models - Conceptual (3)
BIS 331	Electronic Commerce and Security (3)
BIS 342	E-Business Systems (3) (also cross listed as SCM 342)

Consult Professor Sherer for other related courses.

Undergraduate Courses

BIS 120. Business Applications of Java (4)
Business applications and programming in Java. Control structures, arrays, object-oriented programming, string manipulation, graphics, graphical user interfaces, web-based applets. Some previous experience with programming helpful but not required. Lectures plus one two-hour computer lab. Prerequisite: ACCT 151 previously or concurrently.

BIS 111. Introduction to Information Systems (3)
This course examines the fundamental role of information systems in supporting and managing all business functions and enabling firms to compete effectively. Both technical and managerial aspects of information systems are introduced. The course integrates technical infrastructure, database concepts, management decision-making, and business process issues critical to the understanding of operational and strategic information systems. It introduces business applications that support accounting, finance, supply chain management, and marketing. Prerequisite: Excel competency.

BIS 311. Managing Information Systems Development (3)
Managing the development and implementation of information systems for business. Project management for business systems implementation. Business systems analysis and design. Implementation of custom-designed as well as packaged systems. Cost benefit analysis and risk management of systems implementation. Prerequisites: BIS 111 or ACCT 311 or consent of instructor.

BIS 331 (MKT 331). Electronic Commerce (3)
This course covers how businesses and consumers use the Internet to exchange information and complete transactions. Both theoretical concepts and practical skills will be addressed with the scope of the class. Topics include advertising and marketing, ecommerce business and revenue models, online consumer behavior, web site design issues, Internet security, electronic payments, infrastructure issues, privacy issues, and overall electronic commerce strategy. Students will get hands-on experience designing ecommerce web-sites using web authoring software. Prerequisite: BIS 111, MKT 211 or consent of instructor.

BIS 342 (SCM 342). E-Business Systems (3)
Introduction to the implications of key information technologies used within and across businesses to conduct e-business. Includes enterprise resource planning systems, on-line ordering and inventory management systems, data warehousing, data mining, intra/extra nets, efficient consumer response systems, and knowledge management. Readings and case studies will be utilized.

BIS 360. Business Information Systems Practicum (3)
The business information systems practicum provides an opportunity for students to work on an intensive consulting engagement with a business. Students work with client firms on individual or team projects, which focus

on information systems activities such as developing requirements, designing, and implementing systems. Students complete written reports and make formal presentations to clients. May not be taken concurrently with MGT 311. Prerequisites: Junior standing in the College of Business and Economics.

BIS 371. Directed Readings (1-3)
Readings and research information systems; designed for superior students who have special interest in some topic(s) not covered by the regularly scheduled courses. Written term paper(s) required. May be repeated. Prerequisite: preparation in information systems acceptable to program coordinator.

BIS 372. Special Topics (1-3)
Special problems and issues in information systems for which no regularly scheduled course work exists. When offered as group study, coverage varies according to interests of the instructor and students. May be repeated. Prerequisite: preparation in information systems acceptable to program coordinator.

BIS 373. Business Information Systems Internship (1-3)
Based upon a student's work experience, a sponsoring faculty member shall direct reading, projects and other assignments - including a "capstone report." It should be noted that the work experience, by itself, is not the basis for academic credit. The faculty-directed activity may be provided concurrent with the work or as a follow-up to the work experience. In the latter case, arrangements must be made in advance of the work engagement so as to enhance the follow-up experience (keeping logs, concurrent reading assignments, etc.) Student effort is expected to be at least 40 hours per credit. Prerequisites: CSC 17, IE 224 or CSC 241, junior standing in the College of Business and Economics.

Course descriptions for the College of Business and Economics graduate courses can be found in this section (Section V) under the heading of *Business and Economics Graduate Courses.*

Business and Economics Graduate Courses

MBA Prerequisites

GBUS 401. Financial Reporting for Managers and Investors (3)
Corporate financial reporting under Generally Accepted Accounting Principles. Analysis and interpretation of financial statements: accrual accounting, balance sheet valuation, income determination and cash flow analysis. Profit manipulation, window dressing and "creative accounting" through accounting policy choices. Fraudulent financial reporting, uses and limitations of accounting information. Accounting information as a tool for strategic decision making.

ECO 401. Basic Statistics for Business and Economics (3)
Descriptive statistics, probability and probability distributions, estimation, hypothesis testing, correlation and regression, chi-square analysis and analysis of variance. Computer applications.

MBA Program Core Courses

MBA 401. Introduction to the Organization and its Environment (2)
This MBA Core Course will provide a thorough understanding of business organizations and will clarify ways middle and senior managers can create and sustain organizational competitive advantage. The course examines the organization from an overall perspective within the context of the firm's internal and external environment. The second aspect of this course deals with the ability to communicate effectively in today's business and professional environment. Students will examine and practice the written and verbal communications strategies and skills that are essential to their success in business.

MBA 402. Managing Financial and Physical Resources (4)
An MBA core course designed to integrate financial and managerial concepts into operations decisions. Disciplines of accounting, finance and economics are combined to provide substantive foundations for discussing and analyzing data. Implications of analysis are applied to facilitate decision-making in other areas such as marketing, operations (manufacturing, logistics and engineering), human resources, information technology and general management. The major learning objectives will be applied through a series of "living" cases that are centered on analyzing historical financial performance, preparing a business plan, and valuing a business. Prerequisites: MBA 401, GBUS 401 or equivalent.

MBA 403. Managing Information (4)
An MBA core course dealing with concepts and methods involved in the collection, organization and dissemination of information that helps managers make operational and strategic decisions. The course also deals with attributes of information and examines enterprise-wide impacts of local decisions. Revenue, cost, time and quality-based information are accorded equal emphasis, while students are exposed to alternative evaluation methods for decisions related to different parts of the value chain. Topics include: activity-based costing; activity-based management; transaction analysis; operational and strategic decisions such as outsourcing, design partnerships, etc; investment analysis for short life-cycle investments; evaluation of uncertainty, risk and ambiguity; metrics development; compensation policies; segment evaluation methods; target costing and functional analysis; quality function deployment; total cost of ownership; and transfer pricing. In addition, the course deals with: information technology enablers which allow firms to improve value delivered to customers; and evaluation and management of emerging forms of cooperation, such as joint ventures and project based strategic alliances. Prerequisites: MBA 401, GBUS 401 and ECO 401 or equivalents.

MBA 404. Managing Products and Services (4)
An MBA core course focusing on the management of products and services within a firm's value chain. The course addresses exceeding customer expectations, establishing total quality as the core foundation, developing a strong customer focus, creating value through supply chain management, developing new products for competitive advantage, matching aggregate supply with customer demand, and designing market channels and influencing customers. Prerequisite: MBA 401.

MBA 405. Managing People (4)
An MBA core course that examines how effective organizations are created, maintained, and improved. The course will focus on how good people are attracted to an organization and how to make them productive. Topics include: organizational design, job design, staffing, training and development, performance, teams, influence, diversity, change, ethical decision-making, and current people issues facing today's organizations. The course includes a comprehensive simulation (to be conducted on a Saturday during the semester) and a group project which allows students to apply the principles and concepts covered in the course. Prerequisite: MBA 401.

MBA 406. Integrative Experience (3)
An MBA course where students apply the body of knowledge acquired in MBA 401 through 405 through a simulation, case presentations and the cross core project. This course places an emphasis on strategic management and take s the point of view of the general manager to view the organization from an overall perspective in the context of the firm's internal and external environment. In doing so, students examine historical perspectives, contemporary theories, and practical applications all in the spirit of helping them develop a broad understanding of strategic management issues and solutions. By combining high-level class discussions, case analyses, a computer simulation competition and the cross-core project this course exposes students to rigorous theoretical analysis while providing hands-on, simulated real world business experiences. Prerequisites: MBA 401, MBA 402, MBA 403, MBA 404, MBA 405.

Accounting Electives

GBUS 413. Advanced Management Accounting (3)
Issues in management accounting including activity-based costing, activity-based management, strategic cost management, theory of constraints, advanced manufacturing technologies, cost of quality and life-cycle costing. Readings and cases. Prerequisite: MBA 403 or a course in cost accounting.

GBUS 414. Financial Statement Analysis and Interpretation (3)
This course focuses on analysis of financial statements. It develops the skills necessary to interpret and use financial statement information effectively to assess profitability and risk and is intended for individuals likely to become intensive users of financial accounting information. Requirements include readings, case studies, presentations, and written analysis of actual financial statements. Prerequisite: GBUS 401 and MBA 402 or permission of the instructor.

GBUS 437. Federal Taxation and Business Decisions (3)
Impact of federal taxation on the structure and timing of business decisions. Problem-solving methods and research techniques from a managerial perspective. Prerequisite: GBUS 401 or a basic course in accounting.

Finance Electives

GBUS 419. Financial Management (3)
An intermediate level course in corporate finance. Coverage includes capital budgeting techniques including real options, decision tree analysis, risk analysis, advanced cost of capital theories, capital structure theory, dividend policy, working capital management, mergers and acquisitions, restructuring, and bankruptcies. The course emphasizes both theory and practice through lectures, cases, and financial modeling exercises. Prerequisite: MBA 402 or equivalent background. Students not possessing the relevant prerequisites must obtain waivers from the Designated Finance Faculty representative.

GBUS 420. Investments (3)
A survey course in investments. Overview of financial institutions and markets involved in the issuance and trading of securities. Emphasis on valuation and risk assessment of fixed income and equity securities. Construction of optimal portfolios and examination of performance measures. Prerequisite: MBA 402 or equivalent background. Students not possessing the relevant prerequisites must obtain waivers from the Designated Finance Faculty Representative.

GBUS 421. Advanced Investments (3)
Advanced topics relating to valuation/security analysis and portfolio/risk management. Prerequisites: GBUS 419 and GBUS 420 or Designated Finance Faculty Representative Approval.

GBUS 422. Derivatives and Risk Management (3)
The theory and application of a variety of derivative instruments (options, futures contracts, etc.) used in corporation finance and the financial services industry. The focus is on the risk management application vs. a rigorous development of option pricing theory and similar topics. Prerequisites: GBUS 419 and GBUS 420, or Designated Finance Faculty Representative Approval.

GBUS 424. Advanced Topics in Financial Management: (description to change each time course is offered) (3)
Advanced topics relating to specific areas of corporate finance such as: theoretical and empirical examination of recent developments in financial management; asset valuation and capital budgeting including the role of uncertainty, imprecise forecasts, risk preferences, inflation, market conditions, and the global marketplace; working capital management, leasing, mergers, and financing. The course content may vary between instructors and over time. Prerequisite: GBUS 419 and GBUS 420 or Finance Faculty Approval.

GBUS 425. Real Estate Financing and Investing (3)
An upper-level course in modern real estate financing techniques from the perspectives of both the borrower and the lender. Subject matter encompasses the following areas: The principles of financing decisions; financing methods and techniques; institutional sources of funds for real estate; and real estate financing decisions. Prerequisites: GBUS 419 and GBUS 420, or Designated finance Faculty Representative Approval.

GBUS 426. Financial Markets and Institutions (3)
Functions and portfolios of financial intermediaries. Sectional demand and supply of funds, nature and role of interest rates, term structure and forecasting, impact of inflation and regulations on financial intermediaries and markets, and current developments in the financial system. Management of assets and liabilities within the U.S. financial institution's legal and economic constraints. Prerequisite: GBUS 419 and GBUS 420, or designated Finance faculty representative approval.

GBUS 431. Quantitative Finance (3)
Relationship of quantitative models to financial theory and applications. Capital budgeting, portfolio selection, security evaluation, cash management, inventory policy

and credit analysis. Prerequisite: GBUS 419 and GBUS 420 or Finance Faculty Approval.

Management Electives - Organizational Behavior

GBUS 440. Human Resource Management (3)
A survey of personnel management activities in organizations. Topics include human resource planning, recruitment, selection, equal employment opportunity, performance appraisal, compensation, career planning, safety and health, and quality of work life issues. Course consists of lectures, discussion, and case analysis.

GBUS 442. Seminar in Management Consulting (3)
A study of consulting practices in general and their application to small business. Processes include a field study/counseling service to a local business. Emphasis is on the identification and analysis of multidisciplinary problems and opportunities and the implementation of recommendations. Prerequisites: completion of MBA background courses (or equivalent) and permission of the instructor.

GBUS 444. Managerial Communication Skills (3)
Organization, style and strategy of language to inform, direct and persuade. Application of writing, reading, speaking and listening skills to managerial problems. Case studies.

GBUS 445. Labor-Management Administration (3)
A study of the U.S. system of industrial relations, including the evolution and present status of labor law; union organizing efforts; the strategy of negotiations; the substantive provisions of collective bargaining and the administration of collective agreements. Also considered is the role of unions in the implementation of programs for employee self-management and other workplace innovations.

GBUS 446. Commercial Potential Assessment (3)
A study of the process of bringing an invention to market with emphasis on commercial potential. Industrial analysis, competitor intelligence and strategic issues will be emphasized along with the development of market strategy and an overall business plan. Extensive research including data base searches will be included. Instructor permission required.

GBUS 447 Negotiation (3 credits)
The class examines the behavioral foundations of the negotiation process. Topics include: The negotiation process, negotiation planning, power in negotiations, communications in negotiations, tactics, concepts of win-win and win-lose, social styles, individual and team negotiations, ethical considerations, cultural differences, negotiating in sole source (customer) situations, using third parties. The concepts will be exposed through both lectures and simulations.

Management Electives - Operations Research and Analytical Management

GBUS 450. Strategic Supply Management (3)
A survey course designed to introduce the MBA/MSE student to the vital role played by supply management in achieving overall effectiveness for the firm in today's global economy. The course starts by examining the traditional purchasing process and then moves on to an examination of the evolution of purchasing into supply management and, finally, to the role purchasing plays in improving effectiveness of the entire value chain. Course consists of lectures, discussion and case analysis.

GBUS 451. Analytical Methods in Management (3)
Application of management science methods to industrial and commercial problems. Scientific method, decision theory, linear programming, inventory control, regression analysis, forecasting, simulation, and related areas are examined in the context of accounting, finance, marketing and manufacturing.

Marketing Elective

GBUS 453 Transportation and Logistics Management(3)
The control of physical distribution and inventories; the flow of information, products and cash through the integrated supply chain.

GBUS 454 E-Commerce and Marketing Strategy (3)
Impact of e-commerce technologies on firms, industries, and markets. Covers the technologies used in e-commerce, changes in organization structure, industry and behavior, and sales and marketing strategies such as attracting visitors to websites, promotion, distribution, service, pricing, branding, advertising, consumer behavior, measuring effectiveness, societal effects, disintermediation, reintermediation, and strategy implementation. Prerequisite: MBA 403.

GBUS 455 E-Business Enterprise Applications (3)
Implications of key information technologies used within and across businesses to conduct e-business, including customer relationship management, enterprise resource planning, on-line ordering and inventory management, supply chain management, and e-procurement systems, data warehousing, data mining, intra-extranets, and knowledge management. Prerequisite: MBA 403.

GBUS 456 Business Process Redesign with Information Systems (3)
Current topics on the principles, implementation and critical success factors of deploying information systems enabled quality management and process innovation within organizations. Techniques and tools used in implementing quality and process innovation from a managerial and practical perspective. Prerequisite: MBA 403.

GBUS 457 Managing the IS Resource (3)
The issues and management techniques involved in administering the information systems/resource activities in the organization. Management of IS professionals, development and management of project teams, user client relationships, managing vendors, emerging technologies and planning processes. Prerequisite: MBA 403.

GBUS 458 Strategic Information Systems (3)
Understanding the various types of computer based information systems and developing an ability to identify and exploit information technologies to gain competitive advantage, at the individual, group and organizational levels. Prerequisite: MBA 403.

GBUS 459 Survey of Project Management (3)
Provides an overview of the project management framework and knowledge areas. It deals with the day-to-day, hands-on problems of managing a project (defined as a temporary structure within a permanent organization, set up to achieve a specific objective). Areas covered will include: project integration, project scope, project planning and implementation, project control and

evaluation, project cost and risk management, project resource management and organization, and project communication. Cases will be used to illustrate problems and the techniques to solves them. A basic project management software tool will be introduced and utilized in this course. This course is designed for MBA students who want a general exposure to project management concepts. **This course may not be used in the Project Management Certificate Program.**

GBUS 460 Strategic Marketing Management (3)
The course studies the management of contemporary organizations from the perspective of a marketing manager. While the course content addresses the activities required to maintain a strategic fit between an organization's environment and its particular set of objectives and resources, the central focus is on designing strategic marketing actions for various types of organizations. The course pedagogy emphasizes the application of marketing and other business principles through either seminars, simulations, or case discussion.

GBUS 461 Advertising and Promotion Management (3)
A broad overview of managerial decisions involved in developing, planning, presenting, and implementing advertising and promotional activities for business and not-for-profit organizations. Analysis of current campaigns and a term project are semester assignments. Prerequisite: MBA 404.

GBUS 464 Business-to-Business Marketing (3)
This course focuses on marketing strategies and tactics in firms whose customers are other institutions, not individuals. Topics covered include organizational buying behavior, managing strategic buyer-seller relationships, sales force deployment, communication strategies, and so on. Specific attention is given to the impact of information technology and globalization in the business-to-business context.

GBUS 465 Marketing Strategies for New Products and Services (3)
This course focuses on strategies for the development and marketing of new products and services. Illustrative topics covered in the course include diffusion of innovations, new product adoption models, the role of marketing research in various stages of new product development and marketing, product development in technologically intensive environment, and so on.

GBUS 466 Marketing Research and Analysis (3)
This course focuses on procedures for collecting and analyzing relevant information for informed decision making by managers. The process of identifying research questions, developing instruments for collecting information, appropriate interpretation of information, and appropriateness of research methods are some of the topics discussed in this course. The course focuses on the process of doing marketing research as well as the techniques for analyzing information. Discussion of concepts and cases, developing data collection instruments, and doing actual marketing research projects will form the key elements of this course.

GBUS 470 Marketing Communications Strategies (3)
This course focuses on how various elements of communications are integrated to achieve various organizational objectives. In addition to the traditional communication media such as advertising and point of purchase media, emphasis will also be placed on new media and strategies made possible due to the advances in technology. The course will involve discussion of concepts, case analysis and discussion, insights from practitioners, and group projects.

GBUS 471 Product and Brand Management (3)
This course will focus on theories, models, and other tools to manage brands, products, and product lines. Specific attention will be focused on building, measuring, and managing brand equity. The course will be a mixture of lectures, discussions, case analyses, and group exercises.

GBUS 472 Strategies for Services Marketing (3)
The course focuses on the challenges of marketing and managing services (whether in a manufacturing or service business) and discusses the development of strategies for addressing these challenges. The need for cross-functional integration to provide effective service is stressed. Illustrative topics include service quality gap analysis, relationship between superior service and profitability, service encounter analysis, customer lifetime value analysis, services guarantees, and service demand and capacity management.

International Business Electives

GBUS 473 International Finance (3)
Consideration of problems arising from the risks associated with international investing and multinational corporation finance (currency, political, etc.). Focus is on (a) investing in international market given the institutional constraints and differences between domestic markets, and (b) managerial issues relating to corporations, investors, and financial institutions. Prerequisites: GBUS 420 and GBUS 419, or Designated Finance Faculty Representative Approval.

GBUS 474. Legal Aspects of International Business (3)
Various legal problems of engaging in business abroad, including contracts, technology transfer, property ownership, business organizations and labor, using a case and problem-solving approach.

GBUS 475 Global Marketing Strategies (3)
The course is designed to provide a framework within which global marketing operation can be analyzed, understood, and undertaken. The course focuses on the issues that are being faced by firms in today's global marketplace, particularly those that are related to strategy formulation and implementation. The learning experience in this course is placed on global business decision-making, through the use of case studies, projects, and lectures.

GBUS 476. Globalization and Management of Technology (3)
Management of science and technology in the context of international business and the globalization of markets, competition and corporations. Management of global industrial R & D; technology–based global strategic alliances; global external technology sourcing, complex human resources and cross-cultural issues; etc. Develops an appreciation of the scientific and technical capabilities available globally and the potential for global cooperative and/or competition in this regard.

Management of Technology Courses

GBUS 481. Technology, Operations and Competitive Strategy (3)
Develops an understanding and appreciation of the interrelationships among technology, operations and the competitive strategy of the firm. Industry analysis and competitiveness; competitive strategy formulation and implementation; value chain analysis; operations strategy and technology strategy; operation's contributions to competitive advantages in cost, quality and variety and new product introduction.

GBUS 482. R, D & E Project Management (3)
Management of cross-functional project teams for introducing technological innovations in the manufacturing and marketing of new products and services in a variety of industries.

GBUS 483. R & D Management (3)
Developing R&D programs to achieve strategic business objectives; selecting, staffing and managing R&D projects; and transferring research results to commercial functions.

GBUS 484. Science and Technology Policies and Institutions (3)
The science and technology institutional infrastructure and its relationships with management decision-making, including private, public (government) and quasi-public institutions; R&D, regulatory, and policy institutions; and U.S., foreign and international institutions.

GBUS 485. Diffusion and Implementations of Technology (3)
Classical macro-study of adoption and diffusion of innovation, and managing the implementation/utilization/application of new technology in the organization/corporate culture.

GBUS 486. Qualitative Research Methodology (3)
Study of techniques that describe, decode and translate social phenomena. Explores how interpretive researchers plan and conduct studies and present findings. Studies investigators' roles, data sources, observation methods, data-analysis methods and trustworthiness of findings. A field research project is required.

GBUS 494. Fields Projects (1-4)
The field projects course will provide MBA students with an opportunity to apply MBA concepts with an employer, corporate partner or other suitable organization. Students will work with a supervising professor and a corporate representative on a project designed by the student. Students must prepare a written proposal for the project including the expected outcomes and an estimate of the hours required for completion. Students will present their proposal to a faculty member of their choice for approval. The academic rigor and time required to complete the project will determine the number of credits earned.

vSeries (Corporate Entrepreneurship)

GBEN 401. THE BUSINESS PLAN I: Strategic Considerations (2)
This course is first of a two-part sequence that focuses on the initial steps necessary to design and build a high-impact business plan for the start-up company or new enterprise within an existing firm. The development process is integrative, complex, and time-consuming for the entrepreneur. Foundation or strategic-level issues that impact the formation and growth of the new enterprise are addressed. The goal in this first phase is to complete various sections of the business plan that deal with market opportunity, industry trends and developments, company positioning, competitive advantage, and core competencies. This course is project-oriented and makes extensive use of one-on-one instruction between class meetings. Students identify a market opportunity, develop the product/service offering, target potential customers and users, assess market demand, analyze market penetration, and determine the revenue potential of the new venture. 2 Credits

GBEN 402. THE BUSINESS PLAN II: Operating Strategies and Implementation (2)
This course is the second of a two-part sequence that focuses on the final steps necessary to complete the business plan. This phase concentrates on designing the appropriate operational framework and business processes, including technology and infrastructure, that are required to successfully launch the new enterprise. The business plan must also demonstrate that the venture will have strong leadership and a capable management team to deal with uncertainty and drive results. Finally, the business plan must incorporate detailed financial forecasts and financing methods, and should address equity valuation and investor exit strategies. Like its predecessor, this course is project-oriented and makes extensive use of one-on-one instruction between class meetings. Additional emphasis is placed on developing an effective format and packaging of the written document. 2 Credits

GBEN 403. ANATOMY OF ENTREPRENEURSHIP: Start-ups and Established Companies (1)
This interactive seminar focuses on understanding the true meaning of entrepreneurship. The new venture opportunity is profiled from the perspective of the individual entrepreneur who is starting a business and embarking on a new career path involving high risk and reward. Different entrepreneurial management styles are analyzed and highlighted. Course emphasis is also placed on managing innovation and creativity in a corporate environment. Successful implementation of entrepreneurial activities for the large company makes special demands on management to promote discovery and create internal stakeholders. Both start-ups and established companies are placed under the microscope through guest speakers, panel discussion, selected readings, and case analysis. 1 Credit

GBEN 404. MARKET OPPORTUNITY: Targeting Strategies and Selling Tactics (1)
The focal point of any business plan is identifying and understanding the target customer that will be served. The product/service offering must have strong buyer appeal and capture immediate attention in the marketplace. The need to rapidly penetrate a market demands that a marketing mix be designed, built, and implemented in a manner that leads to differentiation and superior positioning. Maximizing marketing firepower with severely limited financial and organizational resources is a major challenge that confronts today's entrepreneurs. Market segmentation strategies, the target marketing process, forming market alliances, and managing the selling process are viewed from the perspective of seed and early stage ventures. 1 Credit

GBEN 405. INTELLECTUAL PROPERTY: Management and Valuation (1)
New technologies create new markets and new venture possibilities. Their discovery and success rate, along with the ability of an enterprise to leverage these assets in markets, depends on how the firm views and manages its investment in intellectual property. Obtaining the necessary legal protection of intellectual property can also serve as an effective barrier to entry and may be a source of competitive advantage. This seminar focuses on the strategic management of intellectual property as a commercial enterprise, covers methods of valuation, and examines various accounting and legal issues that must be considered in strategic-level decision making. 1 Credit

GBEN 406. PERFORMING A BUSINESS ENTERPRISE AUDIT: Developing an Industry Perspective (1)
New ventures must position themselves for long-term growth and market development. Entrepreneurs create enterprises, define their organizations, and build business models based on changes in technology, government regulation, demographics, and shifts in other exogenous variables. A strategy must be crafted that is sustainable over the long run. Success or failure is often predicated on market cycles, market saturation, supply/demand imbalances and other forces that are not controllable. This seminar places emphasis on assessing the market potential and valuation of start-ups from an industry or macro-perspective, particularly from the view of an outside investor. It also focuses on how to gather and make effective use of competitive intelligence. 1 Credit

GBEN 407. PROCESSES AND INFRASTRUCTURE: Creating Production and Delivery (1)
This course provides an overview of the internal capabilities and the process and technology platform required to fully operationalize the business plan. Critical business activities and functions are dissected, such as establishing needed back-end procurement, production, and distribution services that focus on supply chain dynamics and management; determining the scope of front-end call center and e-commerce activities; managing logistics; and utilizing information systems and web-based solutions that effectively link customers, elements of the supply chain, and employees. These topics are explored from the perspective of the start-up and emerging company as well as the large corporation engaged in new venture creation. 1 Credit

GBEN 408. THE NEW VENTURE ORGANIZATION: Management, Design, and Governance (1)
Managing a new enterprise presents unique and difficult challenges for its leadership. Expanding workloads and the increased complexity of tasks resulting from the rapid and sustained growth of the business create the need for a smooth transition from entrepreneurial-style management to professional management. Timing is critical, and for many start-ups it is not an easy bridge to cross. This course dissects the design and characteristics of small organizations, and the need to correctly align structure with strategy. It also considers how entrepreneurial activities should be seeded, managed, organized, and executed within the context of an established company. Under scrutiny are the heavy demands placed upon entrepreneurs and corporate managers to effectively lead and manage under highly uncertain conditions where change is a constant. Additional course emphasis is placed on comprehending the critical role that boards of directors play for start-up companies. 1 Credit

GBEN 409. FINANCIAL FORECASTING: Developing Pro Forma Financial Statements (1)
No business plan would be complete without providing detailed financial projections and identifying the key assumptions that help shape the numbers. The financial translation of business models is expressed through pro forma income statements, balance sheets, and sources and uses of funds. Having this information allows management, investors, and lenders to measure and evaluate future financial performance. This exercise also establishes the capitalization required to launch the venture, support operations, and meet interim goals as the enterprise progresses through the beginning stages of its development. Course emphasis is placed on the use of forecasting methods and breakeven analysis, working capital and cash flow management, and identification of accounting and financial issues that impact on profit measurement and financial risk. 1 Credit

GBEN 410. FINANCING START-UPS: Seeking Outside Venture Capital (1)
This course provides an overview of the venture capital market, examines the nature and role of the venture capitalist, and analyzes whether and how venture capital financing may be the preferred approach in raising outside capital. Venture deals are closely examined in terms of types of equity instrument, methods of valuation, milestones and staged release of funds, special provisions that may include antidilution measures and other protective arrangements, and developing term sheets. Emphasis is also given to dissecting the process and criteria used to seek and attract venture capitalists, including angel investors. Various scenarios and trade-offs are covered in this intensive course. 1 Credit

GBEN 411. ESTABLISHING CREDIT FACILITIES: Asset-Based and Cash Flow Financing (1)
Borrowing from a commercial bank or a credit intermediary can provide outside funding for working capital and equipment purchases in many situations. For seed and early stage firms, attention is often given to asset-based lending programs that make use of first liens on accounts receivable and inventory or fixed assets to provide added legal protection to creditors. For later stage firms, traditional line-of-credit financing may be feasible and desirable from a cash flow standpoint. Various borrowing alternatives, including leasing, are covered in this course along with covenants and restrictions that often apply. Government loan programs, especially those of the Small Business Administration, are also given emphasis. 1 Credit

GBEN 412. DEVELOPING EXIT STRATEGIES: Concepts and Approaches (1)
Sophisticated equity investors require that an exit or harvest plan be developed and that it be viable and capable of being executed within the foreseeable future. Venture capitalists and angel investors anticipate their future departure and a positive financial outcome at the very point the deal is struck in the present. Various planned and unplanned exit strategies are analyzed in this course which include: an initial public offering, offering the

business for sale, merging with another company, franchising, acquisition of shares by some investors, or liquidation of the business. Valuation methods, financial and tax implications, and due diligence are also examined. 1 Credit

GBEN 413. INTEGRATIVE EXPERIENCE/ NEW VENTURE INTERNSHIP (1-4)
Only students enrolled in the Entrepreneurial concentration may elect one of these hands-on, project-orientated courses. Integrative Experience must meet the requirements of formal independent study and involve a new venture situation with a start-up or existing company. Students employed in a New Venture Internship may also qualify for course credit if the same requirements are satisfied.

Project Management

PMGT 401. Project Management: Course Framework & Project Leader Assessment (1)
Introduction to the Project Management Certification Course; syllabus, requirements and deliverables. Students will become acquainted with: the terminology, nine knowledge areas, relationships to other disciplines, project management context and processes. Introduction to the logistical vehicles for course delivery and the tools to be used. Students will also assess themselves as project leaders and explore project leader competencies, roles, responsibilities and stakeholder relationships.

PMGT 402. Project Management: Skills and Abilities for Effective Leadership of Teams (1)
Students will enhance project team leadership skills, define the work environment of project teams, team selection, develop a team charter, clearly define the roles and responsibilities of all project team members, set team guidelines, learn methods to promote teamwork, understand the stages of development, manage team dynamics. Additional skills covered: delegation, managing accountability without direct authority over project team members, managing dysfunctional teams, performance improvement, input to performance appraisals, rewards, recognitions, celebrations. Prerequisite: PMGT 401.

PMGT 403. Project Management: Initiating the Project and Planning Scope and Schedule (2)
Students will learn techniques for deciding whether to undertake a project and for planning project outcomes and schedules. The relationship of projects to organizational planning and budgeting, information and performance appraisals systems will be discussed. Approaches will be shared for identifying and classifying project stakeholders and designing and conducting a cost benefit analysis. How to define desired project outcomes clearly and completely and how to determine project work to be performed using decomposition and templates will be addressed. Students will learn how to develop a project charter, a scope statement, a Work Breakdown Structure, a WBS dictionary and a Linear Responsibility Chart. How to create a network diagram and analyze schedule possibilities using the Critical Path Method (CPM) and the Program Evaluation and Review Technique (PERT) will be explained. Fast tracking and crashing a schedule will also be explored. Displaying a schedule with a Gantt Chart, key events list and activities will be illustrated. How to support these activities using MS Project will be demonstrated. Prerequisites: PMGT 401, PMGT 402

PMGT 404. Project Management: Planning Resources, Communication, Quality and Risk Management (2)
In this course, students will learn how to estimate the needs for personnel and other types of projects resources, to develop a project budget and to plan for additional project support activities. Determining the type, amount and timing of resource needs will be emphasized. Approaches to resource leveling will be discussed. The different types of project costs will be explained. The use of analogous estimating, parametric modeling, bottom- up estimating and computerized tools to estimate costs will be explored. Planning to ensure project quality and coordinate project communications will be will be addressed. Identifying, assessing, and preparing a plan to manage project risks will also be discussed. Planning for project procurement and associated solicitations will be explained. Students will learn how to develop resource matrices, loading charts and grafts and a project budget. How to support these activities using MS Project will be demonstrated. Prerequisites: PMGT 401, PMGT 402, PMGT 403

PMGT 405. Project Management: Project Leader Communications Expertise and Evaluating Team Performance (1)
The purpose of this weekend seminar is to strengthen the project leader's communication skills, change-management skills, conflict resolutions skills, and team evaluation skills. Focus areas will also include the following: understanding the art and science of effective listening, managing multiple expectations, communicating "bad news," and learning tools and techniques for project team evaluation. Prerequisites: PMGT 401, PMGT 402, PMGT 403, PMGT 404

PMGT 406. Project Management: Implementing and Managing Projects (2).
Students will learn techniques and processes to start and perform the actual project work. Suggestions for working successfully in a matrix management environment will be discussed. Information systems to track schedule performance, labor charges and project expenditures will be expressed. Developing escalation procedures to address project conflicts issues will be emphasized. Procedures for controlling labor and fund charges to a project will be introduced. Key project review and decision meetings will be identified. Planning and implementing quality assurance activities will be addressed. Planning for, awarding and administering contracts will be discussed. How to support these activities using MS Project will be demonstrated. Prerequisites: PMGT 401, PMGT 402, PMGT 403, PMGT 404, PMGT 405

PMGT 407. Project Management: Controlling Performance and Assessing Outcomes (2)
Students will learn how to monitor and control project activities in progress and how to bring a project to closure. Approaches for assessing project products and services produced will be explored. Techniques for evaluating schedule and cost performance will be introduced. Variance analysis and earned value analysis will be explained. Quality control and risk monitoring and control will be discussed. Change control systems and procedures will be explained. How to prepare focused progress reports and conduct effective project meetings will be discussed. Requirements for closing out contracts and procurements will be detailed. Obtaining user acceptance, closing labor and

fund charge accounts and other administrative activities will be discussed. Designing and conducting a post-project review will be explored. How to support these activities using MS Project will be demonstrated. Prerequisites: PMGT 401, PMGT 402, PMGT 403, PMGT 404, PMGT 405, PMGT 406

PMGT 408. Project Management: Problem Solving, Decision Making and Ethics (1)
This 2-day seminar focuses on developing problem solving and ethical decision-making skills. Students will learn to recognize project problems, frame the problem, assess risk, manage risk, plan contingencies, recognize the escalation points, and apply alternate methods. Students will also participate in ethical exercises to strengthen their ability to recognize ethical dilemmas and evaluate decisions. Prerequisites: PMGT 401, PMGT 402, PMGT 403, PMGT 404, PMGT 405, PMGT 406, PMGT 407

Accounting

M. S. Core Courses

MACC 401. Professional Issues in Accounting (3)
This course consists of three modules designed to provide students with an overview of professional accounting topics. The first module introduces business case analysis. Cases will be dissected, analyzed and discussed. A range of business topics will be used to demonstrate the case method. The second module examines the behavioral foundations of the negotiation process. Topics include planning, tactics, power, integrative and distributive bargaining, behavioral styles and individual and team negotiations. The third module examines ethical issues as they relate to business. Through debate and case studies, students will be challenged to determine what are acceptable and ethical business practices, primarily in an international environment, and how these practices relate to the highly diverse elements that comprise today's complex, global enterprises. Open only to MSAIA students.

MACC 412. Advanced Information Systems and IS Auditing (3)
This course deals with advanced topics in systems analysis, systems design, systems implementation, internal controls, and auditing of computer-based information systems (CBIS). Students study business process and database modeling techniques, including traditional and REA (Resources, Events, and Agents) modeling. Students use a CASE tool to analyze a business problem and forge a solution that meets internal control and auditing standards. Additionally, the risks, controls, and auditing objectives in key IS areas including operating and data management systems, revenue and expenditure cycles and computer fraud techniques are covered. Students use ACL to perform standard audit tests and fraud detection procedures. Prerequisites: A course in accounting information systems and a course in auditing.

MACC 413. Corporate Financial Reporting: Research, Theory and Practice (3)
This course examines the structure of corporate financial reporting, its role in providing decision-useful information to capital market participants, and theoretical and empirical assessments of its performance. Topics include the FASB's conceptual framework, efficient markets theory and research, positive accounting theory, income determination theory, recognition versus disclosure, harmonization of international accounting principles, and select current reporting issues. Prerequisites: Graduate standing and at least two semesters of financial accounting beyond principles.

MACC 420. Business Consulting: Process and Practice (3)
Provides an overview of the consulting process as it relates to public accounting and other consulting firms. The course also focuses on various aspects of the delivery process such as approaches to gaining and retaining clients, proposal development, pricing mechanisms, defining client needs, models and methodologies of consulting, diagnosing problems, and recommending and implementing change. Several types of consulting will be addressed including strategic, process, technology, and organizational change consulting.

MACC 424. Information Quality Assurance and Business Risk (3)
Focuses on new products and services offered by independent assurance and business risk professionals to improve the quality of management decision making. Building on topics in business strategy, information technology, operations management, and strategic cost management, this course develops an in-depth understanding of industry-based business models and the related universal set of processes, integrated risk management, control self-assessment, and normative control models. Students gain experience with a number of information technology-based assurance service tools. Prerequisite: MACC 412 or concurrent.

MACC 427. Information Analysis for Management and Business Solutions (3)
Focuses on information analysis and technology as an enabler of business solutions. Besides placing technology in the context of organizations, this course exposes students to the interaction of accounting information with information technology, business models, and analysis to bring about the resolution of complex business problems. Topics covered include the impact of technology, economic and financial analysis, simulation of the firm, its functional activities and optimization models. Various issues related to Enterprise Resource Planning (ERP) will be addressed utilizing ERP software. Prerequisite: MACC Core. (To be taken during the last semester of the program.)

Economics

M.S. And Ph.D. Core Courses

ECO 402. Managerial Economics (3)
Application of economic and statistical analysis to managerial decision-making. Business and economics forecasting. Empirical estimation of demand, production and cost functions. Resource allocations and pricing strategies in various market structures. Decisions under risk and uncertainty. Government regulations of business. Cases. Prerequisite: Calculus and ECO 401 or equivalent ECO 411. History of Economic Thought (3) Selected topics in the history of economic thought, with special attention to the origins of modern economic theory. Prerequisite: a graduate course in economic theory.

ECO 412. Mathematical Economics (3)
Applications of various mathematical techniques in the formation and development of economic concepts and theories. Prerequisite: consent of the chair.

ECO 413. Advanced Microeconomics Analysis (3)
A survey of methods of decision-making at the micro-economic level; price theory and econometric applications. Prerequisite: ECO 402 or equivalent.

ECO 414. Advanced Topics in Microeconomics (3)
Resource allocation and price determination. Theories of choice of consumers, firms and resource owners under various market forms. Prerequisites: ECO 401 and ECO 413 or equivalents.

ECO 415. Econometrics I (3)
Computer applications of standard econometric techniques using regression analysis in a single-equation context. Discussion of problems of multicollinearity, heteroscedasticity and autocorrelation. An introduction to simultaneous equation models, identification and estimation problems. Prerequisite: ECO 401 or equivalent.

ECO 416. Econometric Theory (3)
Mathematical and statistical specification of economic models. Statistical estimation and tests of parameters in single and multiple equation models. Prediction and tests of structural changes. Prerequisites: ECO 401 (or equivalent) and calculus.

ECO 417. Advanced Macroeconomics Analysis (3)
Macroeconomic theory and policy. Emphasis on theoretical models and policy implications.

ECO 418. Advanced Topics in Macroeconomics (3)
Models of employment, income and growth in monetary economies. Policies for economic stability and growth. Prerequisite: ECO 417 or equivalent.

ECO 423 Real Options (3)
This is an introductory graduate level course in financial economics. It is intended for students with strong technical backgrounds who are comfortable with mathematical arguments. The course is divided into three main parts: deterministic finance, single-period uncertainty finance and options theory and its applications. Prerequisite: GBUS 420.

ECO 424 Advanced Numerical Methods (3)
This course focuses on techniques that apply directly to economic analysis. A particular emphasis is on problems in finance. The course teaches students how to use EXCEL macros and advanced VBA (the industry standard). It is designed for decision making in business settings.

Economics Electives

ECO 404. Technology, Trade and Economic Growth (1) (required for MOT and MBA-MOT students only)
Overview of the role of technology in economic systems. Productivity and growth effects, relationships to industry structure, impacts on international trade and competitiveness. Prerequisite: intended to be taken concurrently with ECO 402.

ECO 423. Real Options (3)
This is an introductory graduate level course in financial economics, It is intended for students with strong technical backgrounds who are comfortable with mathematical arguments. The course is divided into three main parts: deterministic finance, single-period uncertainty finance and options theory and its applications. Prerequisite: GBUS 420.

ECO 424. Advanced Numerical Methods (3)
This course focuses on techniques that apply directly to economic analysis. A particular emphasis is on problems in finance. The course teaches students how to use EXCEL macros and advanced VBA (the industry standard). It is designed for decision making in business settings.

ECO 425. Cost-Benefit Analysis (3)
Theory and methods of cost-benefit analysis; efficiency and equity as criteria in program evaluation; proper measurement of market and non-market costs and benefits; consideration of risk, uncertainty, appropriate discounting techniques and distributional consequences; applications include the evaluation of health care policies and therapies.

ECO 428. (GBUS 428) Capital and Interest Theory (3)
Theories of interest and capital. Annuities; applications of present value theory; investment valuation under uncertainty and risk; term structure of interest rates; the theory of savings, cost of capital and capital formation. Prerequisite: MBA 402 or equivalent.

ECO 429. (GBUS 429) Monetary Theory (3)
The role of money in the economy from theoretical and empirical perspectives. The influence of money and prices, interest rates, output and employment. Prerequisite: ECO/GBUS 427 or equivalent.

ECO 430. (GBUS 430) Public Finance (3)
The economics of public spending and taxation; principles of government debt management; theories of budgeting and cost-benefit analysis and public choice.

ECO 436. Economic History of the United States (3)
Analysis of the colonial economy, transition to industrialization, and the role of trade and transportation in America's development. A consideration of the importance of slavery to the 19th-century American economy and other New World economies. Origin and development of banking and financial markets. Prerequisites: ECO 401 and ECO 402 or equivalents.

ECO 440. Labor Economics (3)
The economics of labor markets and various labor-market institutions with emphasis on current theoretical and empirical research. Prerequisites: ECO 401 and ECO 402 or equivalents.

ECO 447. Economic Analysis of Market Competition (3)
Mathematical models based on game theory and industrial organization. Cases are used to analyze the strategic interaction of firms and governments as competitors and partners.

ECO 451. Urban Economics (3)
The application of traditional and spatial economics to the location of economic activity focusing on the urban economic problems of business location, housing, land value, land use and intra-urban transportation.

ECO 453. Government Regulation of Business (3)
Analysis of the economic justification for government regulation of private enterprise. Topics include antitrust policy, utilities, and health, safety and environmental regulation. Prerequisite: ECO 402 or equivalent.

ECO 454. Economics of Environmental Management (3)
Economic theory of natural resources. Optimal policies for the development of renewable and nonrenewable resources and environmental quality. Prerequisite: ECO 402 or equivalent.

ECO 455. Health Economics (3)
Economic theory of health care delivery systems. Financing health care services. Case studies of specific economic-financing problems and/or international comparisons of health care delivery. Prerequisite: ECO 401 or ECO 402 or equivalents or permission of the instructor.

ECO 456. Industrial Organization (3)
The goal of the course is to review theoretical and empirical attempts by economists to understand market structures lying between the extremes of perfect competition and monopoly. The course will focus first on describing the current U.S. industrial structure and reviewing models of imperfect competition. The course then shifts to a closer study of individual firm behavior. The final segment of the course is an overview of two significant relationships between government and industry caused by the existence of imperfect competition.

ECO 457. Bio-Pharmaceutical Economics (3)
Characteristics of the market for pharmaceuticals; barriers to entry, competitions and innovation' pricing and regulation; physician prescribing behavior; commercialization and financing of biotech startups; international comparisons of public policy.

ECO 460. Time Series Analysis (3)
Classical decomposition of time series, trend analysis, exponential smoothing, spectral analysis and Box-Jenkins autoregressive and moving average methods.

ECO 461. Forecasting (3)
Methods of economic and business forecasting.

ECO 462. Advanced Statistics for Business and Economics (3)
An expanded development of statistical concepts necessary for business and economic research. Topics include probability theory, sets, density functions and distributions, sampling distributions, point estimation, moment generating functions, maximum likelihood, classical statistical inference, power functions, likelihood ratio tests and non-parametric tests. Prerequisite: calculus.

ECO 463 (IE 458). Topics in Game Theory (3)
A mathematical analysis of how people interact in strategic situations. Topics include normal-form and extensive-form representations of games, various types of equilibrium requirements, the existence and characterization of equilibria, and mechanism design. The analysis is applied to micro-economic problems including industrial organization, inter-national trade, and finance. Prerequisites: Two semesters of calculus, ECO 414 and ECO 412 , or permission of the instructor.

ECO 472 Special Topics in Economics (1-3)
Extended Study of an approved topic not covered in scheduled courses. May be repeated for credit.

ECO 471. International Economic Development (3)
An introduction to the basic theoretical concepts in international economic development and an evaluation of their application by means of a representative sample of the literature.

ECO 472. International Trade Theory (3)
Theories of comparative advantage, factor price equalization, trade and welfare, tariffs, trade and factor movements. Prerequisite: ECO 413 or consent of the chair.

ECO 473. International Monetary Economics (3)
Theory of the balance of payments, the microeconomics of international finance, various approaches to balance-of-payments adjustments, theories of foreign exchange-rate determination and macroeconomic policy under fixed and flexible exchange rates. Prerequisite: ECO 417 or consent of the chair.

ECO 480. Economics of Technological Change (3)
Explores theoretical models and empirical evidence on the economics of innovation and technical change. Includes examination of: the role of technology in competitiveness, industrial structure and economic growth; alternative models of the innovative process; incentives for and other conditions affecting research and development; the evaluation of the justifications for government support of R&D. Prerequisite: ECO 402 or equivalent.

ECO 490 Master's Thesis

ECO 492 Special Topics in Economics (1-3)
Extended study of an approved topic not covered in scheduled courses. May be repeated for credit.

ECO 499 Dissertation

Chemical Engineering

Professors. Philip A. Blythe, Ph.D. (Manchester, England); Hugo S. Caram, Ph.D. (Minnesota); Marvin Charles, Ph.D. (Brooklyn Polytechnic); Manoj K. Chaudhury, Ph.D. (SUNY-Buffalo); John C. Chen, Ph.D. (Michigan), *Carl R. Anderson Professor;* Mohamed S. El-Aasser, Ph.D. (McGill), **Dean of RCEAS***;* Gregory C. Farrington, Ph.D. (Harvard), **President**; James T. Hsu, Ph.D. (Northwestern); Anand Jagota (Cornell); Andrew Klein, Ph.D. (North Carolina State); William L. Luyben, Ph.D. (Delaware); Anthony J. McHugh, Ph.D. (Delaware), **Chair**; William E. Schiesser, Ph.D. (Princeton), *McCann Professor;* Arup K. Sengupta, Ph.D. (Houston); Cesar A. Silebi, Ph.D. (Lehigh); Harvey G. Stenger, Jr., Sc.D. (M.I.T.); Israel E. Wachs, Ph.D. (Stanford).

Associate professor. Mayuresh V. Kothare, Ph.D. (California Institute of Technology).

Professor of Practice. Shivaji Sircar, Ph.D. (Pennsylvania); Kemal Tuzla, Ph.D. (Istanbul Technical University), **Associate chair**

Adjunct professors. William R. Hencke, M.S.E. in CHE (Michigan); Peter G. Simpkins, Ph.D. (Imperial College of Science and Technology).

Principal research scientist. Eric S. Daniels, Ph.D. (Lehigh); E. David Sudol, Ph.D. (Lehigh).

Emeritus professors. Curtis W. Clump, Ph.D. (Carnegie-Mellon); Arthur E. Humphrey, Ph.D. (Columbia); *provost emeritus;* Leslie H. Sperling, Ph.D. (Duke); Fred P. Stein, Ph.D. (Michigan)

The mission of the undergraduate program is "to educate students in the scientific principles of chemical engineering and provide opportunities to explore their applications in the context of a humanistic education that prepares them to address technological and societal challenges."

Chemical engineers serve a wide variety of technical and managerial functions within the chemical processing industry. For a lifetime of effectiveness they need a sound background in the fundamental sciences of chemistry and physics; a working capability with mathematics, numerical methods, and application of computer solutions; and a broad education in humanities, social sciences, and managerial techniques. These bases are applied in a sequence of chemical engineering courses in which logic and mathematical manipulation are applied to chemical processing problems. With the resulting habits of precise thought coupled to a broad base in scientific and general education, Lehigh graduates have been effective throughout industry and in advanced professional education. No effort is made toward any specific industry, but adaptation is rapid and the fundamental understanding forms the base for an expanding career.

The program is also designed to prepare a student for graduate study in chemical engineering. Further study at the graduate level leading to advanced degrees is highly desirable if an individual wishes to participate in the technical development of the field. The increasing complexity of modern manufacturing methods requires superior education for men and women working in research, development, and the design fields or for teaching.

Minor in Biotechnology

The department of Chemical Engineering encourages engineering students to broaden their education by taking a minor. In this regard, a Biotechnology Minor is offered to students majoring in Chemical Engineering. The Biotechnology minor requires 15 credit hours. A detailed listing of the required courses for the Biotechnology Minor can be obtained from the Chemical Engineering Department.

Minor in Chemical Engineering

Minor in Chemical Engineering provides students Chemical Engineering knowledge that they do not acquire in their major, such as knowledge of bio-chemical systems, transport phenomena, reaction engineering. This will widen their skills and help to increase the cooperation between the disciplines, which will lead to increased possibilities for employment.

Physical Facilities

The chemical engineering department is the only engineering department located on Lehigh's 780-acre Mountaintop Campus. Here the department occupies approximately one-third of Iacocca Hall, the 200,000-square-foot flagship building that contains offices, classrooms, and laboratories. Additional plant facilities, and the undergraduate chemical processing laboratory occupy approximately 10,000-square-feet in the nearby Imbt building.

These facilities provide excellent support for a wide range of general laboratory equipment for undergraduate study of the behavior of typical chemical processing units; special equipment for biochemical engineering and for the study of polymers; digital computation for process dynamics study; and special equipment for the study of thermodynamics, kinetics, heat transfer, and mass transfer.

The chemical engineering department has established a senior design laboratory in Iacocca Hall featuring 20 Pentium PCs. In addition, a 10-PC university-maintained computing laboratory is available nearby.

Career Opportunities

Chemical engineers play important roles in all activities bearing on the chemical process industry. These include the functions of research, development, design, plant construction, plant operation and management, corporate planning, technical sales, and market analysis.

The industries that produce chemical and/or certain physical changes in fluids, including petroleum and petrochemicals, rubbers and polymers, pharmaceuticals, metals, industrial and fine chemicals, foods, and industrial gases, have found chemical engineers to be vital to their success. Chemical engineers are also important participants in pollution abatement, energy resources, national defense programs, and more recently in the manufacture of microelectronic devices and integrated circuits.

Special Programs and Opportunities

Co-op Program: The department, in conjunction with the College of Engineering and Applied Science, operates a cooperative program that is optional for specially selected students who are entering their junior year. This program affords early exposure to industry and an opportunity to integrate an academic background with significant periods of engineering practice. Our program is unique in offering two work experiences and still allowing the co-op students to graduate in four years with their class.

OSI Program: The Opportunities for Student Innovation (OSI) program seeks to develop students' propensities for critical assessment and innovative solution of meaningful problems. The OSI program affords selected seniors an opportunity to experience team research leading toward technological benefits. Each project is hosted by a company and carried out under the supervision of a Lehigh faculty member.

Minors and Specializations: Technical minors are available in biotechnology, computer science, environmental engineering, manufacturing systems, materials science and engineering, and polymer science and engineering. Chemical Engineering also offers specialization certificates in polymer science, biotechnology, and process modeling and control.

Overseas: Study abroad is available in exchange programs that have been established by the department for the junior year at the University of Nottingham (United Kingdom) and for the summer following the junior year at the University of Dortmund (Germany).

Requirements of the Major - 133 credit hours are required for graduation with the degree of bachelor of science in chemical engineering.

freshman year (see Recommended Freshman Year)

sophomore year, first semester (18 credit hours)

CHE 31	Material and Energy Balances of Chemical Processes (3)
CHM 31	Chemical Equilibria in Aqueous Systems (3)
PHY 21	Introductory Physics II (4)
PHY 22	Introductory Physics Laboratory II (1)
MATH 23	Calculus III (4)
	elective (3)

sophomore year, second semester (18 credit hours)

CHE 44	Fluid Mechanics (4)
CHE 210	Chemical Engineering Thermodynamics (4)

CHE 179	Professional Development (1)
BIOS 31	Introduction to Cell and Molecular Biology (3)
MATH 205	Linear Methods (3)
	elective (3)

junior year, first semester (18 credit hours)

CHE 151	Introduction to Heat Transfer (3)
CHE 201	Methods of Analysis in Chemical Engineering (3)
CHM 51	Organic Chemistry I (3)
CHM 53	Organic Chemistry Laboratory I (1)
CHM 192	Physical Chemistry Laboratory (2)
	electives (6)

junior year, second semester (18 credit hours)

CHE 242	Introduction to Process Control and Simulation (3)
CHE 244	Mass Transfer and Separation Processes (3)
CHE 211	Chemical Reactor Design (3)
CHM 52	Organic Chemistry II (3)
	electives (6)

senior year, first semester (16 credit hours)

CHM 189	Physical Chemistry II (3)
CHE 202	Chemical Engineering Laboratory I (2)
CHE 233	Process Design I (3)
	electives (8)

senior year, second semester (15 credit hours)

CHE 203	Chemical Engineering Laboratory II (2)
ECE 81	Principles of Electrical Engineering (4)
CHE 234	Process Design II (3)
	electives (6)

There are five types of electives:

(1) Humanities/Social Sciences: See the requirements set by the College of Engineering and Applied Science (Section 3). Note that ECO 1 is required, as well as Freshman English.

(2) Three credit hours from approved courses in other engineering departments (CEE, EECS, IMSE, MEM, MSE).

(3) Chemistry: 3 credit hours of 300-level or higher.

(4) Chemical Engineering: A total of 3 credit hours is required from among CHE 186, or 3xy, or 4xy. CHE 185 does not qualify.

(5) Free electives: 6 credit hours in any subject area.

Electives in (2) to (5) above can be combined with any technical minor in RCEAS.

Undergraduate Courses

CHE 31. Material and Energy Balances of Chemical Processes (3) fall
Material and energy balances with and without chemical reaction. Introduction to phase equilibrium calculations. Applications in chemical process calculations and in design of staged separations: binary distillation, liquid-liquid extraction. Plant trips and special lectures introducing the profession. Prerequisite: CHEM 21 or equivalent and ENG 1 previously or concurrently. (ES 2), (ED 1)

CHE 44. Fluid Mechanics (4) spring
Fluid mechanics and its applications to chemical processes. Momentum and energy balances in fluid flow. Dimensional analysis. Fluid flow in pipes, packed and fluidized beds. Mixing and agitation. Filtration and sedimentation. (ES 3), (ED 1)

CHE 60. Unit Operations Survey (3) spring
The theory of heat, mass and momentum transport. Laminar and turbulent flow of real fluids. Heat transfer by conduction, convection, and radiation. Application to a wide range of operations in the chemical and metallurgical process industries. (ES 2), (ED 1)

CHE 151. Introduction to Heat Transfer (3) fall
Fundamental principles of heat transfer. Fourier's law. Conduction, convection and radiation. Analysis of steady and unsteady state heat transfer. Evaporation and condensation. Applications to the analysis and design of chemical processing units involving heat transfer. Prerequisite: CHE 44. (ES 2), (ED 1)

CHE 179. Professional Development (1) spring
Elements of professional growth, registration, ethics, and the responsibilities of engineers both as employees and as independent practitioners. Proprietary information and its handling. Patents and their importance. Discussions with the staff and with visiting lecturers. A few plant trips. (ES 0), (ES 0)

CHE 185. Undergraduate Research I (3)
Independent study of a problem involving laboratory investigation, design, or theoretical studies under the guidance of a senior faculty member. (ES 3), (ED 0)

CHE 186. Undergraduate Research II (3)
A continuation of the project begun under CHE 185. Prerequisite: CHE 185 or consent of the department chair. (ES 2), (ED 1)

CHE 201. Methods of Analysis in Chemical Engineering (3) fall
Analytical and numerical methods of solution applied to dynamic, discrete and continuous chemical engineering processes. Laplace Transforms. Methods of analysis applied to equilibrium, characteristic value and non-linear chemical engineering problems. Prerequisite: MATH 23 and CHE 44. (ES 2), (ED 0)

CHE 202. Chemical Engineering Laboratory I (2) fall
The laboratory study of chemical engineering unit operations and the reporting of technical results. One three-hour laboratory and one lecture period per week. Independent study and both group and individual reporting. Prerequisite: CHE 151. (ES 1), (ED 1)

CHE 203. Chemical Engineering Laboratory II (2) spring
Laboratory experience with more complex chemical processing situations including processes involving chemical reactions and those controlled automatically. Prerequisite: CHE 244 and CHE 210. (ES 1), (ED 1)

CHE 207. (MATH 207) Introduction to Biomedical Engineering and Mathematical Physiology (3) fall
Topics in human physiology and mathematical analysis of physiological phenomena, including the cardiovascular and respiratory systems, biomechanics, and renal physiology; broad survey of bioengineering. Independent study projects. Prerequisites: MATH 205. (ES 2), (ED 1)

CHE 210. Chemical Engineering Thermodynamics (4) spring
Energy relations and their application to chemical engineering. Consideration of flow and nonflow processes.

Evaluation of the effects of temperature and pressure on the thermodynamic properties of fluids. Heat effects accompanying phase changes and chemical reactions. Determination of chemical and physical equilibrium. Prerequisite: CHE 31. (ES 3), (ED 1)

CHE 211. Chemical Reactor Design (3) spring
The theory of chemical kinetics to the design and operation of chemical reactors. Plug flow and continuous stirred tank reactors. Homogeneous and heterogeneous reaction kinetics. Design of isothermal and adiabatic reactors. Prerequisite: CHE 151, CHE 210 or equivalent. (ES 1), (ED 2)

CHE 233. Process Design I (3) fall
Design of chemical plants incorporating traditional elements of engineering economics and synthesis of steady-state flowsheets with (1) both heuristic and rigorous optimization methods and (2) consideration of dynamic controllability of the process. Economic principles involved in the selection of process alternatives and determination of process capital, operating costs, and venture profitability. Energy conservation, pinch techniques, heat-exchanger networks, and separation sequences. Considerations of market limitations, environmental and regulatory restrictions, and process safety. Use of modern computer-aided software for steady-state and dynamic simulation and optimization. Group design projects. Prerequisites: CHE 211, CHE 242 and CHE 244. (ES 0), (ED 3)

CHE 234. Process Design II (3) spring
Continuation of CHE 233. Prerequisite CHE 233. (ES 0),(ED 3)

CHE 242. Introduction to Process Control and Simulation (3) spring
Dynamic simulation of chemical processes. Transfer functions and block diagrams. Introduction to process control equipment. Open-loop and closed-loop stability analysis using root locus and Nyquist techniques. Design of control systems. Prerequisites: CHE 201, CHE 151, and ENGR 1. (ES 1), (ED 2)

CHE 244. Mass Transfer and Separation Processes (3) spring
Diffusion, fluxes, and component conservation equations. Fick's law. Unsteady state diffusion. Convective mass transfer. Interphase mass transport coefficients. Design of multicomponent-distillation, absorption, extraction, and fixed-bed processes. Prerequisites: CHE 31 and CHE 44. (ES 1), (ED 2)

CHE 281. Chemical Engineering Fundamentals I (4) fall
Fundamentals of material balances, fluid mechanics and heat transfer. Prerequisites: Undergraduate degree in a scientific or engineering discipline or one semester undergraduate level general chemistry, one semester undergraduate level physics (statics and dynamics), and two semesters undergraduate calculus and department permission.

CHE 282. Chemical Engineering Fundamentals II (4) spring
Fundamentals of heat and mass transfer, process energy balances and unit operations. Prerequisites: CHE 281, or equivalent, and department permission.

CHE 283. Chemical Engineering Fundamentals III (4) fall
Fundamentals of thermodynamics, reaction kinetics and reactor analysis, and applied mathematics. Prerequisites: CHE 281 and 282 and department permission.

For Advanced Undergraduates and Graduate Students

CHE 276 (CE 276). Environmental Engineering Processes (3) spring
Processes applied in environmental engineering for air pollution control, treatment of drinking water, municipal wastewater, industrial wastes, hazardous/toxic wastes, and environmental remediation. Kinetics, reactor theory, mass balances, application of fundamental physical, chemical and biological principles to analysis and design.

CHE 301. Process Design (3)
Study of the strategy of chemical process design with emphasis on optimum order of steps, flow diagrams, energy balances, recycle ratios and their effect on the economics of the operation. Survey of methods for ordering equations. Discussion of process optimization for non-linear systems. Effects of uncertainty in process design. (ES 0), (ED 3)

CHE 312. (CHM 312, MAT 312) Fundamentals of Corrosion (3)
Corrosion phenomena and definitions. Electrochemical aspects including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization, and passivity. Non-electrochemical corrosion including mechanisms, theories, and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings, alloys, inhibitors, and passivators. Prerequisite: MAT 205, CHM 187, or equivalent. (ES 3), (ED 0)

CHE 331. Separation Processes (3) fall, every other year
Industrial separation chemistry and processes. Computer solutions for simple and complex multicomponent distillation columns. Azeotropic and extractive distillation. Adsorption, ion exchange and chromatography in packed beds, moving beds and cyclic operation. Synthesis of polymer membrane and its applications to industrial separation processes. (ES 1), (ED 2)

CHE 334. (MAT 334, EES 338) Electron Microscopy and Microanalysis (4) fall
Fundamentals and experimental methods in electron optical techniques including scanning electron microscopy (SEM) conventional transmission (TEM) and scanning transmission (STEM) electron microscopy. Specific topics covered will include electron optics, electron beam interactions with solids, electron diffraction and chemical microanalysis. Applications to the study of the structure of materials are given. Prerequisite: consent of the department chair. (ES 4), (ED 0)

CHE 335. (MAT 335) Principles of Semiconductor Materials Processing (3)
Description and analysis of the processing steps involved in microelectronic material fabrication. Emphasis will be placed on the chemistry of the fabrication steps, mathematical modeling of the transport and chemical reaction phenomena, and interpretation of experimental methods and data. Prerequisites: a course in thermodynamics, and senior standing. (ES 3), (ED 0)

CHE 341. Biotechnology I (3) fall
Applications of material and energy balances; heat, mass, and momentum transfer; enzyme and microbial kinetics; and mathematical modeling to the engineering design and scale-up of bio-reactor systems. Prerequisites: MATH 22, Phys 11, and CHM 187 or the equivalent of each; senior standing; and the consent of the instructor. Closed to students who have taken CHE 441.

CHE 342. Biotechnology II (3) spring
Engineering design and analysis of the unit operations used in the recovery and purification of products manufactured by the biotechnology industries. Requirements for product finishing and waste handling will be addressed. Prerequisite: CHE 341 or equivalent. Closed to students who have taken CHE 442.

CHE 346. Biochemical Engineering Laboratory (3) spring
Laboratory and pilot-scale experiments in fermentation and enzyme technology, tissue culture, and separations techniques. Prerequisites: CHE 341 and either CHE 444 or CHE 342, previously or concurrently. Closed to students who have taken CHE 446.

CHE 350. Special Topics (1-3)
A study of areas in chemical engineering not covered in courses presently listed in the catalog. May be repeated for credit if different material is presented.

CHE 360. (ME 360) Nuclear Reactor Engineering (3)
A consideration of the engineering problems related to nuclear reactor design and operation. Topics include fundamental properties of atomic and nuclear radiation, reactor fuels and materials, reactor design and operation, thermal aspects, safety and shielding, instrumentation and control. Course includes several design projects stressing the major topics in the course. Prerequisite: Senior standing in engineering or physical science. (ES 2), (ED 1)

CHE 364. Numerical Methods in Engineering (3)
Survey of the principal numerical algorithms for: (1) functional approximation, (2) linear and nonlinear algebraic equations, (3) initial and boundary-value ordinary differential equations and (4) elliptic, hyperbolic and parabolic partial differential equations. Analysis of the computational characteristics of numerical algorithms, including algorithm structure, accuracy, convergence, stability and the effect of computer characteristics, e.g., the machine epsilon and dynamic range. Applications of mathematical software in science and engineering.

CHE 367. (MAT 367) Metal Films and Coatings Processing, Structure, and Properties (3)
Focus will be on the processing, structure, and properties of metal films and coatings. Processing methods will include evaporation, sputtering, chemical vapor deposition (CVD), plasma-assisted CVD, ion implantation, electrodeposition, metal bath solidification, weld overlay, thermal spraying and diffusion. Characterization of thin films and coatings will be done with the use of sophisticated analytical instrumentation, including spectroscopic methods, microscopy and diffraction techniques. Characterization methods are explored in conjunction with processing techniques and film/coating properties via class assignments that are designed to introduce students to the archival scientific literature. Prerequisite: Senior standing in chemical engineering or materials science and engineering, or permission of the instructor(s). (ES 1.5), (ED 1.5)

CHE 370. Process Safety and Hazard Analysis (3)
A study of the methodology now available for analyzing hazard frequency and level in chemical processes. Applications to real process examples using hazard and operability analysis, fault tree and event tree analysis, "what if " analysis, and preliminary hazard analysis. Also includes a survey of the field of industrial safety. (ES 1.5), (ED 1.5)

CHE 373. (CE 373). Fundamentals of Air Pollution (3)
Introduction to the problems of air pollution including such topics as: sources and dispersion of pollutants; sampling and analysis; technology of economics and control processes; legislation and standards. Prerequisite: senior standing in the College of Engineering and Applied Science. (ES 1),(ED 2)

CHE 380. Design Projects (1-6) fall-spring
Design project work as a member of a team preferably including students from different disciplines. The project attacks a problem which, when possible, involves one of the local communities or industries. Specific projects are normally guided by faculty from several departments with consultants from off-campus. The course may be repeated for credit. (ED all)

CHE 386. Process Control (3) fall
Open-loop and closed-loop stability analysis using root locus and Nyquist techniques, design of feedback controllers with time and frequency domain specifications. Experimental process identification. Control of multivariable processes. Introduction to sampled-data control theory. Prerequisite: CHE 242 or equivalent. (ES 1), (ED 2)

CHE 387. (ECE 387, ME 387) Digital Control (3) spring
Sampled-data systems; z-transforms; pulse transfer functions; stability in the z-plane; root locus and frequency response design methods; minimal prototype design; digital control hardware; discrete state variables; state transition matrix; Liapunov stability state feedback control (2 lectures and one laboratory per week). Prerequisite: CHE 386 or ECE 212 or ME 343 or consent of instructor. (ES 1.5), (ED 1.5)

CHE 388. (CHEM 388, MAT 388) Polymer Synthesis and Characterization Laboratory (3) spring
Techniques include: free radical and condensation polymerization; molecular weight distribution by gel chromatography; crystallinity and order by differential scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior; morphology and microscopy; surface properties. Prerequisite: senior level standing in CHE, CHM or MAT, or permission of the instructor. (ES 2), (ED 1)

CHE 389. (ECE 389, ME 389) Control Systems Lab (2) spring
Experiments on a variety of mechanical, electrical and chemical dynamic control systems. Exposure to state-of-the-art control instrumentation: sensors, transmitters, control valves, analog and digital controllers. Emphasis on comparison of theoretical computer simulation predictions with actual experimental data. Lab teams will be interdisciplinary. Prerequisite: CHE 242, ECE 212, or ME 343. (ES 1), (ED 1)

CHE 391. (CHEM 391) Colloid and Surface Chemistry (3)
Physical chemistry of everyday phenomena. Intermolecular forces and electrostatic phenomena at interfaces, boundary tensions and films at interfaces, mass and charge transport in colloidal suspensions, electrostatic and London forces in disperse systems, gas adsorption and heterogeneous catalysis. Prerequisite: CHM 187 or equivalent. (ES 3), (ED 0)

CHE 392. (CHM 392) Introduction to Polymer Science (3) fall
Introduction to concepts of polymer science. Kinetics and mechanism of polymerization, synthesis and processing of polymers, characterization. Relationship of molecular conformation, structure and morphology to physical and mechanical properties. Prerequisite: CHM 187 or equivalent. (ES 1.5), (ED 1.5)

CHE 393. (CHM 393, MAT 393) Physical Polymer Science (3) fall
Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline, and paracrystal-line states (including viscoelastic and relaxation behavior) for single-and multi-component systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology, and behavior. Prerequisite: senior level standing in CHE., CHEM, or MAT, or permission of the instructor. (ES 1.5), (ED 1.5)

CHE 394. (CHM 394) Organic Polymer Science I (3) spring
Organic chemistry of synthetic high polymers. Polymer nomenclature, properties, and applications. Functionality and reactivity or monomers and polymers. Mechanism and kinetics of step-growth and chain-growth polymerization in homogenous and heterogenous media. Brief description of emulsion polymerization, ionic polymerization, and copolymerization. Prerequisites: one year of physical chemistry and one year of organic chemistry. (NS)

Graduate Programs

The department of chemical engineering offers graduate programs leading to the master of science, master of engineering, and doctor of philosophy degrees. The programs are all custom tailored for individual student needs and professional goals. These individual programs are made possible by a diversity of faculty interests that are broadened and reinforced by cooperation between the department and several research centers on the campus.

A free flow of personnel and ideas between the centers and academic departments ensures that the student will have the widest choice of research activities. The student is also exposed to a wide range of ideas and information through courses and seminars to which both faculty and center personnel contribute. In addition, strong relationships with industry are maintained by the department and the research centers, some of which operate industrially-sponsored liaison programs whereby fundamental nonproprietary research is performed in areas of specific interest to participating sponsors.

While the department has interacted with most of the centers on campus, it has had unusually strong and continuing liaisons with Emulsion Polymers Institute, Process Modeling and Control Research Center, Biopharmaceutical Technology Institute, Institute for Thermo Fluid Engineering and Science, Materials Research Center, Polymer Interfaces Center, and Zettlemoyer Center for Surface Studies. The Department also has a strong relation with the Bioengineering Program.

In addition to interacting with the centers, the department originates and encourages programs that range from those that are classical chemical engineering to those that are distinctly interdisciplinary. The department offers active and growing programs in adhesion and tribology; emulsion polymerization and latex technology; bulk polymer systems; process control; process improvement studies; rheology; computer applications; environmental engineering; thermodynamics; kinetics and catalysis; enzyme technology; and biochemical engineering.

Career Opportunities

Master of science, master of engineering, and doctor of philosophy graduates in the chemical engineering area are sought by industry for activities in the more technical aspects of their operations, especially design, process and product development, and research. Many of these graduates also find opportunities in research or project work in government agencies and in university teaching and research.

Physical Facilities

The department is well equipped for research in colloids and surface science, adhesion and tribology, polymer science and engineering, catalysis and reaction kinetics, thermodynamic property studies, fluid dynamics, heat and mass transfer, process dynamics and control, and enzyme engineering and biochemical engineering.

The departmental and university computing facilities include PCs and workstations, connected by a university-wide high speed network, which in turn provides worldwide networking via the Internet/WWW.

All of these facilities can access a wide variety of general-purpose, and scientific and engineering software via the university and local networks, including software specifically for the steady state and dynamic simulation of chemical engineering systems. The networks are extended as needed to ensure the chemical engineering department has access to the latest computing technology.

Special Programs

Polymer Science and Engineering. The polymers activity includes work done in the Department of Chemical Engineering as well as the Departments of Chemistry, Materials Science, and Physics, the Materials Research Center, the Center for Polymer Science and Engineering, the Emulsion Polymers Institute, and the Polymer Interfaces Center. More than 20 faculty members from these organizations or areas have major interests in polymers and cooperate on a wide range of research projects. For students with deep interest in the area, degree programs are available leading to the master of science, master of engineering, and doctor of philosophy degrees in polymer science and engineering.

There are three major polymer research thrusts in which chemical engineering students and faculty are involved. These are polymer colloids (latexes), polymer interfaces, and polymer materials. The Emulsion Polymers Institute, with strong industrial support, sponsors projects in the preparation of monosize polymer particles, in mechanisms and kinetics of emulsion, miniemulsion and dispersion polymerization, in latex particle morphology and film-formation, and in rheological properties of latexes and thickeners. The Polymer Interfaces Center has programs in adsorption/characterization, wetting/adhesion, and mechanical behavior. The Engineering Polymers Laboratory investigates the behavior of bulk polymer materials, focusing on multicomponent polymers and composites.

Distance Education

The Department offers some of its regular credit courses each semester via satellite and the World Wide Web for engineers in industry and government. These offerings, which are administered by the Distance Education Office, can lead to the Master of Engineering degree.

Major Requirements

All candidates for the Master of Science degree are required to complete a research report or thesis for which six hours of graduate credit are earned. Course selection is done individually for each student, although CHE 400, CHE 410, CHE 415 and CHE 461 are required.

Candidates for the Master of Engineering degree do not do research; all 30 credit hours are fulfilled by course work. There are no required core courses for those who enter the program with a bachelor's degree in chemical engineering. Course selection is done individually for each student within the University requirements for a master's degree, but no more than six credit hours from the College of Business and Economics may be presented for the degree.

In addition to an approved course and thesis program, the Ph.D. student must pass a qualification examination given during the second year of residence.

Advanced Courses in Chemical Engineering

CHE 400. Chemical Engineering Thermodynamics (3) fall
Applications of thermodynamics in chemical engineering. Topics include energy and entropy, heat effects accompanying solution, flow of compressible fluids, refrigeration including solution cycles, vaporization and condensation processes, and chemical equilibria. Prerequisite: an introductory course in thermodynamics.

CHE 401. Chemical Engineering Thermodynamics II (3)
spring, every other year
A detailed study of the uses of thermodynamics in predicting phase equilibria in solid, liquid, and gaseous systems. Fugacities of gas mixtures, liquid mixtures, and solids. Solution theories; uses of equations of state; high-pressure equilibria.

CHE 410. Chemical Reaction Engineering (3) spring
The application of chemical kinetics to the engineering design and operation of reactors. Non-isothermal and adiabatic reactions. Homogeneous and heterogeneous catalysis. Residence time distribution in reactors. Prerequisite: CHE 211. Hsu

CHE 413. Heterogeneous Catalysis and Surface Characterization (3) fall, every other year
History and concepts of heterogeneous catalysis. Surface characterization techniques, and atomic structure of surfaces and adsorbed monolayers. Kinetics of elementary steps (adsorption, desorption, and surface reaction) and overall reactions. Catalysis by metals, metal oxides, and sulfides. Industrial applications of catalysis: selective oxidation, pollution control, ammonia synthesis, hydrogenation of carbon monoxide to synthetic fuels and chemicals, polymerization, hydrotreating, and cracking. Wachs

CHE 415. Transport Processes (4) spring
A combined study of the fundamentals of momentum transport, energy transport and mass transport and the analogies between them. Evaluation of transport coefficients for single and multicomponent systems. Analysis of transport phenomena through the equations of continuity, motion, and energy. Prerequisite: CHE 461 or equivalent. Silebi, Caram

CHE 419. (MECH 419) Asymptotic Methods in the Engineering Sciences (3)
Introductory level course with emphasis on practical applications. Material covered includes: Asymptotic expansions. Regular and singular perturbations; algebraic problems. Asymptotic matching. Boundary value problems; distinguished limits. Multiple scale expansion. W.K.B. Theory. Non-linear wave equations. Blythe

CHE 421. Heat Transfer (3)
Analysis of steady and unsteady state transfer. Convection, conduction, and radiation. Vaporization and condensation. Heat transfer in high velocity flow in rarified gases. Applications.

CHE 427. (ME 427) Multiphase Flow and Heat Transfer (3)
Heat transfer and fluid dynamics of multiphase systems. Subcooled, nucleate, and film boiling; bubble nucleation; dynamics of bubble growth and collapse; vapor-liquid cocurrent flow regimes; two-phase pressure drop and momentum exchange, low instabilities; convective-flow boiling; simultaneous heat and mass transfer. Prerequisite: CHE 421 or ME 321, or courses in the area of transport phenomena. Chen

CHE 428. Rheology (3)
An intensive study of momentum transfer in elastic viscous liquids. Rheological behavior of solution and bulk phase polymers with emphasis on the effect of molecular weight, molecular weight distribution and branching. Derivation of constitutive equations based on both molecular theories and continuum mechanics principles. Application of the momentum equation and selected constitutive equations to geometries associated with viscometric flows. McHugh, Silebi

CHE 430. Mass Transfer (3) fall, every other year
Theory and developments of the basic diffusion and mass transfer equations and transfer coefficients including simultaneous heat and mass transfer, chemical reaction and dispersion effects. Applications to various industrially important operations including continuous contact mass transfer, absorption, humidification, etc. Brief coverage of equilibrium stage operations as applied to absorption and to binary and multicomponent distillation. Caram, Silebi

CHE 433. (ECE 433, ME 433) State Space Control (3) fall
State-space methods of feedback control system design and design optimization for invariant and time-varying deterministic, continuous systems; pole positioning, observability, controllability, modal control, observer design, the theory of optimal processes and Pontryagin's

Maximum Principle, the linear quadratic optimal regulator problem, Lyapunov functions and stability theorems, linear optimal open-loop control; introduction to the calculus of variations; introduction to the control of distributed parameter systems. Intended for engineers with a variety of backgrounds. Examples will be drawn from mechanical, electrical and chemical engineering applications. Prerequisite: ME 343 or ECE 212 or CHE 386 or consent of instructor. Johnson

CHE 434. (ECE 434, ME 434) Multivariable Process Control (3)
A state-of-the-art review of multivariable methods of interest to process control applications. Design techniques examined include loop interaction analysis, frequency domain methods (Inverse Nyquist Array, Characteristic Loci and Singular Value Decomposition) feed forward control, internal model control and dynamic matrix control. Special attention is placed on the interaction of process design and process control. Most of the above methods are used to compare the relative performance of intensive and extensive variable control structures. Prerequisite: CHE 433 or ME 433 or ECE 433 or consent of instructor. Kothare

CHE 436. (ECE 436, ME 436) Systems Identification (3)
The determination of model parameters from time-history and frequency response data by graphical, deterministic and stochastic methods. Examples and exercises taken from process industries, communications and aerospace testing. Regression, quasilinearization and invariant-imbedding techniques for nonlinear system parameter identification included. Prerequisite: CHE 433 or ME 433 or ECE 433 or consent of instructor. Johnson

CHE 437. (ECE 437, ME 437) Stochastic Control (3)
Linear and nonlinear models for stochastic systems. Controllability and observability. Minimum variance state estimation. Linear quadratic Gausian control problem. Computational considerations. Nonlinear control problem in stochastic systems. Prerequisite: CHE. 433 or ME 433 or ECE 433 or consent of instructor.

CHE 438. Process Modeling and Control Seminar (1) fall-spring
Presentations and discussions on current methods, approaches, and applications. Credit cannot be used for the M.S. degree.

CHE 440. Chemical Engineering in the Life Sciences (3)
Introduction of important topics in life sciences to chemical engineers. Topics include protein and biomolecule structures and characterization, recombinant DNA technology, immunoaffinity technology, combinatorial chemistry, metabolic engineering, bioinformatics. Prerequisite: Bachelor's degree in science or engineering. Hsu

CHE 441. Biotechnology I (3) fall
See the course description listed for CHE 341. In order to receive 400-level credits, the student must do an additional, more advanced term project, as defined by the instructor at the beginning of the course. Closed to students who have taken CHE 341.

CHE 442. Biotechnology II (3) spring
See the course description listed for CHE 342. In order to receive 400-level credits, the student must do an additional, more advanced term project, as defined by the instructor at the beginning of the course. Closed to students who have taken CHE 342.

CHE 444. Bioseparations (3)
Separation techniques for biomolecule isolation and purification. Theory and problems of bioaffinity chromatography, electromigration processes, and aqueous two-phase polymer extraction systems. Engineering principles for scaling-up bioseparation processes. Prerequisite: Consent of the instructor.

CHE 445. Enzyme Engineering (3)
Enzyme characteristics including nomenclature, physical properties, kinetics, and assay methods with emphasis on practical application at commercial scale. Methods of enzyme production and purification. Design and analysis of industrial-scale reactors employing soluble and immobilized enzymes. Prerequisite: Consent of the instructor.

CHE 446. Biochemical Engineering Laboratory (3)
Laboratory and pilot-scale experiments in fermentation and enzyme technology, tissue culture, and separations techniques. Prerequisites: CHE 341 and CHE 444 or CHE 342 previously or concurrently. Closed to students who have taken CHE 346.

CHE 448. Topics in Biochemical Engineering (3)
Analysis, discussion, and review of current literature for a topical area of biotechnology. Course may be repeated for credit with the consent of the instructor. Prerequisite: Consent of the instructor.

CHE 450. Special Topics (1-12)
An intensive study of some field of chemical engineering not covered in the more general courses. Credit above three hours is granted only when different material is covered.

CHE 451. Problems in Research (1)
Study and discussion of optimal planning of experiments and analysis of experimental data. Discussion of more common and more difficult techniques in the execution of chemical engineering research.

CHE 455. Seminar (1-3) fall-spring
Critical discussion of recent advances in chemical engineering. Credit above one hour is granted only when different material is covered.

CHE 460. Chemical Engineering Project (1-6)
An intensive study of one or more areas of chemical engineering, with emphasis on engineering design and applications. A written report is required. May be repeated for credit.

CHE 461 (ME 442/ENGR 452). Mathematical Methods in Engineering (3) Fall
Analytical techniques are developed for the solution of engineering problems described by algebraic systems, and by ordinary and partial differential equations. Topics covered include: linear vector spaces; eigenvalues, eigenvectors, and eigenfunctions. First and higher-order linear differential equations with initial and boundary conditions; Sturm-Liouville problems; Green's functions. Special functions; Bessel, etc. Qualitative and quantitative methods for nonlinear ordinary differential equations; phase plane. Solutions of classical partial differential equations from the physical sciences; transform techniques; method of characteristics.

CHE 464. Numerical Methods in Engineering (3)
See the course description listed for CHE 364. In order to receive 400-level credits the student must do an additional, more advanced term project, as defined by the instructor at the beginning of the course. Schiesser.

CHE 473. (CE 473) Environmental Separation and Control (3)
Theory and application of adsorption, ion exchange, reverse osmosis, air stripping and chemical oxidation in water and wastewater treatment. Modeling engineered treatment processes. Prerequisite: CE 470 or consent of the instructor.

CHE 480. Research (3)
Investigation of a problem in chemical engineering.

CHE 481. Research (3)
Continuation of CHE 480.

CHE 482. (CHM 482, MAT 482) Engineering Behavior of Polymers (3)
A treatment of the mechanical behavior of polymers. Characterization of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analogs. Topics include time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizers, moisture and aging on mechanical behavior.

CHE 483. (CHM 483) Emulsion Polymers (3) fall
Examination of fundamental concepts important in the manufacture, characterization, and application of polymer latexes. Topics to be covered will include colloidal stability, polymerization mechanisms and kinetics, reactor design, characterization of particle surfaces, latex rheology, morphology considerations, polymerization with functional groups, film formation and various application problems.

CHE 484. (CHM 484) Crystalline Polymers (3)
Morphology and behavior of both polymer single crystals and bulk crystallized systems. Relationship between basic crystal physics, thermal and annealing history, orientation and resulting properties. Thermodynamics and kinetics of transition phenomena and a brief treatment of hydrodynamic properties and their relationship to crystallization and processing properties. Prerequisite: CHE 392 or CHE 393 or equivalent.

CHE 485. (CHM 485, MAT 485) Polymer Blends and Composites (3) spring, every other year
Synthesis, morphology, and mechanical behavior of polymer blends and composites. Mechanical blends, block and graft copolymers, interpenetrating polymer networks, polymer impregnated concrete, and fiber and particulate reinforced polymers are emphasized. Prerequisite: any introductory course in polymers.

CHE 486. Polymer Processing (3)
Application of fundamental principles of mechanics, fluid dynamics and heat transfer to the analysis of a wide variety of polymer flow processes. A brief survey of the rheological behavior of polymers is also included. Topics include pressurization, pumping, die forming, calendering, coating, molding, fiber spinning and elastic phenomena. Prerequisite: CHE 392 or equivalent.

CHE 487. Polymer Interfaces (3) spring, every other year
An intensive study of polymer surfaces and interfaces, with special emphasis on thermodynamics, kinetics, and techniques for characterization. Chemistry and physics of adsorbed polymer chains. Diffusion and adhesion at polymer-polymer interfaces, especially as related to mechanical properties such as fracture and toughness will be described. Prerequisite: Introductory polymer course.

CHE 492. (CHM 492) Topics in Polymer Science (3)
Intensive study of topic selected from areas of current research interest such as morphology and mechanical behavior, thermodynamics and kinetics of crystallization, new analytical techniques, molecular weight distribution, non-Newtonian flow behavior, second-order transition phenomena, novel polymer structures. Credit above three hours is granted only when different material is covered. Prerequisite: CHEM 392 or equivalent.

Chemistry

Professors. Robert A. Flowers, II, Ph.D. (Lehigh); *chair*; Jack A. Alhadeff, Ph.D. (Oregon Medical School); Ned D. Heindel, Ph.D. (Delaware), *Howard S. Bunn Professor of Chemistry;* Kamil Klier, Ph.D. (Czechoslovak Academy of Science, Prague), *University Distinguished Professor*; Steven L. Regen, Ph.D. (M.I.T.), *University Distinguished Professor*; Keith J. Schray, Ph.D. (Penn State); Gary W. Simmons, Ph.D. (Virginia); Daniel Zeroka, Ph.D. (Pennsylvania).

Associate professors. Gregory S. Ferguson, Ph.D. (Cornell); Natalie Foster, Ph.D. (Lehigh); James E. Roberts, Ph.D. (Northwestern).

Assistant professor. Li Jia, Ph.D. (Northwestern).

Professor of Practice. Rebecca S. Miller, Ph.D. (Duke), *faculty graduate coordinator.*

CESAR fellows. Theodore N. Mellin, Ph.D. (Purdue), *director*; James J. Bohning, Ph.D. (Northeastern); Thomas B. Lloyd, Ph.D. (Western Reserve); Richard F. Merritt, Ph.D. (M.I.T.); Robert D. Rapp, Ph.D. (Lehigh); Dennis R. Patterson, Ph.D. (Chicago); Alberta Albrecht-Siemiatoski, Ph.D. (Rutgers); Tibor Sipos, Ph.D. (Lehigh).

Active emeriti. Charles S. Kraihanzel, Ph.D. (Wisconsin-Madison); John W. Larsen, Ph.D. (Purdue); James E. Sturm, Ph.D. (Notre Dame).

Chemistry is a versatile subject area and the pursuit of a career in chemistry can be a most intellectually satisfying experience. No other basic science touches and shapes as many aspects of modern society as does chemistry. The study of chemistry has provided solutions to complex problems and has improved the quality of all phases of human life from soft contact lenses and synthetic blood to longer-lasting paint and alternative fuels. A particular strength of this department is in surface and interface chemistry, which bridges many areas of modern science and technology.

Chemists at all levels of education find a market for their skills and knowledge in many employment areas. Chemists provide the technical backbone for the manufacturing industries (pharmaceuticals, plastics, paper, semiconductor electronics technology, and agriculture), for service industries (clinical and forensic laboratories, academe, environmental protection, and information science) and for governmental positions in regulatory agencies and in science policy analyses. Many chemists are employed in nontraditional areas, such as patent law, insurance underwriting, sales, product management, journalism, and even banking.

The alluring challenge of chemistry inspires many bachelor degree recipients to study for advanced degrees within the discipline of chemistry and in other areas, as well. Chemistry or biochemistry is the strongest preparation for graduate studies or for professional school in the health-related disciplines (medicine, pharmacology, and biochemistry), and for other science programs (materials science, polymers, biotechnology, environmental studies, and mineralogy).

The study of chemistry opens doors to satisfying careers, to a stimulating view of the world, and to a professional life in which one's natural tendency to ask "Why? " can lead to personally rewarding endeavors. The undergraduate curriculum in chemistry contains many of the prerequisites for biology, earth and environmental sciences, materials science, molecular biology, physics, and chemical engineering, allowing students to transfer the majority of credits through the sophomore year.

Chemistry students have the opportunity to design their undergraduate curricula for specialization in a variety of fields:

health-related chemistry (including premedical students)

suggested biological sciences electives: 31, 32, 101, 102, 324, 345, 353, 367.
suggested chemistry electives: 336, 371, 372, 377, 378.

chemistry of materials (polymers, solid state, surfaces)

suggested physics electives: 31, 363.
suggested chemistry electives: 312, 388, 391, 392, 393, 394, 396.

environmental chemistry

suggested earth and environmental sciences: 31, 351.
suggested biological sciences electives: 31, 32, 101, 102.
suggested chemical engineering electives: 373.
suggested chemistry elective: 391.
suggested civil engineering electives: 170, 274.

geochemistry

suggested earth and environmental sciences electives: 21, 131.
suggested chemistry electives: 337, 396.

chemistry management

suggested accounting electives: 151, 152, 324.
suggested law elective: 201.
suggested management electives: 280, 302, 321 or 333.
suggested economics electives: 105, 119, 145.
suggested marketing electives: 211, 312.
suggested finance electives: 225, 330.
Some of the above courses can be used to waive required graduate courses for the M.B.A. at Lehigh.

B.S. and B.A. Degrees in Chemistry

The Department of Chemistry offers B.S. chemistry programs in both the College of Arts and Sciences and the College of Engineering and Applied Science. In addition, the department offers a B.A. chemistry program in the College of Arts and Sciences. The B.S. chemistry programs in the two colleges are identical in their chemistry and collateral science requirements and are pre-professional in nature. Students planning to attend graduate school in chemistry or an allied science should elect the B.S. program in whichever college to which they have been admitted. The B.A. program in the College of Arts and Sciences is not a pre-professional program and may be elected by students who do not plan to do graduate work in chemistry or allied science but wish a stronger background in chemistry than is provided in the chemistry minor program. The B.A. program also affords a useful tie-in with health-related chemistry, environmental chemistry, geochemistry or chemistry management options (see above). Students may transfer from the B.S. to B.A. programs or vice-versa as late as the junior year, since basic requirements are the same for the two. Students who are in the B.A. program and make a late decision to attend graduate school in chemistry or allied science will have minimal chemistry preparation for this by electing Chemistry 307, Advanced Inorganic Chemistry.

Department Modern Language and Literature Requirement.

The modern foreign language requirement is met by one of three options: 1. Completion of the second semester of a modern foreign language; 2. Certification of language equivalent to this level taken in high school; 3. Substitution of six credits of science electives. If science electives are chosen, non-science distribution requirement must still be met.

B.S. Degree in Chemistry, College of Arts & Sciences

Summary of Requirements

I. College and University (26 credits)	
a. Arts 1	1 credit
b. English 1, 2	6 credits
c. College Seminar	3 credits
d. College distribution	16 credits
II. Collateral Sciences (28 credits)	
a. Physics 11, 12, 21, 22	10 credits
b. MATH 21, 22, 23, 205	15 credits
c. ENGR 1 or CSE 12	3 credits
III. Chemistry Courses	(47 credits)
a. Introductory Chemistry CHM 75, 76	8 credits
[CHM 21, 22, 31 sequence may be substituted.]	
b. Organic Chemistry CHM 51, 52, 53, 58, 353	10 credits
c. Inorganic Chemistry CHM 205, 307	5 credits
d. Physical Chemistry CHM 187, 192, 341	9 credits
e. Analytical Chemistry CHM 332, 338, 339	7 credits
f. Biochemistry CHM 371	3 credits
g. Technical Writing CHM 201 (W-I course)	2 credits
h. Advanced Chemistry Elective	3 credits
[See list of choices which appears below.]	
IV. Free Electives	(20 credits)
Total Credits	**(121 credits)**

Model Roster

freshman year, first semester (15 credits)

ARTS 1	Choices and Decisions (1)
ENGL 1	Composition and Literature I (3)
CHM 75	Concepts, Models, and Experiments I (4)

MATH 21	Calculus I (4)
	College Seminar (3)

freshman year, second semester (16 credits)

ENGL 2	Composition and Literature II (3)
PHY 11, 12	Introductory Physics I and Laboratory (5)
MATH 22	Calculus II (4)
CHM 76	Concepts, Models and Experiments II (4)

sophomore year, first semester (16 credits)

CHM 51	Organic Chemistry I (3)
CHM 53	Organic Lab I (1)
PHY 21	Introductory Phys. II (4)
PHY 22	Introductory Phys. II Lab (1)
MATH 23	Calculus III (4)
ENGR 1 or CSE 12	Computer Programming (3)

sophomore year, second semester (16 credits)

CHM 52	Organic Chemistry II (3)
CHM 58	Organic Chemistry Lab II (1)
CHM 187	Physical CHEM. I (3)
MATH 205	Linear Methods (3)

distribution requirement — free elective (6)

junior year, first semester (15 credits)

CHM 192	Physical Chemistry Lab (2)
CHM 332	Analytical Chemistry (3)
CHM 341	CHEM. Physics and Bonding (4)
CHM 205	Main Group Elements (2)

modern foreign language requirement (4)

junior year, second semester (15-16 credits)

CHM 201	Technical Writing (2) **or** approved writing intensive course (3)
CHM 307	Advanced Inorganic CHEM. (3)
CHM 338	Instrumental Analysis Lab (2)
CHM 339	Instrumental Analysis (2)
CHM 353	Organic Analysis Laboratory (2)

modern foreign language requirement (4)

senior year, first semester (14 credits)

CHM 371	Elements of Biochemistry I (3)
	advanced chemistry elective (3)*

distribution requirements — free electives (8)

senior year, second semester (14 credits)

advanced chemistry elective (3)*,**

distribution requirements — free electives (11)

** See list of choices which appears below.*

***This becomes a free elective if the advanced chemistry elective was taken in the fall semester of the senior year.*

Advanced Chemistry Elective Requirement

One 3-credit course selected from the following:

CHM 358	Advanced Organic Chemistry
CHM 372	Elements of Biochemistry II
CHM 376	Advanced Chemistry Research Lab
CHM 381	Radiation and Structure
CHM 382	Spectroscopy and Photochemical Kinetics
CHM 391	Colloid and Surface Chemistry
CHM 392	Introduction to Polymer Science
CHM 393	Physical Polymer Science
CHM 394	Organic Polymer Science
PHY 363	Physics of Solids

Students are encouraged to take any second course that sequences the first by means of a free elective.

B.A. Degree in Chemistry, College of Arts and Sciences

Summary of Requirements

I. College and University (26 credits)

a. Arts 1	1 credit
b. English 1, 2	6 credits
c. College Seminar	3 credits
d. College distribution	16 credits

II. Collateral Sciences (22 credits)

a. PHY 11, 12, 13, 22	9 credits
b. MATH 51, 52, 205	10 credits
c. ENGR 1 or CSE 12	3 credits

III.Chemistry Courses	(35-36 credits)
a. Introductory Chemistry CHM 75, 76 [CHM 21, 22, 31 sequence may be substituted.]	8 credits
b. Organic Chemistry CHM 51, 52, 53, 58	8 credits
c. Inorganic Chemistry CHM (205 or307)	2-3 credits
d. Physical Chemistry CHM (187 or 194), 192	5 credits
e. Analytical Chemistry CHM 332	3 credits
f. CHEM./CHEM. Related Courses [At least one course must be a chemistry laboratory numbered 300 or higher. As many as two credits of research (CHM 375) may be used toward meeting the total of seven credits.]	7 credits
g. Technical Writing CHM 201 (W-I course)	2 credits

IV. Free Electives (38 credits)

Total Credits **(121 credits)**

Model Roster

freshman year (30 credits)

ARTS 1	Choices and Decisions (1)
	College Seminar (3)
CHM 75	Concepts, Models and Experiments I (4)
CHM 76	Concepts, Models, and Experiments II (4)
ENGL 1	Composition and Literature I (3)
ENGL 2	Composition and literature II (fiction, poetry, drama) (3)
MATH 51	Survey of Calculus I (4)
MATH 52	Survey of Calculus II (3)
PHY 11	Intro. Phys. I (4)
PHY 12	Intro. Phys. Lab I (1)

sophomore year (30 credits)

CHM 51	Organic Chemistry I (3)
CHM 52	Organic Chemistry II (3)
CHM 53	Organic Chemistry Lab I (1)
CHM 58	Organic Chemistry Lab II (1)
PHY 13	General Phys. (3)
PHY 22	Into. Phys Lab II (1)
MATH 205	Linear Methods (3)
ENGR 1 or CSE 12	Computer Programming (3)

distribution requirements — free electives (12)

junior year (30-32 credits)

CHM 187	Physical Chemistry I (3) **or**
CHM 194	Phys. CHEM. for Biol. Sci. (3)

CHM 192 Physical Chemistry Lab (2)
CHM 201 Technical Writing (2) (W-I course)
or
approved writing-intensive course (3)
CHM 205 Main Group Elements (2) or
CHM 307 Advanced Inorganic Chemistry (3)
CHM 332 Analytical Chemistry (3)
modern foreign language requirement I (4)
modern foreign language requirement II (4)
distribution requirements — free electives (10)

senior year (31 credits)
chem./chem. related courses (7) *
distribution requirements — free electives (24)

** At least one course out of the seven credits required in this category must be a chemistry laboratory numbered 300 or higher. As many as two credits of research (CHM 375) may be used toward meeting the total of seven credits. Courses in this category can be selected from the following suggested tracks but the student in the B.A. degree program need not follow any of these tracks ... the suggested tracks are meant for guidance only:*
Environmental/Analytical: CHM 338, 339, 353
Health Related/Biochemistry/Organic: CHM 353, 358, 371, 372, 377
Materials/Physical/Inorganic: CHM 307, 312, 341, 381, 391
Polymer: CHM 388, 392, 393, 394

B.S. Degree in Chemistry, College of ENGR. & Applied Science

Summary of Requirements

I.	College distribution	24 credits
II.	Physics, math, and computing	28 credits
III.	Chemistry	47 credits
IV.	Unrestricted electives	24 credits
Total credits		**123 credits**

Model Roster

freshman year (30-31 credits)
A student should follow the normal freshman year in the College of Engineering and Applied Science and observe the following note.

Note: It is recommended that, where possible, students planning to major in chemistry take Chemistry 75 in the fall semester and Chemistry 76 in the spring semester of the freshman year. For such students the elective in the spring semester is displaced to a subsequent semester. The Chemistry 21/22/31 sequence may be substituted.

sophomore year, first semester (17 credits)
CHM 51 Organic Chemistry I (3)
CHM 53 Organic Chemistry Laboratory I (1)
PHY 21 Introductory Physics II (4)
PHY 22 Introductory Physics Laboratory II (1)
MATH 23 Calculus III (4)
modern foreign language requirement (4)*
(See details above)

**CHM. 31 Chemical Equilibria will displace this modern foreign language requirement to a subsequent semester if CHM. 31 was not taken in the freshman year.*

sophomore year, second semester (17 credits)
CHM 52 Organic Chemistry II (3)
CHM 58 Organic Chemistry Laboratory II (1)
CHM 187 Physical Chemistry I (3)
MATH 205 Linear Methods (3)
modern foreign language requirement (4)
(See details above)
Humanities/Social Science requirement (3)

junior year, first semester (15 credits)
CHM 192 Physical Chemistry Laboratory (2)
CHM 205 Main Group Elements (2)
CHM 332 Analytical Chemistry (3)
CHM 341 Chemical Physics and Bonding (4)
ECO 1 Economics (4)

junior year, second semester (17-18 credits)
CHM 201 Technical Writing (2) **or**
approved writing-intensive course (3)
CHM 307 Advanced Inorganic CHEM. (3)
CHM 338 Instrumental Analysis Lab (2)
CHM 339 Instrumental Analysis (2)
CHM 353 Organic Analysis Laboratory (2)
Humanities/Social Science requirement (3)
free elective (3)

senior year, first semester (14 credits)
CHM 371 Elements of Biochemistry I (3)
advanced chemistry elective (3)
Humanities/Social Science requirement (3)
free electives (5)

senior year, second semester (13 credits)
advanced chemistry elective (3)*,**
free electives (10)

**See list of choices for the advanced chemistry elective requirement under the B.S. degree in chemistry/College of Arts and Sciences.*

***This becomes a free elective if the advanced chemistry elective requirement was taken in the fall of the senior year.*

Five-Year Bachelor's/Master's Programs

Five-year programs may be arranged for students to receive B.S. or B.A. degrees and the M.S. degrees in chemistry with a concentration in one of several fields of chemistry (inorganic, organic, analytical, physical, polymers, biochemistry, or materials chemistry). A specific program offered by the Department of Chemistry is the five-year B.S./M.S. program, which focuses on materials education from a chemistry perspective. Students are awarded B.S. and M.S. degrees in chemistry upon completion of all requirements. Specific features of the program include participation in a weekly seminar during the academic year for credit, and summer internships for credit in university, industrial, government, or national laboratories. Materials-related electives are selected from suggested lists of courses in materials science, polymers, solid-state chemistry and physics. Additional information may be obtained from Professor Klier.

Five-Year B.S./M.S. Program in Chemistry of Materials

Model Roster

freshman year (30-31 credits)

A student should follow the normal B.S. in chemistry freshman year for the college in which the student is enrolled and should observe the following note.

Note: It is recommended that, where possible, students planning to major in chemistry take Chemistry 75 in the fall semester and Chemistry 76 in the spring semester of the freshman year. For such students the elective in the spring semester is displaced to a subsequent semester. The Chemistry 21/22/31 sequence may be substituted.

summer I

CHM 163 Chemistry of Materials I (4)

sophomore year, first semester (17-18 credits)

CHM 51	Organic Chemistry I (3)
CHM 53	Organic Chemistry Laboratory I (1)
MATH 23	Calculus III (4)
PHY 21	Introductory Physics II (4)
PHY 22	Introductory Physics Lab II (1)
	*Elective, ENGR 1, CSC 10,13 or Modern Foreign Language (3-4)
CHM 363	Science Seminar (1)

sophomore year, second semester (17 credits)

CHM 52	Organic Chemistry II (3)
CHM 58	Organic Chemistry Laboratory II (1)
CHM 187	Physical Chemistry I (3)
MATH 205	Linear Methods (3)
*	Elective, ENGR 1, CSE 12 **or** Modern Foreign Language (6)
CHM 363	Science Seminar (1)

summer II

CHM 263 Chemistry of Materials II (4)

junior year, first semester (14 credits)

CHM 192	Physical Chemistry Laboratory (2)
CHM 205	Main Group Elements (2)
CHM 332	Analytical Chemistry (3)
CHM 341	Chemical Physics and Bonding (4)
CHM 363	Distribution requirement/elective (3)

junior year, second semester (15-16 credits)

CHM 201	Technical Writing (2) **or** approved writing-intensive course (3)
CHM 307	Advanced Inorganic Chemistry (3)
CHM 338	Instrumental Analysis Laboratory (2)
CHM 339	Instrumental Analysis (2)
CHM 363	Science Seminar (1)
*	Distribution requirements (3)
**	Program related electives (2)

summer III

Off-campus experience in an industrial, national or government laboratory

senior year, first semester (16 credits)

CHM 363	Science Seminar (1)
	Advanced Chemistry Elective (3)
*	Distribution requirement (3)
/*	Program related electives (9)

senior year, second semester (16 credits)

CHM 363	Science Seminar (1)
*	Electives (6)
/*	Program related electives (9)

fifth year leading to MS degree

summer IV

CHM 421 Chemistry Research (3)

fifth year, fall semester (10 credits)

CHM 402	Physical Inorganic Chemistry (3)
CHM 421	Chemistry Research (3)
***	Program related electives (4)

fifth year, spring semester (10 credits)

CHM 443	Solid State Chemistry (3)
CHM 481	Graduate Seminar (1)
***	Program related electives (6)

** Courses which meet college distribution requirements.*

*** Some appropriate program related electives are:*

PHY 362	Atomic and Molecular Physics(3)
PHY 363	Solid State Physics (3)
MAT 10	Materials Laboratory (1)
MAT 33	Engineering Materials and Processes (3)
MAT 201	Physical Properties of Materials (3)
MAT 203	Structure Characterization Materials (3)
MAT 204	Processing/Properties - Polymeric Materials (3)
MAT 214	Processing/Properties of Ceramic Materials (3)
MAT 216	Diffusion and Phase Transformations (3)
MAT 302	Electronic Properties of Materials (3)
CHM 312/MAT 312	Fundamentals of Corrosion (3)
MAT 317	Imperfections in Crystals (3)
MAT 334	Electron Microscopy, Microanalysis(4)
MAT 343/CHM 393	Physical Polymer Science (3)
CHM 353	Organic Analysis Laboratory (3)
CHM 375	Research Chemistry Laboratory (1-3)
CHM 376	Advanced Research Chemistry Lab (1-6)
CHM 394/CHE 394	Organic Polymer Sciences (3)

****Graduate level course in chemistry, physics or materials science.*

B.S. in Biochemistry

An interdepartmental B.S. in Biochemistry major is offered in the College of Arts and Sciences. Faculty in both Chemistry (Schray) and Biological Sciences (Lowe-Krentz and Iovine) serve as advisors depending on student interest. Majors should be declared in the Department of Biological Sciences. Please see the section on biochemistry for details of the major.

Minor in Chemistry

A minor in chemistry may be achieved by completing the following requirements:

CHM 31	Chemical Equilibria in Aqueous Systems (3)
CHM 51	Organic Chemistry I (3)
CHM 53	Organic Chemistry Laboratory I (1)
CHM 187	Physical Chemistry I (3)
CHM 192	Physical Chemistry Laboratory (2)
CHM 332	Analytical Chemistry (3)
Total Credits	**(15 credits)**

Necessary pre- or co-requisites for the above would be CHM 21 and 22, MATH 21 and PHY 11.

Students who wish to minor in chemistry but whose major program requires any of the above courses may achieve the minor with substitutions approved by the department chair.

CESAR

The Center for Emeritus Scientists in Academic Research (CESAR) was established in 1999 and provides a unique opportunity for Chemistry or Biology majors to partner with retired scientists who have a desire to continue their industrial research. Through the program, CESAR Fellows mentor students, enhance student opportunities to conduct research, and provide singular insight into the world of industrial chemistry. In return, Lehigh University provides administrative support, research laboratories and equipment to specially selected retired scientists from industry. Further details can be found at the web site: http://www.lehigh.edu/inche/CESAR.html.

Undergraduate Courses in Chemistry

CHM 5. Chemistry and National Issues (3) spring
For majors other than science and engineering. Chemistry and current controversies. The atmosphere: global warming, ozone depletion, pollution. Water pollution and treatment. Energy generation and side effects. Health: chemicals of life, drugs, carcinogens, personal care. Materials: natural and synthetic. Food: production and preservation. Chemistry: benefits and liabilities. CHM 22 may be taken concurrently for laboratory credit. (NS)

CHM 21. Introductory Chemical Principles (4) fall-spring
An introduction to important topics in chemistry. These include atomic structure, bonding in inorganic and organic compounds, states of matter, chemical equilibrium, acid-base theories and electrochemistry. Three lectures, one recitation. (NS)

CHM 22. Chemical Principles Laboratory (1) fall-spring
A laboratory course to be taken concurrently with CHM 21. One three-hour laboratory period per week. (NS)

CHM 31. Chemical Equilibria in Aqueous Systems (3) fall-spring
A study of the theoretical basis and practical applications of equilibria in aqueous solutions, including acid-base, precipitation-solubility, metal-ligand, oxidation-reduction and distribution equilibria. Introduction to chemical thermodynamics, spectrophotometry, potentiometry and chromatography. The laboratory work emphasizes the qualitative and quantitative analysis of equilibria in aqueous media. Prerequisite: CHM 21, MATH 21, 31 or 51. Two lectures and one three-hour laboratory period. (NS)

CHM 51. Organic Chemistry I (3) fall
Systematic survey of the typical compounds of carbon, their classification, and general relations; study of synthetic reactions. Prerequisite: CHM 21 or 75. (NS)

CHM 52. Organic Chemistry II (3) spring
Continuation of CHM 51. Prerequisite: CHM 51. (NS)

CHM 53. Organic Chemistry Laboratory I (1) fall
Preparation of pure organic compounds. Modern techniques of characterization. Prerequisite: CHM 51 previously or concurrently. (NS)

CHM 58. Organic Chemistry Laboratory II (1) spring
Continuation of Organic Chemistry Laboratory I. Prerequisite: CHM 53 previously; CHM 52 previously or concurrently. (NS)

CHM 75. Concepts, Models and Experiments I (4) fall
A first-semester course in chemistry for students planning to major in chemistry, biochemistry, chemical engineering, materials science, or other chemistry-related fields. Chemical and physical properties, structures, bonding concepts, and quantitative analysis. Laboratory includes synthesis, separation and analysis procedures; computer applications to chemistry. Three lectures, one laboratory. (NS)

CHM 76. Concepts, Models and Experiments II (4) spring
Continuation of Chemistry 75. Three lectures, one laboratory. Prerequisite: CHM 75 or departmental consent. (NS)

CHM 163. Chemistry of Materials I (4) summer
Research laboratory for students enrolled in the five-year B.S./M.S. chemistry of materials program. (NS)

CHM 177. Introduction to Research (1-2) fall-spring
For advanced freshmen and sophomore chemistry majors. May be repeated for credit. Prerequisite: Consent of department chair. (NS)

CHM 187. Physical Chemistry I (3) spring
Development of the principles of thermodynamics and their application to systems in which composition is of major concern: solutions, chemical and phase equilibria. Elements of chemical reaction kinetics. Prerequisite: CHM 31 or 76, and MATH 21, 31 or 51 previously or concurrently. (NS)

CHM 189. Physical Chemistry II (3) fall
A continuation of Chemistry 187. Kinetic theory of gases, statistical thermodynamics, electrolytes in solution, electrochemistry, corrosion, colloid and surface chemistry and the solid state. Prerequisites: CHM 187, MATH 23, PHY 21. (NS)

CHM 192. Physical Chemistry Laboratory (2)
Laboratory studies that illustrate the various fields of study in experimental physical chemistry. Prerequisite: CHM 187. (NS)

CHM 194. Physical Chemistry for Biological Sciences (3) fall
The principles and applications of physical chemical concepts to systems of biological interest, including the gas laws, thermodynamics of metabolic reactions, colligative properties, electrochemical equilibria, reaction kinetics and enzyme catalysis, and transport of macromolecules and viruses. Prerequisite: CHM 21 or 75. (NS)

CHM 201. Technical Writing (2)
Principal types of written communications used by professional chemists including informative abstracts, research proposals, progress reports, executive summaries for nonchemist decision makers and proper written experimental procedures, tables, schemes and figures. Prerequisite: junior standing in chemistry major or consent of the department chair. (ND)

CHM 205. Main Group Elements (2) fall
Chemistry of the main group elements. Prerequisite: CHM 31 or 76. (NS)

CHM 209. Chemistry of Organic and Inorganic Materials (3) fall
A systematic study of the most important organic and inorganic structures, covering synthesis, nomenclature, reactions, and properties. Grouping of elements with similar properties within the periodic table is stressed. The nature of the covalent bond will be developed. Reactions involving alkenes (especially vinyls), hydroxyl, amine, oxirane, and halogen groups will be emphasized. Crystal structures and physical properties. Prerequisite: CHM. 21 or 75. (NS)

CHM 250. Special Topics (1-3)
Selected topics in chemistry. May be repeated for credit when different topics are offered. (NS)

CHM 263. Chemistry of Materials II (4) summer
Research laboratory for students enrolled in the five-year B.S./M.S. chemistry of materials program. (NS)

CHM 307. Advanced Inorganic Chemistry (3) spring
Introduction to transition metal complexes; theories of bonding; kinetics and mechanisms of transition metal complex reactions; selected aspects of organometallic chemistry; bioinorganic chemistry. Prerequisite: CHM 341. (NS)

CHM 312. (CHE 312, MAT 312) Fundamentals of Corrosion (3) fall
Corrosion phenomena and definitions. Electrochemical aspects including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization and passivity. Non-electrochemical corrosion including mechanisms, theories and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings alloys, inhibitors, and passivators. Prerequisite: MAT 205 or CHM 187. (NS)

CHM 332. Analytical Chemistry (3) fall
Theory and practice of chemical analysis. Principles of quantitative separations and determinations; theory and application of selected optical and electrical instruments in analytical chemistry; interpretation of numerical data, design of experiments, solute distribution in separation methods. Prerequisites: CHM 31 and 51. (NS)

CHM 336. Clinical Chemistry (3) spring
Applications of analytical chemistry to clinical problems. Discussion of methods in common use and the biochemical-medical significance of the results. Prerequisites: CHM 332 and 52. Schray. (NS)

CHM 337. (MAT 333) X-ray Diffraction of Materials (3) fall
Introduction to crystal symmetry, point groups, and space groups. Emphasis on materials characterization by X-ray diffraction and electron diffraction. Specific topics include crystallographic notation, stereographic projections, orientation of single crystals, textures, phase identification, quantitative analysis, stress measurement, electron diffraction, ring and spot patterns, convergent beam electron diffraction (CBED), and space group determination. Applications in mineralogy, metallurgy, ceramics, microelectronics, polymers, and catalysts. Lectures and laboratory work. Prerequisite: MAT 203 or EES 131 or senior standing in chemistry. Lyman, Chan. (NS)

CHM 338. Instrumental Analysis Laboratory (2) spring
Laboratory studies of modern methods of instrumental analysis emphasizing function and characteristics of instrumentation, data, processing, and experimental design. Prerequisites: CHM 339 previously or concurrently. (NS)

CHM 339. Instrumental Analysis (2) spring
Principles and applications of modern methods of analytical analysis including optical spectroscopy, nuclear magnetic resonance spectroscopy, mass spectrometry, electrochemical methods, chromatography, thermal methods, and surface characterization. Prerequisite: CHM 332 .(NS)

CHM 341. Chemical Physics and Bonding (4) fall
Development of ideas relating to the nature of the chemical bond. Emphasis placed on the quantum chemistry of atoms and molecules. Statistical thermodynamics of gaseous and solid systems. Diffraction effects in crystalline solids. Elements of point group theory. Prerequisites: CHM 187, MATH 205, PHY 21. (NS)

CHM 350. Special Topics (1-3)
Selected advanced topics in chemistry. May be repeated for credit when different topics are offered. (NS)

CHM 353. Organic Analysis Laboratory (2) spring
Identification of organic compounds as single components and mixtures. Application of combined chemical and spectral assay techniques. Use and interpretation of data from nuclear magnetic resonance, infrared, and mass spectroscopic examinations. Separation techniques for mixtures. Prerequisites: CHM 52 and 58. (NS)

CHM 358. Advanced Organic Chemistry (3) fall
Reaction mechanism types and supporting physical-chemical data. Classes of mechanisms include elimination, substitution, rearrangement, oxidation-reduction, enolate alkylations, and others. Prerequisite: one year of organic chemistry. (NS)

CHM 363. Science Seminar (1) fall-spring
Discussion of current research in materials chemistry. For students enrolled in the five-year B.S./M.S. chemistry of materials program. May be repeated for credit. (NS)

CHM 368. Advanced Organic Laboratory (2)
The synthesis and study of organic compounds illustrating the important techniques and special pieces of apparatus commonly used in organic chemical research. Prerequisite: one year of organic chemistry and laboratory. (NS)

CHM 371. (BIOS 371) Elements of Biochemistry I (3) fall
A general study of carbohydrates, proteins, lipids, nucleic acids, and other biological substances and their importance in life processes. Protein and enzyme chemistry are emphasized. Prerequisite: one year of organic chemistry. (NS)

CHM 372. (BIOS 372) Elements of Biochemistry II (3) spring
Dynamic aspects of biochemistry: enzyme reactions including energetics, kinetics and mechanisms, metabolism of carbohydrates, lipids, proteins and nucleic acids, photosynthesis, electron transport mechanisms, coupled reactions, phosphorylations, and the synthesis of biological macromolecules. Prerequisite: CHM 371. (NS)

CHM 375. Research Chemistry Laboratory (1-3) fall-spring
An introduction to independent study or laboratory investigation under faculty guidance. Prerequisite: consent of faculty research supervisor. (NS)

CHM 376. Advanced Research Chemistry Laboratory (1-6) fall-spring
Advanced independent study or laboratory investigation under faculty guidance. Prerequisite: 3 credits of CHM 375. Consent of faculty research supervisor. May be repeated for credit. (NS)

CHM 377. (BIOS 377) Biochemistry Laboratory (3) fall
Laboratory studies of the properties of chemicals of biological origin and the influence of chemical and physical factors on these properties. Laboratory techniques used for the isolation and identification of biochemicals. Prerequisite: CHM 371, previously or concurrently. (NS)

CHM 378. (BIOS 378) Biochemical Preparations (1-3) spring
A laboratory course involving the preparation or isolation, purification and identification of chemicals of biological origin. Prerequisites: CHM 377 and 372, previously or concurrently. (NS)

CHM 381. Radiation and Structure (3)
Quantum chemistry and group theory applied to molecular orbital theory of bonding, structure, and spectroscopy. Study of selection rules for chemical and photochemical reactions. Prerequisites: CHM 341 and MATH 205. (NS)

CHM 382. Spectroscopy and Photochemical Kinetics (3) spring
Applications of electronic, infrared, and microwave spectroscopy to the study of molecular structure. Chemical consequences of intramolecular excitation; quantum efficiencies and reaction mechanisms; pulse excitation and dynamics of elementary processes. Prerequisite: CHM 341. (NS)

CHM 385. Physical Chemistry of Printing Inks (3) fall
Physical chemical mechanisms of printing processes; composition, dispersion processes for pigments, rheology and printability of inks; color-matching; development of solventless inks and specialty inks. Prerequisite: CHM 187 or equivalent. (NS)

CHM 388. (CHE 388) Polymer Synthesis and Characterization Laboratory (3) spring
Techniques include: free radical and condensation polymerization; molecular weight distribution by gel chromatography; crystallinity and order by differential scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior; morphology and microscopy; surface properties. Prerequisites: CHM 187, 189 or 341 and 51. El-Aasser. (NS)

CHM 391. (CHE 391) Colloid and Surface Chemistry (3) fall
Physical chemistry of everyday phenomena. Intermolecular forces and electrostatic phenomena at interfaces, boundary tensions and films at interfaces, mass and charge transport in colloidal suspensions, electrostatic and London forces in disperse systems, gas adsorption and heterogeneous catalysis. Prerequisite: CHM 187 or equivalent. Chaudhury. (NS)

CHM 392. (CHE 392) Introduction to Polymer Science (3) spring
Introduction to concepts of polymer science. Kinetics and mechanisms of polymerization; synthesis and processing of polymers, characterization. Relationship of molecular conformation, structure and morphology to physical and mechanical properties. Prerequisite: CHM 187 or equivalent. Sperling. (NS)

CHM 393. (CHE 393, MAT 393) Physical Polymer Science (3) fall
Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline and paracrystalline states (including viscoelastic and relaxation behavior) for single- and multi-component systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology and behavior. Prerequisite: one year of physical chemistry. Sperling. (NS)

CHM 394. (CHE 394) Organic Polymer Science I (3) spring
Organic chemistry of synthetic high polymers. Polymer nomenclature, properties, and applications. Functionality and reactivity or monomers and polymers. Mechanism and kinetics of step-growth and chain-growth polymerization in homogenous and heterogenous media. Brief description of emulsion polymerization, ionic polymerization, and copolymerization. Prerequisites: one year of physical chemistry and one year of organic chemistry. (NS)

CHM 396. (MAT 396) Chemistry of Nonmetallic Solids (3) spring
Chemistry of ionic and electronic defects in nonmetallic solids and their influence on chemical and physical properties. Intrinsic and impurity controlled defects nonstoichiometric compounds, defect interactions. Properties to be discussed include: diffusion, sintering, ionic and electronic conductivity, solid-state reactions, and photoconductivity. Prerequisite: CHM 187 or MAT 205 or equivalent. (NS)

Graduate Programs in Chemistry

The department of chemistry offers graduate studies leading to several advanced degrees. These include master of science and doctor of philosophy degrees in chemistry, a doctor of arts in chemistry, master of science and doctor of philosophy degrees in pharmaceutical chemistry and a master of science in clinical chemistry. Master of science and doctor of philosophy degrees in chemistry may be obtained by study and research in any appropriate area of chemistry. Additional information concerning the pharmaceutical chemistry and clinical chemistry programs may be obtained from Section IV of this catalog. The doctor of arts degree includes broad course work in many of the major subdisciplines of chemistry and requires two areas of specialization. A laboratory problem in chemistry (at the M.S. level) and a chemical education project (at the doctoral level) are required. A teaching internship (CHM 411) and an industrial externship are part of the degree program a program which is particularly intended to upgrade college teachers presently employed in academia but not holding the doctorate.

The chemistry department also admits students to the master of science and doctor of philosophy degree programs in polymer science and engineering. These are interdisciplinary programs which are described in Section IV of this catalog and are not administered by the chemistry department. The following information on admissions, proficiency examinations and other policies applies to all of the programs listed above but not to the interdisciplinary polymer science and engineering program.

Admission to graduate study in chemistry assumes that a student has met, or is willing to meet though further study, minimum undergraduate requirements for a bachelor's degree in chemistry. This would include (beyond two semesters of introductory chemistry) two semesters of organic chemistry, two semesters of physical chemistry, two semesters of analytical chemistry and one semester of inorganic chemistry. A promising student whose degree is in a field related to chemistry (e.g., biology, chemical engineering) may be admitted to graduate study in chemistry provided that any deficiencies in basic chemistry preparation are made up in the first year of graduate study, noting that some of the courses required for this may not carry graduate credit.

The chemistry department will administer proficiency examinations at the advanced undergraduate level in analytical, biochemistry, inorganic, organic and physical chemistry to all regular graduate students at the time of matriculation. Each student is required to take three examinations. Information regarding material to be covered on these examinations will be sent to each student several months in advance of matriculation. It is expected that each student will prepare diligently for these tests. A student who performs well on one or more of these tests has an opportunity to take advanced level and special topics courses at an earlier than normal time and may in fact begin graduate research during the first year. A Ph.D. candidate must show proficiency in three areas and an M.S. candidate in two areas within the first year in residence. A student who fails one or more of the proficiency examinations will meet with Professor Miller, faculty graduate coordinator, to determine an appropriate course of action in light of the exam performance, projected major and degree aspiration. Two optional routes are available for demonstration of proficiency. (1) The student through self-study and auditing of appropriate courses may prepare for a retaking of a proficiency examination at the beginning of the second semester in residence. (2) Alternatively, the student may enroll in appropriate 300 or 400 level courses during the first year in residence. A grade of B- or better in an appropriate 300-400 level course will be considered equivalent to passing the proficiency examination in that area. Courses taken as a means of demonstrating proficiency will be acceptable on the M.S. or Ph.D. graduate program.

The Master of Science in Chemistry degree requires a total of 30 credits, and may be obtained by one of three options: 1) a minimum of 30 course credits, 2) a minimum of 27 course credits and a 3 credit literature review paper (taken under CHM 421, Chemistry Research), or 3) a minimum of 24 course credits and 6 credits of experimental research (CHM 421). Each option requires a minimum of 18 credits at the 400 level (15 of which must be in chemistry) and one credit of CHM 481 (Seminar). There are no other specifically required courses for the M.S. degree, allowing each student to design a curriculum that fits their needs and interests. Normally, work for the master's degree can be completed in 18 calendar months of full-time study.

Completion of a doctor of philosophy degree program normally requires a minimum of four years full-time work after entrance with a bachelor's degree. There are few specific course credit requirements for the Ph.D.; however, approved degree programs generally have at least 24 hours of course work (including any applied toward a master's degree) and 6 credits of research. Thus, the program consists of approximately one-third formal course work and two-thirds independent study and research. There is a two-credit seminar requirement (CHM 481). After Ph.D. proficiency has been established and the research advisor selected (this must be done by the end of the first year in residence), the major hurdles are the doctoral examinations (both written and oral) in the student's area of concentration which must be passed by the end of 2 1/2 years of residence. If this hurdle is surmounted, the remaining time is spent completing (and ultimately defending) the dissertation research under the guidance of the research adviser and the dissertation committee.

Most of the chemistry facilities are housed in the 90,000-square-foot chemistry complex, first occupied in 1975. The seven-story Seeley G. Mudd Building affords laboratory space of modern design; the top three floors are devoted to research laboratories. Some biochemistry research is located in Iacocca Hall of the Mountaintop Campus. Pharmaceutical chemistry research is located in the Seeley G. Mudd Building. Solid-state chemical research is located in the Sherman Fairchild Laboratory, in Whitaker Laboratory, and in the Seeley G. Mudd Building. Polymer chemistry research laboratories are located in Whitaker Laboratory, Iacocca Hall on the Mountaintop Campus, and the Seeley G. Mudd Building.

Current Research Projects

Current research projects of interest are listed below.

Analytical Chemistry. NMR studies of organic solids and polymers; electrochemical reduction and oxidation mechanisms of organic compounds; clinical-biomedical applications, mechanisms of electrode processes, adsorption.

Biochemistry. Characterization of lysosomal glycosidases and glycosyl transferases; functional role of carbohydrates in glycoproteins; abnormal glycoprotein metabolism in human diseases; development of *in vitro* evaluation techniques for prescreening candidate pharmaceuticals; structural dynamics and molecular associations of biologically significant molecules.

Inorganic Chemistry. Synthesis, characterization and catalytic chemistry of transition metal organometallic complexes; applications of molecular mechanics and molecular orbital theories in studies of inorganic and organic derivatives of the representative main group elements and transition metals; synthesis of solid catalysts including oxides, sulfides, zeolites and supported metals; use of organometallic and coordination chemistry in the synthesis of thin-film materials, and as a guiding principle in adhesion. Use of organometallic chemistry as a vehicle for various catalytic transformations including polymerization and small molecule synthesis; lanthanide chemistry.

Materials and Polymer Chemistry. Inorganic and organometallic chemistry in the synthesis of thin-film materials; synthesis at and dynamics of polymer interfaces; polymerization catalysis; synthesis, structure, conformation and properties of high polymers; techniques and kinetics of emulsion polymerization and film formation; acoustic, optical, permeability, dielectric and mechanical behavior of thin films, coatings and bulk polymers; molecular structure, relaxation behavior and energetics of fracture; elastic and viscoelastic behavior of interpenetrating and rubbery networks; effects of ordering in the glassy state and crystallization on physical properties; crystallization under the influence of shear gradients; physical chemistry of polymer composites such as polymer-concrete and filled polymers; interfacial characteristics and interactions in polymer-inorganic systems; NMR studies of polymers in aqueous solutions and gels; ionic motion through polymer films.

Organic Chemistry. Synthesis of medicinal agents, correlation of molecular structure with pharmacological behavior; chemical models for biochemical reactions; biosynthesis involving indole intermediates; chemistry of monolayers and organized molecule assemblages; coal chemistry; organometallic reaction mechanisms; protein folding and renaturation; molecular recognition; calorimetry; electrochemical studies of electron transfer reactions.

Physical Chemistry. Chemistry at surfaces and interfaces of catalysts, coatings, structural alloys and microelectronics using an array of surface sensitive methods; NMR and XPS imaging, ARXPS and ARUPS, surface diffraction methods including XPD, surface dynamics in nano, meso and macroscopic dimensions, STM/AFM in UHV and "real " environments, theory including **ab initio** FLAPW-DFT for periodic systems for interpretation of XPS, UPS, optical, QNMR, FTIR and Raman spectra, as well as transition states both in thermal and photochemical reactions; NMR studies of polymer adsorption and polymer miscibility; the macromolecular structure of kerogens; mineral matter catalyzed reactions in petroleum formation; carbon catalyzed reactions; applications of electronic structure theory to spectral simulation, reactivity, transition states, and excited states; statistical mechanics of order-disorder transitions.

Major Instrumentation

Chemistry research spans all areas: analytical, biochemistry, inorganic, organic, physical, and polymer. Special equipment available for graduate research in chemistry is as follows.

Biochemistry research facilities—HPLCs, GCs, FPLC, ultracentrifuges, DNA synthesizer, scintillation and gamma counters, cold rooms, cell disintegrator, zone and disc electrophoresis apparatus, column chromatograph, autoclave, ultra-low temperature freezers (–90 and –135C), rotary vaporator, Milli-Q water purification system, shaking heated water baths, spectropolarimeter with circular dichroism capability. Cell culture facilities—complete with optical microscopes having fluorescent and photographic capabilities, liquid scintillation equipment. Catalysis facility—fully automated high pressure reactors with on-line gas chromatographs. Coal research and analysis facility—complete with ultracentrifuge, gas chromatographs, gel permeation chromatograph, vapor pressure osmometer, dry boxes. Electron optical facilities—transmission electron microscopy with x-ray fluorescence analysis capability, scanning electron microscope, and scanning electron microprobe. Gas chromatographs, including a PE sigma 3 for inverse gas chromatography. Liquid chromatographs—high performance for analytical and preparative work. NMR spectrometers—300 MHZ solid state, 360 MHZ for solutions and imaging, 500 MHZ spectrometer for solutions. Photochemistry equipment—lamps and filters for selected wavelength work. Polarographs, chronopotentiometers, electrophoresis apparatus, electrochemical impedance, electrochemical scanning tunneling microscope, potentiostats, and rotating disk electrode. Titration equipment (automated and computer interfaced), portable data interface (8-channel 50 KHz), digital readout polarimeter, Vibron elastoviscometers, radio-tracer equipment, including a gamma counter, differential refractometer, rheometer. Spectrometers—uv/visible double beam automated, uv/visible/nearir, Fourier transformir with diffuse reflectance, photoacoustic and attenuated total reflectance capability, laser Raman, GC mass spectrometers, time-of-flight (TOF) mass spectrometer with 252Cf desorption source. Mssbauer spectrometer, positron annihilation spectrometer. Surface analysis facilities—rotating anode high-sensitivity high-energy resolution ESCA with imaging capability (ESCA is equipped with automated angular data acquisition). Surface science facility—Auger electron spectroscopy, low energy electron diffraction (LEED), high resolution electron energy loss spectroscopy (HREELS), photocorrelation spectroscopy for submicron particle analysis. Ellipsometer, contact angle capabilities, gas adsorption apparatus (BET), temperature programmed desorption (TPD), atomic force microscope, instructional scanning tunneling microscope, and light scattering. Microcalorimeter (flowing with uv and refractive index detectors), differential scanning calorimeter (DSC).

The NMR Laboratory is jointly operated with Air Products and Chemicals and the ESCA Laboratory is jointly operated with AT&T. A microcomputer laboratory consisting of 18 pentium-based personal computers and a computer laboratory with five SGI Octane work stations are jointly operated with LTS.

Graduate Courses in Chemistry

CHM 400. Laboratory Safety (0) fall

Accident prevention; emergency response; government regulations; facilities for handling and storage disposal of hazardous materials; emergency facilities; liabilities. Lectures, multi-media presentations, hands-on training by practitioners.

CHM 402. Physical Inorganic Chemistry (3) alternate years

Aufbau principle and coupling of angular momenta is used to describe atomic and molecular term states. Group theoretical principles will be utilized in studies of molecular orbital and ligand field theories of bonding. Prerequisite: CHM 341 or equivalent. Klier

CHM 403. Advanced Topics in Inorganic Chemistry (1-3) alternate years

Topics of contemporary interest in inorganic chemistry. This course may be repeated when a different topic is offered. Prerequisite: CHM 307 or equivalent.

CHM 405. Organometallic Chemistry (3) alternate years

The chemistry of compounds containing carbon to metal bonds. Among topics covered are the following: organic compounds of the representative elements from Group I to IV; the chemistry of ferrocene and related pi-bonded organometallic complexes; metal carbonyl and nitrosyl complexes; dioxygen and dinitrogen complexes; organic synthesis utilizing organometallic catalysts.

CHM 411. Teaching Internship (3-6) fall-spring
The preparation, teaching and grading of one or two undergraduate lecture courses with appropriate supervision by senior faculty members. Observation and evaluation of the intern is effected by classroom visits and videotape review. Prerequisite: candidacy in the doctor of arts program or permission of the department chair. May be repeated for credit.

CHM 421. Chemistry Research (1-6)
Research in one of the following fields of chemistry: analytical, inorganic, organic, physical, polymer, biochemistry.

CHM 423. Bio-organic Chemistry (3) alternate years
An examination of biochemistry on the basis of organic chemical principles. Emphasis on reaction mechanisms of biochemical transformations and methods for elucidation of these mechanisms, i.e., kinetics, isotope effects, exchange techniques, inhibition studies, substrate analog effects and organic model studies. Prerequisite: CHM 358. Schray

CHM 424. Medicinal and Pharmaceutical Chemistry (3) alternate years
Principles of drug design, structure-activity relationships in antibacterial, antimalarial, anti-inflammatory and psychoactive drugs; synthesis and modes of action of pharmacologically active agents radioactive pharmaceuticals. Prerequisite: one year of organic chemistry. Heindel

CHM 430. Chemical and Biochemical Separations (3) spring, alternate years
Theory and applications of equilibrium and nonequilibrium separation techniques at both the analytical and preparative levels. Solvent and buffer extractions, chromatographic separations (e.g., thin layer, partition, gas liquid, gel filtration, ion exchange, affinity, supercritical fluid), electrophoretic separations (e.g., gel, capillary, isoelectric focusing, immunoelectrophoresis), centrifugal separations (e.g., differential, velocity sedimentation, density gradient) and other separation methods (e.g., dialysis, ultrafiltration). Examples will focus on biological applications. Alhadeff

CHM 431. Contemporary Topics in Analytical Chemistry (1)
Discussion of the current literature in analytical chemistry, including spectroscopy, separations, and electrochemistry. Students find current papers and lead discussions. May be repeated for credit.

CHM 432. Chemometrics (3) fall, alternate years
Mathematical and statistical methods for experimental design, calibration, signal resolution, and instrument control and optimization.

CHM 433. Electroanalytical Chemistry (3) alternate years
Theory and applications of selected electrochemical techniques; solutions to mass transport problems, treatment of electron transfer kinetics and kinetics of associated chemical reactions, and critical evaluation of adsorption and other factors associated with electrochemical processes. Prerequisite: CHM 332 or equivalent.

CHM 434. Advanced Topics in Spectroscopy (3) fall, alternate years
Fundamentals of interactions of electromagnetic radiation with matter: electronic, vibrational, scattering based spectroscopies, instrumentation and signal processing. Advanced applications to the analysis of molecular structure and chemical processes including surface analysis, time-resolved spectroscopies, and ultrasensitive spectroscopic techniques. Messmer

CHM 435. Advanced Topics in Clinical Chemistry (3)
Selected areas of clinical chemistry such as chemical toxicology, pathogenic microbial biochemistry in vivo diagnostic methodology, therapeutic drug monitoring, or other advanced topics. May be repeated for credit when a different topic is offered.

CHM 436. Special Topics in Analytical Chemistry (1-3)
Topics of contemporary interest in analytical chemistry. May be repeated for credit when a different topic is offered.

CHM 437. (BIOS 437) Pathophysiological Chemistry (3) spring
Biochemical basis of human diseases involving abnormal metabolism of proteins, nucleic acids, carbohydrates, and lipids. Emphasis on the correlation of the clinical presentation of disease processes seen as physiological dysfunctions with clinical laboratory methods. Lectures, student presentations, and clinical case discussions. Prerequisite: consent of the department chair. Alhadeff

CHM 438. Advanced Topics in NMR (3) spring, alternate years
Fundamental aspects of NMR analysis; instrumental design; data acquisition and processing parameters; nuclear spin relaxation; theory of spin dynamics; product operator formalism; density matrix theory; multidimensional methods; analysis strategies. Roberts

CHM 441. Chemical Kinetics (3) alternate years
A study of kinetic processes. Phenomenological chemical kinetics; order, mechanism effect of external variables on rate. Theories of the rate constant. Relation between thermodynamics and kinetics. Applications to selected systems such as unimolecular decompositions, molecular beams and diffusion-limited processes. Prerequisite: one year of physical chemistry.

CHM 443. (MAT 443) Solid-State Chemistry (3) alternate years
Crystal structure, diffraction in crystals and on surfaces, bonding and energy spectra in solids dielectrics, surface states and surface fields in crystals. Prerequisite: one course in linear algebra and one course in quantum mechanics. Klier

CHM 445. Elements of Physical Chemistry (4)
Quantum chemistry of simple systems, molecular structure and spectroscopy, statistical and classical thermodynamics. Prerequisite: CHM 341 or its equivalent.

CHM 451. Physical Organic Chemistry (3) alternate years
An introduction to quantitative organic chemistry including relationships between structure and reactivity, medium effects on reactions, introduction to orbital symmetry effects in organic reactions, and reaction mechanisms. Prerequisite: CHM 358 or consent of department chair.

CHM 453. Heterocyclic Compounds (3) alternate years
An intensive study of the syntheses, reactions and properties of heteroaromatic compounds including derivatives of thiophene, pyrrole, furan, indole, pyridine, quinoline, the azoles and the diazines — all considered from the viewpoint of modern theories of structure and reaction mechanisms. Prerequisite: CHM 358.

CHM 455. Organic Reactions (3) alternate years
Intensive survey of modern synthetic organic chemistry from a mechanistic standpoint. Classical Name-reactions, olefin synthesis, organometallic reagents in synthesis, Woodward-Hoffmann rules, electrocyclic processes, enolate chemistry, and related reactions. Prerequisite: CHM 358.

CHM 456. Spectral Analysis (3) fall
Use of data from nuclear magnetic resonance, infrared, ultraviolet, and mass spectrometric techniques for the determination of structure of organic compounds. Emphasis on information from one- and two-dimensional proton and carbon NMR, and a mechanistic interpretation of data from mass spectrometry. Foster

CHM 457. Organic Reaction Mechanisms (3)
Intensive in-class problem solving that involves the formulation of reasonable reaction mechanisms for complex multistep pathways, i.e. organic transformations that proceed via highly energetic intermediates such as carbocations, carbanions, free radicals, carbenes, and nitrenes.

CHM 458. Topics in Organic Chemistry (1-3)
An intensive study of limited areas in organic chemistry. May be repeated when a different topic is offered.

CHM 466. Advanced Organic Preparations (2-3)
A laboratory course of instruction in advanced techniques of the preparation of organic compounds.

CHM 467. (BIOS 467) Principles of Nucleic Acid Structure (3) alternate years
An examination of the principles underlying nucleic acid structure including stereochemistry, electrostatics, hydration, torsional constraints, sequence specific effects, and interaction with nuclear proteins. Special emphasis will be placed on DNA structure. Prerequisite: one year of biochemistry and one year of physical chemistry or permission of the department chair. Behe

CHM 468. (BIOS 468) Principles of Protein Structure (3) alternate years
An examination of the principles underlying protein structure including stereochemistry, preferred tertiary structures, protein homology, excluded volume effects, time dependent structural fluctuations, and prediction of protein structure from sequence information. Prerequisites: one year of biochemistry and one year of physical chemistry or permission of the department chair. Behe

CHM 469. (BIOS 469) Biochemical Problem Solving I (1) fall
Applications of material covered in BIOS/CHM 371 including techniques used in research. Prerequisite: BIOS/CHM 371 previously or concurrently.

CHM 470. (BIOS 470) Biochemical Problem Solving II (1) spring
Applications of concepts covered in BIOS/CHM 372 including techniques used in research. Prerequisite: BIOS/CHM 372 previously or concurrently.

CHM 471. (BIOS 471) Eucaryotic Biochemistry (3) alternate years
Biochemistry of selected eucaryotic processes including hormone chemistry, blood clotting, immunochemistry, vision chemistry, muscle chemistry and photosynthesis. The second part of the course will involve presentation and discussion of the current literature by class participants. Prerequisite: BIOS/CHM 372 or consent of department chair. Lowe-Krentz

CHM 472. (BIOS 472) Lipids and Membranes (3) alternate years
Structure, physical properties and functions of lipids and their biological aggregates. Techniques for studying lipid assemblies, enzymes which act on lipids, membrane proteins and lipoproteins will also be discussed. Prerequisite: BIOS/CHM 372 or consent of department chair. Lowe-Krentz

CHM 473. (BIOS 473) Biochemistry of Complex Carbohydrates (3) alternate years
Consideration of the structure, function and metabolism of complex carbohydrates (glycolipids, glycoproteins and proteoglycans) with particular emphasis on glycoproteins. The first part of the course will consist of lectures to familiarize the student with basic terms, concepts and processes. The second part will involve critical readings, presentation and discussion of the current primary research literature by class participants. Alhadeff

CHM 475. Advanced Topics in Chemistry (1)
Audiovisual courses in topics such as acid-base theory, NMR, chromatography, electroanalytical chemistry and mass-spectroscopy interpretation; course material obtained from the American Chemical Society. May be repeated for credit.

CHM 477. (BIOS 477) Topics in Biochemistry (1-3)
Selected areas of biochemistry, such as mechanisms of enzyme action, new developments in the chemistry of lipids, nucleic acids, carbohydrates and proteins. May be repeated for credit when different topics are offered. Prerequisite: consent of the department chair.

CHM 479. (BIOS 479) Biochemical Techniques (3)
Laboratory studies of the techniques and principles involved in the isolation, identification, and biochemical transformation of carbohydrates, lipids, nucleic acids and proteins. Prerequisite: CHM 371 or its equivalent previously or concurrently.

CHM 480. (BIOS 480) Advanced Biochemical Preparations (1-3)
An advanced laboratory course in the preparation, isolation, purification, and identification of biochemically produced materials. Emphasis is placed on materials and procedures of current interest in biochemistry. Prerequisite: consent of the department chair.

CHM 481. Chemistry Seminar (1)
Student presentations on current research topics in the student's discipline but not on subjects close to the thesis. A one-hour presentation and attendance at other presentations are required for credit. May be repeated for credit, up to six times.

CHM 482. (CHE 482, MAT 482) Engineering Behavior of Polymers (3) spring
Mechanical behavior of polymers. Characterization of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analogs. Topics

include time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizer, moisture, and aging on mechanical behavior.

CHM 483. (CHE 483) Emulsion Polymers (3) fall
Fundamental concepts important in manufacture, characterization, and application of polymer latexes. Topics include colloidal stability, polymerization mechanisms and kinetics, reactor design, characterization of particle surfaces, latex rheology, morphology considerations, polymerization with functional groups, film formation and various application problems. Prerequisite: previous course in polymers.

CHM 484. (CHE 484) Crystalline Polymers (3) spring
Morphology and behavior of both polymer single crystals and bulk crystallized system. Relationship between basic crystal physics, thermal and annealing history, orientation and resulting properties. Thermodynamics and kinetics of transition phenomena and a brief treatment of hydrodynamic properties and their relationship to crystallization and processing properties.

CHM 485. (CHE 485, MAT 485) Polymer Blends and Composites (3) fall
Synthesis, morphology and mechanical behavior of polymer blends and composites. Mechanical blends block and graft copolymers, interpenetrating polymer networks, polymer impregnated solids and fiber and particulate-reinforce polymers are emphasized. Prerequisite: any introductory course in polymers.

CHM 487. Topics in Colloid and Surface Chemistry (3)
Applications of colloid chemistry; special topics in surface chemistry. Lectures and seminar. May be repeated for credit as different topics are covered. Prerequisite: CHM 391.

CHM 488. Advanced Topics in Physical Chemistry (1-3)
Advanced topics in physical chemistry, such as photochemistry and molecular beam dynamics, Fourier transform spectroscopy, kinetics of rapid reactions, theory of magnetic resonance, liquids and solutions. May be repeated for credit when different topics are offered.

CHM 489. Organic Polymer Science II (3) alternate years
Continuation of CHM 394. Theory and mechanism of ionic vinyl-addition chain-growth polymerization. Chain copolymerization by radical and ionic mechanism. Mechanism of ring-opening polymerization, stereochemistry of polymerization including ionic, coordination, and Ziegler-Natta mechanisms. Reactions of polymers, including crosslinking, reaction of functional groups, graft and block copolymers, and polymer carriers and supports. Prerequisite: CHM 394 or equivalent.

CHM 491. Physical Chemistry of Organic Polymer Coatings (3) alternate years
Pigment/bonder geometry. Oil absorption of pigments. Critical Pigment Volume Concentration concept. Pigment dispersion including surface tension, capillarity, works of dispersion, transfer and flocculation, and dispersing-mixing equipment. Solubility parameter concept. Coating viscosity and viscometers. Evaporation of solvents including water. Coating rheology, mill base letdown, and pigment settling. Film application including leveling, sagging, slumping and draining. Prerequisite: CHM 393 or 394 or equivalent.

CHM 492. (CHE 492) Topics in Polymer Science (3)
Intensive study of topics selected from areas of current research interest such as morphology and mechanical behavior, thermodynamics and kinetics of crystallization, new analytical techniques, molecular weight distribution, non-Newtonian flow behavior, second-order transition phenomena, novel polymer structures. Credit above three hours is granted only when different material is covered. Prerequisite: CHM 392 or equivalent

CHM 493. Organic Chemistry of Organic Polymer Coatings (3) alternate years
Film information from solution and dispersion, and application of coatings. Mechanism and kinetics of curing glyceride oils, varnishes and alkyd resins, unsaturated polyesters, thermoplastics cellulose, acrylic and vinyl resins, epoxy resins, polyurethanes, amine- and phenol-formaldehyde resins, thermosetting vinyl and acrylic copolymers, water-based systems, natural and synthetic rubber, and silicone resins. New solutions coatings. Prerequisite: CHM 393 and 394 or equivalent.

CHM 494. Quantum Chemistry (3) alternate years
Principles and applications of quantum mechanics to chemical problems. Applications to chemical bonding, molecular structure, reactivity and spectroscopy. Prerequisite: CHM 445 or consent of the department chair.

CHM 495. Statistical Thermodynamics (3) alternate years
Principles and applications of statistical mechanics to chemical problems. A study of the techniques for evaluating the properties of matter in bulk from the properties of molecules and their interactions. Prerequisite: CHM 445 or consent of the department chair.

Civil and Environmental Engineering

Professors. Arup K. SenGupta, Ph.D. (Houston), *chair and Peter C. Rossin Professor*; Gerard P. Lennon, Ph.D. (Cornell), *associate chair*; John L. Wilson, Ph.D. (Pittsburgh), *graduate officer*; Richard Sause, Ph.D. (U.C. Berkeley), *director, Center for Advanced Technology for Large Structural Systems and Joseph T. Stuart Professor;* M. Sorensen, Ph.D. (U.C. Berkeley); Richard N. Weisman, Ph.D. (Cornell).

Associate professors. Horace Moo-Young, Ph.D. (RPI); Peter Mueller, Dr. sc. techn. (ETH, Zurich); Sibel Pamukcu, Ph.D. (L.S.U.); Stephen P. Pessiki, Ph.D. (Cornell), Weixian Zhang, Ph.D. (Johns Hopkins).

Assistant professors. Derick Brown, Ph.D. (Princeton); Kristen L. Jellison, Ph.D (M.I.T.); Clay Naito Ph.D. (U.C. Berkeley); Yunfeng Zhang Ph.D. (Cal. Tech.).

Active emeriti. John W. Fisher, Ph.D. (Lehigh); Le Wu Lu, Ph.D. (Lehigh); Alexis Ostapenko, Sc.D. (M.I.T.); David A. VanHorn, Ph.D. (Iowa State); Ben-Tseng Yen, Ph.D. (Lehigh).

Civil engineering occupies a prominent position as one of the major fields in the engineering profession. Civil engineers are concerned with all aspects of the conception, planning, design, construction, operation, and maintenance of major physical works and facilities that are essential to modern life. Civil engineering projects are typically characterized by extreme size, complexity, durability, and cost. Examples include bridges, buildings, transportation facilities, tunnels, coastal facilities, dams, foundations, and waterways.

Environmental Engineering is a relatively young interdisciplinary branch of the engineering profession that has emerged from the societal needs to educate engineers in the causes, control, and prevention of environmental pollution while maintaining industrial and economic growth. Traditionally, environmental engineers were involved in designing and constructing drinking water treatment plants, sewage treatment facilities and water distribution networks. More recently, the environmental engineering profession has greatly expanded and the activities include: detection and modeling fate and transport of contaminants in both natural and engineered environments; applying technology-based solutions for restoring environmental quality; developing and/or modifying industrial processes for ecological preservation and enhanced sustainability. Previously, environmental engineering was included as part of the civil engineering program. Starting in Fall, 2002, it can also be pursued as a separate B.S. degree that will be considered for accreditation at the next college review in 2006-2007.

Our **Departmental Mission** is to educate students in the principles and methods essential to the practice and advancement of civil and environmental engineering. Our students are prepared to apply and continually cultivate knowledge that will enable them to become successful practitioners, innovators and leaders in serving the needs of a complex society. The accredited **Civil Engineering** Bachelor of Science degree program objectives are: (1) Provide our students with an education in the fundamental principles and scientific methods essential to contemporary civil engineering. (2) Provide our students the opportunity to study broad topics of civil engineering. (3) Develop our students to be proficient in four areas of civil engineering: environmental, hydraulic, geotechnical, and structural engineering. (4) Provide our students the opportunity to study advanced topics in one or more areas of civil engineering. (5) Provide broad career opportunities for our students by integrating planning, economics, finance, probability and statistics, management and organizational structure, and presentation of real-life engineering experiences in the curriculum. (6) Provide opportunities for our students to develop and exhibit team building, leadership, and continued education/learning skills. (7) Provide opportunities for our students to develop and use communication skills. (8) Develop opportunities, both inside and outside of the classroom, for understanding professional practice issues which include ethical responsibilities, political, international, historical, cultural, societal, and diversity issues. The **Environmental Engineering** Bachelor of Science degree program objectives are: (1) Provide our students with an education in the fundamental principles and scientific methods essential to contemporary environmental engineering. (2) Provide our students the opportunity to study broad topics of environmental engineering. (3) Develop our students to be knowledgeable of introductory level fundamentals in eight environmental engineering focus areas: water supply and resources, environmental chemistry, hazardous waste management, environmental system modeling, wastewater management, solid waste management, atmospheric system and air pollution control, and environmental and occupational health. (4) Develop our students to be proficient in advanced principles in three environmental engineering focus areas: water supply and resources, environmental chemistry, hazardous waster management. (5) Provide broad career opportunities for our students by integrating planning, economics, finance, probability and statistics, management and organizational structure and presentation of real-life engineering experiences in the curriculum. (6) Provide opportunities for our students to develop and exhibit team building, leadership, and continued education/learning skills. (7) Provide opportunities in most required courses for our students to develop and use communication skills. (8) Develop opportunities, both inside and outside of the classroom, for understanding professional practice issues which include ethical responsibilities, political, international, historical, cultural, societal, and diversity issues.

A technical minor in Environmental Engineering, available for students outside the department, consists of a prerequisite (CHEM 31), three courses chosen from CEE 170, CEE 274, CEE 373 (CHE 373), and CEE 276 (CHE 276), and one additional course from the required list or from CEE 222, CEE 323 (EES 323), CEE 327 (EES 327), CEE 345, CEE 274, CEE 276, CHE 321, CHE 331, CHE 370, EES 353, and EES 376. At least two of the courses must be from the CEE department.

Both undergraduate programs include a strong base of mathematics, including calculus and probability and statistics, and the physical sciences, followed by a course in planning and engineering economics and a broad range of required and elective courses in engineering science, analysis and design in the areas listed above in each set of program objectives. In addition, the civil engineering program has an engineering science and a surveying requirement and the environmental engineering program has a course in risks, regulations, and policy. Both programs are enriched with a series of required and elective courses in the humanities and social sciences. Elective courses in both programs extend across the areas of structural, geotechnical, hydraulic, environmental, construction and project management, and transportation engineering. Additional elective courses in the environmental program are available from chemical engineering, chemistry, and earth and environmental science. In each curriculum, emphasis is placed on the development of a solid knowledge of civil or environmental engineering fundamentals. Concomitantly, the program is threaded with instruction and opportunities in computer applications.

The civil and environmental engineering programs prepare individuals for entry into the engineering profession or for entry into high-quality programs of graduate study. With proper selection of electives, students may also prepare for entrance into schools of law or medicine, or into master's-level programs in engineering management or business administration. The civil engineering program is fully accredited, and application for accreditation of the new environmental engineering will be sought at the first opportunity, e.g. after graduation of the first class of students.

Five-year programs are available for students interested in a second bachelor's degree in a major in the College of Arts and Sciences (see listings under Arts-Engineering; Civil Engineering and Earth and Environmental Sciences).

Recommended Sequence of Courses, B.S. in Civil Engineering

The normal freshman engineering year is 30 credits (see Section III). The required HSS Advanced Requirement of 13 credits shown below to be three 3-credit courses and one 4-credit course. Other options are possible.

sophomore year, first semester (17 credit hours)

MATH 23	Analytic Geometry and Calculus III (4)
MECH 2	Elementary Engineering Mechanics (3)
CEE 10	Engineering/Architectural Graphics and Design (3)
CEE 11	Surveying (1)
CEE 12	Civil Engineering Statistics (2)
ECO 1	Principles of Economics (4)

sophomore year, second semester (18 credit hours)

MATH 205	Linear Methods (3)
MECH 12	Strength of Materials (3)
CEE 170	Introduction to Environmental Engineering (4)
PHYS 21	Introductory Physics II (4)
PHYS 22	Introductory Physics Lab II (1)
HSS	Humanities/Social Sciences Elec. (3)

junior year, first semester (17 credit hours)

MAT 33	Engineering Materials and Processes (3)
CEE 121	Mechanics of Fluids (3)
CEE 123	Civil Engineering Materials (1)
CEE 142	Fundamentals of Soil Mechanics (3)
CEE 159	Structural Analysis I (4)
	*Engineering Science Elective (3)

junior year, second semester (18 credit hours)

CEE 117	Numerical Methods in Civil Engineering (2)
CEE 262	Fund. of Structural Steel Design (3) or
CEE 264	Fund. of Structural Concrete Design (3)
CEE 222	Hydraulic Engineering (3)
CEE 242	Principles and Practices of Geotechnical Engineering (3)
HSS	Humanities/Social Sciences Elec. (4)
CEE	**Approved Elective (3)

senior year, first semester (17 credit hours)

CEE 202	CEE Planning and Engineering Economics (3)
CEE 203	Professional Development (2)
HSS	Humanities/Social Sciences Elec. (3)
CEE	**Approved Electives (6)
	Free Elective (3)

senior year, second semester (17 credit hours)

CEE 290	Capstone Design (3)
HSS	Humanities/Social Science Elective (3)
CEE	**Approved Electives (8)
	Free Elective (3)

**MECH 102, ME 104, or ECE 81.*

***Seventeen CEE elective credits approved by the CEE department chairperson; list on department web site.*

Elective opportunities total 42 credit hours. The selection of elective courses is to be in consultation with student's academic adviser in the Department of Civil and Environmental Engineering. A total of 134 credit hours is required for the bachelor's degree in civil engineering.

Recommended Sequence of Courses, B.S. in Environmental Engineering

The normal freshman engineering year is 30 credits (see Section III). Using the 4 credits of POLS 111 leaves 9 credits to complete required HSS Advanced Requirement of 13 credits, shown below to be three 3-credit courses.

sophomore year, first semester (17 credit hours)

MATH 23	Calculus III (4)
CHEM 51	Organic Chemistry I (3)
CHEM 53	Organic Chem Lab (1)
MECH 2	Elementary Engineering Mechanics (3)
CEE 12	Civil ENGR. Statistics (2)
ECO 1	Principles of Economics (4)

sophomore year, second semester (18 credit hours)

MATH 205	Linear Methods (3)
PHY 21	Intro Physics II (4)
PHY 22	Intro Physics II Laboratory (1)
CEE 170	Intro. Environmental ENGR (4)
CEE 272	Environmental Risk Assessment (2)
POLS 111	Politics of Environment (4)

junior year, first semester (16 credit hours)

CEE 121	Mechanics of Fluids (3)
CEE 142	Fund. Soil Mechanics (3)
CEE 276	Env. ENGR. Processes (3)
CHE 31	Matl. & Energy Bal. of CHE Process (3)
EES 21	Intro. to Planet Earth (4)

junior year, second semester (18 credit hours)

CEE 222	Hydraulic Engineering (3)
CEE 274	Environmental Water Chemistry (3)
CHE 60	Unit Ops Survey (3)
CEE 275	Enviro-Geo-Hydraulics Lab (2)
HSS	Humanities/Soc. Sciences Elective (3)
EES 31	Intro. Env/Organismal Biology (4)

senior year, first semester (17 credit hours)

CEE 202	CEE Planning and Engr. Economics (3)
CEE 203	Professional Development (2)
CEE 378	Solid & Haz. Waste Management (3)
CEE 379	Environmental Case Studies (3)
TE*	Technical Elective (3)
FE	Free Elective (3)

senior year, second semester (18 credit hours)

CEE 377**	Environmental Engr. Project (3)
TE*	Technical Electives (6)
HSS	Humanities/Social Sci. Elective (6)
FE	Free Electives

**9 technical (approved) elective credits approved by the academic advisor to satisfy proficiency in three focus areas of water supply and resources, environmental chemistry, and hazardous waste management; approved list available from CEE department.*

***A total of 134 credits is required for the bachelor's degree in Environmental Engineering.*

Undergraduate Courses

CEE 10. (ARCH 10). Engineering/Architectural Graphics and Design (3) fall
Graphical communication of civil engineering and architectural projects using manual techniques and commercial state-of-the-art computer software. Topics include visualization and sketching; orthographic, isometric and other drawings; points, lines and planes in descriptive geometry; site design; overview of geographical information systems and 3-D applications. Teamwork on design projects with oral and graphical presentations. Not available to students who have taken ME 10.

CEE 11. Surveying (1) fall
Theory and practice of basic engineering surveying measurements and analysis. Topics to include field note taking, datums and measurement precision, equipment and techniques for measuring distance, elevation and angles, electronic distance measurement, topographic surveys, GPS and hydrographic surveys. Hands on experience with the use of survey levels, transits/theodolites and a total station will be provided. (ED 1)

CEE 12. Civil Engineering Statistics (2) fall
Basic engineering statistics with a civil engineering orientation. Topics to include: random variables and histograms; central tendency, dispersion and skew; probability density functions and cumulative distribution functions, basic probability concepts and selected probability models, return period analysis, linear regression and least squares, correlation analysis, propagation of errors. (ES 1, ED 1)

CEE 104. Readings in Civil Engineering (1-4)
Study of selected technical papers, with abstracts and reports. May be repeated for credit. Prerequisite: consent of the department chair.

CEE 117. Numerical Methods in Civil Engineering (2) spring
Techniques for computer solution of linear and non-linear simultaneous equations; eigenvalue analysis; finite differences; numerical integration; numerical solutions to ordinary differential equations. Case studies in the various branches of civil engineering. Prerequisites: Engineering 1, MATH 205. (ES 2, ED 0)

CEE 121. Mechanics of Fluids (3) fall
Fluid properties and statics; concepts and basic equations for fluid dynamics. Forces caused by flowing fluids and energy required to transport fluids. Dynamics similitude and modeling of fluid flows. Includes laboratory experiments to demonstrate basic concepts. Prerequisite: MECH 2. (ES 3, ED 0)

CEE 123. Civil Engineering Materials (1) spring
Properties of commonly used civil engineering materials focusing on concrete. Concrete coverage includes cement chemistry and manufacture; cement hydration and microstructure; mixture design; mechanical properties; admixtures; in-service performance and deterioration mechanisms. Includes some laboratory work. (ES 1)

CEE 142. Fundamentals of Soil Mechanics (3) Fall
Fundamental principles of physical index properties of soils, water flow through soils, stress and deformation phenomena in soils and strength parameters of soils. Weight-volume relationships, consistency, gradation, and classification. Soil mineralogy, composition, and fabric; clay-water electrolyte system. Geological processes, and engineering properties of rocks. Soil compaction, consolidation, shear strength, stress-strain, Mohr-Coulomb failure analysis. Laboratory experiments to measure physical and mechanical properties of soils. Prerequisite: MECH 2. (ES 2, ED 1)

CEE 159. Structural Analysis I (4) fall
Elastic analysis of statically determinate beams, frames, and trusses; deflections by the methods of virtual work and moment area; influence lines for determinate structures; modeling for structural analysis; flexibility, stiffness, and approximate methods of analysis of indeterminate structures. Prerequisite: MECH 12. (ES 4, ED 0)

CEE 170. Introduction to Environmental Engineering (4) spring
Characterization and evaluation of natural water resources. Principles of basic water chemistry. Water and wastewater treatment processes. Sludge treatment, air pollution and multi-media transport. Pollutants mass balance and oxygen transfer. Field trips to water and wastewater process facilities. Laboratory experiments on water and wastewater characterization. Prerequisites: CHEM 21. (ES 3, Other 1).

CEE 171. Fundamentals of Environmental Technology (4)
Pollution control technologies and how they work for water, air, and solid wastes. Assessment and management of risk as applied to remediation of contaminated wastes. Role of life cycle analysis of products in risk reduction. Technologies leading to sustainable environment. Government policies and regulations, including litigation and Best Available Technology. Prerequisite: one advanced science course or permission of instructor. Not available to students in RCEAS.

CEE 202. CEE Planning and Engineering Economics (3) fall
The planning and management of civil engineering projects. Modeling and optimization methods, project management techniques. Financial decision-making among alternatives. Present value and discounted cash flow analysis; incremental analysis and rate-of-return criteria. (ES 1, ED 2)

CEE 203. Professional Development (2) fall
Elements of professionalism; professional ethics; engineering registration; continuing education; responsibilities of an engineer in industry, government, private practice; role of professional and technical societies. (ES 0, ED0, Other 2)

CEE 205. Design Problems (1-6)
Supervised individual design problems, with report. Prerequisite: consent of the department chair. (ED 1-6)

CEE 207. Transportation Engineering (3) spring
Principles of the design of transportation facilities with emphasis on highways and airports in the areas of geometric, drainage, and pavement design. Design problems. Prerequisites: CEE 11 or CEE 14. (ES 0, ED 3)

CEE 211. Research Problems (1-6)
Supervised individual research problems, with report. Prerequisite: consent of the department chair.

CEE 222. Hydraulic Engineering (3) spring
Pipe and pump hydraulics, engineering hydrology, ground water hydraulics, and open channel hydraulics. Laboratory experiments in applied hydraulics.

Prerequisite CEE 121, ME 231, or equivalent. (ES 1, ED 2)

CEE 242. Principles and Practices of Geotechnical Engineering (3) spring
The principles related to evaluation of the interactions between the soil environment and man-made facilities. Site exploration and in-situ soil characterization. Construction use of soils, soil-like materials, and geosynthetics in civil engineering facilities. Ground improvement techniques. One and two-dimensional flow, flow nets, uplift pressures on structures, and liquefaction. Failure theories, stress paths, settlement. Stability of earth slopes, dams and levees. Lateral earth pressures and retaining walls. Bearing capacity of soils for shallow foundations. Prerequisite: CEE 142. (ES 2, ED 1)

CEE 244. Foundation Engineering (3) fall
Application of theories and principles of soil mechanics to foundation design of constructed facilities. In-situ soil test and measurement, subsurface exploration and soil sampling. Bearing capacity, settlement, lateral earth pressure principles. Design of shallow foundations: spread footings, beams on elastic foundations, mat foundations. Design of retaining walls: mechanically stabilized earth, concrete and sheet pile walls, walls for excavations. Design of deep foundations: single piles, pile foundations, drilled piers and caissons. Prerequisite: CEE 242 (ES 1.5, ED 1.5)

CEE 258. Structural Laboratory (3)
Experimental study of behavior of members and structures. Planning, executing, and reporting experimental studies. Introduction to instrumentation and data acquisition. Nondestructive testing of civil engineering structures. Steel, rein-forced concrete, and other materials. Prerequisite: CEE 262 and CEE 264. (ES 2, ED 1)

CEE 259. Structural Analysis II (3) fall
Analysis of statically indeterminate structures, methods of slope deflection and moment distribution; consideration of side-sway and nonprismatic members. Influence lines for determinate and indeterminate structures. Flexibility and stiffness matrix methods for computerized analysis. Use of computer library programs. Prerequisite: CEE 159. (ES 3, ED 0)

CEE 262 Fundamentals of Structural Steel Design (3) spring
Introduction to steel structures. Behavior, strength and design of structural members, including members subjected to axial tension, axial compression, flexure and combined compression and flexure. Basic methods of joining members to form a structural system. Use of design specifications. Prerequisite: CEE 159. (ES 1, ED 2).

CEE 264. Fundamentals of Structural Concrete Design (3) spring
Analysis, design, and detailing of reinforced concrete members and simple systems for strength and serviceability requirements, including beams, columns, and slabs. Introduction to prestressed concrete. Prerequisite: CEE 159. (ES 1, ED 2)

CEE 266. Construction Management (3) spring
An overview of mangement and construction techniques used in engineering ventures and projects. Scheduling, estimation, construction methods, financial controls, contracts, labor relations and organizational forms. Case studies and lecturers from industry. Prerequisites CEE 159 and CEE 202, or instructor's approval.

CEE 272. Environmental Risk Assessment (2) spring
Effects of chemical releases on human health; ecological risks. Application of risk assessment methodology, including hazard identification, exposure assessment, toxicity assessment, and risk characterization. Accounting for uncertainty in data during risk management, risk reduction and implementation of regulations and environmental policy.

CEE 274. Environmental Water Chemistry (3) spring
Chemical principles and applications of those principles to the analysis and understanding of aqueous environmental chemistry in natural waters and wastewaters. The chemistry of ionic equilibria, redox reactions, precipitation/dissolution, acid-base concepts, buffer capacity, complexation, hydrolysis and biological reactions. Prerequisite: CHEM 31 or CEE 170. (ES 2, Other 1)

CEE 275. Environmental, Geotechnics and Hydraulics Laboratory (2) Spring
Applying fundamentals of soil properties, hydraulics and environmental science through appropriate laboratory experiments for solution of environmental engineering problems. Experiments will include solute transport in surface and subsurface medium; characterization of soils, sludges and water; treatment of water and wastewater including biological processes. Illustration of techniques to generate design parameters for scale-up. Prerequisite: CEE 170, previously or concurrently. (ES 1, ED 1)

CEE 276. (CHE 276). Environmental Engineering Processes (3) fall
Processes applied in environmental engineering for air pollution control, treatment of drinking water, municipal wastewater, industrial wastes, hazardous/toxic wastes, and environmental remediation. Kinetics, reactor theory, mass balances, application of fundamental physical, chemical and biological principles to analysis and design. Prerequisite: CEE 170 or equivalent. (ES 2, ED 1).

CEE 279. (BIOS 259, EES 259) Microbial Ecology (4)
The role of microorganisms in the environment. Topics include: Survey of microbial classification, structure, and metabolism; study of microbes at population, community, and ecosystem levels of organization; the role of microbes in biogeochemical cycles; application of microbes to bioremediation and resource recovery problems. Prerequisite: EES 31 and EES 152, or consent of instructor.

CEE 281. Special Topics (1-6)
A study of selected topics in civil and environmental engineering not included in other formal courses. A design project or an interdisciplinary study of a problem related to civil or environmental engineering may be included. Civil and environmental engineering students working on design projects involving students from other departments or colleges working in cross-disciplinary teams may be included. A report is required. Prerequisite: consent of the department chair.

CEE 290. CEE Design Project (3) spring
Supervised design projects applying the fundamentals of engineering science and the concepts of planning and systems analysis in the design of practical engineering works. The scope includes needs analysis, formulation of the design problem statement and evaluative criteria; analysis of alternative solutions and the generation of

specifications. Economic, social, environmental, aesthetic and safety constraints are considered. Practicing professional engineers are invited to serve as consultants. Written and oral reports are required. Prerequisite: Senior standing. (ES 0, ED 3)

CEE 316 (EES 316). Hydrogeology (4)
Interrelationships of geologic materials and processes with water; entry, storage, interaction, and flow of water through permeable earth materials; evaluation, development, and management of ground-water resources. Lectures and recitation/laboratory. Prerequisites: EES 21 or EES 101. (ES 4)

CEE 320 (EES 320). Engineering Hydrology (3) fall
Rainfall-runoff analysis, overland flow, hydrograph theories, modeling. Frequency analysis of extreme events. Flood routing. Design storms. Floodplain hydraulics, floodplain delineation. Prerequisite: CEE 222. (ES 2, ED 1)

CEE 321. Open Channel Hydraulics (3) fall
Energy and momentum concepts, frictional resistance in open channels. Rapidly and gradually varied flow in open channels; unsteady flow in open channels; channel and culvert design. Prerequisite: CEE 222. (ES 2, ED 1)

CEE 323 (EES 323). Environmental Groundwater Hydrology (3) spring
The study of subsurface water, its environment, distribution, and movement. Included are flow patterns, well hydraulics, and an introduction to the movement of contaminants. Design problems are included to simulate flow with analytical and numerical models, and contaminant migration using analytical models. Prerequisites: CEE 121, CEE/EES 316 or permission of instructor. (ES 2, ED 1)

CEE 327 (EES 327). Surface Water Quality Modeling (3) spring
Fundamentals of modeling water quality parameters in receiving water bodies, including rivers, lakes, and estuaries. Modeling of dissolved oxygen, nutrients, temperature, and toxic substances. Emphasis on water quality control decisions as well as mechanics and model building. Prerequisites: CEE 121, CEE 222 and CEE 170 or permission of instructor. (ES 3, ED 0)

CEE 335. Coastal Engineering (3) fall
Linear wave theory and wave characteristics; survey of nonlinear theories; tides, tsunamis, storm surge and basin resonance; wind-generated wave spectra, statistics and forecasting; wave-structure interaction; nearshore circulation and sediment transport; interaction of littoral processes with structures. Prerequisite: CEE 121. (ES 2, ED 1)

CEE 341. Ground Improvement Engineering (3)
The mechanisms of soil stabilization; principles and techniques; grouting and injection methods; reinforced earth methods, dynamic consolidation; deep compaction; sand drains; laboratory and field studies; geotextiles and geomembranes. Prerequisite: CEE 242 or equivalent. (ES 1.5, ED 1.5)

CEE 342. Experimental Geotechnical Engineering (3)
Experimental studies dealing with the measurement of soil properties in the laboratory and *in situ;* application of these properties to design; consolidation; strength of soils in triaxial compression, tensile strength, and other shear tests, including measurement of pore water pressures; model design and analysis; dynamic tests; field measurement of *in situ* soil properties; laboratory and field instrumentation. Prerequisites: CEE 242 and senior standing. (ES 1.5, ED 1.5)

CEE 344. Behavior of Soils as Engineering Materials (3)
Soil mineralogy, bondage, crystal structure and surface characteristics; clay-water electrolyte system; soil fabric and its measurement; soil structure and physical property relationships; soil depositional and compositional characteristics; engineering properties of soils as they relate to soil mineralogy, fabric and composition: volume change behavior, intergranular stresses, shear strength and deformation behavior, conduction behavior, coupled and direct flow phenomena. Prerequisite: CEE 242. (ES 3, ED 0)

CEE 345. Geo-Environmental Engineering (3)
Principles of interaction of soil and rock with various environmental cycles. Physical and chemical properties of soil. Environmental site characterization: drilling technology, geotechnical and geophysical methods, monitoring well design and construction, groundwater, soil and gas sampling procedures, sensor technologies. Contaminant transport, detection and containment. Principles of containment facilities: landfills, leachate collection, cut-off walls, permeable barriers, stability analysis. Soil and groundwater restoration stabilization, bioremediation, washing, electrotechnologies, soil vapor technologies. Prerequisite: CEE 242. (ES 2.5, ED 0.5)

CEE 346. Fundamentals of Designing with Geosynthetics (3) spring
Fundamental and current theories of designing soil structures with geosynthetics. Roads and highway applications; reinforced embankments; slope stabilization; waste containment systems; erosion control; filtration and drainage. Prerequisite: CEE 242. (ES 1.5, ED 1.5)

CEE 352. Structural Dynamics (3) fall
Analysis of linear structural systems to time-dependent loads. Free and forced vibration. Classical and numerical methods of solution. Lumped-mass techniques, energy methods, and introduction to matrix formulation of dynamic problems. Application to design. Prerequisites: MATH 205, CEE 159, and MECH 102. (ES 3, ED 0)

CEE 361. Bridge Systems Design (3)
Introduction to bridge structural systems in steel and concrete. Loads and specifications. Design and analysis of bridge structural components. Prerequisites or co-requisites: CEE 259, CEE 262, CEE 264. (ES 1, ED 2)

CEE 363. Building Systems Design (3) spring
Building structural systems in steel, reinforced concrete and composite steel and concrete. Design loads (dead, live and environmental) and methodologies. Structural systems behavior and design. Design of floor systems, beam-columns, connections, walls, and overall frames. Final design. Prerequisites or co-requisites: CEE 259, CEE 262, and CEE 264. (ES 1, ED 2)

CEE 365. Prestressed Concrete (3) fall
Principles of prestressing. Analysis and design of basic flexural members. Instantaneous and time-dependent properties of materials. Prestress losses. Additional topics may include continuity, partial prestressing, compression

members, circular prestressing, etc. Prerequisite: CEE 264 or consent of the department chair. (ES 2, ED 1)

CEE 366. Finite Element Method in Structural Engineering (3) spring
The finite element method: fundamental concepts, theory, modeling, and computation for the analysis of structures. One, two, and three-dimensional finite elements. Isoparametric formulation and implementation for various kinds of elements. Applications to problems in the behavior of structural elements and systems including analysis of trusses, beams, plates, and frames and bridge systems. Extensions to nonlinear analysis and advanced topics. Use of contemporary commercial software. Prerequisites: CEE 259. (ES 3, ED 0)

CEE 371. Reaction Kinetics in Environmental Engineering (3)
Theory of reaction kinetics and its application to the design and operation of chemical, physico-chemical and biological reactions in water, wastewater, and hazardous waste treatment. Basic design equations for various types of reactors and migration of pollutants in the environment. CEE 471 is a graduate version of this course. Prerequisite: CEE 276 (CHE 276). (ES 2, Other 1)

CEE 373. (CHE 373). Fundamentals of Air Pollution (3)
Introduction to the problems of air pollution including such topics as: sources and dispersion of pollutants, sampling and analysis; technology of economics and control processes; legislation and standards. Prerequisite senior standing in the College of Engineering and Applied Science. (ES 2, ED 1)

CEE 376. Environmental Biotechnology (3)
Fundamentals of microbiology and biochemistry applied to natural and engineered environmental systems. Systems ecology, energetics and kinetics of microbial growth, nutrition and toxicology, use of microorganisms for pollution monitoring and control. Pathogenicity and disease transmission, water quality using biological indices. Prerequisites: CEE 276 (CHE 276) and EES 31. (ES 2, ED 1)

CEE 377. Environmental Engineering Design (3) spring
Team-oriented course to develop design skills in the area of environmental engineering. Project components typically include: air pollution, drinking water, municipal wastewater, industrial wastes, hazardous/toxic wastes, and environmental remediation. Project work typically includes: a background report, a design report , and an oral presentation. Tools used in the design process may include simulation models. Prerequisite: CEE 170 and CEE 276 (CHE 276). (ES 0, ED 3)

CEE 378. Solid and Hazardous Waste Management (3)
Regulations for collection, transportation, disposal and storage of hazardous wastes. Containment systems, monitoring, new and available technologies to minimize, transform, destroy, detoxify and eliminate the hazardous components of the wastes. Environmentally benign processes and life cycle analysis. CEE 478 is a graduate version of this course. Prerequisite: CEE 276 (CHE 276). (ES 1, ED 2)

CEE 379. (EES 379). Environmental Case Studies. (3 to 4)
Supervised multidisciplinary team projects investigating site characterization and environmental remediation design and environmental policy and financial implications of environmental projects. OHSA approved Health and Safety training provided. Prerequisites: EES 21, EES 31 plus 5 EES courses or permission of the instructor (CEE prerequisites: CEE 274 and CEE 276 (CHE 276)). Staff

CEE 381. Special Topics (1-3)
A study of selected topics in civil engineering, not included in other formal courses. A report is required. Prerequisite: consent of the department chair.

CEE 385. Research Procedures Seminar (1) fall
Planning and execution of research projects, survey of current research, elements of proposals and budgets. Literature search procedures. Presentation of data, and of written and oral reports. Guidelines for visual aids.

Graduate Programs

Graduate studies in civil and environmental engineering enable the student to build upon the broad background of undergraduate education in preparation for professional practice at an advanced level, for research and development, or for teaching.

The selection of graduate courses and research opportunities offered in the department permits the development of individual program objectives that may be concentrated in one of the technical specialty areas, or, alternatively, may extend over the broad field of civil engineering. The department offers advanced work in the specialty areas of structural engineering, geotechnical engineering, hydraulic engineering, hydrology, coastal engineering, and environmental engineering, leading to the degrees of master of science, master of engineering, and doctor of philosophy in civil engineering or environmental engineering.

A graduate program leading to the M.S. normally is concentrated in one, or possibly two, of the technical specialty areas, and consists of a number of courses designed to fulfill the individual student's program objectives. Each candidate for the M.S. is required to submit a thesis representing three to six credit hours (CEE 491, listed below), or alternatively, a report based on a research course of at least three credits (CEE 429,439,449,469,479 or 481). The balance of the program will consist of courses in the specialty area(s).

A graduate program leading to the M.Eng. degree stresses engineering applications and design. The courses may extend across the various specialty areas in civil engineering. Each candidate for the M.Eng. may choose to complete an individual engineering project representing three to six credits (CEE 480) in place of the thesis or research report required for the M.S. or to take a minimum of 30 course credits without a research or design project.

The doctoral program, which leads to the Ph.D., normally includes courses in the major field, courses in minor fields, and a dissertation presenting results of original research. Holders of master's degrees planning to become candidates for the Ph.D. take a qualifying examination at the first opportunity following one semester in residence. After qualification, the candidate, the candidate's departmental Ph.D. committee, and the department chair formulate the program of work.

The laboratories of the department are located in the Fritz Engineering Laboratory. The laboratory offers outstanding facilities for research and instruction in structural engineering, geotechnical engineering, hydraulic engineering, hydrology, coastal engineering, environmental engineering, and related fields. In particular, the structural testing equipment includes dynamic testing machines, a five-million-pound universal hydraulic testing machine, and other special loading apparatus. Included in the latter are the facilities of the Center for Advanced Technology for Large Structural Systems (ATLSS center) located on the mountaintop section of the campus. These include the largest 3-dimensional test bed in the U.S.A. and specialized earthquake testing facilities. The hydraulic facilities include a wave tank, several flumes, a 10-cfs recirculating flow system, and two multipurpose tanks for model studies. Brochures describing the research facilities and programs are available on request.

In addition to departmental courses, a number of courses offered by the departments of mechanical engineering and mechanics, chemistry, chemical engineering, materials science and engineering, earth and environmental sciences, and biology may also be considered a part of the major field in civil and environmental engineering. A list of such courses is available through the department chair.

A number of research assistantships and teaching assistantships are available to provide financial aid to students of outstanding promise. The half-time research or teaching activities required of holders of assistantships provides a valuable educational experience that supplements the formal course offerings. The graduate course offerings of the department are programmed to fit the schedule of half-time assistants, and to accommodate part-time students. A very limited number of scholarships and fellowships are available to provide financial aid for full-time study.

Graduate Courses in Civil Engineering

CEE 405. Analytical and Numerical Methods I (3)
Analytical and numerical methods used in Civil Engineering, with emphasis on ordinary and partial differential equations. Analytical and numerical solutions of ordinary and partial differential equations. Initial and boundary value problems. Numerical integration, numerical error, and approximations of functions and data points. Finite differences, solution of systems of linear equations, eigenvalue problems, and solution of nonlinear equations. Prerequisite: MATH 205 or equivalent.

CEE 408. Computer Methods in Civil Engineering (3)
Numerical and computer-oriented methods especially applicable to the solution of complex problems arising in various fields of civil engineering. Solutions of well-and ill-conditioned linear and nonlinear systems. Eigenvalue formulation of stability and dynamic problems. Reduction techniques, integration schemes for large structural systems. Optimal design by linear programming. Introduction to problem-oriented languages and computerized design. Prerequisite: CEE 405

CEE 409. Finite Element Method in Structural Mechanics (3) spring
Basic principles and equations governing the finite element method. Analysis of planar, axisymmetric, plate and articulated structures, with emphasis on analytical modeling. Accuracy and convergence studies, utilizing different discretizations and various types of elements. Case studies include application and extension to material nonlinearities, bridges, containment vessels, and soil-structure interaction. Prerequisites: CEE 405 and CEE 413 or equivalent.

CEE 412. Methodologies of Structural Design (2)
Probabilistic analysis of uncertainties associated with structural design. Characterization of loads including dead and live loads, wind, earthquake, and vehicular loads. Variability of structural resistance based on strength limit states as well as serviceability. Assessment of safety and reliability. Deterministic and probabilistic methodologies of design. Prerequisite: CEE 215 or permission of instructor.

CEE 413. Mechanics and Behavior of Structural Members (3) fall
Behavior of structural members, under a variety of loading conditions in the elastic and inelastic range. Introduction to the theory of elasticity and plasticity. Basics of linear elastic fracture mechanics and fatigue. Analysis of structural member behavior in axial, bendings, shear, and torsion. Stability analysis of beam-columns. Beams on elastic foundations. Energy concepts and their use in structural analysis. Prerequisites: CEE 259 or equivalent.

CEE 414. Analysis and Design of Steel and Composite Structural Members (3)
Fundamentals of limit state design. Ultimate strength analysis of steel and steel-and-concrete composite columns, beams, beam-columns, and members subjected to torsion and combined torsion and bending. Flexural and torsional instability. Background and requirements of current design codes. Prerequisites: CEE 261 or equivalent.

CEE 415. Analysis and Design of Ductile Steel Structural Systems (3)
Inelastic behavior of steel and steel structural members. Plastic limit strength analysis of continuous beams and frames. Effect of variable repeated loading. Methodology and code requirements for design based on plastic strength. Applications to seismic-resistant building structures. Current research. Prerequisites: CEE 261 or equivalent.

CEE 420. Surface Wave Mechanics (3)
Elements of hydrodynamics and wave boundary conditions; linear wave theory and wave characteristics; nonlinear wave theories and application; wind wave generation, analysis and prediction; long waves; design wave determination; laboratory investigation of surface waves. Prerequisite: consent of instructor.

CEE 424. Surface Water Hydrology (3)
Advanced analysis and methods in surface water hydrology. Linear and non-linear hydrograph methods. Kinematic wave and other hydraulic routing techniques. Advanced techniques for evaporation, infiltration, and snow melt. Prerequisite: CEE 320 (EES 320) or equivalent.

CEE 425. Hydraulics of Sediment Transport (3)
Hydrodynamic forces on particles, settling velocity. Sediment transport in open channel: tractive force theory, bed load and suspension theory, total load and wash load. Bedform mechanics, cohesive channel hydraulics. Sediment transport in closed conduits. Shore processes

and coastline hydraulics. Prerequisite: CEE 321 or equivalent.

CEE 427. Transport of Contaminants in Groundwater (3)
Theory of groundwater flow and transport of contaminants in the groundwater system. State-of-the-art groundwater flow and contaminant transport models used to solve governing equations of groundwater flow and transport of chemically reactive solutes. Selected case studies will be analyzed. Prerequisite: CEE 323 (EES 323) or permission of instructor.

CEE 428. Advanced Topics in Hydraulics (1-3)
Recent developments in hydromechanics and hydraulics. Topics to be selected from: wave mechanics, theory of flow through porous media, dispersion, hydrodynamic forces on structures, potential flow, free streamline theory, open channel hydraulics, computer methods. Prerequisites: CEE 321 and consent of the department chair. May be repeated for credit.

CEE 429. Hydraulic Research (1-6)
Individual research problems with reports. May be repeated for credit.

CEE 436. Advanced Topics in Coastal Engineering (1-3)
Advanced study of selected topics in coastal engineering such as: non-linear wave theory, design of coastal structures, shore protection and stabilization, numerical solution of coastal hydrodynamics. Selection of topics will depend on particular qualifications of staff, as well as on the interests of the students. Prerequisite: CEE 335. May be repeated for credit.

CEE 439. Coastal Engineering Research (1-6)
Individual research problems with reports. May be repeated for credit.

CEE 441. Soil Dynamics (3) fall
Vibration of elementary systems, wave propagation, dynamic soil properties, vibration of soils, foundation vibrations, dynamic bearing capacity, dynamic earth pressure problem and retaining wall, liquefaction of soils, earthquake problems. Prerequisite: CEE 244 or consent of the department chair.

CEE 443. Advanced Soil Mechanics I (3) fall
The origin, composition, and physico-chemical properties of soils and their influence on the engineering properties and behavior of soils; transmission of water in saturated and unsaturated soils; advanced theory of compaction; compression and consolidation; theories of shear strength. Prerequisite: a course in soil mechanics.

CEE 444. Advanced Soil Mechanics II (3) spring
Fundamental and advanced theories of soil mechanics applicable to earth structures and foundation design; stresses in homogeneous and layered systems for ideal elastic, plastic and viscoelastic soils; lateral earth pressures, thermo-geotechnics. Prerequisite: CEE 443.

CEE 445. Advanced Foundation Engineering (3) fall
Current theory and practice relating to the design of foundations for buildings and other structures. Analysis and limitation of settlements; bearing capacity analyses of shallow and deep foundations; flexible and rigid retaining structure design; dynamic effects; anchor and other special foundations; site investigations; design criteria for foundations; load and environmental factors. Prerequisite: a course in soil mechanics.

CEE 447. Advanced Topics in Geotechnical Engineering (1-3)
Advanced studies in selected subjects related to geotechnical engineering. The general areas may include: stress-strain-time relationships of soils, colloidal phenomena in soils, ground water flow and see page, soil dynamics, soil plasticity, numerical methods applied to soil mechanics, earth dam design, theories of layered systems and their application to pavement design, rock mechanics. The studies specifically undertaken in any particular semester depend on the availability of staff and the interest of students. Prerequisite: consent of the department chair. May be repeated for credit.

CEE 448. Plasticity and Limit Equilibrium in Geotechnical Engineering (3) spring
Application of plasticity in soil mechanics, new concepts and theories and the requirements for modeling of actual test performance of soils, limit yield/failure criteria, constitutive relations of stress-strain-time, concepts of critical state soil mechanics, rheological performance, application to problems of stability of slopes, bearing capacity of foundations and active/passive earth pressures. Prerequisite: CEE 244, or consent of the department chair.

CEE 449. Geotechnical Research (1-6)
Individual research problems relating to soil engineering, with report. Prerequisite: a course in soil mechanics.

CEE 450. Advanced Structural Analysis I (3)
Theory and methods of linear and second order structural analysis. Linear theory and stiffness properties of structural members and linear transformations of structural analysis. Application of virtual work principles and development of displacement (stiffness) method of analysis in matrix form. Introduction to second order theory of structural members and second order equations of structural analysis. Prerequisite: CEE 259 or equivalent.

CEE 451. Advanced Structural Theory (3) fall
Specialized methods of analysis; moment distribution. General treatment of deformation methods using matrix algebra. Selected topics in structural theory: influence lines, multi-story building frames, space structures. Introduction to finite element method; nonlinear problems. Prerequisite: CEE 450.

CEE 452. Fatigue and Fracture of Structures - An Interdisciplinary View (3)
This course examines the fatigue and fracture characteristics of steel structures from metallurgical, mechanical and structural engineering views. Both theory and experimental background are provided and applied to case studies and code development.

CEE 454. Plate and Shell Structures (3)
Plates and slabs loaded transversely in their plane. Buckling and postbuckling behavior of elastic and inelastic plates. Membrane and bending analysis of cylindrical, rotational, and hyperbolic-paraboloidal shells. Emphasis on engineering methods. Design considerations. Prerequisites: CEE 405 and consent of the department chair.

CEE 455. Advanced Structural Dynamics (3)
Analysis and design of structures to resist wind, earthquake, and blast loading. Matrix methods and computer

applications. Non-linear and elasto-plastic response. Damping characteristics of structures and structural components, spectral analysis, dynamic instability. Characteristics of aerodynamic and seismic forces and explosions. Introduction to vibration of three-dimensional structural systems. Prerequisites: CEE 352 or MECH 406, CEE 405 and CEE 450 or equivalent.

CEE 456. Behavior and Design of Earthquake Resistant Structures (3)
Characteristics of earthquakes, effects of earthquakes on structures. Response of linear elastic structures to earthquakes. Response of inelastic structures to earthquakes. Behavior of structural components under cyclic loading. Principles of earthquake-resistant design. Seismic design procedures and their implementation in codes. Prerequisite: CEE 352 or equivalent.

CEE 457. Theory and Design of Steel Structures (3)
Analysis and design of steel structures; structural connections; composite steel-concrete systems and other components. Consideration of residual stress; brittle fracture; fatigue strength; fastener systems. Study of current research and application to design practice.

CEE 458. Repair and Retrofit of Steel Structures (3)
Various types of construction problems experienced during the fabrication, erection, and service of steel structures are examined. Problems include material related defects, repair of welds, mix matches, stability and erection related deformation. Case studies of failures and serious construction deficiencies are reviewed and evaluated.

CEE 459. Advanced Topics in Plastic Theory (3) fall
Fundamentals of the mathematical theory of plasticity; the general theorems of limit analysis and their applications to beams under combined loading, arches, space frames, plates and shells. Limit analysis of two- and three-dimensional problems in soil, concrete, rock, and metal. Current developments. Prerequisite: CEE 359.

CEE 460. Experimental Methods in Structural Engineering (3)
Study of methods and equipment used in a modern structural engineering research laboratory. Topics include small-scale modeling theory; operational and performance characteristics of transducers; detailed examination of specific transducers for measurement of strain, force, displacement, velocity, acceleration, and temperature; loading systems and controls; data acquisition and signal conditioning; introduction to nondestructive testing of structures.

CEE 461. Advanced Bridge Engineering (3)
Students in CEE 461 cover the same topics described under CEE 360, but in more depth. In addition each student conducts an intensive study of a bridge-related topic of his or her choice. A short written technical report on the findings of this study is required. Prerequisites: CEE 262 and CEE 264.

CEE 462. Stability of Structural Systems (3)
Stability analysis of structures systems, including moment-resisting and braced frames, trusses, and plate and box girders. Bracing requirements. Elastic and inelastic second-order analysis. Design considerations. Special topics. Prerequisites: CEE 413 or equivalent.

CEE 463. Advanced Mechanics of Reinforced Concrete (3)
Consistent mechanics for the design of reinforced concrete with or without prestress. Limit theorems of the theory of plasticity and their application to beams, slabs, and disturbed regions. Applications may include beams in flexure and combined flexure, axial load, and torsion; slabs (strip method, yield line analysis); corbels, deep beams, and other disturbed regions (truss models, strut-and-tie models, and associated failure mechanisms). Prerequisites: CEE 263 or equivalent.

CEE 464. (MECH 416) Analysis of Plates and Shells (3)
Bending of rectangular and circular plates, plates under lateral loads, plates with thermal and inelastic strains, effect of in-plane forces, large deflections, buckling of plates. Geometry and governing equations of shells, shells of revolution, membrane states, edge solutions, solution by numerical integration, nonsymmetrical problems, buckling of shells, applications to pressure vessels. Prerequisites: MATH 205; MECH 305 or equivalent course in advanced mechanics of materials.

CEE 466. Concrete Shell Structures (3)
Analysis and design of concrete shell structures. Folded plates, cylindrical shells, and shells of double curvature. Typical practical problems. Prerequisites: CEE 405 and consent of the department chair.

CEE 467. Advanced Topics in Structural Engineering (1-3)
Advanced study of selected topics in structural mechanics and engineering, such as: finite element methods, suspension system; space frames; stability of nonlinear systems; coldformed and lightweight construction; optimization and reliability; second-order phenomena in structures; interaction of structures with the environment; structural use of plastics; composite construction, etc. Selection of topics will depend on particular qualifications of the staff, as well as on the interests of the students. Prerequisite: consent of the department chair. May be repeated for credit.

CEE 468. (MECH 415) Stability of Elastic Structures (3)
Basic concepts of instability of a structure; bifurcation, energy increment, snap-through, dynamic instability. Analytical and numerical methods of finding buckling loads of columns. Postbuckling deformations of cantilever column. Dynamic buckling with nonconservative forces. Effects of initial imperfections. Inelastic buckling. Buckling by torsion and flexure. Variational methods. Buckling of frames. Instability problems of thin plates and shells. Prerequisite: MATH 205.

CEE 469. Structural Research (1-6)
Individual research with reports. May be repeated for credit.

CEE 470. Reaction Kinetics in Environmental Engineering (2)
Theory of reaction kinetics and its application to the design and operation of chemical, physico-chemical and biological reactors in water and wastewater treatment. Basic design equations for various types of reactors and migration of pollutants in the environment.

CEE 471. Water Treatment Facilities (3)
Theory and design of water treatment system components. Emphasis on coagulation, flocculation,

sedimentation, filtration, and disinfection. Estimation of design parameters from laboratory experiments. Prerequisite: CEE 276 (CHE 276) or equivalent.

CEE 472. Waste Water Treatment Facilities (3)
Theory and design of water pollution control systems. Emphasis on film flow and suspended growth biological reactors for organic and nutrient removal. Sludge production, stabilization, dewatering and ultimate disposal. Prerequisite: CEE 276 (CHE 276) or equivalent.

CEE 473. (CHE 473). Environmental Separation and Control
Theory and application of adsorption, ion exchange, reverse osmosis, air stripping and chemical oxidation in water and wastewater treatment. Modeling engineered treatment processes. Prerequisite: CEE 470 or consent of the instructor.

CEE 474. Aquatic Chemistry (3)
Applying basic principles of aqueous chemistry for quantifying complex, environmental systems. Specific examples of air-water-soil interactions and consequent effects. Heterogeneous equilibria with more than one solid phase. Kinetics and thermodynamics of some important ionic and biological reactions. Prerequisite: CEE 274.

CEE 475. Advanced Topics in Environmental Engineering (1-3)
Advanced concentrated study of a selected topic in environmental engineering such as non-point source pollution control, water reuse systems, new concepts in treatment technology, toxic substance control, etc. The instructor and student select topic. Courses may include specialized laboratory research, literature review, and specialty conference attendance. Prerequisite: Department chair approval.

CEE 476. Environmental Engineering Microbiology (3)
Fundamentals of microbiology and biochemistry applied to environmental systems and water quality control. Systems ecology, energetics and kinetics of microbial growth, nutrition and toxicology, use of microorganisms for pollution monitoring and control. Pathogenicity and disease transmission, water quality using biological indices. Prerequisite: CEE 276 (CHE 276) or a suitable course in biology.

CEE 477. Transport of Pollutants in Surface Waters (2)
Fundamental models of pollution migration in streams, estuaries and oceans. Diffusion, mass transport, dispersion, biological, physical, and chemical interactions. Effects on water quality especially oxygen nutrient and toxics levels. Prerequisites: CEE 470, 471, 472.

CEE 478. Toxic and Hazardous Wastes (3)
Regulations for collection, transportation, disposal and storage of hazardous wastes. Containment systems, monitoring, types of liners, new and available technologies to eliminate or recover the hazardous components of the wastes. Prerequisite: CEE 274 or CEE 276 (CHE 276).

CEE 479. Environmental Engineering Research (1-6)
Individual research problems in environmental engineering with report. May be repeated for credit.

CEE 480. Civil Engineering Project (1-6)
An intensive study of one or more areas of civil engineering, with emphasis on engineering design and applications. A written report is required. May be repeated for credit.

CEE 481. Special Problems (1-6)
An intensive study, with report, of a special field of civil engineering, which is not covered in the other courses. A design project or an interdisciplinary study of a problem related to civil engineering may also be included. May be repeated for credit.

CEE 483. Graduate Seminar (1-3)
Study of current topics in civil engineering.

CEE 491. Thesis (1-6)

CEE 499. Dissertation (1-15)

Civil and Environmental Engineering and Earth and Environmental Sciences

This program is designed for students interested in combining programs in two departments: civil & environmental engineering and earth & environmental science, leading to two bachelor of science degrees, one of the engineering B.S. degrees (civil engineering or environmental engineering) and one of the science B.S. degrees in earth and environmental sciences (environmental sciences, geological sciences or ecology). Both degrees would be awarded at the end of the fifth year. This program is one of the dual degree programs mentioned in the Five-Year Programs section. The student will have a primary advisor in the P.C. Rossin College of Engineering and Applied Sciences and a secondary advisor in the Arts and Sciences College. The program provides alternatives for students who may decide not to complete the two-degree program. Students who make this decision prior to the beginning of the fourth year may qualify at the end of that year for the bachelor of science in civil engineering, as well as a minor in earth and environmental sciences. Also, if a student decides after two years to pursue only a bachelor of science degree in the EES department, it is possible to complete the requirements in four years. If the decision to work toward this degree is made during the fourth year, at least one additional semester is required to qualify for either B.S. degree. Interested students should consult with the respective departmental advisors to create a schedule of courses to resolve conflicts or if a specified course is not offered that semester. Required courses and major electives for the different EES B.S. degree programs are listed in the catalog entry for EES; note that the exact number of required EES courses varies slightly among the three B.S. programs (with required credits in required major courses ranging from 52 to 56), as do the courses and numbers of credits in the math and collateral sciences. **Cross-listed EES/CEE courses** used to satisfy Civil Engineering Approved Electives can reduce the individual semester and total program credits when chosen to satisfy EES program requirements. Additional useful information can be found on the web sites (http:/www.lehigh.edu/ incee/incee.html and http://www.ees.lehigh.edu).

Suggested outline of courses for B.S. in Environmental Science and B.S. in Civil Engineering

The **freshman engineering year** (see Section III) is often 30 credits. HSS Advanced Requirement elective of 13 credits, shown below to be three 3-credit courses and one 4-credit course. Other options to complete this requirement are possible.

A total of 160-175 credit hours is needed for both degrees depending on how many credits in the EES are satisfied by taking CEE Approved Electives that are cross-listed with EES courses**.

second year, first semester (17 credit hours)

MATH 23	Analytic Geometry and Calculus III (4)
MECH 2	Elementary Engineering Mechanics (3)
CHM 31	**Chemical Equilibria in Aqueous Systems (3)
EES 21	Introduction to Planet Earth (4)
CEE 11	Surveying (1)
CEE 12	Civil Engineering Statistics (2)

second year, second semester (18 credit hours)

PHY 21	Introductory Physics II (4)
PHY 22	Introductory Physics Laboratory II (1)
MECH 12	Strength of Materials (3)
EES 31	Introduction to Environmental/Organismal Biology (4)
MATH 205	Linear Methods (3)
MAT 33	Engineering Materials and Processes (3)

third year, first semester (17 credit hours)

CEE 121	Mechanics of Fluids (3)
CEE 142	Soil Mechanics (3)
EES	Course suggested as only 100 and 200 level (4)
EES	Course suggested as only 100 and 200 level (4)
CEE 10	Architectural/Engineering Graphics and Design (3)

third year, second semester (18 credit hours)

CEE 242	Principles and Practices of Geotechnical Engineering (3)
CEE 222	Hydraulic Engineering (3)
CEE 170	Introduction to Environmental Engineering (4)
EES	Course suggested as only 100 and 200 level (4)
ECO 1	Principles of Economics (4)

fourth year, first semester (18 credit hours)

CEE 117 Numerical Methods in Civil Engineering (2)
CEE 159 Structural Analysis I (4)
EES Course 100 to 300 levels (4)
EES Course 100 to 300 levels (4)
EES Course 100 to 300 levels (4)

fourth year, second semester (19 credit hours)

CEE 262	Fundamentals of Structural Steel Design (3)
or CEE 264	Fundamentals of Structural Concrete Design (3)
CEE Course	**Civil Engineering Approved Elective (3)
ENGR. Course	*Engineering Science Elective (3)
EES Course	100 to 300 levels (4)
HSS	Humanities/Social Sciences AR Electives (6)

year 4/5 summer (0-8 credit hours)

Select 0, 1, or 2 courses from

EES Course	100 to 300 levels (4)
EES Course	100 to 300 levels (4)

fifth year, first semester (11-19 credit hours)

CEE 202	Civil Engineering Planning and Engineering Economics (3)
CEE 203	Professional Development (2)
CEE Course	**Civil Engineering Approved Elective (3)
HSS	Humanities/Social Sciences AR Elective (3)

Select 0, 1, or 2 courses from below so the total here and year 4/5 summer is 8 credits of Tier 3 courses:
EES Course 100 to 300 levels, possibly seminar (4)
EES Course 100 to 300 levels, possibly senior seminar (4)

fifth year, second semester (19 credit hours)

CEE	**Civil Engineering Approved Electives (8)
CEE 290	Civil Engineering Capstone Design Project (3)
H/SS	Humanities/Social Sciences AR Electives (4)
EES Course	100 to 300 levels, possibly senior seminar (4)

**MECH 102, ME 104, or ECE 81.*

***CHEM 31 plus fourteen additional credits of CEE Approved Electives are required; see list on CEE web-site that includes five CEE/EES cross-listed courses: CEE 279 (EES 259), CEE 316 (EES 316), CEE 320 (EES 320), CEE 323 (EES 323), CEE 327 (EES 327), and CEE 379 (EES 379).*

Suggested outline of courses for B.S. in Environmental Science and B.S. in Environmental Engineering

The **freshman engineering year** (see Section III) is often 30 credits. HSS Advanced Requirement elective of 13 credits shown below to be three 3-credit courses and one 4-credit course. Other options to complete this requirement are possible.

A total of 160-168 credit hours is needed for both degrees, unless some EES requirements are simultaneously satisfied by taking Environmental Engineering Technical Electives that are cross-listed between CEE and EES.

second year, first semester (18 credit hours)

MATH 23	Calculus III (4)
MECH 2	Elementary Engineering Mechanics (3)
CHEM 51	Organic CHEM I (3)
CHEM 53	Organic Chem Lab I (1)
EES 21	Introduction to Planet Earth (4)
HSS	Humanities/Social Sciences AR Elective (3)

second year, second semester (16 credit hours)

MATH 205	Linear Methods (3)
PHY 21	Introductory Physics II (4)
PHY 22	Introductory Physics Lab II (1)
CEE 170	Introduction to Environmental Engineering (4)
EES 31	Introduction to Environmental /Organismal Biology (4)

third year, first semester (19 credit hours)

CEE 12	Civil Engineering Statistics (2)
CEE 276	Env. Engineering Processes (3)
EES Course suggested as only 100 and 200 level (4)	
EES Course suggested as only 100 and 200 level (4)	
HSS	Humanities/Social Science Elective (3)
CHE 31	MAT. & Energy Bal. Of CHE Process (3)

third year, second semester (18 credit hours)

CEE 274	Environmental Water Chemistry (3)
CHE 60	Unit Ops Survey (3)
ECO 1	Principles of Economics (4)
EES Course suggested as only 100 and 200 level (4)	
EES	Course 100 to 300 levels (4)

fourth year, first semester (17 credit hours)

CEE 121	Mechanics of Fluids (3)
CEE 142	Fundamentals of Soil Mechanics (3)
CEE 378	Solid & Haz. Waste Management (3)
EES Course	100 to 300 levels (4)
EES Course	100 to 300 levels (4)

fourth year, second semester (15 credit hours)

CEE 222	Hydraulic Engineering (3)
CEE 272	Env. Risk Assessment (2)
CEE 275	Enviro-Geo-Hydraulics Lab (2)
EES Course	100 to 300 levels (4)
HSS	POLS 111 Politics of the Environment (4)

year 4/5 summer (0-8 credit hours)

Select 0, 1, or 2 courses from
EES Course 100 to 300 levels (4)
EES Course 100 to 300 levels (4)

fifth year, first semester (11-19 credit hours)

CEE 202	CEE Planning and Engr. Economics (3)
CEE 203	Professional Development (2)
CEE 379	(EES 379) Env. Case Studies (4)
	Technical electives* (2)

Select 0, 1, or 2 courses from below so the total here and year 4/5 summer is 8 credits of Tier 3 courses:

EES Course	100 to 300 levels, possibly senior seminar (4)
EES Course	100 to 300 levels, possibly senior seminar (4)

fifth year, second semester (16 credit hours)

CEE 377	Environmental Engineering Design (3)
HSS	Humanities/Social Sciences AR Elective (3)
	Technical elective* (7)
FE	Free Elective (3)

**9 technical (approved) elective credits approved by the academic advisor to satisfy proficiency in three focus areas of water supply and resources, environmental chemistry, and hazardous waste management; approved list available from CEE department.*

Classical Studies

Professors. Charles Robert Phillips, III, Ph.D. (Brown); David B. Small, Ph.D. (Cambridge)

Associate professor. Barbara Pavlock, Ph.D. (Cornell), *head of program.*

The study of classics examines first the origins and growth of Greek and Roman culture in the Mediterranean area and second its impact on that area (and others) until the present. This study is by nature interdisciplinary: the study of language and literature, history, philosophy and religion, archaeology, economics and science all contribute to an appreciation of Greco-Roman civilization.

Students in either major or minor programs may concentrate in various combinations of these and other disciplines as they relate to ancient civilization. The diversity of the program should encourage the student to follow her or his special interests while simultaneously gaining an overview of classical civilization.

Courses in ancient Greek and Latin lead to proficiency in language while introducing the student to major literary texts. The Joseph A. Maurer Classics Prize is awarded yearly, at the discretion of the program, to the senior(s) who has demonstrated outstanding achievement in classics (ancient Greek or Latin) and/or classical civilization. Courses in classical civilization require no knowledge of the ancient languages; they offer introductions to various disciplines of classics with frequent reference to modern perspectives. Upper-level courses tend to be small, fostering closeness between faculty and students.

Petitions are required for freshmen to take 100-level or higher courses and for sophomores to take 200-level or higher courses.

Major Programs. Students may major either in classical civilization or in classics. The classics major offers a comprehensive view of language and culture; it is possible to begin an ancient language at Lehigh and to complete the major program successfully. The classical civilization major enables the student to gain a broad perspective on Greek and Roman civilization. The program welcomes double majors and the educational perspectives to be derived from combining ancient and modern studies.

Classics as a major has stood the test of time, offering helpful preparation for careers in widely diverse fields in the professions, business, and public service. Lehigh classics majors have gone on to law school, the ministry, business school, with appropriate science courses to medical school, graduate work in classics, and to all kinds of entry-level employment.

Departmental Honors. A student may be recommended for program honors by vote of the program based on the student's course work.

Minor Program. The minor in classical civilization or classics consists of a minimum of 15 credit hours. Students may focus on any aspect of classical studies, either singly or in combination. The program can arrange individual courses of study. CLSS 121/ANTH 121 may not be counted toward the minor in classical civilization.

Study Abroad. Lehigh University is a cooperating institution of the Intercollegiate Center for Classical Studies at Rome. Lehigh students are eligible for tuition grants at Athens and Rome.

Major in Classical Civilization

This major allows the student to gain an overview of Greco-Roman culture through the literature, archaeology, and history along with basic language study. A minimum of 30 to 33 credit hours, depending upon previous preparation in language study, is required for this major.

Any four of the following:

CLSS 52 (ENGL 52)	Classical Epic (3)
CLSS 54 (ENGL 54, THTR 54)	Greek Tragedy (3)
CLSS 56 (ENGL 56)	Topics in Greek and Roman Literature (3)
CLSS 58 (ENGL 58, THTR 58)	Greek and Roman Comedy (3)
CLSS 174 (ANTH 174, ART 174, ARCH 174)	Greek Archaeology (3)
CLSS 176 (ANTH 176, ART 176, ARCH 176)	Roman Archaeology (3)

Any two courses in ancient history

Any two electives from the remaining program offerings (ANTH 178 may be included)

One course in either Latin or Greek on the intermediate level (or LAT/GRK 1, 2, 11, or 12, depending on previous background)

Major in Classics

This major allows the student to concentrate in ancient Greek, Latin or both. Specific programs for this major are worked out for each student with due consideration for the individual's particular previous study of the language(s). Thus a student may begin ancient Greek or Latin at Lehigh and successfully complete a major in it.

A minimum of 30 to 33 credit hours, depending upon previous language study, is required for this major.

Required Major Courses

Latin 1 and 2 or Greek 1 and 2, depending on prior preparation

Latin 11 and 12, or Greek 11 and 12, depending on prior preparation

Three advanced courses in the major language minimum

any two ancient history courses

At least two electives from the remaining program offerings

Courses in Classical Civilization (CLSS)

CLSS 21. (HIST 21) Greek History (4) fall
The development of civilization from palaeolithic times to the world empire of Alexander the Great. The social, economic, religious, philosophic, artistic and literary development of the ancient world; the origin of political institutions. Phillips (SS)

CLSS 22. (HIST 22) Roman History (4) spring
Rome from its origins to A.D. 476. Political, social and religious developments. Transformation of the late Roman Empire to the early medieval period. Phillips (SS)

CLSS 50. Mythology (3) fall
Introductory study of the myth-making process, both ancient and modern; emphasis on Greek myth. (SS)

CLSS 52. (ENGL 52) Classical Epic (3)
Study of major epic poems from Greece and Rome. Works include Homer's *Iliad* and *Odyssey*, Apollonius' *Argonautica*, Vergil's *Aeneid,* and Ovid's *Metamorphoses*. Pavlock (HU)

CLSS 54. (ENGL 54, THTR 54) Greek Tragedy (3)
Aspects of Greek theater and plays of Aeschylus, Sophocles, and Euripides in their social and intellectual contexts. Pavlock (HU)

CLSS 56. (ENGL 56) Topics in Greek and Roman Literature (3)
Classical literature in translation, including themes or specific periods in Greek or Roman literature. May be repeated for credit, as topics vary. Pavlock (HU)

CLSS 58. (ENGL 58, THTR 58) Greek and Roman Comedy (3)
Study of comedy as a social form through plays of Aristophanes, Menander, Plautus, and Terence. Pavlock (HU)

CLSS 91. Independent Study (1-4)

CLSS 108. Ancient Technology (3) spring
Technology and technique from the stone ages to the beginning of the industrial age; their effects on society. Attitudes to technology in ancient myth literature, philosophy, and religion. (SS)

CLSS 112. (ANTH 112) Doing Archaeology (4)
Principles of archaeological method and theory. Excavation and survey methods, artifact analysis, dating techniques, and cultural reconstruction. Course includes field project. Prerequisite: ANTH 1 or department permission. Small (SS)

CLSS 114 (REL 114) Christian Origins: New Testament and the Beginnings of Christianity (4)
Early Christianity from its beginnings until the end of the second century. Coverage includes the Jewish and Hellenistic matrices of Christianity, traditions about the life of Jesus and his significance, and the variety of belief and practice of early Christians. Emphasis on encountering primary texts. Wright. (HU)

CLSS 121. (ANTH 121) Environment and Culture (4)
Impact of environment upon cultural variability and change. Comparative study of modern and past cultures and their environments as well as current theories of human/ environmental interaction. Prerequisite: ANTH 1 or department permission. Small (SS)

CLSS 127. (ANTH 127) Early Civilizations (4)
Introduction to early civilizations in the Near East, Mediterranean, Africa, Europe, and the New World. Similarities and differences in economics, politics, social organization, and religion. Prerequisite: ANTH 1 or department permission. Small (SS)

CLSS 131. (PHIL 131) Ancient Philosophy (4) fall
Historical survey of selected texts and issues in the classical world, from the pre-Socratics through Aristotle, with emphasis on the origins of the western philosophical traditions in ethics, metaphysics, and epistemology. (HU)

CLSS 132. (PHIL 132) Hellenistic Philosophy (4)
Historical survey of selected texts and issues in Post-Aristotelian Greek and Roman philosophy from the fourth century B.C. to the third century A.D. Areas of focus may include epicureanism, stoicism, academic and pyrrohnian scepticism, and neoplatonism. (HU)

CLSS 152. (HIST 152, WS 152) Women in Antiquity (4)
Interdisciplinary study of women in Greece and Rome. Literary, archaeological and historical evidence and approaches. Cross-cultural material. (SS)

CLSS 161. (HIST 161) Roman Law (4)
Examination of Roman legal systems from the *Twelve Tables* to the *Digest of Justinian*. Emphasis on development of legal concepts and their historical context. Readings in primary sources; lectures; discussion. Phillips (SS)

CLSS 171. Independent Study (1-4)

CLSS 174. (ANTH 174, Art 174, ARCH 174) Greek Archaeology (3)
Ancient Greek culture from the neolithic to Hellenistic periods. Reconstructions of Greek social dynamics from the study of artifacts. Small (SS)

CLSS 176. (ANTH 176, Art 176, ARCH 176) Roman Archaeology (3)
Cultures of the Roman Empire. Reconstructions of social, political, and economic dynamics of the imperial system from the study of artifacts. Small (SS)

CLSS 180. (ANTH 180) Cultures of the Greeks and Romans (4)
Analysis of Greek and Roman cultures. Focus on kinship, political and economic organization, sexual practices, burial practices, gender construction, religions, art, literature and warfare. Small (SS)

CLSS 204. (ARCH 204) Ancient City and Society (3)
Ancient theories of city and city planning; attitudes to life in the city; rise of urban civilization from Neolithic prototypes through the Near East, Egypt, Greece, Rome, and New World; insights applicable to current urban problems. Small (SS)

CLSS 213. (REL 213) Ancient Roman Religion (4)
Religious experience of the Roman people from prehistory to end of the empire. Nature of polytheism and its interactions with monotheism (Christianity, Judaism). Theories of religion. Emphasis on primary source materials. Phillips (SS)

CLSS 231. (PHIL 231) Figures/Themes in Ancient Philosophy (4)
This seminar course will involve in-depth focus upon a major ancient thinker (e.g. Plato, Aristotle, Sextus Empiricus, Plotinus, etc.) or the classical treatment of a particular theme (e.g. "human nature, " "the good life, " ethical or political theory, etc.) . Content varies. May be repeated more than once for credit. (HU)

CLSS 251. (REL 251) Classical Mythology (3)
Myth, religion, and ritual in ancient Greece and Rome. Emphasis on primary sources; introduction to ancient and modern theories of religion. Cross-cultural material. (SS)

CLSS 281. Readings (3) fall
Advanced study of a historical period or theme. Emphasis on primary sources. Prerequisites: CLSS 21 or 22 and consent of the program head. (ND)

CLSS 282. Readings (3) spring
Advanced study of a historical period or theme. Emphasis on primary sources. Prerequisites: CLSS 21 or 22 and consent of the program head. (ND)

CLSS 291. Independent Study (1-4)

CLSS 311 (HIST 311) Twins and Sins: The Rise of Rome (3-4)
Rome from its origins to the mid-third century B.C. Emphasis on foundation legends, the power of the monarchy, and development of Roman political and religious institutions. Papers, quizzes, discussions. (SS) Phillips

CLSS 312. (HIST 312) Decline and Fall of the Roman Empire (3-4)
Political, social, and economic history of the Roman Empire, A.D. 117-A.D. 565. Romanization of the provinces, diffusion of Christianity, and special attention to transformation to medieval period. Includes readings in translation of primary sources. Phillips (SS)

CLSS 313. (HIST 313) Golden Age of Greek Democracy (3-4)
Greek history of the seventh through fifth centuries B.C. Emphasis on the contrasting political and social systems of Athens and Sparta with consideration of related economic and military history. Attention to art, gender, literature, religion. Discussion and lectures; papers. Phillips (SS)

Class 314. (HIST 314) Age of Caesar and Christ (3-4) spring
Roman history of the first century A.D. political, cultural, and socio-economic changes; special attention to the evolution of absolute power. Lectures, discussions, papers. Phillips (SS)

CLSS 345. (ANTH 345) Evolution of the State (4)
Theories of state formation. Comparison of evolutionary trajectories of early states in the Near East, Mediterranean, and the New World. Prerequisite: ANTH 1 or department permission. Small (SS)

Courses in Ancient Greek

GRK 1. Elementary Ancient Greek I (3) fall
Fundamentals of the Greek language. Grammatical exercises and short passages of easy prose. Staff (HU)

GRK 2. Elementary Ancient Greek II (3) spring
Continued work in Greek vocabulary, forms, and syntax. Selected readings in Greek. Prerequisite: GRK 1. Staff (HU)

GRK 11. Intermediate Ancient Greek (3) fall
Readings in Herodotus, Homer, or Xenophon. Grammar review. Students should have completed two semesters of elementary ancient Greek or the equivalent. (HU)

GRK 12. Intermediate Ancient Greek (3) spring
Plato: Euthyphro, Apology and Crito, or other dialogues. Students should have completed two semesters of elementary Greek or the equivalent. (HU)

GRK 91. Independent Study (1-4)

GRK 111. Greek Drama (3)
Representative plays of Sophocles, Euripides and Aristophanes. Literary study of the drama. Prerequisite: GRK 12. (HU)

GRK 112. Readings in Ancient Greek (3)
Readings of Greek prose and poetry, authors will vary. May be repeated for credit. . Prerequisite: GRK 12. (HU)

GRK 113. Greek Historians (3)
Selections from Herodotus, Thucydides or Xenophon. Study of Greek historiography. Prerequisite: GRK 12. (HU)

GRK 171. Independent Study (1-4)

GRK 271. Readings (3) fall
Intensive readings in one author or in a selected genre. Prerequisites: six credit hours at the 100 level and consent of the program head. (HU)

GRK 272. Readings (3) spring
Intensive readings in one author or in a selected genre. Prerequisites: six credit hours of courses at the 100 level and consent of the program head. (HU)

GRK 291. Independent Study (1-4)

Courses in Latin

LAT 1. Elementary Latin I (3) fall
Fundamentals of grammar and syntax. Emphasis on language structure and vocabulary building. (HU)

LAT 2. Elementary Latin II (3) spring
Continuation of grammar, easy Latin prose and poetry. Students should have completed one semester of elementary Latin or the equivalent. (HU)

LAT 11. Intermediate Latin (3) fall
Readings in Latin prose or poetry. Consolidation of reading ability; introduction to literary analysis. Students should have completed two semesters of elementary Latin or the equivalent. (HU)

LAT 12. Intermediate Latin (3) spring
Readings in Latin prose or poetry. Consolidation of reading ability; introduction to literary analysis. Students should have completed two semesters of elementary Latin or the equivalent. (HU)

LAT 91. Independent Study (1-4)

LAT 111. Catullus and Horace (3)
Translation and analysis of selected lyrics, focusing on imagery systems. Introduction to metrics. May be repeated for credit. Prerequisite: LAT 12 or consent of the program head. (HU)

LAT 112. Latin Prose (3)
Readings from Latin prose literature of the late republic and early empire; selections may include Cicero's letters, Sallust, Pliny's letters. May be repeated for credit as content changes. Prerequisite: Latin 12 or consent of the program head. (HU)

LAT 113. Vergil (3)
Selections from the Aeneid. Vergil's creation of a Latin epic and its complex perspective. Metrics. May be repeated for credit. Prerequisite: LAT 12 or consent of the program head. (HU)

LAT 114. Livy (3)
Selections from the early books of Livy's histories focusing on his creation of a Roman mythos. Style. Prerequisite: LAT 12 or consent of the program head. (HU)

LAT 115. Ovid (3)
May include selections from the Ars Amatoria, Fasti, and the Metamorphoses, with attention to the problem of the ideology of Augustean Rome. May be repeated for credit. Prerequisite: LAT 12 or consent of the program head. (HU)

LAT 116. Petronius (3)
Selections from the Satyricon, focusing on language usage and epic parody. Prerequisite: LAT 12 or consent of the program head. (HU)

LAT. 171. Independent Study (1-4)

LAT 211. Readings (3) fall
Intensive readings in one author or in a selected genre. Prerequisites: six hours of courses at the 100 level and consent of the program head. (HU)

LAT 212. Readings (3) spring
Intensive reading in one author or in a selected genre. Prerequisites: six hours of courses at the 100 level and consent of the program head. (HU)

LAT 291. Independent Study (1-4)

Cognitive Science

Program Director: John B. Gatewood, 758-3814; jbg1@lehigh.edu

Cognitive Science Faculty: Susan Barrett, Ph.D. (Brown), *Psychology*; Gordon Bearn, Ph.D. (Yale), *Philosophy*; Mark H. Bickhard, Ph.D. (Chicago), *Psychology, Philosophy, Computer Science and Engineering, College of Education*; Glenn D. Blank, Ph.D. (Wisconsin-Madison), *Computer Science and Engineering*; John B. Gatewood, Ph.D. (Illinois), *Anthropology*; Michael J. Gill, Ph.D. (Texas), *Psychology*; Steven L. Goldman, Ph.D. (Boston), *Philosophy*; Laura M. Gonnerman, Ph.D. (Southern California), *Psychology*; Edwin J. Kay, Ph.D. (Lehigh), *Computer Science and Engineering*; G. Drew Kessler, Ph.D. (Georgia Inst. of Technology), *Computer Science and Engineering*; Kiri Lee, Ph.D. (Harvard), *Modern Language and Literature*; Alexander Levine, Ph.D. (UC-San Diego), *Philosophy*; Barbara C. Malt, Ph.D. (Stanford), *Psychology*; Gerald W. McRoberts, Ph.D. (Connecticut), *Psychology*; Gordon B. Moskowitz, Ph.D. (NYU), *Psychology*; Ageliki Nicolopoulou, Ph.D. (UC-Berkeley), *Psychology*; John Nyby, Ph.D. (Texas), *Biological Sciences*; Padraig G. Seaghdha, Ph.D. (Toronto), *Psychology*

Cognitive science is the interdisciplinary study of how humans think and how machines think: How can our understanding of the way humans think improve the performance of machines that are meant to behave intelligently? How can our understanding of the ways to make machines behave intelligently improve our understanding of the way humans think? The disciplines most commonly involved in cognitive science studies are psychology, linguistics, computer science, philosophy, neuroscience, and anthropology.

The College of Arts and Sciences offers an undergraduate major and minor in Cognitive Science, as well as a graduate minor and a graduate certificate. Because of its broad interdisciplinary character, a cognitive science major prepares a student for a wide variety of careers or graduate study programs. The courses required for the major also readily lend themselves to a double major for those students in the humanities, natural sciences, social sciences, or computer science who have overlapping interests in cognitive science.

The B.A. with a major in Cognitive Science requires a minimum of 13 courses: 11 within the major itself and 2 in collateral areas. All majors are required to take

COGS 7, an introduction to cognitive science. The remainder of the major is built around a core of four second-tier courses, one from each of four disciplines most central to cognitive science, i.e., linguistics, cognitive psychology, philosophy, and artificial intelligence. In addition, majors must complete five major electives selected from three topical areas related to cognitive science (with no more than two in one area). The final integration of coursework occurs in the required senior seminar, COGS 301, in which students focus on a topic of their choice from a branch of cognitive science.

The collateral course requirements are: CSE 15 and either MATH 9 (fall) or MATH 21. Students who want to take CSE/MATH 261 as a major elective course should choose MATH 21 (a prerequisite for CSE/MATH 261) rather than MATH 9. Additional coursework in mathematics is strongly recommended, as are: PSYC 1, ANTH 1, ANTH 145, and BIOS 31/32.

B.A. in Cognitive Science

Required Introductory Course (4)

COGS 7. Introduction to Cognitive Science (4) spring

Collateral Requirements (8)

CSE 15. Introduction to Computer Science (4)
and
MATH 9. Introduction to Finite Mathematics (4) fall,
or
MATH 21. Calculus I (4)

Disciplinary Core Courses (15)

COGS 140. Introduction to Linguistics (4)
PSYC 117. Cognitive Psychology (4) [prereq: PSYC 1 or COGS 7]
PHIL 250. The Minds of Robots and Other People (4)
CSE 327. Artificial Intelligence Theory and Applications (3) [prereq: CSE 15]

Major Electives (15-20, five courses)

After completing the introductory sequence and the four core courses, students must complete a minimum of five courses from three of the following groups with no more than two courses from any one group.

Artificial Intelligence and Expert Systems:

CSE 17. Structured Programming and Data Structures (4) [prereq: CSE 15]
CSE 262. Programming Languages (3) [prereq: CSE 17]
CSE 355. Topics on Intelligent Decision Support Systems (3) [prereq: CSE 327 or 340]
CSE 365. Natural Language Understanding (3) [prereq: CSE 262]
CSE 368. Artificial Intelligence (3) [prereq: CSE 17]

Students who qualify may take:

CSE 413. Robotics and Intelligent Machines (3)
CSE 414. Expert Systems (3) [prereq: CSE 368]

Formal Models:

PHIL 114. Fundamentals of Logic (4)
PHIL 265. Philosophy of Mathematics (4)
MATH 303 (PHIL 303). Mathematical Logic (3-4) [prereq: PHIL 114]
CSE 261 (MATH 261). Discrete Structures (3) [prereq: MATH 21]
CSE 318. Automata and Formal Grammars (3) [prereq: CSE 261]

Philosophy:

PHIL 139. Contemporary Philosophy (4)
PHIL 220. Knowledge and Justification (4)
PHIL 260. Philosophy of Language (4)

Cognitive Psychology:

PSYC 307. Seminar in Cognition (4) [prereq: PSYC 117 or 176 or COGS 7]
PSYC 320. Psychology of Language (4) [prereq: PSYC 117 or 176 or COGS 7]
PSYC 322. Atypical Language (4) [prereq: PSYC 117 or 176 or COGS 7 or 140]
PSYC 351. Cognitive Development in Childhood (4) [prereq: PSYC 107 or 117 or COGS 7]
PSYC 369. Memory (4) [prereq: PSYC 117 or 176 or COGS 7]

Sociocultural Influences on Cognition:

ANTH 376. Culture and the Individual (4) [prereq: ANTH 1 or COGS 7]
PSYC 314 (SSP 314). Social Cognition and Social Action (4) [prereq: PSYC 110 or SR 111]
PSYC 365. Human Development in Cross-Cultural Perspective (4) [prereq: PSYC 107 or 109 or SSP/PSYC 121 or ANTH 1]
SSP 135. Human Communication (4)
SSP 302. The Sociology of Cyberspace (4)

Neuroscience:

PSYC 176. Mind and Brain (4) [prereq: PSYC 1 or COGS 7]
PSYC 373. Sensation and Perception (4) [prereq: PSYC 117 or 176 or COGS 7]
BIOS 177. Behavioral Neuroscience I (3) [prereq: BIOS 31 and CHEM 21 or 75]
BIOS 276. Behavioral Neuroscience II (3) [prereq BIOS 177]

Senior Seminar (4 hours)

After completing the sophomore introductory sequence and the four core courses, students pursue their own interests in their selections of major electives. The required senior seminar brings classmates together so that they can teach each other what they have learned in their respective concentrations. This integrates the material in the program and provides students the opportunity to undertake independent projects.

Recommended Timing of Courses

Freshman	*Sophomore*
COGS 7 (spring)	PSYC 117
CSE 15	COGS140
MATH 9 or 21	1 major elective
Junior	*Senior*
PHIL 250	2 major electives
CSE 327	COGS 301 (spring)
2 major electives	

Minor in Cognitive Science

The minor in Cognitive Science requires the following six courses, or appropriate substitutions:

COGS 7.	Introduction to Cognitive Science (4)
COGS 140.	Introduction to Linguistics (4)
PSYC 117.	Cognitive Psychology (4)
PHIL 250.	The Minds of Robots and Other People (4)
CSE 327.	Artificial Intelligence Theory and Applications (3)
MATH 9.	Introduction to Finite Mathematics (4),
or	
CSE 261.	Discrete Structures (3)

Course Descriptions

COGS 7. Introduction to Cognitive Science (4) spring
What is a mind? How is the mind related to the brain? Could we make an artificial mind? Issues concerning knowledge representation and intelligence in minds and computers as investigated by psychologists, philosophers, linguists, neuroscientists, and researchers in artificial intelligence.

COGS 140 (ANTH 140, MLL 140, PSYC 140). Introduction to Linguistics (4)
Relationship between language and mind; formal properties of language; language and society; how languages change over time. No pass/fail option.

COGS 161. Supervised Research (2-4 credits)

COGS 301. Senior Seminar in Cognitive Science (4) spring
Integration of the material from cognitive science via topics chosen by the students.

COGS 361. Independent Research (2-4 credits)

COGS 399. Thesis (2-4 credits)

COGS 423 (PSYC 423). Foundations of Cognitive Science (3)
Survey of fundamental theory and methodologies from artificial intelligence, linguistics, cognitive psychology, philosophy, and neuroscience, as well as salient research problems such as knowledge acquisition and representation, natural language processing, skill acquisition, perception and action, and the philosophical question of intentionality.

COGS 478 (PSYC 478). Ontological Psychology (3)
Principles and constraints for modeling psychological phenomena. Representation; perception; memory; knowing; learning; emotions; consciousness; language; rationality.

For Graduate Students

There are two concentrations in Cognitive Science available for post-baccalaureate students: a Graduate Minor and a Graduate Certificate. The minor is intended for students currently enrolled in a degree-granting graduate program at Lehigh University. By contrast, the certificate is intended for non-degree students.

Graduate Minor in Cognitive Science

The minor gives graduate students who are enrolled in Lehigh University degree programs, such as computer science or psychology, an opportunity to develop expertise in the interdisciplinary study of information processing by humans as well as intelligent machines. Graduate students investigating mental processes such as language processing, reading, perception and action, planning, problem-solving, learning, category formation, or applications such as artificial intelligence or educational technology are encouraged to participate, with the approval of an advisor in their major program, by contacting the Director of the Cognitive Science Program. On completion of the program, the Director of the Cognitive Science Program will issue a letter to the student certifying that he or she has met the requirements of the minor.

The Graduate Minor requires five graduate level courses: COGS 423, a graduate seminar, plus *four* electives from the list below (or approved substitutions). At least two of the four electives must be taken outside the student's home department. Special topics courses with a cognitive science emphasis may also count toward the minor, with the approval of the Cognitive Science Supervisory Committee. Courses taken toward the minor may also fulfill requirements of the student's major program, with the approval of the major department.

Contact person: John B. Gatewood (Director, Cognitive Science Program) 758-3814; jbg1@lehigh.edu

Graduate Certificate in Cognitive Science

This concentration is intended for people working in technology-related businesses and other qualified individuals with an interest in cognitive science. The purpose of the certificate program is to provide non-degree post-baccalaureate students an interdisciplinary perspective on human and machine intelligence.

The Graduate Certificate requires four graduate level courses: COGS 423, a graduate seminar, plus *three* electives from the list below. At least two of the three electives must be at the 400-level, and the three electives must be spread over at least two departments.

Contact person: Carol Sabo-Berrian (Coordinator, Psychology Department) 758-5073; cas7@lehigh.edu

Required Course

COGS 423 (PSYC 423). Foundations of Cognitive Science

Approved Electives (for both concentrations)

Computer Science:

CSE 413.	Robotics and Intelligent Machines
CSE 414.	Expert Systems
CSE 416.	Advanced Issues in Knowledge-based Systems

CSE 417.	Topics in Information Retrieval
CSE 429.	Virtual Environments

Psychology:

PSYC 402.	Developmental Psychology
PSYC 403.	Cognitive Psychology
PSYC 406.	Social Cognition
PSYC 443.	Seminar in Language Acquisition
PSYC 448.	Seminar in Psychology of Language
PSYC 464.	Naive Realism in Social Judgment
PSYC 476.	Seminar in Cognition
PSYC 478 (COGS 478).	Ontological Psychology
PSYC 480.	Seminar in Cognitive Development

Philosophy:

(Note: 200-level courses may be taken by graduate students if the courses are not in the student's major.)

PHIL 250.	The Minds of Robots and Other People

Sociology and Anthropology:

SSP 402.	The Sociology of Cyberspace
ANTH 376.	Culture and the Individual

Additional Electives (Graduate Certificate only)

Computer Science:

CSE 327.	Artificial Intelligence Theory and Applications
CSE 331.	User Interface Systems and Techniques
CSE 332.	Multimedia Design and Development
CSE 347.	Data Mining
CSE 355.	Topics on Intelligent Decision Support Systems
CSE 368.	Artificial Intelligence Programming

Psychology:

PSYC 307.	Seminar in Cognition
PSYC 313.	Person Perception
PSYC 314 (SSP 314).	Social Cognition and Social Action
PSYC 317.	Psychology of Emotions
PSYC 320.	Psychology of Language
PSYC 321.	Language Development
PSYC 322.	Atypical Language
PSYC 351.	Cognitive Development in Childhood
PSYC 365.	Human Development in Cross-Cultural Perspective
PSYC 369.	Memory
PSYC 373.	Sensation and Perception

College Scholar Program, Roy Eckardt

Director. Ian Duffy, *professor of history.*

Advisory Council. Mark Bickhard, *professor of psychology;* Gary DeLeo, *professor of physics;* Robin Dillon, *professor of philosophy;* Elizabeth Fifer, *professor of English;* Lucy Gans, *professor of art and architecture*; Norman Girardot, *professor of religion studies;* Michael Kuchka, *professor of biological sciences.*

For program requirements, see College Scholar Program, section III.

389. Honors Project for College Scholars (1-8)
Opportunity for college scholars to pursue an extended project for senior honors. May be repeated for credit up to a maximum 12 credit hours. Transcript will identify department in which project was completed.
Prerequisite: consent of department chair.

CS 281-284. College Scholar Seminar (4)
Seminars for college scholars. May be repeated for credit. Prerequisite: consent of program director. (**HU**)

Communication

See listings under Minor Programs in the College of Arts and Sciences and under Journalism and Communication.

Computer Engineering

Professors Henry Baird, Ph.D. (Princeton); Rick Blum, Ph.D. (Pennsylvania); Donald Bolle, Ph.D. (Purdue); D. Richard Decker, Ph.D. (Lehigh); Bruce D. Fritchman, Ph.D. (Lehigh); Edwin J. Kay, Ph.D. (Lehigh); Henry F. Korth, Ph.D. (Princeton); Alastair D. McAulay, Ph.D. (Carnegie Mellon); Kenneth K. Tzeng, Ph.D. (Illinois).

Associate Professors Mooi Choo Chuah. Ph.D. (U. of California); Daniel D. Lopresti, Ph.D. (Princeton); Meghanad D. Wagh, Ph.D. (I.I.T., Bombay).

Assistant Professors Mark Arnold, Ph.D. (U. of Manchester Inst. of Science and Technology); Liang Cheng, Ph.D. (Rutgers); Brian Davison, Ph.D. (Rutgers); Tiffany Jing Li, Ph.D. (Texas A&M); Shalinee Kishore, Ph.D. (Princeton); William M. Pottenger, Ph.D. (U. Illinois); John R. Spletzer. Ph.D. (U. of Pennsylvania); Zhiyuan Yan, Ph.D. (Illinois Urbana-Champain).

Undergraduate Programs

Mission Statement for the Engineering Program

The mission of the computer engineering program is to prepare computer engineers to meet the challenges of the future; to promote a sense of scholarship, leadership and service among our graduates; to instill in the students the desire to create, develop, and disseminate new knowledge; and to provide international leadership to the computer engineering profession.

Program Educational Objectives in Computer Engineering

- To provide students with the fundamental knowledge for the practice of computer engineering, and to develop their ability to formulate, and analyze computer engineering problems in practice by applying the fundamental knowledge of mathematics, science and engineering.
- To provide the broad education necessary to understand the impact of computer engineering solutions in a global, societal and environmental context.
- To provide students with the foundation and desire for advanced education or graduate study, to instill an awareness of continual changes in their profession in a global context, and to instill the desire for continued life-long learning.

- To instill responsible professional attitudes and ethics, to develop skills in communicating effectively, and in working productively in a multidisciplinary environment.
- To provide an environment which enables students to pursue their individual goals in a program that is flexible, challenging and supportive.

Bachelor of Science in Computer engineering

The required courses for this degree contain the fundamentals of electronic circuits, signal theory, logic design, computer architecture, structured programming, data structures, software engineering and discrete mathematics. A strong foundation in the physical sciences and in mathematics is required. Approved technical electives, chosen with the advisor's consent, are selected in preparation for graduate study or entry into industry according to individual interests. The program totals 136 credit hours and is offered jointly by the CSE and the ECE department.

The recommended sequence of courses follows:

See Freshman Year Requirements, Section III.

Sophomore Year, First Semester (17 credit hours)

ECE 81	Introduction to Electrical Engineering (4)
ECE 33	Introduction to Computer Engineering (4)
PHY 21, 22	Introductory Physics II and Laboratory II (5)
MATH 23	Analytic Geometry and Calculus III (4)

Sophomore Year, Second Semester (19 credit hours)

CSE 17	Structured Programming and Data Structures (4)
ECE 82	Sophomore Laboratory (1)
ECE 108	Signals and Systems (4)
ECO 1	Principles of Economics (4)
MATH 205	Linear Methods (3)
HSS	Elective (3)

Junior Year, First Semester (17 credit hours)

ECE 121	Electronic Circuits Laboratory (2)
ECE 123	Electronic Circuits (3)
CSE 109	Systems Programming (3)
MATH 231	Probability and Statistics (3) or
MATH 309	Theory of Probability (3)
	approved technical elective * (3)
	free elective (3)

Junior Year, Second Semester (17 credit hours)

CSE 216	Software Engineering (3)
ECE 138	Digital Systems Laboratory (2)
ECE 201	Computer Architecture (3)
CSE 261	Discrete Structures (3)
	free elective (3)
	HSS elective (3)

Senior Year, First Semester (18 credit hours)

ECE 257	Senior Lab Project I (3)
ECE 319	Digital System Design (3)
CSE 303	Operating System Design (3)
	HSS elective (6)
	free elective (3)

Senior Year, Second Semester (17 credit hours)

ECE 258	Senior Lab Project II (2)
	approved technical electives* (9)
	HSS elective (3)
	free elective (3)

**Approved technical electives (15 credits) are subjects in the area of science and technology. They are not restricted to offerings in the department of Computer Science and Engineering. One elective must be an engineering science elective from another department. CSE 252 is not an approved technical elective.*

Graduate Programs

Graduate programs of study provide a balance between formal classroom instruction and research and are tailored to the individual student's professional goals. The programs appeal to individuals with backgrounds in computer or information science, in computer engineering, in electrical engineering, in mathematics, or in the physical science. Research is an essential part of the graduate program. The research topics are listed in the departmental descriptions for Computer Science and Engineering(CSE) and Electrical and Computer Engineering (ECE) which jointly administer the computer engineering program. *Individual courses are listed in the catalog descriptions of the CSE and ECE departments.*

The Master of Science degree requires the completion of 30 credit hours of work and may include a six credit hour thesis for Computer Engineering degrees. A program of study must be submitted in compliance with the graduate school regulations. An oral presentation of the thesis is required.

The Master of Engineering degree requires the completion of 30 credit hours of work, which includes design-oriented courses and an engineering project. A program of study must be submitted in compliance with the college rules. An oral presentation of the project is required.

The Ph.D. degree in computer engineering requires the completion of 42 credit hours of work (including the dissertation) beyond the master's degree (48 hours if the master's degree is not from Lehigh), the passing of a departmental qualifying examination appropriate to each degree within one year after entrance into the degree program., the passing of a general examination in the candidate's area of specialization, the admission into candidacy, and the writing and defense of a dissertation. Competence in a foreign language is not required.

The program has a core curriculum requirement for graduate students. The purpose of this requirement is to guarantee that all students pursuing graduate studies in the department acquire an appropriate breadth of knowledge of their discipline. To satisfy the core curriculum requirements in Computer Engineering, students need to complete at least two courses in the computer hardware/architecture area, at least two courses in a second area, and at least one course in a third area. In each of the three areas at least one course must be at the 400 level. The areas are: computer software systems, signal processing and communications, computer software applications, and circuits and systems. See www.cse.lehigh.edu for details about these areas.

Courses from other universities or undergraduate studies may be used to satisfy these requirements, by petition, at the discretion of the department faculty. Additional graduate program information may be obtained from the program's graduate coordinator.

Computer Science and Business Program

Program Directors. James A. Hall, Ph.D. (Oklahoma State University) *associate professor of accounting and information systems*; Edwin Kay, Ph.D. (Lehigh University) *professor of computer science and engineering*.

The computer science and business (CSB) program is offered jointly by the College of Business and Economics and the Computer Science and Engineering department in the P.C. Rossin College of Engineering and Applied Science. This carefully crafted 136 credit hour program integrates technology skills in software development with a solid background in business and economics. Deep immersion in both of these areas distinguishes CSB from programs offered by other universities. At the same time it is well balanced with approximately one third of the courses in liberal arts, one-third in computer science, and one-third in business.

Students enrolled in the CSB program obtain the skills and training needed to understand business functions and business related problems, to analyze business-user information needs, to design computer based information systems, and to implement systems solutions within business organizations. Graduates of the program are ideal candidates for placement within large consulting firms, small consulting teams, and startup companies. This program also prepares students to become the Chief Information Officers, decision makers, and general managers of information age corporations.

After four years the program leads to a degree in Computer Science and in Business, which is jointly awarded by the College of Business and Economics and the P.C. Rossin College of Engineering and Applied Science. The CSB major is designed to meet the accreditation requirements for Computer Science (CSAB) and is accredited in Business (AACSB).

Degree Requirements:

The required courses for the CSB degree constitute the fundamentals of structured programming, discrete mathematics, algorithms, computer architectures, programming languages, software engineering, accounting, finance, marketing, management and economics. None of the program requirements for the CSB major may be taken pass/fail. The recommended sequence of courses is presented below:

Freshman year, first semester (18 credit hours)

ENGL 1	Composition and Literature I(3)
ECO 1	Principles of Economics (4)
MATH 21	Calculus I (4)
BUS 1	Intro to Business (3)
CSE 15	Intro to Computer Science (4)

Freshman year, second semester (16 credit hours)

ENGL 2	Composition and Literature II (3)
MATH 22	Calculus II (4)
PHY 11,12	Intro to Physics I and Lab (5)
CSE 17	Structured Programming and Data Structures (4)

Sophomore year, first semester (17 credit hours)

PHY 21	Intro to Physics II (4)
ECE 33	Intro to Computer Engineering (4)
MATH 205	Linear Methods (3)
ACCT 151	Intro to Financial Accounting. (3)
CSE 261	Discrete Structures (3)

Sophomore year, second semester (15 credit hours)

CSE 109	Systems Programming (3)
CSE 241	Data Base systems (3)
ACCT 152	Intro to Managerial Accounting (3)
MATH 231	Probability and Statistics (3)
ECO 129	Money and Banking (3)

Junior year, first semester (18 credit hours)

MKT 211	Principles of Marketing (3)
CSE 342	Fundamentals of Internetworking (3)
FIN 225	Business Finance (3)
CSB 311	Computer Applications in Business (3)
ECO 146	Applied Microeconomics (3)
CSB	Professional Elective (3)*

Junior year, second semester (18 credit hours)

CSE 216	Software Engineering (3)
CSB 312	Design of Integrated Business Applications I (3)
ECE 201	Computer Architecture (3)
LAW 201	Legal Environment for Business (3)
HSS	Humanities/Social Sciences elective (6)**

Senior year, first semester (16 credit hours)

CSE 303	Operating System Design (3)
MGT 280	Management of People and Operations (4)
CSB	Professional Elective (3) *
CSB 313	Design of Integrated Business Applications II (3)
HSS	Humanities/Social Sciences elective(3)**

Senior year, second semester (18 credit hours)

MGT 301	Business Management Policies (3)
CSE 340	Design and Analysis of Algorithms (3)
CSB	Professional Electives (6) *
CSE 262	Programming Languages (3)
HSS	Humanities/Social Sciences electives (3)**

**One CSB Professional Elective must be a course in the sciences.*

*** At least 6 hours of HSS electives must be in humanities (HU).*

CSB Tracks

Students can use their CSB professional electives to develop areas of concentrations or tracks from courses offered within the CSE department or CBE. In certain cases, the student's advisor may also approve courses from other departments. Some examples of CSB tracks are presented below:

Accounting

ACCT 315	Financial Accounting I
ACCT 324	Cost Accounting
ACCT 320	Auditing

Business Economics Consulting

ECO 322	Competitor and Market Analysis
ECO 333	Economics of Business Decisions
ECO 357	Econometrics

Finance

	FIN 323	Investments
	FIN 328	Corporate Finance
	FIN 334	Derivatives

Computer Science Graduate School

	CSE 302	Compiler Design
	CSE 318	Automata and Formal Grammars
	CSE 392	Independent Research

Corporate IT Development

	CSE 271	Programming in C and Unix
	CSE 313	Computer Graphics
	CSE 332	Multimedia Design and Development

Software Development

	CSE 271	Programming in C and Unix
	CSE 302	Compiler Design
	CSE 330	Advanced Software Engineering Tools

Course Descriptions

CSB 311. Computer Applications in Business (3) fall
Application of computer technology to business problems. Transaction processing systems which support the revenue, conversion, and expenditure cycles of manufacturing, service, and retail business organizations. Process modeling, data modeling, internal control, corporate IT governance, and systems development techniques. Application of CASE technology to a hypothetical business project. Prerequisites: ACCT 152 or ACCT 108 and CSE 17 or equivalent.

CSB 312. Design of Integrated Business Applications I (3) spring
Integrated Product Development (IPD) Capstone Course I. Industry-based business information systems design project. Information systems design methodology, user needs analysis, project feasibility analysis of design alternatives, and integrated product development methodology. Formal oral and written presentations to clients. Prerequisite: CSB 311.

CSB 313. Design of Integrated Business Applications II (3) fall
Integrated Product Development (IPD) Capstone Course II. This course extends the industry-based project initiated in CSB 312 into its implementation phase. Detailed design, in-house system construction and delivery, commercial software options, and systems maintenance and support. The practical component of the course is supplemented by several classroom-based modules dealing with topics that lie at the boundary of computer science and business. Formal oral and written presentations to clients. Prerequisite: CSB 312

Computer Science and Engineering

Professors. Henry F. Korth, Ph.D. (Princeton), *chair;* Edwin J. Kay, Ph.D. (Lehigh), *associate chair;* Henry Baird, Ph.D. (Princeton); Samuel L. Gulden, M.A. (Princeton); Donald J. Hillman, Ph.D. (Cambridge, England); Roger N. Nagel, Ph.D. (Maryland), *Harvey E. Wagner professor of manufacturing systems engineering.*

Associate professors. Glenn D. Blank, Ph.D. (Wisconsin-Madison); Mooi Cho Chuah, Ph.D. (U. of California); Daniel P. Lopresti, Ph.D. (Princeton).

Assistant professors. Mark Arnold, Ph.D. (U. of Manchester Inst. of Science and Tech.); Liang Cheng, Ph.D. (Rutgers University); Brian D. Davison, Ph.D. (Rutgers University); Jeff Heflin, Ph.D. (U. Maryland); Christine Hofmeister, Ph.D. (U. Maryland); G. Drew Kessler, Ph.D. (Georgia Inst. of Technology); Hector Munoz-Avila, Ph.D. (University of Kaiserslautern, Germany); William M. Pottenger, Ph.D. (U. Illinois); John R. Spletzer, Ph.D. (U. of Pennsylvania).

Adjunct lecturer. Stephen G. Corbesero, M.S. (Lehigh).

The department of computer science and engineering (CSE) offers undergraduate and graduate programs of study in computer science and computer engineering, along with research opportunities in these fields. Computer science is the study of computer algorithms, software systems, and the effective use of computers to solve real-world problems and to develop new applications. Computer engineering is the study of how to develop new computer systems and how to integrate computers with electronic devices. Lehigh's majors prepare students for graduate school or for any of the different careers in computer science, computer engineering or computer systems analysis. Computer science and computer engineering and their related careers represent, in the US workplace, the largest field of engineering - larger than all others, including electrical engineering, combined. More discussion on the career potential, as well as the most up to date course offerings can be found on our departmental web site, www.cse.lehigh.edu.

Lehigh University offers a bachelor of science degree in computer science from the P. C. Rossin College of Engineering and Applied Science. It offers the bachelor of science degree in computer science, and the bachelor of arts degree with a major in computer science, from the College of Arts and Sciences. It also offers a bachelor of science in Computer Science and Business, jointly supported by the P.C. Rossin College of Engineering and Applied Science and the College of Business and Economics. A minor in computer science is available except to students majoring in computer or electrical engineering. Graduate study in the department leads to the degrees of master of science and doctor of philosophy (Ph.D.) in computer science. In conjunction with the department of Electrical and Computer Engineering (ECE), a bachelor of science degree in computer engineering and the master of science and Ph.D. degrees in computer engineering are also offered in the P.C. Rossin College of Engineering and Applied Science. In conjunction with the College of Business and Economics, the

CSE department also takes part in the masters of business and engineering (MB&E) program and in the integrated business and engineering major.

The undergraduate programs emphasize the fundamental aspects of their respective areas, with extensive hands-on experiences for the students. Electives permit students to tailor their programs according to their interests and goals, whether they be in preparation for graduate study or entry into industry. The programs have electives that allow students to select courses offered by other departments. This can help prepare them for activities that straddle departmental boundaries or for entry into professional schools such as medicine or management. Students have the opportunity to synthesize and apply their knowledge in a senior design project. Students are encouraged to become involved in the many research projects within the department, and may use independent study courses and their senior project as a way to participate while receiving course credit.

The graduate programs allow students to deepen their professional knowledge, understanding, and capability within their subspecialties. Each graduate student develops a program of study in consultation with his or her graduate advisor. Key thrust areas in the department include:

Computer Systems Engineering: computer architecture, computer arithmetic, DSP systems, sensor networks, robotics, mobile and wearable computing, and networking.

Software Systems Engineering: software architectures, parallel and distributed computing, object-oriented software, middleware, Web-based systems and networked software systems.

Information Systems Engineering: database, data mining, bioinformatics, computer graphics and virtual environments, optimization, multimedia systems, expert systems, artificial intelligence and computer vision.

Both graduate and undergraduate research are encouraged.

The department maintains a number of computer laboratories in support of computer science and computer engineering and the ECE department maintains additional laboratories supporting the hardware aspects of computer engineering. The department has research laboratories in vision and software technology, parallel and distributed computing, graphics and virtual environments, computer architecture and arithmetics, and software architecture. These laboratories and their associated research activities are described more completely in the departmental web site (www.cse.lehigh.edu). While these laboratories are research oriented, they are also used for undergraduate projects. In conjunction with the ECE department, the CSE department maintains public laboratories of Sun workstations and PCs for class assignments and projects.

Computer laboratory usage is an essential part of the student's education. The primary department resources include a network of more than 60 Sun workstations, file servers, and compute servers running the Unix operating system. These systems provide an array of software tools for our students and researchers including programming languages (C, C++, Java, Smalltalk, Perl, etc.), software development tools, software and hardware simulators, and computer-aided design packages. In addition to the workstations, the department maintains a collection of PC-compatible computers for CSE students, including a set of machines that can be dedicated to hardware/software projects. Many of the these machines are running Linux or FreeBSD. The department also provides various application-specific systems, including multimedia stations with sound and video capture and generation capabilities, workstations for image processing and visualization, virtual environment tracking and head-mounted display systems, and wearable computers. The department's computers are connected via multiple high-speed Ethernet, fiber optic, wireless, and ATM networks, which are in turn connected to the university's backbone network. The university is connected through multiple T1 connections to the internet. Students are not required by the department nor the university to own a personal computer, but many find such a tool a valuable asset. In addition to the departmental resources, the university, as distinct from the department, provides a distributed network of about 75 high-performance workstations and over 300 PC-compatible computers in public sites throughout the campus.

A detailed description of the curricular programs follows with a listing of the required courses and with a listing of the departmental course offerings. The departmental courses carry the prefixes CSE for computer science and ECE for electrical and computer engineering. The student is urged to consult both listings for courses appropriate to his/her career goal.

Undergraduate Programs

Mission Statement for the Computer Science and Engineering Programs

The mission of the computer science and computer engineering programs is to prepare computer scientists and computer engineers to meet the challenges of the future; to promote a sense of scholarship, leadership and service among our graduates; to instill in the students the desire to create, develop, and disseminate new knowledge; and to provide international leadership to the computer science and engineering professions.

Program Educational Objectives in Computer Science and Engineering

- To provide students with the fundamental knowledge for the practice of computer science and computer engineering, and to develop their ability to formulate, analyze and solve computer science and computer engineering problems in practice by applying the fundamental knowledge of mathematics, science, and engineering.
- To provide the broad education necessary to understand the impact of computer science and computer engineering solutions in a global, societal, and environmental context.
- To provide students with the foundation and desire for advanced education or graduate study, to instill an awareness of continual changes in their profession in a global context, and to instill the desire for continued life-long learning.

- To instill responsible professional attitudes and ethics, to develop skills in communicating effectively, and in working productively in a multidisciplinary team environment.
- To provide an environment which enables students to pursue their individual goals in a program that is flexible, challenging and supportive.

Bachelor of Science in Computer engineering

See catalog entry for Computer Engineering.

Bachelor of Science in Computer Science

Bachelor of Science in Computer Science degree programs are available to students through either the College of Arts and Sciences or the P. C. Rossin College of Engineering and Applied Science. The program offered by the P. C. Rossin College of Engineering and Applied Science is accredited by the Computer Science Accreditation Board, Inc. The two programs are identical in the fundamental requirements in mathematics and computer science, and the programs are appropriate for entry into management or industrial positions. They are also appropriate for continued graduate study, though students considering graduate study are strongly encouraged to consider taking part in a research project during their junior year. The two BS programs differ in their non-computer science content in that the students must fulfill the distribution requirements of the respective colleges. The result of this difference is that the Arts and Sciences program requires 127 credit hours, whereas the P. C. Rossin College of Engineering and Applied Science program requires 134 credit hours. Students with interests in management, finance, data processing, and information handling may find the Arts and Science College program more appropriate and students with interests in engineering and science applications may find the Engineering and Applied Science College program more appropriate.

The required courses for the degrees contain the fundamentals of discrete mathematics, structured programming, algorithms, computer architectures, compiler design, operating systems, and programming languages. A strong foundation in mathematics is required. The recommended sequence of courses is as follows:

P. C. Rossin College of Engineering and Applied Science:

Bachelor of Science in Computer Science

See freshman year requirements, section III.

sophomore year, first semester (17 credit hours)

MATH 23	Analytic Geometry and Calculus III (4)
PHY 21, 22	Introductory Physics II and Laboratory(5)
CSE 17	Structured Programming and Data Structures (4)
ECE 33	Introduction to Computer Engineering (4)

sophomore year, second semester (16 credit hours)

CSE 109	Systems Programming (3)
CSE 262	Programming Languages (3)
ECO 1	Principles of Economics (4)
MATH 205	Linear Methods (3)
	approved technical elective *#(3)

junior year, first semester (18 credit hours)

CSE 261	Discrete Structures (3)
MATH 231	Probability and Statistics (3) **or**
MATH 309	Theory of Probability (3)
	HSS electives ## (6)
	approved technical elective* (3)
	approved professional elective** (3)

junior year, second semester (18 credit hours)

CSE 340	Design and Analysis of Algorithms (3)
ECE 201	Computer Architecture (3)
CSE 216	Software Engineering (3)
CSE 252	Computers, the Internet, and Society (3)
	HSS electives ## (3)
	free elective (3)

senior year, first semester (18 credit hours)

CSE 303	Operating System Design (3)
CSE 318	Automatic & Formal Grammars (3)
CSE 379	Senior Project (3)
MATH 230	Numerical Methods (3)
	HSS elective ## (3)
	free elective (3)

senior year, second semester (17 credit hours)

CSE 302	Compiler Design (3)
	HSS electives ## (5)
	approved technical electives* (6)
	approved professional elective** (3)

*Approved technical electives (12 credits) are subjects in the area of science and technology. They are not restricted to courses in the department of Computer Science and Engineering. They are chosen by the student, with the approval of the major advisor. One of these electives must be a hardware-oriented elective. Hardware-oriented courses include ECE 81, ECE 316, ECE 138, ECE 319, ECE 320, CSE 209, or any other hardware-oriented course approved by the advisor. CSE 252 is not an approved technical elective.

***Approved professional electives(6 credits) are chosen by the student, with the approval of the major advisor, to support the professional objectives of the student. These may include technical, business, or non-technical courses. CSE 252 is not an approved professional elective.*

#Computer Science students should be aware that many ECE courses require ECE 81. Taking ECE 81 as an approved technical elective before the junior year will afford greater flexibility in choosing ECE electives.

Computer science students are required to have at least 27 credits of HSS electives to fulfill graduation requirements, and to satisfy the "depth and breadth " requirement for the college.

College of Arts and Sciences:

Bachelor of Science in Computer Science

See the distribution requirements of the College of Arts and Sciences, section III.

freshman year, first semester (17 credit hours)

ENGL 1	Composition and Literature (3)
MATH 21	Analytic Geometry and Calculus I (4)
CSE 15	Introduction to Computing (4)
	distribution (6)

freshman year, second semester (17 credit hours)

ENGL 2	Composition and Literature: Fiction, Drama, Poetry (3)
MATH 22	Analytic Geometry and Calculus II (4)
CSE 17	Structured Programming and Data Structures (4)
	distribution (6)

sophomore year, first semester (17 credit hours)

MATH 23	Analytic Geometry and Calculus III (4)
ECE 33	Introduction to Computer Engineering (4)
	distribution (9)

sophomore year, second semester (15 credit hours)

CSE 109	Systems Programming (3)
CSE 262	Programming Languages (3)
MATH 205	Linear Methods (3)
	approved technical elective* (3)
	distribution (3)

junior year, first semester (15 credit hours)

CSE 261	Discrete Structures (3)
MATH 231	Probability and Statistics (3)
	approved technical elective* (3)
	approved professional elective** (3)
	free elective (3)

junior year, second semester (15 credit hours)

CSE 340	Design and Analysis of Algorithms (3)
ECE 201	Computer Architecture (3)
CSE 216	Software Engineering (3)
	distribution (3)
	approved technical elective* (3)

senior year, first semester (15 credit hours)

CSE 303	Operating System Design (3)
CSE 318	Automata & Formal Grammars (3)
CSE 379	Senior Project (3)
MATH 230	Numerical Methods (3)
	free elective (3)

senior year, second semester (15 credit hours)

CSE 252	Computers, the Internet and Society (3)
CSE 302	Compiler Design (3)
	approved technical elective* (3)
	approved professional electives ** (6)

**Approved technical electives (12 credits) are subjects in the area of science (12 credits) and technology. They are not restricted to courses in the department of Computer Science and Engineering. They are chosen by the student, with the approval of the major advisor. One of these electives must be a hardware-oriented elective. Hardware-oriented courses include ECE 81, ECE 316, ECE 138, ECE 319, ECE 320, CSE 209, or any other hardware-oriented course approved by the advisor. To satisfy the A&S College distribution requirements, the approved elective choices must include a science course with an attached laboratory. CSE 252 is not an approved technical elective.*

***Approved professional electives (9 credits) are chosen by the student, with the approval of the major advisor, to support the professional objectives of the student. These may include technical, business, or non-technical courses. CSE 252 is not an approved professional elective.*

College of Arts and Sciences:

Bachelor of Arts in Computer Science

This program of 121 credit hours is intended for students who desire a strong liberal arts program with a concentration in computer science. The program contains the fundamentals of computer science, including discrete mathematics, structured programming, data structures, programming languages, computer organization, compiler design, and operating systems. The recommended course sequence is as follows:

See the distribution requirements of the College of Arts and Sciences, section III.

freshman year, first semester (14 credit hours)

ENGL 1	Composition and Literature (3)
MATH 21	Analytic Geometry and Calculus I (4)
CSE 15	Introduction to Computing (4)
	distribution (3)

freshman year, second semester (14 credit hours)

ENGL 2	Composition and Literature: Fiction, Drama, Poetry (3)
MATH 22	Analytic Geometry and Calculus II (4)
CSE 17	Structured Programming and Data Structures (4)
	distribution (3)

sophomore year, first semester (16 credit hours)

CSE 261	Discrete Structures (3) or
MATH 243	Algebra (3)
ECE 33	Introduction to Computer Engineering (4)
	distribution (9)

sophomore year, second semester (15 credit hours)

MATH 43	BMSS Linear Algebra (3)
CSE 109	Systems Programming (3)
ECE 201	Computer Architecture (3)
	distribution (6)

junior year, first semester (15 credit hours)

	hardware-oriented elective
or	free elective *(3)
	distribution (6)
	free elective (6)

junior year, second semester (15 credit hours)

CSE 262	Programming Languages (3)
	free elective
or	hardware-oriented elective *(3)
	distribution (6)
	free elective (3)

senior year, first semester (16 credit hours)

CSE 303	Operating System Design (3)
CSE 318	Automata and Formal Grammars (3)
	distribution (3)
	free electives (7)

senior year, second semester (16 credit hours)

CSE 302	Compiler Design (3)
	distribution (6)
	free electives (7)

** The student's program must contain at least one hardware-oriented elective course. Hardware-oriented courses include ECE 81, ECE 316, ECE 138, ECE 319, ECE 320, CSE 209, or any other hardware-oriented course approved by the advisor.*

Minor in Computer Science

The minor in computer science provides a basic familiarity with software development and programming, and computer organization, and essential elements of computer science. This minor is not available to students of the CSE or ECE departments. Engineering students should note that ENGR 1 plus CSE 16 is a substitute for CSE 15. The minor requires 18 credit hours, consisting of the following:

CSE 15	Introduction to Computing (4)
CSE 17	Structured Programming and Data Structures (4)
ECE 33	Introduction to Computer Engineering (4)

and **two** CSE electives from the following list:

CSE 109	Systems Programming (3)
CSE 216	Software Engineering (3)
CSE 241	Data Base Systems (3)
CSE 261	Discrete Structures (3)
CSE 271	Programming in C and the Unix Environment (3)
CSE 262	Programming Languages (3)
CSE 327	Artificial Intelligence Theory and Practice (3)
CSE 340	Design and Analysis of Algorithms (3)

P. C. Rossin College of Engineering and Applied Science

Graduate Programs

Note: For information about graduate degrees in Computer Engineering, see the catalog entry for Computer Engineering.

Graduate programs of study provide a balance between formal classroom instruction and research and are tailored to the individual student's professional goals. The programs appeal to individuals with backgrounds in computer or information science, in computer engineering, in electrical engineering, in mathematics, or in the physical sciences. Research is an essential part of the graduate program. The research topics were listed earlier in the departmental description.

The Master of Science degree requires the completion of 30 credit hours of work and may include a three credit hour thesis. A program of study must be submitted in compliance with the graduate school regulations. An oral presentation of the thesis is required.

The Master of Engineering degree requires the completion of 30 credit hours of work, which includes design-oriented courses and an engineering project. A program of study must be submitted in compliance with the college rules. An oral presentation of the project is required.

The Ph.D. degree in computer science requires the completion of 42 credit hours of work (including the dissertation) beyond the master's degree (48 hours if the master's degree is not from Lehigh), the passing of a departmental qualifying examination appropriate to each degree within one year after entrance into the degree program, the passing of a general examination in the candidate's area of specialization, the admission into candidacy, and the writing and defense of a dissertation. Competence in a foreign language is not required.

The CSE department has a core curriculum requirement for graduate students in each of the degree programs. The purpose of this requirement is to guarantee that all students pursuing graduate studies in the department acquire an appropriate breadth of knowledge of their discipline.

Computer Science: To satisfy the comprehensives/core, students need to complete at least two (2) courses in each of the following areas, with at least one (1) 400 level course in three (3) of the four areas: Systems; Compilers/Languages/Software Systems; Theory; and Computer Applications. For details on these requirements, see the department's web site www.cse.lehigh.edu.

Courses from other universities or undergraduate studies may be used to satisfy these requirements, by petition, at the discretion of the department faculty. Additional graduate program information may be obtained from the department's graduate coordinator.

Departmental Courses

Departmental courses are listed under the prefix CSE. Students should also consult the ECE department listing because computer engineering courses are found under either prefix, and because electives can be chosen from either department. The reader should consult both listings.

Computer Science (CSE)

For Undergraduate Students

CSE 12. Survey of Computer Science (3)
Topics in computer science, Java programming and web page design. Includes multimedia laboratory. Not available to students who have taken CSE 15, 16, or ENGR 1.

CSE 15. Introduction to Computer Science (4)
Introduction to topics in computer science and programming skills in Java and C++. Prerequisite for CSE 17. Includes multimedia laboratory. No prerequisites. Not available to students who have taken CSE 12, 16, or ENGR 1.

CSE 16. Multimedia laboratory of Computer Science (1)
Survey of topics in computer science. Multimedia laboratory only. No prerequisites. Not available to students who have taken CSE 12 or 15.

CSE 17. Structured Programming and Data Structures (4)
Algorithmic design and implementation in a high level, object-oriented language such as C++. Recursion, lexical programs, pointers, data structures, and their applications. Prerequisites: CSE 15, or ENGR 1, or permission of the instructor.

CSE 109. Systems Software (3)
Advanced programming and data structures, including dynamic structures, memory allocation, data organization, symbol tables, hash tables, B-trees, data files. Object-oriented design and implementation of simple assemblers, loaders, interpreters, compilers, and translators. Practical methods for implementing medium-scale programs. Prerequisite: CSE 17.

CSE 190. Special Topics (1-3)
Supervised reading and research. Prerequisite: consent of the department head.

CSE 209. Assembly Language Programming (3) fall
Design and development of assembly language programs for computer systems. Interactive input-output, handling interrupts, system architecture, hardware-software tradeoffs. Evaluation of program efficiency. Prerequisite: CSE 109.

CSE 216. Software Engineering (3) spring
The software life-cycle; life-cycle models; software planning; testing; specification methods; maintenance. Emphasis on team work and large-scale software systems, including oral presentations and written reports. Prerequisite: CSE 109.

CSE 241. Data Base Systems (3)
Data modeling; database design; normalization; query languages; client-server database systems; enterprise systems; Internet applications. Prerequisite: CSE 12, 15, or CSE 17 or consent of instructor. Not available to students who have credit for IE 224.

CSE 252. (STS 252) Computers, the Internet, and Society (3)
An interactive exploration of the current and future role of computers, the Internet, and related technologies in changing the standard of living, work environments, society and its ethical values. Privacy, security, depersonalization, responsibility, and professional ethics; the role of computer and Internet technologies in changing education, business modalities, collaboration mechanisms, and everyday life. (SS)

CSE 261. (MATH 261) Discrete Structures (3) fall and spring
Topics in discrete structures chosen for their applicability to computer science and engineering. Sets, propositions, induction, recursion; combinatorics; binary relations and functions; ordering, lattices and Boolean algebra; graphs and trees; groups and homomorphisms. Various applications. Prerequisites: MATH 21.

CSE 262. Programming Languages (3)
Use, structure and implementation of several programming languages. Prerequisite: CSE 17.

CSE 271. Programming in C and the Unix Environment (3)
C language syntax and structure. C programming techniques. Emphasis on structured design for medium to large programs. Unix operating system fundamentals. Unix utilities for program development, text processing, and communications. Prerequisite: CSE 17.

CSE 302. Compiler Design (3) spring
Principles of artificial language description and design. Sentence parsing techniques, including operator precedence, bounded-context, and syntax-directed recognizer schemes. The semantic problem as it relates to interpreters and compilers. Dynamic storage allocation, table grammars, code optimization, compiler-writing languages. Prerequisites: CSE 109 and CSE 318.

CSE 303. Operating System Design (3) fall
Assemblers, executive systems, multiprogramming, time sharing. Concurrent tasks, deadlocks, resource sharing. Construction of a small operating system. Prerequisites: ECE 201 and CSE 109.

CSE 313. Computer Graphics (3)
General principles; algorithms; display devices and organization; methods of interaction; design of visual interactive systems. Prerequisite: CSE 109.

CSE 318. Automata and Formal Grammars (3) fall
Formal languages, finite automata, context-free grammars, Turing machines, complexity theory, undecidability. Prerequisite: CSE 261.

CSE 327. Artificial Intelligence Theory and Practice (3)
Introduction to the field of artificial intelligence: Problem solving, knowledge representation, reasoning, planning and machine learning. Use of AI systems or languages. Advanced topics such as natural language processing, vision, robotics, and uncertainty. Prerequisite: CSE 12 or 15 or 17.

CSE 330. Advanced Software Engineering Tools (3)
CASE tools; portability and reusability of software; experimental methods in software engineering; automatic programming. Prerequisite: CSE 216.

CSE 331. User Interface Systems and Techniques (3)
Principles and practice of creating effective human-computer interfaces. Design and user evaluation of user interfaces; design and use of interface building tools. Programming projects using a variety of interface building tools to construct and evaluate interfaces. Prerequisite: CSE 109 or consent of the instructor.

CSE 332. Multimedia Design and Development (3)
Analysis, design and implementation of multimedia software, primarily for computer-based training. Projects emphasize user interface design, content design with storyboards or scripts, creation of graphics, animation, audio and video materials, and software development using high level authoring tools. Prerequisite: CSE 14 or CSE 17. Blank.

CSE 335. Topics on Intelligent Decision Support Systems (3)
Topics on intelligent decision support systems (IDSSs). The course will be self-contained and study some of the AI techniques that are used to build IDSSs including:

case-based reasoning, decision trees and knowledge representation. Several application areas of these techniques will be covered including: help-desk systems, e-commerce, and knowledge management. Credit will not be given for both CSE 335 and CSE 435. Prerequisite: CSE 327 or CSE 340 or consent of the instructor.

CSE 336 (ECE 336) Embedded Systems (3)
Use of small computers embedded as part of other machines. Limited-resource microcontrollers and state machines from high description language. Embedded hardware: RAM, ROM, flash, timers, UARTs, PWM, A/D, multiplexing, debouncing. Development and debugging tools running on host computers. Real-Time Operating System (RTOS) semaphores, mailboxes, queues. Task priorities and rate monotonic scheduling. Software architectures for embedded systems. Prerequisite: CSE 17.

CSE 340. (MATH 340) Design and Analysis of Algorithms (3) spring
Algorithms for searching, sorting, counting, graph and tree manipulation, matrix multiplication, scheduling, pattern matching, fast Fourier transform. Minimum time and space requirements are established, leading to the notion of abstract complexity measures and the intrinsic complexity of algorithms and problems, in terms of asymptotic behavior. The question of the correctness of algorithms is also treated. Prerequisites: MATH 22 and CSE 261 (MATH 261).

CSE 342. Fundamentals of Internetworking (3)
Architecture and protocols of computer networks. Protocol layers; network topology; data-communication principles, including circuit switching, packet switching and error control techniques; sliding window protocols, protocol analysis and verification; routing and flow control; local and wide area networks; network interconnection; client-server interaction; emerging networking trends and technologies; topics in security and privacy. Prerequisite: CSE 109.

CSE 345 WWW Search Engines (3)
Study of algorithms, architectures, and implementations of WWW search engines; Information retrieval (IR) models; performance evaluation; properties of hypertext crawling, indexing, searching and ranking; link analysis; parallel and distributed IR; user interfaces. Credit will not be given for both 345 and 445. Prerequisite: CSE 109.

CSE 347. Data Mining (3)
Overview of modern data mining techniques: data cleaning; attribute and subset selection; model construction, evaluation and application. Fundamental mathematics and algorithms for decision trees, covering algorithms, association mining, statistical modeling, linear models, neural networks, instance-based learning and clustering covered. Practical design, implementation, application and evaluation of data mining techniques in class projects. Prerequisites: Either CSE 17 and MATH 231, or BIS 120 and ECO 145.

CSE 350. Special Topics (3)
Selected topics in the field of computer science not included in other courses. May be repeated for credit.

CSE 352. E-commerce Applications Technology and Strategy (3)
E-commerce applications for business: enterprise resource planning, (ERP); customer relationship management (CRM) and supply chain management (SCM); information innovation strategies and their dependence on a common technology architecture; technical, logistical and cultural implications of building and operation information integration systems applications. Consent of instructor.

CSE 365. Natural Language Processing (3)
Computer analysis of human languages, such as English. Syntactic parsing and semantic interpretation of sentences; morphological recognition of words and idioms. Applications of natural language processing such as database queries. Prerequisite: CSE 262 or equivalent familiarity with Prolog, Lisp.

CSE 366. Object-Oriented Programming (3)
The implementation of object orientation in languages such as Smalltalk and Java. Objects, classes, inheritance, graphical interfaces, applets, exception-handling, and multi-threading. Prerequisite: CSE 17.

CSE 368. Artificial Intelligence Programming (3)
The use of LISP and related languages to simulate intelligence on computers. Prerequisite: CSE 262 or approval of the department head.

CSE 375. Hardware & Software Topics in Parallel Computing (3)
Introduction to parallel computing, covering both hardware and software topics such as interconnection networks, SIMD, MIMD, and hybrid parallel architectures, parallel languages, parallelizing compiler techniques and operating systems for parallel computers. Prerequisites: ECE 201 and CSE 303 previously or concurrently, or consent of the instructor.

CSE 376. Parallel Algorithms (3)
Parallel algorithms for searching, sorting, matrix processing, network optimization, and selected graph problems. Implementation and efficiency measures of parallel algorithms also considered. Prerequisite: CSE 375 or CSE 340 or consent of instructor.

CSE 379 Senior Project (3)
Design, implementation, and evaluation of a computer science capstone project conducted by student teams working from problem definition to testing and implementation; written progress reports supplemented by oral presentations. Prerequisite: senior standing.

CSE 392. Independent Study (1-3)
An intensive study, with report, of a topic in computer science which is not treated in other courses. May be repeated for credit. Prerequisite: Consent of instructor.

For Graduate Students

CSE 403. Theory of Operating Systems (3)
Principles of operating systems with emphasis on hardware and software requirements and design methodologies for multi-programming systems. Global topics include the related areas of process management, resource management, and file systems. Prerequisite: CSE 303 or equivalent.

CSE 404. (ECE 404) Computer Networks (3)
Study of architecture and protocols of computer networks. The ISO model; network topology; data-communication principles, including circuit switching, packet switching and error control techniques; sliding window protocols, protocol analysis and verification; routing and flow control; local area networks; network interconnection; topics in security and privacy.

CSE 409. Theory of Automata and Formal Grammars (3)
Finite automata. Pushdown automata. Relationship to definition and parsing of formal grammars. Prerequisite: CSE 318.

CSE 411. Advanced Programming Techniques (3)
Deeper study of programming techniques, data structures, backtracking, recursion. Applications of basic theoretical disciplines such as automata theory and formal language theory. Assignments using a contemporary programming language. Prerequisite: CSE 17 or consent of department head.

CSE 412. Object-Oriented Programming (3)
Objects, messages, classes and inheritance; the model-view-controller paradigm. Prototyping the user interface.

CSE 413. Robotics and Intelligent Machines (3)
Software aspects of robot and intelligent machine controls. Fundamental control issues through language and artificial intelligence implementations.

CSE 414. Expert Systems (3)
The design and development of knowledge-based expert systems. Rule-based protocols. Knowledge engineering. Programming application. Prerequisite: CSE 368.

CSE 415. Database Topics (3)
Design issues in integrated database systems. Database entities and their relationships. Prerequisite: CSE 241 or equivalent.

CSE 416. Advanced Issues in Knowledge-based Systems (3)
Advanced techniques and current applications of knowledge-based systems. Emphasis on knowledge engineering techniques through the development of a substantial system. Prerequisite: CSE 414. Hillman and Blank

CSE 417. Topics in Information Retrieval (3)
Selected topics in the design of advanced retrieval systems. Prerequisite: CSE 241 or equivalent.

CSE 422. Advanced Topics in Compiling (3)
Topics from general parsers, attributed translation, attribute grammars, two-level grammars, expression optimization, data flow, code optimization, compiler compilers, implementation languages, multi-tasking languages. Prerequisite: CSE 302 or consent of the department head.

CSE 429. Virtual Environments (3)
Software and technology of virtual environment systems. Current research in virtual environments. User tracking, display, and view rendering hardware. VE application programming libraries, real-time rendering techniques, 3D model representations, networking systems for distributed and multi-user environments, 3D user interaction techniques.

CSE 430. Textual Data Mining (3)
Theory and algorithms for topics in textual data mining and statistical natural language processing (NLP). Fundamental mathematics and linguistics of statistical NLP; probability theory and information theory. Text mining algorithms and applications. Practical design, implementation, application and evaluation of statistical NLP and textual data mining techniques in class projects. Prerequisite: CSE 347

CSE 432. Object-Oriented Software Engineering (3)
Design and construction of modular, reusable, extensible and portable software using statically typed object-oriented programming languages (Eiffel, C++, Objective C). Abstract data types; genericity; multiple inheritance; use and design of soft-ware libraries; persistence and object-oriented databases; impact of object-oriented programming on the software life cycle.

CSE 435. Topics on Intelligent Decision Support Systems (3)
AI techniques used to build IDSSs: case-based reasoning, decision trees and knowledge representation. Applications: help-desk systems, e-commerce, and knowledge management. This course, a version of 335 for graduate students, requires research projects and advanced assignments. Credit will not be given for both CSE 335 and CSE 435.

CSE 437. Program Semantics (3)
Theories and techniques of program semantics and program verification. Topics may be chosen from denotational semantics, operational semantics, Floyd-Hoare semantics, temporal logic, dynamic logic, algebraic semantics, continuous semantics, recursive function theory or a current semantic theory. Gulden

CSE 438. Software Architecture (3)
Design and description of software architecture for large systems. Current research topics in software architecture. Individual projects are a significant part of this course. Projects may include the design of a new architecture, reverse engineering the architecture of an existing system, or investigation of a research topic in software architecture. Prerequisite: CSE 216 or CSE 432 or consent of the instructor.

CSE 440. Graph Theory and Application (3)
Fundamental concepts of and algorithms for graphs, including: connectivity, planarity, network flows, matchings, colorings, traversals, duality, intractability and applications. Prerequisite: CSE 340 or consent of instructor.

CSE 445 WWW Search Engines (3)
Study of algorithms, architectures, and implementations of WWW search engines. Information retrieval (IR) models; performance evaluation; properties of hypertext crawling, indexing, searching and ranking; link analysis; parallel and distributed IR; user interfaces. This course, a version of 345 for graduate students, requires research projects and advanced assignments. Credit will not be given for both CSE 345 and CSE 445.

CSE 450. Special Topics (3)
Selected topics in computer science not included in other courses. May be repeated for credit.

CSE 463. Advanced Issues in Natural Language Processing (3)
Advanced techniques and current applications of natural language systems. Complex syntax and semantics, discourse coherence and planning, natural language interfaces and other applications. Prerequisite: CSE 365 or CSE 465. Blank

CSE 465. Seminar in Natural Language Processing (3)
Writing and presenting reviews of research issues in natural language, knowledge representation, speech processing and other applications. Requires concurrent attendance in CSE 365, Natural Language Processing.

CSE 491. Research Seminar (1-3)
Regular meetings focused on specific topics related to the research interests of department faculty. Current research will be discussed. Students may be required to present and review relevant publications. May be repeated for credit up to a maximum of three (3) credits. Prerequisite: Consent of instructor.

CSE 492. Independent Study (1-3)
An intensive study, with report of a topic in computer science that is not treated in other courses. May be repeated for credit. Prerequisite: Consent of instructor.

Cooperative Graduate Education

The P.C. Rossin College of Engineering and Applied Science permits graduate students to spend part of their research experience in industry, business, or a government agency. In general, the external research experience should be complementary to their graduate studies at Lehigh University and can count towards their degree program through ENGR 400 (Engineering Co-op for Graduate Students) and through thesis/dissertation credits (see below).

Subject to university/federal regulations, when enrolled in courses at Lehigh University, a student can work for a maximum of 20 hours at the company/laboratory (co-op partner). If not enrolled in courses other than ENGR 400 and for thesis (490) or dissertation (499) credits, a student will be permitted to work full time at the co-op partner. Full time employment over the summer will also be permitted. Maintenance of full-time status, however, requires that during the semester students must be registered for the minimum number of credit hours as listed in R&P.

MS/MEng Co-op programs

- ENGR 400 can be taken for a maximum of 6 credits, with at most 3 credits in any registration period.
- A further 6 credits for thesis/project/independent study can be part of the industrial experience.
- Minimum of 18 course credit hours, excluding ENGR 400 and Thesis (490) must be obtained through Lehigh University

Ph.D. program

- Beyond the master's program, ENGR 400 can be taken for a maximum of 9 credits, with at most 3 credits in any registration period.
- In addition to ENGR 400 credits, a maximum of 9 dissertation credits (499) can also be obtained as part of the co-op experience.

ENGR 400. Engineering Co-op for Graduate Students
Supervised cooperative work assignment to obtain practical experience in field of study. Requires consent of department chairperson. When on a cooperative assignment, the student must register for this course to maintain continuous student status. Limit to at most 3 credits per registration period. No more than 6 credits can be applied towards a master's degree and no more than an additional 9 credits towards a Ph.D. The credits must be taken P/F.

Cooperative (Undergraduate) Education

The P.C. Rossin College of Engineering and Applied Science offers opportunities to students for cooperative work assignments with industrial or business firms and government agencies. In all cases, cooperative work assignments are optional on the part of the student and there is no obligation for the student to accept permanent employment nor for the cooperating organization to offer permanent employment.

The student must register for a full semester of courses in the summer prior to the first work assignment. When on a cooperative assignment, the student must roster ENGR 200, to maintain full-time student status, and must complete all required university procedures. The university treasurer establishes the fee for ENGR 200. Participation in a cooperative education program does not relieve the student from any regular requirement for the academic curriculum in which he or she is enrolled.

200. Cooperative Undergraduate Education (3-6)
Supervised cooperative work assignment to obtain practical experience. Prerequisite: acceptance into the program. Pass/fail grading only.

Design Arts

The Design Arts program engages the undergraduate liberal arts student in creative work that focuses on visual communication design with an emphasis on digital media. The program emphasizes the creation of art and design using digital technology instead of a pottery wheel or an easel.

Design Arts is a multidisciplinary major emphasizing the intersection of design with the fields of art, architecture, applied art, industrial art, and all their related fields. Therefore, the programmatic emphasis is on establishing a broad spectrum of inter-related courses within the major so as to address the myriad issues confronting the modern designer.

The major is designed to provide a firm foundation in traditional studio work. The foundation courses enhance all areas of the design concentration and provide a common background of experience and knowledge. The program also contains a wide range of intellectual bases in theory and history in order to afford each individual student a broad perspective.

Design Arts courses introduce students to the fields of design (graphic, product, and computer generated). Students interested in pursuing a major will be prepared to advance to graduate training or entry level positions in design. In addition to a General Studies option, which offers a broad topical approach to the expansive field of design, students may choose one of three more focused concentrations. (1) Graphic Design will prepare students for entry-level positions in a wide range of fields, including the printing industry, web based media, exhibition design, publishing advertising, and posters, or they may enter graduate programs and pursue MFA degrees. (2) Product Design students study the creation and application of creating objects for use in, for example, industrial applications, art objects, furniture, toys, exhibit and trade design, electronic products, household items, and recreational equipment. The industrial designer works closely with engineers, marketers, and ergonomists to create products. (3) Students studying Digital Imaging will learn the production of computer-generated imagery for the information and entertainment fields. Digital imagists produce animation, special effects, and interactive media and create for films, games, special effects, motion graphics and other fields.

The program also offers minors in Graphic Design, Product Design, Digital Imaging, and Web Design. Students interested in the Design Arts program may contact Prof. Drew Francis (Theatre Department, *dmf4@lehigh.edu)* for more information.

Design Arts Major

1. **Media Skills Sequence (12-13 credit hours)**
   a. DES/ART 3 Design Foundations I (3)
   b. DES/ART 4 Design Foundations II (3)
   c. DES 5 Digital Foundation (3)
   d. Choose one of the following (in consultation with the major advisor):
      ART 11 Drawing I (3)
      ART 35 Painting I (3)
      ART 13 Sculpture I (3)
      ART 15 Figure (3)
      THTR 87 Design for the Theatre (4)

2. **Theory Sequence (minimum 6 credits)**
   a. DES 60 Design Process (3)
   b. Choose one from the following (in consultation with the major advisor):
      DES/ART 68 Color Theory (3)
      DES 164 Ergonomics (3)

3. **History and Intellectual Context Sequence (9 credits, minimum)**

Choose at least one of the following Design courses:
DES 66 Design History (3)
DES 266 History of Contemporary Design (3)
DES 366 Case Studies in Design History (3)

Other courses that may be used in addition to at least one of the above:

ANTH 376	Culture and the Individual (4)
ART 1	Art History: Ancient and Medieval (3)
ART 2	Art History: Renaissance to Present (3)
ARCH 1	Architectural History I (3)
ARCH 2	Architectural History II (3)
HUM 126	Professional Ethics (4)
IR 23	Alternative World Views (4)
ART 179	History of Photography (1)
ART/ARCH 206	Medieval Art and Architecture (3)
ART/ARCH 207	Renaissance Art and Architecture (3)
ARCH 209	Architecture and Ideas (3)
ARCH 210	20th-Century Architecture (3)
ART 120	20th-Century Art (4)
CSE 252	Computers, the Internet, and Society (3)
PHIL 250	The Minds of Robots and Other People (4)
PHIL 123	Aesthetics (4)
PSYCH 140	Introduction to Linguistics (4)
SSP 135	Human Communication (4)
SSP 327	Mass Communication and Society (4)
MKT 313	Marketing Communication (3)
ARTS 250	Communication: Cultures, Behaviors, Attitudes (3)
THTR 129	History of Fashion and Style (4)

4. **Design Sequences for Major Concentrations (21 Credits, minimum)**

The student must complete Design Foundations I, Design Foundations II, and Digital Foundation prior to completing the Design Sequence. It is strongly recommended that the three foundation courses be completed prior to beginning the major concentration.

a. General Studies

Select at least 21 credits of coursework from the available courses in Design Arts and ART, Architecture and Design in consultation with the Design Arts major advisor.

b. Graphic Design concentration

Required concentration courses (12 credits)

DES/ART 53	Graphic Design I (3)
DES/ART 153	Graphic Design II (3)
DES/ART 253	Graphic Design III (3)
ART 77	Photography I (3)

Select at least 9 credits from the following:

DES 70	Web Design I (3)
DES 170	Web Design II (3)
DES 80	Computer Imaging I (3)
DES 40	Product Design I (3)

DES/ENGR/ BUS 211	Integrated Product Development (IPD) Projects I (3)
DES/ENGR/ BUS 212	Integrated Product Development (IPD) Projects II (2)
DES 260	Exhibit Design (3)
DES 375	Design Internship (1-4)
ARCH/CE 10	Engineering/Architectural Graphics & Design (3)
ART 11	Drawing I (3)
ART 35	Painting I (3)
ART 275	Museography and Museology (4)
DES 268	Advanced Design Project (1-4)
DES 370	Special Topics in Design (1-4)
THTR 250	Lighting Design (4)
THTR 251	Scene Design (4)
CSE 12	Survey of Computer Science (3)
CSE 332	Multimedia Design and Development (3)

c. Product Design concentration

Required concentration courses (12 credits)

DES 40	Product Design I (3)
DES 140	Product Design II (3)
DES 240	Product Design III (3)
DES/ART 148	Furniture Design I (3)

Select at least 9 credits from the following:

DES 80	Computer Imaging I (3)
DES 70	Web Design I (3)
DES/ART 53	Graphic Design I (3)
DES 260	Exhibit Design (3)
DES/ENGR/ BUS 211	Integrated Product Development (IPD)Projects (3)
DES/ENGR/ BUS 212	Integrated Product Development (IPD)Projects II (2)
DES 375	Design Internship (1-4)
DES/ART 248	Furniture Design II (3)
ART 11	Drawing I (3)
ART 35	Painting I (3)
ARCH/CE 10	Engineering/Architectural Graphics and Design (3)
ART 77	Photography I (3)
ART 175	Museum Work (3)
ART 275	Museography and Museology (4)
DES 268	Advanced Design Project (1-4)
DES 370	Special Topics in Design (1-4)
THTR 251	Scene Design (4)
THTR 252	Costume Design (4)
THTR 250	Lighting Design (4)

d. Digital Imaging concentration

Required concentration courses (12 credits)

DES 80	Computer Imaging I (3)
DES 180	Computer Imaging II (3)
DES 280	Computer Imaging III (3)
DES/ART 53	Graphic Design I (3)

Select at least 9 credits from the following:

DES 70	Web Design I (3)
DES 170	Web Design II (3)
DES 148	Furniture Design I (3)
DES/ENGR/ BUS 211	Integrated Product Development (IPD)Projects I (3)
DES/ENGR/ BUS 212	Integrated Product Development (IPD)Projects II (2)
DES 375	Design Internship (1-4)
ART 11	Drawing I (3)
ART 35	Painting I (3)
ART 77	Photography I (3)
ART 175	Museum Work (3)
ARCH/CE 10	Engineering/Architectural Graphics and Design (3)
DES 268	Advanced Design Project (1-4)
DES 370	Special Topics in Design (1-4)
THTR 251	Scene Design (4)
THTR 252	Costume Design (4)
CSE 12	Survey of Computer Science (3)
CSE 332	Multimedia Design and Development (3)

Design Arts Minors

1. Graphic Design minor (total 18 to 20 credits)

a. Foundation (6 credits); choose two from the following:

DES/ART 3	Design Foundations I (3)
DES/ART 4	Design Foundations II (3)
DES 5	Digital Foundation (3)

b. Theory and History (3 to 4 credits); choose one of the following:

DES 60	Design Process (3)
DES/ART 68	Color Theory (3)
DES 266	History of Contemporary Design (3)
DES 164	Ergonomics (3)
DES 366	Case Studies in Design History (3)

c. Concentration (9 to 10 credits):

DES/ART 53	Graphic Design I (3)
DES/ART 153	Graphic Design II (3)

Elective in Design (to be chosen in consultation with advisor)

2. Product Design minor (total 18 to 20 credits)

a. Foundation (6 credits); choose two from the following:

DES/ART 3	Design Foundations I (3)
DES/ART 4	Design Foundations II (3)
DES 5	Digital Foundation (3)

b. Theory and History (3 to 4 credits); choose one of the following:

DES 60	Design Process (3)
ART/DES 68	Color Theory (3)
DES 266	History of Contemporary Design (3)
DES 164	Ergonomics (3)
DES 366	Case Studies in Design History (3)

c. Concentration (9 to 10 credits):

DES 40	Product Design I (3)
DES 140	Product Design II (3)

Elective in Design (to be chosen in consultation with advisor)

3. Digital Imaging minor (total 18 to 20 credits)

a. Foundation (6 credits); choose two from the following:

DES/ART 3	Design Foundations I (3)
DES/ART 4	Foundation Design II (3)
DES 5	Digital Foundation (3)

b. Theory and History (3 to 4 credits); choose one of the following:

DES 60	Design Process (3)
DES/ART 68	Color Theory (3)
DES 266	History of Contemporary Design (3)
DES 164	Ergonomics (3)
DES 366	Case Studies in Design History (3)

c. Concentration (9 to 10 credits):

DES 80	Computer Imaging I (3)
DES 180	Computer Imaging II (3)

Elective in Design (to be chosen in consultation with advisor)

4. Web Design minor (total 18 to 20 credits)

a. Foundation (6 credits); choose two from the following:

DES/ART 3	Design Foundations I (3)
DES/ART 4	Design Foundations II (3)
DES 5	Digital Foundation (3)

b. Theory and History (3 to 4 credits); choose one of the following:

DES 60	Design Process (3)
DES/ART 68	Color Theory (3)
DES 266	History of Contemporary Design (3)
DES 164	Ergonomics (3)
DES 366	Case Studies in Design History (3)

c. Concentration (9 to 10 credits):

DES 70	Web Design I (3)
DES 170	Web Design II (3)

Elective in Design (to be chosen in consultation with advisor)

Undergraduate courses

DES 3. (ART 3) Design Foundations I (3)
An introduction to the basic elements and principles of design. Course involves use of various materials to solve 2-D design problems in studio and computer lab. Required for all majors in department. Staff (**HU**)

DES 4. (ART 4) Design Foundations II (3)
An introduction to the basic elements and principles of design. Course involves use of various materials to solve 3-D design problems in studio and computer lab. Problem solving in variety of materials for 3-D design including assemblages, models, constructions, and conceptual forms. Required for all majors in department. Staff (**HU**)

DES 5. Digital Foundation (3)
Introduction to a variety of 2-D and 3-D software applications for digital design. Students will acquire a basic understanding of digital image manipulation, graphic layout tools, 2-D CAD techniques, and 3-D rendering. (**ND**)

DES 40. Product Design I (3)
Introduction to the field of Industrial Design. Through the reverse engineering of existing products and analysis of these artifacts with drawing and modeling, students will acquire an understanding of the various aesthetic, technological, and business issues a designer must consider when creating a product. Computer modeling milling to rapid prototype, three-dimensional design projects. Prerequisite: DES/ART 3. (**HU**)

DES 53. (ART 53) Graphic Design I (3)
Design principles are explored with emphasis on visual communication. Students learn basic concepts for design and typography including the vocabulary and historical precedence of graphic design and computer graphics. Introduction to professional-level formal exercises contributes to the development of visual thinking and original ideas. Prerequisite: ART/DES 3. (**HU**)

DES 60. Design Process (3)
Students will study how an idea becomes a final product by analyzing their own actions and role industrial designers play in the development of products. (**HU**)

DES 66. Design History (3)
History of product design in the context of a product's artistic, cultural, technological, and business context. (**HU**)

DES 68. (ART 68) Color Theory (3)
Application of color in design. Color in graphics, product, digital imaging, and all related fields of design. (**HU**)

DES 70. Web Design I (3)
Introduction to the design and fabrication of web pages. Students will learn how to create pages using HTML and web fabrication software, with an emphasis on aesthetic and structure. (**ND**)

DES 80. Computer Imaging I (3)
Introduction to 3-D computer modeling, animation, and rendering, commonly used in the entertainment industry. Students create and edit an original 3-D animated movie. Students will also learn about 2-D and 3-D visualization techniques, used in the creation of storyboards and the narrative of the movie. Prerequisite: DES/ART 3.

DES 140. Product Design II (3)
Introduction to manufacturing and materials for the industrial/product designer. Model-making and investigating the interaction of the product and the application. The emphasis is on user-centered design. Students will create original product designs, developing proficiency in various traditional and virtual visualization techniques and learn about product styling. Prerequisite: DES 40. (**ND**)

DES 148. Furniture Design I (3)
Design methodology, fabrication techniques, and methods of design presentation. Prerequisite: DES/ART 4. (**HU**)

DES 153 (ART 153). Graphic Design II (3)
Aspects of design are inter-related in function, concept or planning processes. Students focus on the poster in order to solve a variety of contemporary design problems. Professional-level formal team exercises include a series of informative posters, identify systems, publication, and advertising design. Computer graphics and Macintosh lab are employed as integral design tools in graphic design. Prerequisite: ART/DES 53 (**HU**)

DES 164. Ergonomics (3)
Introduction to physical, emotional, and psychological ways design interacts with people. Analyze real design problems and create solutions. (**HU**)

DES 170. Web Design II (3)
Creation of dynamic content in web design. Various 2-D animation software applications and simple scripting will be explored. Prerequisite: DES 70. (ND)

DES 180. Computer Imaging II (3)
Creation of original 3-D models, renderings, and animations, while learning advanced modeling techniques, character animation, particles, and compositing. Prerequisite: DES 80. (ND)

DES 211. Integrated Product Development (IPD) 1 (3) spring
Business, engineering, and design arts students work in cross-disciplinary teams of 4-6 students on conceptual design including marketing, financial and economic planning, economic and technical feasibility of new product concepts. Teams work on industrial projects with faculty advisers. Oral presentations and written reports. Prerequisite: junior standing in business, economics, arts, design or engineering. Mechanical Engineering students must register for ME 211. (ND)

DES 212. Integrated Product Development (IPD) 2 (2) fall
Business, engineering, and design arts students work in cross-disciplinary teams of 4-6 students on the detailed design including fabrication and testing of a prototype of the new product designed in the IPD course 1. Additional deliverables include a detailed production plan, marketing plan, detailed base-case financial models, project and product portfolio. Teams work on industrial projects with faculty advisors. Oral presentations and written reports. Prerequisite: BUS/DES/ ENGR 211. (ND)

DES 240. Product Design III (3)
Development of products with emphasis on innovative ways of understanding the role of the object in people's lives. Prerequisite: DES: 140. (ND).

DES 248. (ART 248) Furniture Design II (3)
Advanced fabrication. Contemporary art issues and furniture history. Prerequisite DES/ART 148. (HU)

DES 253 (ART 253) Graphic Communication III (3)
A combination workshop/seminar course in which the student, as part of a design team, through classroom and individual discussion with the instructor and respective non-profit clients, develops and produces a minimum of two major design projects. Readings and classroom discussions of contemporary graphic design history and current trends form an essential part of the course. Prerequisite: DES/ART 153 (HU)

DES 260. Exhibit Design (3)
Team projects in development of exhibits for museums, conferences, or educational centers. Project work is supplemented by lectures and demonstrations. Teams will produce real and virtual exhibit prototypes and will design and maintain an exhibit website. (HU)

DES 266. History of Contemporary Design (3)
History of modern design from mid-19th century to the present. Studies and discussion of contemporary issues and technology in Design Arts. Topics will include green design, digital technology, current legal and ethical principles, and other issues. (HU)

DES 268. Advanced Design Projects (1-4)
Advanced projects or studies applying Design Arts practices or theories. Prerequisite: consent of instructor. May be repeated for credit. Department permission required. (ND)

DES 280. Computer Imaging III (3)
Advanced animation with emphasis on experimental techniques and new technologies in animation and motion graphics. Emphasis on effects, compositing, and the use of digital technology in the post-production process. Students will work on various assignments to gain a first-hand understanding of how various tools and techniques are used to create realistic effects. Prerequisite: DES 180. (ND)

DES 366. Case Studies in Design History (3)
History of design. Study of specific products in context with regard to their impact on art, culture, and technology. (HU)

DES 370. Special Topics in Design (1-4)
Current topics in design, with selected readings, discussions, and studio work as required. May be repeated for credit. Prerequisite: two 100-level Design courses. Department permission. (ND)

DES 375. Design Internship (1-4)
Practical experience following apprenticeship model. Requires approval of instructor and host prior to beginning of the term, with a memorandum of understanding outlining student work responsibilities and educational objectives for the experience. (ND)

DES 376. Design Thesis (3)
Project or presentation in a selected area of design. Intended for senior majors in design. Prerequisite: consent of the director in conjunction with advisor. (ND)

Earth and Environmental Sciences

Professors. Gray E. Bebout, Ph.D. (U.C., Los Angeles); Edward B. Evenson, Ph.D. (Michigan); Kenneth P. Kodama, Ph.D. (Stanford); Anne S. Meltzer, Ph.D. (Rice); Craig E. Williamson, Ph.D. (Dartmouth); Peter K. Zeitler, Ph.D. (Dartmouth).

Associate professors. David J. Anastasio, Ph.D. (Johns Hopkins); Bruce R. Hargreaves, Ph.D. (U.C., Berkeley); Donald P. Morris, Ph.D. (Colorado); Carl O. Moses, Ph.D. (Virginia), associate dean of the College of Arts and Sciences; Frank J. Pazzaglia, Ph.D. (Penn State).

Assistant professors. Lisa Windham, Ph.D. (Rutgers); Zicheng Yu, Ph.D. (Toronto); Steve Peters, Ph.D. (Michigan).

Adjunct professor. Daniel E. Lawson, Ph.D. (Illinois).

Research scientists. Gabriella Dee, Ph.D. (Lehigh); Bruce D. Idleman, Ph.D. (SUNY, Albany); Kirsten Kessler, Ph.D. (Max Plank Institute); Bangyeon Kim, Ph.D. (Lehigh); Robert E. Moeller, Ph.D. (Cornell); Stéphane Sol, Ph.D. (Queen's University).

Emeritus professors. Paul B. Myers, Jr., Ph.D. (Lehigh); Dale R. Simpson, Ph.D. (Caltech); Bobb Carson, Ph.D. (Washington).

The Department of Earth and Environmental Sciences (EES) is Lehigh's home for teaching and research in the areas of ecology, environmental science, and geology. Matters of environmental quality and natural resources will increasingly impact people and society in the years to come, and the EES department offers a range of undergraduate and graduate programs that provide students with an understanding of Earth's biosphere, atmosphere, lithosphere, and hydrosphere, with an emphasis on how these components function as an integrated Earth system. Training in Earth and Environmental Sciences can lead to technical and scientific careers in research, environmental consulting, government agencies, and the petroleum industry, and can also serve as an excellent liberal arts degree that provides context and preparation for careers in areas such as law, policy, journalism and economics.

Faculty in the EES department have a wide range of interests and strong reputations in the fields of geology, ecology, and environmental sciences. In instruction at all levels, the department emphasizes field experiences and experiential learning, as well as the development of quantitative and communication skills. The EES department maintains a relaxed and personal atmosphere in which students can interact with faculty in many ways, including seminars, special symposia on topics of the students' choice, field research, departmental field trips and social events like picnics, canoe trips, softball games, and fishing expeditions.

At the undergraduate level, students may choose from a number of degree programs, including a B.A. in Earth and Environmental Sciences and separate B.S. degree programs in Environmental Sciences, Ecology, and Geological Sciences. The flexible B.A. program provides students an opportunity to acquire breadth, design a specialized program, or find room for a double major. This degree is well suited to students with career aspirations in areas such as engineering, environmental law, journalism, economics, government, among many other possibilities. The B.S. degrees, while still offering considerable flexibility, provide the more in-depth technical training required for graduate school and scientific careers, and are well suited for students seeking employment as professionals in the earth and environmental sciences.

An accessible minor program is available for students wishing to add insight into earth and environmental sciences to any number of other technical or non-technical degree programs, helping students distinguish themselves as they prepare to enter today's fast-evolving job markets and graduate programs. The department also offers a five-year program that combines a B.A. or B.S. degree with an M.S. degree in earth and environmental sciences.

For students with strong interests in areas such as hydrology, water and soil remediation, hazards and associated engineering and construction strategies, EES, in conjunction with the Department of Civil and Environmental Engineering (CEE), offers a-five-year program leading to dual B.S. degrees in EES and CEE (students having these interests may also want to see the description of the B.S. in Environmental Engineering in the catalog entry for the Department of Civil and Environmental Engineering).

EES offers graduate training leading to either the M.S. or Ph.D. in Earth and Environmental Sciences. The EES graduate program is marked by close faculty-student collaboration. Graduate students can take advantage of strong externally funded faculty research programs and the extensive analytical and computing facilities available in the department; these facilities and specific EES research programs are described in some detail on the EES departmental web page at www.ees.lehigh.edu.

Field Work and Experiential Learning

The EES department offers its students diverse and abundant field experiences. Supervised internships coordinated by the Lehigh Earth Observatory (LEO) allow students at all levels to become engaged in projects involving cross-disciplinary research, assessment, and consulting work. A 6-credit, 4-week field geology camp conducted each summer in the Rocky Mountains, (EES 341), and a parallel program in the Rockies available to introductory-level students (EES 41) provides field-based training. Students can participate in the department's long-standing research programs in limnological and ecological research in the Pocono Lakes region, and participate in a summer course in lake ecosystems offered in the Poconos. Undergraduate students can also become involved in forefront research programs. In recent years, students have played a role in research in the Himalaya, Alaska, California, Idaho, Argentina, and Italy, in addition to more nearby sites in Pennsylvania, West Virginia, New York, and New Jersey. Most EES undergraduate- and graduate - level courses include field experiences in the form of one-day or weekend-long field trips, and the department sponsors an annual field trip, for all interested EES members (past destinations have included Puerto Rico, Iceland, Scotland, Newfoundland, Argentina, and the Grand Canyon).

The following descriptions of programs in the Department of Earth and Environmental Sciences are organized as follows:

Minor in Earth and Environmental Sciences
Bachelor of Arts Degree in Earth and Environmental Sciences
Bachelor of Sciences Degrees in:
Environmental Sciences
Ecology
Geological Sciences
Combined B.A. or B.S. and M.S. Program in Earth and Environmental Sciences
Department Honors in Earth and Environmental Sciences
Civil and Environmental Engineering and Earth and Environmental Sciences (Dual B.S. Degrees Program)

Graduate Studies

Requirements for a Minor in Earth and Environmental Sciences

A minor is designed for students wishing to explore an area of Earth or Environmental Sciences in conjunction with a major program in another field for personal development or career enhancement.

The Earth & Environmental Sciences minor program consists of any 4 EES courses, for a minimum of 15 credits, approved by an EES advisor. Natural science (**NS**) designated EES College seminars (EES 90) may be used to meet minor requirements. Ideally, a minor should focus on a particular area of Earth or Environmental Sciences, For example, any four courses from the following foci:

Aquatic Sciences (EES 21, 31, 257, 316, 351, 376, 386)
Earth System Science (EES 21, 31, 282, and 112 or 152)
Ecology (EES 31, 152, 253, 255, 351, 357, 384)
Environmental Science (EES 3, 11, 21, 31, 183, 282, 385)
Geochemistry (EES 21, 131, 273, 334, 376)
Geology (EES 21, 41, 131, 213, 223, 341)
Geophysics (EES 21, 201, 204, 223, 303, 305, 309)
Surficial Processes (EES 11, 21, 41, 112, 213, 316, 357)

Degree Requirements for a B.A. in Earth and Environmental Sciences

The B.A. degree is designed with flexibility in mind and is recommended for students interested in a sound liberal arts degree that will permit them to bring a scientific perspective to a wide variety of careers. The degree also permits students to take a double major, or design a specialized program tailored to specific topics in the earth and environmental sciences. Students who choose the B.A. but are interested in attending graduate school should talk to their faculty advisor and consult the B.S. program descriptions to see the type of requirements that may be required for graduate admission.

University and College Requirements (at least 26 credits)

Arts and Science 1 (1)
College Seminar (3)
English Composition (2 courses for 6 credits)

Distribution requirements (at least 2 humanities courses for at least 8 credits and at least 2 social science courses for at least 8 credits)

Junior Writing Requirement:

The ability to express oneself clearly in writing is a critical skill for success in any chosen career. It is also integral to the learning experience. Students are encouraged to take courses that help develop written skills in their major. To help ensure this, the College of Arts and Sciences requires each student to complete at least one writing intensive course and receive certification from the instructor of that course. EES 213 (Process Sedimentology, Stratigraphy, and Surficial Processes); EES 255 (Ecological Field Methods) and EES 257 (Methods in Water Quality Analysis) are designated as writing intensive in EES and fulfill the junior writing requirement. Students may also fulfill this requirement by taking writing intensive courses in other departments (although this is not encouraged).

MATH and Collateral Science Requirements (at least 8 credits)

1 semester of math equivalent to MATH 12 or above for at least 4 credits.

1 additional course from Chemistry, MATH, or Physics, for at least 4 credits.

Students interested in scientific careers or pursuing graduate education in the sciences are recommended to take at least two additional math and collateral science courses chosen in consultation with an advisor.

Required courses for the major (at least 32 credits)

Required Core (8 credits)

EES 21	Introduction to Planet Earth (4)
EES 31	Introduction to Environmental and Organismal Biology (4)

Major electives (24 credits)

6 other EES courses at the 100 level or above for at least 24 credits. One of these courses must be designated as an EES senior seminar (EES 303, 326, 359, 379, 385). May include up to 2 Biosciences courses including Bios 31/32. College seminar (EES 90), Supervised Internship (EES 293) and Supervised Research (EES 393) credits do not count towards the 32 credit major requirement.

Free electives

Courses chosen from anywhere in the University's curriculum, sufficient credits to bring the total to a minimum of 121 credits.

Degree Requirements for Bachelor of Sciences Degree Programs in EES

The Department of Earth and Environmental Sciences offers three B.S. programs, in Environmental Sciences, Geological Sciences, and Ecology, for which the specific requirements are itemized below. For all three of the B.S. degree programs, the following courses are required (in addition to the requirements specific to the three B.S. programs and listed in the next sections):

University and College Requirements (at least 26 credits)

Arts and Science 1 (1)
College Seminar (3)
English Composition (2 courses for 6 credits)
Distribution requirements (at least 2 humanities courses for at least 8 credits and at least 2 social science courses for at least 8 credits).

Junior Writing Requirement:

The ability to express oneself clearly in writing is a critical skill for success in any chosen career. It is also integral to the learning experience. Students are encouraged to take courses that help develop written skills in their major. To help ensure this, the College of Arts and Sciences requires each student to complete at least one writing intensive course and receive certification from the instructor of that course. EES 213 (Process Sedimentology, Stratigraphy, and Surficial Processes); EES 255 (Ecological Field Methods); and EES 257 (Methods in Water Quality Analysis) are designated as writing intensive in EES and fulfill the junior writing requirement. Students may also fulfill this requirement by taking writing intensive courses in other departments, although this is not encouraged.

B.S. in Environmental Sciences

MATH and Collateral Science Requirements (24 credits)

MATH 21	Calculus I (4) or MATH 51 Survey of Calculus I (4)
MATH 12	Basic Statistics (4) **or** other approved statistics course
CHEM 21 and CHEM 22	Introduction to Chemical Principles Lecture and Lab (5) **and**
CHEM 31	Chemical Equilibria in Aqueous Solutions (3) **or**
CHEM 75	Concepts, Models, and Experiments I (4) **and**
CHEM 76	Concepts, Models, and Experiments II (4)
Physics 10	General Physics I (4) **or**
Physics 11	Introductory Physics (4) **and**
Physics 12	Introductory Physics Laboratory (1)

MATH and collateral science elective for at least 3 credits (3)

Be advised that many graduate programs in science and many employment opportunities require additional courses in math and collateral sciences. Talk with an advisor about career objectives and recommended math and collateral science skills.

Required Courses for the Major (at least 55 credits)

Required Core (32)

EES 21	Introduction to Planet Earth (4) (Note: possible substitution by EES 41)
EES 31	Introduction to Environmental and Organismal Biology (4)
EES 112	Geomorphology (4)
EES 131	Introduction to Rocks and Minerals (4)
EES 152	Ecology (4)
EES 273	Environmental Thermodynamics (4)
EES 282	Climate, Geosphere, and Biosphere (4)

One of the following senior seminars:

EES 379	Environmental Case Studies (4)
EES 385	Human Impact on Natural Environment (4)

Major Electives: 6 courses for at least 23 credits with at least 1 course from each of the following 4 categories

At least one of the following in Water Resources

EES 257	Methods in Water Quality Analysis (4)-Junior writing
EES 316	Hydrogeology (4)
EES 351	Limnology (4)-senior seminar
EES 376	Geochemistry of Natural Waters (4)
CE 274	Environmental Water Chemistry (3)
CE 320	Flood Hydrology and Hydraulics (3)
CE 326	Engineering Groundwater Hydrology (3)
CE 327	Surface Water Quality Modeling (3)

At least one of the following in Environmental Biology

EES 253	Plants and Plant Communities (4)
EES 259	Microbial Ecology (4)
EES 265	Environmental Animal Physiology (4)
EES 357	Paleoecology and Landscape History (4)
EES 386	Wetlands (4)
CE 376	Environmental Biotechnology (3)

At least one of the following in Environmental Methods and Systems

EES 109	Geographic analysis of our changing world (4)
EES 113	Life, Climate, and the Rock Record (4)
EES 183	Environmental Instruments and Data (4)
EES 204	Environmental Geophysics (4)
EES 255	Ecological Field Methods (4)-Junior writing
EES 287	Introduction to Environmental Isotopes (2)
EES 319	GIS and Computational Analysis in Geomorphology (4)
EES 341	Field Geology (8)-Field experience
EES 384	Lake Ecosystems (4)-Field experience
CE 170	Introduction to Environmental Engineering (3)

At least one of the following in Landscape Materials and Processes

EES 213	Process Sedimentology, Stratigraphy, and Surface Processes (4) - Junior writing
EES 223	Structural Geology and Tectonics (4)
EES 303	Active Tectonics (4)
EES 309	Mineral Magnetism and Earth Processes (4)
CE 142	Fundamentals of Soil Mechanics (3)
CE 143	Soil Mechanics (3)

Note: EES 393 (Supervised Research in EES) and EES 293 (Supervised Internship in EES) (1-4) may be applied towards the major elective requirement at the advisor's discretion. A maximum of 2 credits of EES 293 may be applied towards the degree; a maximum of 4 credits of EES 393 and 293 combined may be applied towards the degree.

Free Electives:

Courses chosen from anywhere in the University's curriculum, sufficient credits to bring the total to a minimum of 121.

Field Experience:

Course, internship, or employment preapproved by the advisor meet the EES field experience requirement. Course credit is not required to fulfill this requirement; however, EES 41, 341, and 384 will satisfy this requirement.

B.S. in Ecology

MATH and Collateral Science Requirements (at least 31 credits)

MATH 21 Calculus I (4) (can be replaced by MATH 75 (2) and MATH 76 (2)) **and** MATH 22 Calculus II (4)
or
MATH 51 Survey of Calculus I (4) and MATH 52 Survey of Calculus II (3)
MATH 12 Basic Statistics (4) or another approved statistics course
CHEM 21 and CHEM 22 Introduction to Chemical Principles Lecture and Lab (5) **and**
CHEM 31 Chemical Equilibria in Aqueous Solutions (3), **or**
CHEM 75 Concepts, Models, and Experiments I (4) and CHEM 76 Concepts, Models, and Experiments II (4)
PHYS 10 General Physics I (4) **or** Physics 11 Introductory Physics (4)

PHYS 12	Introductory Physics Laboratory (1)
BIOS 31	Introduction to Cell and Molecular Biology (3)
BIOS 32	Introduction to Cell and Molecular Biology Lab (1)
BIOS 101	Genetics (3)

Required Courses for the Major (at least 52 credits)

Required Core (32 credits)

EES 21	Introduction to Planet Earth (4) (Note:possible substitution by EES 41)
EES 31	Introduction to Environmental and Organismal Biology (4)
EES 152	Ecology (4)
EES 253	Plants and Plant Communities (4)
EES 259	Microbial Ecology (4)
EES 265	Environmental Animal Physiology (4)
EES 282	Climate, Geosphere, and Biosphere (4)
EES 359	Case Studies in Ecosystem Ecology (4)-senior seminar

One of the following in Earth's Surface Processes

EES 112	Geomorphology (4)
EES 213	Process Sedimentology, Stratigraphy, and Surface Processes (4)-Junior writing
EES 316	Hydrogeology (4)
EES 376	Geochemistry of Natural Waters

Two of the following in Ecological Processes

EES 255	Ecological Field Methods (4)-Junior writing
EES 351	Limnology (4)-senior seminar
EES 357	Paleoecology and Landscape History (4)
EES 384	Lake Ecosystems (4)-Field experience
EES 386	Wetlands (4)

Major electives chosen from the following list for at least 8 credits

EES 109	Geographic Analysis of our Changing World (4)
EES 112	Geomorphology (4)
EES 113	Life, Climate, and the Rock Record (4)
EES 183	Environmental Instruments and Data (4)
EES 213	Process Sedimentology, Stratigraphy, and Surficial Processes (4)-Junior writing
EES 255	Ecological Field Methods (4)-Junior writing
EES 257	Methods in Water Quality Analysis (4)-Junior writing
EES 287	Introduction to Environmental Isotopes (2)
EES 316	Hydrogeology (4)
EES 351	Limnology (4)-senior seminar
EES 357	Paleoecology and Landscape History (4)
EES 376	Geochemistry of Natural Waters (4)
EES 384	Lake Ecosystems (4)-Field experience
EES 386	Wetlands (4)
Bios 133	Invertebrate Zoology (4)
Bios 241	Vertebrate Natural History (4)
Bios 317	Evolution (3)
Bios 324	Bacteriology (3)
Bios 325	Bacteriology Lab (2)
Bios 329	Herpetology (3)
Bios 335	Animal Behavior (3)
Bios 336	Animal Behavior Laboratory (3)
Bios 337	Behavioral Ecology (3)

Note: EES 293 (Supervised Research in EES) and EES 293 (Supervised Internship in EES) (1-4) may be applied towards the major elective requirement at the advisor's discretion. A maximum of 2 credits of EES 293 may be applied towards the degree; a maximum of 4 credits of EES 393 and 293 combined may be applied towards the degree.

Free Electives:

Courses chosen from anywhere in the University's curriculum, sufficient credits to bring the total to a minimum of 121.

Field Experience:

Course, internship, or employment preapproved by the advisor meet the EES field experience requirement in field-oriented ecology. Course credit is not required to fulfill this requirement; however, EES 384 will satisfy this requirement.

B.S. in Geological Sciences

MATH and Collateral Science Requirements (at least 24 credits)

MATH 21 Calculus I (4) (can be replaced by MATH 75 (2) and MATH 76 (2)) and MATH 22 Calculus II (4),

or

MATH 51 Survey of Calculus I (4) and MATH 52 Survey of Calculus II (3)

CHEM 21 and CHEM 22 Introduction to Chemical Principles Lecture and Lab (5) and CHEM 31 Chemical Equilibria in Aqueous Solutions (3)

or

CHEM 75 Concepts, Models, and Experiments I (4) and CHEM 76 Concepts, Models, and Experiments II (4)

Physics 10 General Physics I (4) and Physics 12 Introductory Physics Laboratory I (1) and Physics 13 General Physics and Physics 14 General Physics Laboratory

or

Physics 11 Introductory Physics I (4) and Physics 12 Introductory Physics Laboratory I (1) and

Physics 21 Introductory Physics II (4) and Physics 22 Introductory Physics Laboratory II (1)

Required Courses for the Major (at least 54 credits)

Required Core (30)

EES 21	Introduction to Planet Earth (4) (Note: possible substitution by EES 41)
EES 31	Introduction to Environmental/Organismal Biology (4)
EES 113	Life, Climate, and the Rock Record (4)
EES 131	Introduction to Rocks and Minerals (4)
EES 213	Process Sedimentology, Stratigraphy, and Surface Processes (4)-Junior writing
EES 223	Structural Geology and Tectonics (4)
EES 341	Field Geology (6)-Field experience

One of the following in Surface Processes

EES 112	Geomorphology (4)
EES 316	Hydrogeology (4)

One of the following in Geophysics

EES 301	Seismology, (4)
EES 305	Geodynamics (4)
EES 309	Mineral Magnetism and Earth Processes (4)

One of the following in Geochemistry or Petrology

EES 334	Petrology of the Crust and Mantle (4)
EES 376	Geochemistry of Natural Waters (4)

One of the following senior seminars

EES 303	Active Tectonics (4)
EES 326	Geologic Evolution of North America (4)

Major electives chosen from the following list for at least 8 credits

EES 112	Geomorphology (4)
EES 273	Environmental Thermodynamics (4)
EES 282	Climate, Geosphere, Biosphere (4)
EES 287	Introduction to Environmental Isotopes (2)
EES 301	Seismology (4)
EES 303	Active Tectonics (4) - Senior seminar
EES 305	Geodynamics (4)
EES 309	Mineral Magnetism and Earth Processes (4)
EES 316	Hydrogeology (4)
EES 319	Computational Geomorphology (4)
EES 326	Geological Evolution of North America (4)-senior seminar
EES 334	Petrology of the Crust and Mantle (4)

EES 357	Paleoecology and Landscape History (4)
EES 376	Geochemistry of Natural Waters (4)
EES 386	Wetlands (4)

Note: EES 393 (Supervised Research in EES) and EES 293 (Supervised Internship in EES) (1-4) may be applied towards the major elective requirement at the advisor's discretion. A maximum of 2 credits of EES 293 may be applied towards the degree; a maximum of 4 credits of EES 393 and 293 combined may be applied towards the degree.

Free Electives:
Courses chosen from anywhere in the University's curriculum, sufficient credits to bring the total to a minimum of 121.

Field Experience:
Course, internship, or employment preapproved by the advisor meet the EES field experience requirement. Course credit is not required to fulfill this requirement; however, EES 41 and 341 will satisfy this requirement.

Combined B.A. or B.S. and M.S. Program in Earth and Environmental Sciences

The Department of Earth and Environmental Sciences offers a five-year combined B.A. or B.S. and M.S. program. The department offers an M.S. degree in Earth and Environmental Sciences (refer to the description of Graduate Programs in EES following the listing of undergraduate course descriptions). Students working toward the BA or B.S. degrees who are enrolled in this program complete the full requirements for either degree and apply some 300- and 400-level course credits taken as an undergraduate towards the M.S. degree without additional undergraduate tuition cost. The program is designed for those students who (1) will have at least nine credits of appropriate M.S. course credits in excess of undergraduate requirements completed by the end of the senior year, including one EES graduate core course (EES 415, 426, or 484), (2) have completed a minimum of three credits of EES 393 (Supervised Research) as part of the baccalaureate program, and (3) have demonstrated superior academic achievement.

Application for admission to the program should be made no later than the beginning of the first semester of the senior year and must be approved by the department's Graduate Instruction Committee. The application must include (1) a current baccalaureate degree audit, (2) the proposed M.S. course program, and (3) a letter of recommendation from the proposed M.S. thesis adviser. Students enrolled in this program should make application for admission to full-time graduate status during the first semester of the senior year.

After receiving the bachelor's degree and becoming enrolled in the graduate program students in the dual-degree program become eligible for financial aid including appointment to a teaching or research assistantship or graduate fellowship. Admission to the program does not guarantee financial aid.

Department Honors in Earth and Environmental Sciences

Students in either the B.A. or B.S. degree programs may undertake a program that leads to graduation with department honors. To participate, the student must (1) have a minimum major GPA of 3.25 and an overall cumulative GPA of 3.0 expected at graduation, (2) complete at least four credits of EES 393 (Supervised Research in Earth and Environmental Sciences), and (3) prepare a written honors thesis on the EES 393 research project. To graduate with honors students should (1) file a written request with the EES undergraduate instruction coordinator no later than the beginning of the senior year (preferably during the junior year), (2) constitute an advisory committee of two EES faculty plus the student's research supervisor to guide the research, (3) prepare a research proposal for committee's approval, and (4) give an oral presentation of research results and conclusions at a department seminar before the last day of classes in the second semester of the senior year. The committee should approve the research proposal and the honors thesis by signing the required form and cover sheet, which will be filed with the Department.

Civil and Environmental Engineering and Earth and Environmental Sciences

This program is designed for students interested in combining programs in two departments: Civil & Environmental Engineering and Earth & Environmental Sciences, leading to two bachelor of science degrees, civil engineering and one of the B.S. degrees in earth and environmental sciences (the EES department awards B.S. degrees in Environmental Sciences, Geological Sciences, and Ecology). Both degrees would be awarded at the end of the fifth year. This program is one of the dual degree programs mentioned in the Five-Year Programs section. The student will have a primary advisor in the P.C. Rossin College of Engineering and Applied Sciences and a secondary advisor in the Colleges of Arts and Sciences. The program provides alternatives for students who may decide not to complete the two-degree program. Students who make this decision prior to the beginning of the fourth year may qualify at the end of that year for the bachelor of science in civil engineering, as well as a minor in earth and environmental sciences. Also, if a student decides after two years to pursue only a bachelor of science degree in the EES department, it is possible to complete the requirements in four years. If the decision to work toward this degree is made during the fourth year, at least one additional semester is required to qualify for either B.S. degree. Interested students should consult with the respective departmental advisors to create a schedule of courses to resolve conflicts or if a specified course is not offered that semester. Required courses and major electives for the different EES B.S. degree programs are listed in the catalog entry for EES; note that the exact number of required EES courses varies slightly among the three B.S. programs (with required credits in required major courses ranging from 52 to 55), as do the courses and numbers of credits in the math and collateral sciences. Cross-listed EES/CEE courses used to satisfy Civil Engineering Approved Electives can reduce the individual semester and total program credits when chosen to satisfy EES program requirements. Additional useful information can be found on the web sites (www.lehigh.edu/~incee/incee.html and www.ees.lehigh.edu).

Suggested outline of courses

The freshman engineering year (see Section III) is often 31 credits by choosing a freshman H/SS Advanced Requirement elective of 3 credits, leaving 10 credits to be taken in subsequent years to complete the requirement of 13 credits, shown below to be two 3-credit courses and one 4-credit course. Other options to complete this requirement are possible.

second year, first semester (17 credit hours)

MATH 23	Analytic Geometry and Calculus III (4)
MECH 2	Elementary Engineering Mechanics (3)
CHM 31	**Chemical Equilibria in Aqueous Systems (3)
EES 21	Introduction to Planet Earth (4)
CE 11	Surveying (1)
CE 12	Civil Engineering Statistics (2)

second year, second semester (18 credit hours)

PHY 21	Introductory Physics II (4)
PHY 22	Introductory Physics Laboratory II (1)
MECH 12	Strength of Materials (3)
EES 31	Introduction to Environmental and Organismal Biology (4)
MATH 205	Linear Methods (3)
MAT 33	Engineering Materials and Processes (3)

third year, first semester (17 credit hours)

CE 121	Mechanics of Fluids (3)
CE 142	Soil Mechanics (3)
EES Course (4)	suggested as only 100 and 200 level
EES Course (4)	suggested as only 100 and 200 level
CE 10	Architectural/Engineering Graphics and Design (3)

third year, second semester (18 credit hours)

CE 242	Principles and Practices of Geotechnical Engineering (3)
CE 222	Hydraulic Engineering (3)
CE 170	Introduction to Environmental Engineering (4)
EES Course (4)	suggested as only 100 and 200 level
ECO 1	Principles of Economics (4)

fourth year, first semester (18 credit hours)

CE 117	Numerical Methods in Civil Engineering (2)
CE 159	Structural Analysis I (4)
EES Course	(4) 100 to 300 levels
EES Course	(4) 100 to 300 levels
EES Course	(4) 100 to 300 levels

fourth year, second semester (18 credit hours)

CE 262	Fundamentals of Structural Steel Design (3) **or**
CE 264	Fundamentals of Structural Concrete Design (3)
CE	**Civil Engineering Approved Elective (4)
Engineering Course	* Engineering Science Elective (3)
EES Course	(4) 100 to 300 levels
H/SS	Humanities/Social Sciences AR Elective (4)

year 4/5 summer (0-8 credit hours)

Select 0, 1, or 2 courses from

EES Course	(4) 100 to 300 levels
EES Course	(4) 100 to 300 levels

fifth year, first semester (11-19 credit hours)

CE 202	Civil Engineering Planning and Engineering Economics (3)
CE 203	Professional Development (2)
CE	**Civil Engineering Approved Electives (3)
H/SS	Humanities/Social Sciences AR Elective (3)

Select 0, 1, or 2 courses from below so the total here and year 4/5 summer is 8 credits:

EES Course	(4) 100 to 300 levels, possibly senior seminar
EES Course	(4) 100 to 300 levels, possibly senior seminar

fifth year, second semester (18 credit hours)

CE	**Civil Engineering Approved Electives (8)
CE	***Civil Engineering Capstone Design Project Elective (3)
H/SS	Humanities/Social Sciences AR Electives (3)

EES Course (4) 100 to 300 levels, possibly senior seminar

*MECH 102, ME 104, or ECE 81.

***CHEM 31 plus fifteen additional credits of CEE Approved Electives are required; see list on CEE web-site that includes five CEE/EES cross-listed courses: CE 279 (EES 259), CE 316 (EES 316), CE 320 (EES 320), CE 323 (EES 323), CE 327 (EES 327), and CE 379 (EES 379).*

****Usually CE 290, but can be a multidisciplinary teaming version of CE 205, CE 328, CE 336, CE 347, CE 360, CE 377 or CE 381*

A total of 159 to 174 credit hours is needed for both degrees depending on how many credits in the EES are satisfied by taking CEE Approved Electives that are cross-listed with EES courses**.

Undergraduate Courses

EES 2 (ES 2). Environmental Science: Systems and Solutions (4)
An overview of environmental issues, problems, and solutions from an Earth systems perspective. A review of how natural systems create the environment and how society is a part of these systems rather than distinct from them. Includes consideration of issues like resource management, natural and induced hazards, land use, habitat degradation, and environmental impact. Course intended for non-science majors with an interest in the environment, how it works, and what's important to sustain a habitable planet. Environmental issues on local, national, and global scales are considered and compared. Fulfills science distribution requirement. Lecture and recitation, class discussions, debates, and case studies. Meltzer (NS).

EES 3. Global Environmental Change (4)
Review of the environmental systems that carry out the exchange of energy and matter between the solid earth, the oceans, the atmosphere, and the biosphere. Examination of the global environmental change that has been a fact of life on Earth for several billion years, the role of humans in causing global environmental change, and the potential impact of such change on humans; debate over what course of actions is required to ensure the continued habitability of this planet. The course is intended for non-science majors wishing to learn more about the science behind current environmental issues, and fulfills a distribution requirement in science. Lectures, class discussions, debates, and group projects. Zeitler (NS)

EES 7. Introduction to Environmental Science (3-4)
Natural science course equivalent to success demonstrated with a score of 4 or 5 on the environmental science advanced placement exam of the College Testing Service. 4^{th} credit and laboratory experience awarded to students who demonstrate sufficient laboratory experience in their high school AP class. (NS)

EES 11. Environmental Geology (3)
Analysis of the dynamic interaction of geologic processes and human activities. Catastrophic geologic processes (earthquakes, volcanoes, landslides), pollution of geologic systems, and engineering case studies. Evenson (NS)

EES 21. Introduction to Planet Earth (4)
Processes within the Earth and dynamic interactions among the solid earth, the atmosphere, and the oceans. Lectures, laboratories, and field trips. Anastasio, Kodama (NS)

EES 31. Introduction to Environmental and Organismal Biology (4)
Introduction to the structure, function, and evolution of living systems, with emphasis at the levels of organism, population, community, and ecosystem. Lectures and laboratories. Morris, Windham (NS)

EES 41. Physical Geology and Geomorphology in the Rocky Mountains (6) summer
Principles of Physical Geology and geomorphology taught in the field. Four weeks of morning lectures and afternoon field exercises conducted in field settings in South Dakota, Wyoming, and Idaho during the summer session. See EES 341 description for location details. May substitute for EES 21 (see EES 21 description for content); see Introductory Sequence section of EES program description for restrictions on overlapping credit. Prerequisite: consent of Field Camp Director Pazzaglia (students must apply through the Lehigh Field Camp Program). Pazzaglia (NS)

EES 90. Freshman Seminar (3)

EES 93. Freshman Supervised Internship in Earth and Environmental Sciences (1-2)
Experiential learning opportunities supervised by EES faculty, including fieldwork, data collection or analysis, literature review, and information management. A maximum of two credits is allowed. Prerequisite: consent of supervising faculty. (ND)

EES 105. (ASTR 105, PHY 105) Planetary Astronomy (4)
Structure and dynamics of planetary interiors, surfaces and atmospheres. Models for the formation of the solar system and planetary evolution. Internal structure, surface topology, and composition of planets and other bodies in our solar system. Comparative study of planetary atmospheres. Organic materials in the solar system. Properties of the interplanetary medium, including dust and meteoroids. Orbital dynamics. Planets orbiting other stars. (NS)

EES 109. Geographic Analysis of our Changing World (4)
This course will introduce students to maps, spatial data, and electronic tools for geographic analysis. Fundamental geographic and database concepts will include map types, spatial referencing systems, map projection systems, map scale, and database characteristics. Tools including ArcGIS Desktop software and Global Positioning System receivers will be used to acquire and analyze spatially referenced data sets drawn from diverse sources and disciplines relating to the environment. Students will use their new skills in geographic analysis to develop an electronic portfolio, including a question-based map project. This course will prepare students for more advanced geographic analysis within the arts, humanities, social sciences, natural sciences, or engineering. Lecture-demonstrations and recitation. Hargreaves (NS)

EES 112. Geomorphology (4)
Systematic study of the origin, evolution, and distribution of the Earth's topographic features; land forms analyzed in terms of chemical and physical processes responsible for their development. Lectures and required 3-day field trip. Prerequisites: EES 11, 21, or 101. Evenson (NS)

EES 113. Life, Climate, and the Rock Record (4)
Interactions of the biosphere with the solid Earth. Formation and evolution of the physical Earth. How we know that the Earth is old. The rise of life, its evolution, extinctions, and preservation in the rock record. The Earth's circulatory system and biogeochemical cycles. The geologic record of past climate change at geologic and human dimensions. Lectures, discussions, lab, field trips to collect fossils. Prerequisites or concurrent: EES 21, EES 31. Zeitler (NS)

EES 123. Structural Geology and Tectonics (4)
Application of basic concepts of stress, strain, and material properties to the study of folds, faults, and rock fabrics. Plate tectonic processes and plate margin deformation. Introduction to map and field techniques. Lectures, laboratories, and two all-day field trips. Prerequisite: EES 21. Anastasio (NS)

EES 131. Introduction to Rocks and Minerals (4)
Hand-specimen identification of the major mineral groups and rock types. Atomic structure of minerals; relationship of mineral structure to chemical and physical properties. Placement of igneous, sedimentary, and metamorphic rocks into a plate tectonics context. Introduction to optical mineralogy and x-ray diffraction techniques. Lectures, laboratories, field trips. Prerequisite: EES 21 or EES 41 or consent of instructor. Bebout (NS)

EES 152. (BIOS 152) Ecology (4)
Basic principles and applications of ecological interrelationships. Examination of ecological phenomena at the individual, population, community, and ecosystem levels. Impact of human activities on global ecosystems. Prerequisite: EES 31. Williamson (NS)

EES 183. Environmental Instruments and Data (4)
Obtaining quality data from sensors and instruments requires an understanding of their properties including inherent limitations, sensitivity, and calibration. Large data sets generated by electronic instruments require careful management to retain full information content. Activities include sensor and instrument use, team projects, multimedia presentations, and extensive use of relational databases. 3 lecture/demonstration periods per week and one laboratory period. A weekend trip to calibrate research instruments and deploy team projects. Prerequisites: EES 21, EES 31, or consent of instructor. Hargreaves (NS)

EES 204 (PHY 204). Environmental Geophysics
A field based survey course reviewing the major geophysical techniques as applied to subsurface environmental problems including: seismic, ground penetrating radar, gravity, magnetics, and electrical resistivity. Course includes reviews of theory, experiment design, data collection, data reduction, data analysis, and technical report writing. Lectures and laboratory. Prerequisites: EES 21. Meltzer and Kodama (NS).

EES 213. Process Sedimentology, Stratigraphy, and Surficial Processes (4)
A process-based, field-oriented introduction to sedimentary rocks, stratigraphy, and surficial processes. Labs and lectures are integrated in a problem-oriented approach. Students will be asked to evaluate sedimentary rocks in local field settings as a backdrop to understanding stratigraphy, facies, and the surficial processes responsible for erosion, transportation, and deposition of earth surface materials. Course requires one or more weekend field trips. Prerequisite: EES 21 or consent of the instructor. Pazzaglia (NS)

EES 253. Plants and Plant Communities (4)
Structure and function of plants and plant communities. Discussion of plant physiology and environmental factors controlling plant distribution; structural and physiological adaptations of plants to their environment; the role of the physical environment, competition, herbivory, and disturbance in structuring plant communities; the evolution of plants and communities. Prerequisite: EES 31. Windham (NS)

EES 255. Ecological Field Methods (4)
An intensive field course designed to familiarize students with field sampling techniques, data analysis, and report writing related to field-based ecological research. Includes description and mapping of plant and animal communities, population dynamics, and plant-animal interactions in both terrestrial and aquatic habitats. Weekend field trip to Lacawac Sanctuary. Pre- or co-requisite: EES 152. Williamson (NS)

EES 257. Methods in Water Quality Analysis (4)
Survey of methods used in water quality analysis. The course will include: (1) theory and application of standard techniques and instrumentation, (2) quantitative analysis or modeling of existing or acquired data sets, and (3) data presentation and scientific report writing. Fulfills college writing intensive course requirements. Includes both lectures and laboratories. Prerequisite: CHEM 21/22. Morris (NS).

EES 259. (CE 279) Microbial Ecology (4)
The role of microorganisms in the environment. Topics include: Survey of microbial classification, structure, and metabolism; study of microbes at population, community, and ecosystem levels of organization; the role of microbes in biogeochemical cycles; application of microbes to bioremediation and resource recovery problems. Fall (alternate (even) years). Prerequisite: EES 31 and EES 152, or consent of instructor. Morris (NS)

EES 265. Environmental Animal Physiology (4)
Response of animals to their environment, including adaptations for stressful habitats and homeostatic mechanisms. Levels of response and adaptation range from cells and tissues to organ systems and whole organisms. Lecture and recitation. Prerequisites: EES 31 and BIOS 31. Hargreaves (NS)

EES 273. Environmental Thermodynamics (4)
Development of fundamental macroscopic thermodynamic principles with applications to geochemical, atmospheric, and aquatic systems. Topics include the laws of thermodynamics, thermodynamic relationships, phase transitions, aerologic diagrams, chemical equilibria, chemical potential diagrams, and stability in different systems. Lectures and recitation. Prerequisites: two semesters of calculus, one semester each of chemistry and physics; EES 21 and 31. Moses (NS)

EES 282. Climate, Geosphere, and Biosphere (4)
Interactions of Earth-surface fluids (air and water) with the organic and inorganic components of the Earth system, as expressed through climate, landscape evolution, biogeography, and biogeochemical cycles. Modern processes and historical perspective on environmental change. Lectures, discussion, and laboratory. Prerequisites: EES 21 and 31. Yu (NS)

EES 287. Introduction to Environmental Isotopes (2)
Survey of applications of stable isotopes and radioisotopes toward understanding of Earth's environment, considering both inorganic and organic processes, and with some emphasis on the use of isotopes in hydrologic studies. This course involves both field sampling and laboratory analytical experiences in a group project utilizing stable isotopes. Prerequisite: EES 21 or EES 31. Bebout (NS)

EES 293. Supervised Internship in Earth and Environmental Sciences (1-4)
Experiential learning opportunities supervised by EES faculty, including data collection or analysis, literature review, and information management most likely as part of a long-term, continued project. The student should submit a work plan that describes activities involved and credits requested. A maximum of two credits of EES 293 and no more than four credits combined from EES 293 and 393 may be applied to EES B.S. degrees (additional credits apply to free electives). Prerequisite: consent of supervising faculty.

Advanced Undergraduates and Graduate Students

EES 301. Seismology: Images and Dynamics of the Earth's Interior (4)
An examination of how earthquakes and active source seismology are used to image subsurface structure and stratigraphy and to understand tectonic processes. Fundamentals of seismic wave propagation in the Earth. Study of earthquakes, reflection, and refraction techniques at crustal, lithospheric, and whole Earth scales. Practical applications, experiment design, data collection, processing, analysis, and interpretation. Field and laboratory projects. Prerequisites: EES 21. Meltzer (NS)

EES 303. Active Tectonics (4)
An integrative look at how internal and external processes shape the Earth. Review of the observations and evidence leading to a unified understanding of how physical processes in the Earth's interior shape the external surface on which we roam. Topics include issues in continental dynamics such as mountain building, basin formation, and the interplay between tectonics and climate. Lectures, problem sets, modeling exercises, student projects and presentations. Prerequisite: EES 21, EES 31, plus 5 additional EES courses. Meltzer, Pazzaglia (NS)

EES 305. Geodynamics (4)
An introduction to the basic physics of important geological processes including: plate tectonics, plate tectonic driving mechanisms, flexure of the lithosphere, heat flow from the Earth, cooling of the oceanic lithosphere, subsidence of sedimentary basins, the global gravity field, isostasy, the geoid, the Earth's moments of inertia, rock rheology, mantle convection and cooling of the Earth, and the mechanics of faulting. Geodynamic modeling will also be covered. Prerequisite: one year of calculus. Kodama (NS)

EES 309. Mineral Magnetism and Earth Processes (4)
The use of earth material magnetic properties to study environmental and geologic systems and processes. Techniques of magnetic measurements, characteristics of the Earth's magnetic field, and mineral magnetism. Prerequisites: EES 21, Phys 11/12. Kodama (NS)

EES 316. (CE 316) Hydrogeology (4)
Water plays a critical role in the physical, chemical, and biological processes that occur at the Earth's surface. This course is an introduction to surface and groundwater hydrology in natural systems, providing fundamental concepts and a process-level understanding using the hydrologic cycle as a framework. Geochemistry will be integrated to address natural variations and the human impact on the environment. Topics covered include: watershed hydrology, regional and local groundwater flow, water chemistry, and management of water resources. Lectures and recitation/laboratory. Prerequisite: EES 21. Peters (NS)

EES 319. GIS and Computational Analyses in Geomorphology (4) [3 for graduate registration]
Introduction of various computational approaches to advanced geomorphology, hydrology, and environmental science. The course uses DEM topographic data as a keystone in introducing the UNIX operating system, the SGI platform, FORTRAN programming, cartographic and modeling applications such as GMT, and GIS applications such as ARC/INFO. Students will be responsible for the development of at least one new computation approach to their respective thesis/research projects. Prerequisite: EES 21, 31, 109, 112, or permission of the instructor. Pazzaglia. (NS)

EES 320. (CE 320) Flood Hydrology and Hydraulics (3)
Rainfall-runoff analysis, overland flow, hydrograph theories, modeling. Frequency analysis of extreme events. Flood routing. Design storms. Floodplain hydraulics, floodplain delineation. Prerequisite: CE 222. (ES 2), (ED 1)

EES 323. (CE 323) Environmental Groundwater Hydrology (3) spring
The study of subsurface water, its environment, distribution, and movement. Included are flow patterns, well hydraulics, and an introduction to the movement of contaminants. Design problems are included to simulate flow with analytical and numerical models, and contaminant migration using analytical models. Prerequisites: CE 121 or CE/EES 316 or permission of instructor. (ES 2, ED 1)

EES 326. Geologic Evolution of North America (4)
A senior seminar on the lithologic, tectonic, and morphologic evolution of North America; developed within the framework of the plate tectonic theory. Prerequisite: EES 21, EES 31, plus 5 additional EES courses. Anastasio (NS)

EES 327. (CE 327) Surface Water Quality Modeling (3) spring
Fundamentals of modeling water quality parameters in receiving water bodies, including rivers, lakes, and estuaries. Modeling of dissolved oxygen, nutrients, temperature, and toxic substances. Emphasis on water quality control decisions as well as mechanics and model building. Prerequisites: CE 121, CE 222 and CE 270. (ES 3), (ED 3)

EES 334. Petrology of the Crust and Mantle (4)
Crust and mantle evolution as recorded by the mineralogy, texture, and geochemistry of igneous, sedimentary, and metamorphic rock. Origin of the three rock types in various plate tectonic settings. Mass and energy transfer among the crust, mantle, hydrosphere, biosphere, and atmosphere through time. Petrographic study of selected rock suites and introduction to other modern analytical techniques used in petrology/geochemistry. Lectures, laboratories, field trips. Prerequisite: EES 131 or consent of instructor. Bebout (NS)

EES 341. Field Geology (8) summer
Field methods and geologic mapping projects using the diverse tectonic and geomorphic settings of the Rocky Mountains as the classroom. Major projects are completed in northwestern Wyoming and southeastern Idaho where the student is exposed to all major rock types and a range of surficial deposits, as well as compressional and extensional structures. Additional short studies are completed in the Badlands and Black Hills of South Dakota, the Grand Tetons and Devils Tower, Wyoming and related areas. Four weeks in the field; summer session. Prerequisite: consent of Field Camp Director Pazzaglia (students must apply through the Lehigh Field Camp Program); major in EES, EES 21 and 131 (EES 112, 113, 223 recommended). Pazzaglia, Anastasio, Bebout (NS)

EES 351. Limnology (4)
Physical, chemical, and biological aspects of freshwater environments, including cyclic and seasonal changes. Major groups of organisms and their interactions. EES 21, EES 31 plus 5 EES courses or permission of the instructor. Williamson (NS)

EES 357. Paleoecology and Landscape History (4)
Principle and methodology of paleoecology, with emphasis on palynology. Applications of paleo-records in tracing flora, vegetation, climate and landscape history. Long-term ecological interactions and ecosystem responses to past environmental change. Field and laboratory experiences in collecting and characterizing sediments and in processing and interpreting fossil pollen and other proxy data (including stable isotopes). Emphasis on the Holocene and late glacial period. Students will explore the regional vegetation, climate and landscape history by coring and analyzing a lake. Course requires one or more weekend day-long field trips. Spring in odd years. Prerequisite: EES 253 or EES 213 or consent of course instructor. Yu (NS).

EES 359. Case Studies in Ecosystem Ecology (4)
This course serves as a senior capstone seminar for students with an interest in ecology. Students will use a multidisciplinary approach to analyze and interpret data related to cutting-edge research in the field of ecosystem ecology. Prerequisite: EES 21, EES 31, plus 5 additional EES courses. Hargreaves (NS).

EES 376. Geochemistry of Natural Waters (4)
Introduction to aqueous geochemistry. Topics covered include the fundamentals of equilibrium thermodynamics and kinetics, acid-base equilibria, oxidation-reduction reactions, carbon chemistry, and isotopic techniques. Geochemical interactions will be studied in the context of the atmosphere, lithosphere, and hydrosphere. Prerequisites: EES 21 or 31 required, CHM 21 or 75 recommended. Peters (NS)

EES 379. (CE 379) Environmental Case Studies (3 to 4)
Supervised multidisciplinary team projects investigating site characterization and environmental remediation design and environmental policy and financial implications of environmental projects. OHSA approved Health and Safety training provided. Prerequisites: EES 21, EES 31 plus 5 EES courses or permission of the instructor (CE prerequisites: CE 274, CE 276). Staff

EES 384. Lake Ecosystems (4)
Advanced concepts and methods in lake ecosystem ecology. The course provides a theoretical framework but emphasizes hands-on laboratory and field techniques for measurement of physical, chemical, and biological properties of aquatic ecosystems. This three week residential field course is offered at the Lacawac Sanctuary field station in the Pocono Mountains of Pennsylvania. The course typically begins during the last week of May. Prerequisite: EES 31 and EES 152 or consent of instructors. Limited enrollment. Hargreaves, Morris, and others. (NS)

EES 385. Human Impact on the Natural Environment (4)
Review of major environmental systems and the human impacts on those systems. Integrates understanding from previous coursework in environmental science and engineering. Seminar format with student presentations. Prerequisites: EES 21, EES 31, plus 5 additional EES courses, or by permission of the instructor. Moses

EES 386. Wetlands (4)
Lecture/lab on wetland structure and function. Course will survey such topics as wetland development, classification, hydrology, plants, animals, soils, biogeochemistry, delineation, mitigation and management. Lecture and laboratory components will include mandatory field trips, exposure to sampling equipment and methods, and participation in a team project on wetland restoration. Prerequisites: EES 21, 31, 282, or permission of the instructor. Windham

EES 393. Supervised Research in Earth and Environmental Sciences (1-4)
Research opportunities supervised by EES faculty to carry out a well-defined project, including exposure to problem definition, selection of research approach, and communication of results. The student should prepare a proposal and, if taking 3 or more credits, should present the results at Undergraduate Research Symposium and write a research thesis. Both proposal and thesis are filed with EES Department. No more than four credits may be applied to EES B.S. degrees (additional credits apply to free electives). Prerequisite: consent of supervising faculty.

Graduate Studies

The Department of Earth & Environmental Sciences offers graduate programs leading to the M.S. and Ph.D. in Earth and Environmental Sciences. We offer one degree to emphasize and reinforce what we feel is an important and growing trend in ecology, environmental science, and geology, namely the blending of expertise and perspectives from many disciplines. Research is an integral component of all EES graduate programs and leads to an M.S. thesis or Ph.D. dissertation prepared under a research supervisory committee and chaired by a departmental faculty research advisor. An advising commitment by one or more faculty members is required for graduate admission.

The University has outlined the general academic requirements for M.S. and Ph.D. students in its Graduate Student Handbook, and EES has additional Departmental requirements that must also be fulfilled. It is the student's responsibility to insure that all graduation requirements are met. All graduate students work with an advisor who chairs the student's broader supervisory committee. Graduate students make annual presentations of their research to the Department. All graduate students are required to take two of the Department's three graduate core courses (EES 415, 426, and 484). M.S. students complete 30 credits of coursework and thesis research and orally present a written thesis that encompasses the findings and conclusions of their research. Candidates for the Ph.D. must pass a qualifying examination prior to the end of the first semester in residence and a general examination (candidacy examination) prior to the end of the third semester in residence. Both examinations are administered by a committee assembled by the student in consultation with the advisor. Ph.D. candidates must also defend their written dissertation at a public oral presentation. For more details beyond this brief summary, please see the graduate handbook on line at: www.ees.lehigh.edu/graduate/grad_handbook. html#masters.

Research Facilities

Our Department is well equipped for a broad range of field and laboratory investigations in the Environmental, Ecological, and Geological Sciences. Our laboratories and equipment include:

- Complete petrographic microscopy facilities, rock-crusher, ball mill, rock saws, and cathodoluminescence and camera lucida digitizing capabilities;
- Complete laboratory for Ar-Ar, U-Th/He, and fission-track geochronology including dual UV and CO2 lasers, VG 3600 noble-gas mass spectrometer, Balzers quadrupole mass spectrometer, dedicated He and Ar extraction lines with low-blank furnaces, all under full LabVIEW automation;
- A stable isotope geochemistry laboratory equipped with a Finnigan MAT model 252 mass spectrometer with vacuum extraction lines for O, H, C, S, and N isotope analyses;
- Downhole geochemical sampling equipment;
- A microbial ecology laboratory;
- A newly renovated UV exposure laboratory with automated phototron;
- A plant ecology and wetlands research laboratory;
- A water quality and UV-research laboratory equipped with vacuum extraction lines, a spectrophotometer, and field PUV meters;
- An aqueous geochemistry laboratory with a Waters computer-assisted ion chromatograph, an ARL 34000 inductively-coupled plasma atomic emission spectrometer, a Netzsch DTA/TGA instrument, and a high-pressure core-holder/column reactor for flow-through experiments ;
- A sedimentation and soils analysis laboratory including equipment for particle size analysis;
- A paleomagnetism laboratory with a magnetically shielded room, a 2G superconducting magnetometer and built-in af demagnetizer, Molspin spinner magnetometer, a Schonstedt AF demagnetizer modified to

apply pARMs, and an ASC thermal demagnetizer, and a KLY-3S Kappabridge magnetic susceptibility system, and an ASC impulse magnetizer;

- A reflection seismology laboratory has equipment including broadband seismometer linked to global networks; computer workstations for seismic processing, Bison DIFP multi-channel seismograph, various seismic energy sources, and ground-penetrating radar;
- Field geophysical equipment includes a Bison shallow resistivity apparatus, a Worden Master gravimeter, and a Geometrics portable proton precession magnetometer;
- Geomorphology lab including a Topcon total station, flow gages, an ISCO water and flow rate sampler, LASCI digitizer, complete airphoto analysis facility, and a flume facility in the CEE hydraulics lab. We also maintain several PC and UNIX computer labs devoted to GIS (ArcGIS) and large spatial digital topographic databases;
- Equipment to conduct research in environmental biology includes microscopes, environmental chambers, centrifuges, sampling nets, current meters, incubators, and autoclaves. A remotely operated vehicle (ROV) fitted with a video camera can be used to monitor plankton behavior and dynamics in aqueous environments;
- A floating plankton laboratory to integrate ecosystem studies of modern water-column and sediment communities with historical studies of sediment deposition;
- A sediment-coring and -analysis facilities, tree ring lab, and pollen extraction lab with complimentary equipment for research in paleoclimatology;
- EES is also home to the Pocono Comparative Lakes Program (PCLP), an interactive research and educational program that supports multidisciplinary research of lake systems and focuses on three 'core' lakes that serve as model systems for experimental and comparative studies of aquatic communities and ecosystems. The program's field station is at the Lacawac Sanctuary in the Pocono Mountains;

Graduate Courses

EES 405. Paleo- and Environmental Magnetism (3)
Topics in paleomagnetism and environmental magnetism. Class will design and conduct a research project, read the relevant literature and write a research paper. May be repeated for credit. Prerequisite: EES 309 or consent of course instructor. Kodama

EES 407. Seismology (3)
Seminar on advanced topics in seismology, review of classic and current literature. Topics include but are not limited to: wave propagation in ideal media and earth materials, seismic imaging of complex structures, tomography, modeling, and high-resolution seismic imaging. May be repeated for credit. Prerequisite: an introductory geophysics course. Meltzer

EES 412. Advanced Fluvial and Tectonic Geomorphology (3)
Lecture, seminar, lab, and field-based investigation of the classic and contemporary geomorphologic literature using the processes and evolution of a watershed and its dynamic interaction with tectonics as a integrative common theme. Topics change according to student interest but typically include hillslope hydrology, channel hydraulic geometry, landscape response to climate, and biogeomorphology. Course is designed to expose students to graduate-level research problems and provide guidance on how to transform those problems into proposal-quality research topics and/or publishable manuscripts. Includes several weekend field trips and a practicum using the hydraulics lab flume facility. Prerequisite: EES 21,31,112, or consent of instructor. Pazzaglia.

EES 414. Glacial and Quaternary Geology (3)
Study of the origin, distribution, and movement of present and past glaciers. Special emphasis on glacial land forms and deposits, Quaternary stratigraphy and dating techniques, periglacial phenomena, and Pleistocene environments. Lectures and required field trips. Prerequisite: Consent of instructor. Evenson

EES 415. Paleoclimatology (3)
Principles of physical climatology: climate system, energy budget, atmospheric and ocean circulations, and their interactions. Earth's climate history, with an emphasis on the Quaternary. Records and mechanisms of past climate variations at various (from orbital to interannual) time scales. Causes of climate variations linking to tectonic processes, variations in Earth's orbit and solar insolation, atmospheric composition and biogeochemical cycles, and atmosphere-ocean-ice sheet interactions. Biosphere responses to past climatic changes. Approaches to studying paleoclimate. Paleoclimate simulations and paleo-perspectives in addressing future climate change issues. Prerequisite: graduate standing in EES, or consent of course instructor. Yu.

EES 418. Advanced Quaternary Geology (3)
Lecture, seminar, lab, and field-based investigations of topics in Quaternary geology including glacial geology, geomorphology, soil geomorphology, biogeomorphology, and Quaternary geochronology. Quaternary field methods are a common themes to all topics. Field exercises will expose students to methods in the mapping of surficial deposits. Includes several weekend field trips. Prerequisite: EES 21, 31,112, or consent of instructor. Pazzaglia, Evenson.

EES 426. Tectonic Processes (3)
Current models of tectonic processes in intraplate settings and at plate boundaries. Critical evaluations by the class of the geological, geochemical and geophysical data sets which gave rise to these models. Prerequisites: graduate standing in EES, or consent of department chairperson. Staff

EES 427. Orogenic Belts (3)
Geometry, kinematics, and mechanics of compressional orogenic belts. Course will emphasize deformational, depositional, and metamorphic processes in forearc and backarc regions. Lectures, seminars, and field trips. Prerequisites: EES 131, EES 213, EES 223, or their equivalents. Anastasio

EES 428. Stress and Strain in Rocks (3)
Theory of continuum mechanics and application to analytical methods of geological strain analysis, rock material properties and micro-mechanisms of rock deformation, and tectonic fabric development, kinematic analysis. Lectures and laboratories. Prerequisite: EES 223 or equivalent. Anastasio

EES 429. Methods and Applications of Geochronology (3)
Examination of isotopic techniques used to measure geologic time, and their applications. Lectures, laboratories, research projects, field trips. Prerequisite: graduate standing in EES. May be repeated for credit. Zeitler

EES 438. Petrogenetic Processes (3)
Metamorphism, melting, and magmatism in the Earth's crust and mantle. Tectonic evolution, crust-mantle heat and mass transfer, fluid-rock interactions, and rate processes. Varying combinations of lecture and seminar formats. May be repeated for credit when topics differ. May include laboratory and field experience and computational exercises. Prerequisite: consent of course instructor. Bebout

EES 451. Advanced Limnology and Paleolimnology (3)
In-depth discussion of current issues in the fields of limnology and paleolimnology. Consideration of both the modern behavior of lake ecosystems, as well as lacustrine dynamics in the past based on interpretation of the fossil record. Topics may range from the interaction of lakes with their watersheds and the atmosphere to the dynamics of algal communities. Prerequisite: EES 351 or equivalent. Williamson

EES 453. Advanced Microbial Ecology (3)
Lectures and seminars will focus on topics of current interest in the microbial ecology of pelagic (freshwater and marine), sediment, and/or soil environments. Emphasis will be placed on the role of microbes in ecosystems level processes such as energy transformations and elemental cycling. May include laboratory and field exercises. Prerequisite: graduate standing or consent of course instructor. Morris

EES 455. Advanced Plants and Ecosystems (3)
Intensive study of current issues in plant and terrestrial ecosystem processes. Core curriculum will focus on interactions of plant physiology with terrestrial biogeochemistry (water, energy, elemental fluxes). Seminar discussions will focus on current topics in plant functions at community and ecosystem scales, from historical and future perspectives. Windham.

EES 458. Global Change Ecology (3)
Lectures, seminars, writing, and instruction in quantitative approaches to the ecology of climate change and UV radiation from an ecological perspective. Emphasis will be on the interactive effects of climate change and UV on other ecological processes at the individual, population, community, and ecosystem levels involving both plants and animals. Instruction in writing of scientific proposals that could be submitted to national funding agencies will be a core learning tool in this course. All students will write a proposal related to the ecology of climate change and UV on a topic approved by their advisor. Prerequisite: EES 152 or equivalent. Williamson

EES 459. Reconstructing Environmental Change(3)
Lectures, seminars, and in-depth discussion on current issues and selected topics in Quaternary paleoecology and paleoclimatology. Survey of techniques in studying and reconstructing environmental changes and biological responses. Use of multiple proxy data from paleoarchives (e.g., ice cores, lake sediments) to address nature of past climate variability. Quantitative analyses of paleo-records to test paleoecological hypothesis (e.g., multivariate analysis) and to infer possible causes and forcing mechanisms of past climate change (e.g., time series analysis). May include field and laboratory exercises. Prerequisite: EES 415, or consent of course instructor. Yu.

EES 471. Stable Isotope Chemistry - Theory, Techniques, and Applications in the Earth and Environmental Sciences (3)
Distributions of stable isotopes (primarily of O, H, C, S, and N) in the lithosphere, hydrosphere, biosphere, and atmosphere. Topics include mechanisms of fractionation and mixing, advancements in techniques for extractions and mass spectrometry, and recent applications of stable isotopes in the earth and environmental sciences. Lectures, seminars, laboratory sessions. Prerequisite: consent of instructor. Bebout

EES 473. Aqueous Geochemistry (3)
Advanced study of physical and inorganic aqueous geochemistry, including homogeneous and heterogeneous equilibria, kinetics, and surface processes in water-rock systems. Computational modeling of water-rock systems. Prerequisites: computer programming (C, Pascal, or Fortran), and consent of instructor. Moses

EES 484. Aquatic Ecosystems (3)
Theoretical and experimental approaches to understanding physical and chemical influences in aquatic environments on organisms and their community, population, and systems ecology. Field trip. Prerequisite: graduate standing in EES. Staff

EES 485. Advanced Topics in Geophysics (1-6)
Intensive study of topics in geophysics not covered in more general courses. May be repeated for credit. Prerequisites: MATH 21, EES 21, or permission of the instructor.

EES 487. Advanced Bio-Optics (3)
Bio-optics includes the ecosystem role and fate of solar radiation and the optical properties of biotic and abiotic components of ecosystems. This course will explore advanced topics through selected readings, data analysis, and modeling. Topics will emphasize aquatic ecosystems and may include optical models, atmospheric factors, inherent and apparent optical properties, algal fluorescence, photoadaptation and photodamage, ultraviolet radiation, and optical stratification. Prerequisite: EES 484 or consent of course instructor. Hargreaves

EES 490. Thesis Research (1-6)
Masters' thesis research directed by research committee. 3-6 credits required for EES M.S. programs. May be repeated for credit. Prerequisite: Permission of research adviser.

EES 491. Investigations in Earth and Environmental Sciences (1-6)
Research on a special problem; field, laboratory, or library study; report required. Credit above three hours granted only when a different problem is undertaken.

EES 492. Advanced Topics in Modern and Quaternary Processes (1-6)
Intensive study of topics in Modern and Quaternary geology not covered in more general courses. May be repeated for credit.

EES 493. Advanced Topics in Tectonics (1-6)
Intensive study of tectonic processes and products not covered in more general courses. May be repeated for credit.

EES 494. Advanced Topics in Aquatic Ecosystems (1-6)
Intensive study of aquatic ecosystems not covered in more general courses. May be repeated for credit.

EES 499. Dissertation Research (1-15)
Ph.D. dissertation research directed by research committee. May be repeated for credit. Prerequisite: Permission of research adviser.

Economics

Professors. J. Richard Aronson, Ph.D. (Clark); James Dearden, Ph.D. (Penn State); Thomas J. Hyclak, Ph.D. (Notre Dame), *chair, department of economics;* Arthur E. King, Ph.D. (Ohio State); Vincent G. Munley, Ph.D. (S.U.N.Y.); Anthony P. O'Brien, Ph.D. (Berkeley); Larry W. Taylor, Ph.D. (North Carolina); Robert J. Thornton, Ph.D. (Illinois).

Associate professors. Mary E. Deily, Ph.D. (Harvard); Frank R. Gunter, Ph.D. (Johns Hopkins); Judith A. McDonald, Ph.D. (Princeton); Todd A. Watkins, Ph.D. (Harvard).

Assistant professors. Shin-Yi Chou, Ph.D. (Duke), Neville Francis, Ph.D. (U.C. San Diego); Stephen Snyder, Ph.D. (Maryland); Wenlong Weng, Ph.D. (Stanford).

Active emeriti. Nicholas W. Balabkins, Ph.D. (Rutgers); Alvin Cohen, Ph.D. (Florida); Jon T. Innes, Ph.D. (Oregon); John R. McNamara, Ph.D. (Rensselaer); Eli Schwartz, Ph.D. (Brown).

Though economics is variously defined, modern-day definitions generally suggest that it is the study of the principles that govern the efficient allocation of resources. One of the greatest of the 19^{th} century economists who did much to uncover these principles suggested a broader definition. Alfred Marshall described economics as "a study of mankind in the ordinary business of life . . . a part of the study of man." This dual nature of economics, technical and humanistic, is reflected in the fact that at Lehigh the economics major is available to students in the College of Arts and Sciences as well as in the College of Business and Economics.

College of Business and Economics

Major in Economics

Students in the College of Business and Economics electing to major in economics must take the college core courses listed in the College of Business and Economics section of this catalog. They must also take ECO 119 and at least 12 credit hours of 200 and 300-level economics courses beyond the core requirements. These courses may be chosen so as to form an area of specialization or to provide a broad exposure to the various aspects of the discipline. In any case, students should consult with the major advisor in forming their programs.

Major in Business Economics

The business economics major prepares students for careers as business consultants or analysts by teaching the application of microeconomic theory to the analysis of critical business issues. The emphasis is on rigorous, quantitative business analysis through the use of theoretical and mathematical models and econometric analysis of data. Students electing the major in business economics must take the college core courses, ECO 322, ECO 333, ECO 357, two elective courses from an approved list, and a course involving student research on a problem identified by an external client. Students should consult with the major advisor in forming their program.

College of Arts and Sciences

Major in Economics

The B.A. major in economics is designed to prepare students for graduate study in economics or law, and for entry into careers in business, government or service organizations. The requirements for the economics major are:

1. The economics core (16 credits): ECO 1, ECO 105 or 146, ECO 119, ECO 129 and ECO 145.
2. Collateral calculus courses (7 or 8 credits): MATH 51 and 52 or MATH 21 and 22. MATH 51 and 52 are terminal math classes for students planning on careers in fields that are primarily non-quantitative. MATH 21 and 22 are for students considering careers or graduate programs that require a stronger math background.
3. Five elective courses in economics at the 200 or 300 level (15 credits). Students may count only two 200 level courses toward the completion of the economics major.

Students are free to select any five economics courses to meet their elective requirements. However, the faculty of the economics department has developed recommended course clusters to meet the differing needs of students. These include course recommendations for those interested in:

Graduate study in economics
Careers in consulting and financial services
International economics and global markets
Political economy and public policy

Interested students are encouraged to consult with the major advisors in the economics department to select elective courses that match their needs and interests.

Honors in Economics

Economics majors who wish to be considered for departmental honors must consult with their major advisor and request such consideration by the beginning of their senior year. The criteria for departmental honors are:

1. Completion of the major program with at least 33 credits of economics and a grade point average in those courses of 3.5 or better.
2. Submission of an acceptable research paper to the Departmental Honors committee. To qualify a candidate for honors this paper must report on original research conducted solely by the student as part of an economics course. The student should consult with the instructor of that course for suggestions for improving the paper prior to submitting it to the committee. The committee will notify students of submission deadlines and other requirements for satisfying this criterion.

Minor in Economics

A minor in economics consists of 12 credit hours beyond ECO 1. Required courses in the minor are: ECO 105 or 146, 119 or 129 and two elective courses. Elective courses must be chosen from among the 200 and 300-level economics offerings with at least one 300-level elective. ECO 371 does not count towards the minor. This minor is available only to students in the College of Arts and Sciences and in the College of Engineering and Applied Science. Interested students should contact the minor advisor.

Undergraduate Courses

ECO 1. Principles of Economics (4)
A one-semester course in the principles of economics. General topics covered are: supply and demand; pricing and production decisions of firms; the role of government in the economy; the determination of national income; money and banking; monetary and fiscal policy; and government finance. (SS)

ECO 64. (AAS 64, HIST 64). Plantation to Ghetto (2)
Examination of topics in the economic history of African Americans from the 1500s to the present. Explores the slave trade, slavery, the post-Civil War South, the black family, migration, urbanization, and race and poverty. Prerequisites: ECO 1 recommended. (SS)

ECO 105. Intermediate Microeconomic Analysis (3)
Determination of prices in terms of the equilibrium of the business enterprise and consumer choice in markets of varying degrees of competition; analysis of market structures; determination of wages, rent, interest and profits. Prerequisite: ECO 1. Not available for credit to students who have taken ECO 146. (SS)

ECO 111. (ES 111). Introduction to Environmental Economics (4)
An examination of the interactions between our economic systems and the environment. Pollution as a consequence of human activity within a framework for analyzing the relationships between environmental quality, scarcity of resources and economic growth. How to develop appropriate policies to deal with these issues. Prerequisite: ECO 1. (SS)

ECO 119. Intermediate Macroeconomic Analysis (3)
Macroeconomic measurement, theory and policy. The use of alternative macroeconomic models to analyze the level of national income, inflation, unemployment, economic growth; the balance of payments, and exchange rate determination. Prerequisite: ECO 1. (SS)

ECO 129. Money, Banking, and Financial Markets (3)
The nature and functions of money. Global money and financial markets. The role of commercial and central banks. Effects of the interest rate, exchange rate, and the money supply on the economy. Examination and evaluation of current and past monetary policies. Prerequisite: ECO 1. (SS)

ECO 130. (WS 130) Economics of Race and Gender (2)
The question of the role of race and gender in economic decision-making is explored. Various sorts of discrimination are discussed in an economic framework and possible remedies are evaluated. The historical role of race and gender in the economy is also discussed. Prerequisite: ECO 1. (SS)

ECO 131. The Canadian Economy (2)
This course analyzes the economic challenges facing the Canadian economy. Some of the issues include: Canada's record on inflation and unemployment; the distribution of income; the role of natural resources; and Canada's health-care and educational systems. Canada's monetary and fiscal policies, and Canada's performance in the international economy will also be examined. Prerequisite: ECO 1. (SS)

ECO 134. Evolution of the Automobile Industry (2)
This course traces the development of the automobile industry from its origin at the turn of the century to the present. Topics include: the Model T and mass production; the development of installment purchases; dealer-company relations; worker-company relations; the rise of imports; and the decline of traditional mass production. Prerequisite: ECO 1. (SS)

ECO 138. Athletic Complex Design (3)
This course is for students to participate in cross discipline Integrated Learning Experience (ILE) research projects. The twin purposes of the course are to provide real-world, team-oriented learning experiences and to apply economic analysis in evaluating the costs and benefits of newly proposed, or renovations and expansions of existing, athletic facilities. Prerequisite: ECO 105 or ECO 146. (SS)

ECO 145. Statistical Methods (3)
Descriptive statistics, probability and probability distributions, sampling, estimation, hypothesis testing, chi-squared tests, simple regression and correlation. **(ND) Note:** Students may not receive credit for both MATH 12 and ECO 145.

ECO 146. Applied Microeconomic Analysis (3)
The application of economic analysis to managerial and public policy decision-making. Prerequisites: ECO 1, 145 or equivalent course. Not available for credit to students who have taken ECO 105. (SS)

ECO 158. LUCORPS Projects (3)
This course involves teams of students in community-oriented research projects. The twin purposes of the course are to provide real-world, team-oriented learning experiences and to provide a resource for local governments and community organizations that would allow them to draw upon the expertise of our students as consultants in analyzing problems and formulating policy. Prerequisite: ECO 1. (SS)

For Advanced Undergraduates and Graduate Students

ECO 209. Comparative Economic Systems (3)
An analysis of the micro- and macro-economic, institutional and political dimensions of various economic systems, with particular emphasis on former centrally planned economies in their transition to a market orientation. Prerequisite: ECO 1. (SS)

ECO 210. Economic Evolution (3)
Structural changes, social transformation, and sources of the long-term growth of the U.S. economy. Prerequisite: ECO 1. (SS)

ECO 231. Business History (3)
The historical context of the development of the modern business firm in the United States. The roles of entrepreneurship, economic structure, technology, and government policy in the shaping of current business practices. Prerequisite: ECO 1. (SS)

ECO 234. Labor-Management Relations (3)
An analytical study of the U.S. system of industrial relations, including the evolution of the labor movement, worker choice on the issue of union representation, the process of collective bargaining and the impact of collective bargaining on the management of the firm. Prerequisite: ECO 1. (SS)

ECO 235. Labor Economics (3)
The economic analysis of labor markets, with emphasis on labor supply and demand, wage and employment theory, and the economics of unionism and other labor market institutions. Prerequisite: ECO 1. (SS)

ECO 237. Transportation Economics (3)
The principles of transportation in theory and practice. Transport models and their relationship to economic activity. Analysis and evaluation of transportation policies, industry structure and performance. Prerequisite: ECO 1. (SS)

ECO 240. Ireland's Public Sector (3)
This course focuses on public sector programs—and the method used to finance them—in Ireland and compares their structure to that found in both the United States and other countries of Western Europe. Topics include: the policy of neutrality and military (peace-keeping) operations, environmental protection, social welfare programs, health care, education at the primary, secondary and tertiary levels, and key infrastructure areas such as urban planning and transportation systems. Special attention is devoted to how membership in the European Union has impacted the evolution of these programs in Ireland. Prerequisite: ECO 1. (Offered only through Lehigh in Ireland Study Abroad Program). (SS)

ECO 246. Business Cycles and Forecasting (3)
A study of short-term business fluctuations, growth, forecasting and stabilization. Prerequisites: ECO 1 and a course in statistics. (ND)

ECO 303. Economic Development (3)
Economic development, economic growth and their political environment are discussed in detail. The principal economic development theories are examined. These theories are used to examine a variety of development issues including planning, poverty, rural-urban relationships, physical and human capital accumulation, international trade, and the environment. Emphasis on institutions and development policy. Prerequisite: ECO 105 or 146. (SS)

ECO 311. Environmental Economics (3)
Resource allocation implications of environmental degradation. Analysis of the benefits and costs associated with alternative pollution control programs and strategies. Prerequisite: ECO 105 or 146. (SS)

ECO 312. Urban Economics (3)
The analysis of economic problems related to urban areas; the nature and function of cities; the economic and spatial characteristics of urban activity. Prerequisite: ECO 105 or 146. (SS)

ECO 313. History of Economic Thought (3)
A survey of the important historical writings that form the foundation of today's mainstream economic theory. Emphasis is on the period from 1750 to 1950 and on such notable economists as Smith, Ricardo, Walras, Marshall and Keynes. Prerequisite: ECO 105 or 146 or 119. (SS)

ECO 314. Energy Economics (3)
The economic theory of natural resource allocation over time. Economics of exhaustible and renewable resources. Environmental effects of energy production and consumption. Government regulation of the energy industry. Computer models for energy system forecasting and planning. Prerequisite: ECO 105 or 146. (SS)

ECO 315. Industrial Organization (3)
Structure of American industry. Development of economic models to describe behavior in markets with varying degrees of competition. Technological innovation, relationship between industry concentration and rates of return on capital, role of information and advertising, dynamics of monopoly and oligopoly pricing. Prerequisite: ECO 105 or 146. (SS)

ECO 322. Competitor and Market Analysis (3)
Competitors, partners, and firms and governments strategically interact. This course uses game theory to analyze issues like pricing by competitors, vertical integration and contracting issues in supplier-buyer relationships, collective actions and joint ventures, and research and development program. Students use both mathematical models and cases to analyze these interactions. Prerequisites: ECO 105 or 146, ECO 145 and MATH 21, 31 or 51. (SS)

ECO 323. Evolution of Business Strategy (3)
Analyzes how business firms have adapted to changes in technology, relative factor prices, globalization, and the extent of government intervention in the market. Material will be presented through discussion of case studies from the nineteenth and twentieth centuries. Prerequisite: ECO 1. (SS)

ECO 324. The Economics of the Sports Industry (3)
This course analyzes the role of basic economic forces in shaping today's sports industry. Topics include: competition in the market for professional franchises; public subsidies for stadiums and arenas, compensation of professional athletes, the NCAA as an economic enterprise, and the impact of athletics on a university's budget. Prerequisite: ECO 105 or 146. (SS)

ECO 325 (MKT 325). Quantitative Marketing Analysis (3)
This course explores economics and management science approaches to improve marketing decision making and marketing interactions in such areas as strategic marketing, e-marketing, advertising, pricing, sales force management, sales promotions, new products, and direct marketing. The development, implementation, and use of quantitative models are emphasized. Cases are used to illustrate how these models can be applied. Students have the opportunity to learn how to use and evaluate models through spreadsheet-based assignments. Prerequisites: MKT 211, ECO 145, ECO 105 or 146, and MATH 21, 31 or 51. (SS)

ECO 327. Real Options and Investment Strategy (3)
This is an introductory course in financial economics. It focuses on the principles underlying financial decision making, with applications to stocks, bonds, and real estate. It is intended for students with strong technical backgrounds who are comfortable with mathematical arguments. The course is divided into three main parts: deterministic finance, single-period uncertainty finance, and options theory. Prerequisite: FIN 323. (ND)

ECO 332. Monetary-Fiscal Policy (3)
Monetary, credit and fiscal policies of governments and central banks with particular reference to the policies of the United States Treasury and the Federal Reserve System. Prerequisite: ECO 119 or 129. (SS)

ECO 333. The Economics of Business Decisions (3)
Students analyze business problems using economic logic and techniques like mathematical programming, margin-

al analysis and decision making under risk and uncertainty. New topics like asymmetric information and the analysis of organizations are introduced. Case studies are emphasized. Prerequisites: ECO 105 or 146, ECO 145, and MATH 21, 31 or 51. (SS)

ECO 336. Business and Government (3)
Analysis of government involvement in the private sector. The problems of monopoly, oligopoly, and externalities in production and consumption. Optimum responses to market failure and analysis of the performance of actual government policies. Prerequisite: ECO 105 or 146. (SS)

ECO 339. International Trade (3)
The theory of international trade; the theory of tariffs; United States commercial policies; the impact of growth and development of the world economy. Prerequisite: ECO 105 or 146. (SS)

ECO 340. International Finance (3)
Analysis of balance of payments and disturbances and adjustment in the international economy; international monetary policies. Prerequisite: ECO 119 or 129. (SS)

ECO 342. Economic Development in China (3)
An examination of the economic, political and social forces at work in the development process in China since 1949. Special emphasis on post-1978 market reforms, the rural-urban divergence, the role of foreign trade and investment, the accumulation of human capital, and the deterioration of the physical environment. Course concludes with a detailed discussion of possible futures of the Chinese economy. Prerequisite: ECO 303. (SS)

ECO 343. European Economic Integration (3)
Study of the problems of economic integration throughout Europe, especially in the Post-Cold War era among Western, Central and Eastern European nations. Prerequisite: ECO 209 (may be taken concurrently with permission of instructor). (SS)

ECO 346. Numerical Methods for Business Decisions (3)
This course provides a connection between textbook economics/finance and the problems of real world business. It emphasizes practical numerical methods rather than mathematical proofs. Problems in finance are emphasized. The course teaches students how to use EXCEL macros and advanced VBA (the industry standard) programming techniques to model and manipulate financial data. Prerequisite: FIN 323. (ND)

ECO 351. Introduction to Mathematical Economics (3)
Application of mathematical techniques to economic problems of optimization and to economic models. Prerequisites: ECO 105 or 146 and 119 and MATH 21, 31 or 51. (ND)

ECO 352. Advanced Statistical Methods (3)
Advanced probability theory, probability and sampling distributions, and classical statistical inference. Index numbers, multiple regression, correlation, and analysis of variance. Spectral analysis, Box-Jenkins auto-regressive and moving average stochastic processes. Prerequisites: ECO 105 or 146 and a course in statistics. (ND)

ECO 353. Public Finance: Federal (3)
A course dealing with the expenditures and revenues of the federal government. Major topics include public choice theory, benefit-cost analysis, the theory of public goods, the economics of taxation and the design of tax structures. Prerequisite: ECO 105 or 146. (SS)

ECO 354. Public Finance: State and Local (3)
A course dealing with the expenditures and revenues of state and local governments. Major topics include the theory of fiscal federalism, intergovernmental fiscal transfers, the design of state and local tax structures, capital budgeting and debt finance, pension funds and school finance. Prerequisite: ECO 105 or 146. (SS)

ECO 357. Econometrics (3)
Problems in construction, evaluation and use of econometric models. Applications based on research and case studies. Prerequisites: ECO 105 or 146 or 119 and a course in statistics. (ND)

ECO 358 (IE 358). Game Theory (3)
A mathematical analysis of how people interact in strategic situations. Applications include strategic pricing, negotiations, voting, contracts and economic incentives, and environmental issues. Prerequisites: ECO 105 or 146 and MATH 21, 31 or 51. (SS)

ECO 362. Martindale Research Seminar (1-3)
This course prepares students to undertake research on various topics in business and/or economics. Admission to this course is limited to student associates of the Martindale Center for the Study of Private Enterprise. Consent of the instructor is required. Course may be repeated for credit up to a maximum total number of 3 hours credit. (ND)

ECO 368. Health Economics (3)
Supply and demand in the health service markets for the U.S. and Canada. Unique features of health care which interfere with competitive market allocation and pricing. Overview of insurance systems and other payment methods. Prerequisites: ECO 105 or 146 and a course in statistics. (SS)

ECO 371. Special Topics in Economics (3)
Study in various fields of economics, designed for the student who has a special interest in a subject not included in the regular course schedule or for the student interested in pursuing a significant supervised research project in economics. Students interested in enrolling in this course must submit a written proposal to a member of the faculty with expertise in the proposed subject area and to the department chair prior to the registration period for the relevant semester. Prerequisite: ECO 105 or 146 or 119. This course may count towards the ECO major only once; it does not count towards the ECO minor. (ND)

ECO 401. Basic Statistics for Business and Economics (3)
Descriptive statistics, probability and probability distributions, estimation, hypothesis testing, correlation and regression, chi-square analysis and analysis of variance. Computer applications.

ECO 402. Managerial Economics (3)
Application of economic and statistical analysis to managerial decision-making. Business and economic forecasting. Empirical estimation of demand, production and cost functions. Resource allocation and pricing strategies in various market structures. Decisions under risk and uncertainty. Government regulation of business. Cases. Prerequisite: Calculus and ECO 401 or equivalent.

ECO 404. Technology, Trade and Growth (1)
Overview of the role of technology in economic systems. Productivity and growth effects, relationships to industry structure, impacts on international trade and competitiveness. Prerequisite: intended to be taken concurrently with ECO 402.

ECO 411. History of Economic Thought (3)
Selected topics in the history of economic thought, with special attention to the origins of modern economic theory. Prerequisite: a graduate course in economic theory.

ECO 412. Mathematical Economics (3)
Applications of various mathematical techniques in the formation and development of economic concepts and theories. Prerequisite: consent of the instructor.

ECO 413. Advanced Microeconomics Analysis (3)
A survey of methods of decision-making at the microeconomic level; price theory and econometric applications. Prerequisite: ECO 402 or equivalent.

ECO 414. Advanced Topics in Microeconomics (3)
Resource allocation and price determination. Theories of choice of consumers, firms and resource owners under various market forms. Prerequisites: ECO 401 and ECO 413 or equivalents.

ECO 415. Econometrics (3)
Computer applications of standard econometric techniques using regression analysis in a single-equation context. Discussion of problems of multicollinearity, heteroscedasticity and autocorrelation. An introduction to simultaneous equation models, identification and estimation problems. Prerequisite: ECO 401 or equivalent.

ECO 416. Econometric Theory (3)
Mathematical and statistical specification of economic models. Statistical estimation and tests of parameters in single and multiple equation models. Prediction and tests of structural changes. Prerequisites: ECO 401 (or equivalent) and calculus.

ECO 417. Advanced Macroeconomics Analysis (3)
Macroeconomic theory and policy. Emphasis on theoretical models and policy implications.

ECO 418. Advanced Topics in Macroeconomics (3)
Models of employment, income and growth in monetary economies. Policies for economic stability and growth. Prerequisite: ECO 417 or equivalent.

ECO 423. Real Options (3)
This is an introductory graduate level course in financial economics. It is intended for students with strong technical backgrounds who are comfortable with mathematical arguments. The course is divided into three major parts: deterministic finance, single-period uncertainty finance, and options theory and its applications. Prerequisite: GBUS 420

ECO 424. Advanced Numerical Methods (3)
This course focuses on techniques that apply directly to economic analyses. A particular emphasis on problems in finance. The course teaches students how to use EXCEL macros and advanced VBA (the industry standard). It is designed for decision making in business settings. Prerequisite: GBUS 420.

ECO 425. Cost-Benefit Analysis (3)
Theory and methods of cost-benefit analysis; efficiency and equity as criteria in program evaluation; proper measurement of market and non-market costs and benefits; consideration of risk, uncertainty, appropriate discounting techniques and distributional consequences; applications to the evaluation of health care policies and therapies.

ECO 428. Capital and Interest Theory (3)
Theories of interest and capital. Annuities; applications of present value theory; investment valuation under uncertainty and risk; term structure of interest rates; the theory of savings, cost of capital and capital formation. Prerequisite: GBUS 406/MBA 402 or equivalent.

ECO 429. Monetary Theory (3)
The role of money in the economy from theoretical and empirical perspectives. The influence of money and prices, interest rates, output and employment.

ECO 430. Public Finance (3)
The economics of public spending and taxation; principles of government debt management; theories of budgeting and cost-benefit analysis and public choice.

ECO 436. Economic History of the United States (3)
Analysis of the colonial economy, transition to industrialization, and the role of trade and transportation in America's development. A consideration of the importance of slavery to the 19th-century American economy and other New World economies. Origin and development of banking and financial markets. Prerequisites: ECO 401 and ECO 402 or equivalents.

ECO 440. Labor Economics (3)
The economics of labor markets and various labor-market institutions with emphasis on current theoretical and empirical research. Prerequisites: ECO 401 and ECO 402 or equivalents.

ECO 447. Economic Analysis of Market Competition (3)
Mathematical models based on game theory and industrial organization. Cases are used to analyze the strategic interaction of firms and governments as competitors and partners.

ECO 451. Urban Economics (3)
The application of traditional and spatial economics to the location of economic activity focusing on the urban economic problems of business location, housing, land value, land use and intra-urban transportation.

ECO 453. Government Regulation of Business (3)
Analysis of the economic justification for government regulation of private enterprise. Topics include antitrust policy, utilities, and health, safety and environmental regulation. Prerequisite: ECO 402 or equivalent.

ECO 454. Economics of Environmental Management (3)
Economic theory of natural resources. Optimal policies for the development of renewable and nonrenewable resources and environmental quality. Prerequisite: ECO 402 or equivalent.

ECO 455. Health Economics (3)
Economic theory of health care delivery systems. Financing health care services. Case studies of specific economic-financing problems and/or international comparisons of health care delivery.
Prerequisite: ECO 401 or ECO 402 or equivalents or permission of the instructor.

ECO 456. Industrial Organization (3)
The goal of the course is to review theoretical and empirical attempts by economists to understand market structures lying between the extremes of perfect competition and monopoly. The course will focus first on describing the current U.S. industrial structure and reviewing models of imperfect competition. The course then shifts to a closer study of individual firm behavior. The final segment of the course is an overview of two significant relationships between government and industry caused by the existence of imperfect competition.

ECO 457. Bio-Pharmaceutical Economics (3)
Characteristics of the market for pharmaceuticals; barriers to entry, competition and innovation; pricing and regulation; physician prescribing behavior; commercialization and financing of biotech startups; international comparisons of public policy.

ECO 460. Time Series Analysis (3)
Classical decomposition of time series, trend analysis, exponential smoothing, spectral analysis and Box-Jenkins autoregressive and moving average methods.

ECO 461. Forecasting (3)
Methods of economic and business forecasting.

ECO 462. Advanced Statistics for Business and Economics (3)
An expanded development of statistical concepts necessary for business and economic research. Topics include probability theory, sets, density functions and distributions, sampling distributions, point estimation, moment generating functions, maximum likelihood, classical statistical inference, power functions, likelihood ratio tests and non-parametric tests. Prerequisite: calculus.

ECO 463 (IE 458). Topics in Game Theory (3)
A mathematical analysis of how people interact in strategic situations. Topics include normal-form and extensive-form representations of games, various types of equilibrium requirements, the existence and characterization of equilibria, and mechanism design. The analysis is applied to micro-economic problems including industrial organization, inter-national trade, and finance.
Prerequisites: Two semesters of calculus, ECO 414 and ECO 412 , or permission of the instructor.

ECO 471. International Economic Development (3)
An introduction to the basic theoretical concepts in international economic development and an evaluation of their application by means of a representative sample of the literature.

ECO 472. International Trade Theory (3)
Theories of comparative advantage, factor price equalization, trade and welfare, tariffs, trade and factor movements.
Prerequisite: ECO 413 or consent of the chair.

ECO 473. International Monetary Economics (3)
Theory of the balance of payments, the microeconomics of international finance, various approaches to balance-of-payments adjustments, theories of foreign exchange-rate determination and macroeconomic policy under fixed and flexible exchange rates. Prerequisite: ECO 417 or consent of the chair.

ECO 475. Special Topics in Economics (1-3)
Extended Study of an approved topic not covered in scheduled courses. May be repeated for credit.

ECO 480. Economics of Technological Change (3)
Explores theoretical models and empirical evidence on the economics of innovation and technical change. Includes examination of: the role of technology in competitiveness, industrial structure and economic growth; alternative models of the innovative process; incentives for and other conditions affecting research and development; the evaluation of the justifications for government support of R&D. Prerequisite: ECO 402 or equivalent.

ECO 491. Master's Thesis

ECO 499. Dissertation

Education, College of

The College of Education has one academic department, the Department of Education and Human Services. The department faculty and program offerings are listed below followed by descriptions of course offerings. More details on specific degree requirements and on university graduate school regulations can be found in the section Advanced Study and Research.

Department of Education and Human Services

Professors. Sally A. White, Ph.D. (Univ. of New Mexico), *dean*; Linda M. Bambara, Ed.D. (Vanderbilt); Ward M. Cates, Ed.D. (Duke); Christine L. Cole, Ph.D. (Wisconsin-Madison); George J. DuPaul, Ph.D. (Rhode Island); Asha K. Jitendra, Ph.D. (Oregon); J. Gary Lutz, Ed.D. (Lehigh); Edward S. Shapiro, Ph.D. (Pittsburgh), *Iacocca Professor of Education*; Arnold R. Spokane, Ph.D. (Ohio State); George P. White, Ed.D. (Vanderbilt); Perry A. Zirkel, J.D., Ph.D. (Connecticut), LL.M. (Yale).

Associate professors. Nicholas Ladany, Ph.D. (SUNY-Albany) *chairperson;* H. Lynn Columba, Ed.D. (Louisville); Michael P. George, Ed.D. (Missouri-Columbia); Warren R. Heydenberk, Ed.D. (Colorado); Lee Kern, Ph.D. (Univ. of South Florida); April E. Metzler, Ph.D. (Florida); Tina Q. Richardson, Ph.D. (Maryland); Karen E. Stout, Ph.D. (Univ. of Minnesota); Bruce M. Taggart, Ph.D. (Connecticut);

Assistant professors. Mary Jean Bishop, Ed.D. (Lehigh); Jennifer M. Brill, Ph.D. (Georgia); Alec M. Bodzin, Ph.D. (North Carolina State); Grace I.L. Caskie, Ph.D. (University of North Carlonia); Kathryn Ann DiPietro, Ph.D. (Tennessee); Lana L. Edwards, Ph.D. (Oregon); Daphne Pappas Hobson, Ed.D. (Columbia University Teacher's College); Arpana G. Inman, Ph.D. (Temple); Patricia H. Manz, Ph.D. (Univ. of Pennsylvania); C. Russell Mayo, Ed.D. (Univ. of Virginia); Teri A. Melton, Ed.D. (Lehigh); Jill Sperandio, Ph.D. (University of Chicago); Andrew E. Walker , Ph.D. (Utah State).

Professor of Practice. Timothy R. Lucas, M.A. (William Patterson College); George W. Roesser, Ed.D. (Temple); Barbara A. Wilson, Ed.D. (Lehigh).

Adjunct faculty. Gary C. Alexander, Ph.D. (Univ. of Minnesota); Lisa Andrejko, Ed.D. (Lehigh); Ann P. Monroe-Baillargeon, Ph.D. (Syracuse); Jeanette S. Berkley, Ed.D. (Lehigh); M. Kristine Bronson, Ph.D. (SUNY-Albany); John F. Campion, Ed.D. (Nova Southeastern); Joseph P. Carney, Ph.D. (St. John's); Lila U. Carrick, Ed.D. (Lehigh); Richard O. Coe, Ed.D. (Temple); Alvin L. Crawley, Ed.D. (Massachusetts-Amherst); Brad K. Cressman, Ed.D. (Lehigh); Patricia T. Doloughty, Ed.D. (Lehigh); Louise E. Donohue, Ed.D. (Lehigh); Lisa Ann Draper, Ph.D. (Pennsylvania State);

Robert H. Egolf, Ph.D. (Lehigh); F. Laird Evans, Ed.D. (Lehigh); David L. Fallinger, Ed.D. (Pennsylvania State); Diane E. Flisser, Ed.D. (Lehigh); Scott R. Garrigan, Ed.D. (Lehigh); Nancy L. George, Ed.D. (Univ. of Missouri-Columbia); Ronald Goldberg, Ph.D. (Lehigh); Mary Rita Goodman, Ed.D. (Lehigh); Jackie L. Gower, M.Ed. (Lehigh); Roberta A. Heydenberk, Ed.D. (Lehigh); Alexandra Hilt, M.S. (Syracuse); Claire Smith Hornung, Ed.D. (Smith College); Joel B. Ingersoll, Ph.D. (Fairleigh Dickinson); Kevin Kelly, Ph.D. (Lehigh); Clark M. Kirkpatrick, Ph.D. (Alabama); Freya Koger, Ph.D. (Lehigh); Ochan Kusuma-Powell, Ed.D. (Columbia); Robert L. Leight, Ed.D. (Lehigh); James LoGiudice, M.Ed. (Webster); Carla J. Manno, Ph.D. (Univ. of Virginia); Ronald J. Marino, Ph.D. (Michigan State); Michael McAllister, Ph.D. (Oregon); Gary P. McCartney, Ed.D. (Temple); John T. McGovern, Ed.D. (Temple); Kevin J. McHugh, Ed.D. (Lehigh); Robert A. Mesaros, Ph.D. (Univ. of Pennsylvania); Marilyn B. Miller, Ed.D. (Univ. of Pennsylvania); Philip B. Monteith, Ed.D. (Vanderbilt); James R. Newcomer, Ed.D. (Lehigh); Rosalyn P. Pitts, Ph.D. (Lehigh); Thomas J. Power, Ph.D. (Univ. of Pennsylvania); Eve Proffitt, Ed.D. (Kentucky); Carol M. Richman, Ph.D., (Virginia Commonwealth); Maura L. Roberts, Ph.D. (Lehigh); Tina M. Sachar (Lehigh); Kristin D. Arndt-Sawka, Ph.D. (Lehigh); Bruce S. Sharkin, Ph.D. (Univ. of Maryland); Anita Sharma, Psy.D. (George Washington); Timothy J. Silvestri, Ph.D. (Lehigh); David R. Snyder, Ed.D. (Lehigh); Sheryl S. Solow, Ed.D. (Lehigh); Connie Titone, Ed.D. (Harvard); Larry Upton, Ph.D. (Univ. of Minnesota); Jeffrey S. VanLone, Ph.D. (West Virginia); Susan Van Zant, Ed.D. (United States International); David W. Warren, Ph.D. (Claremont); David R. Weiskotten, Ph.D. (Lehigh);

Affiliated faculty. Susan Barrett (Psychology); Mark H. Bickhard (Psychology); Ian T. Birky (Counseling Services); Marvin Charles (Chemical Engineering); Beth R. Golden (Counseling Services); Roy C. Herrenkohl (Sociology and Anthropology); Diane T. Hyland (Psychology); Vincent G. Munley (Economics); William Newman (Psychology); Ageliki Nicolopoulou (Psychology); John Nyby (Biological Sciences); Padraig G. O'Seaghdha (Psychology); Neal G. Simon (Biological Sciences).

The department offers master's degrees and/or professional certification in counseling and human services, educational technology, educational leadership, elementary and secondary education, school counseling, and special education as well as the Ed.S. degree and professional certification in school psychology and special education. Ed.D. degree programs are offered in curriculum and instruction, educational leadership, educational technology, and elementary education. Ph.D. degrees are offered in counseling psychology, school psychology, and special education. While general courses are listed separately, the courses pertinent to each program are listed below.

Education

EDUC 383. Supervised Research in Applied Psychology (1-3)
Provides undergraduate junior and senior psychology majors a formal supervised research experience in applied psychology. Students are assigned for the semester to a research team led by a participating faculty member in the counseling psychology or school psychology programs in the College of Education. (Repeatable up to 6 credits.)

EDUC 388. Statistical Computing (3)
Use of one or more major statistical software packages. Principles of data coding, editing, integrity checking, and management. Emphasis on link between personal computers, mainframes, and other software. Prerequisite: EDUC 408 or consent of instructor.

EDUC 402. Developmental Psychology (3)
Survey of theories and research concerning perceptual, cognitive, social, and personality development through infancy and childhood. Prerequisite: Graduate standing or consent of instructor.

EDUC 403. Research (3)
Basic principles of research; techniques of gathering and analyzing data; design of studies in education. Emphasis on critical reviews of research reports representing various methodologies. Research report required.

EDUC 408. Introduction to Statistics (3)
Organization and description of data. Principles of statistical inference including hypothesis testing, interval estimation, and inferential error control. Emphasis on application.

EDUC 409. Analysis of Experimental Data (3)
Emphasis on analysis of variance designs including one-way, factorial, nested, and repeated measures designs. Introduction to multiple regression and the analysis of covariance. Prerequisite: EDUC 408 or consent of instructor.

EDUC 410. Univariate Statistical Models (3)
The univariate general linear model. Principles of expressing models and hypotheses about those models. Emphasis on similarity among the analysis of variance, multiple regression, and the analysis of covariance. Examples of non-standard models and generalization to complex designs. Prerequisite: EDUC 409 or consent of the instructor.

EDUC 411. Multivariate Statistical Models (3)
The multivariate general linear model. Principles of expressing multivariate models and hypotheses about those models. Emphasis on similarity among the multivariate analysis of variance, multiple regression, and the analysis of covariance. Examples of non-standard models and generalization to complex designs. Prerequisite: EDUC 410 or consent of the instructor.

EDUC 412. Advanced Applications of Psychometric Principles (3)
Conceptual examination of exploratory and confirmatory factor analysis, cluster analysis, latent-trait modeling, and other advanced psychometric topics. Prerequisites: EDUC 409 or equivalent or SCHP/CPSY 427.

EDUC 416. (SR 416) Quasi-Experimentation and Program Evaluation (3)
Social science research methods for non-laboratory settings. Detailed examination of a dozen quasi-experimental research designs, three dozen threats to validity, possible controls, and uses in social program evaluation. Nonmathematical presentation.

EDUC 451. Applied Principles of Cognitive Psychology (3)
Basic principles and contemporary theories of cognitive psychology will be covered, especially regarding the application of these principles to education. Experimental research relevant to contemporary theories of cognitive psychology and the application of these theories in educational settings will be reviewed.

EDUC 461. Single-Subject Research Design (3)
Experimental designs for use with small N's. Topics include design theory and application, experimental validity (internal, external, statistical conclusions and construct validity) and an overview of data analysis procedures.

EDUC 471. (CPSY 471) Diversity and Multicultural Perspectives (3)
Examination of the influence of culture, gender, and disabilities on behavior and attitudes. Historical and current perspectives on race, culture, gender, and minority group issues in education and psychology. Lecture/small group discussion. Course is restricted to graduate students in the College of Education only.

EDUC 473. (SR 473) Social Basis of Human Behavior (3)
Development of human behavior from a social psychological perspective. Emphasis placed on the impact of society upon school-age children and adolescents.

EDUC 486. Doctoral Qualifying Research Project (1-3)
Design and implement research project under faculty supervision to meet requirements for doctoral programs. May be repeated for credit.

EDUC 491. Advanced Seminars: (with subtitle) (1-6)
Intensive study and discussion of a specialized area. Title will vary. May be repeated for credit as title varies.

EDUC 493. Internship in: (with subtitle) (1-6)
Opportunity for students to apply theory to practice in a variety of educational settings. Students will be supervised in the field and participate in seminars dedicated to addressing specific concerns and issues encountered during their experience. Prerequisite: consent of the program director.

EDUC 494. Field Work in: (with subtitle) (3)
Identification of significant problems in an educational environment, review of the literature, and development of appropriate research plans.

EDUC 495. Independent Study in: (with subtitle) (1-6)
Individual or small group study in the field of specialization. Approved and supervised by the major adviser. May be repeated.

EDUC 496. Doctoral Research Seminar (3)
For doctoral students. Research design and application to various kinds of educational problems; data collection and analysis. Criticism and evaluation of student proposals. May be repeated for a maximum of nine credits.

Counseling Psychology

CPSY 407. (SCHP 407). Crisis Management in the Schools. (3)
This course is designed to provide students with knowledge and skills related to crisis preparedness and intervention in the schools. Relevant theories and research literature will be explored as well as practical elements of crisis response that are applicable to all school systems. In addition, intervention strategies and protocols will be examined and discussed. Permission of instructor is required.

CPSY 427. (SCHP 427) Standardized Tests, Measurement and Appraisal (3)
Principles of psychological measurement (e.g., tests construction, technology, validity, reliability, functional utility). Ethical, legal, and cultural issues in the administration and interpretation of psychological tests. Case conceptualization, reporting and presentation.

CPSY 429. Diagnostic Interview Laboratory (1)
Principles of psychological measurement (e.g., tests construction, technology, validity, reliability, functional utility). Ethical, legal, and cultural issues in the administration and interpretation of psychological tests. Case conceptualization, reporting and presentation. One-credit diagnostic laboratory is mandatory for counseling majors but optional for students from other programs. Lab covers diagnostic interviewing and systems for the identification and classification of behavioral and psychological disorders.

CPSY 430. Professional Seminar (4)
Professional, ethical, and legal issues in counseling. Management and delivery of counseling services in a culturally diverse society. Professional development, certification, licensure, and role identification. A required one-credit laboratory extends counseling skill acquisition and examines ethical and legal issues in counseling cases.

CPSY 436. Culture-Centered Career Intervention (3)
Examination of the career development process and interventions for children, adolescents, and adults with a culture-centered perspective. Study of theorists, vocational assessment process, and occupational and psychological information systems.

CPSY 439. Theory and Practice of Group Counseling (3)
Introduction to the process of group counseling and therapy. Selection of group members; group rules; group procedures with children, adolescents and adults; ethical considerations with groups. Study of research on group processes, group therapy, and group leadership. Prerequisites: permission of the program coordinator required.

CPSY 440. Introduction to Family Counseling (3)
Research and current trends in the practice of family counseling. Overview and analysis of major theoretical approaches of family therapy.

CPSY 442. Counseling and Therapeutic Approaches (3)
Theory, research, and technique of counseling within a cultural context. Prerequisites: Admission to CPSY master's program or permission of counseling psychology program coordinator.

CPSY 443. Counseling and Therapeutic Approaches Laboratory (1)
One-credit laboratory will cover counseling skills used in diverse theoretical approaches. Must take along with CPSY 442.

CPSY 445. Elementary School Counseling and Guidance (3)
Emphasizes professional concerns of the elementary school counselor in working with teachers, parents, administrators, and other specialists. Policies, practices,

and curriculum concerns, as they affect the development of the child. Prerequisite: CPSY 430.

CPSY 448. Secondary School Counseling and Guidance (3)
Establishing an effective secondary counseling and guidance program within the framework of the school setting. Policies, procedures, and curriculum concerns as they affect the student. Professional approaches to involve students, teachers, administrators, and parents in the counseling and guidance activities of the secondary school. Prerequisite: CPSY 430.

CPSY 460. (PSYCH 475) Theories of Psychological Counseling (3)
Analysis and synthesis of concepts drawn from counseling theorists. Research and current trends in counseling concerning educational, social and vocational problems. Prerequisites: admission to the Ph.D. program in counseling psychology or permission of the counseling psychology program coordinator.

CPSY 461. Assessment of Adult Intellectual Functioning (3)
Administration and interpretation of individual tests/batteries of adult intelligence and neuropsychological functioning. Consideration of psychological and cross-cultural issues in intellectual assessment. Preparation of psychological reports. Prerequisite: CPSY 427 and permission of the instructor.

CPSY 462. Assessment of Personality (3)
Consideration of issues and methods of personality assessment, including ethical and legal issues, and cross-cultural issues. Practice in the administration of instruments used for personality assessment. Supervised experience and report writing. Prerequisites: CPSY 427 and admission to the Ph.D. program in counseling psychology.

CPSY 466. Current Issues in Counseling and Therapy (1-6)
Examination of an area of counseling or therapy that is of topical interest to students and faculty. Permission of program director required. May be repeated for credit.

CPSY 470. Independent Study and Research (1-6)
Individual or small group study in the field of counseling. Approved and supervised by the major adviser. May be repeated for credit.

CPSY 471. (EDUC 471) Diversity and Multicultural Perspectives (3)
Examination of the influence of culture, gender, and disabilities on behavior and attitudes. Historical and current perspectives on race, culture, gender, and Lehigh minority group issues in education and psychology. Lecture/small group discussion. Course is restricted to graduate students in the College of Education only.

CPSY 472. Human Development Across the Lifespan (3)
An examination of prevailing theories of human growth and development across the lifespan. Examination of the interactive effect of various age groups upon one another. Particular emphasis on the helping relationships.

CPSY 473. (SCHP 473) Advanced Research Methods in Applied Psychology (1-3)
For doctoral students in applied psychology. Issues and methods of research design, data collection and data analysis. Advanced discussion of quantitative, qualitative and single-case research design. Admission to the Ph.D. program in counseling psychology or school psychology or permission of the instructor.

CPSY 476. Supervision of Counseling (1-6)
For candidates for supervisor's certificate or doctorate in counseling. Observation and supervision of counseling practicum students. Prerequisites: CPSY 480 and permission of instructor.

CPSY 480. Practicum (1-4)
Twenty hours of weekly supervised practicum training for advanced graduate students in individual, group, and family counseling and therapy. Prerequisites: CPSY 442 and permission of instructor. May be repeated for credit.

CPSY 481. Advanced Multicultural Counseling (3)
This seminar covers models and theories of multicultural counseling and intervention. Students should be actively engaging in practice with multicultural clients in a practicum or field site, and these cases will form part of the basis of course discussions. Prerequisites: CPSY 471, admission to the doctoral program in counseling psychology, and permission of the counseling psychology program coordinator.

CPSY 483. Field Work in Counseling (3-6)
Twenty hours of weekly supervised professional practice in a school or agency setting as an extension of CPSY 480, Practicum. On-site supervision, audio and/or video recordings and case presentations required. Prerequisites: CPSY 480 and permission of the counseling psychology program coordinator.

CPSY 485. Advanced Psychopathology (3)
This class will cover etiology, assessment, interviewing techniques, establishing a therapeutic alliance, and treatment planning in adult mental disorders. In depth coverage will be given to Axis II disorders. The diagnosis and classification of abnormal behavior using DSM-IV-R medical model will be emphasized. Alternate theories of abnormal psychology will also be discussed. Prerequisite: PSYCH 435, Abnormal Psychology.

CPSY 486. Family Counseling Clinic (3-6)
Supervised practicum training for advanced graduate students in family counseling and therapy. Techniques and methods of conducting family counseling and therapy. Prerequisites: CPSY 480 and CPSY 440.

CPSY 487. Advanced Doctoral Practicum I (4)
Supervised clinical experience for entry-level doctoral students with emphasis on the development of intake skills, assessment procedures and intervention skills. Audio and video recording, individual and group supervision. Prerequisite: Admission to the doctoral program in counseling psychology and permission of the counseling psychology practicum coordinator.

CPSY 488. Advanced Doctoral Practicum II (4)
Supervised clinical experience with emphasis on advanced skills in interpretation, case conceptualization from a theoretical perspective, termination and referral, and in the broad array of professional activities normally conducted by a counseling psychologist. Audio and video recording, individual and group supervision. Prerequisites: CPSY 487 and permission of the counseling psychology practicum coordinator.

CPSY 489. Advanced Doctoral Practicum III (1)
Supervised field experience in counseling and therapeutic settings for doctoral students with specific populations.

In consultation with on-site supervisor, the student will develop an area of focus for this practicum that will include therapy experience, training and additional assessment skills as needed. Repeatable for a total of 3 credits. Prerequisites: CPSY 488 and permission of the counseling psychology practicum coordinator.

CPSY 491. Advanced Doctoral Practicum IV (1)
Supervised field experience in counseling and therapeutic settings for doctoral students with specific populations. In consultation with on-site supervisor, the student will develop an area of focus for this practicum that will include therapy experience, training and additional assessment skills as needed. Repeatable for a total of 3 credits. Prerequisites: CPSY 489 and permission of the counseling psychology practicum coordinator.

CPSY 492. Advanced Field Placement (1)
Students perform counseling in university and community agencies under the supervision of the Ph.D. psychologists at the field placement. Open only to students in counseling psychology. This course does not meet the requirements for CPSY 466. Course may be repeated for up to 2 credits. Prerequisites: CPSY 491 and permission of the counseling psychology practicum coordinator.

CPSY 498. Counseling Psychology Doctoral Internship (1)
A one year full-time or two year half-time supervised internship in professional psychology. Student functions as regular staff member. Regular contact with academic advisor required in addition to end-of-semester evaluation by the internship site and the student. Prerequisite: CPSY 491 and permission of the counseling psychology program coordinator. (Repeatable for a total of 3 credits).

Educational Leadership

EDL 400. Introduction to Organizational Leadership: Theory and Practice (3)
Development of theories of administration and applications in educational institutions. Administrative behavior in organizational settings; administrator's leadership role in decision-making, evaluation, and conflict resolution.

EDL 405. The Principalship (3)
Major problems of organization and administration of schools, types of organization, pupil promotion, program of studies, teaching staff, pupil personnel, contract management, time allotment, plant and equipment, and community relations. Prerequisite: EDL 400.

EDL 406. School Principals Clinic (3-6)
Simulated materials workshop on administrative decision-making open to practicing and prospective elementary and secondary school administrators.

EDL 407. Development and Leadership of Middle Level Programs (3)
Exploration of the design of programs to meet the needs of the pre and early adolescent learners with a focus on organizational structure, instructional practices, curriculum design, staffing, student assessment, and community involvement.

EDL 420. Leading and Managing Curriculum and Instruction Programs (3)
Exploration of the theory, research and practice associated with an effective curriculum and instruction program. Topics include program planning, implementation and evaluation, legal issues, contract management, and budgetary considerations. Emphasis on field-based research and data-based decision making in program design and evaluation.

EDL 422. Curriculum Management for the School Executive (3)
A survey of the methods used to facilitate a curriculum development process based on the theories and findings from research and practice. Application of concepts to practical problems in curriculum leadership to acquire skills in the change process for instruction innovation. Emphasis on current theory and research in standards, technology, and curriculum integration.

EDL 428. Practicum in Supervision of Curriculum and Instruction I (2)
Supervised field experience in all aspects of district-wide curriculum and instructional activities. Requires monthly seminar meetings.

EDL 429. Practicum in Supervision of Curriculum and Instruction II (2)
Advanced supervised field experience in all aspects of district-wide curriculum and instructional activities. Requires monthly seminar meetings. Pre-requisite: EDL 428.

EDL 430. Development and Administration of Special Education Programs (3)
Exploration of the research and practice of an effective special education program. Emphasis on curriculum development, field-based research, and data-based decision making program design and evaluation, and the relationship of the special education program to the pupil services program and the regular curriculum.

EDL 432. Special Education Law (3)
An overview of the relevant legislation, regulations, and case law concerning the education of students with disabilities in pre-k through secondary school.

EDL 434. Leadership and Management of Special Education Programs (3)
Introduction to the management practices related to effective leadership of special education programs including budget development and management, staffing, instructional practices, student assessment practices, and parent involvement.

EDL 438. Practicum in Supervision of Special Education and Pupil Services Programs I (2)
Supervised field experience in all aspects of district-wide special education programs. Requires monthly seminar meetings.

EDL 439. Practicum in Supervision of Special Education and Pupil Services Programs II (2)
Supervised field experience in all aspects of district-wide special education programs. Requires monthly seminar meetings. Pre-requisite: EDL 438.

EDL 440. Development and Administration of Pupil Services Programs (3)
Exploration of the research and practice of an effective comprehensive pupil services program. Emphasis on involvement of community agencies, field-based research, and data-based decision-making, program design and evaluation, and the relationship of the pupil services program to the regular and special education curriculum.

EDL 442. Leadership and Management of Pupil Services Programs (3)
Overview of the management practices related to effective leadership of pupil services programs, including budget development and management, staffing, instructional practices, community agency partnerships, student assessment, legal issues, and parent involvement.

EDL 450. Curriculum Design in a Global Society (3)
Exploration of global issues and their effects on what is taught in schools, specifically in international schools. Emphasis on the analysis of curriculum and the influence that culture plays in decision making.

EDL 452. Comparative Education (3)
Survey of education practices abroad. Systems of articulation, social and legal foundations, and structure in government. Emphasis on the nature and purpose schools in various cultural contexts and the major problems and trends occurring throughout the world.

EDL 466. Supervision of Instruction (3)
Analysis of the principles underlying the organization and supervision of instruction; application to specific teaching situations K-12.

EDL 467. Supervision and Professional Development (3)
Emphasis on establishing skills in human resource management and supervision, including staff selection, supervision models, assessment and feedback methods, managing a diverse workforce, and adult development related to professional growth options. This course is designed specifically for individuals enrolled in a supervisory certification program.

EDL 468. Applied Learning Theory for School Leadership (3)
Overview of the foundations, principles, and theories of curriculum, teaching, and learning. Emphasis on historical perspectives, teaching and learning for understanding, and schools as professional organizations. The purpose is to provide prospective administrators with the background for developing a balanced and challenging school-wide curriculum, for supervising instruction, and for supporting school improvement.

EDL 469. Advanced Instructional Supervision (3)
A staff development approach to supervision designed to extend the supervisor's knowledge of and skills in applying clinical techniques to instructional supervision.

EDL 470. Special Topics in Educational Leadership: (with subtitle) (1-6)
Intensive study and discussion of a specialized area. Title will vary. May be repeated for credit as title varies.

EDL 473. Human Resources Management (3)
Overview of the effective utilization of the human resources of educational organizations. Trends in human resource planning, recruitment, selection, development, evaluation, compensation and contract administration.

EDL 476. School Financial Management (3)
Theoretical and practical foundation in financial management emphasizing the economics of education, financing and distribution of funds, and the management of funds at the school and district level.

EDL 477. Seminar in School-Community Relations (3)
Analysis and development of the communication and public relations skills needed by educators in dealing with the public.

EDL 479. School Law (3)
Effect of school law on administration of public school systems; analysis and synthesis of judicial interpretations of the constitutions, statutes, rules, regulations, and common law relating to educational issues.

EDL 481. Policy and Politics in Public Education (3)
Analysis of the forces, factors, agencies, formal governmental systems and informal subsystems that influence educational policy in local districts and state and national governments.

EDL 485. The Superintendency (3)
A theoretical and historical examination of superintendents' leadership, school board/superintendent relations, and the array of duties and demands upon the superintendency.

EDL 486. Superintendency Clinic (3)
Practical experiences in meeting the challenges inherent in the position of superintendent and associated central office positions. Emphasis on the five basic functional roles of the superintendent: CEO to school board, human resources manager, instructional leader, financial manager, and director of community relations.

EDL 488. Program Evaluation (3)
The historical background, theory, methodology, and current practices of program evaluation in the human services area. Emphasis on conducting evaluations of educational programs and gathering data to make effective program decisions. Participants are required to design a program evaluation research plan.

EDL 489. Doctoral Seminar in School Administration (3)
Analysis of the theoretical, empirical, and conceptual aspects of contemporary issues in educational administration and their implications for policy formulation and implementation in educational institutions. Prerequisite: Official standing as a doctoral student in educational leadership.

Educational Technology

EDT 401. Foundations of Educational Technology (3)
History and overview of the field with consideration of key learning theories and principles that guide designers and developers. Identification of prominent figures and organizations, key issues and terms, and useful resources in the field. Consideration of forces affecting adoption of innovation with a focus on future directions in teaching and learning with technology.

EDT 404 Interactive Multimedia Programming (3)
Introduction to programming interactive multimedia applications in education and training. Emphasis on creating applications utilizing sound, video, graphics and other digital resources.

EDT 408. Advanced Learning Theories Applied to Educational Technology: (with subtitle) (3)
Advanced seminar examining theories of socio-historical psychology and their application to educational technology. -Topics will vary (for example, Vygotsky's Theories Applied to Educational Technology, Communication Theories Applied to Educational Technologies, Group Dynamics Theories Applied to Educational Technologies). May be repeated for credit under different topic. Prerequisite: EDT 401.

EDT 415. Topics in Educational Technology: (with subtitle) (3)
Current issues and practices related to the use or adoption of educational technology. Topics will vary (for example, The Role of Educational Technology in Teaching Persons with Special Needs; Educational Technology in the Workplace; Managing Educational Technology Product Development). May be repeated for credit as topic varies.

EDT 422. Design 1: The Systematic Design of Instruction (3)
Introductory exploration of instructional design models and philosophies and their implications for teaching and learning using technology. Heavy focus on instructional message design. Applies perception theory, communication theory, and learning theory to the design of instructional media. Students in this course design instructional materials employing the theories and guidelines explored. Pre/co-requisite: EDT 401.

EDT 425. Design 2: Applied Instructional and Interface Design Principles (3)
Exploration and application of design models for learning. Special emphasis on graphical user interfaces in education and training. Prerequisite: EDT 422.

EDT 428. Design 3: Advanced Instructional Design (3)
Advanced instructional design and interface issues. Design of instructional environments, selection of instructional metaphors, impact of the interface on the user, and demands of designing for newer learning technologies. Prerequisite: EDT 425.

EDT 432. Development 1: Website and Resource Development for Learning (3)
Introduction to resource development and HTML editing tools used in the creation of eLearning Websites. Covers fundamentals of: HTML and commercial Web-creation software packages; scanners and digital video cameras; and use of digital resource creation-and-manipulation programs.

EDT 435. Development 2: Interactive Multimedia Programming for Learning (3)
Introduction to creating educational applications utilizing sound, video, graphics and other digital resources. Prerequisite: EDT 432.

EDT 438. Development 3: Advanced Development of Instructional Resources and Technologies (3)
Focus on using more sophisticated Website and digital resource development-and-manipulation tools to create multimedia learning materials. Topics will vary (for example, Database-Driven Web Development; Assistive Devices for Special Populations; Programming Hand-held Devices; Audio Resource Development; Media Production for Instructional Programming). May be repeated for credit under different topic. Prerequisite: EDT 435.

EDT 470. Technology Across the Curriculum (3)
Curricular issues related to using technology in various school settings. Technology's varying roles in schools. Emphasis on instructional and curricular concerns and how technology affects educational decisions.

EDT 471. Planning for Implementing Technology in School Settings (3)
Logistics of implementing technology in educational settings. Covers staffing, budgeting, and facilities development and management, staff development, and proposal preparation.

EDT 485. Applied Research in Educational Technology (3)
Approaches and techniques applicable to empirical research studies in educational technology, both quantitative and qualitative. Students design and carry out small-scale investigations of research questions and hypotheses related to educational technology and write up research reports of their findings and conclusions. Prerequisites: EDT 425 and EDUC 403.

EDT 490. Integrating Experience in Instructional Design and Development (3)
Project-based design and development. Students work in teams to design and develop internal or external instructional technology projects under the direction of a faculty member. Prerequisites: EDT 425 and EDT 435.

School Psychology

SCHP 402. (SPED 402) Applied Behavior Analysis (3)
Theory and application of behavior modification methods in classroom and clinical settings. Topics include behavior analysis, outcome research, task utilization, and single case research.

SCHP 404. Historical and Contemporary Issues in School Psychology (3)
History of psychology, education, and school psychology. Roles and function of school psychologist; legal and ethical aspects of school psychology.

SCHP 406. Research Methods and Design (3)
This course is designed to provide skills in the use and application of research methodologies and in the conceptualizing and writing of research proposals. Specifically, the course is focused on developing conceptual knowledge of specific research methods, interpreting data using specific methods of analysis, and developing independent research skills focused around one's own research project. The course is primarily designed for doctoral students in School Psychology and Special Education. Permission of instructor is required.

SCHP 407. (CPSY 407). Crisis Management in the Schools (3)
This course is designed to provide students with knowledge and skills related to crisis preparedness and intervention in the schools. Relevant theories and research literature will be explored as well as practical elements of crisis response that are applicable to all school systems. In addition, intervention strategies and protocols will be examined and discussed. Permission of instructor is required.

SCHP 412. Consultation Procedures (2)
Observational methodology utilized in consultation; rationale, theory and methods of consultation; individual, group and parent consulting. Study of research on the consultation process. Students must also register for one credit of SCHP 431.

SCHP 422. Assessment of Intelligence (3)
Administration and interpretation of individual tests of intelligence used in school evaluation and preparation of psychological reports. Prerequisite: permission of instructor.

SCHP 423. Behavioral Assessment (3)
Techniques of behavioral assessment including direct observation, interviews, checklists, rating scales, self-monitoring and role-play tests. Prerequisite: permission of instructor.

SCHP 425. Assessment and Intervention in Educational Consultation (3)
Collection and use of data in designing classroom interventions. Curriculum based assessment, direct behavioral assessment, and structured interviews, and the interrelationship with diagnoses are emphasized within the behavioral consultation model. Utilization of data from actual case studies. Prerequisites: SCHP 402, SCHP 423.

SCHP 426. Advanced School and Family Interventions (3)
Overview of school-based and family-based intervention strategies for children and adolescents presenting interpersonal, emotional, developmental or behavioral challenges. Examples of topics covered include crisis intervention, peer-mediated interventions, self-management interventions, behavioral parent training, interventions for child abuse/neglect and computer-assisted instruction. Prerequisite: SCHP 402 or permission of instructor.

SCHP 427. (CPSY 427) Standardized Tests, Measurement and Appraisal (3)
Principles of psychological measurement (e.g., tests construction, technology, validity, reliability, functional utility). Ethical, legal, and cultural issues in the administration and interpretation of psychological tests. Case conceptualization, reporting and presentation.

SCHP 429. Special Topics in School Psychology (with subtitle) (1-3)

SCHP 431. Practicum in Consultation Procedures (1-3)
Supervised experience in conducting school-based consultations. Co-requisite, SCHP 412.

SCHP 432. Practicum in Assessment of Intelligence (1-3)
Supervised experience in the administration and interpretation of intelligence tests. Co-requisite, SCHP 422.

SCHP 433. Practicum in Behavioral Assessment (1-3)
Supervised experience in conducting behavioral assessments in school settings. Co-requisite, SCHP 423.

SCHP 434. (SPED 434) Applied Research Practicum (1-3)
Designing and conducting research projects in applied settings.

SCHP 435. Practicum in Assessment & Intervention in Educational Consultation (1-3)
Supervised experience in conducting curriculum-based assessments and designing intervention strategies for educational problems. Co-requisite, SCHP 425.

SCHP 436. Specialized Practicum in School Psychology (with subtitle) (1-3)
Supervised field experience in school psychology with a specific population or setting. May be repeated for credit. Permission of instructor required.

SCHP 437. Advanced Child Psychopathology (3)
Advanced training in the definition, classification, etiology, long-term outcome, and treatment of children and adolescents with various psychopathological disorders. Emphasis is placed upon the assessment and treatment of child and adolescent psychopathology in school settings. Prerequisites: admission to doctoral program or by permission of instructor.

SCHP 438. Health/Pediatric Psychology (3)
Introduction to training in the definition, etiology and behavioral/academic characteristics of children and adolescents with medical disorders. Emphasis is placed on the assessment and treatment of educational and behavioral sequelae of medical disorders in both school and health settings. Prerequisites: admission to doctoral program in school psychology or permission of instructor.

SCHP 439. Comprehensive School Health Programs (3)
Examination of school-wide programs designed to address health care needs of children and adolescents in school settings. Focus is on development of primary prevention and integration of educational, medical, social and community resources. Permission of instructor required.

SCHP 440. Applications of Pediatric School Psychology
Focus on further development of students' knowledge and application of pediatric school psychology. The etiology and developmental course of pediatric medical conditions will be examined, emphasizing the impact on school, family and community environments. Prerequisite: SCHP 438 or SCHP 439 or permission of instructor.

SCHP 442. Doctoral Practicum in School Psychology (1-6)
Field-based experience in providing psychological services in school and/or clinical settings. Prerequisite: admission to doctoral program. May be repeated for credit.

SCHP 443. Certification Internship (1-6)
Full-time experience in clinical/educational settings. Student must complete a minimum of 1,200 clock hours under joint supervision of faculty and field supervisor. May be repeated for credit.

SCHP 444. Doctoral Internship (1-6)
Full-time experience in clinical/educational settings. Student must complete a minimum of 1,500 clock hours under joint supervision of faculty and field supervisor. May be repeated for credit.

SCHP 473. (CPSY 473) Advanced Research Methods in Applied Psychology (1-3)
For doctoral students in applied psychology. Issues and methods of research design, data collection and data analysis. Advanced discussion of quantitative, qualitative and single-case research design. Admission to the Ph.D. program in counseling psychology or school psychology or permission of the instructor.

SCHP 496. Doctoral Seminar in School Psychology (with subtitle) (3)
Selected topics in school psychology (titles will vary) including professional issues, assessment and intervention in school settings, and supervision of school psychology services. May be repeated for credit. Prerequisite: admission to doctoral program.

Special Education

SPED 330. Special Topics in Special Education: (with subtitle)(1-3)
Current issues in the education of individuals with special needs. Titles vary. May be repeated for credit as title varies.

SPED 332. Education and Inclusion for Individuals with Special Needs (3)
Legal, educational and social issues related to the special education of individuals with mental retardation, physical disabilities, emotional/behavioral disorders, learning disabilities, visual and hearing impairments, health impairments and those who are intellectually gifted. Emphasis will be on meeting the diverse needs of students in general education classrooms and settings.

SPED 338. (PSYCH 338) Emotional and Behavioral Disorders of Children (3)
Definition, classification, etiology, treatment, and historical perspective of children and adolescent disorders.

SPED 402. (SCHP 402) Applied Behavior Analysis (3)
Theory and application of behavior modification methods in classroom and clinical settings. Topics include behavior analysis, outcome research, task utilization, and single case research.

SPED 418. Life Skills and Transition Strategies (3)
Curriculum and methods for teaching skills of daily living and preparing students with disabilities for transition to adult living. Includes vocational training, community skills, home and daily living, self-care, leisure, communication and functional academics. Emphasis on transition planning for students with physical disabilities, emotional disturbance, learning disabilities, developmental disabilities, traumatic brain injury, autism, severe disabilities and related challenges.

SPED 419. Academic and Curricular Strategies for Individuals with Disabilities (3)
Methods course designed to increase knowledge of instruction of reading, language arts, mathematics and content area skills. Emphasis on instructional design and strategies, evaluation of commercial textbooks and possible modifications needed for use with individuals with disabilities.

SPED 420. Intern Teaching: Certification (2-3)
Competency-based practice in application of procedures for teaching a broad spectrum of individuals with special needs in preparation for Level I Certification as a Teacher of the Mentally or Physically Handicapped. Prerequisite: consent of program coordinator one semester before registering for this course.

SPED 428. Positive Behavior Support (3)
The design of comprehensive, multicomponent behavior support plans for individuals with disabilities who engage in challenging behaviors. Topics include functional assessment strategies, antecedent and setting event interventions, alternative skill training, consequence strategies, lifestyle interventions and teaming strategies. Taught from a noncategorical perspective. Prerequisite: SPED 402 or permission of the instructor.

SPED 429. Professional Seminar (3)
Master's seminar on current issues in the area of special education and research design. Prerequisite is 18 graduate credits in special education.

SPED 430. Advanced Seminar in Special Education (3)
Advanced issues relating to the field of special education. Titles will vary.

SPED 434. (SCHP 434) Applied Research Practicum (1-3)
Designing and conducting research projects in applied settings.

SPED 440. Early Academic Intervention (3)
Explores the potential effectiveness of interventions to prevent academic failure of children at risk for learning difficulties. Emphasis on research-based interventions in the areas of beginning reading, language and vocabulary, writing and spelling, awareness of print and exposure to print, and mathematics (number sense).

SPED 442. Learning Disabilities: Inclusion and Issues (3)
Explores major topics, issues, and trends in the area of learning disabilities. An overview of historical foundations of learning disabilities, theoretical perspectives and medical aspects, definition, etiology, characteristics, assessment, service delivery models, educational approaches, and instructional design. Emphasis on inclusion strategies for adjusting and adapting to the mainstream settings in preschool, school, and post school environments.

SPED 444. Classroom Management (3)
Introduction to positive behavior support strategies to improve student behavior. Topics include school-wide and class-wide interventions and functional assessment to develop individualized behavior support plans. Prerequisite: Enrollment in special education program.

SPED 446. Practicum/Seminar in Academic Interventions (3)
Supervised field work with emphasis on designing and implementing academic interventions. Emphasis on collaboration with general education teachers and parents. Requires one-hour monthly seminar meetings. This course is restricted to students enrolled in the Academic Intervention Specialist program.

SPED 448. Practicum/Seminar in Positive Behavior Specialist 1 (3)
Introductory supervised field work with emphasis on conducting functional assessments, designing positive behavior support plans, and teaming with families and professionals. Requires one-hour weekly meetings with faculty and other practicum students. This course is

restricted to students enrolled in the Positive Behavior Specialist program.

SPED 450. Practicum/Seminar in Positive Behavior Specialist 2 (3)
Advanced field work with emphasis on resolving difficult case problems in positive behavior support. Requires one-hour weekly meetings with faculty and other practicum students. This course is restricted to students enrolled in the Positive Behavior Specialist program.

SPED 452. Assessment and Planning for Individuals with Disabilities (3)
Educational assessment procedures for individuals with special needs. Understanding and applying formal and informal assessments. Emphasis on curriculum-based assessment for placement and monitoring student progress in instructional materials. Translating assessment information to develop an individualized instructional plan for a student with a disability.

SPED 465. Advanced Methods for Inclusion (3)
Advanced techniques for educating students with disabilities in general education based on current research and practice. Accommodations and planning for physical inclusion. Instructional inclusion through embedded instruction, adaptations, and curriculum overlapping. Decision hierarchies for level of instructional adaptation. Social inclusion methods through methods of social facilitation. Taught from a non-categorical perspective and addresses students with all levels of disability (e.g., mild and severe). Prerequisite: SPED 332, admission to the special education program, or permission of instructor.

SPED 490. Doctoral Seminar in Special Education (3)
Advanced knowledge of issues and research in the education of individuals with special needs. Topics will vary. May be repeated for credit. Prerequisite: admitted for doctoral studies.

Technology-Based Teacher Education

TBTE 312. Classroom Practice (1-3)
Experience in elementary and secondary classrooms as related to theories of child and adolescent development, classroom didactics, and philosophies of education. Problem-centered discussion and observations. May be repeated for credit. Prerequisite: consent of the program director.

TBTE 314. Seminar in Elementary and Secondary Education (3)
Critical analysis and discussion of classroom instructional practices based on experiences of participants as they engage in teaching experiences. Prerequisite: consent of the program director.

TBTE 391. Workshops (1-3)
Cooperative study of current educational problems. Provides elementary, secondary, and special education teachers an opportunity to work at their own teaching levels and in their own fields. Limited to six credits during a summer session but the student may register for more than one workshop provided there is no duplication in subject matter.

TBTE 394. Special Topics in Education: (with subtitle) (1-3)
Examination of a topic of research or professional interest in education. Subtitle will vary. May be repeated for credit as subtitle varies.

TBTE 403. Child Development (3)
A study of physical, intellectual, emotional and social aspects of child development as they relate to the elementary schools.

TBTE 404. Youth in Society (3)
Social development, characteristics, and problems of adolescents and young adults. Impact of relationships with sibling, peers, adults, subcultures, in the context of changing institutions and values.

TBTE 405. Introduction to Testing and Evaluation (3)
Construction and evaluation of the teacher-made test. Selection of published tests and interpretation of individual and group results. Use and misuse of tests in assessing achievement.

TBTE 406. Tools for K-12 Teaching and Learning (3)
Application of technology in school-based instructional settings. This course addresses the use of technology tools and resources to enhance and manage learning. Students will demonstrate skills in design and development of Web sites, evaluation and use of educational software, production and integration of digital media, and other key competencies.

TBTE 407. Designing for K-12 Teaching and Learning (3)
Theoretical, philosophical and curricular foundations of instruction. This course explores theories of learning and their application, implications for the use of technology and standards-based education. Special emphasis on planning, developing and assessing instruction. Prerequisite: Successful prior completion of TBTE 401.

TBTE 410. The Writing Process (3)
Developmental characteristics of children's writing and relationships among writing, spelling and reading. Predictors of writing achievement, teaching strategies and activities, and evaluation schemes will be emphasized, K-12.

TBTE 412. Curriculum and Instruction in Social Studies (3)
Curriculum, content, teaching strategies, and instructional materials of the social studies field. Emphasis will be placed on organizing content, using appropriate methods, testing and evaluation, and innovations for social studies at the elementary, middle, and high school levels. Attention will be given to examining textbooks, courses of study, and teacher-made materials.

TBTE 420. Reading in Elementary Education (3)
Principles of teaching reading in elementary schools. Selection of appropriate materials, methods, and techniques. Beginning reading instruction and the development of strategies for teaching vocabulary and comprehension in narrative and expository texts.

TBTE 422. Language Arts in Elementary Education (3)
Principles of language learning and the development of communication skills in elementary schools. Methods of teaching listening, speaking, handwriting, spelling, punctuation, and grammar. Selection of appropriate materials and textbooks.

TBTE 424. Children's Literature in Elementary Education (3)
Role of literature in the instructional program of the elementary schools. Use of trade books for individualized instruction in reading, language arts, mathematics, science, and social studies.

TBTE 426. Science in Elementary Education (3)
Principles of the elementary science program. Demonstrations and discussions of appropriate materials and techniques for teaching science concepts to elementary school students. Enrollment limited to available lab space.

TBTE 428. Mathematics in Elementary Education (3)
Mathematical skills and concepts for the elementary school program. Sets, systems of numeration, experience with numbers, operations with numbers, number concepts and numerals, and elements of geometry.

TBTE 440. Reading and Critical Thinking in Middle Level and High School Education (3)
Focuses on expository reading development in content areas such as language arts, mathematics, science and social studies. Practical teaching strategies in critical areas, such as comprehension and study skills. Review of research and methods for improving the reading development of students.

TBTE 442. English in Middle Level and High School Education (3)
Curricula, philosophy, methods, strategies, and materials in the teaching of English. Literature, genres, and the nature of text and text differences. Critical analysis and drawing inferences from narrative text and poetry. Applications of technology and assessment principles.

TBTE 446. Science in Middle Level and High School Education (3)
Curricula, philosophy, methodology, strategies and safety in the teaching of middle and high school science. Emphasis on laboratory and instructional technology, at-risk and underrepresented students and current models of science education. Permission of the instructor. Enrollment limited to available lab space.

TBTE 448. Mathematics in Middle Level and High School Education (3)
Curricula, instructional activities, and manipulative aids applicable to mathematics courses in middle level and high schools. Teaching strategies and materials appropriate for teaching mathematics will be emphasized.

TBTE 461. Participation in Teaching (3)
Study, directed observation of, and initial practice in the various phases of teaching in a laboratory-demonstration school or in area elementary and secondary schools. Prerequisite: consent of the program director.

TBTE 463. Intern Teaching (2-3)
Intensive practice in the application of principles of teaching. Supervision is provided by the cooperating school and by the university. Prerequisite: consent of the program director.

TBTE 464. Intern Teaching Seminar (3)
Critical analysis and discussion of classroom instructional practices. Discussion and illustration based on experience of participants as they engage in intern teaching. Prerequisite: consent of the program director.

TBTE 466. Programs for Gifted and Talented (3)
Characteristics of gifted children; teaching gifted children; programs for the gifted in elementary and secondary schools.

TBTE 471. School Curriculum (3)
Curricular innovations. Applications of curricular designs K-12. Subject matter and course design. Integration and importance of the fine arts and physical education in the curriculum.

TBTE 473. Curriculum Construction (3)
Theoretical models of curriculum design and evaluation. Scope, sequence, articulation, continuity, and balance in designs. Organizing for curriculum planning, development, implementation and change. K-12.

TBTE 480. Advanced Doctoral Seminar in Curriculum and Instruction (with subtitle) (3)
Seminar on special topics such as curriculum management, integration of curriculum, middle school curriculum, etc. May be repeated for credit. For doctoral students or with the consent of the instructor.

Electrical and Computer Engineering

Professors. Donald Bolle, Ph.D. (Purdue) *interim chair*; Rick S. Blum, Ph.D. (Pennsylvania); D. Richard Decker, Ph.D. (Lehigh); Douglas R. Frey, Ph.D. (Lehigh); Bruce D. Fritchman, Ph.D. (Lehigh); Miltiadis Hatalis, Ph.D. (Carnegie Mellon); Carl S. Holzinger, Ph.D. (Lehigh); James C. M. Hwang, Ph.D. (Cornell); Thomas L. Koch, Ph.D. (Cal Tech), Director of the Center for Optical Technologies; Alastair D. McAulay, Ph.D. (Carnegie Mellon); Kenneth K. Tzeng, Ph.D. (Illinois); Marvin H. White, Ph.D. (Ohio State), Sherman Fairchild professor of electrical engineering.

Associate professors. Nick Ladany *chairperson*; Yujie Ding, Ph.D. (Johns Hopkins); Karl H. Norian, Ph.D. (Imperial College, London; Boon Ooi, Ph.D. (Glasgow, UK); Meghanad D. Wagh, Ph.D. (I.I.T., Bombay).

Assistant Professors. Tiffany Jing Li, Ph.D. (Texas A&M); Shalinee Kishore, Ph.D. (Princeton); Nelson Tansu, Ph.D. (Winconsin-Madison); Zhiyuan Yan, Ph.D. (Illinois Urbana-Champaign); Svetlana Tatic-Lucic, Ph.D. (Cal Tech.)

Professor of Practice. William Haller, M.S. (Lehigh).

The department of electrical and computer engineering (ECE) offers undergraduate and graduate programs of study along with supporting research for students interested in the field of electrical engineering. It also jointly supports undergraduate and graduate programs in computer engineering, and computer science with the computer science and engineering (CSE) department. Graduate study leads to the degrees master of science, master of engineering, and doctor of philosophy in electrical engineering, and the master of science and doctor of philosophy in computer engineering.

The undergraduate programs emphasize the fundamental aspects of their respective areas. Engineering design concepts are introduced early in the curriculum, and required instructional laboratories introduce design as a hands-on activity. Electives permit students to tailor their programs according to their interests and goals, whether they be in preparation for graduate study or entry into industry. Students are free to select courses offered by other departments and are encouraged to do so when appropriate. In this way they can prepare themselves for activities which straddle departmental boundaries or for entry into professional schools such as medicine or management. Students have the opportunity to synthesize and apply their knowledge in a senior design project. Students may use the senior design project as a way to participate in the various research projects in the department.

The department maintains a number of laboratories in support of its curricular programs. These laboratories include the sophomore laboratory, junior electronic circuits laboratory, microcomputer laboratory, electromechanics laboratory, lightwave laboratory, digital signal processing laboratory, and the digital systems laboratory. The department has research laboratories in computer architectures, wireless communications, optoelectronics, compound semiconductors, electron device physics, microelectronics fabrication, signal processing, and communications. These laboratories are described more completely in the departmental graduate brochure. These laboratories, among others, are available for undergraduate projects.

The graduate programs allow students to deepen their professional knowledge, understanding, and capability within their subspecialties. Each graduate student develops a program of study in consultation with his or her graduate advisor. Key research thrust areas in the department include:

1. Microelectronics and Nanotechnology.
2. Wireless Communications and Networking.
3. Optoelectronics.
4. Bio-Engineering.

Graduate research is encouraged in these and other areas.

Computers and computer usage are an essential part of the student's environment. The university provides a distributed network of about 75 high-performance workstations and over 300 PC-compatible microcomputers in public sites throughout the campus. The ECE department, in conjunction with the CSE department, has state-of-the-art systems to augment and extend the generally available university systems. A primary resource is a network of more than 60 Sun workstations, file servers, and compute servers, running the Unix operating system. With over 60 gigabytes of storage, CD-ROM drives, tape drives, and accelerated graphics, these systems provide an array of software tools for students and researchers including programming languages (C, C++, Pascal, FORTRAN, etc.), software development tools, software and hardware simulators, and electronic computer-aided design packages. In addition to the workstations, the department maintains a collection of PC-compatible microcomputers for ECE students, including a set of machines which can be dedicated to hardware/software projects. The workstations and microcomputers are connected via multiple high-speed ethernet, fiber optic, and ATM networks, which are in turn connected to the university's backbone network, and to the external world through Internet 2. Students are not required by the department nor the university to own a personal computer, but many find such a tool a valuable asset.

A detailed description of the curricular programs follows with a listing of the required courses and with a listing of the departmental course offerings. The departmental courses carry the prefix ECE for electrical and computer engineering. Courses given by the Computer Science and Engineering department have the prefix CSE. Students are urged to search both listings for courses appropriate to their career goals.

Undergraduate Programs

Mission Statement for the Electrical Engineering and Computer Engineering Programs

The mission of the electrical engineering and computer engineering programs is to prepare engineers to meet the challenges of the future, to promote a sense of scholarship, leadership, and service among our graduates, to instill in the students the desire to create, develop, and disseminate new knowledge, and to provide international leadership to the electrical engineering and computer engineering professions.

Program Educational Objectives in Electrical Engineering and Computer Engineering

1. To provide students with the fundamental knowledge for the practice of electrical and computer engineering, and to develop their ability to formulate, analyze and solve electrical and computer engineering problems in practice by applying the fundamental knowledge of mathematics, science, and engineering.
2. To provide the broad education necessary to understand the impact of electrical and computer engineering solutions in a global, societal, and environmental context.
3. To provide students with the foundation and desire for advanced education or graduate study, to instill an awareness of continual changes in their profession in a global context, and to instill the desire for continued life-long learning.
4. To instill responsible professional attitudes and ethics and to develop skills in communicating effectively in working productively in a multidisciplinary team environment.
5. To provide an environment which enables students to pursue their individual goals in a program which is flexible, challenging and supportive.

Bachelor of Science in Electrical Engineering

The required courses for this degree contain the fundamentals of linear circuits, systems and control theory, electronic circuits, signal theory, physical electronics, electromagnetic theory, energy conversion, digital systems, and computing techniques. A strong foundation in the physical sciences and in mathematics is required. Approved electives, chosen with the advisor's consent, are selected in preparation for graduate study or entry into industry according to individual interests. The program totals 136 credit hours. The recommended sequence of courses follows:

See freshman year requirements, section III.

sophomore year, first semester (17 credit hours)

ECE 33	Introduction to Computer Engineering (4)
ECE 81	Principles of Electrical Engineering (4)

PHY 21, 22	Introductory Physics II and Laboratory II (5)
MATH 23	Analytic Geometry and Calculus III (4)

sophomore year, second semester (18 credit hours)

ECE 82	Sophomore Laboratory (1)
ECE 108	Signals and Systems (4)
ECE 126	Fundamentals of Semiconductor Devices (3)
MATH 205	Linear Methods (3)
ECO 1	Principles of Economics (4)
	HSS elective (3)

junior year, first semester (17 credit hours)

ECE 121	Electronic Circuits Laboratory (2)
ECE 123	Electronic Circuits (3)
ECE 202	Introduction to Electromagnetics (3)
MATH 208	Complex Variables (3)
	HSS elective (3)
	free elective (3)

junior year, second semester (17 credit hours)

ECE 125	Circuits and Systems (3)
ECE 138	Digital Systems Laboratory (2)
ECE 203	Introduction to Electromagnetic Waves (3)
MATH 231	Probability and Statistics (3)
	approved technical elective* (3)
	free elective (3)

senior year, first semester (18 credit hours)

ECE 136	Electromechanics (3)
ECE 257	Senior Lab I (3)
	HSS elective (3)
	approved technical electives* (6)
	free elective (3)

senior year, second semester (17 credit hours)

ECE 258	Senior Lab II (2)
	approved technical electives* (9)
	HSS elective (3)
	free elective (3)

**Approved technical electives are subjects in the area of science and technology. Students must select a minimum of four courses from the ECE or CSE course listings, with a minimum of two courses in one of the technical areas described in the following list. Students must also choose at least one engineering elective in either materials, mechanics, thermodynamics, fluid mechanics or physical chemistry, and at least one science elective in physics, chemistry or biology. For students interested in solid-state electronics, quantum mechanics is recommended for the science elective.*

Approved Technical Electives for Electrical Engineering

Breadth Requirement: Minimum of 4 ECE or CSE elective courses.

Depth Requirement: Minimum of 2 courses in one of the technical areas described below.

A. Solid-State Circuits

ECE 308	Physics and Models of Electronic Devices (3)
ECE 332	Design of Linear Electronic Circuits (3)
ECE 333	Medical Electronics (3)
ECE 351	Microelectronics Technology (3)
ECE 355	Applied Integrated Circuits (3)
ECE 361	Introduction to VLSI Circuits (3)
ECE 362	Introduction to VLSI System Design (3)

B. Signal Processing and Communications

ECE 212	Control Theory (3)
ECE 339	Graphical Signal Processing (3)
ECE 340	Adaptive Signal Processing (3)
ECE 342	Communication Theory (3)
ECE 343	Digital Signal Processing (3)
ECE 344	Statistical Signal Processing (3)
ECE 345	Speech Synthesis and Recognition (3)
ECE 375	Computer Vision (3)
ECE 387	Digital Control (3)
ECE 389	Control Systems Laboratory (2)
ME 342	Control Systems (3)

C. Microwaves and Lightwaves

ECE 254	Microwave-Lightwave Laboratory (2)
ECE 346	Microwave Circuits and Techniques (3)
ECE 347	Introduction to Integrated Optics (3)
ECE 348	Lightwave Technology (3)
ECE 371	Optical Information Processing (3)
ECE 372	Optical Networks (3)

D. Computers

CSE ***	Any CSE course except CSE 12, CSE 15, or CSE 252
ECE 201	Computer Architecture (3)
ECE 316	Microcomputer System Design (3)
ECE 319	Digital System Design (3)
ECE 320	Logic Design (3)

Note: ECE 350 Special Topics (3) (The area of each course must be evaluated individually)

Bachelor of Science in Computer Engineering

See catalog entry for Computer Engineering.

Graduate Programs

Graduate programs of study provide a balance between formal classroom instruction and research and are tailored to the individual student's professional goals. The programs appeal to individuals with backgrounds in electrical or computer engineering, mathematics, or the physical sciences. Research is an essential part of the graduate program. Major research areas include:

Wireless Communications and Networking

Signal design (CDMA, OFDM, etc), near-far communication strategies, space-time diversity coding, channel and interference modeling, digital audio and video compression, digital signal processing, novel devices, communication networks, image processing, data fusion, and compound semiconductor devices.

Microelectronics Devices, Integrated Circuits, VLSI Design

Mixed Signal design, Silicon integrated circuit technology, processing, fabrication and testing. Semiconductor device physics, nano scale devices, CMOS VLSI logic design and verification, computer-aided design (CAD), VLSI chip architectures, computer architecture including embedded systems and systems-on-a-chip. New sensors, actuators and novel microsystems, ranging from microelectromechanical-systems (MEMS) to chemical microreactors and Biochips.

Optoelectronics and Photonics
Fiber optic communications and networks, nonlinear optics and solitons, optical switching, novel devices, and optical computing. Free-space optical communication systems.

The Master of Science degree requires the completion of 30 credit hours of work that may include a six credit hours thesis for the EE and CompE degrees. A program of study must be submitted in compliance with the graduate school regulations. An oral presentation of the thesis is required.

The Master of Engineering degree requires the completion of 30 credit hours of work, which includes design-oriented courses and an engineering project. A program of study must be submitted in compliance with the college rules. An oral presentation of the project is required.

The Ph.D. degree in electrical engineering requires the completion of 42 credit hours of work (including the dissertation) beyond the master's degree (48 hours if the master's degree is non-Lehigh), the passing of a departmental qualifying examination appropriate to each degree within one year after entrance into the degree program, the passing of a general examination in the candidate's area of specialization, the admission into candidacy, and the writing and defense of a dissertation. Competence in a foreign language is not required.

The ECE Department has a core curriculum requirement for graduate students in each of the degree programs. The purpose of this requirement is to guarantee that all students pursuing graduate studies in the department acquire an appropriate breadth of knowledge of their discipline.

Electrical Engineering: To satisfy the core curriculum requirements in Electrical Engineering, students must select three (3) courses from the following five (5) different areas: ECE 343 Digital Signal Processing; ECE 401 Advanced Computer Architecture; ECE 402 Advanced Electromagnetic Theory; ECE 420 Advanced Circuits and Systems; ECE 451 Physics of Semiconductor Devices.

Computer Engineering: *see catalog entry for Computer Engineering.*

M.S. in Photonics

The Masters of Science degree in Photonics is an interdisciplinary degree that is designed to provide students with a broad training experience in the various aspects of photonics, including topics in Physics, Electrical Engineering and Materials Science and Engineering. It covers both theoretical and practical topics in areas such as fiber optics, integrated optics, lasers, nonlinear optics and optical materials to prepare the students to work in industry directly after graduation. The program is also designed so as to make it possible for students who wish to continue on for a Ph.D., to still satisfy the requirements of their individual departments for the more advanced degree. For details on this program, see the separate catalog section under Interdisciplinary Graduate Study and Research.

Departmental Courses

Courses are listed under the prefixes ECE and CSE. Generally, electrical engineering courses carry the ECE prefix and appear in the following listing. Computer science courses carry the CSE prefix. Computer engineering courses are found under either prefix. The CSE courses are listed in the Computer Science and Engineering department section in this catalog. The reader should consult both listings.

Electrical and Computer Engineering (ECE)

For Undergraduate Students

ECE 33. Introduction to Computer Engineering (4) fall
Analysis, design and implementation of small digital circuits. Boolean algebra. Minimization techniques, synchronous sequential circuit design, number systems and arithmetic. Microcomputer architecture and assembly level programming. Prerequisite: ENGR 1 or CSE 17.

ECE 81. Principles of Electrical Engineering (4) fall and spring
Circuit elements and laws. Behavior of simple linear networks. Characteristics of electronic devices and device models. Introduction to functional circuits, such as operational amplifier and logic devices. Principles of electromechanical energy conversion and power systems. Includes a weekly session for review and discussion. Prerequisite: MATH 22. Co-requisite: Phys 21.

ECE 82. Sophomore Lab (1) spring
An introduction to the fundamental laboratory instrumentation and measurement techniques of electrical and computer engineering. Five or six experiments based on the fundamental concepts discussed in the prerequisite courses. Introduction to PSPICE and application of various computer aids to design and documentation. Discussions of electrical components and laboratory safety. Use of an engineering notebook and report writing. One three-hour laboratory per week. Prerequisites: ECE 33 and ECE 81, previously.

ECE 108. Signals and Systems (4) spring
Continuous and discrete signal and system descriptions using signal space and transform representations. Includes Fourier series, continuous and discrete Fourier transforms, Laplace transforms, and z-transforms. Introduction to sampling. Prerequisite: ECE 81.

ECE 121. Electronic Circuits Laboratory (2) fall
One lecture and one laboratory per week. Experiments illustrating the principles of operation of electronic devices and their circuit applications. Basic electronic instrumentation and measurement techniques. Co-requisite: ECE 123.

ECE 123. Electronic Circuits (3) fall
Methods for analyzing and designing circuits containing electronic devices. Topics include device models, basic amplifier configurations, operating point stabilization, frequency response analysis, and computer-aided analysis of active circuits. Prerequisite: ECE 108.

ECE 125. Circuits and Systems (3) spring
Formulation of linear circuit equations in the time and frequency domain. Complete solutions of difference and differential equations. Network theorems. Basic stability and feedback concepts. Modulation theory, sampling theory and basic digital signal processing ideas. Prerequisite: ECE 108.

ECE 126. Fundamentals of Semiconductor Devices (3) spring
Introduction to the physics of semiconductors in terms of atomic bonding and electron energy bands in solids.

Charge carriers in semiconductors and carrier concentration at thermal equilibrium. Principles of electron and hole transport, drift and diffusion currents, generation and recombination processes, continuity. Treatment of semiconductor devices including p-n junctions, bipolar junction transistors and field effect transistors. Prerequisite: ECE 81.

ECE 136. Electromechanics (3) fall
Two lectures and one laboratory per week. An experimental introduction to electromechanical energy conversion. Basic concepts of magnetic fields and forces and their application to electrical apparatus including electromechanical transducers, transformers, AC and DC machines. Prerequisite: ECE 81.

ECE 138. Digital Systems Laboratory (2) spring
Implementation issues and techniques for digital logic design. Combinational and sequential logic design using standard integrated circuits. I/O and interrupt processing. Design and implementation of real-time complex digital logic using microprocessor systems. Prerequisite: ECE 33.

ECE 162. Electrical Laboratory (1) spring
Experiments on circuits, machines, and electronic devices. Elementary network theory. Survey laboratory for students not majoring in electrical or computer engineering. Prerequisite: ECE 81.

ECE 201. Computer Architecture (3) spring
Structure and function of digital computers. Computer components and their operations. Computer interconnection structures. Memory system and cache memory. Interrupt driven input/output and direct memory access. Instruction sets and addressing modes. Instruction pipelining. Floating-point representation and arithmetic. Alternative architectures: RISC vs. CISC and introduction to parallel architectures. Prerequisite: ECE 33.

ECE 202. Introduction to Electromagnetics (3) fall
Elements of vector analysis, Coulomb's law, Biot-Savart's and Ampere's laws, Lorentz Forces, Laplace's, and Maxwell's equations, boundary conditions, methods of solution in static electric and magnetic fields, including finite element numerical approach. Quasistationary fields, inductance. Prerequisites: MATH 205, Phys. 21.

ECE 203. Introduction to Electromagnetic Waves (3) spring
Uniform plane waves in free space and in materials, skin effect. Waves in transmission lines and waveguides, including optical fibers. Energy and power flow, Poynting's theorem. Reflection and refraction. Resonators. Radiation and diffraction. Prerequisite: ECE 202.

ECE 212. Control Theory (3)
Introduction to feedback control. Dynamic analysis of linear feedback systems in the time and frequency domain, with emphasis on stability and steady-state accuracy. Major analytical tools: signal-flow graphs, root-locus methods. Nyquist plot, Bode analysis. Cascade compensation techniques. Prerequisite: ECE 125.

ECE 254. Microwave-Lightwave Laboratory (2)
Basic microwave and optical measurement techniques, design procedures and practical concepts. Practical aspects of fiber optics, optical transmission, and modulation. Two three-hour sessions per week. Co-requisite: ECE 346.

ECE 256. Honors Project (1) spring
Open by invitation only to students who have completed ECE 251, Senior Project. Selection is based upon the quality of the senior project with regard to ingenuity, design approach and completeness. The objective of this course is to carry the successful senior projects forward to completion of a technical paper suitable for publication or submission to a technical conference. A written paper and oral presentation are required by mid-semester. Oral presentations will be made before an appropriate public forum. Enrollment limited.

ECE 257. Senior Lab I (3)
With ECE 258, provides a complete design experience for Electrical and Computer Engineers. Research, planning, and completion of the initial design for a project involving hardware and/or software, integrating the many facets of their undergraduate program. Instruction in technical writing, product development, ethics and professional engineering, and presentation of design and research. Two three hour sessions and one additional two hour session per week.

ECE 258. Senior Lab II (2)
Continuation of ECE 257. Complete design, construction, and testing of projects selected and developed in ECE 257. Present final design reviews and project presentations. Submit a final written report. Discuss development issues, including manufacturability, patents, and ethics. Two three-hour sessions per week. Prerequisite: ECE 257 or departmental approval.

ECE 308. Physics and Models of Electronic Devices (3)
Physics of metal-semiconductor junction, p-n junctions, and MOS capacitors. Models of Schottky barrier and p-n junction diodes, JFET, MOSFET, and bipolar transistors. Prerequisite: ECE 126. Hatalis or White.

ECE 316. Microcomputer System Design (3) spring
Content is primarily hardware oriented, but software issues are covered where required. Includes performance characteristics of the more popular devices on the market today. Specific topics include: basic microcomputer structure, bus interconnections, memory systems, serial and parallel interfacing, CRT controllers, interrupt structures, DMA. Prerequisite: ECE 33. Holzinger.

ECE 319. Digital System Design (3) fall
Design techniques at the register transfer level. Control strategies for hardware architectures. Implementation of microprogramming, intersystem communication and peripheral interfacing. Hardware design languages and their use in design specification, verification and simulation. Prerequisite: ECE 138.

ECE 320. Logic Design (3)
Review of basic switching theory, vector boolean algebra, canonical implementations of medium size circuits, threshold logic, fault detection in combinational and sequential logic, Multivalued and Fuzzy logic, regular expressions, nondeterministic sequential machines. Prerequisite: ECE 33.

ECE 332. Design of Linear Electronic Circuits (3)
Introduction to a variety of linear design concepts and topologies, with contemporary audio networks providing many of the concrete examples. Topics include low- and high-level preamps; equalizers and filters; mixers; volt-

age-controlled amplifiers; input and output stage modifications; power amplifiers; analog switching and digital interface circuitry. Prerequisites: ECE 123 and ECE 125. Frey.

ECE 333. Medical Electronics (3)
Bioelectric events and electrical methods used to study and influence them in medicine, electrically excitable membranes, action potentials, electrical activity of muscle, the heart and brain, bioamplifiers, pulse circuits and their applications. Prerequisite: ECE 123 or equivalent. Norian.

ECE 339. Graphical Signal Processing (3)
Application of graphical programming to mathematical principles in data analysis and signal processing. Review of digital signal processing, use of structures, arrays, charts, building virtual instruments, graphical programming for linear algebra, curve fitting, solving differential and difference equations, signal generation, DFT and FFT analysis, windowing and filtering. Prerequisite: ECE 108.

ECE 340. Adaptive Signal Processing (3)
Introduction to the uses and practice of modern adaptive signal processing. Theory and design of discrete-time optimum linear filters and adaptive filters. AR, MA, and ARMA processes are introduced. Common adaptive filtering algorithms are derived and discussed for transversal and ladder structures, including, LMS, Least Squares, and RLS algorithms. Kalman filtering is introduced with some applications. Some programming will be required, using preferably Maple or Matlab. Prerequisites: ECE 125 and MATH 231 or MATH 309. Frey.

ECE 341 Fundamentals of Wireless Communications (3)
Overview of wireless communication systems basics. Cellular concept and other wireless systems. System design fundamentals. Mobile Radio Propagation Modeling: Flat, Frequency Selective, Fast, Slow fading channels, Path Loss Models. Multiple access. Modulation Techniques for wireless. Introduction to wireless networking. Wireless systems and standards. Future wireless systems. Prerequisite: ECE 108 or permission of instructor.

ECE 342. Communication Theory (3)
Theory and application of analog and digital modulation. Sampling theory with application to analog-to-digital and digital-to-analog conversion techniques. Time and frequency division multiplexing. Introduction to random processes including filtering and noise problems. Introduction to statistical communication theory with primary emphasis on optimum receiver principles. Prerequisites: ECE 125 and MATH 309 or MATH 231.

ECE 343. Digital Signal Processing (3)
Study of orthogonal signal expansions and their discrete representations, including the Discrete Fourier Transform and Walsh-Hadamard Transform. Development of fast algorithms to compute these, with applications to speech processing and communication. Introduction to the z-transform representation of numerical sequences with applications to input/output analysis of discrete systems and the design of digital filters. Analysis of the internal behavior of discrete systems using state variables for the study of stability, observability and controllability. Prerequisite: ECE 108.

ECE 344. Statistical Signal Processing (3)
Introduction to random processes, covariance and spectral density, time average, stationarity, and ergodicity. Response of systems to random inputs. Sampling and quantization of random signals. Optimum filtering, estimation, and hypothesis testing. Prerequisites: MATH 231 or MATH 309, and ECE 108. Blum.

ECE 345. Speech Synthesis and Recognition (3)
Application of digital technology to generation and recognition of speech by machines. The analytical tools required for digitizing and encoding speech signals; the methods currently used for synthesizing and recognizing speech; various hardware products available to perform these tasks. Prerequisite: ECE 108. Holzinger.

ECE 346. Microwave Circuits and Techniques (3)
Impedance transformation along waveguides. Matching techniques. Applications of Smith Chart. Resonators as circuit elements. Scattering and transfer matrices. S-parameter design of transistor amplifiers. Stability. Noise. Reflection type amplifiers. Prerequisite: ECE 203 or equivalent.

ECE 347. Introduction to Integrated Optics (3)
Theory of dielectric waveguides (ray and wave approach). Modes in planar slab optical guides and in waveguides with graded index profiles. Coupled-mode formalism and periodic structures. Coupling of optical beams to planar structures. Switching and modulation of light in dielectric guides: phase, frequency and polarization modulators; electro-optic, acousto-optic and magneto-optic modulators. Semiconductor lasers. Fabrication of semiconductor components. Recent advances. Prerequisites: ECE 202 and ECE 203.

ECE 348. Lightwave Technology (3)
Overview of optical fiber communications. Optical fibers, structures and waveguiding fundamentals. Signal degradation in fibers arising from attenuation, intramodal and intermodal dispersion. Optical sources, semiconductor lasers and LEDs. Rate equations and frequency characteristics of a semiconductor laser. Coupling efficiency of laser diodes and LEDs to single-mode and multimode fibers. PIN and avalanche photodetectors. Optical receiver design. Transmission link analysis. Prerequisite: ECE 203.

ECE 350. Special Topics (3)
Selected topics in the field of electrical and computer engineering not included in other courses. May be repeated for credit.

ECE 351. Microelectronics Technology (3)
Technology of semiconductor devices and of integrated circuits, including crystal growth and doping, phase diagrams, diffusion, epitaxy, thermal oxidation and oxide masking, lithography. The major emphasis will be on silicon technology, with additional lectures on GaAs technology. Prerequisite: ECE 126.

ECE 355. Applied Integrated Circuits (3)
Emphasis on understanding of terminal characteristics of integrated circuits with excursion into internal structure only as necessary to assure proper utilization in system design. Classes of devices studied include operational amplifiers, digital-to-analog and analog-to-digital converters, linear multipliers, modulators, and phase-locked loops. Prerequisites: ECE 108 and 123. Holzinger.

ECE 361. Introduction to VLSI Circuits (3)
The design of Very Large Scale Integrated (VLSI) Circuits, with emphasis on CMOS Standard Cell design. Topics include MOS transistor physics, device behavior and device modeling, MOS technology and physical layout, design of combinational and sequential circuits, static and dynamic memories, and VLSI chip organization. The course includes a design project using CAE tools for layout, design rule checking, parameter extraction, and SPICE simulations for performance prediction. Two one-hour lectures and three hours of laboratory per week. Prerequisite: ECE 123.

ECE 362. Introduction to VLSI System Design (3)
Structured hierarchical approach to the design of digital VLSI circuits and systems. Use of CAE tools for design and verification. Topics include: systems aspects of VLSI design, design methodologies, schematic capture, functional verification, timing simulation, use of a CMOS standard cell library and of a silicon compiler. The course includes a semester-long design project, with the design to be fabricated by a foundry. Two one-hour lectures and three hours of design laboratory per week. Prerequisite: ECE 138.

ECE 371. Optical Information Processing (3)
Introduction to optical information processing and applications. Interference and diffraction of optical waves. 2D optical matched filters that use lenses for Fourier transforms. Methods and devices for modulating light beams for information processing, communications, and optical computing. Construction and application of holograms for optical memory and interconnections. Prerequisite: ECE 108. McAulay.

ECE 372. Optical Networks (3)
Study the design of optical fiber local, metropolitan, and wide area networks. Topics include: passive and active photonic components for optical switching, tuning, modulation and amplification; optical interconnection switches and buffering; hardware and software architectures for packet switching and wavelength division multiaccess systems. The class is supported with a laboratory. Prerequisite ECE 81. McAulay.

ECE 373. Optical Communications Laboratory (2)
Fundamental optical instrumentation used for test and measurement in optical communications. The theoretical principles of operation of the instruments and the significance of the parameters measured in optical communications will be covered. Fields of measurement include: optical power, optical spectrum analysis, wavelength measurement, laser diode characterization, polarization analysis, modulation analysis, insertion loss measurements, optical reflectometry for component characterization, optical time domain reflectometry and backscatter measurements, dispersion measurement, and characterization of fiber amplifiers. Prerequisite: ECE 347 or ECE 348 or ECE 371 or ECE 372, or equivalent.

ECE 375. Computer Vision (3)
Acquisition and processing of digital images. Interpretation of vision modalities. Intermediate level vision, including segmentation, texture, and shape representation. Three-dimensional scene understanding from stereo, texture, shading and photometric stereo. Basics of high level vision. Prerequisite: ECE 108 or equivalent or consent of instructor.

ECE 387. (CHE 387, ME 387) Digital Control (3)
Sampled-data systems; z-transforms; pulse transfer functions; stability in the z-plane; root locus and frequency response design methods; minimal prototype design; digital control hardware; discrete state variables; state transition matrix; Liapunov stability; state feedback control. Prerequisite: CHE 386 or ECE 212 or ME 342 or consent of instructor.

ECE 389. (CHE 389, ME 389) Control Systems Laboratory (2)
Experiments on a variety of mechanical, electrical and chemical dynamic control systems. Exposure to state-of-the art control instrumentation: sensors, transmitters, control valves, analog and digital controllers. Emphasis on comparison of theoretical computer simulation predictions with actual experimental data. Lab teams will be interdisciplinary. Prerequisites: CHE 386, ME 343, ECE 212.

ECE 392. Independent Study (1-3)
An intensive study, with report of a topic in electrical and computer engineering which is not treated in other courses. May be repeated for credit. Prerequisite: Consent of instructor.

For Graduate Students

ECE 401. Advanced Computer Architecture (3)
Design, analysis and performance of computer architectures; high-speed memory systems; cache design and analysis; modeling cache performance; principle of pipeline processing, performance of pipelined computers; scheduling and control of a pipeline; classification of parallel architectures; systolic and data flow architectures; multiprocessor performance; multiprocessor interconnections and cache coherence. Prerequisite: ECE 201 or equivalent.

ECE 402. Advanced Electromagnetics (3)
Maxwell's equations for various media and boundary geometries. Electromagnetic wave propagation through anisotropic and nonlinear media. Guided waves, layered media and resonators. Radiation, antennas, strong and weak scattering. Scalar and vector diffraction, and periodic structures. Numerical solutions for boundary value problems. Prerequisites: ECE 202 and ECE 203.

ECE 404. (CSE 404) Computer Networks (3)
Study of architecture and protocols of computer networks. The ISO model; network topology; data-communication principles, including circuit switching, packet switching and error control techniques; sliding window protocols, protocol analysis and verification; routing and flow control; local area networks; network interconnection; topics in security and privacy.

ECE 407. Linear and Nonlinear Optics (3)
Diffraction theory, Gaussian beams. Optical resonators and waveguides. Crystal optics, second harmonic generation, parametric amplification. Third order nonlinearities and associated phenomena such as phase conjugation, optical bistability, self-focusing, optical switching, solutions, etc. Photorefractive effect. Brillouin and Raman scattering.

ECE 410. Digital Communication Systems (3)
Unified description of digital communication systems based on signal space concepts. Analysis of system performance in the presence of channel noise and bandwidth limitations. Comparison of many different types of digital-modulation techniques, combined with

error correction, against theoretical limits. Both bandpass and baseband systems are considered. Optimum methods of detection are considered for all systems. Suboptimum techniques such as adaptive equalization are considered for baseband systems. Basic spread-spectrum concepts are introduced. Prerequisites: ECE 108 and either MATH 231 or MATH 309 or equivalents.

ECE 411. Information Theory (3)
Introduction to information theory. Topics covered include: development of information measures for discrete and continuous spaces study of discrete-stochastic information courses, derivation of noiseless coding theorems, investigation of discrete and continuous memoryless channels, development of noisy channel coding theorems. Fritchman

ECE 412. Advanced Digital Signal Processing (3)
Design and analysis of signal processing algorithms, number theoretic foundations of algorithm design, bilinear algorithms, computational techniques for digital filtering and convolution, Fourier transform and its algorithms, number theoretic transforms and applications to digital filtering, general and special purpose signal processor designs, application specific techniques in signal processing. Prerequisite: ECE 343 or consent of the department chairman. Wagh

ECE 414. Signal Detection and Estimation (3)
Brief review of probability and random process theory. Hypothesis Testing as applied to signal detection. Various optimality criterion including Bayes and Neyman-Pearson and their applications in digital communications, radar, and sonar systems. Optimum and locally optimum detection schemes for Gaussian and non-Gaussian noise. Estimation of unknown signal parameters. Topics of current interest including, distributed signal detection, robust signal detections and quantization for detection as time permits. Prerequisites: ECE 108 and MATH 231 or MATH 309. Blum

ECE 415. Numerical Processors (3)
Design strategies for numerical processors, cellular array adders and multipliers, conditional sum and carry-save asynchronous processors, data recoding and Booth's algorithms, use of alternate numerical bases, CORDIC trigonometric calculator, accumulator orientations, bit slice and bit-sequential processors, pipelining and parallel processing considerations. Prerequisite: ECE 201. Wagh

ECE 416. VLSI Signal Processing (3)
The fundamentals of performance-driven VLSI systems for signal processing. Analysis of signal processing algorithms and architectures in terms of VLSI implementation. VLSI design methodology. Includes a design project which requires use of a set of tools installed on SUN workstations for behavioral simulation, structural simulation, circuit simulation, layout, functional simulation, timing and critical path analysis, functional testing, and performance measurement. Prerequisite: ECE 361, ECE 343, or equivalent.

ECE 417. Pattern Recognition (3)
Decision-theoretic, structural, and neural network approaches to pattern recognition. Pattern vectors and feature extraction. Classifiers, decision regions, boundaries and discriminant functions. Clustering and data analysis. Statistical pattern recognition, parametric and nonparametric approaches. Syntactic pattern recognition. Introduction to neural networks, with examples of back propagation and self-organization algorithms. Prerequisites: MATH 205 and MATH 231, or equivalent.

ECE 420. Advanced Circuits and Systems (3)
Review of the fundamentals of Circuits and Systems theory, including the time and frequency domain response of linear time-invariant circuits. Equation formulation for general lumped circuits, including node voltage and loop current analysis. Basic graph theoretic properties of circuits including Tellegen's Theorem. Discussion of passivity and reciprocity including multiport network properties. State space formulation and solution of general circuits (and systems). Modern filter concepts, including synthesis techniques for active filters and externally linear filters, such as Log Domain filters. Techniques for the analysis of weakly nonlinear systems, as time permits. Prerequisites: Graduate standing, ECE 125 or equivalent.

ECE 423. Digital Image Processing (3)
Fundamentals of imaging acquisition and geometry. Fourier, Hadamard, Walsh and Wavelet Transforms and their usage in image segmentation and understanding. High-pass and low-pass filtering in frequency and spatial domains. Multiresolution analysis and spatial scale filtering. Shape and texture representation and recognition. Prerequisite: ECE 343 or equivalent.

ECE 431. Topics in Switching Theory (3)
Emphasis on structural concepts motivated by recent advances in integrated circuit technology. Major topics include: logical completeness, decomposition techniques, synthesis with assumed network forms, systolic architectures, systolic lemma and its applications, bit serial architectures. Prerequisite: ECE 320 or equivalent. Wagh

ECE 433. (CHE 433, ME 433) State Space Control (3)
State-space methods of feedback control system design and design optimization for invariant and time-varying deterministic, continuous systems; pole positioning, observability, controllability, modal control, observer design, the theory of optimal processes and Pontryagin's Maximum Principle, the linear quadratic optimal regulator problem, Lyapunov functions and stability theorems, linear optimal open loop control; introduction to the calculus of variations; introduction to the control of distributed parameter systems. Intended for engineers with a variety of backgrounds. Examples will be drawn from mechanic-al, electrical and chemical engineering applications. Prerequisite: ME 343 or ECE 212 or CHE 386 or consent of instructor.

ECE 434. (CHE 434, ME 434) Multivariable Process Control (3)
A state-of-the-art review of multivariable methods of interest to process control applications. Design techniques examined include loop interaction analysis, frequency domain methods (Inverse Nyquist Array, Characteristic Loci and Singular Value Decomposition) feed forward control, internal model control and dynamic matrix control. Special attention is placed on the interaction of process design and process control. Most of the above methods are used to compare the relative performance of intensive and extensive variable control structures. Prerequisite: CHE 433 or ME 433 or ECE 433 or consent of instructor.

ECE 435. Error-Correcting Codes (3)
Error-correcting codes for digital computer and communication systems. Review of modern algebra concentrating on groups and finite fields. Structure and properties of linear and cyclic codes for random or burst error correction covering Hamming, Golay, Reed-Muller, BCH and Reed-Solomon codes. Decoding algorithms and implementation of decoders. Prerequisite: CSE 261 or equivalent. Tzeng

ECE 436. (CHE 436, ME 436) Systems Identification (3)
The determination of model parameters from time-history and frequency response data by graphical, deterministic and stochastic methods. Examples and exercises taken from process industries, communications and aerospace testing. Regression, quasilinearization and invariant-imbedding techniques for nonlinear system parameter identification included. Prerequisite: CHE 433 or ME 433 or ECE 433 or consent of instructor.

ECE 437. (CHE 437, ME 437) Stochastic Control (3)
Linear and nonlinear models for stochastic systems. Controllability and observability. Minimum variance state estimation. Linear quadratic Gaussian control problem. Computational considerations. Nonlinear control problem in stochastic systems. Prerequisite: CHE 433 or ME 433 or ECE 433 or consent of instructor.

ECE 447. Introduction to Integrated Optics (3)
Theory of dielectric waveguides (ray and wave approach). Modes in planar slab optical guides and in waveguides with graded index profiles. Coupled-mode formalism and periodic structures. Coupling of optical beams to planar structures. Switching and modulation of light in dielectric guides: phase, frequency and polarization modulators; electro-optic, acousto-optic and magneto-optic modulators. Semiconductor lasers. Fabrication of semiconductor components. Recent advances. The course is an extension of ECE 347 for graduate students and it will include research projects and advanced assignments. Prerequisites: ECE 202 and ECE 203.

ECE 448. Lightwave Technology (3)
Overview of optical fiber communications. Optical fibers, structures and waveguiding fundamentals. Signal degradation in fibers arising from attenuation, intramodal and intermodal dispersion. Optical sources, semiconductor lasers and LEDs. Rate equations and frequency characteristics of a semiconductor laser. Coupling efficiency of laser diodes and LEDs to single-mode and multimode fibers. PIN and avalanche photodetectors. Optical receiver design. Transmission link analysis. The course is an extension of ECE 348 for graduate students and it will include research projects and advanced assignments. Prerequisite: ECE 203.

ECE 450. Special Topics (3)
Selected topics in electrical and computer engineering not covered in other courses. May be repeated for credit.

ECE 451. Physics of Semiconductor Devices (3)
Crystal structure and space lattices, crystal binding, lattice waves and vibrations, electrons and atoms in crystal lattices. Quantum mechanics and energy band theory, carrier statistics, Boltzmann transport theory, interaction of carriers with scattering centers, electronic and thermal conduction. Magnetic effects. Generation and recombination theory. Application to p-n junctions. Prerequisite: ECE 126 or equivalent. Decker, Hatalis or White

ECE 452. Advanced Semiconductor Diode and Transport Theory(3)
Properties of metal-semiconductor contacts, Schottky barriers, ohmic contacts, hot electrons, intervalley scattering, velocity saturation, secondary ionization, avalanche breakdown. Applications to microwave devices such as avalanche and Gunn diodes, Schottky barrier diodes, tunnel diodes and PIN diodes. Prerequisite: ECE 451. Decker

ECE 455. Theory of Metal Semiconductor and Heterojunction Transistors (3)
Physics of metal semiconductor and heterojunction field effect transistors (MESFET and HEMT). Theory of semiconductor heterojunctions. Properties of heterojunction bipolar transistors (HBT): Equivalent circuits, applications to microwave amplifiers, oscillators, and switching circuits. Prerequisite: ECE 451. Decker

ECE 460. Engineering Project (3-6)
Project work in an area of student and faculty interest. Selection and direction of the project may involve interaction with industry. Prerequisite: consent of department chairperson.

ECE 461. Theory of Electrical Noise (3)
Definitions: noise temperature, spectral density. Noise sources: quantum, thermal, shot, generation-recombination, flicker noise. Representation and optimization of noisy networks. Prerequisites: Phys 31 and ECE 126. Decker

ECE 463. Design of Microwave Solid State Circuits (3)
Equivalent circuit modeling and characterization of microwave semiconductor devices, principles of impedance matching, noise properties and circuit interaction, introduction to the design of high power and non-linear circuits. Decker

ECE 467. Semiconductor Material and Device Characterization (3)
This course covers the main characterization techniques used in semiconductor industry. Emphasis is given to the electrical characterization methods although some optical, and physical analytical techniques are reviewed. The principles and the experimental set up for measuring the following parameters are covered: resistivity; carrier and doping concentration; contact resistance and Schottky barrier height; device series resistance; MOSFET's channel length and threshold voltage; carrier mobility; oxide and interface trapped charge; and carrier lifetime. Laboratory sessions provide hands-on experience on some of the above methods. Prerequisites: ECE 126 and ECE 308, or equivalent. Hatalis

ECE 469. Process Modeling for Semiconductor Devices (3)
Students will design and "manufacture" a Si or GaAs transistor through process simulation of ion implantation, epitaxial growth, diffusion and contact formation, etc. I-V characteristics and small signal parameters, suitable for digital and microwave circuit simulation programs, will be derived. Complementary to ECE 463 and 471. Prerequisite: ECE 308 or 351. Hwang

ECE 471. Optical Information Processing (3)
Introduction to optical information processing and applications. Interference and diffraction of optical waves. 2D optical matched filters that use lenses for Fourier transforms. Methods and devices for modulating light beams for information processing, communications, and optical computing. Construction and application of holograms for optical memory and interconnections. The course is an extension of ECE 371 for graduate students and it will include research projects and advanced assignments. Prerequisite: ECE 108.

ECE 472. Optical Networks (3)
Study the design of optical fiber local, metropolitan, and wide area networks. Topics include: passive and active photonic components for optical switching, tuning, modulation and amplification; optical interconnection switches and buffering; hardware and software architectures for packet switching and wavelength division multiaccess systems. This class is supported with a laboratory. The course is an extension of ECE 372 for graduate students and it will include research projects and advanced assignments. Prerequisite: ECE 81.

ECE 473. Optical Communications Laboratory (2)
Fundamental optical instrumentation used for test and measurement in optical communications. The theoretical principles of operation of the instruments and the significance of the parameters measured in optical communications will be covered. Fields of measurement include: optical power, optical spectrum analysis, wavelength measurement, laser diode characterization, polarization analysis, modulation analysis, insertion loss measurements, optical reflectometry for component characterization, optical time domain reflectometry and backscatter measurements, dispersion measurement, and characterization of fiber amplifiers. Prerequisite: ECE 347 or ECE 348 or ECE 371 or ECE 372, or equivalent.

ECE 474. Analog CMOS VLSI Design (3)
The fundamentals of analog circuit design with CMOS linear IC techniques. Discrete Analog Signal Processing (DASP) is accomplished with switched-capacitor CMOS circuits. Analog building blocks include operational amplifiers, S/H circuits, comparators and voltage references, oscillators, filters, modulators, phase detectors/shifters, charge transfer devices, etc. Analog sub-system applications are phase-locked loops (PLL's), A/D and D/A converters, modems, sensors, adaptive filters and equalizers, etc. The emphasis is on the physical operation of analog CMOS integration circuits and the design process. Prerequisite: ECE 355 or equivalent. White

ECE 476. Analysis and Design of Analog Integrated Circuits (3)
Device and circuit models of bipolar and field effect transistors; bipolar and MOS integrated circuit technology; passive components; parasitic and distributed elements; amplifier gain stages; subthreshold gain stages; current sources and active loads; temperature and supply independent biasing; output stage design; frequency response and slew rate limitation; operational amplifier and analog multiplier design. Circuit simulation using SPICE. Prerequisite: ECE 308 or equivalent.

ECE 478. Analysis and Design of Digital Integrated Circuits (3)
Large signal models and transient behavior of MOS and bipolar transistors. Basic inverter and logic gate circuits. Noise margins, operating speed, and power consumption of various logic families, including MOS, CMOS, saturated logic TTL, ECL, and IIL. Regenerative logic circuits and digital memories. Circuit design and computer-aided circuit analysis for LSI and VLSI circuits. Prerequisite: ECE 308 or equivalent.

ECE 479. Advanced MOS VLSI Design (3)
The design of very large scale NMOS and CMOS integrated circuits. Strong emphasis on device physics, and on novel circuit design approaches for VLSI implementation. Examination of second-order effects involved in designing high performance MOS digital integrated circuits, with the goal of pushing the design process to the limits determined by our current understanding of semiconductor device physics and of the currently available technologies. The topics include device physics (subthreshold conduction, short channel effects), important circuit innovations (substrate bias generators, sense amplifiers), systems aspects (clocking, timing, array structures), as well as static and dynamic circuit implementations. Design project, using VLSI design automation tools. Prerequisites: ECE 308 (or equivalent) and ECE 361.

ECE 483. Advanced Semiconductor Devices for VLSI Circuits (3)
Theory of small geometry devices for VLSI circuits. Emphasis of MOS bipolar device static and dynamic electrical characteristics. Carrier injection, transport, storage, and detection in bulk and interfacial regions. Limitations of physical scaling theory for VLSI submicron device structures. MOS physics and technology, test pattern device structures, charge-coupled devices, MNOS nonvolatile memory devices, and measurement techniques for device and process characterization. The influence of defects on device electrical properties. Prerequisite: ECE 451. White

ECE 485. Heterojunction Materials and Devices (3)
Material properties of compound semiconductor heterojunctions, quantum wells and superlattices. Strained layer epitaxy and band-gap engineering. Theory and performance of novel devices such as quantum well lasers, resonant tunneling diodes, high electron mobility transistors, and heterojunction bipolar transistors. Complementary to ECE 452. Prerequisite: ECE 451. Hwang

ECE 486. Integrated Solid-State Sensors (3)
The physical operation of sensor-based, custom integrated circuits. Emphasis on the integration of sensors, analog, and digital circuits on a silicon chip with CMOS technology. Sensors include photocells, electrochemical transducers, strain gauges, temperature detectors, vibration and velocity sensors, etc. Analysis of sensor-circuit performance limits including signal-to-noise, frequency response, temperature sensitivity, etc. Examples of sensor-based, custom I.C.'s are discussed and analyzed with CAD modeling and layout. Prerequisite: ECE 451. White

ECE 491. Research Seminar (1-3)
Regular meetings focused on specific topics related to the research interests of department faculty. Current research will be discussed. Students may be required to present and review relevant publications. May be repeated for credit up to a maximum of three (3) credits. Prerequisite: Consent of instructor.

ECE 492. Independent Study (1-3)
An intensive study, with report, of a topic in electrical and computer engineering which is not treated in other courses. May be repeated for credit. Prerequisite: Consent of instructor.

ECE 493. Solid-State Electronics Seminar (3)
Discussion of current topics in solid-state electronics. Topics selected depend upon the interests of the staff and students and are allied to the research programs of the Sherman Fairchild Laboratory for Solid State Studies. Student participation via presentation of current research papers and experimental work. Prerequisite: consent of instructor. May be repeated for credit.

Electrical Engineering

See listings under Electrical and Computer Engineering

Electrical Engineering and Engineering Physics

This dual-degree curriculum is particularly well suited for students seeking thorough preparation in the field of electronic device physics. It is a combination of the basic electrical engineering and engineering physics curriculums and requires 162 credit hours, distributed over five years. The student will earn two degrees: B.S. in electrical engineering and B.S. in engineering physics.

Two alternative course sequences are listed below. Students who follow the course sequence in the column on the left will complete 135 credit hours, including all of the required electrical engineering courses, by the end of the fourth year and the rest of 163 credit hours at the end of the fifth year. Since the electrical engineering degree requires 136 credit hours, students normally will complete the requirements for that degree at the end of the ninth semester. It is possible for a student to earn the electrical engineering degree at the end of the eighth semester by accumulating the extra credit hour through advanced placement and/or overload credits.

In the alternate course sequence in the column on the right, the student completes 132 credit hours by the end of the fourth year, including all the required physics courses, and the rest of the 163 credits at the end of the fifth year. Since 131 credit hours are required for the engineering physics degree, the student will complete the requirements for that degree at the end of the fourth year, and the requirements for the electrical engineering degree at the end of the fifth year.

Students interested in a dual-degree program combining physics (rather than engineering physics) and electrical engineering should consult the Physics section of this catalog. That program allows the student to earn the B.S. in physics and the B.S. in electrical engineering.

Students interested in either dual-degree program should contact Prof. G. J. Borse, Department of Physics.

The recommended sequences of courses for the two different EEEP sequences are:

EE-EP		EP-EE	
Freshman year (see Section III)			
Sophomore year, first semester			
PHY 21	(4)	PHY 21	(4)
PHY 22	(1)	PHY 22	(1)
ECE 33	(4)	ECE 33	(4)
ECE 81	(4)	ECE 81	(4)
MATH 23	(4)	MATH 23	(4)
	[17]		[17]
Sophomore year, second semester			
PHY 31	(3)	PHY 31	(3)
ECE 108	(4)	ECE 108	(4)
ECE 82	(1)	ECE 82	(1)
MATH 205	(3)	MATH 205	(3)
MATH 208	(3)	MATH 208	(3)
ECO 1	(4)	ECO 1	(4)
	[18]		[18]
Junior year, first semester			
ECE 121	(2)	ECE 121	(2)
ECE 123	(3)	ECE 123	(3)
PHY 212	(3)	PHY 212	(3)
MATH 231	(3)	EP- Ap.Elec.	(3)
MATH 322	(3)	MATH 322	(3)
HSS	(3)	HSS	(3)
	[17]		[17]
Junior year, second semester			
PHY 213	(3)	PHY 213	(3)
PHY 215	(4)	PHY 215	(4)
ECE 125	(3)	ECE 125	(3)
ECE 126	(3)	ECE 126	(3)
ECE 138	(2)	PHY 262	(2)
HSS	(3)	HSS	(3)
	[18]		[18]
Senior year, first semester			
ECE 257	(3)	PHY 340 or ME 104	(3)
PHY 362	(3)	PHY 362	(3)
PHY 363	(3)	PHY 363	(3)
ECE-Ap.Elec.	(3)	EP-Ap.Elec.	(3)
HSS	(3)	HSS	(3)
	[15]		[15]
Senior year, second semester			
ECE 136	(3)	ECE 138	(2)
ECE-Ap.Elec.	(9)	EP-Ap.Elec.	(5)
HSS	(3)	HSS	(3)
Elective	(3)	Electives	(6)
	[18]		[16]
Fifth year, first semester			
EP-Ap.Elec.	(6)	ECE-Ap.Elec.	(3)
Electives	(6)	MATH 231	(3)
PHY 340 or ME 104	(3)	ECE 257	(3)
		Electives	(6)
	[15]		[15]
Fifth year, second semester			
PHY 262	(2)	ECE 136	(3)
EP-Ap.Elec.	(6)	ECE-Ap.Elec.	(9)
Electives	(6)	Elective	(3)
	[14]		[15]
Total Credits	[163]	Total Credits	[163]
Credits in 4 yrs	[135]	Credits in 4 yrs	[132]

EP approved electives*

fall	spring
PHY 369	PHY 273
ECE 257	ECE 258
ECE 351	ECE 316
ECE 361	ECE 320
ECE 355	ECE 332
PHY 382	ECE 348
ECE 308	
PHY 380	

*** Must include ECE 257 or 258 or PHY 273*

Engineering

ENGR 1 and ENGR 5 are required of all engineering and applied science majors and are taken in the recommended freshman year.

ENGR 1. Engineering Computations (3) fall-spring
An introductory survey of computing for students in engineering and the sciences. The course covers basic programming concepts, structures and algorithms. Applications to solving scientific problems. Case studies from utilization of computers in various engineering disciplines. Prerequisite: none.

ENGR 5. Introduction to Engineering Practice (3)
First year practical engineering experience; introduction to concepts, methods and principles of engineering practice. Problem solving, design, project planning, communication, teamwork, ethics and professionalism; innovative solution development and implementation. Introduction to various engineering disciplines and degree programs.

ENGR 160. Engineering Internship (1-3)
This course offers students who have attained at least Jr2 standing an opportunity to complement coursework with a work experience. Detailed rules for this course can be obtained from the Associate Dean of Engineering. Report required. P/F grading.

ENGR 200. Engineering Co-op (3)
Undergraduate students who are officially enrolled in the college's co-op program are eligible for 1-6 credits of free electives. These credits will be taken P/F. Typically, students will take 3 credits of ENGR 200 for the fall semester of junior year work experience and another 3 credits the following summer.

ENGR 211. Integrated Product Development (IPD) I (3) spring
Business, engineering, and design arts students work in cross disciplinary teams of 4-6 students on conceptual design including marketing, financial and economic planning, economic and technical feasibility of new product concepts. Teams work on industrial projects with faculty advisors. Oral presentations and written reports. Prerequisite: junior standing in engineering, business or arts and science. (Mechanical Engineering students must register for ME 211).

ENGR 212. Integrated Product Development II (2) fall
Business, engineering and design arts students work in cross disciplinary teams of 4-6 students on the detailed design including fabrication and testing of a prototype of the new product designed in the IPD course 1. Additional deliverables include a detailed production plan, marketing plan, detailed base-case financial models, project and product portfolio. Teams work on industrial projects with faculty advisors. Oral presentations and written reports. Prerequisite: ENGR 211

ENGR 400. Engineering Co-op for Graduate Students (3)
Supervised cooperative work assignment to obtain practical experience in field of study. Requires consent of department chairperson. When on a cooperative assignment, the student must register for this course to maintain continuous student status. Limit to at most three credits per registration period. No more than six credits can be applied towards a master's degree and no more than an additional nine credits towards a Ph.D. The credits must be taken P/F.

ENGR 452. (CHE 461, ME 442) Mathematical Methods in Engineering (3) fall
Analytical techniques are developed for the solution of engineering problems described by algebraic systems, and by ordinary and partial differential equations. Topics covered include: linear vector spaces; eigenvalues, eigenvectors, and eigenfunctions. First and higher-order linear differential equations with initial and boundary conditions; Sturm-Louiville problems; Green's functions. Special functions; Bessel, etc. Qualitative and quantitative methods for nonlinear ordinary differential equations; phase plane. Solutions of classical partial differential equations from the physical sciences; transform techniques; method of characteristics.

ENGR 475. Research (1)
Projects conducted under the supervision of a faculty advisor. Includes analytical, computational or experimental work, literature searches, assigned readings. Regular meetings with the advisor to consider progress made and future direction are required. The course is open only to graduate students and may be repeated for credit. Prerequisite: Graduate standing and departmental approval.

Engineering Mathematics

Professors. Philip A. Blythe, Ph.D. (Manchester, England); Terry J. Delph, Ph.D. (Stanford); D. Gary Harlow, Ph.D. (Cornell) *chair:* Stanley H. Johnson, Ph.D. (Berkeley); Jacob Y. Kazakia, Ph.D. (Lehigh); Alistair K. Macpherson, Ph.D. (Sydney); Herman F. Nied (Lehigh); Kenneth N. Sawyers, Ph.D. (Brown); Eric Varley, Ph.D. (Brown).

Associate professor. Alparslan Öztekin (Illinois).

Emeritus professors. Dominic G.B. Edelen, Ph.D. (Johns Hopkins); Fazil Erdogan, Ph.D. (Lehigh); Arturs Kalnins, Ph.D. (Michigan); Ronald S. Rivlin, Sc.D. (Cambridge); Gerald F. Smith, Ph.D. (Brown).

The *Division of Engineering Mathematics* was established within the Department of Mechanical Engineering and Mechanics to foster interdisciplinary research in the application of mathematics to the engineering and physical sciences. Interaction with industry is actively encouraged, and appropriate programs are designed for part-time students. Program content for all students is developed through close consultation with division faculty.

For a description of the graduate programs in applied mathematics see the discussion under Interdisciplinary Graduate Programs. Engineering mathematics courses are listed under mechanical engineering and mechanics.

English

Professors. Barry M. Kroll, Ph.D. (Michigan), *Robert D. Rodale Professor of Writing, chairperson*; Peter G. Beidler, Ph.D. (Lehigh), *Lucy G. Moses Distinguished Professor;* Addison C. Bross, Ph.D. (Louisiana State); Alexander M. Doty, Ph.D. (Illinois); Jan S. Fergus, Ph.D. (C.U.N.Y.); Elizabeth N. Fifer, Ph.D. (Michigan); Edward J. Gallagher, Ph.D. (Notre Dame); Rosemary J. Mundhenk, Ph.D. (U.C.L.A.), Barbara H. Traister, Ph.D. (Yale)

Associate professors. Scott Paul Gordon, Ph.D. (Harvard); David Hawkes, Ph.D. (Columbia); Edward E. Lotto, Ph.D. (Indiana) *director*, Center for Writing, MATH and Study Skills*;* Barbara Pavlock, Ph.D. (Cornell).

Assistant professors. Kate Crassons, Ph.D. (Duke); Beth Dolan, Ph.D. (North Carolina); Dawn Keetley, Ph.D. (Wisconsin); Seth Moglen, Ph.D. (U.C. Berkeley); Amardeep Singh, Ph.D. (Duke); Stephanie Watts, Ph.D. (Missouri); Edward Whitely, Ph.D. (Maryland).

Professor of Practice. Bob Watts, Ph.D. (Missouri).

Visiting Professor, *Writer-in-Residence, Berman Center.* Ruth K. Setton, Ph.D. (Rice).

Undergraduate Major in English

The major in English is designed to give students experience in reading, analyzing, and formulating thoughts about people and ideas that matter; an understanding of how literary artists find the appropriate words to express their thoughts and feelings; and a basic knowledge of the historical development of British, American and world literature.

Students who major in English go on to careers in teaching, writing, law, business, science, medicine, engineering—and many others. The analytical and communication skills acquired in the study of literature and writing will be of use in almost any profession or human activity. Depending on their interests, abilities, and career plans, students who major in English are encouraged to consider double majors or one or two minors in other fields. The major in English is flexible enough to allow cross-disciplinary study with ease.

The student majoring in English chooses from an extensive list of courses. To ensure breadth of coverage each English major is required to take the following courses:

English 100	Working with Texts	(4)
English 290	Senior Seminar	(4)

Four 300-level courses distributed over the following periods (British or American survey may substitute for one 300 level course):

- British to 1660 (ENGL. 125, 327, 328, 360, 362, 364)
- British 1660-1900 (ENGL. 125,126, 331, 366, 367, 369, 371, 372)
- American to 1900 (ENGL. 123,376,377,378)
- 20th C American, British, World, Film, Popular Culture (Engl124, 126, 379, 380, 383,3 84, 385, 386, 387)

In addition, each English major elects at least three more courses in literature or film with the following qualifications:

- at least one at the 300-level if a survey fulfills one of the period requirements

These nine courses are the *minimum* for the major. Many of our students will elect to take more, depending on their career plans, their other majors and minors, their plans to study abroad, and so on. Each major has a departmental advisor to assist in selecting courses and to offer counsel about career plans.

The department strongly recommends that any student contemplating the possibility of advanced study of literature at the graduate level should work toward departmental honors.

Departmental Honors in English

In order to receive departmental honors the English major must attain a 3.5 grade-point average in courses presented for the major and must complete at least 44 credit hours of course work in English (beyond English 1 and 2). For the additional credits beyond the 36 required of all English majors, honors students must take the following courses:

ENGL 309 Interpretation: Critical Theory & Practice, **or**

ENGL 312 Studies in Literary and Cultural Theory **and**

ENGL 307 Thesis Proposal, **and**

ENGL 308 Thesis

Because most graduate schools require language examinations, the department also strongly recommends that students going for honors achieve at least second-year college competency in at least one foreign language. Students who complete the courses required for departmental honors but who do not achieve the necessary grade-point average will receive the bachelor of arts degree with a major in English.

Presidential Scholars

Students who anticipate becoming Presidential Scholars should speak to the Director of Graduate Studies in their junior year.

Minors in English

The Department of English offers two minors, each requiring 16 hours of course work beyond English 1 and 2. Students' major advisors monitor the minor programs, but students should consult the minor advisor in the Department of English when setting up a minor program.

To minor in English students take 4 courses in literature or film, one at the 300 level.

To minor in writing, students take ENGL 171, ENGL 173, or ENGL 174 and ENGL 201, ENGL 347 or ENGL 373. They must also take two more courses chosen from ENGL 171, 173, 174, 201, 281, 347, 373 JOUR 11, 111, 123, 212.

Graduate Work in English

We prepare our students to meet contemporary demands for faculty who value excellence in teaching and scholarship.

The Master of Arts Program

Applicants for the M.A. program should have an undergraduate English major. Students who did not major in

English may be admitted but will need to supplement their undergraduate training in English.

Candidates for the master's degree must complete at least 30 credit hours. Students take at least seven of the required courses (including "thesis papers") at the 400 level but may select the balance of their curricula from 300-level course offerings. Course work for the M.A. must include two courses in literature before 1660; two courses in the period between 1660 and 1900; two courses from 1900 to the present; and one course in literary theory. At least **two** of these courses must be in American literature and at least four in British literature. Up to six hours of collateral work in other departments may be included in a master's program.

Instead of writing the traditional "thesis," M.A. candidates write two or three shorter "thesis papers," certified by faculty advisors as ready for submission to a session organizer as a conference presentation or to a professional journal for possible publication.

The Doctor of Philosophy Program

The department admits to its doctoral program only students of proven competence and scholarly promise. An average of 3.5 in M.A. course work and strong endorsements from graduate instructors are minimum requirements for acceptance.

Doctoral candidates with a Lehigh master's degree are required to take eight courses and register for 42 credit hours beyond the M.A. Those entering the doctoral program with a master's from another institution are required to take nine courses and register for 48 credit hours.

Candidates must also demonstrate a reading knowledge of one or two foreign languages after having agreed on choices with the director of graduate studies.

No later than six months after completing their course work, candidates will take written and oral examinations in one major field and two minor fields.

Candidates write their dissertations after having their dissertation proposals approved by the department and being admitted to candidacy by the appropriate college.

Freshman Composition Requirement

With the two exceptions noted below, all undergraduate students take six credit hours of freshman English courses: English 1 and English 2 (or one of the alternatives to ENGL 2 such as 4, 6, 8 or 10. The exceptions are:

- Students who receive Advanced Placement or received 700 or higher on SAT II.
- Students with English as a Second Language. Categories include students on non-immigrant visas, students on immigrant visas, registered aliens, and citizens either by birth or by naturalization.

Students in all these categories for whom English is not the first language may petition for special instruction through the program in English as a Second Language.

At matriculation, all foreign students take an English language competence test to determine the kind of instruction best suited to their needs. Matriculating freshmen judged to be qualified will roster ENGL 1, followed by ENGL 2, 4, 6, 8, or 10. Others will be enrolled in ENGL 3, followed by ENGL 5 (or 2, 4, 6, 8, or 10).

Students enrolled in the English as a Second Language program are expected to reach a level of competence comparable to those in the usual freshman program. The form of instruction, however, will differ in the ESL program by taking into account the special language and cultural needs of non-native speakers.

Matriculating students in all the above categories who are entering at a level above the freshman year, but who need composition credit, should consult the department for advice.

Freshman Courses

ENGL 1. Composition and Literature (3) fall
Emphasis on the writing process, especially on revising for cogency and clarity. Topics drawn mainly from everyday life and culture. Students must receive a grade of C- or higher to advance to English 2.

ENGL 2. Composition and Literature II (3) spring
Continuation of ENGL 1. Emphasis on making informed, thoughtful, and well-supported claims about issues of broad public concern. Topics vary by section. Texts include both expository and literary selections, as well as films and other media. Prerequisite: a grade of C- or higher in ENGL 1.

ENGL 3. Composition and Literature I for ESL Writers (3) fall
Idiomatic English both oral and written, with a strong emphasis on producing well-organized, coherent essays. Enrollment limited to non-native speakers; placement is determined by placement testing or ESL director's recommendation.

ENGL 4. Composition and Literature II: Special Topic A (3) spring
Continuation of ENGL I. Similar to ENGL 2, except that the topic will be announced in advance. Topics vary from year to year. Students must register through the English department. Prerequisites: ENGL 1 and consent of department.

ENGL 5. Composition and Literature II for ESL Writers (3) spring
Continuation of English 3.

ENGL 6. Composition and Literature: Special Topic B (3) spring
Continuation of ENGL I. Similar to ENGL 2, except that the topic will be announced in advance. Topics vary from year to year. Students must register through the English department. Prerequisites: ENGL 1 and consent of department.

ENGL 8. Composition and Literature: Special Topic C (3) spring
Continuation of ENGL I. Similar to ENGL 2, except that the topic will be announced in advance. Topics vary from year to year. Students must register through the English department. Prerequisites: ENGL 1 and consent of department.

ENGL 10. Composition and Literature: Special Topic D (3) spring
Continuation of ENGL I. Similar to ENGL 2, except that the topic will be announced in advance. Topics vary from year to year. Students must register through the English department. Prerequisites: ENGL 1 and consent of department.

ENGL 11. Literature Seminar for Freshmen (3) fall
Alternative to Composition and Literature for freshmen who have earned exemption from English 1 and qualify for a seminar in literature. Recommended especially for qualified students who are considering a major in the humanities. Topics vary by section. Prerequisite: score of 4 or higher on Advanced Placement Test in English or 700 or higher on the SAT II Subject Test in Writing.

Undergraduate Courses

English 52, 54, 56, and 58 are open to all undergraduates, including first-year students also taking freshman English. Courses numbered at the 100-level are open to students who have completed or who are exempt from the required six hours of freshman English. First-year students who have completed English 1 with a grade of A or A– may roster one of the 100-level courses as a second English course to be taken concurrently with the second-semester English composition requirement.

Prerequisites: Each course is a self-contained unit. None has any other prerequisite than two semesters of freshman English. Thus, students may roster English 126 whether or not they have had, or ever plan to take, English 125. For all courses above 200, it is understood that students will have completed six hours of freshman English, even though that is not specified in the course description.

ENGL 38. (AAS 38) Introduction to African Literature (3)
Sub-Saharan African literary themes and styles; historical and social contexts, African folktales, oral poetry, colonial protest literature, postcolonial writing, and films on contemporary Africa. (HU)

ENGL 52. (CLSS 52) Classical Epic (3)
Study of major epic poems from Greece and Rome. Works include Homer's *Illiad* and *Odyssey*, Apollonius' *Argonautica*, Vergil's *Aeneid*, and Ovid's *Metamorphoses*. (HU)

ENGL 54. (CLSS 54, THTR 54) Greek Tragedy (3)
Aspects of Greek theater and plays of Aechylus, Sophocles, and Euripides in their social and intellectual contexts. (HU)

ENGL 56. (CLSS 56) The Ancient Novel (3)
Examination of the origins of the novel in Greece and Rome. Includes the picaresque novel. (HU)

ENGL 58. (CLSS 58, THTR 58) Greek and Roman Comedy (3)
Study of comedy as a social form through plays of Aristophanes, Menander, Plautus, and Terence. (HU)

ENGL 60. (THTR 60) Dramatic Action (4)
How plays are put together; how they work and what they accomplish. Examination of how plot, character, aural and visual elements of production combine to form a unified work across genre, styles and periods. Recommended as a foundation for further studies in design, literature of performance. (HU)

ENGL 91. Special Topics (1-4)
A topic, genre, or approach in literature or writing not covered in other courses. (HU)

ENGL 100. Working with Texts (4)
A course to help students to become, through intense practice, independent readers of literary and other kinds of texts; to discern and describe the devices and process by which texts establish meaning; to gain an awareness of the various methods and strategies for reading and interpreting texts; to construct and argue original interpretations; to examine and judge the interpretations of other readers; to write the interpretive essay that supports a distinct position on some literary topic of importance; and to learn to find and assimilate into their own writing appropriate information from university library resources. To be rostered as early as possible in the English major's program. Departmental approval required. (HU)

ENGL 120. Literature from Developing Nations (4)
Contemporary literature from Africa, Central and South America, and Asia. Prerequisite: six hours of freshman English. (HU) Cannot be taken pass/fail.

ENGL 121. Topics in African-American Literature (4)
Selected works of African American literature and/or the literatures of the African diaspora. May be repeated for credit as title varies. Prerequisite: six hours of first-year English. (HU) Cannot be taken pass/fail.

ENGL 122. Speculative Fiction (4)
The study of "hard" science fiction and mythic fantasy from philosophical and scientific as well as aesthetic and literary perspectives. Prerequisite: six hours of freshman English. (HU) Cannot be taken pass/fail.

ENGL 123. American Literature I (4)
American literary works through the mid-19th century. Prerequisite: six hours of freshman English. (HU) Cannot be taken pass/fail.

ENGL 124. American Literature II (4)
American literature from the middle of the 19th century to the present. Prerequisite: six hours of freshman English. (HU) Cannot be taken pass/fail.

ENGL 125. British Literature I (4)
British literature and literary history from Beowulf through the Pre-Romantics. Prerequisite: six hours of freshman English. (HU) Cannot be taken pass/fail.

ENGL 126. British Literature II (4)
British literature and literary history from the Romantic period into the 20th century. Prerequisite: six hours of freshman English. (HU) Cannot be taken pass/fail.

ENGL 127. (THTR 127) The Development of Theatre and Drama I (4)
Historical survey of western theatre and dramatic literature from their origins to the Renaissance. (HU)

ENGL 128. (THTR 128) The Development of Theatre and Drama II (4)
Historical survey of western theatre and dramatic literature from the Renaissance to the modern era. (HU)

ENGL 155. The Novel (4)
Selected novels, with attention to such matters as narrative, characterization, and cultural context. Prerequisite: six hours of freshman English. (HU) Cannot be taken pass/fail.

ENGL 157. Poetry (4)
Selected traditional and modern poetry, with attention to voice, form, and cultural context. Prerequisite: six hours of freshman English. (HU) Cannot be taken pass/fail.

ENGL 163. Topics in Film Studies (4)
History and aesthetics of narrative film. May be repeated for credit as subject varies. Prerequisite: six hours of freshman English. (HU) Cannot be taken pass/fail.

ENGL 170. Amaranth (1)
Amaranth editorial staff. Students can earn one credit by serving as editors (literary, production, or art) of Lehigh's literary magazine. Work includes soliciting and reviewing manuscripts, planning a winter supplement and spring issue, and guiding the magazine through all phases of production. Editors attend weekly meetings with the faculty advisor. Prerequisite: consent of the department chairperson. May be repeated for credit. (ND)

ENGL 171. Writing for Audiences (4)
Practice in writing in a variety of discourse modes for different audiences. Consideration of the role of style, clarity, and careful observation in writing. Prerequisite: six hours of freshman English. (ND)

ENGL 173. Personal Writing (4)
Practice in writing from immediate experience, with emphasis on accurate, persuasive descriptive writing. Prerequisite: six hours of freshman English. (ND)

ENGL 174. Creative Writing Workshop (4)
Practice in and classroom criticism of creative writing done by students taking the course. Title may vary: Short Story; Drama; Poetry; etc. May be repeated for credit. Prerequisite: six hours of freshman English. (ND)

ENGL 175. Individual Authors (4)
Intensive study of the works of one or more literary artists, such as Austen, Hemingway, and Kerouac. May be repeated for credit as artists and works vary. Prerequisite: six hours of freshman English. (HU) Cannot be taken pass/fail.

ENGL 177. Individual Works (4)
Intensive study of one or more literary works, such as *Moby Dick* and *Stories of John Cheever.* May be repeated for credit as works vary. Prerequisite: six hours of freshman English. (HU) Cannot be taken pass/fail.

ENGL 183. Independent Study (1-4)
Individually supervised study of a topic in literature, film, or writing not covered in regularly listed courses. Prerequisite: consent of the department chairperson. (HU)

ENGL 187. Themes in Literature (4)
Study of a theme as it appears in several works of literature, such as Utopia and the quest. May be repeated for credit as titles and themes vary. Prerequisite: six hours of freshman English. (HU) Cannot be taken pass/fail.

ENGL 189. Popular Literature (4)
The form of literature that has been designated in one way or another as "popular," such as folklore and detective fiction. May be repeated for credit as titles vary. Prerequisite: six hours of freshman English. (HU) Cannot be taken pass/fail.

ENGL 191. Special Topics (1-4)
A topic, genre, or approach in literature or writing not covered in other courses. Prerequisite: six hours of freshman English. (HU)

ENGL 201. Special Topics in Writing (1-4)
Approaches not covered in other writing courses. Individual projects. May be repeated for credit. (ND)

ENGL 281. Writing Internship (1-4)
Projects on- or off-campus in professional, governmental, or service organizations. Experience must include extensive writing that can be submitted for review. Enrollment limited to juniors or seniors with a major or minor in English. May be repeated for credit. Prerequisite: approval of department internship adviser or department chair. (ND)

ENGL. 282. Professional Internship (2-4)
Supervised projects, on- or off-campus, in professional, government, or service organizations. An interested student must submit a proposal, demonstrating the project's relevance to the study of language, texts, or communication, to the department's internship adviser. May be repeated for a maximum of 4 credits. Internship credits do not count toward major in English. Prerequisite: junior or senior standing and approval by department internship adviser. (ND)

ENGL 290. Senior Seminar (4)
In-depth study of a problem, issue, question, or controversy. Enrollment limited to 15 students. Required writing intensive course for English majors. May be repeated for credit, space permitting, as title varies. Department Approval Required. Prerequisite: senior English major standing. (HU)

ENGL 291. Special Topics (1-4)
A topic, genre, or approach in literature or writing not covered in other courses. (HU)

Graduate Students taking 300-level courses receive 3 credits; undergraduates receive 4 credits.

ENGL 301. Topics in Literature (4)
A theme, topic, or genre in literature, such as autobiography as literature and the gothic novel. May be repeated for credit as titles vary. (HU)

ENGL 307. Undergraduate Thesis Proposal (1)
Course to be enrolled by senior honors students preparing to write honors thesis. Course requirements include conducting preliminary research for the thesis and writing a detailed thesis proposal and bibliography. May not be rostered concurrently with English 308. (HU)

ENGL 308. Undergraduate Thesis (3)
Open to advanced undergraduates who wish to submit theses in English. Prerequisite: consent of department chairperson. (HU)

ENGL 309. Interpretation: Critical Theory and Practice (4)
Introduction to recent literary and cultural theory, such as New Criticism, Structuralism, Marxism, Psychoanalytic approaches, Reader-response Criticism, Deconstruction, Feminist Theory, New Historicism, and Cultural Criticism. (HU)

ENGL 310. Introduction to Methods of English as a Second Language Instruction (4)
An introduction to teaching English as a second language including the theory and principles of second language acquisition, ESL methods, materials, and current trends such as computer assisted language instruction. With sufficient effort, students will learn to plan and teach an ESL/EFL class in the four areas of Writing, Reading, Speaking and Listening, choose appropriate materials for varying age and proficiency levels, and most importantly, have a concrete approach to teaching ESL/EFL. Required classroom observing and tutoring hours that can be completed in Lehigh's ESL classes, in Lehigh's ELLC language lab, or in the local public school ESL classes. Course restricted to upperclass and graduate students.

ENGL 311. (WS 311) Literature of Women (4)
Women's works about women. Besides re-reading familiar feminists' fiction, drama, and poems, an introduction to contemporary and often experimental works by less famous writers. (HU)

ENGL 312. Studies in Literary and Cultural Theory (4)
Study of a particular contemporary theoretical approach to literature, film, or other cultural texts. May be repeated for credit as the topic changes. (HU)

ENGL 314. Teaching English as a Second Language: A Practicum (1)
Companion course to English 310 (Intro to Methods of English as a Second Language). This course will include class meetings that focus on guided discussions of the practical application of principles and practices of ESL pedagogy in a real-world environment. Supervised ESL classroom student teaching/tutoring required. Prerequisite: English 310.

ENGL 316. Native American Literature (4)
Fiction by modern American Indian writers like N. Scott Momaday, Leslie Marmon Silko, James Welch, Michael Dorris, and Louise Erdrich. Some attention given to the history of the relationships and conflicts between Native Americans and the federal government, white agricultural and business interests, and educational and religious interests. (HU)

ENGL 318. Topics in African-American Literature and Culture (4)
Special Topics in African-American culture and/or the cultures of the African diaspora. Topics may be focused by period, genre, thematic interest or interdisciplinary method including, for example, "Nineteenth-century African-American Literature and Politics", "African-American Folklore", "Black Atlantic Literature", "The Harlem Renaissance", "African-American Women Writers". May be repeated for credit as title varies. (HU)

ENGL 327. Chaucer (4)
The *Canterbury Tales*, with some attention to other Chaucerian works and other works that may have provided source-materials for Chaucer's tales. Chaucer's language and the literary, intellectual, social, and historical backgrounds to his work. (HU)

ENGL 328. (THTR 328) Shakespeare (4)
An introduction to Shakespearean drama including comedies, histories, tragedies, and romances. Emphasis on textual study, cultural contexts, and performance strategies. (HU)

ENGL 331. Milton (4)
The poetry and prose of John Milton in the context of the English Revolution. Particular attention to the intersection of theology and philosophy, and of the personal with the political. (HU)

ENGL 347. The Essay (4)
Practice of the essay, including such forms as the personal, academic, or argumentative essay. Emphasis on developing a strong personal voice and learning to use other voices. Intensive revision. Prerequisite: ENGL 171,173, or 174, or permission of writing minor advisor. (ND)

ENGL 360. Middle English Literature (4)
Major literary works of the Middle English period by authors other than Chaucer. Emphasis on Piers Plowman, the Gawain/ Pearl Poet, and the metrical romances. (HU)

ENGL 362. The Sixteenth Century (4)
Humanist, Petrarchan and dramatic traditions in the literature of renaissance England. Readings from such authors as Erasmus, More, Wyatt, Sidney, Spenser, and Marlowe. (HU)

ENGL 364. The Seventeenth Century (4)
Literature of the seventeenth century, by such writers as Donne, Herbert, Jonson, Browne, Burton, Milton, Hobbes, Bunyan, and Locke, chronicling the unprecedented variety of aesthetic, political, and social innovations in this "century of revolution." (HU)

ENGL 366. The Restoration and Early Eighteenth Century (4)
Restoration and early eighteenth-century literature, with attention to the cultural forces that shaped the writers and their works. Readings will include Dryden, Behn, Rochester, Wycherley, Congreve, Swift, Finch, Pope, Addison and Steele. (HU)

ENGL 367. The Eighteenth Century (4)
Poetry, drama and prose of the eighteenth century, with attention to cultural forces that shaped the writers, their works, and their position in the canon. Readings of Montagu, Burney, Wollstonecraft, Austen, Fielding, Richardson, Johnson, Sheridan, Sterne, in addition to a few earlier writers. (HU)

ENGL 369. British Romantic Literature (4)
Poetry and prose of Wordsworth, Coleridge, Byron, Shelley, and Keats within the contemporary, political, religious, and social context. (HU)

ENGL 371. British Victorian Literature: Prose and Poetry (4)
Poetry and prose of Tennyson, Browning, Arnold, Swinburne, Carlyle, Mill, Newman, and Ruskin within the contemporary political, religious, and social contexts. (HU)

ENGL 372. British Victorian Literature: Fiction (4)
Major fiction of the Victorian era by such writers as Dickens, Eliot, Thackeray, and Hardy within historical, social, and aesthetic contexts. (HU)

ENGL 373. Advanced Creative Writing Workshop (4)
Advanced practice in and classroom criticism of creative writing done by students taking the course. Emphasis may vary among: fiction, poetry, creative essay, drama, etc. May be repeated for credit. Prerequisite: English 174, or permission of writing minor advisor. (ND)

ENGL 375. Major Authors (1-4)
The works of one or more major literary figures studied in depth. May be repeated for credit as titles and authors vary. (HU)

ENGL 376. Early American Literature (4)
The literature of New England, the Middle Colonies, the South, and the Southwest from Columbus to the close of the eighteenth century, emphasizing our cultural and artistic diversity. (HU)

ENGL 377. American Romanticism (4)
Emerson, Thoreau, Whitman, Hawthorne, Melville, Dickinson, Poe, and their contemporaries. Philosophical, historical, and social background, as well as the aesthetic study of romantic literary works. (HU)

ENGL 378. American Realism (4)
Theory and practice of realistic and naturalistic fiction from the Civil War to the early twentieth-century: Twain, Howells, James, Norris, Crane, Dreiser, Wharton, and regionalists. (HU)

ENGL 379. Twentieth-Century American Literature (4)
American literature before World War II. Lectures and class discussion of major fiction and poetry. (HU)

ENGL 380. Contemporary American Literature (4)
American literature since World War II. Lectures and class discussions of new writers and of recent works of established writers. (HU)

ENGL 382. Themes in American Literature (4)
Intensive study of one topic in American literature. Readings from the colonial period to the present. May be repeated for credit as title varies. (HU)

ENGL 383. Modernism and Post-Modernism in Fiction (4)
The "anti-realistic' novel; time/space, point of view, narrative voice, structure as meaning. Kafka, Woolf, Beckett, Nabokov, Robbe-Grillet, Faulkner, Borges, Hawkes, Stein. (HU)

ENGL 384. Twentieth-Century World Literature (4)
World literature (Europe, Asia, South America, Africa) from 1900 to present. (HU)

ENGL 385. Modern British and Continental Literature (4)
World English literature and continental literature before World War II. Lectures and class discussion of major fiction. (HU)

ENGL 386. Contemporary British and Continental Literature (4)
World English literature and continental literature after World War II. (HU)

ENGL 387. Film History, Theory, and Criticism (4)
Study of film with the focus on particular genres, directors, theories, periods, or topics. Weekly film screenings. May be repeated for credit as title varies. (HU) Cannot be taken pass/fail.

ENGL 388. Independent Study (1-4)
Individually supervised study of a topic in literature, film, or writing not covered in regularly listed courses. Prerequisite: consent of department chairperson. (HU)

ENGL 391. Special Topics (1-4)
A topic, genre, or approach in literature or writing not covered in other courses. (HU)

Graduate Courses in English

The following courses are seminars, ordinarily limited to no more than twelve graduate students, but undergraduate English majors who are planning to go on to graduate school in English and who have shown proficiency in the study of literature may petition to take one of these seminars in their senior year.

ENGL 400. Supervised Teaching (1)
Practical experience in teaching through assisting a faculty teacher in conduct of a regularly scheduled undergraduate course. Open only to graduate students with at least one semester of graduate course work at Lehigh University and a GPA of at least 3.5 Usually rostered in conjunction with 485. Prerequisite: Consent of the department chairperson.

ENGL 421. History of the English Language (3)
The phonology, grammar, and lexicon of English from the beginnings to the present.

ENGL 423. Anglo-Saxon Language and Literature (3)
An introductory study of the Anglo -Saxon culture through its language and literature. Special attention given to translation and interpretation of the epic poem *Beowulf.*

ENGL 433. Middle English Literature (3)
Course may be repeated for credit as title varies. Possible offerings: Arthurian Romance and History: An inquiry into medieval Arthurian literature from Celtic traditions to Malory's *Morte D'Arthur.* Focus given to the confluences these texts craft between fantasy and politics, and the problems of a literary history that understands "romance" and "history" as opposing terms.
Chaucer: A study of selected works by Geoffrey Chaucer, with attention to his language, his sources, his cultural backgrounds that inform his poetry, and trends in modern criticism of his works.
Insular Literary Cultures: A study of selected "British" works from a variety of cultures (Scots, Irish, Welsh, Middle-English, Anglo-Norman, Monastic, Lollard, etc.) written (or popular) from 1300-1500. Careful attention given to reading texts in a larger cultural (and "multicultural") context.
Origins of British Drama: A study of several medieval plays, like *Everyman,* the *Second Shepherds' Play,* and selected plays in one of the mystery play cycles. Brief consideration of the dramatic techniques of Chaucer's poetic fiction as a precursor to the drama that was to flourish centuries later.

ENGL 439. Sixteenth-Century British Literature (3)
Course may be repeated for credit as title varies. Possible offerings:
Renaissance Love Poetry: Study of the sixteenth century sonnet sequence, epyllion, and Ovidian lyric. Works by Wyatt, Surrey, Marlowe, Sidney, Fulke Greville, Spenser, and Shakespeare.
City and Court under Elizabeth and James: Study of how the City (London) and the Court under each monarch are represented in contemporary texts—in drama, poetry, letters, sermons, and prose tracts.

ENGL 441. Seventeenth-Century British Literature (3)
Course may be repeated for credit as title varies. Possible offerings:
Literature of the English Revolution: Examination of the causes, circumstances, and consequences of the English Revolution as expressed from 1640-1670. Readings in: Hobbes, Harrington, Lilburne, Milton, Marvell, and Bunyan.
Theology and Interpretation in the Renaissance: Drawing on the hermeneutics of Luther and Calvin, the course will focus on how English writers of the sixteenth and seventeenth centuries elaborated a distinctively Protestant mode of signification. Writers studied will include Jonson, Donne, Herbert, Traherne, Browne, and Bunyan.

ENGL 442. Restoration and Eighteenth-Century British Literature (3)
Course may be repeated for credit as title varies. Possible offerings:
Restoration and Early Eighteenth-Century Drama: Examination of the drama written between 1660 and 1720 and of the culture shaping it and shaped by it. Cavendish, Philips, Dryden, Behn, Wycherley, Etherege, Congreve, Shadwell, Steele will be among the writers we study.
Tory Feminist? Close investigation of the complex position of early modern women writers (including Cavendish, Philips, Behn, Pix, Centlivre, Finch, Montagu); consideration of the conditions of authorship, for men and women, in late seventeenth-century Britain.
Frances Burney and Jane Austen: Major novels of Burney and the novels and juvenilia of Austen in their social and literary contexts. Examination of what it means to be a professional woman writer between 1770-1820.
Literature in the Marketplace: Study of the eighteenth-century marketplace through examining "canonical" works in relation to the print culture that engendered and then imitated them. Sources for this examination include periodical literature, children's books, "minor" fiction, and booksellers' records.

ENGL 445. Nineteenth-Century British Literature (3)
Course may be repeated as title varies. Possible offerings:
The Victorian Novel and Poststructural Theory: Intensive study of three or four Victorian novels, by writers such as Dickens, Eliot, Bronte, and Thackeray, through the lens of Feminist, Marxist, Psychoanalytical, Deconstructive, and Cultural theory.
The Problem of Knowledge in the Victorian Age: Given the new kinds of knowledge emerging in their time, such writers as Dickens, Carlyle, Mill, Marx, Eliot, Tennyson, Browning, Arnold, Ruskin, and Newman had to ponder the question: What notions—religious doctrines, for example, or scientific observations—should be considered "knowledge"?

ENGL 449. Twentieth-Century British Literature (3)
Course may be repeated as title varies. Possible offerings:
James Joyce: Close examination of the works of James Joyce, with special attention to style, narrative voices, and thematic complexity.
Modern British Fiction: Concentration on one or more major figures: Joyce, Conrad, Shaw, Forster, Woolf, Lawrence, Beckett. Revitalized "New Critical" approaches.

ENGL 471. Early American Literature (3)
Course may be repeated as title varies. Possible offerings:
Benjamin Franklin and the American Character: In-depth study of Franklin's work, life, and career, as well as study of his influence and reputation through works written about him—some loving, some vicious—from John Adams to John Updike.
Early American Literature: A broad survey of literature from Columbus to the end of the eighteenth century, focusing on important writers, geographical and cultural diversity, and diverse literary forms (history, sermon, poetry, autobiography, novel, travel narrative, political essay).

ENGL 473. Nineteenth-Century American Literature (3)
Course may be repeated as title varies. Possible offerings:
Emerson, Dickinson, Frost: Emerson's philosophy, literary theory, and poetry as the context in which we consider the poetry of Dickinson and Frost.
Literary Watersheds: Close reading, critical reputation, and contemporary approaches to four works that transformed and invented our national literature: *Moby Dick, Uncle Tom's Cabin, Walden,* and *Leaves of Grass.*
Henry James: Close Examination of the works of The Master: short stories, novellas, and major novels. Varied critical approaches.
Literary Realism and Naturalism: Selected fiction by one or more of the following pioneers in American literary realism and literary naturalism: Henry James, Mark Twain, Stephen Crane, William Dean Howells, Frank Norris, and Theodore Dreiser.

ENGL 477. Modern American Literature (3)
Course may be repeated for credit as topic varies. Possible offerings:
Ernest Hemingway: Heightened "New Critical" approaches to the short stories and major novels of Ernest Hemingway.
Modern American Fiction: Heightened "New Critical" approaches to one or more major fiction writers from 1900 to 1950: Hemingway, Faulkner, Fitzgerald, Dos Passos, West, Porter.
Modern Southern Writers: Major Southern writers since 1920 from all regions including Styron, O'Connor, Williams, Faulkner, Welty, Percy, Porter, Ransom, Tate, and Warren. All genres, and some sub-genres like "Southern Gothic," will be studied, along with social and philosophical influences.
Modern American Poetry: The significant poets from 1900 to 1960. The major emphasis falls upon Eliot, Pound, Stevens, and Williams, but other poets could include Cummings, Frost, Stein, Hughes, Lowell, Plath, Moore, Dickey, Roethke, and Warren.
Contemporary American Poetry: Poets from the 1960's to the present. Such poets as Creeley, Ginsberg, Levine, Rich, Plath, Lorde, Lowell, Kinnell, Baraka.
Contemporary American Drama: Drama from the 1950's to the 1990's. Such playwrights as Mamet, Shepard, Fornes, Wilson, Norman, Howe, Wasserstein, Durang and others.
Contemporary Native American Fiction: Short stories and novels by American Indian writers since the mid-1960's, including Momaday, Silko, Welch, Dorris, and Erdrich. There will be special focus on the novels of Louise Erdrich.

ENGL 480. Composition and Rhetoric (3)
Basic theories and works in composition and rhetoric, with some attention to classical rhetoric, but with primary emphasis on modern rhetoric and discourse theory, including Burke, Kinneavy, Moffett, and Britton, as well as theories of the writing process. Consideration of linguistics as it applies to teaching writing, and the history of teaching writing in America.

ENGL 481. Theory and Criticism (3)
Course may be repeated for credit as title varies. Possible offerings:
Theories of Authorship in Literature and Film: Material from Western Romanticism through theorists such as Derrida, Barthes, and Foucault. Focus on film *auteurism* and structuralist, post-structuralist, and feminist, Marxist, and gay/lesbian challenges to and reconceptualization of notions of authorship. *The Ideology of the Aesthetic:* Consideration of the aesthetic impulse and its relationship to rhetoric and literary criticism. Readings from Lentricchia, Eagleton, the Frankfurt School, Jameson, Burke, Bakhtin, and Bourdieu. *Feminist Theory and Speculative Fiction:* How woman's concerns find

expression in non-realistic fiction by Le Guin, Russ, McKillip, Tepper, Elgin, Slonczewski, and Tiptree. Collateral readings in feminist theory. *Advanced Critical Theory:* Study of several important and influential recent theoretical texts. Emphasis on "pure" rather than "applied" theory: readings from Macherey, Derrida, Baudrillard, Kristeva, and Jameson. *Feminist Theory: Culture, Gender, and Agency*: A study of selected works of feminist theory with special emphasis on the interventions gender theorists have made into discourses of culture and agency. Readings from Irigaray, Kristeva, Rubin, deBeauvoir, Hooks, Spillars, Abel, Alarcon, Harraway, Butler , and others.

ENGL 485. Introduction to Writing Theory (2)
Survey of major approaches and theoretical issues in the field of composition and rhetoric. Required of all new teaching assistants in the department. Usually rostered in conjunction with 400 or 486.

ENGL 486. Teaching Composition: A Practicum (1)
Introduction to teaching writing at Lehigh. Bi-weekly discussions of practical issues and problems in the teaching of freshman composition. Required of all new teaching assistants in the department. Usually rostered in conjunction with English 485.

ENGL 487. Teaching with Technology: A Practicum (1)
Hands-on introduction to the tools and skills necessary to teach with the computer, along with some attention to appropriate pedagogy. Prerequisite: consent of graduate program coordinator.

ENGL 490. Master's Thesis (3)
Writing master's thesis papers.

ENGL 491. Special Topics (1-3)
A topic, genre, or approach in literature or writing not covered in other courses. May be repeated for credit as title varies. Prerequisite: consent of the graduate program coordinator.

ENGL 493. Graduate Seminar (3)
Intensive study of the works of one or more authors, or of a type of literature. May be repeated for credit as title varies.

ENGL 495. Independent Study (3)
Individually supervised course in an area of literature, film or writing not covered in regularly listed courses. Prerequisite: consent of the graduate program coordinator.

ENGL 499. Dissertation (1-9)
Research and study for comprehension exams.

English as a Second Language

Program Director. Timothy Bonner

Credit Instruction: English as a Second Language (ESL) credit courses are offered to both undergraduates and graduates who wish to increase English proficiency in the areas of writing, reading, speaking, and presentation skills. All credit courses are at an advanced level of English study. For undergraduates, these courses are designed to supplement English department required courses, such as courses towards the freshman writing requirement. Graduate students should contact their departments regarding acceptance of credit towards residency requirements. ESLP courses may be repeated for credit with a maximum of three repetitions. ESL credit courses are open to regularly enrolled students or General College Division students with placement or permission by ESL Director.

StepUp. Intensive English Program. A non-credit intensive ESL program called StepUp is offered to intermediate to advanced ESL students who wish to study university/academic English in a challenging environment. This program is open to the general public. Contact the ESL program for information and a brochure or refer to our website, www.lehigh.edu/˜inesl.

English Testing. English language proficiency testing is required for all incoming undergraduate and graduate students whose first language is not English during student orientations in August and January. Placement in courses will be determined based on the results. New Teaching Assistants must take the SPEAK test prior to the beginning of the semester (A TSE score of 55-60 is acceptable). Students who do not pass the SPEAK are not eligible for a TA position. Contact the ESL Office for an appointment upon arrival to campus. Refer to our website for additional information.

The Freshman Composition Requirement. The courses English 3 and English 5 (Composition and Literature for ESL Writers I and II,) may be applied towards the composition requirement for undergraduates. See the English department course listings for additional information.

ESL Teacher Training. ESL in conjunction with the English Department offers English 310 (Introduction to Theories and Methods of ESL Instruction) and English 314 (ESL Teaching Practicum). See the English Department course listings for descriptions.

For more information about English as a Second Language at Lehigh, refer to our web site at www.lehigh.edu/~inesl.

Courses:

ESLP 1 ESL Academic Writing and Grammar (1)
Instruction in understanding and using advanced English sentence structures in writing. Advanced academic vocabulary and grammar development to improve writing sophistication and accuracy. Required for graduate students who score below 73 on the Michigan Test and/or for students needing additional writing proficiency. 4 hours per week.

ESLP 2 ESL Academic Writing and Reading (1)
The writing process and composing skills, editing skills, vocabulary development and reading fluency for ESL students. Required for graduate students who score below 73 on the Michigan Test and/or for students needing additional writing proficiency. Undergraduates may enroll after or concurrent with English 3. 4 hours per week.

ESLP 3 ESL Clear Speech and Conversation (1)
Conversational English, colloquial language and idioms, pronunciation and accent reduction and practice in basic listening skills for an academic setting. 4 hours per week.

ESLP 4 ESL Academic Speaking (1)
Correct use of grammatical structures in oral English and practice in accurate pronunciation. ESL students will explore the functions of American English in an academic setting. 4 hours per week.

ESLP 11 ESL Technical Writing and Composition (1)
Formal composition and technical writing including general technical vocabulary, technical sentence structure, and research skills for the advanced ESL student.

Prerequisite: successful completion of ESLP 2 (ESL Academic Writing and Reading) or ENGL 5, or with permission of ESL Director. 4 hours per week.

ESLP 12 ESL Advanced Speech and Presentation Skills (1)
Development of advanced speaking skills and presentation techniques through a study of formal spoken rhetoric, accent improvement, and presentation skills. For the undergraduate or graduate student seeking formal speech skills and/or for teaching assistants. (Required for TAs with SPEAK scores 200 - 225.) Prerequisite: successful completion of ESLP 3 or 4 , or SPEAK score 180+, or permission of ESL Director. 4 hours per week.

ENGL 314. Teaching English as a Second Language: A Practicum (1)
Companion course to English 310 (Intro to Methods of English as a Second Language). This course will include class meetings that focus on guided discussions of the practical application of principles and practices of ESL pedagogy in a real-world environment. Supervised ESL classroom student teaching/tutoring required. Prerequisite: English 310.

ENGL 316. Native American Literature (4)
Fiction by modern American Indian writers like N. Scott Momaday, Leslie Marmon Silko, James Welch, Michael Dorris, and Louise Erdrich. Some attention given to the history of the relationships and conflicts between Native Americans and the federal government, white agricultural and business interests, and educational and religious interests. (HU)

ENGL 318. Topics in African-American Literature and Culture (4)
Special Topics in African-American culture and/or the cultures of the African diaspora. Topics may be focused by period, genre, thematic interest or interdisciplinary method including, for example, "Nineteenth-century African-American Literature and Politics", "African-American Folklore", "Black Atlantic Literature", "The Harlem Renaissance", "African-American Women Writers". May be repeated for credit as title varies. (HU)

ENGL 327. Chaucer (4)
The Canterbury Tales, with some attention to other Chaucerian works and other works that may have provided source-materials for Chaucer's tales. Chaucer's language and the literary, intellectual, social, and historical backgrounds to his work. (HU)

ENGL 328. (THTR 328) Shakespeare (4)
An introduction to Shakespearean drama including comedies, histories, tragedies, and romances. Emphasis on textual study, cultural contexts, and performance strategies. (HU)

ENGL 331. Milton (4)
The poetry and prose of John Milton in the context of the English Revolution. Particular attention to the intersection of theology and philosophy, and of the personal with the political. (HU)

ENGL 347. The Essay (4)
Practice of the essay, including such forms as the personal, academic, or argumentative essay. Emphasis on developing a strong personal voice and learning to use other voices. Intensive revision. Prerequisite: ENGL 171,173, or 174, or permission of writing minor advisor. (ND)

ENGL 291. Special Topics (1-4)
A topic, genre, or approach in literature or writing not covered in other courses. (HU)

Graduate Students taking 300-level courses receive 3 credits; undergraduates receive 4 credits.

ENGL 301. Topics in Literature (4)
A theme, topic, or genre in literature, such as autobiography as literature and the gothic novel. May be repeated for credit as titles vary. (HU)

ENGL 307. Undergraduate Thesis Proposal (1)
Course to be enrolled by senior honors students preparing to write honors thesis. Course requirements include conducting preliminary research for the thesis and writing a detailed thesis proposal and bibliography. May not be rostered concurrently with English 308. (HU)

ENGL 308. Undergraduate Thesis (3)
Open to advanced undergraduates who wish to submit theses in English. Prerequisite: consent of department chairperson. (HU)

ENGL 309. Interpretation: Critical Theory and Practice (4)
Introduction to recent literary and cultural theory, such as New Criticism, Structuralism, Marxism, Psychoanalytic approaches, Reader-response Criticism, Deconstruction, Feminist Theory, New Historicism, and Cultural Criticism. (HU)

ENGL 310. Introduction to Methods of English as a Second Language Instruction (4)
An introduction to teaching English as a second language including the theory and principles of second language acquisition, ESL methods, materials, and current trends such as computer assisted language instruction. With sufficient effort, students will learn to plan and teach an ESL/EFL class in the four areas of Writing, Reading, Speaking and Listening, choose appropriate materials for varying age and proficiency levels, and most importantly, have a concrete approach to teaching ESL/EFL. Required classroom observing and tutoring hours that can be completed in Lehigh's ESL classes, in Lehigh's ELLC language lab, or in the local public school ESL classes. Course restricted to upperclass and graduate students.

ENGL 311. (WS 311) Literature of Women (4)
Women's works about women. Besides re-reading familiar feminists' fiction, drama, and poems, an introduction to contemporary and often experimental works by less famous writers. (HU)

ENGL 312. Studies in Literary and Cultural Theory (4)
Study of a particular contemporary theoretical approach to literature, film, or other cultural texts. May be repeated for credit as the topic changes. (HU)

Environmental Studies

Professors: Stephen H. Cutcliffe, Ph.D. (Lehigh), *Professor of Science, Technology and Society and History and Director of Science, Technology and Society program;* Sharon M. Friedman, M.A. (Penn State), *Professor of Journalism and Communication and Director of Science and Environmental Writing Program;* John B. Gatewood, Ph.D. (Illinois), *Professor of Sociology and Anthropology;* Kenneth L. Kraft, Ph.D. (Princeton), *Professor of Religion Studies;* Gerard P. Lennon, Ph.D. (Cornell), *Professor of Civil Engineering;* Anne S. Meltzer, Ph.D. (Rice), *Chairperson and Professor of Earth and Environmental Sciences;* Vincent G. Munley, Ph.D. (SUNY at Binghamton), *Professor of Economics;* David B. Small, Ph.D. (Cambridge), *Professor of Sociology and Anthropology.*

Associate Professors: Edward E. Lotto, Ph.D. (Indiana), *Associate Professor of English and Director of the Center for Writing, Math and Study Skills;* Albert H. Wurth, Jr., Ph.D. (North Carolina), *Associate Professor of Political Science.*

Assistant Professors: Alec M. Bodzin, Ph.D. (North Carolina State), *Assistant Professor of Education;* Derick G. Brown, Ph.D. (Princeton), *Assistant Professor of Civil and Environmental Engineering.*

Interim Program Director: Sharon M. Friedman, Department of Journalism and Communication.

This new Bachelor of Arts degree examines the cultural, economic, historical, political and social factors that influence local, national, international and global environmental issues and policies. Investigating a wide range of perspectives, it includes a broad exposure to many factors confronting humans as they struggle with complex problems and possible solutions to environmental questions.

The interdisciplinary program includes courses in 4 colleges and 10 different departments. Most of its courses are in social science disciplines but there are also offerings in humanities, education, science, mathematics and engineering. The program has been designed so students will develop a broad understanding of social science environmental concerns, along with a basic familiarity with environmental science, statistics and research methods. Of benefit to all students interested in environmental issues, this new B.A. degree will complement existing B.A. and B.S. programs in Earth and Environmental Sciences and the B.S. program in Environmental Engineering.

The B.A. Program

The B.A. program is intended for students who are interested in environmental affairs from the perspective of the social sciences and humanities. This degree will prepare students for a variety of career options including positions in policy agencies at the federal, state and local government levels, corporate management, non-profit organizations, environmental journalism or environmental law. It also will prepare students for graduate studies in a number of environmental policy and social science fields.

The B.A. is specifically designed to be broadly inclusive yet flexible enough to allow for double majors and minors in other fields. Double majors or minors in social science fields such as anthropology, communication, history, international relations, journalism, political science, psychology, science and environmental writing or sociology could easily be accomplished. Minors in the sciences, such as Earth and Environmental Sciences, also can be easily completed. If students are not pursuing a double major, a minor in another field to complement the Environmental Studies major is highly recommended but not required.

The major consists of three required and four core courses, plus four elective courses chosen from a list that follows. The B.A. is considered a social science major and most of its courses fulfill college social science distribution requirements. Its collateral requirements, which include a social science research methods course, one course in statistics and three basic science courses, can be used to fulfill college math and science distribution requirements.

Honors: To graduate with honors, a major in Environmental Studies must maintain a 3.2 overall average, attain a 3.5 average in the courses constituting the major program, and complete an honors thesis in the senior year.

Environmental Studies Major

Required and Core Courses (28 credits)

Required Courses:

ES 1	Introduction to Environmental Studies (4)
ES (EES) 2	Environmental Science: Systems and Solutions (4)
ES 381	Senior Seminar: Issues in Environmental Studies (4)

Core Courses: At Least 4 of the 7 following courses:

ES 101	Environmental Policies and Planning (4)
ES 102	Environmental Values and Ethics (4)
ES 111 (ECO 111)	Introduction to Environmental Economics (4)
ES 115 (JOUR 115)	Communicating about the Environment (4)
ES 121 (ANTH 121)	Environment and Culture (4)
ES 171 (CEE 171)	Fundamentals of Environmental Technology (4)
ES 315 (HIST 315)	American Environmental History (4)

Major Electives (16 credits including two courses at the 200 level or above):

ANTH. 305	Anthropology of Fishing (4)
ARTS 196	Sustainable Development: The Costa Rican Experience (1-4)
CEE 272	Environment, Risk Regulation and Policy (2)
ECO. 311	Environmental Economics (3)
ENGL. 201-11	The Environmental Imagination (4)
EES 109	Geographical Analysis of our Changing World (4)
ES 10	Environment and the Consumer Society (4)
ES (JOUR) 116	Risky Business (4)
ES 131	Internship (1-2)
ES 181	Independent Study (1-4)
ES 371	Special Topics (1-4)
ES 391	Honors Thesis (4)

IR 344	Politics of Oil (4)
JOUR. 125	Environment, the Public and the Mass Media (4)
JOUR (STS) 323	Controversies (4)
POLS 111	Politics of the Environment (4)
POLS 328	U.S. Politics and the Environment (4)
POLS 375	Seminar: Green Polity (4)
REL 6	Religion and the Ecological Crisis (4)
REL 254	Buddhism and Ecology (4)
TBTE 394	Special Topics in Education - Environmental Education (3)

In addition, new courses may be offered annually. Students should check with the program director for an updated list.

Collateral Requirements (18-20 credits)

Required (8 credits)

MATH 12	Basic Statistics (4)

A calculus course may be substituted with permission of the program director.

SR 111	Research Methods and Data Analysis (4)

Electives: At least one EES and two other science courses (10-12 credits): *More advanced science or environmental engineering courses may be substituted with the permission of the program director.*

CHEM 5	Chemistry and National Issues (3)
CHEM 21	Introductory Chemical Principles (4)
EES 3	Global Environmental Change (4)
EES 11	Environmental Geology (3)
EES 21	Introduction to Planet Earth (4)
EES 31	Introduction to Environmental Biology (4)
PHY 5	Concepts in Physics (4)

Minor in Environmental Studies

A minor in Environmental Studies consists of four 4-credit courses, for a total of 16 credits. These should include ES 1, one course from the core set for the major, and two courses from either the core or elective courses for the major. One of the two courses must be at the 300-level course.

Environmental Studies Courses

ES 1. Introduction to Environmental Studies (4) Fall

Gateway to the field of Environmental Studies, the course surveys central issues and themes confronting humanity in the natural world on a national and global basis. Topics include humankind's role in environmental change; society's response to the dynamism of nature; cultural evaluations of nature; population dynamics; resource availability and pollution sinks; land use patterns; sustainability and consumerism; environmental justice and ethics; policy and planning. (SS)

ES (EES) 2. Environmental Science: Systems and Solutions (4) Spring

An overview of environmental issues, problems, and solutions from an Earth systems perspective. A review of how natural systems create the environment and how society is a part of these systems rather than distinct from them. Includes consideration of issues like resource management, natural and induced hazards, land use, habitat degradation, and environmental impact. Course intended for non-science majors with an interest in the environment, how it works, and what's important to sustain a habitable planet. Environmental issues on local, national, and global scales are considered and compared. Fulfills science distribution requirement. Lecture and recitation, class discussions, debates, and case studies. Meltzer (NS)

ES 10. Environment and the Consumer Society (4). Spring

Is there such a thing as sustainable consumption, or will life on Earth become increasingly imbalanced? Will our grandchildren accuse us of "devouring" their future? This multidisciplinary course investigates these issues, both locally and globally from the perspectives of anthropology, history, communication and politics. Topics include cultural causes of and responses to past environmental disasters; biological and cultural limits to growth; overfishing the commons; resources and land use issues; communication in a consumer culture; and politics and governmental regulations. Team projects researching the environmental impacts of campus consumption will be included. (SS)

ES 101. Environmental Policy and Planning (4) Fall

Analysis of the framework that has been established to protect the environment and promote sustainable growth. Focus on the roles of the different branches of the U.S. government and the relative responsibilities of state and local governments within this framework as well as key international accords. Consideration of the political nature of environmental issues and the social forces influencing environmental protection. (SS)

ES 102. Environmental Values and Ethics (4)

A broad survey of the role of values and ethics in environmental issues. How have humans perceived their relation to nature across vast spans of time and culture? Do premodern ecological views still have lessons to teach contemporary citizens? Contemporary developments such as environmental justice, deep ecology, ecofeminism, bioregionalism, campus ecology, ecopsychology and issues of ecological identity will be explored. (HU)

ES 111 (ECO 111). Introduction to Environmental Economics (4)

An examination of the interactions between our economic systems and the environment. Pollution as a consequence of human activity within a framework for analyzing the relationships between environmental quality, scarcity of resources and economic growth. How to develop appropriate public policies to deal with these issues. Prerequisite: ECO. 1. (SS)

ES 115 (JOUR 115). Communicating about the Environment (4)

Introduction to the need for and ways to communicate about environmental issues to laypersons, government officials, journalists, members of the judiciary and technical experts. Explores case studies of good and bad communication about environmental issues. Internet communication, including the efficacy of placing governmental reports and databases on the Web for public consumption, will be evaluated. (SS)

ES 116 (JOUR 116). Risky Business (4) summer
This course explores the risks and effects of environmental contamination on human health and behavior as well as the role of the mass media in alerting citizens to potential environmental health risks. Environmental topics vary but usually include air and water pollution, endocrine disrupters and radioactive waste. S. Friedman **(SS)**

ES 131. Internship (1-2)
Practical experience in the application of environmental studies for both on- and off-campus organizations. Course is designed to provide credit for supervised experiential learning experiences. May be repeated for credit up to four credits. Prerequisite: consent of the program director. **(ND)**

ES 171 (CEE 171). Fundamentals of Environmental Technology (4)
Pollution control technologies and how they work for water, air and solid wastes. Assessment and management of risk as applied to remediation of contaminated wastes. Role of life cycle analysis of products in risk reduction. Emphasis on technologies leading to sustainable environment. Government policies and regulations, including litigation and Best Engineering Practices. Prerequisite: A course designated **NS**. Not available to students in RCEAS. **(ND)**

ES 181. Independent Study (1-4)
Directed readings or research on an Environmental Studies topic. May be repeated for credit up to four credits. Prerequisite: consent of the program director. **(HU or SS)**

ES 371. Special Topics (1-4)
Intensive, research-oriented study of a subject or issue in Environmental Studies not covered in other courses. For students of demonstrated ability and adequate preparation. May be repeated for credit up to four credits. Prerequisite: consent of the program director. **(HU or SS)**

ES 381. Senior Seminar: Issues in Environmental Studies (4)
Advanced seminar focusing on discussion and research on specialized subjects in Environmental Studies. Subject matter varies from semester to semester. Intended for Environmental Studies majors and minors but open to others. Prerequisites: ES 1, 2 or another EES course, and one core course or consent of the program director. **(SS)**

ES 391. Honors Thesis (1-4)
Directed undergraduate research thesis required of students who apply and qualify for graduation with program honors. Prerequisite: consent of the program director. **(HU or SS)**

Finance

Professors. Stephen G. Buell, Ph.D. (Lehigh); Richard J. Kish, Ph.D. (Florida), *chairman, Perella Department of Finance*; Nandu Nayar, Ph.D. (Iowa), *Hans Baer Chair in International Finance*.

Associate professors. James A. Greenleaf, Ph.D. (N.Y.U.); Stephen F. Thode, D.B.A. (Indiana); Geraldo M. Vasconcellos, Ph.D. (Illinois).

Assistant professors. Anne-Marie Anderson, Ph.D. (U of Arizona); David H. Myers, Ph.D. (U of Washington).

Professor of practice. Samuel C. Weaver, Ph.D. (Lehigh).

Adjunct professors. David L. Muething, Ph.D. (M.I.T.).

In the era of a growing competitive global economy, finance has become increasingly important and complex. This has led to an expansion of career opportunities within corporations, investment firms, and financial institutions worldwide. These opportunities are varied and often overlap with other disciplines such as accounting, information systems, and marketing. It is also important that students engage in extracurricular activities that might complement their academic studies.

The domestic financial services industry has been at the forefront of global finance and will remain as one of our relative strengths within a global economy. Lehigh, in turn, enjoys a relative advantage in this regard as Lehigh alumni are well respected in all areas of finance. Our program has also been able to take advantage of our proximity to many financial institutions.

The finance major offered by the Perella Department of Finance requires 18 credit hours beyond the core requirements. Each finance major must successfully complete the 2-course foundation requirement; the 2-course depth requirement; and the 2-course breadth requirement as outlined below.

2-Course Foundation Requirement

FIN 323	Investments
FIN 328	Corporate Financial Policy

2-Course Depth Requirement

Choose 2 depth electives from the following list of finance offerings.

FIN 324	Security Analysis and Portfolio Management
FIN 330	Financial Markets and Institutions
FIN 333	Global Finance
FIN 334	Derivatives and Management of Risk
FIN 335	Advanced Topics-Financial Management
FIN 336	Real Estate Finance

2-Course Breadth Requirement

Choose 2 breadth electives within one of the following four breadth tracks.

Track 1: Financial Analysis

ACCT 315	Financial Accounting I
ACCT 316	Financial Accounting II
ACCT 318	Financial Statement Analysis

Track 2: Financial Engineering

ECO 357	Econometrics
ECO 358	Game Theory
ECO 346	Numerical Methods for Business Decisions
ECO 327	Real Options

Track 3: Financial Marketing

MKT 319	Development and Marketing of New Products
MKT 320	Global Marketing
MKT 325/ECO 325	Quantitative Marketing Analysis

Track 4: Financial Mathematics

MATH 205	Linear Methods
MATH 231	Probability and Statistics
MATH 242	Linear Algebra
MATH 309	Theory of Probability
MATH 334	Mathematical Statistics

MATH 338	Regression Analysis
MATH 467	Financial Calculus I

Undergraduate Courses

For Advanced Undergraduates and Graduate Students

Courses numbered 200 and above in the College of Business and Economics are open to sophomores only on petition.

FIN 225. Introduction to Finance (3)
An introductory finance course stressing the links between corporate finance and investments. Major topic areas will include financial statement analysis , time value of money, risk and return valuation of stocks and bonds, capital budgeting, and cost of capital. Prerequisites: ECO 129, ECO 145, MATH 51, ACCT 151.

Finance Foundation Courses:

FIN 323. Investments (3)
The nature of risk and the form of returns on financial assets from the viewpoint of various constituents. Investor objectives, attitudes, and constraints are considered within the risk-return matrix within the context of valuation. Prerequisites: FIN 225, ACCT 152, and ECO 146.

FIN 328. Corporate Financial Policy (3)
The study of management issues related to capital budgeting, working capital, leasing, mergers, and financing. Prerequisites: FIN 225, ACCT 152, and ECO 146.

Finance Depth Requirement Courses:

FIN 324. Security Analysis and Portfolio Management (3)
Valuation of equity and debt instruments factoring in the influence earnings forecasts and expectations, uncertainty, required returns, supply and demand for securities and funds, and investor attitudes. Portfolio management concepts include the implications of market factors, technical analysis, timing, and screening of securities. Prerequisites: FIN 323 and FIN 328.

FIN 330. Financial Markets and Institutions (3)
Functions and portfolios of financial intermediaries. Sectional demand and supply of funds, nature and role of interest rates, term structure and forecasting, impact of inflation and regulation on financial intermediaries and markets, and current developments in the financial system. Management of assets and liabilities within the U.S. financial institution's legal and economic constraints. Prerequisites: FIN 323 and FIN 328.

FIN 333. Global Finance (3)
Issues that underlie the investment, financing, and dividend decisions of multinational firms from both the buyer's and seller's viewpoints. Current transactions in foreign currencies, direct and portfolio investment and associated risk management when dealing in foreign countries. Prerequisite: FIN 323 and FIN 328.

FIN 334. Derivatives and Management of Risk (3)
Theoretical and practical aspects of various instruments and markets that involve financial derivative instruments. Emphasis on the management of risk for corporate managers and portfolio managers. Prerequisite: FIN 323 and FIN 328.

FIN 335. Advanced Topics – Financial Management (3)
Advanced topics relating to specific areas of corporate finance such as: bond refunding, asset valuation and capital budgeting including the role of uncertainty, imprecise forecasts, risk preferences, inflation, market conditions, and the global marketplace; working capital management, leasing, mergers, and financing. The course content may vary between instructors and over time, therefore, the course descriptor is subject to change each time the course is offered. May be repeated. Prerequisite: FIN 323 and FIN 328.

FIN 336. Real Estate Finance (3)
An advanced survey of modern residential and commercial real estate financing techniques from the perspective of the borrower and the lender. Topics include: the principles of financing decisions; financing methods and techniques, institutional sources of funds for real estate, and real estate financing decision-making. The course includes lectures, demonstrations, spreadsheet software exercises, and guest speakers. Prerequisite: FIN 323 and FIN 328.

Additional finance offerings that cannot be used to fulfill the finance depth requirement:

FIN 371. Directed Readings (3)
Readings in various fields of finance designed for the student with a special interest in some field of finance not covered in scheduled courses. May be repeated. Prerequisite: consent of sponsoring instructor.

FIN 372. Special Topics (1-3)
Special problems and issues in finance for which no regularly scheduled course work exists. When offered as group study, coverage varies according to interests of instructor and students. May be repeated. Prerequisite: consent of sponsoring instructor.

FIN 273. Finance Internship I (1 credit)
Based on a student's work experience, a sponsoring faculty member shall direct readings, projects, and other assignments—including a "capstone report." It should be noted that the work experience (at least 80 hours), by itself, is not the basis for academic credit. The faculty directed activity must be provided concurrent with the work. Course registration and related arrangements must be made in advance of the work engagement. This course must be taken Pass/Fail and cannot be used to satisfy finance major requirements. Prerequisites: ECO 129, ECO 145, MATH 51, ACCT 151, declaration of a finance major, and department approval.

FIN 373. Finance Internship II (1 credit)
Based on a student's work experience, a sponsoring faculty member shall direct readings, projects, and other assignments—including a "capstone report." It should be noted that the work experience (at least 80 hours), by itself, is not the basis for academic credit. The faculty directed activity must be provided concurrent with the work. Course content and work experience should have added rigor from Finance Internship I due to the satisfactory completion of the finance core (FIN 323 and FIN 328). Course registration and related arrangements must be made in advance of the work engagement. This course must be taken Pass/Fail and cannot be used to satisfy finance major requirements. Prerequisites: FIN 323, FIN 328, declaration of a finance major, and department approval.

FIN 374. Portfolio Management Practicum (1-3)
Readings, projects and papers designed to complement the leadership and analytical activities associated with the management of the Student Investment Club or Thompson portfolios and similar activities. May be repeated. Prerequisites: FIN 323 and permission of instructor.

Course descriptions for the College of Business and Economics graduate courses can be found in this section (Section V) under the heading of *Business and Economics Graduate Courses.*

Fine Arts

See listings under Art and Architecture.

Five-Year Programs

Several ways exist for students to obtain two degrees in five years of study. See listings under ARTS-Engineering; ARTS-Master of Business Administration; Civil Engineering and Earth and Environmental Sciences; Electrical Engineering and Engineering Physics; Engineering-Master of Business Administration; and College of Education.

Foreign Culture and Civilization

See listings under Modern Languages and Literature.

Foreign Literature

See listings under Classics and under Modern Languages and Literature.

French

See listings under Modern Languages and Literature.

Geology

See listings under Earth and Environmental Sciences

German

See listings under Modern Languages and Literature.

Government

See listings under Political Science

Greek

See listings under Classics.

Hebrew

Modern Hebrew is taught in the Department of Modern Languages and Literature. Biblical Hebrew is taught in the Department of Religion Studies.

History

Professors. Jean R. Soderlund, Ph.D. (Temple), *chairperson;* Michael G. Baylor, Ph.D. (Stanford); Stephen H. Cutcliffe, Ph.D. (Lehigh), *History and STS;* Ian P.H. Duffy, D.PHIL. (Oxford, England); Steven L. Goldman, Ph.D. (Boston), *Andrew W. Mellon Distinguished Professor in the Humanities;* Tom F. Peters, Dr. Sc. (Swiss Federal Institute of Technology, ETH Zurich); C. Robert Phillips, Ph.D. (Brown), *Classics and Ancient History;* James S. Saeger, Ph.D. (Ohio State); William R. Scott, Ph.D. (Princeton); Roger D. Simon, Ph.D. (Wisconsin).

Associate professors. Gail A. Cooper, Ph.D. (U.C., Santa Barbara); John Pettegrew, Ph.D. (Wisconsin); John K. Smith, Ph.D. (Delaware).

Assistant professors. Monica Najar, Ph.D. (Wisconsin); John Savage, Ph.D. (N.Y.U.).

Professor of Practice. Kimberley Carrell-Smith, Ph.D. (Delaware).

The history major introduces students to the study of the causes and consequences of change through an examination of political, economic, social, cultural, and intellectual developments and institutions over time. The department's goal is to train its majors to think critically about the events and forces that have shaped the modern world, to analyze and interpret sources and evidence, and to view issues from a variety of perspectives. Those skills have served students well in a wide range of careers. Lehigh history majors have frequently gone on to law school or to work in various areas of education, journalism, public affairs, and business. The major also provides an excellent basis for graduate training in a wide range of public policy fields. The department offers a program of independent research under the direction of an individual faculty member (History 391, 392). A maximum of six credits may be used toward this project. Normally students pursue their research in the second semester of the junior year and the first semester of their senior year; the project may also be undertaken during the senior year. Students who do well on their research project will graduate with department honors. The writing intensive requirement must be filled by a course in the history department. For advanced placement, please see Section I.

The department recommends that students intending to major in history take MATH 12, Basic Statistics, to fulfill their college math requirement.

Department Major Requirements

A history major consists of 35 hours, normally nine courses, as follows:

HIST 11	Survey of Europe to 1648.
HIST 12	Survey of Europe Since 1648.
HIST 201	Historical Perspectives, **or**
HIST. 202	Historical Research

One course in the history of Asia, Africa, or Latin America: HIST 5, 49, 50, 75, 76, 177, 340, 341, 342, 359, 368.

HIST 104, 300, 303, 371, 391, 392, or provisional courses may be used to fulfill this requirement in accordance with their contents and emphases.

Minimum of 12 hours of courses numbered 303 or higher (except HIST 306).

To graduate with a history major, a minimum 24 hours must be graded course work taken at Lehigh.

Requirements for Honors
Students wishing to graduate with honors must have a minimum GPA of 3.25 in history, 39 credits and must have completed History 391.

History Minor Requirements
Each student's minor program is prepared in consultation with the advisor of minors in the history department. *Advanced placement credit may not be used for the minor program.*

- 15 credits
- at least 4 credits at 200 or 300 level
- maximum of one course (4 credits) of transfer or cross-listed courses may count toward minor.

Concentration in Public History
History majors may earn a concentration in Public History by completing a total of 16 hours in the following courses:

HIST 305	Public History (4), required
HIST 306	Internship in Public History (4), required
ART 175, 275, 370, or 375	Museology (3)
EDT 405	Website and Resource Development (3) (seniors by petition)
HIST 336	Bethlehem and the Lehigh Valley (4)
HIST 338	Techniques in Public History (2-4 credits, may be repeated for up to 8 credits)
HIST 339	Managing Nonprofit Organizations (4)
HIST/ANTH 370	Historical Archeology (4)

Undergraduate Courses in History
Petitions are required for first-year students to take 100-level or higher courses, and for sophomores to take 200-level or higher courses. HU - fills humanities distribution requirements; SS - fills social science requirements; ND - not designated.

HIST 5. (AAS 5) African Civilization (4)
Sub-Saharan Africa through the millennia of the ancient world to the present. Human origins, state and non-state systems, the external slave trade, colonialism, resistance to European rule, independence movements, and neo-colonialism. (SS) Keim, Scott

HIST 7. Technology in America's Industrial Age (4)
Traces the development of American technology from the pre-industrial colonial era until America's emergence as the world's leading industrial power. The interactions between technology and culture, society, politics, and the economy will also be addressed. (SS) Smith

HIST 8. Technology in Modern America (4)
Traces the evolution of modern American technology, including automobiles, aircraft, computers, nuclear weapons, television, space, pharmaceuticals, and biotechnology. Includes critiques of technology such as environmentalism. The interactions of technology and culture, society, politics, and the economy will also be addressed. (SS) Smith

HIST 11. Survey of Europe to 1648 (4)
Development of European history from Rome to the 17^{th} century. End of the ancient world, origins and growth of medieval civilization, the Renaissance and Reformation. (HU) Baylor

HIST 12. Survey of Europe Since 1648 (4)
The rise of modern nation states; the scientific and industrial revolutions; social movements and the French and Russian revolutions; impact of Enlightenment philosophy, nationalism, liberalism, imperialism and fascism; the development of modern class structure and transformations in gender relations, art, popular culture and society. (HU) Savage

HIST 15. English History (4)
The history of England to 1688. The origins of representative government, the development of English social institutions, the unification of England, and the Renaissance and Reformation in England. (HU) Duffy

HIST 16. English History (4)
English political and social institutions from 1688 to the present. The evolution of parliamentary government, the rise of modern parties, the industrial revolution, and recent social philosophies. (HU) Duffy

HIST 21. (CLSS 21) Greek History (4)
The development of civilization from paleolithic times to the world empire of Alexander the Great. The social, economic, religious, philosophic, artistic, and literary development of the ancient world; the origin of political institutions. (SS) Phillips

HIST 22. (CLSS 22) Roman History (4)
Rome from its origins to A.D. 476. Political, social and religious developments. Transformation of the late Roman Empire to the early medieval period. (SS) Phillips

HIST 41. United States to 1865 (4)
Native American cultures; European settlement; development of slavery and free labor systems; the Revolution; founding of the new nation; 19^{th} century social, economic, cultural, and political development; Civil War. (SS) Najar, Soderlund

HIST 42. United States, 1865-1941 (4)
America's transformation into an industrial and global power from Reconstruction after the Civil War to the Great Depression; includes social, political, and cultural developments. (SS) Carrell-Smith

HIST 43. United States Since 1939 (4)
World War II; Cold War at home and abroad; Civil Rights movement; the 1960s: Vietnam, the welfare state and social upheavals; new forms of cultural expression; feminism; rise of neo-conservatism. (HU) Pettegrew

HIST 49. History of Latin America (4)
Spanish and Portuguese colonization of America and the struggles for independence, preceded by a brief view of the ancient American civilizations and Iberian backgrounds. (SS) Saeger

HIST 50. History of Latin America (4)
Continuation of HIST 49. The development of the Latin American nations in the 19^{th} and 20^{th} centuries. (SS) Saeger

HIST 64. (AAS 64, ECO 64) Plantation to Ghetto (2)
Examination of topics in the economic history of African Americans from the 1500s to the present. Explores the slave trade, slavery, post-Civil War South, the black family, migration, urbanization, and race and poverty. (SS) O'Brien, Scott

HIST 75. (MLL 75, Asia 75) Chinese Civilization (4)
The development of traditional Chinese thought, beliefs, technology, and institutions from a historical perspective, from earliest times to China's encounter with the West. (**HU or SS**) Pankenier

HIST 76 (Asia 76, MLL 76) Understanding Contemporary China (4)
An overview of recent history, politics, economy, religion, problems of modernization, popular culture, and attitudes. Contemporary Chinese society viewed against the backdrop of tradition and the tumultuous history of twentieth-century China. (SS)

HIST 90. First-Year Seminar in History (3)
Seminar for first-year students on a particular theme or topic. (**HU or SS** depending on topic of seminar).

HIST 104. Themes in History (2 - 4)
Seminar on a particular theme or topic not covered by a currently listed offering. (**HU or SS** depending on topic of seminar).

HIST 105. Sports in Modern America (4)
Surveys the social, cultural, and political role of sports in America since the Civil War. By addressing the development of sports and its relationship with race, class, ethnicity, gender, the media, popular culture, and government, this class will examine the impact of sports in making the America and Americans of the twentieth century. (HU)

HIST 107. Technology and World History (4)
Development of technology and its relationship to political, economic, military and cultural aspects of world civilization from pyramids to the present. (SS) Smith

HIST 109. The Built Environment of New York: 1624-2001 (4)
How the physical environment of New York City, particularly Manhattan, came to be. Course themes include the evolution of land use, housing, changing economic functions of the city, immigration, cultural life, social communities, and changing technology. Topics include: settlement of lower Manhattan, the street system, immigrant neighborhoods and the Lower East Side, Greenwich Village, Central Village, Central Park, the elevated trains and the subways, the Brooklyn Bridge, apartment living, specialized shopping and entertainment districts, skyscrapers, Harlem, Rockefeller Center, the automobile and highway system, public housing, the World Trade Center. Usually taught in the summer in New York with walking tours to many of the locations listed above. (HU) Simon

HIST 110. American Military History (4)
The American military tradition from colonial times to the present. America's wars and the development and operation of military institutions within the political, economic, ideological, and technological milieu of American society. (SS) Saeger

HIST 111. Engineering in the Modern World (4)
Roles played by engineers and engineering in the modern world, focusing on major achievements and failures, prominent engineers, and evolution of the profession. (SS) Smith

HIST 117. (STS 117/WS117) Women, Science and Technology (4)
Explores the impact of technology and science on women's social roles and the contribution of women engineers and scientists to their disciplines. Will focus on the American experience. Among the topics discussed are invention, design, laboratory research, education, engineering, professionalism, labor force participation, office mechanization, household appliances, virtual spaces, childcare and reproduction. (SS) Cooper

HIST 120. Revolutionary America (4)
Origins and development of the American republic from 1750 through the adoption of the Federal Constitution. (SS) Najar, Soderlund

HIST 124. (WS 124) Women in America (4)
Roles of women in American society from colonial to present times: attitudes toward women, female sexuality, women's work, and feminism. (SS) Cooper, Najar

HIST 129. (AAS 129) Black Political Thought in America (4)
Black leadership, organizations, and philosophy in America from Reconstruction to the Civil Rights Era; ideas and programs of Booker T. Washington, W.E.B. DuBois, Marcus Garvey, Malcolm X and Martin Luther King, Jr. (SS) Scott

HIST 130. (AAS 130) African American History (4)
Blacks in America from the first importation of Africans to the implementation of civil rights laws. West African origins, slave trade, slavery, free blacks and emancipation and study of Reconstruction, segregation, urbanization, and the struggle for racial equality. (SS) Scott

HIST 132. An Introduction to Canada (2)
A brief overview of major themes in Canadian history with emphasis on economic and political developments in the 19^{th} and 20^{th} centuries. (SS) Simon

HIST 135. Era of Jefferson and Jackson (4)
Colonial beginnings; the Articles of Confederation and the Constitution; the creation of a new nation; the development of American political parties; the antebellum American state. (SS) Najar

HIST 136. Era of the Civil War and Reconstruction (4)
American abolitionism and the origins of the Civil War; the Second American Revolution; Reconstruction and its sequel. (SS) Najar

HIST 145. (STS 145) Introduction to the History of Science (4)
The history of modern science, primarily physical and biological, with emphasis on the development of major theoretical models since the 17^{th} century. (SS) Goldman

HIST 150. Medieval Civilization (4)
Formation and development of western culture to about 1400. Rise of universities and towns, legal development and origins of representative government, origins of nation-states, scholasticism and decline of the medieval church. (HU) Savage

HIST 152. (CLSS 152/WS 152) Women in Antiquity (4)
Interdisciplinary study of women in Greece and Rome. Literary, archaeological and historical evidence and approaches. Cross-cultural material. (SS) Phillips

HIST 153. (WS 153) Women in European History, 1500-Present (4)
Examines the position of women in Europe since the Renaissance. Particular attention is given to changing conceptions of women and their roles in society, the evo-

lution of women's work, the origins, growth and impact of feminism, and gender distinctions as reflected in law, politics, popular culture and leisure. (SS)

HIST 154. (REL 154) The Holocaust: History and Meaning (4)
The Nazi Holocaust in its historical, political and religious setting. Emphasis upon the moral, cultural and theological issues raised by the Holocaust. (HU)

HIST 156. The Late Middle Ages and the Renaissance (4)
The transition from medieval to early modern society from the fourteenth to the early sixteenth centuries. The general crisis of European civilization in the late Middle Ages; the rise and development of the Italian Renaissance; the spread of Renaissance culture from Italy to northern Europe. (HU) Baylor

HIST 157. (REL 157) Europe in the Age of the Reformation (4)
The breakup of the religious culture of medieval Christian Europe in the reformation movements of the sixteenth century. The origins and varieties of Protestantism; the intersection of religious ideas and politics in Germany, Switzerland, Britain, France, and the Netherlands; the "wars of religion" and the emergence of the European state system. (HU) Baylor

HIST 158. Europe in the 17th and 18th Centuries (4)
Transformation of European civilization from the 30 Years War to the outbreak of the French Revolution. Origins and development of the European state system; absolutism; commercial expansion and competition for empire; science; the Enlightenment and its impact on European culture and politics. (HU) Baylor

HIST 159. Revolutionary Europe, 1789-1870 (4)
Revolutions and reactions; the rise and spread of liberalism, nationalism, and socialism. (HU) Duffy

HIST 160. Europe in the Age of Total War, 1870-1945 (4)
Origins of two world wars; revolutionary governments in Germany, Italy, and Russia. (HU) Duffy

HIST 161. (CLSS 161) Roman LAW (4)
Examination of Roman legal systems from the *Twelve Tables* to the *Digest* of Justinian. Emphasis on development of legal concepts and their historical context. Readings in primary sources; lectures; discussion. (SS) Phillips

HIST 162. Contemporary Europe (4)
Development of European States since 1945; European Community; Soviet influence and collapse. (HU) Savage

HIST 163. France Since 1789 (4)
France's tumultuous transformation from an absolutist monarchy to a modern democratic republic. Explores major cultural, social and economic changes, with particular attention given to industrialization and urbanization, gender and class, church and state relations, the French Left and France's unique contribution to modern philosophy, art and culture. (SS) Savage

HIST 177. (Asia 177, MLL 177) China Enters the Modern Age (4)
The collapse of the imperial order and China's agonizing transformation into a modern nation over the past 150 years. The impact of imperialism, war, radical social change, and protracted revolution on Chinese beliefs, values, and institutions. (HU **or** SS) Pankenier

HIST 180. (REL 180) Religion and the American Experience (4)
The historical development of major religious groups in this country from colonial times to the present. Their place in social and political life, and the impact of the national experience upon them. Emphasis on religious freedom and pluralism, and the church-state relationship. (HU)

For Advanced Undergraduates And Graduate Students

Graduate students may take 300 level courses, for which they receive 3 credits. Undergraduates must take them for 4 credits.

HIST 201. Historical Perspectives (4)
Methodologies and interpretations of Western historians from ancient times to the present. (HU) Baylor

HIST 202. Historical Research (4)
An introduction to historical interpretation, research design, and methodology. Students will research and write a paper on a historical topic using secondary and primary sources. (SS)

HIST 213. (CLSS 213, REL 213) Ancient Roman Religion (4)
Religious experience of the Roman people from prehistory to end of the empire. Nature of polytheism and its interactions with monotheism (Christianity, Judaism). Theories of religion. Emphasis on primary source materials. (SS) Phillips

HIST 303. Topics in History (2 - 4)
Intensive study in a particular area of history for advanced students. Topics may vary; may be repeated for credit with consent of advisor. (HU **or** SS depending on topic of seminar)

HIST 305. Public History (3-4)
An examination of the public role of history in modern society, with focus on issues facing historians in museums, historical societies, archives, historic preservation, the federal government, and other organizations in the public sphere. (SS) Carrell-Smith

HIST 306. Internship in Public History (2-4)
Professionally supervised work in a museum, historical society, archive, or other historical agency. Written journal or report evaluating the experience is required. Permission of department chair required. May be repeated for a maximum of six credits. May not be counted toward the major requirement of 12 hours of courses numbered 303 or higher. (ND) Carrell-Smith

HIST 308. Industrial America Since 1945 (3-4)
Explores efforts to achieve both prosperity and security in the postwar era. Among the topics discussed: new technologies, consumer culture, disposable products, advertising, defense spending, technical assistance, and multinational corporations. (SS) Cooper

HIST 311. (CLSS 311) Twins and Sins: The Rise of Rome (3-4)
Rome from its origins to the mid-third century B.C. Emphasis on foundation legends, the power of the monarchy, and development of Roman political and religious institutions. Papers, quizzes, discussions. (SS) Phillips

HIST 312. (CLSS 312) Decline and Fall of the Roman Empire (3-4)
Political, social, and economic history of the Roman Empire, A.D. 117-A.D. 565. Romanization of the provinces, diffusion of Christianity, and special attention to transformation to medieval period. Includes readings in translation of primary sources. (SS) Phillips

HIST 313. (CLSS 313) Golden Age of Greek Democracy (3-4)
Greek history of the seventh through fifth centuries B.C. Emphasis on the contrasting political and social systems of Athens and Sparta with consideration of related economic and military history. Attention to art, gender, literature, religion. Discussion and lectures; papers. (SS) Phillips

HIST 314. (CLSS 314) Age of Caesar and Christ (3-4)
Roman history of the first century A.D. Political, cultural, and socio-economic changes; special attention to the evolution of absolute power. Lectures, discussions, papers. (SS) Phillips

HIST 315. (ES 315) American Environmental History (3-4)
Relationship between Americans and their natural environment from the colonial period to the present: impact of European settlement, attitudes toward wilderness, role of technological development, rise of preservation and conservation movements, establishment of national parks, recent environmental protection legislation. (SS) Cutcliffe

HIST. 318 History of North American Indians (3-4)
The history of American Indians from before European contact to the present. Emphasis will be placed on the diversity of native peoples of eastern North America and how patterns of interaction between native Americans and Euro-Americans have changed over time. Discussion format, research paper. (SS) Soderlund

HIST 319. Colonial America (3-4)
Founding and growth of colonies in North America through 1763. Emphasis on motives for settlement, Native American-European relations, and the economic, social, and political development of the British West Indies and mainland provinces. (SS) Soderlund

HIST 323. American Cultural History Since 1900 (3-4)
Development of American popular culture and media: popular press, Hollywood, radio, television, sports, and advertising, and the meanings these institutions have created in 20th-century United States. (HU) Pettegrew

HIST 325. (SSP 325, WS 325) History of Sexuality and the Family in the U.S. (3-4)
Changing conceptions of sexuality and the role of women, men, and children in the family and society from the colonial to the post-World War II era. Emphasis on the significance of socio-economic class and cultural background. Topics include family structure, birth control, legal constraints, marriage, divorce, and prostitution. (SS) Najar

HIST 326. (SSP 326) Social Class in American History (3-4)
Emphasis on the 19th and 20th century, focusing on: emergence of a white-collar middle class; condition and treatment of the poor and growth of the welfare state; conditions of industrial workers, struggle to organize unions and their later decline; indicators of social status and exclusion among the rich; changing distribution of income and wealth over time and extent of social mobility. (SS) Simon

HIST 328. American Intellectual History Since 1900 (3-4)
Social, literary, and political thought in the 20th-century with emphasis on pragmatism and progressivism, maturation of American literary culture, ideas of American exceptionalism at mid-century, civil rights movement and feminism, neo-conservatism and recent trends. (HU) Pettegrew

HIST 331. (AAS 331) United States and Africa (3-4)
Reciprocal relationships between North America and the African continent from the slave trade in the 17th century to the 20th century Afrocentric movement; impact of Americans on the shaping of modern Africa, Pan-African relations; influence of African Americans on US policies toward Africa. (SS) Scott

HIST 332. (AAS 332) Slavery and the American South (3-4)
The emergence and demise of the "peculiar institution" of African American slavery in British North America and the Old South. African background; colonial beginnings; 19th century slave community; the ruling race and proslavery ideology; the death of slavery and its aftermath; slavery and freedom in a comparative context. (SS)

HIST 333. American City to 1900 (3-4)
Settlement and planning of colonial towns; role of towns in the revolutionary era; industrialization and relationship of economic and technological change to urbanization; establishment of urban institutions; Irish and German immigration; beginnings of suburbanization; downtowns and the creation of a civic culture. Required field trip. (SS) Simon

HIST 334. American City in the Twentieth Century (3-4)
Immigration; Progressive "reforms;" urban planning and zoning; impact of automobile and suburbanization; Depression and New Deal; public housing and racial ghettoes; urban decline and "renewal." Required field trip. (SS) Simon

HIST 336 Bethlehem and the Lehigh Valley (3-4)
Local history focusing on Native American communities, Moravian settlement, natural resources, industrial firms, immigration and ethnic communities, organized labor, housing patterns and urban sprawl, high-tech industry, and tourism. Includes an analysis of techniques used in presenting these topics to the public. (SS) Smith

HIST 338 Techniques in Public History (2 or 4)
Designed to introduce students to a variety of public history techniques. Instructor will focus on *one* of the following topics each term: archives, documentary film, exhibit design, historical editing, material culture, oral history. May be repeated to a maximum of 8 credits. (HU)

HIST 339. Managing Nonprofit Organizations (3-4)
Addresses the effective management of nonprofit organizations, focusing on operations, administration, legal, marketing, finance and accounting issues in the nonprofit environment and emphasizing organizations such as museums and preservation organizations. (SS)

HIST 340. (Asia 340) History of Japanese Industrialization since 1800 (3-4)
The late Tokugawa economic development, rise of an entrepreneurial class, importation of western technology, and the rise of social, political, and economic institutions which support industrial growth. (SS) Cooper

HIST 341. Mexico and Central America (3-4)
Emphasis on Mexico and Guatemala from the era of the Aztec through the wars of independence to the 20th century revolutions. (SS) Saeger

HIST 342. Argentina, Brazil and Chile (3-4)
Eighteenth-century Spanish imperial readjustments, independence, the emergence of new societies, 20th-century extremist movements, and the problems of developing nations. (SS) Saeger

HIST 345. Victorian Britain (3-4)
Development of democracy, liberalism, religious ferment, industrialization, class conflict, socialism, and empire in Victorian Britain. (HU) Duffy

HIST 346. Great Britain in the 20th Century (3-4)
Effects of world wars, loss of great power status, economic decline, social conflict, welfare state, modern political parties, Irish problem in 20th century Britain. (HU) Duffy

HIST 347. Russia to 1855 (3-4)
Emergence of Russian autocracy; impact of the Mongol invasions; Westernization and transformation of society and culture; economic development toward emancipation of the serfs. (HU)

HIST 348. Russia Since 1855 (3-4)
Russia in the context of European history: emancipation of the serfs and impact upon political, social, economic development; reasons for the growth of revolutionary pressure; collapse of autocracy; the revolutions of 1917; the Soviet era and the collapse of the Soviet Union. (HU)

HIST 349. Revolutions in Modern European History (3-4)
Explores the origins, meanings, and impact of European revolutions from a theoretical and comparative perspective. Focuses on the English (1642-1660), the French (1789-1799), and the Russian Revolution (1917-1929), and how they reflected and shaped new ideologies and policies related to human rights, economic development, popular sovereignty, nationalism, class and gender politics, and State and society relations. (SS) Savage

HIST 350. 19th Century Paris and the Invention of Modernity (3-4)
This course considers the dramatic destruction and rebuilding of the city of Paris in the decades after 1850 and how changes in the built environment shaped social relations, political authority and cultural expression. Topics include the politics of city planning and architectural design; the history of the engineering profession, technology and the building trades; reactions to crime, disease and prostitution in the modern city; the 1848 Revolution, Paris Commune and political theory; the origins of photography, Impressionist painting and cinema; and the creation of mass consumer society. (HU) Savage

HIST 356. European Cultural History (3-4)
Transformation of European culture from the 18th century to the present. The Enlightenment, cultural impact of the French and industrial revolutions, romanticism and ideologies of the 19th century, contemporary European thought. (HU) Savage

HIST 357. Early Modern Germany, 1500-1850 (3-4)
The emphasis will be on one or more of the following topics: the Reformation, the Thirty Years' War and its impact, absolutism, the rise of Prussia, the failure of German liberalism. (HU) Baylor

HIST 358. Modern Germany, 1850 to Present (3-4)
Focus on one or more of the following topics: nationalism and unification, the Second Empire, World War I, the Weimar republic, the Nazi movement, the Third Reich, and post-war Germany. (HU) Baylor

HIST 359. (AAS 359) History of South Africa (3-4)
South Africa's history from its earliest human settlement to its emergence as a racist political order and transition to a non-racial democratic state. Includes comparisons with political thought and practices in the U.S. (SS) Scott

HIST 360. American Legal History (3-4)
The interrelationship between law and social development with emphasis on modern period. Founding of constitutional government and balance of power within the federal system, the problem of slavery, legal support and regulation of business, and the use of law in various reform and civil rights movements. (SS) Pettegrew

HIST 361. (ARCH 361) Evolution of Highrise Building Construction (3)
The new materials iron and concrete led to new ways of thinking about building. The Industrial Revolution initiated the development of our modern culture of building and our current urban society. (HU) Peters

HIST 363. (ARCH 363) Evolution of Long-SPAN Bridge Building (3)
New materials, forms of education and technology contributed to advance structural understanding. Specialization and the rise of technological thinking led to new bridge types and increasing span size. (HU) Peters

HIST 365. (ARCH 365) Evolution of the Modern Building Process (3)
The criteria of trade—time and money—entered the world of building in the 19th century. The unplanned interlude between the design and the inauguration of a building became a new professional field: the building process. (HU) Peters

HIST 368. Seminar in Latin American History (3-4)
Readings and individual investigation of selected topics. (SS) Saeger

HIST 370. (ANTH 370) Historical Archeology (3-4)
This course examines the unique nature of historical archaeology of post-contact America. Topics include reconstructing the past through the archaeological and historical record, exhibiting past culture, and capturing the real or imagined past. Course includes fieldwork and visits to famous archaeological sites. (SS) Small

HIST 371. Independent Study (1-4)
Directed readings in a topic or area of history not covered by current course offerings. For students of demonstrated ability and adequate preparation. Prerequisite: consent of department chair. May be repeated for credit with permission up to a maximum of six credits. (ND)

HIST 391. Honors Thesis in History (4)
Opportunity for undergraduate majors in history to pursue an extended project for senior honors. By invitation and department permission only. (**ND**)

HIST 392. Honors Thesis in History (2)
Continuation of History 391 available under exceptional circumstances where additional credit for honors project is warranted. Department permission only. (**ND**)

Graduate Work in History

Lehigh University has been granting advanced degrees in history for more than seventy years. Its graduates have become university and college professors, secondary school teachers and administrators, museum directors, and public servants. The graduate program focuses primarily on the areas in which the department is particularly strong in faculty and resources, notably Colonial America and the history of technology and science. The department works closely with the Lawrence Henry Gipson Institute for Eighteenth Century Studies which sponsors yearly symposia and provides research support for both faculty and students. The history of technology program is closely tied to Lehigh's Science, Technology, and Society program.

Lehigh's libraries are especially rich in materials for graduate research in history, particularly in the fields listed above. They have an extensive collection of scholarly periodicals and monographs. Graduate programs provide intensive and specialized study, and the policy of limited enrollment permits close relations between faculty and students.

Admission to graduate study in history is competitive and dependent upon the applicant's undergraduate preparation and record, recommendations, and Graduate Record Examination scores. Besides general requirements for College of ARTS and Sciences graduate programs, the following special requirements apply to graduate study in history.

Master of Arts

There are two masters programs. Under Plan I, a candidate may earn the degree by successfully completing 27 hours of approved course work and submitting a thesis of the length and quality that would make it suitable for publication as a scholarly article. The paper may build on work presented in a graduate research seminar in the program. Candidates continuing toward a doctorate should select Plan I. Candidates declaring Plan II take 30 hours of approved course work and pass examinations in two fields chosen from American, British, European, and Latin American history, and History of Technology. Candidates in either plan are required to maintain a 3.0 average in all graduate work and to take History 401 and History 404 or 405.

M.A. in History with Concentration in Public History

Students may earn through either Plan I or Plan II (see above), an M.A. in History with a concentration in Public History by completing a total of 36 hours of approved course work, including a minimum of 10 credits and maximum of 12 credits in approved Public History courses.

HIST 305	Public History (3), required
HIST 306	Internship in Public History (3), required but may be waived for equivalent experience
ART 370	Special Topics in Museum Studies (1-4)
EDT 405	Website and Resource Development (3)
HIST 336	Bethlehem and the Lehigh Valley (3)
HIST 339	Managing Nonprofit Organizations(3)
HIST/ ANTH 370	Historical Archeology (3)
HIST 438	Techniques in Public History (2 or 3 credits, may be repeated for up to 8 credits)

Doctor of Philosophy

Students in the Ph.D. program in history must maintain a 3.50 average after two semesters of study. During the second semester, doctoral students select one major and three minor fields in which to take comprehensive written and oral examinations. The dissertation will be in the major field. The dissertation advisor will chair a special committee that will oversee the student's graduate program. The other members of the special committee will be those faculty who are examiners in the selected fields and one professor from another department relevant to the candidate's major field. No professor may direct more than one field, but the direction of a field may involve two professors. An original dissertation is required and it must be successfully defended to the examining committee.

All Ph.D. students must spend at least one year in residency as a full time student at Lehigh. They must take Historical Research (401) or, if they completed HIST 401 or its equivalent at the M.A. level, a 450-series research seminar. Students who enter the Ph.D. program with an M.A. from another university must also take either Readings in the History of the Atlantic World (404) or Readings in the History of Industrial America (405). Students are encouraged to take both seminars if appropriate to their course of study. All Ph.D. students must take at least 18 hours of directed readings courses (440 series or equivalent) beyond the M.A., and HIST. 481, Teaching History.

Major Fields. Major fields are Technology, Modern Britain, Colonial America, Nineteenth Century United States, Twentieth Century United States. (The Nineteenth and Twentieth century fields may be divided topically rather than chronologically; for example, a student may be examined in labor/social history 1800-present, and in political history 1800-present.)

Minor Fields. Any of the major fields listed above may also be minor fields. Examples of other minor fields are American Studies; Ancient History; Early Modern Europe; Modern Europe; Latin America; Environmental History; Japan; Public History; Science, Technology and Society studies.

Language Requirements. The student's special committee deter-mines whether proficiency in a foreign language or proficiency in statistical methods will be required for the doctoral degree.

More detailed regulations are given in the *Handbook for Graduate Work in History,* available in the history department office.

Graduate Courses in History

HIST 401. Historical Research (3)
Techniques of research in history: training in the critical handling of documentary materials, in measuring the value of evidence, and in formal presentation of the results of research. Students will write an original research paper using primary materials. Required of all graduate students in history.

HIST 404. Readings in the History of the Atlantic World, 1500-1900 (3)
Core readings offering a comparative and integrative approach to studying the development of nations, economic systems and trade, colonization, and cultural encounters among the people of Europe, Africa, and the Americas.

HIST 405. Readings in the History of Industrial America (3)
Core readings in the history of technology and the larger framework of intellectual, social, economic, and political history. Includes comparative studies in the history of industrializing Europe and Japan.

HIST 407. Seminar in the History of American Industrial Technology (3)
Origin and evolution of American technology and industry from the 19th century to the present. Investigates dynamics of major industries in national and international context. Not open to students who have taken HIST 307. Smith

HIST 438. Techniques in Public History (2 or 3)
Designed to introduce students to a variety of public history techniques. Instructor will focus on *one* of the following topics each term: archives, documentary film, exhibit design, historical editing, material culture, oral history. May be repeated to a maximum of 8 credits.

HIST 440. Readings in Colonial American History (3)
Study in small groups under the guidance of a faculty member of the literature of the 17th and 18th centuries. May be repeated for credit with the permission of the faculty advisor.

HIST 441. Readings in Nineteenth Century American History (3)
Study in small groups under the guidance of a faculty member of the literature of the 19th century. May be repeated for credit with the permission of the faculty advisor.

HIST 442. Readings in Twentieth Century American History (3)
Study in small groups under the guidance of a faculty member of the literature of the 20th century. May be repeated for credit with permission of the faculty advisor.

HIST 443. Readings in English History (3)
Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem, or area of English history. May be repeated for credit with permission of the faculty advisor.

HIST 444. Readings in Latin American History (3)
Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem, or area of Latin American history. May be repeated for credit with permission of the faculty advisor.

HIST 445. Readings in the History of Science (3)
Study in small groups under the guidance of a faculty member on the history of science. May be repeated for credit with permission of the faculty advisor.

HIST 446. Readings in the History of Technology (3)
Study in small groups under the guidance of a faculty member of the history of technology. May be repeated for credit with the permission of the faculty advisor.

HIST 447. Readings in European History (3)
Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem or aspect of European history. May be repeated for credit with permission of the faculty advisor.

HIST 452. Research in American History (3)
An intensive research seminar on a phase of American history. May be repeated for credit with permission of the department chair.

HIST 453. Research in English History (3)
An intensive research seminar on a phase of English history. May be repeated for credit with permission of the department chair.

HIST 454. Research in Latin American History (3)
An intensive research seminar on a phase of Latin American history. May be repeated for credit with permission of the department chair.

HIST 455. Research in History of Science and Technology (3)
An intensive research seminar on a phase or aspect of the history of science and technology. May be repeated for credit with permission of the department chair.

HIST 457. Research in European History (3)
An intensive research seminar on a phase of European history. May be repeated for credit with permission of the department chair.

HIST 471. Special Topics in History (1-3)
Individual study under the direction of a faculty member of a topic in history. May be repeated for credit.

HIST 472. Special Topics in History (1-3)
Individual study under the direction of a faculty member of a topic in history. May be repeated for credit.

HIST 473. Special Topics in History (1-3)
Individual study under the direction of a faculty member of a topic in history. May be repeated for credit.

HIST 481. Teaching History (1)
Focuses on the practical aspects of college teaching, including teaching methods, preparation of syllabi and exams, grading papers and exams, and dealing with problems such as plagiarism. Required for teaching assistants, teaching fellows, and Ph.D. students in the Department of History.

Humanities

Eccentral Committee:

Gordon C.F. Bearn, Ph.D. (Yale), Philosophy and Director Humanities Center; Beth Dolan, Ph.D. (North Carolina), English; Drew Francis, M.F.A (Brandeis), Theatre; Alexander Levine, Ph.D. (UC San Diego), Philosophy; John Savage, Ph.D. (NYU), History; Amardeep Singh, Ph.D. (Duke), English; Stephanie P. Watts, Ph.D. (Missouri-Columbia), English.

The Humanities Program is devoted to freeing faculty and students from the discipline of the disciplines, to finding a way to the space between the disciplines, the space where the sparks of intellectual excitement fly, sparks that ignite the pleasures and passions that characterize the best of university life.

The humanities are construed so broadly that they will include any aspect of intellectual investigation which is relevant to understanding whatever humans are or have been, whatever humans have produced or are producing.

It remains an open question whether any discipline at all is irrelevant to the understanding of human life and work. Even such apparently far-flung investigations as the thermodynamics of far from equilibrium systems are already being used to understand the evolution of forms of human society, and both Goedel's work on the foundations of mathematical logic and Bohm's ontological interpretation of quantum mechanics have already been used at some distance from their original homes. Although "humanities" is the name of this program, "inclusion" is its watchword.

Intellectual work always faces a trade-off between the intensities of connection and the intensities of concentration: between the power of an analysis which excludes every concern and every method of investigation save one and the power of an analysis which reveals the amazing ways an inert site of investigation can be aroused by bringing out the myriad connections that reach out from that site in all directions at once. Divided by department and by college, by discipline and sub-discipline, universities are disposed to accentuate the centripetal powers of concentration at the expense of the centrifugal powers of connection. It is important, therefore, that there be elements within the university that draw people and disciplines out of the center of their fields. This is the eccentral mission of the Humanities Program.

Humanities Minor Programs

The Humanities Minor Programs provide homes for the homeless interdisciplines, interdisciplinary areas of concentration that do not have *official* departmental or interdepartmental homes. There are currently two minors in the humanities, and there may be more in the future.

a) Medieval Studies Minor in Humanities

Advisor, Michael Mendelson, Associate Professor of Philosophy

The Medieval Studies Minor requires that a student take 4 courses (16 credits) from the following list. At the discretion of the Advisor for the Medieval Studies Minor, a student may count any other course (not on this list) towards the minor.

ART 1	Art History: Ancient and Medieval
ART 206/ ARCH 206	Medieval Art and Architecture
CLSS 52	Classical Epic
LAT 113	Virgil
LAT 115	Ovid
ENGL 327	Chaucer
ENGL 360	Middle English Literature
HIST 15	English History to 1688
HIST 150	Medieval Civilization
FREN 302	Medieval French Stories
FREN 303	Arthurian Romances
MUS 233	Medieval and Renaissance Music
PHIL 133	Medieval Philosophy
PHIL 233	Figures and Themes in Medieval Philosophy
ANTH 312	The Anthropological Signature of the Past
THTR 127	The Development of Theatre and Drama from Ritual to Renaissance.

b) Ethics Minor in Humanities

Advisors. Lloyd H. Steffen, Professor of Religion Studies and Gordon C.F. Bearn, Professor of Philosophy.

The Ethics Minor construes ethics more broadly than as the subject of philosophical treatises. The Ethics Minor is especially concerned with the way ethical challenges arise outside the semi-technical philosophical field of ethics itself, that is, in the pursuit of the various professions and in the conduct of life, generally.

The Ethics Minor consists of 4 courses (16 credits) from the following list. At least one course must come from the first five italicized members of the list. At the discretion of an Advisor for the Ethics Minor, a student may count any other course (not on this list) towards the minor.

PHIL105	*Ethics*
PHIL 116	*Bioethics*
REL 3	*Religion Ethics and Society*
HUM 126	*Professional Ethics*
HUM 137	*Ethics in Practice*
AAS 103 (SSP 103)	Sociological Perspectives onRacial and Ethnic Communities
AAS 166 (SSP 166)	Who Gets What?: The Social Problems of Wealth and Inequality
AAS 310 (SSP 310/WS 310)	Gender, Race and Sexuality: The Social Construction of Differences
AAS 379 (SSP 379)	Race and Class in America
ECO 130 (WS 130)	Economics of Race and Gender
ECO 368	Health Economics
E & S 1	Environment and the Consumer Society
HIST 154 (REL. 154)	The Holocaust: History and Meaning
HUM 126	Professional Ethics
HUM 137	Ethics in Practice
HUM 373	Independent Ethics Project.
IR 23	Alternative World Futures
JOUR 122.	Media Ethics and LAW
COMM 252	Interpersonal Relationships Private and Public
PHIL 1	The Examined Life
PHIL 3 (REL 3)	Religion Ethics and Society
PHIL 105	Ethics
PHIL 116	Bioethics
PHIL 117	Race and Philosophy
PHIL 122	Philosophy of LAW
PHIL 124 (REL 124)	Reason and Religious Experience
PHIL 127	Existentialism
PHIL 140 (AS 140)	Eastern Philosophy
PHIL 205	Contemporary Ethics
PHIL 217	Figures/Themes in Race and Philosophy
PHIL 240 (AS 240)	Figures and Themes in Eastern Philosophy
PHIL 364 (POLS 364)	Issues in Contemporary Political Thought
POLS 111	The Politics of the Environment
POLS 179 (WS 179)	Politics of Women
POLS 329	Propaganda, Media, and American Politics

POLS 330	Movements and Legacies of the 1960's
PSYC 314 (SSP)	Social Cognition and Social Action
REL 6	Religion and the Ecological Crisis
REL 68	Practical Justice: From Social systems to Responsible Community
REL 158 (WS 158)	Sex and Gender in Judaism: The Feminist Critique
REL 167	Engaged Buddhism
REL 184 (WS184)	Religion, Gender, and Power
REL. 225	Topics in Religion and Ethics
STS 11	Technology and Human Values

Honors in Humanities

The honors program in Humanities is designed to facilitate research beyond the disciplinary frame of a student's major. In order to earn Honors in Humanities students must *(1)* have a GPA of at least 3.5 and *(2)* apply to the director of the Humanities Center detailing how they intend to complete the rest of these requirements, namely, *(3)* completing 3 courses (9-12 credits) from at least 2 different departments that have been selected with the help of the director so as to prepare the student to *(4)* complete a year long thesis under the guidance of two faculty members representing two different departments.

Successful completion of the honors thesis in humanities will be decided by two faculty advisors for the thesis. The thesis will count for honors in the two home departments of the advisors only if the home departments also certify that the thesis has been satisfactorily completed.

Applications to the director should be completed by the beginning of the second semester of the student's Junior year. The application should describe the anticipated project and show how the three preparatory courses constitute appropriate preparation for the thesis. If the final thesis does not meet with the approval of the two advisors then the student will not receive honors in humanities but he or she will receive grades and credit for the courses taken and the thesis written.

Course Offerings

HUM 126. (PHIL 126, REL 126) Professional Ethics (4)

An examination of the moral rules and action guides that govern various professions. Professions to be examined will include health (physician and nursing); legal; counseling and psychiatry; engineering; military; clergy; teaching. Attention will be given to modes of ethical reasoning and how those modes are practically applied in professional life and activity. Among issues to be discussed will be the limits of confidentiality; employer authority; power relationships; obligations to the public; professional rights; sexual boundaries; whistle-blowing; safety and risk; computer ethics; weapons development; discrimination; professional review of ethical infractions. Course will include guest lectures and case studies. Steffen. (HU)

HUM 137. (PHIL 137, REL 137) Ethics in Practice (1-4)

A variable content course focusing on ethical issues arising in a particular profession, such as law, health, business, engineering, military. Variable credit. May be taken more than once. Steffen. (HU)

HUM 150. Humanities Seminar (4)

Variable Content. An opportunity for humanities faculty to involve students in the exciting and accessible aspects of their research. May be taken more than once for credit. Staff (HU)

HUM 224. Lehigh Review (1-4)

Students will produce the annual edition of the *Lehigh Review*, the journal of undergraduate academic (non-fiction) writing. The production tasks are divided into one 4 credit editorial board and three 1 credit pass-fail modules (reviewing, distribution, images). Students may enroll in *either* the 4 credit editorial board *or* in one or more of the 1 credit modules. Admission is by application at the Humanities Center. (HU)

HUM 250. Intermediate Humanities Seminar. (4)

Interdisciplinary Seminar. Normally a team taught seminar bringing various disciplines to bear on a specific topic which will change from semester to semester. May be taken more than once for credit. Staff. (HU)

HUM 271. Humanities Independent Study (1-4)

Individual investigation of an author, book or topic designed in collaboration with a faculty sponsor. Tutorial meetings; substantial written work. May be repeated more than once for credit. Consent of faculty sponsor required. (HU)

HUM 350. Advanced Humanities Seminar. (4)

Interdisciplinary Seminar. Normally a team taught seminar bringing various disciplines to bear on a specific topic which will change from semester to semester. May be taken more than once for credit. Staff.

HUM 371. Humanities Advanced Independent Study (1-4)

Advanced individual investigation of an author, book, or topic designed in collaboration with a faculty sponsor. Tutorial meetings; substantial written work. May be repeated more than once for credit. Consent of faculty sponsor required. (HU)

HUM 373. (PHIL 373, REL 373) Independent Ethics Project (4)

Supervised ethics research into a topic approved by the advisor for the Humanities Minor in Ethics. An option for completing the ethics minor. For ethics minors only. (HU)

HUM 390. Humanities Honors Thesis, first semester (4)

An opportunity for students admitted to the humanities honors program to pursue independent research under the guidance of two faculty members representing two different departments. If the student's work does not satisfy the two advisors, the student will receive a grade for the course but will not receive honors.

HUM 391. Humanities Honors Thesis, second semester (4)

Continuation of HUM 390. If the student's work does not satisfy the two advisors, the student will receive a grade for the course but will not receive honors.

HUM 450. Theory Seminar (1-3)

Sustained investigation of a single theorist or theoretical problem relevant to research in the humanities. Theorists studied could come from beyond this list: Butler, Harraway, Irigaray, Derrida, Foucault, Deleuze, Baudrillard, Kristeva, Eliade, Freud, Marx, Lacan, Barthes, Gramsci, Guattari, Cornel, Cixous, Wittig, Hall, Gilroy, Bataille, Blanchot, Rorty, Fish, and so on. Problems studied could come from beyond this list: Power, Identity, Race, Sexuality, Writing as a Woman, Essentialism, Jouissance, Nomadism, Social Constructivism, Popular Culture, and so on. May be taken more than once for credit.

Industrial and Systems Engineering

Professors. Keith M. Gardiner, Ph.D. (Manchester); Mikell P. Groover, Ph.D. (Lehigh); Nicholas G. Odrey, Ph.D. (Penn State); Robert H. Storer, Ph.D. (Georgia Tech); S. David Wu, Ph.D. (Penn State) *chair*; Emory W. Zimmers, Jr., Ph.D. (Lehigh).

Associate professors. Joseph C. Hartman, Ph.D. (Georgia Tech); Louis J. Plebani, Ph.D. (Lehigh); Gregory L. Tonkay, Ph.D. (Penn State) *associate chair*; George R. Wilson, Ph.D. (Penn State).

Assistant professors. Rosemary T. Berger, Ph.D. (Northwestern); Jeffrey T. Linderoth, Ph.D. (Georgia Tech); Eugene Perevalov, Ph.D. (Texas-Austin) ; Theodore K. Ralphs, Ph.D. (Cornell); Andrew M. Ross, Ph.D. (California-Berkeley); Lawrence V. Snyder (Northwestern).

Emeritus professor. John W. Adams, Ph.D. (North Carolina).

Mission Statement

To pursue excellence and national prominence in the areas of manufacturing, operations research, information technology and related fields of industrial engineering through innovative teaching, distinguished research and scholarship, and active professional leadership. Building on its unique strength and national reputation in undergraduate education and industrial research, the department strives for leadership in educational innovation, multidisciplinary research, and industrial partnership. Our ultimate mission is to produce leaders who have learned to think critically and analytically, have the skills and techniques to comprehend and create new knowledge, and are willing to serve and inspire others.

Physical Facilities

The industrial and systems engineering department is located in the Harold S. Mohler Laboratory at 200 West Packer Avenue at the northwest corner of the Lehigh University Asa Packer campus. The Mohler Lab building contains the classrooms, laboratories, and faculty offices of the department. Labs in the Mohler Laboratory building include:

Computer Integrated Manufacturing (CIM) Laboratory. The CIM lab contains a variety of computer systems and software that includes computer-aided design and engineering (CAD and CAE), numerical control part programming, discrete event simulation, facilities design, process design, and process control.

Manufacturing Technology Laboratory (MTL). The MTL contains equipment for instruction and research in manufacturing processes, numerical control (NC), NC part programming, material handling and storage, industrial control systems, and metrology.

Automation and Robotics Laboratory. This lab contains a variety of industrial robots and other automated systems to provide students with hands-on experience in the planning and use of this kind of equipment.

Electronics Manufacturing Laboratory (EML). The EML contains equipment for instruction and research in electronics assembly, soldering, screen printing, wire bonding, inspection, and other processes associated with printed circuit card fabrication and assembly.

Work Systems Laboratory. This classroom-laboratory affords the opportunity for undergraduate students to analyze and plan human work activities for individual workstations and worker team situations. A full-scale manual assembly line is available for study.

Considerable use is made of university computer facilities in IE coursework. An IE/computing center PC laboratory containing 16 PCs is located in the Mohler Laboratory building.

B.S. in Industrial Engineering

Industrial Engineering (IE*)* is concerned with the analysis, design, and implementation of integrated systems of people, materials, information, and equipment to accomplish useful work. The discipline of industrial engineering is applicable in nearly all industries, whether the industry involves manufacturing of a product or delivery of a service. Job functions performed by IEs include: systems analysis, cost estimation, capital equipment selection, engineering economy, facilities planning, production planning and scheduling, inventory control, quality control, information systems, project management, operations management, engineering management, as well as methods analysis and work measurement. Manufacturing systems engineering (MSE) is a specialty field associated with industrial engineering that emphasizes functions and technologies such as process planning, plant layout design, manufacturing resource planning, production management, production line design, automation, robotics, flexible manufacturing systems, and computer integrated manufacturing.

Career Opportunities

IE graduates are sought by nearly all industrial corporations as well as government agencies and other service institutions. Major employers of our graduates include management consulting firms, manufacturing companies, banks, hospitals, railroads, the postal service, and transportation/logistics services. A typical career path of an industrial engineer is to start in an entry-level engineering position or as a technical analyst and to progress through various management positions in the firm or institution. Significant numbers of industrial engineers ultimately become chief executive officers, chief operating officers, and chief technology officers in their respective organizations.

Program Educational Objectives

IE graduates should:

1. have a broad knowledge of mathematics, science and general engineering. Furthermore, this knowledge can be applied to Industrial Engineering related problems
2. have a fundamental grounding in the fields of statistics, manufacturing, operations research, information technology, production analysis and control, and operations management that reflect current needs and trends
3. have the detailed and relevant knowledge and ability to perform design and solve problems related to integrated systems that include people, materials, information, equipment, and energy

4. have the ability to design, conduct, and analyze experiments in laboratories, companies, and on systems models
5. have the ability to form, lead, and participate on multi-disciplinary teams that solve problems in engineering and business
6. have an awareness of global, societal, and discipline specific issues necessary to identify, formulate and solve problems
7. be aware of the NSPE professional code of ethics and have an appreciation of social and legal concerns
8. have the ability to seek out, understand and apply new information and procedures to their professional development, thus giving them an appreciation for life-long learning
9. communicate effectively through oral and written presentations using appropriate technologies

IE Curriculum

The IE curriculum is designed to provide graduates with the skills and knowledge that employers expect of young industrial engineers beginning their professional careers, and to instill the ability for life-time learning. It includes the basic mathematical, physical, and social sciences, together with the principles and methods of engineering analysis and design that are specific to industrial engineering. These principles and methods include probability and statistics, engineering economy, cost accounting, operations research, computer simulation, work methods and measurement, manufacturing processes, production and inventory control, and information technology.

Specialized industrial engineering electives in the senior year include: advanced operations research, operations management, organization planning and control, statistical quality control, database design, web technologies, and data communications technologies. Electives related to manufacturing systems engineering include: computer integrated manufacturing, industrial robotics, facilities planning and material handling, production engineering, and metal machining analysis. The IE degree requires a minimum of 133 credit hours.

Specialty Areas in Industrial Engineering

The industrial engineering curriculum emphasizes four specialty areas: (1) manufacturing systems and processes, (2) operations research, (3) information and systems engineering, and (4) production and operations management. The IE curriculum includes 18 credit hours of advanced (300 IE level) courses plus 3 credit hours of engineering elective and 6 credit hours of free elective. Students can emphasize one of these areas if they choose, or select courses from several areas to design their own individual programs. Listed below are the advanced courses associated with the four specialty areas (including courses in other departments).

Manufacturing Systems and Processes. Students interested in this area should select courses from the following list:

IE 300-level electives: IE 319, IE 324, IE 332, IE 340, IE 342, IE 344 (cross-listed with Mat 344), IE 345, IE 347

ENGR or free electives: Mat 309, Mat 314, Mat 335, Mat 342, Mat 367

Operations Research. Students interested in this area should select courses from the following list:

IE 300-level electives: IE 316, IE 332, IE 339, IE 372

ENGR or free electives: IE 170, CSE 327, CSE 340, ME 340

Free electives: ECO 358, MATH 312, MATH 338, MATH 341

Information and Systems Engineering. Students interested in this area should select courses from the following list:

IE 300-level electives: IE 307, IE 309, IE 310, IE 316, IE 339, IE 341, IE 342, IE 345, IE 372

ENGR or free electives: IE 170, IE 275, CSE 327, CSE 340, CSE 368, ECE 319, ECE 320, ECE 345

Production and Operations Management. Students interested in this area should select courses from the following list:

IE 300-level_electives: IE 319, IE 324, IE 332, IE 334, IE 340,IE 342

Free electives: MGT 309, MGT 331, MGT 333

IE Major Requirements

See freshman year requirements, section III.

sophomore year, first semester (16 credit hours)	
IE 111	Engineering Probability and Statistics (3)
IE 112	Computer Graphics (1)
MATH 23	Calculus III (4)
PHY 21, 22	Introductory Physics II and Laboratory (5)
MAT 33	Engineering Materials and Processes (3)
sophomore year, second semester (17-18 credit hours)	
IE 121	Applied Engineering Statistics (3)
IE 131	Work Systems and Facilities Planning (3)
IE 132	Work Systems Laboratory (1)
ME 104	Thermodynamics I (3)
ACCT 108	Fundamentals of Accounting (3)
HSS	Humanities/Social Sciences elective (3-4)*
junior year, first semester (17-18 credit hours)	
IE 215	Fundamentals of Modern Manufacturing (3)
IE 216	Manufacturing Laboratory (1)
HSS	Humanities/Social Science Elective (3-4)*
MATH 205	Linear Methods (3)
MECH 2	Elementary Engineering Mechanics (3)
ECO 1	Principles of Economics (4)
junior year, second semester (16 credit hours)	
IE 122	Software Tools (1)
IE 226	Engineering Economy (3)
IE 220	Introduction to Operations Research (3)
IE 224	Information Systems Analysis and Design (3)
ECE 81	Principles of Electrical Engineering (4)
IE	elective (3)**
summer	
IE 100	Industrial Employment (0)

senior year, first semester (18-19 credit hours)

IE 251	Production and Inventory Control (3)
IEOR elective	(IE 316 or IE 339) (3)***
IE	elective (3)**
HSS	Humanities/Social Sciences elective (6-7)*
FE	free elective (3)

senior year, second semester (18 credit hours)

IE 154	Senior Project (3)
IE 305	Simulation (3)
IE	elective (3)**
IE	elective (3)**
ENGR	engineering elective (3)****
FE	free elective (3)

Notes:

**HSS elective credit totals must satisfy the college HSS program*

***IE elective courses are chosen from the current offering of 300-level IE courses*

****IEOR elective is either IE 316 or IE 339 (could be fall or spring).*

*****Engineering elective is any course offered in the CEAS that IE undergraduates are eligible to take, including IE 300-level courses.*

Special Opportunities for IE students

The following special opportunities are available to majors in industrial engineering and information & systems engineering:

Nontechnical Minor. Students may choose to pursue a nontechnical minor in an area of the humanities and social sciences. The minors program section of this catalog should be consulted for details.

Technical Minor. Technical minors such as materials science, environmental engineering, and computer science are available through other departments in the P. C. Rossin College of Engineering and Applied Science. Consult the specific department for more details.

Graduate Courses. Seniors in industrial and systems engineering can petition to take up to two graduate IE courses (400-level) to satisfy two of their five 300-level elective IE course requirements. The petitioning senior must have a good scholastic record (generally above a 3.0 GPA).

Senior Thesis Option. Students interested in continuing on to graduate school or performing research are encouraged to take the senior thesis option. In this option a student takes IE 155 as an engineering or free elective. After IE 155, IE 156 is taken as the thesis is written. The sequence of these 2 courses can replace IE 154.

Technical Minor in Manufacturing Systems Engineering

The minor in manufacturing systems engineering provides a concentration of courses in the manufacturing and production areas. This minor is not available to students majoring in industrial engineering. It requires 16 credits.

5th Year Master of Management Science Option

Students enrolled in the IE or ISE curricula can pursue a fifth-year Master of Management Science program. Students in the management science program take a mixture of engineering and business courses. Admission is not guaranteed. For details see the management science section of the catalog or contact the ISE department.

5th Year Master of Information and Systems Engineering Option

Students enrolled in the IE or ISE curricula can pursue a fifth year Master of Information and Systems Engineering program. Students in the Master of I&SE program take a mixture of engineering, computer science, and business courses. Admission is not guaranteed. For details see the M.S. and M.Eng. of Information and Systems Engineering section of the catalog or contact the ISE department.

Undergraduate Courses

IE 100. Industrial Employment (0)
Usually following the junior year, students in the industrial engineering curriculum are required to do a minimum of eight weeks of practical work, preferably in the field they plan to follow after graduation. A report is required. Prerequisite: Sophomore standing.

IE 111. Engineering Probability and Statistics (3) fall
Random variables, probability models and functions, and expected values. Statistical inference, estimation, hypothesis testing, and goodness of fit. Prerequisite: MATH 22.

IE 112. Computer Graphics (1) fall
Introduction to interactive graphics and construction of multi-view representations in two- and three-dimensional space. Applications in industrial engineering. Prerequisites: Sophomore standing in industrial engineering, ENGR 1.

IE 121. Applied Engineering Statistics (3) spring
The application of statistical techniques to solve industrial problems. Regression and correlation, analysis of variance, quality control, and reliability. Prerequisite: IE 111 or MATH 231.

IE 122. Software Tools (1) spring
Introduction to application software tools used to solve stochastic and deterministic problems. Problem design and solution will be drawn from IE 220. Co-requisite: IE 220.

IE 131 Work Systems and Facilities Planning (3) spring
Techniques of methods analysis, work design and measurement, and facilities design. Operations analysis, workplace ergonomics, worker-machine systems, assembly systems, time study, predetermined time systems, work sampling, incentive systems, and plant layout design. Prerequisite: IE 111 or equivalent, either previously or concurrently.

IE 132. Work Systems and Facilities Planning Laboratory (1) spring
Laboratory exercises and projects in methods analysis, operations analysis, plant layout, and related topics. Co-requisite: IE 131.

IE 154. Senior Project (3) fall and spring
The use of industrial engineering techniques to solve a major problem in either a manufacturing or service environment. Problems are sufficiently broad to require the design of a system. Human factors in system design. Laboratory. Prerequisite: Senior standing in industrial engineering.

IE 155. Senior Thesis I (3)
In depth study of a research topic in industrial engineering supervised by an ISE department faculty member. Requires completion of a formal research proposal and a public presentation of the proposal at the end of the semester. Prerequisite: Senior standing.

IE 156. Senior Thesis II (3)
Continued in depth study of a research topic in industrial engineering supervised by an ISE department faculty member. Requires a formal thesis and public presentation of the results. IE 156 can be substituted for IE 154 in the IE curriculum when taken in sequence after IE 155. Prerequisite: IE 155.

IE 168. Production Analysis (3) spring
A course for students not majoring in industrial engineering. Engineering economy; application of quantitative methods to facilities analysis and planning, operations planning and control, work measurement, and scheduling. Prerequisites: MATH 21 or 51.

IE 170. Algorithms in Systems Engineering (3)
Introduction to the use of computers to solve problems arising in systems engineering. Focus on the design and implementation of algorithms for systems modeling, systems design, systems analysis, and systems optimization. Fundamentals of computer systems, basic data structures, the design and implementation of efficient algorithms, and application of algorithms to the design and optimization of complex systems such as those arising in transportation, telecommunications, and manufacturing. Prerequisites: ENGR 1, CSE 17.

IE 171. Algorithms in Systems Engineering Laboratory (1)
Laboratory exercises and projects in the design and implementation of algorithms for systems modeling, systems design, systems analysis, and systems optimization. Co-requisite: IE 170.

IE 185. ISELP Honors Seminar (1)
Study of problem solving, principles of enterprise systems, and creative use of information technology in controlled environments. Emphasis on teamwork, self-knowledge, and communication skills. Department permission required. May be repeated for credit.

For Advanced Undergraduates and Graduate Students

IE 215. Fundamentals of Modern Manufacturing (3) fall
Study of modern production methods. Machining, bulk and sheet metal working processes, and electronics manufacturing. Introduction to automation, numerical control, and industrial robots. Prerequisite: MAT 33.

IE 216. Manufacturing Laboratory (1) fall
Laboratory exercises and experiments in manufacturing processes and systems. pre-requisite or concurrent: IE 215.

IE 220. Introduction to Operations Research (3) spring
Introduction to deterministic and stochastic methods in operations research. Mathematical programming, queuing theory, and other modeling techniques. Emphasis on formulation, analysis and solution of operations problems. Prerequisites: IE 111 or MATH 231.

IE 224. Information Systems Analysis and Design (3) spring
An introduction to the technological as well as methodological aspects of computer information systems. Content of the course stresses basic knowledge in database systems. Database design and evaluation, query languages and software implementation. Students that take CSE 241 cannot receive credit for this course.

IE 226. Engineering Economy and Decision Analysis (3) spring
Economic analysis of engineering projects; interest rate factors, methods of evaluation, depreciation, replacement, break-even analysis, after-tax analysis. Decision-making under certainty and risk. Prerequisite: IE 111 or MATH 231, either previously or concurrently.

IE 251. Production and Inventory Control (3) fall
Techniques used in the planning and control of production and inventory systems. Forecasting, inventory models, operations planning, and scheduling. Prerequisites: IE 121 and IE 220.

IE 275. Fundamentals of Web Applications (3)
Introduction to web technologies required to support the development of client side and server side components of Internet based applications. Students will be exposed to the problems of design, implementation, and management by way of assigned readings, class discussion, and project implementation. Term project. Prerequisites: either IE 224 or CSE 241 previously or concurrently.

IE 305. Simulation (3)
Applications of discrete and continuous simulation techniques in modeling industrial systems. Simulation using a high-level simulation language. Design of simulation experiments. Prerequisites: IE 121 and IE 220.

IE 307. Advanced Systems Analysis and Design (3) spring
Study of advanced techniques and their application in the analysis and design of information systems. Emphasis is placed on tools and techniques used for structured analysis and design, and on prototyping of systems. Prerequisite: IE 224 or equivalent.

IE 309. Introduction to Information Systems (3) fall
Study of information systems analysis and design with emphasis on management issues. Interfaces between information systems and databases and data communications are examined. Effects of information systems on organizational relationships are considered. Example information system will be designed and implemented. Prerequisite: IE 224 or equivalent.

IE 310. Database Analysis and Design (3) spring
Conceptual analysis of data is considered through data structures and models. Logical design of databases is studied in the context of the relational model of data. Prerequisite: IE 224 or equivalent.

IE 316. Optimization Models and Applications (3)
Modeling and analysis of operations research problems using techniques from mathematical programming. Linear programming, integer programming, multi-criteria optimization, stochastic programming, and nonlinear programming using an algebraic modeling language. Prerequisite: IE 220 or equivalent.

IE 319. Facilities Planning and Material Handling (3)
Facilities planning including plant layout design and facility location. Material handling analysis including transport systems, storage systems, utilizing equipment, and automatic identification and data capture. Prerequisite: IE 131 or consent of department chair.

IE 321. Experimental Industrial Engineering (1-3)
Experimental projects in selected fields of industrial engineering, approved by the instructor. A written report is required. May be repeated for academic credit.

IE 324. Industrial Automation and Robotics (3)
Introduction to robotics technology and applications. Robot anatomy, controls, sensors, programming, work cell design, part handling, welding, and assembly. Laboratory exercises. Prerequisites: MECH 2, MATH 205.

IE 328. Engineering Statistics (3)
Random variables, probability functions, expected values, statistical inference, hypothesis testing, regression and correlation, analysis of variance, introduction to design of experiments, and fundamentals of quality control. Prerequisite: MATH 23 or equivalent. This course cannot be taken by IE undergraduates.

IE 332. Product Quality (3)
Introduction to engineering methods for monitoring, control, and improvement of quality. Statistical models of quality measurements, statistical process control, acceptance sampling, and quality management principles. Some laboratory exercises. Prerequisite: IE 121.

IE 334. Organizational Planning and Control (3) fall
Design of organization and procedures for managing functions of industrial engineering. Analysis and design of resources planning and control, including introduction of change in man-machine systems; manpower management and wage administration. Prerequisite: Junior Standing.

IE 339. Stochastic Models and Applications (3)
Introduction to stochastic process modeling and analysis techniques and applications. Generalizations of the Poisson process; renewal theory and applications to inventory theory, queueing, and reliability; Brownian motion and stationary processes. Prerequisite: IE 220 or equivalent.

IE 340. Production Engineering (3) fall
Develop plans of manufacturing for discrete parts. Product design analysis and engineering materials utilization. Economic analysis of process design alternatives. Introduction to mechanization, automation, and flexible manufacturing systems. Term project. Laboratory. Prerequisite: IE 215.

IE 341. Data Communication Systems Analysis and Design (3)
An introduction to the hardware as well as performance evaluation of data communication networks. Emphasis on data transmission, encoding, data link control, communication networking techniques, and queuing/simulation analysis of network performance. Prerequisite: IE 224 and IE 220 or equivalent.

IE 342. Computer Integrated Manufacturing (3) spring
Analysis and design of manufacturing systems. Principal topics: computer-based techniques, decision support systems, applications of information technology to enterprise systems, value stream mapping. Introduction to: high performance work systems, manufacturing management measurement techniques, optimization strategies for discrete parts manufacturing, lean and agile manufacturing methods. Term project. Prerequisite: IE 224, IE 215 or equivalent.

IE 344. (MAT 344/ME 344) Metal Machining Analysis (3) spring
Intensive study of metal cutting emphasizing forces, energy, temperature, tool materials, tool life, and surface integrity. Abrasive processes. Laboratory and project work. Prerequisite: IE 215 or ME 240 or Mat 206.

IE 345. Manufacturing Information Systems (3)
A study of contemporary Information Technology solutions used to support the manufacturing function from product concept and design through production planning, manufacture, and delivery. Emphasis will be placed on information exchange protocol standards used to improve the overall integration of manufacturing systems. Prerequisites: IE275.

IE 347. Electronics Manufacturing (3)
Manufacturing processes required in electronics assembly, through-hole printed circuit cards, surface-mount printed circuit boards, and thick film hybrids. Testing and inspection procedures. Includes laboratory. Prerequisite: senior standing in engineering.

IE 358. (ECO 358). Game Theory (3)
A mathematical analysis of how people interact in strategic situations. Applications include strategic pricing, negotiations, voting, contracts and economic incentives, and environmental issues. Prerequisites: ECO 105 or 115 and MATH 21, 31 or 51.

IE 362. (MSE 362). Logistics and Supply Chain Management (3)
Modeling and analysis of supply chain design, operations, and management. Analytical framework for logistics and supply chains, demand and supply planning, inventory control and warehouse management, transportation, logistics network design, supply chain coordination, and financial factors. Students complete case studies and a comprehensive final project. Prerequisite: IE 220 and IE 251 or equivalents, or instructor approval.

IE 372. Systems Engineering Design (3)
Analysis, design, and implementation of solutions to problems in manufacturing and service sectors using information technology. Emphasis on problem identification and the evaluation of proposed solutions and implementations. Term Project. Prerequisites: IE 220, 275.

IE 385. ISELP Honors Project Seminar (1)
Application of problem solving to real enterprise systems projects. Emphasis on leadership, teamwork, design, and communication skills. Requires a written honors project report. Department permission required. Senior standing. May be repeated for credit.

Graduate Programs

Several programs leading to master's and doctoral degrees are offered by the Department of Industrial and Systems Engineering. All graduate students in the M.S. IE, M.Eng. IE and Ph.D. IE programs are required to satisfy core requirements in manufacturing and operations research. To satisfy the core requirement in manufacturing, the student must complete either IE 340 or IE 342.

To satisfy the core requirement in operations research, the student must complete either IE 305 or IE 316. Core requirements may also be satisfied by previous coursework. In this case, the student must petition the ISE graduate committee to wave the core requirement in the relevant area. All core course prerequisites must also be satisfied. Prerequisites may be satisfied by (1) previous course work, (2) completing the prerequisite course without graduate credit, or (3) passing the final examination of the prerequisite course with a grade of B or better.

A Ph.D. student is required to complete core requirements with grades of B or better before being formally admitted to Ph.D. candidacy.

Further information about graduate programs is contained in an ISE graduate brochure available from the department. In addition, several documents are available from the department that describe the requirements for each of our graduate programs.

M.S. in Industrial Engineering

The minimum program for the master of science degree in IE consists of 24 credit hours of approved coursework and completion of a satisfactory thesis. Courses in other departments for which the student has the prerequisites may be integrated into the MSIE program. Subject to advisor approval, up to nine credit hours of 300 and 400-level courses from other departments may be included in the IE masters program. The other department courses usually include other engineering disciplines, mathematics, computer science, and business and economics.

M.Eng. in Industrial Engineering

This program of study is for those students whose interests are toward engineering design rather than research. The program provides opportunity to gain breadth of field by required coursework in all areas of study within the department. In addition, an engineering project must be completed under the supervision of the faculty.

M.S. in Information and Systems Engineering

The master of science program in I&SE requires a minimum of 24 credit hours of approved coursework and completion of a satisfactory thesis or 27 credit hours of approved coursework and completion of a 3 credit hour project. See separate catalog listing under Information and Systems Engineering.

M.Eng. in Information and Systems Engineering

The master of engineering program in I&SE requires a minimum of 30 credit hours of approved coursework. See separate catalog listing under Information and Systems Engineering.

M.S. in Management Science

This program requires a minimum of 30 credit hours of approved coursework. The program leads to the master of science degree in management science. See separate catalog listing under Management Science.

M.S. in Manufacturing Systems Engineering

This is an interdisciplinary graduate program leading to the master of science degree in manufacturing systems engineering. See separate catalog listing under Manufacturing Systems Engineering.

M.S. in Quality Engineering

This is a specialized graduate program offered by the Department of Industrial and Manufacturing Systems Engineering leading to the master of science degree in quality engineering. See separate catalog listing under Quality Engineering.

Ph.D. in Industrial Engineering

The graduate program leading to the doctor of philosophy (Ph.D.) degree is organized to meet the individual goals and interests of graduate students whose professional plans include teaching, consulting, or research in an educational, governmental, or industrial environment. Each doctoral candidate is required to demonstrate: (1) a high level of proficiency in one or more fields of industrial and manufacturing systems engineering, and (2) a capacity for independent research through the preparation of a dissertation related to his/her field of specialization.

Areas of Graduate Study

The areas of graduate study emphasized in the Department of Industrial and Systems Engineering are as follows:

Manufacturing Systems and Processes. Graduate study in manufacturing involves coursework and research in any of a variety of subjects, including manufacturing processes, automation, robotics, numerical control, computer integrated manufacturing, process control, material handling, and production scheduling. In manufacturing processes, the department specializes in the material removal processes, such as machining (e.g., turning, milling, drilling, grinding) and nontraditional processes (e.g., water jet cutting, electrochemical machining). Additional manufacturing process technologies are covered in other departments in the P. C. Rossin College of Engineering and Applied Science, in particular, the materials science and engineering department.

Operations Research. The operations research graduate area is intended to prepare students to analyze, formulate, and solve problems using analytical methods and computational techniques. Topics emphasized in the department include mathematical programming, combinatorial optimization, queuing theory, neural networks, and stochastic processes. There are many settings in which operations research problems are encountered, but those which arise in the context of manufacturing are of particular interest to the Department of Industrial and Systems Engineering. Students can expect to study challenging problems at both the master's and doctoral levels.

Information Technology. Graduate study in information systems covers the methodological and technological development of computer information systems. Of particular interest at Lehigh are the systems needed to drive integrated manufacturing and service industries. Such systems are becoming increasingly important in the trend toward real-time planning and control, with embedded decision making capabilities. Topics include data communication, telecommunication and computer networks, database processing systems, artificial intelligence and expert systems, object-oriented technology, and computer-based production planning and inventory control. The information systems area is further supplemented by courses offered by the Department of Electrical Engineering and Computer Science.

IE 404. Simulation (3)
Applications of discrete and continuous simulation techniques in modeling industrial systems. Simulation using a high-level simulation language. Design of simulation experiments. This course is a version of IE 305 for graduate students, with research projects and advanced assignments. Prerequisites: IE 121 or IE 328 and IE 220 or equivalent.

IE 405. Special Topics in Industrial Engineering (3)
An intensive study of some field of industrial engineering.

IE 406. Introduction to Mathematical Programming (3)
Techniques for the solution and analysis of deterministic linear models used in operations research. Linear programming, network flow, and integer linear programming. Emphasis on modeling techniques, algebraic modeling languages and commercial solvers.

IE 408. Management of Information Systems (3)
Philosophies and methods for systematic planning, development, and implementation of management information systems. Concepts of information resource management, and strategic and long-range planning of information systems and services. Prerequisite: IE 224 or ACCT 311 or equivalent.

IE 409. Time Series Analysis (3)
Theory and applications of an approach to process modeling, analysis, prediction, and control based on an ordered sequence of observed data. Single or multiple time series are used to obtain scalar or vector difference/differential equations describing a variety of physical and economic systems. Prerequisite: IE 121 or equivalent.

IE 410. Design of Experiments (3)
Experimental procedures for sorting out important causal variables, finding optimum conditions, continuously improving processes, and trouble shooting. Applications to laboratory, pilot plant and factory. Prerequisite: Some statistical background and experimentation in prospect, IE 121 or equivalent.

IE 411. Networks and Graphs (3)
This course examines the theory and applications of networks and graphs. Content of the course stresses on the modeling, analysis and computational issues of network and graph algorithms. Complexity theory, trees and arborescences, path algorithms, network flows, matching and assignment, primal-dual algorithms, Eulerian and Hamiltonian walks and various applications of network models. Prerequisite: IE 406 or equivalent.

IE 412. Quantitative Models of Supply Chain Management (3)
Analytical models for logistics and supply chain coordination. Modeling, analysis, and computational issues of production, transportation, and other planning and decision models. Logistics network configuration, risk pooling, stochastic decision-making, information propagation, supply chain contracting, and electronic commerce implication. Prerequisite: IE 351, and IE 316 or IE 406 or equivalent.

IE 413. Advanced Engineering Economy and Replacement Analysis (3)
Measuring economic worth, economic optimization under constraints, analysis of economic risk and uncertainty. Emphasis on analytical methods to evaluate the economic desirability of replacement and retirement options in capital investment. Prerequisites: IE 220 and IE 226 or equivalents.

IE 414. Heuristic Methods in Combinatorial Optimization (3)
Heuristic methods for solving combinatorial and discrete optimization problems such as routing, scheduling, partitioning and layout. Introduction to NP-completeness theory, exact and inexact methods, performance analysis, fast and greedy heuristics, Lagrangean heuristics, and various search techniques including simulated annealing, genetic algorithms, Tabu search and iterative constructive heuristics.

IE 415. Manufacturing Management (3)
Analysis of the factors entering into the development of manufacturing management philosophy; decision-making process in areas of organization, planning, operation, and control of manufacturing. Influence of the social, technical, and economic environment upon manufacturing management decisions.

IE 416. Dynamic Programming (3)
The principle of optimality and recursive solution structure; multidimensional problems; reduction of dimensionality and approximation; stochastic control; non-serial systems; relationship to calculus of variation; applications. Prerequisite: IE 316 or equivalent.

IE 417. Nonlinear Programming (3)
Advanced topics in mathematical programming with emphasis on modeling and analysis of non-linear optimization problems. Convex analysis, unconstrained and constrained optimization, duality theory, Lagrangian relaxation, and methods for solving non-linear programs, including descent methods, Newton methods, conjugate gradient methods, and penalty and barrier methods. Prerequisite: IE 406 or equivalent.

IE 418. Integer Programming (3)
Advanced topics in mathematical programming with emphasis on modeling and analysis of optimization problems with integer variables. Polyhedral theory, theory of valid inequalities, duality and relaxation, computational complexity, and methods for solving integer programs, such as branch and bound. Prerequisite: IE 406 or equivalent.

IE 419. Sequencing and Scheduling (3)
Systematic analysis of models for the planning and scheduling of systems that produce goods or services. Resource planning techniques, static and dynamic scheduling methods and algorithms. Prerequisites: IE 351, and IE 316 or IE 406, or equivalent.

IE 422. Measurement and Inspection Systems (3)
Study of measurement instruments and sensors for manufactured products. Metrology standards, performance characteristics of measuring devices, calibration, error analysis, and gaging. Mechanical, optical, and other techniques. On-line monitoring and control for product quality, and sensor integration and fusion. Prerequisite: IE 328 or equivalent.

IE 424. Robotic Systems and Applications (3)
Detailed analysis for robotic systems in manufacturing and service industries. Task planning and decomposition, motion trajectory analysis, conveyor tracking, error detection and recovery, end effector design, and systems integration. Prerequisite: IE 324 or consent of instructor.

IE 425. Inventory Management and Production Planning (3)
Advanced study of heuristic, algorithmic, and analytical methods for inventory, production planning, and distribution models and systems. Forecasting, scheduling of production facilities, single stage and multi-echelon inventory control, and facility location- production allocation models. Prerequisites: IE 3XX and IE 339, or equivalent.

IE 426. Optimization Models and Applications (3)
Modeling and analysis of operations research problems using techniques form mathematical programming. Linear programming, integer programming, multi-criteria optimization, stochastic programming and nonlinear programming using an algebraic modeling language. This course is a version of IE 316 for graduate students, with research projects and advanced assignments. Closed to students who have taken IE 316. Prerequisite: IE 220 or equivalent background.

IE 429. Stochastic Models and Applications (3)
Introduction to stochastic process modeling and analysis techniques and applications. Generalization of the Poisson process; renewal theory, queueing, and reliability; Brownian motion and stationary processes. This course is a version of IE 39 for graduate students, with research projects and advanced assignments. Closed to students who have taken IE 339. Prerequisite: IE 220 or equivalent background.

IE 430. Management Science Project (3)
Analysis of a management problem and design of its solution incorporating management science techniques. An individual written report is required. Recommended to be taken in the last semester of the program.

IE 431. Operations Research Seminar (3)
Extensive study of selected topics in techniques and models of operations research.

IE 433. Manufacturing Engineering Seminar (3)
Extensive study of selected topics in the research and development of manufacturing engineering techniques.

IE 437. Advanced Database Analysis and Design (3)
Intensive treatment of design and application of modern database technology, including information modeling and logical design of databases. Emphasis on applications to the manufacturing environment. Prerequisite: IE 310 or equivalent.

IE 438. Advanced Data Communication Systems Analysis and Design (3)
Study of technological development, operational algorithms and performance analysis in data networks. Emphasis on recent developments in communication technologies, modeling and simulation of large-scale networks, routing models and algorithms, and flow control issues. Prerequisite: IE 341 and IE 316, or equivalents.

IE 439. Queueing Systems (3)
Queueing theory and analysis of manufacturing, distribution, telecommunications, and other systems subject to congestion. Design and analysis of queueing networks; approximation methods such as mean value analysis, uniformization, fluid and diffusion interpretations; numerical solution approaches. Prerequisite: IE 339 or instructor permission.

IE 441. Financial Engineering Projects (3)
Analysis, design and implementation of solutions to problems in financial services using information technology, mathematical modeling, and other financial engineering techniques. Emphasis on real-world problem solving, problem definition, implementation and solution evaluation.

IE 442. Total Quality Management (3)
Principles and techniques of TQM; principles of Deming, Juran, Taguchi, and others; standards, metrics, costs, benchmarking, quality circles, and continuous improvement; Malcolm Baldrige and other awards, ISO 9000, case studies.

IE 443. (MSE 427) Automation and Production Systems (3)
Principles and analysis of manual and automated production systems for discrete parts and products. Cellular manufacturing, flexible manufacturing systems, transfer lines, manual and automated assembly systems, and quality control systems. Prerequisite: IE 215 or equivalent.

IE 445. Assembly Processes and Systems (3)
Joining processes including welding, brazing, soldering, and adhesive bonding. Mechanical assembly methods. Manual assembly lines and line balancing. Automated assembly. Product design considerations including Design for Assembly. Prerequisite: IE 215 or equivalent.

IE 446. Discrete Event Dynamic Systems (3)
Modeling of Discrete Event Dynamic systems (DEDS) particularly as applied to industrial systems. Modeling procedures with focus on Petri Nets. Hierarchical Petri Net modeling, performance analysis, behavioral and structural properties, and various synthesis and analytical techniques. Relationships to state space concepts, simulation, and finite state automata are introduced. Emphasis on use of such nets for the control of industrial systems. Prerequisites: Permission of instructor.

IE 447. Stochastic Programming and Financial Analysis (3)
Finding optimal decisions in problems such as portfolio management and financial planning. Emphasis on implementation and tools for solving difficult stochastic programming instances and application of stochastic programming to financial portfolio analysis. Requires basic knowledge of linear programming, elementary analysis, and probability.

IE 448. Industrial Control Systems for Manufacturing (3)
Techniques used to control manufacturing systems: numerical control, digital control, programmable logic controllers, and sensors.

IE 449. Advanced Computer-Aided Manufacturing (3)
Numerical control in manufacturing; CAD/CAM systems; computer monitoring and control of manufacturing operations; adaptive control of manufacturing operations. Manufacturing resource planning, computer-aided process planning, and shop floor control. Prerequisite: IE 342 or consent of the department chair.

IE 451. Intelligent Manufacturing Systems (3)
Informational and control structures, architectures, and analysis techniques for autonomous and semi-autonomous manufacturing systems. System architectures

and techniques, knowledge based systems in production, and techniques based on fuzzy systems and neural networks. Applications in manufacturing systems control, process planning, and design and management problems in newly developing manufacturing and production systems. Prerequisite: Permission of instructor.

IE 458 (ECO 463). Topics in Game Theory (3)
A mathematical analysis of how people interact in strategic situations. Topics include normal-form and extensive-form representations of games, various types of equilibrium requirements, the existence and characterization of equilibria, and mechanism design. The analysis is applied to microeconomic problems including industrial organization, international trade, and finance. Prerequisites: Two semesters of calculus, ECO 412 and ECO 414, or permission of the instructor.

IE 460. Engineering Project (1-3)
Intensive study of an area of industrial engineering with emphasis upon design and application. A written report is required.

IE 461. Readings (1-3)
Intensive study of some area of industrial engineering that is not covered in general courses.

IE 490. Thesis (1-6)

IE 499. Dissertation (1-15)

Information and Systems Engineering

B.S. in Information and Systems Engineering

Information and systems engineering (I&SE) is a bachelor of science degree program that produces graduates who understand the complex facets of modern information systems, and the integration of these systems in industrial, service and financial organization. The degree program, offered through the Department of Industrial and Systems Engineering, constitutes a broad based curriculum focusing on three core areas: (1) Information Economics, (2) Quantitative Systems Analysis, and (3) Information Technology. The core areas are coupled with general engineering and business background courses. Information economics studies the formulation, structure, and operational dynamics of information-centric systems in the context of industrial organizations, service sector economics, and financial institutions. Topic areas range from fundamental theory and methodologies in systems science and engineering, to issues in complex supply networks, e-Business, electronic marketplaces, and financial engineering. Quantitative systems analysis studies operations research and computational tools for analyzing complex systems and their information components. Topic areas include mathematical programming, optimization, decision analysis, large-scale modeling and simulation, decentralized decision processes, stochastic processes, sequencing and scheduling, parallel and distributed algorithms, and algorithm design. Information technology and applications studies computer and communication technologies needed to design and implement information system applications. Topic areas include the applications of information technology in manufacturing and business environments, including electronic commerce, supply chain and enterprise information systems, manufacturing information systems, and intelligent manufacturing control. The I&SE degree requires 132 credit hours.

I&SE Major Requirements

See freshman year requirements, section III.

sophomore year, first semester (16 credit hours)

IE 111	Engineering Probability and Statistics (3)
MATH 23	Calculus III (4)
PHY 21, 22	Introductory Physics II and Laboratory (5)
CSE 17	Structured Programming and Data Structures (4)

sophomore year, second semester (17 credit hours)

IE 121	Applied Engineering Statistics (3)
IE 170	Algorithms in Systems Engineering (3)
IE 171	Algorithms in Systems Engineering Laboratory (1)
MATH 205	Linear Methods (3)
ACCT 108	Fundamentals of Accounting (3)
ECE 81	Principles of Electrical Engineering (4)

junior year, first semester (17 credit hours)

IE 122	Software Tools (1)
IE 220	Introduction to Operations Research (3)
IE 224	Information Systems Analysis and Design (3)
BIS 211	Management Information Systems (3)
ECO 1	Principles of Economics (4)
MECH 2	Elementary Engineering Mechanics (3)
or ME 104	Thermodynamics I (3)
or MAT 33	Engineering Materials Processing (3)

junior year, second semester (18-19 credit hours)

IE 226	Engineering Economy (3)
IE 275	Fundamentals of Web Applications (3)
IE 305	Simulation (3)
HSS	Humanities/Social Science Elective (6-7)*
FE	free elective (3)

summer

IE 100	Industrial Employment (0)

senior year, first semester (15-16 credit hours)

IE 316	Advanced Operations Research Techniques (3)
IE 345	Manufacturing Information Systems (3)
IE 372	Systems Engineering Design (3)
TE	Technical Elective (3)**
HSS	Humanities/Social Sciences elective (3-4)*

senior year, second semester (18 credit hours)

IE 154	Senior Project (3)
IE 339	Stochastic Models
IE341	Data Communication Systems Analysis and Design (3)
TE	Technical Elective (3)**
HSS	Humanities/Social Sciences elective (3)*
FE	free elective (3)

Notes:

**HSS elective credit totals must satisfy the college HSS program*

***Technical Electives from approved list*

Information and Systems Engineering Leadership Program

The Information and Systems Engineering Leadership Program (ISELP) is an honors program linked to the Information and Systems Engineering degree offered by the Department of Industrial and Systems Engineering. The program builds on the industry-based capstone design model used in the department for over 30 years. Students in this program have close interaction with industry for mentoring and project work beginning in the freshman year and carrying through the entire degree program. Students will progress in leadership roles until as seniors they are leading projects for the underclassmen. Close interaction with industrial mentors and industrial projects in systems engineering and information technology will insure that students can apply what they learn in the classroom to real-world problems. Projects will be developed primarily through Lehigh's Enterprise Systems Center (ESC).

Participants in this program will graduate with these highly valued leadership skills and competencies:

- Self-knowledge and the ability to work well with others;
- Confidence to lead change;
- Ability to identify and solve unstructured problems;
- Proven ability to design, build and implement high value-added systems.

Students are offered admission to the program during the matriculation process. In addition, students that select the I&SE degree and maintain a high cumulative GPA at the end of the freshman year will be eligible to join the program.

Students in the ISELP must satisfy all degree requirements for the I&SE degree. In addition, both semester of the sophomore and junior years and the first semester of the senior year the student registers for IE 185 ISELP Honors Seminar. In the last semester of the senior year the student registers for IE 385 ISELP Honors Project Seminar. IE 385 requires a written honors project report. The additional 6 credits of seminar are above the degree requirements for the I&SE degree and may not be used as Free Elective credits in that program.

Special Opportunities for I&SE students

The following special opportunities are available to majors in information systems and engineering:

Nontechnical Minor. Students may choose to pursue a nontechnical minor in an area of the humanities and social sciences. The minors program section of this catalog should be consulted for details.

Technical Minor. Technical minors such as materials science, environmental engineering, and computer science are available through other departments in the P. C. Rossin College of Engineering and Applied Science. Consult the specific department for more details.

Graduate Courses. Seniors in the Department of Industrial and Systems Engineering can petition to take up to two graduate IE courses (400-level) to satisfy two of their five 300-level elective IE course requirements. The petitioning senior must have a good scholastic record (generally above a 3.0 GPA).

Senior Thesis Option. Students interested in continuing on to graduate school or performing research are encouraged to take the senior thesis option. In this option a student takes IE 155 as an engineering or free elective. After IE 155, IE 156 is taken as the thesis is written. The sequence of these 2 courses can replace IE 154.

5th Year Master of Management Science Option

Students enrolled in the ISE curricula can pursue a fifth-year Master of Management Science program. Students in the management science program take a mixture of engineering and business courses. Admission is not guaranteed. For details see the management science section of the catalog or contact the ISE department.

5th Year Master of Information and Systems Engineering Option

Students enrolled in the ISE curricula can pursue a fifth year Master of Information and Systems Engineering program. Students in the Master of I&SE program take a mixture of engineering, computer science, and business courses. Admission is not guaranteed. For details see the M.S. and M.Eng. of Information and Systems Engineering section of the catalog or contact the ISE department.

Master Programs in Information and Systems Engineering

The goal of the M.S. in Information and Systems Engineering (I&SE) program is to provide advanced educational and research opportunities related to operations research, quantitative and computational analysis, large scale optimization, system simulation, information-centric systems, and the integration of information systems in industrial, service and financial organizations. The program will emphasize three core areas: (1) Information Economics, (2) Quantitative Systems Analysis, and (3) Information Technology. Graduates of the program will be operations research analysts, systems engineers and information technology specialists who are employed by virtually all organizations, especially in consulting, multi-national operations, transportation, logistics, financial institutions, and telecommunications.

New communications technologies, the web, and recent advances in computing are profoundly changing the operations of business and industry. The increasingly complex intertwining of organizations coupled with continued automation of business processes creates new and complex large-scale systems of enterprises, people, capital equipment, and information. With these changes comes the need for engineers capable of understanding and integrating these emerging systems. The needs extend far beyond the micro level details of computer hardware and software, instead requiring systems integration, large-scale optimization and control, and knowledge of the operations of industry. It is the combination of the systems perspective, the analytical focus, and development of computing skills that sets the I&SE education apart. The program will be comprised of three core areas:

Information Economics: The formulation, structure, and operational dynamics of information-centric systems in the context of industrial organizations, service sector economics, and financial institutions. Topic areas range from fundamental theory and methodologies in systems science and engineering, to issues in complex supply networks, e-Business, electronic marketplaces, and financial engineering. This area of concentration is based on the solid foundations of science and economics through which we envision the long-term development of modern information systems.

Quantitative Systems Analysis: Operations research and computational tools for analyzing complex systems and their information components. Topic areas include mathematical programming, optimization, decision analysis, large-scale modeling and simulation, decentralized decision processes, stochastic processes, sequencing and scheduling, parallel and distributed algorithms, and algorithm design. This area of concentration forms the methodological base for the design, integration, implementation, and management of information systems in large-scale organizations.

Information Technology and Applications: Computer and communication technologies needed to design and implement information system applications. Of specific focus will be the applications of information technology in manufacturing and business environments, including electronic commerce, supply chain and enterprise information systems, manufacturing information systems, and intelligent manufacturing control. This area concentrates on the technological aspects of modern information systems such as database systems, software development, and web-based systems.

Program Requirements

M.S. in Information and Systems Engineering

The master of science program in I&SE requires a minimum of 24 credit hours of approved coursework and completion of a satisfactory thesis or 27 credit hours of approved coursework and completion of a 3 credit hour project. Four core courses are required: IE 316, IE 341, IE 362, and IE 404. In addition, 4 courses are chosen from a list of approved courses that covers the areas of information economics, quantitative systems analysis, and information technology and applications.

M.Eng. in Information and Systems Engineering

The master of engineering program in I&SE requires a minimum of 30 credit hours of approved coursework. No thesis or project is required. Four core courses are required: IE 316, IE 341, IE 362, and IE 404. In addition, 4 courses are chosen from a list of approved courses that covers the areas of information economics, quantitative systems analysis, and information technology and applications.

Program Prerequisites:

(1) A candidate embarking on the master's program must possess a Bachelors degree in engineering or the mathematical or physical sciences. (2) The candidate must satisfy the following incoming course prerequisites: CSC 17, IE 220, and IE 224, or equivalents.

Core Courses (Four courses required of all I&SE students):

IE 316	Advanced Operations Research Techniques (3)
IE 341	Data Communication Systems Analysis and Design (3)
IE 362	Logistics and Supply Chain Management (3)
IE 404	Simulation (3)

ISE Electives (select at least four from the following courses, organized into three groups corresponding to the three information and systems engineering areas identified above.):

1. Information Economics

BIS 311	Managing Information Systems Development (3)*
BIS 331	Electronic Commerce and Security (3)*
ECO 412	Mathematical Economics (3)
ECO 413	Advanced Microeconomic Analysis (3)
ECO 415	Econometrics (3)
ECO 447	Economic Analysis of Market Competition (3)
IE 334	Organizational Planning and Control (3)
IE 442	Total Quality Management (3)

2. Quantitative Systems Analysis

IE 328	Engineering Statistics (3)
IE 339	Stochastic Processes (3)
IE 406	Introduction to Mathematical Programming
IE 409	Time Series Analysis (3)
IE 410	Design of Experiments (3)
IE 411	Networks and Graphs (3)
IE 413	Advanced Engineering Economy and Replacement Analysis (3)
IE 414	Heuristic Methods in Combinatorial Optimization (3)
IE 416	Dynamic Programming (3)
IE 417	Nonlinear Programming (3)
IE 418	Integer Programming (3)
IE 419	Sequencing and Scheduling (3)
IE 439	Queueing Systems (3)
IE 446	Discrete Event Dynamic Systems (3)
IE 458 (ECO 463)	Game Theory (3)

3. Information Technology and Applications

CSE 313	Computer Graphics (3)*
CSE 330	Advanced Software Engineering Tools (3)*
CSE 340	Design and Analysis of Algorithms (3)*
CSE 366	Object-Oriented Programming (3)
CSE 403	Theory of Operating Systems (3)*
CSE 411	Advanced Programming Techniques (3)
CSE 412	Object-Oriented Programming (3)
CSE 414	Expert Systems (3)*
CSE 415	Database Topics (3)*
CSE 416	Advanced Issues in Knowledge-based Systems (3)*
CSE 432	Object-Oriented Software Engineering (3)
ECE 401	Advanced Computer Architecture (3)*
ECE 404	Computer Networks (3)
IE 307	Advanced Systems Analysis and Design (3)
IE 309	Introduction to Information Systems (3)
IE 310	Database Analysis and Design (3)
IE 324	Industrial Automation and Robotics (3)
IE 332	Quality Control (3)
IE 342	Computer Integrated Manufacturing (3)
IE 345	Manufacturing Information Technology (3)
IE 424	Robotic Systems and Applications (3)
IE 437	Advanced Database Analysis and Design (3)
IE 438	Advanced Data Communication Systems Analysis and Design (3)
IE 443	Automation and Production Systems (3)

IE 449	Advanced Computer-Aided Manufacturing (3)
IE 451	Intelligent Manufacturing Systems (3)

**Prerequisites may pose difficulties.*

Free Electives (for M.Eng. select any two graduate courses subject to approval of graduate coordinator).

Integrated Business and Engineering Honors Program

Program directors. Stephen G. Buell, Ph.D. (Lehigh), *professor of finance*; Robert H. Storer, Ph.D. (Georgia Tech), *professor of industrial and systems engineering.*

The Integrated Business and Engineering Honors Program (IBE) is offered jointly by the College of Business and Economics and the P. C. Rossin College of Engineering and Applied Science. The program recognizes the need for today's leaders in business and industry to have a sound foundation in both commerce and technology.

Since the beginning of the Industrial Revolution, technology has had a profound and ever increasing effect on the products businesses offer, and the processes by which they are produced. More recently however, technology has begun to effect the manner in which business is conducted. Information Age technology is driving new business concepts including e-commerce, virtual enterprises, and mass customization. Technological growth continues at an explosive rate, and, as it does, commerce and technology become ever more intertwined. A fundamental understanding of business, technology, and how they fit together, will be a prerequisite for success in the future global economy. The IBE Honors Program is designed to provide students with this essential perspective.

Graduates of this integrated program will possess a unique set of skills and competencies. In addition to the mastery of the concepts and procedures taught in individual courses in each college, the IBE Honors Program develops competencies that require an integrated knowledge from both engineering and business. These competencies will be developed through courses, integrative elements and program experience (such as field visits, guest lectures and internships).

The state-of-the-art honors program leads to the Bachelor of Science in Business and Engineering. The very demanding 137 credit IBE program is a carefully planned integration of courses in business and engineering with additional requirements in mathematics, the sciences, English and the humanities.

In addition to the above requirements, the IBE Honors Program has a foreign language proficiency requirement which can be satisfied in a number of ways: by achieving a score of 5 on a foreign language AP exam; by entering Lehigh with at least a B+ average in fours years of a single foreign language in high school; by demonstrating

Degree Requirements:

Area	Credits	Details
English Composition and Literature	(6)	ENGL 1 and 2 Composition and Literature I and II
Humanities and Social Science	(10)	Must include COMM 130 Public Speaking or SSP 135 Human Communication
Computing	(3)	ENGR 1 ENGR Computations or CSC 11 Intro to Computing
MATH and Science Core	(30)	MATH 21, 22, 23 and 231 Calculus I, II and III and Probability and Statistics; Physics 11,12, 21 and 22 Introductory Physics I and II; CHEM 21 and 22 Introductory Chemical Principles
Engineering Core	(20)	Set of engineering courses developed for each particular major
Business and Economics Core	(32)	ACCT 151 and 152 Introduction to Financial and Managerial Accounting I and II, BIS 111 MIS; ECO 1, 146 and 129 Principles, Applied Micro Analysis and Money and Banking; FIN 225 Business Finance; LAW 201 Legal Environment of Business; MGT 280 Management of People and Operations; MKT 211 Contemporary Marketing
Major	(18)	Specific major in either business or engineering
Integrated IBE Courses	(12)	Freshman year courses (4 credits); Sophomore and junior year seminars (2 credits); Senior year capstone course (6 credits)
Free electives	(6)	May be taken from any department in the University
Summer internships	(0)	At least one industrial internship is required. International internships are encouraged.
TOTAL	(137)	

proficiency through a standardized test administered by the Department of Modern Languages and Literature; or by passing the second intermediate level course in a foreign language at Lehigh (e.g., Spanish 12). International students with both English proficiency and fluency in any second language other than English or English dialects will satisfy the language requirement. Students with some language background in high school will be assigned to the appropriate starting course at Lehigh following testing by the Department of Modern Languages and Literature. Students with no previous experience in a second language may need to take 16 foreign language credits (4 courses, each at 4 credits). Students may devote six credits of humanities and social science electives, and 6 credits of free electives to language courses. Thus, students with absolutely no foreign language background may need an additional four credits above the 137 required for graduation.

Interdisciplinary Technology

See listings under Science, Technology and Society.

International Relations

Professor and Chair. Henri J. Barkey, Ph.D. (Pennsylvania), *Bernard L. and Bertha F. Cohen Professor*

Professors. Rajan Menon, Ph.D. (Illinois), *Monroe J. Rathbone Professor*; Bruce E. Moon, Ph.D. (Ohio State); Raymond F. Wylie, Ph.D. (London-England).

Associate professor. Chaim D. Kaufmann, Ph.D. (Columbia).

Assistant professor. Janice Bially Mattern, Ph.D. (Yale).

Emeritus professors. Zdenek J. Slouka, Ph.D. (Columbia), Oles M. Smolansky, Ph.D. (Columbia).

The Field of International Relations: The reality of an interdependent world is brought home to us every day. Fast-flying, highly accurate nuclear weapons have breached the state's ability to protect its citizens as never before. National economies are so sensitive to the trade and monetary policies and instability of other countries that governments are forced to recognize the limitations of purely national economic policies in a highly interdependent world. Resource depletion, pollution, refugee relief, the indebtedness of developing countries, and nuclear proliferation are truly global problems beyond the ability of any one state, no matter how powerful, to address alone.

The Department of International Relations seeks to provide students with a systematic understanding of world politics. The questions that preoccupy scholars of international relations are too numerous to list here, but students who major in international relations can expect to acquire a detailed knowledge of topics such as: contending theories of world politics; the foreign policies of the major powers; the international relations of major regions; international security and arms control; regional conflicts; global problems such as terrorism, refugee relief, and pollution; the politics of global economic relations; and the role of international organizations such as the United Nations, the International Monetary Fund, and the World Bank. As should be apparent from this list, international relations is a multi-disciplinary field and draws upon concepts and theories from political science, history, economics, anthropology, sociology, philosophy, religion studies, and psychology. Majors are encouraged to take courses in these disciplines.

The Curriculum: Students considering course work in international relations are strongly encouraged to visit the International Relations web site *(www.lehigh.edu/ininr/ininr.html)*. Prospective International Relations majors should enroll in IR 10 and ECO 1 as early as possible. IR majors should fulfill the mathematics portion of their college distribution requirements with MATH 12 (Basic Statistics).

Major in International Relations

The major consists of ten courses for a total of 39-40 credits. The courses required are:

Gateway courses (two courses)

IR 10 Introduction to World Politics (4)
ECO 1 or 11 or 12 (3-4)

Functional core (three courses).

IR 56 European International Relations (4)
IR 125 International Political Economy (4)
IR 205 Theories of International Relations (4)

Area studies focus (two courses)

Any two IR courses that focus on a region of the world other than North America. Certain courses offered by other departments may also qualify. See the International Relations department for a complete list.

Advanced courses (two courses)

Any two courses numbered 300-387 and 393. However, the same course may not be counted towards both the area studies and advanced course requirements.

Free elective.

Any 4-credit IR course other than IR 90.

Departmental Honors

To graduate with honors, a major in international relations must:

(a.) attain an average of at least 3.5 in the courses constituting the major program; and

(b.) complete a two-semester honors thesis in the senior year.

Minor in International Relations

The minor consists of four 4-credit courses, for a total of 16 credits: IR 10, one advanced IR elective numbered 300-387 and 393, and two free IR electives other than IR 90.

Beyond the Curriculum: In close cooperation with the international education office, the department assists students interested in study abroad programs. In addition, Lehigh has an array of summer programs, which involve course work and/or internships in such countries as China, the Czech Republic and the United Kingdom.

Every semester speakers with expertise on various aspects of world affairs visit Lehigh. The department arranges the annual Cohen International Relations Lecture Series, which has featured speakers such as Ernesto Zedillo, Anthony Zinni, Gareth Evans, Strobe Talbott, Randall Robinson, Robert McNamara, Valery Giscard d'Estaing, Vaclav Havel, Hans Dietrich Genscher, Kim Campbell, Oscar Arias, Wole Soyinka, Andrei Kozyrev, Anthony Lake, and George Mitchell.

The student-run World Affairs Club sponsors a number of activities each year, including student-faculty socials, guest speakers and related programs. It organizes the Model United Nations program to which Lehigh sends a delegation each year. Another delegation is sent annually to the European Union Simulation in Washington, D.C. From time to time, delegations are also sent to other student conferences, including West Point and the U.S. Naval Academy.

The department has an active program in conjunction with Career Services to help place students in internships. We strongly encourage students to obtain an internship. Most of these internships are likely to be in New York or Washington, D.C.

Upon Graduating: While a degree in international relations does not lead to a specific career in the way that, for example, accounting or engineering does, a major in international relations, by emphasizing clarity in speech and writing, analytical skills, and a detailed knowledge of world politics prepares students for careers in government, journalism, law, international business, and teaching and research. Recent IR graduates currently work in all of these fields. Some have gone directly into careers upon graduating; others have enrolled in graduate school prior to employment.

Undergraduate Courses

IR 1. Current Issues in World Affairs (3)
This is a survey course designed primarily for non-IR majors or minors. The purpose is to acquaint students with some of the concepts and historical facts behind current global issues. The content of this course will, in part, be dictated by international events as they unfold. Wylie. (SS)

IR 10. Introduction to World Politics (4)
Introduction to the major principles, concepts, and theories of international relations, along with a historical background focusing on the 19th and 20th centuries. Topics to be covered include the nature of power, balance of power theories, national interest,decision-making in foreign policy, theories of war and expansion, patterns of cooperation, and international political economy. Menon. (SS)

IR 23. Alternative World Futures (4)
After a survey of the major political, military, economic, and social trends of the 20th century, the course will examine the challenges that are likely to confront the world in the 21st century. Topics to be explored include environmental and population problems, the changing nature of war, ethnic conflict and nationalism, and the emerging balance of global economic and military power. Menon. (SS)

IR 34. Society, Technology and War since the Renaissance (4)
How changes in human social organization and war over the last thousand years have interacted with each other, in both directions: the impact of social, economic, and technological change on the purposes and methods of war; and the impact of war mobilization needs and of war itself on social change, including democratization; economic planning; and emancipation of disadvantaged groups in society. The American and French revolutions; the Civil War; World Wars I and II; Vietnam; Afghanistan; Iraq; the law of war; atrocities; the nuclear and information revolutions; military institutions in advanced societies today. Kaufmann. (SS)

IR 56. European International Relations (4)
Examines the evolution of the modern states system in Europe. Conceptual, theoretical and historical topics include the transition from feudalism to the Westphalian system, nationalism, imperialism, the causes of war and attempted peace settlements, the Cold War, the European Union, and the impact of the collapse of the USSR on the political and strategic structure of Europe. Bially Mattern. (SS)

IR 57. The European Union (2)
Introduction to the history, institutions and policies of the European Union. Focus on the individual member states and on the issues of enlargement and further integration. A half-semester course. Wylie (SS)

IR 61. (ASIA 61) Pacific Asian International Relations (4)
Introduction to Pacific Asian international relations, with emphasis on post-1945 period: historical background; Cold War conflicts; China's rise to power; Japan's growing role; Korea and the NIC's; Southeast Asia; U.S. and Russian policies; current and future issues. Wylie (SS)

IR 72. The United States in the Global Economy (4)
Political problems and policy issues arising out of the economic relations between the U.S. and the rest of the world. U.S. foreign economic policy. Decision-making processes and political influences on policy. Economic diplomacy. Declining U.S. economic pre-eminence. Moon. (SS)

IR 74. United States Foreign Policy (4)
Major themes and trends in U.S. foreign policy, with attention to both the historical evolution of contemporary policy and key current problems. Emphasis is on critical examination of the interests and values that underlie the goals of policy and the theories that shape perceptions of how they can be met. Sources of U.S. policy, including decision-making structures, policy processes, and the role of the public and media. Kaufmann, Moon. (SS)

IR 81. Middle East in World Affairs to 1945 (4)
Political, economic, and social forces behind the rise of modern states in the Middle East; area's role in international politics from Napoleon's invasion of Egypt to the end of World War II. Staff. (SS)

IR 82. Middle East in World Affairs Since 1945 (4)
Rise of Turkish, Iranian, and Arab nationalism; creation of Israel; decline of British and French power; growth of U.S. and Soviet influence; Middle East as the world's major oil producer. Staff. (SS)

IR 119. Issues in International Relations (1-4)
Readings on selected themes in world politics, with theme to change each semester. Offered on an occasional basis only. Staff. (SS)

IR 120. Globalization and World Politics (4)
An exploration of the economic, political, cultural, and military manifestations of globalization and the effects on the internal order of states and the relations among them. Prerequisite: IR 10. Menon, Moon. (SS)

IR 125. (POLS 125) International Political Economy (4)
Principles governing the interaction between the economic and political components of international phenomena. Political causes and consequences of trade

and investment. Foreign economic policy and its relationship to domestic economic policy and other aspects of foreign policy. Determinants of foreign economic policy. Prerequisites: Economics 1, 11 or 12; and IR 10. Moon. (SS)

IR 127. Research in International Relations (4)
Research skills in international relations. The role of theory, models and evidence in the explanation of international phenomena. Literature review; problem formulation; theory construction; research design, methods and measures; collection, analysis and interpretation of data; principles of hypothesis testing. Professional writing, either through individual research projects under faculty supervision or an apprenticeship in ongoing faculty research projects. Prerequisite: Consent of the instructor. Moon (SS)

IR 132. Nationalism and Ethnic Conflict (4)
The ideal of nationalism exerts a powerful pull on almost all people everywhere. This course investigates the sources of nationalism and national identity; the manipulation of nationalist feelings for political purposes; and the sources of national and ethnic conflict. Proposals for managing ethnic conflict and their records of success (or failure). Recent and current cases, such as the Israeli-Palestinian conflict; ethnic relations in Iraq; the Balkans; others as current events demand. Prospects for the futures of nationalism, ethnic conflict, and ethnic conflict management. Kaufmann (SS)

IR 136. International Terrorism (4)
After 9/11, we must ask: Have we seen the peak of global terrorism, or is the worst still to come? This course examines psychological, religious, and political explanations of terrorism; reasons for the increasing scale of terrorism and the more frequent targeting of Americans; major terrorist organizations, structures, and means of operation; threats and vulnerabilities facing the United States and the West; legal and moral statuses of terrorism; means of coping with terrorism as an individual and through national policy. Kaufmann (SS)

IR 145. International Organization (4 credits)
Examines how cooperation is achieved and sustained in world politics. Under what circumstances does cooperation take place? What role do formal international organizations (such as the UN) play? What roles do norms, values, and ethics play? Can cooperation last? Questions pursued theoretically and in practical terms across topical issues (e.g., human rights, poverty, the environment, international law). Prerequisite: IR 10. Bially, Mattern. (SS)

IR 161. (ASIA 161) China in World Affairs (4)
China in world affairs, emphasizing role in Pacific Rim: historical background; domestic politics; foreign and security policies; relations with regional and global powers; policies toward Asia and Third World; current and future issues. Wylie. (SS)

IR 163. (ASIA 163) Japan in World Affairs (4)
Japan in world affairs, emphasizing role in Pacific Rim: historical background; domestic politics; foreign and security policies; relations with regional and global powers; policies toward Asia and Third World; current and future issues. Wylie. (SS)

IR 164. (ASIA 164, REL 164) Japan's Response to the West (4)
A survey of Japanese history and culture from 1500 to the present, following the theme of Japan's contact with the West. What enabled Japan to modernize and Westernize so successfully? Topics covered include: the expulsion of Christianity, the first samurai mission to the U.S., the postwar American occupation, and contemporary issues. Readings include Japanese novels and short stories (in translation). Kraft. (SS)

IR 167. Diplomacy of Russia to 1917 (4)
Expansion of the Russian Empire; principles of Russian foreign policy and their specific applications under the Tsarist governments, treated partially as background of Soviet policy; interaction between Russian domestic and foreign affairs. Staff. (SS)]

IR 168. Diplomacy of the USSR, 1917-1991 (4)
Topical and chronological survey of Soviet foreign relations; Soviet efforts to survive in a hostile capitalist environment; consolidation of gains made during World War II; origins of Cold War; frictions within the Communist Bloc (Eastern Europe, China); nuclear arms race; striving for detente; activity in the Third World; Gorbachev and collapse. Staff. (SS)

IR 169. International Relations of Russia and Eastern Europe (4)
The Soviet collapse and the emergence of Russia. Russia's relations with the other newly-independent states that emerged following the disintegration of the Soviet Union. The international relations of Eastern Europe (including the Balkans). Menon. (SS)

IR 177. International Relations of Latin America (4)
Survey of major international and domestic crises facing Central and South America. Examines factors affecting Latin American system of states such as international debt, involvement of foreign powers, and social and political instabilities. Barkey. (SS)

IR 205. Theories of International Relations (4)
The role of theory in historical explanation, prediction, and policy. Issues of theory design and testing. Important theoretical approaches to international relations, including Realism; the Democratic Peace; the domestic politics of foreign policy; history and myth-making; psychological explanations. Prerequisites: IR 10 and 56. Bially Mattern (SS)

IR 222. Political Economy of North-South Relations (4)
Political economy of relations between developed and less developed countries. Issues arising from trade, investment, and foreign aid. Consequences of North-South transactions. Controversies over system structure and reform proposals for international institutions (e.g.World Bank, IMF, WTO). Prerequisite: IR 125 or permission of instructor. Moon. (SS)

IR 246. (JOUR 246) International Communication (4)
Role of international news media in world affairs. Global theories of the press; process and influence of U.S. reporting of international affairs; survey of global media systems; global communication controversies. Lule. (SS)

IR 302. Rise and Decline of Empires (4)
An overview of the expansion, over-extension, and collapse of empires. Focus on alternative theories of empires as well as historical cases. Prerequisites: IR 10 and 56. Menon. (SS)

IR 321. Economic Relations of Advanced Industrial Societies (4)
Foreign economic policies of advanced industrial nations. Bilateral and multilateral economic relations; international economic regimes and institutions; interdependence and cooperation; managing conflict. Prerequisite: IR 125. Moon. (SS)

IR 322. Poverty and Development (4)
Patterns and causes of poverty in poor countries. Diagnosis of development problems and evaluation of development planning. Explanations for choices of development policy, especially issues of trade, foreign aid, and foreign direct investment. Written and oral presentation of individual country research. Corequisite: IR 222. Moon. (SS)

IR 323. Political Economy of Newly Industrializing Countries (4)
Issues of development, debt and adjustment in newly industrializing countries. Analysis of the differences between the development strategies adopted in Latin America and East Asia. Explanations for patterns of success and failure. Origins of underdevelopment; the politics of failed development strategies; the challenge of the increasingly competitive world economy and relations with the U.S. and other developed nations. Prerequisite: IR 125. Barkey. (SS)

IR 334. Prospects for Peace in the 21st Century (4)
Will the 21st century be more or less peaceful than the "terrible 20th?" This course examines theories of war and international insecurity; nationalism; ethnic conflict; terrorism; the nuclear revolution; the special situation of the American superpower in the early 21st century. We also explore tools of war prevention and resolution, including deterrence and alliances; international institutions and norms; efforts against proliferation of weapons of mass destruction, and humanitarian intervention and peacekeeping; and American policy choices between unilateral and multilateral approaches. Prerequisite: IR 10. Kaufmann. (SS)

IR 344. International Politics of Oil (4)
Historical influence of oil in international politics and the role it plays today. Focus on differing views of producers, such as Middle Eastern and Latin American states, and consuming nations, largely the economically developed Western states. Barkey. (SS)

IR 347. Non-State Actors in a Globalized World (4)
Role of non-state political groups (e.g. international advocacy organizations, multinational corporations, news media, terrorists, etc.) in world affairs. Thematic focus on globalization, the relationship between non-state and state actors, and the implications of non-state actors for the future of world order. Themes explored through past and current events (e.g., the WTO demonstrations, 9-11, the CNN effect, AIDs, anti-sweatshop campaigns.) Prerequisite: IR10. Bially (SS)

IR 354. International Relations of the Middle East (4)
Importance of the Middle East in contemporary world politics; strategic location and natural resources as factors affecting interests of the great powers. Interplay of international, regional and internal forces. Prerequisite: IR 81 or 82. Staff. (SS)

IR 364. (ASIA 364) International Relations of Pacific Asia (4)
Research-oriented seminar on contemporary international relations of Pacific Asia. Special emphasis on China, Japan and regional and global powers. Substantial research paper on topic of student's own choice is required. Prerequisite: IR 61 or 161 or 163 or 164. Wylie. (SS)

IR 367. Seminar in the International Relations of Russia and other Post-Soviet states (4)
Analysis of foreign relations of Russia and the other fourteen states that emerged after the collapse of the USSR. Staff. (SS)

IR 388. Honors Thesis in International Relations (4)
Honors thesis in international relations for majors with senior standing and with a 3.5 GPA who wish to engage in an intensive, two-semester research project under the direct guidance of a faculty member in the student's special area of interest. Departmental permission required. May be repeated for credit. Staff. (SS)

IR 390. Readings in International Relations (1-4)
Directed course of readings intended for students with special competence or interest in fields of international relations not fully covered by regular course offerings. May be repeated for credit. Departmental permission required. Staff. (SS)

IR 391. Internship in International Relations (1-4)
Internship in public or private agency. May be repeated for credit. Departmental permission required. Staff. (SS)
IR 393. Seminar in International Relations (4)
Advanced seminar focusing on discussion and research on specialized subjects in international relations. Variable subject matter. Offered by faculty on rotating basis. May be repeated for credit. Senior standing and departmental permission required. Staff. (SS)

IR 394. Special Topics in International Relations (1-4)
Intensive, research-oriented study for students with a special competence or interest in fields of international relations not fully covered by regular course offerings. May be repeated for credit. Departmental permission required. Staff. (SS)

Japanese

See Listings under Modern Languages and Literature.

Jewish Studies

The Jewish studies minor, coordinated by the Philip and Muriel Berman Center for Jewish Studies, provides students with the opportunity to explore the history, literature, religion, and social institutions of the Jewish people from its inception to the present. The diverse selection of courses highlights the interaction of Judaism with other cultures and societies in Europe, the Middle East, and the United States. The program is designed to appeal to students with varied interests and fields of concentration. Students of psychology and sociology often discover that courses in Jewish studies enhance their understanding of such topics as individual and group identity, prejudice and anti-Semitism, assimilation, and religious-cultural pluralism. Students of history will find that the study of Jewish society and culture enhances their understanding of European and American culture.

Through the study of Jewish religion and philosophy, students engage such issues as God, religious faith and doubt, spirituality, moral responsibility, evil, and human suffering. By studying Judaism comparatively with another religious tradition, students heighten their understanding of each tradition. Studying Jewish literature introduces students to a broad spectrum of literary forms and themes from diverse periods and cultural settings.

The Berman Center for Jewish Studies supplements formal course offerings through an extensive program of lectures, colloquia, films, field trips, and other cultural events. The Center offers financial awards for students who wish to study at the Hebrew University in Jerusalem or Tel Aviv University. Lehigh professors also conduct a "Lehigh in Israel" summer program, conditions permitting. Students seeking further information on programs in Israel and available financial awards may contact Shirley Ratushny at the Berman Center. Students should coordinate their minor program in Jewish studies with the director of the Center, Dr. Laurence J. Silberstein, Maginnes Hall.

Students pursuing a minor in Jewish studies must fulfill 16 credit hours from the following courses. (A maximum of eight credit hours of Hebrew may be counted.) Updated lists of courses are available from the Berman Center, Maginnes 324.

HEBR 1	Elementary Modern Hebrew I (4)
HEBR 2	Elementary Modern Hebrew II (4)
HEBR 11	Intermediate Modern Hebrew I (4)
HEBR 12	Intermediate Modern Hebrew II (4)
IR 81	Middle East in World Affairs to 1945 (4)
IR 82	Middle East in World Affairs Since 1945 (4)
PHIL/REL 129	Jewish Philosophy (4)
PHIL 133	Medieval Philosophy (4)
REL 73	The Jewish Tradition (4)
REL 111	Jewish Scriptures/Old Testament (4)
REL 112	The Beginnings of Judaism and Jewish Origins: Jewish Diversity in the Greco-Roman World (4)
REL 121	Sources for the Life of Jesus: Jewish and Christian Context (4)
REL 132	Hasidic Tales (4)
REL/WS 138	Women in Jewish History (4)
REL/ANTH 139	Jewish Folklore (4)
REL 150	Judaism in the Modern World (4)
REL 152	American Judaism (4)
REL 153	The Spiritual Quest in Contemporary Jewish Life (4)
REL/HIST 154	The Holocaust: History and Meaning (4)
REL 155	Responses to the Holocaust (4)
REL 156	Israel, Zionism, and the Renewal of Judaism (4)
REL/WS 158	Sex and Gender in Judaism (4)
REL 174	Contemporary Theology (4)
REL 186	Judaism in Israel and the United States (4)
REL 230	The Mystical Tradition: Judaism (4)
REL 371	Directed Readings (1-4)
US 85	American Jews: Politics and Culture (3)

Journalism and Communication

Professor. Sharon M. Friedman, M.A. (Penn State), *director of science and environmental writing program;* Carole M. Gorney, M.S.J. (Northwestern), APR, Fellow (PRSA) *director of public relations minor;* Jack Lule, Ph.D. (Georgia)

Associate professor. Walter W. Trimble, M.A. (Ohio State) *chair*

Assistant professor. Kathy Olson, Ph.D. (University of North Carolina)
Lecturer. Nancy S. Ross, M.A.T. (Cincinnati).

Adjunct professors. Kenneth Friedman, Ph.D. (Penn State); Glenn Kranzley, B.A. (Penn State); Robert Rosenwein, Ph.D. (Michigan); William White, M.A. (Ohio State).

The Department of Journalism and Communication offers major and minor programs in journalism and science and environmental writing, a minor in public relations, and an interdisciplinary communication minor.

Journalism is crucial to the public life of a democracy. At its best, journalism serves as a watchdog to government, offers a voice for the powerless at home and abroad, entertains and instructs the public, represents the views of varied constituencies, monitors and protects the environment and public resources, and provides a common memory for a people.

The purpose of the journalism program is to provide students with the knowledge and skills to fulfill such roles. The program emphasizes research, writing, editing, and critical thinking and analysis. Students integrate online technology with legal and ethical thinking and a global perspective that will prepare them for numerous opportunities in and out of journalism.

In the journalism major, students take courses in news and feature writing, editing and design, a professional internship, and varied courses in online journalism. Supported by the endowed Rodale Online Communication Program, the department has a national reputation in online journalism. All courses have online research and writing components.

A second major available to students is the science and environmental writing program. Students learn to write about pure and applied scientific research, technology, engineering, the environment and medicine and health for a variety of audiences ranging from the general public to scientists and engineers in industry and government. Students can also gain experience in the science and environmental writing field research program. A minor in science and environmental writing is available that may be valuable for students with majors in science or engineering.

In the public relations minor, students take courses in public relations principles, writing, case studies, applied public relations and a practicum. Students learn to apply public relations in specialties such as public affairs, hospital, health care and corporate communication.

An interdisciplinary minor in communication is offered for students interested in developing oral communication skills and a better understanding of how people share meaning through persuasive use of rhetoric, logic and symbols in public, one-to-one and small group communication.

Career opportunities are numerous for graduates of the department.

Students find work in traditional journalism organizations, such as newspapers, wire services, magazines, cable, television and radio stations, and other media outlets. Students find work too in new media, such as web sites and other digital production activities.

Students also find work in public relations positions, with responsibilities in government, corporations, hospitals, health care organizations, universities, sports information, nonprofit agencies and other groups.

A background in journalism, with its emphasis on research and writing, also proves to be excellent preparation for many other fields and provides a fine basis for the study and practice of law, graduate study in a variety of disciplines, government service, teaching and business management.

Students in science and environmental writing can expect to pursue careers in science, health and environmental journalism in both the traditional and online media; public relations for scientific societies, environmental organizations, government agencies, universities or hospitals; technical writing for industry and government agencies, and other areas, such as management, administration and teaching. The program also prepares students for graduate study in science or environmental writing, journalism and other disciplines.

The interdisciplinary minor in communication will be useful to students interested in organizational and written communication, law, business, philosophy, government, marketing, teaching, telecommunication or other careers where successful communication is important.

Required Math Course. Understanding statistical information has become extremely important in modern society. MATH 12, Basic Statistics, is required for students taking a journalism or science and environmental writing major. Students should take MATH 12 to fulfill the college's distribution requirement. ECO 145, Statistical Methods, is an acceptable alternative. For science/science writing double majors, calculus will be considered as a substitute for statistics.

Journalism Major

Core Courses

JOUR 1	Brown & White (1)
JOUR 2	Brown & White (1)
JOUR 3	Brown & White (1)
JOUR 4	Brown & White (1)
JOUR 11	News Writing (4)
JOUR 13	Editing (2)
JOUR 14	Publication Design (2)
JOUR 122	Media Ethics & Law (4)

Advanced Courses

JOUR 211	Reporting (4) *
Or JOUR 212	Feature Writing (4)*
JOUR 361	Internship (4)
Senior Seminar:	Journalism or Communication course at 300 level (4)

** (JOUR 211 and JOUR 212 fulfill junior writing intensive requirement)*

Required Electives

Two additional Journalism or Communication courses; one of them at the 200 level or above (8)

Total credits: (36)

Collateral Requirements

Students must also complete an academic minor or another major with a minimum of 16 credits

Journalism/Science and Environmental Writing Major

Core Courses

JOUR 1	Brown and White (1)
JOUR 2	Brown and White (1) or
JOUR 231	Science Writing Practicum (1)
JOUR 123 or 311	Basic Science and Technical Writing (4)
or	
JOUR 11	News Writing (4)
JOUR 13	Editing (2)
JOUR 14	Publication Design (2)
JOUR 211	Reporting (4)

Advanced Courses

JOUR/STS 124	Politics of Science (4)
JOUR 125	Environment, the Public and the Mass Media (4)
JOUR/STS 323	Controversies (4)
JOUR 361	Internship (4)

Required Electives

One additional Journalism or Communication course. (4)

Total credits: (34)

Collateral Requirements

Students must also complete 16 credits in science for the journalism/science and environmental writing major.

Required science courses. A minimum of 16 credits in the physical, biological, environmental or social sciences or engineering is required. These hours can be concentrated in any one area or distributed among all five areas, although an area concentration is recommended. Dual majors in journalism/science and environmental writing and a science are encouraged. Science courses should be chosen in consultation with the major adviser.

Science and environmental writing field research program. Available to science, environmental and technical writing students at the junior or senior level, this program provides practical experience in scientific research and science writing for students who work on and write about research projects directed by university scientists and engineers. Another segment of the program allows students to attend major scientific meetings as fully accredited science reporters. Students observe professional science writers in action and write their own stories about the scientific sessions and press conferences held at the meetings.

Journalism Minor

Students who wish to declare a minor program in journalism must be majors in another discipline and take the following:

JOUR 1-2	Brown & White (2)
JOUR 11	News Writing (4)
JOUR 13	Editing (2)
JOUR 14	Publication Design (2)
JOUR 212	Feature Writing (4)

One other Journalism course at or above the 100 level (4)

Total credits: (18)

Public Relations Minor

Required Collateral Course

JOUR 11	News Writing (4)
or	
JOUR 123	Basic Science and Technical Writing (4)

Required courses

JOUR 127	Public Relations Principles (4)
JOUR 228	Writing With the Media (4)
JOUR 229	Public Relations Case Studies (4)
JOUR 233	Public Relations Practicum (4)**

Total credits: (16)

*** Two semesters of two-credit public relations practicum are required. The practicum projects provide students with experience in public relations activities and campaigns conducted on campus, or in regional and national student competitions. Projects will be assigned by the instructor, in consultation with the student.*

Science and Environmental Writing Minor

JOUR 1	Brown and White (1) or
JOUR 231	Science Writing Practicum (1)
JOUR 11	News Writing (4) or
JOUR 123	Basic Science and Technical Writing (4)
JOUR 124	Politics of Science (4)
JOUR 125	Environment, the Public and the Mass Media (4)
JOUR 323	Controversies (4)

Total credits: (17)

Communcation Minor

Purpose: This interdisciplinary minor guides students to a better understanding of how people share meaning through interpersonal, group and organizational communication as well as mass media and new media. Students take courses in public speaking, group process, interpersonal communication, persuasion, marketing, advertising, mass communication, and online communication.

The minor requires 15-16 credit hours, with a minimum of four courses. The required course is COMM 130, Public Speaking. A second course should be chosen from the Communication Core courses, section one. A third course should be taken from the Communication Choice courses, section two. The fourth course may come from either section. At least one course must be 200-level or above.

Courses may be taken in any order. That is, COMM 130 does not need to be taken first in the sequence. A student may count one course for both a major and a minor.

With the consent of a participating instructor and the director of the minor, a student may elect to take COMM 325, Special Topics in Communication, as one of the courses for the minor. This is not a regular course, but a project designed by the student, with the help of an instructor.

Courses in the minor may have prerequisites. Please check the catalog. To declare this minor, contact Dina Wills, in the Department of Journalism and Communication.

Communication Core Courses Section 1

SSP 125	Small Groups (4)
SSP 135	Human Communication (4)
SSP 312	Communication in Groups (4)
SSP/JOUR 327	Mass Communication and Society (4)
COMM 130	Public Speaking (4) (required)
COMM 143	Persuasion and Influence (4)
COMM 252	Interpersonal Relationships: Private and Public (4)
COMM 331	Business and Professional Speaking (4)
JOUR/IR 246	International Communication (4)

Communication Choice Courses Section 2

ARTS 250	Communication: Cultures, Behaviors, Attitudes (3)
ART 77	Photography (3)
ART 53	Graphic Communication I (3)
COMM 325	Special Topics in Communication (1-4)
ENGL 171	Writing for Audiences (4)
JOUR 101	Media, Sports, and Society (4)
JOUR 102	How to Watch TV (4)
JOUR 122	Media Ethics and LAW (4)
JOUR 123	Basic Science and Technical Writing (4)
JOUR 125	Environment, the Public, and the Mass Media (4)
JOUR 127	Public Relations Principles (4)
JOUR 141	Photojournalism (4)
JOUR 229	Public Relations Case Studies (4)
JOUR 240	Writing for Broadcasting (4)
JOUR 323	Controversies (4)
JOUR 366	Online Journalism
MKT 313	Integrated Marketing Communications (3)
POLS 229	Propaganda, Media, and American Politics (4)
PSYCH 301	Industrial Psychology (4)
SSP 302	The Sociology of Cyberspace (4)

Prerequisites for Jounalism Courses

NOTE: Journalism and Communication courses build on one another. Some courses thus require prerequisites before students can register for the class. Check the course schedule each semester.

Media Internships

All majors in journalism and journalism/science and environmental writing take professional internships during their senior year or the preceding summer. The internships provide real-world experience with newspapers, magazines, cable, television or radio stations, web sites or in public relations settings. Science writing minors may take an internship instead of working on *The Brown and White*.

Course Listings

JOUR 1. Brown and White (1) every semester
This course is a student's first semester on the staff of the semi-weekly undergraduate newspaper. Students register for this course, attend a meeting on the first Wednesday of the semester, and are placed on the staff. Because this is an introductory training class, JOUR 1 is for students with freshman or sophomore standing; juniors only with consent of department chair. Lule/Trimble. **(ND)**

JOUR 2-8. Brown and White (1) every semester
Enrollment constitutes continued membership on the staff of the semi-weekly undergraduate newspaper. These courses are taken consecutively after a student has completed JOUR 1. For a second semester on the newspaper, a student registers for JOUR 2. For a third semester,

JOUR 3. For a fourth semester, JOUR 4. And so on. Prerequisite: JOUR 1. Lule/Trimble. (ND)

JOUR 10 Brown and White (1-2) every semester
Enrollment constitutes an editorial position on the staff of the semi-weekly undergraduate newspaper. Editors are chosen by the instructors and the newspaper's editorial board. May be repeated for a maximum of eight credits. Prerequisites: JOUR 1 and permission of the department chair. Lule/Trimble

JOUR 11. News Writing (4) every semester
Preparation and practice in gathering and writing news; definition and components of news; structure and style of the news story; introduction to interviewing and editing. (ND)

JOUR 13. Editing (2) every semester
Study of and practice in editing and rewriting stories for newspapers and magazines; fact-checking; headline writing; ethics. Prerequisite: Jour 11 or Jour 123. Trimble, Olson. (ND)

JOUR 14. Publication Design (2) every semester
Study of and practice in techniques of newspaper and magazine design, including typography, grids, and use of photographs and other artwork; microcomputer-based desktop publishing. Prerequisite: Jour 11 or Jour 123. Trimble, Olson. (ND)

JOUR 101. Media, Sports and Society (4) summer
Analysis of social, political and economic implications of media sports coverage; emphasis placed on media coverage of events of international scope, such as the World Cup, World Series and the Olympics; special attention paid to the role of the sports press in coverage of issues such as AIDS, racism, sexism, drug use and terrorism. Lule. (SS)

JOUR 102. How to Watch TV (4) summer
Analysis and discussion of television programming from the standpoint of its potential effects on audience perceptions, public opinion, social issues and values, individual learning, and behavior. Programming viewed both inside and outside the classroom includes news programs, news magazines, talk shows, sitcoms, dramas, cartoons, soap operas, commercials, and infomercials. To help focus discussions, students are assigned appropriate readings from the popular media and social science research. Gorney. (SS)

JOUR 111. Sportswriting (4) summer
Principles and practice of writing about sports for general print and specialized publications; emphasis placed on instruction in reporting, writing and editing; topics covered include the history of sports journalism; recent trends in the field; ethical considerations, and the exploration of social and political issues through sportswriting. Lule. (ND)

JOUR 112. Children and Television (4) summer
The course examines the many social science research issues surrounding television for children, including questions about cartoon and program violence, unethical advertising, the role of the FCC and stereotypes. The course will also examine television about children, such as media coverage of homelessness, health care, poverty, hunger and famine, which take their biggest toll on children. Lule (SS)

Jour 114. Technical Communication (4) summer
This online course covers basic tools needed to write about all kinds of science and technical information for academic papers, term papers, proposals, reports, theses and dissertations. Involves practice with feedback on definitions, descriptions, cause and effect relationships, process writing, concept maps, graphics, classification, comparison and more. K Friedman. (ND)

JOUR 115 (ES 115). Communicating About the Environment (4)
Introduction to the need for and ways to communicate about environmental issues to laypersons, government officials, journalists, members of the judiciary and technical experts. Explores case studies of good and bad communication about environmental issues. Internet communication, including the efficacy of placing governmental reports and databases on the Web for public consumption, will be evaluated. (SS)

JOUR 116 (ES 116). Risky Business (4) summer
This course explores the risks and effects of environmental contamination on human health and behavior as well as the role of the mass media in alerting citizens to potential environmental health risks. Environmental topics vary but usually include air and water pollution, endocrine disrupters and radioactive waste. S. Friedman. (SS)

JOUR 122. Media Ethics and Law (4) fall
First Amendment theory and history; ethical and legal issues involving libel, privacy, obscenity, newsgathering, access, and fair trials; national and international concerns over censorship, prior restraint and manipulation and control of information. Lule, Olson. (SS)

JOUR 123. Basic Science and Technical Writing (4) every semester
Study of and practice in writing about scientific and technical subjects for audiences ranging from the general public to scientists and engineers. Starts with basic science writing for lay audiences, emphasizing organization and clear writing techniques. As the course progresses, material becomes more technical, concentrating on how to write effective technical reports, descriptions, papers and memoranda. Also explores problems of conveying highly complex technical information to multiple audiences, factors that influence science communication to the public, and interactions between scientists and journalists. K. Friedman. (SS)

JOUR 124. (STS 124) Politics of Science (4) fall
Analysis of the multi-dimensional interaction between the federal government and the scientific community. Explores historical growth of the science-government connection, the scientific establishment both past and present, and the role of scientific advice to the White House and Congress. Also examines scientific ethics, public attitudes toward science, science-society interactions and case studies of scientific controversies. S. Friedman (SS)

JOUR 125. Environment, the Public and the Mass Media (4) fall
Extensive exploration of local, national and international environmental problems and their social, political and economic impacts. Analysis of mass media coverage of complex environmental issues and the media's effects on public opinion and government environmental policies. Examination of environmental journalism principles and practices in the United States and around the world. S. Friedman (SS)

JOUR 127. Public Relations Principles (4) fall
Emphasis on management function of public relations, including research, planning, counseling, programming, communication and evaluation. Study of communication

and persuasion theory, public opinion and ethics. Student teams work outside class for a community client, helping research, plan and implement an actual public relations program during the semester. Gorney. (SS)

JOUR 129. Specialized Writing in Public Relations (3) fall
Preparation and writing of promotional and publicity materials, including public service announcements, for radio and television; preparation of audio-visual materials and presentations; planning and conducting news conferences; media interview techniques in negative situations; writing informational and persuasive speeches for others. Students will produce finished public service announcements and will be videotaped giving actual media interviews. Prerequisite: JOUR. 11, 123, 228 or consent of department chair. Gorney. (ND)

JOUR 135. (SPSY 135) Human Communication (4)
Processes and functions of human communication in relationships and groups. Rosenwein. (SS)

JOUR 141. Photojournalism (4)
Ethics and history of photojournalism; instruction and practice in basic camera techniques; scanning and digital manipulation of black and white and color photographs using Adobe Photoshop; cropping and sizing photographs and production of layouts using QuarkExpress. Trimble (ND)

JOUR 211 Reporting (4) every semester
Principles and practice of news reporting; techniques for gathering, organizing and writing news; emphasis placed on story conception, interviewing methods, library skills, Internet research, news style and clear, concise writing. Students will develop, report and write numerous stories. Students will also gain greater understanding of fundamental reporting concepts in relation to the use of sources, accuracy, fairness, privacy and other issues of professional responsibility. Prerequisites: JOUR 11 or JOUR 123 and JOUR 13. Lule. (SS)

JOUR 212. Feature Writing (4) every semester
Conceiving and developing feature stories for newspapers and magazines; interviewing techniques; writing non-fiction using the techniques of the novelist; marketing free-lance projects. Prerequisite: JOUR 11, 123 and JOUR 13. Trimble. (ND)

JOUR 214. Reporting of Public Affairs (4)
Reporting and writing news of government on the local, county, state and federal levels; civil and criminal courts; labor, environment, housing and community planning news. Prerequisites: JOUR 11 or 123 and POLS 177. Trimble. (ND)

JOUR 215. Advanced Publication Design (3)
Advanced study of publication design: newspapers, magazines, pamphlets, annual reports; symbols, typography, grids, use of photographs and infographics; use of Macintosh computer in page production, and in creating and manipulating art for publication. Prerequisite: JOUR 13 or permission of the department chair. Trimble. (ND)

JOUR 220. Reporting on Business and Economics (3)
The principles behind the economy, the markets and companies and how to report on them; the role of business reporting in the media; the use of computer technology in business reporting. Prerequisite: JOUR 11 or JOUR 123 and ECO 1. (SS)

JOUR 228. Working With The Media (4) spring
An overview of the many situations and issues involved in working with the mass media. Students learn techniques used to generate positive publicity, minimize negative media coverage, and maintain successful relationships with reporters, editors and producers. Students also gain hands-on experience with planning, writing and designing publicity and promotional materials for use in mass and specialized media. Prerequisite: Jour 11 or Jour 123, and Jour 127. Gorney. (ND)

JOUR 229. Public Relations Case Studies (4) fall
Analysis of public relations programs and practices in business and industry, government, and non-profit organizations. Study focuses on principles that govern employee, community, consumer and media relations, as well as issues management and special events and promotions. Students select, research and write fully documented case studies using both primary and secondary sources, as well as preparing Power Point slides to support oral presentations throughout the semester. Prerequisite: JOUR 127. Gorney. (ND)

JOUR 231. Science Writing Practicum (1-4) spring
On-site experience as accredited science reporter at major scientific meetings, or writing and research in university laboratories as part of science writing field research program. May be repeated for a maximum of eight credits. Prerequisites: JOUR 11 or JOUR 123 or JOUR 311, junior standing, and consent of the department chair. S. Friedman. (ND)

JOUR 232. Journalism Practicum (1-4) every semester
Practical application of journalism principles and skills in semester-long projects, as well as various on- and off-campus work experiences. Course is designed to provide credit for supervised experience, particularly through study abroad programs, that does not meet the more rigorous, required internship. May be repeated for maximum of eight credits. Prerequisites: consent of department chair. Lule (ND)

JOUR 233. Public Relations Practicum (1-4) every semester.
Practical application of public relations principles to various semester-long projects, including newsletter production, web-site maintenance, client services for The Firm, program and special events development, and planning and implementation of an annual spring conference. The amount of credit is negotiable with the instructor based on the extent and complexity of the projects undertaken. Senior public relations minors only. Gorney. (ND)

JOUR 240. Writing for Broadcasting (4) spring
Basic writing style for radio and television news, and scripting newscasts in a variety of formats, including electronic news gathering and voice overs. Scripting and storyboarding for commercials and public service announcements. A three-hour writing lab is included. A portion of the course is devoted to study and discussion of issues related to television news coverage. Gorney. (ND)

JOUR 242 Web Writing & Design (4)
This course examines the ways in which writing and design are influenced by online technology. Students will learn principles and practice of hypertext, Web writing and Web design and will plan and create Web sites that

tell stories using the unique features of online technology. Prerequisites: JOUR 11 or JOUR 123 or JOUR 228. Olson (ND)

JOUR 246. (IR 246) International Communication (4)
Role of international news media in world affairs. Global theories of the press; process and influence of U.S. reporting of international affairs; survey of global media systems; global communication controversies. Lule. (SS)

JOUR 306. Applied Public Relations (4) spring
Study and application of crisis planning, management and communication principles to problems faced by a variety of profit and non-profit organizations. Study includes effective handling of the release of bad news, negative media coverage, and opposition; planning interviews, news briefings and news conferences. The class works together outside of class to prepare written plans on how to respond to a simulated crisis at various stages of escalation. The cases may be developed by the instructor, or may involve participation in competitive programs sponsored by professional and academic public relations societies. Senior public relations minors only. Prerequisite: JOUR 127 and 229. Gorney. (ND)

JOUR 311. Science and Technical Writing (3-4) every semester
Study of and practice in writing about scientific and technical issues for multiple audiences. Emphasis on developing effective writing and organizational skills and translating scientific information for a wide range of audiences. Similar in content to JOUR 123, but should be taken instead by upperclassmen (3-4 credits) and graduate students (3-4 credits). K. Friedman (SS) 4 credits for upperclassmen and 3 for graduate students

JOUR 312. Advanced Science Writing (3-4)
Further practice, on individual basis, in science writing techniques. Prerequisite: JOUR 123 or 311. S. Friedman. (ND)

JOUR 313. Special Topics in Science Communication (1-4)
Research or writing involving a topic, medium or issue in science, environmental or technical communication not covered in other courses. Prerequisite: Eight hours in science or environmental writing or consent of the department chair. S. Friedman. (SS)

JOUR 314. Technical Communication (3-4) summer
This online course covers basic tools needed to write about all kinds of science and technical information for academic papers, term papers, proposals, reports, theses and dissertations. Involves practice with feedback on definitions, descriptions, cause-and-effect relationships, process writing, concept maps, graphics, classification, comparison and more. Taken by seniors for 4 credits and graduate students for 3 credits. K. Friedman. (ND)

JOUR 320. Journalism Proseminar (3) spring
Intensive research and writing on contemporary issues and problems facing the mass media; methods and approaches for studying the mass media; course culminates with a seminar thesis based on original and comprehensive research. Prerequisite: nine hours in journalism, public relations or communication or consent of the department chair. Lule. (SS)

JOUR 323. (STS 323) Controversies (4) spring
Exploration of science, health and environmental controversies from the dual perspectives of scientific uncertainty and mass media coverage. Examines genetic engineering and biotechnology, environmental health risks, and human behavior research. Includes discussion of ethical and social responsibilities and interactions of scientists, journalists and the public. S. Friedman. (SS)

JOUR 324 (SSP 324). Health Communication and the Internet (4) spring
This interdisciplinary class examines the role of the Internet in changing the way lay people, the mass media and medical organizations think and behave regarding health and medical care. It explores the nature of traditional and online health communication, and highlights online health issues such as access, quality of information, economics, privacy, and ethics. S. Friedman and J. Lasker. (SS)

JOUR 325. Special Topics in Public Relations (1-4) every semester
Research and writing or performance involving a topic, medium or issue in public relations involving some aspect of professional application or theory that expands on the body of knowledge or covers some material not covered in other courses. Prerequisite: Junior or senior standing or consent of department chair. Gorney. (ND)

JOUR 327. (SPSY 327) Mass Communication and Society (4)
A review of theories and research on the relationship of mass communication to social processes. Intensive analysis of selected media products (e.g., TV news, dramas, and sitcoms; films; print; music videos, etc.). Prerequisites: ANTH 1 or SSP 5 or SSP 21 or ANTH 11 or ANTH 12. Rosenwein. (SS)

JOUR 361. Internship (4)
Professionally supervised work on newspapers, magazines, Web sites radio and television stations, or with public relations organizations. Some internships involve science writing. May be repeated for a maximum of eight credits. Prerequisite: Senior standing and declared major in journalism or science writing. S. Friedman (ND)

JOUR 365. Advanced Research and Reporting (4) fall
Planning, researching and writing comprehensive news projects; special attention paid to computer-assisted research, online resources, investigative techniques, interviewing skills, reporting on local, county, state and federal governments and courts; emphasis also given to organizing and writing in-depth articles. Prerequisites: eight hours in journalism and senior standing or permission of department chair. Lule, Trimble (ND)

JOUR 366. Online Journalism (4) spring
The course examines the social, cultural, political, legal and economic influence of online technology on journalism and the role of journalism in society. Emphasizing critical thinking and analysis, the course studies the ways in which digital technology has changed the way journalists research, write, edit and design. Prerequisite: JOUR 11 or JOUR 123, JOUR 122, or consent of department chair. Lule, Olson. (ND)

JOUR 389. College Scholar Project (1-8)
Opportunity for college scholars to pursue an extended project. May be repeated for credit. College-wide course designation. Transcript will identify department in which project was completed. Prerequisite: consent of department chair. Staff. (ND)

JOUR 390. Honors Thesis (1-4)
Directed undergraduate research thesis required of students who apply for and qualify for graduation with departmental honors. Staff. (ND)

JOUR 391. Special Topics in Journalism (1-4)
Directed research or writing involving a subject or issue in journalism not covered in other courses. May be repeated for credit. Prerequisite: 12 hours in journalism or consent of the department chair. Staff. (ND)

Communication Courses

COMM 65. Interpersonal Communication in a Changing World (3) every semester
This course helps develop a better understanding of how we communicate with others, verbally and non-verbally, individually and in groups; and how communication affects how we develop our own concept of who we are. The course examines critical thinking and how it relates to the communication process. The concepts of stigma and prejudice are examined in the context of interpersonal communications. This is a first-year class, open to freshmen only. (ND)

COMM 130. Public Speaking (4) every semester
Applying the principles of public speaking to making informative and persuasive presentations effectively. Emphasis on speech composition and effective oral communication skills. Ross. (HU)

COMM 143. Persuasion and Influence (4) fall
The social, symbolic, and rhetorical means of persuasion and how this persuasive influence is expressed in politics, advertising, and the mass media. Course includes two group projects, a term paper, 3-4 brief synthesis papers and a take-home final. Wills (SS)

COMM 144. Effective Interviewing (3) spring
Theory of effective interviewing; how to plan and structure an interview outline; types of questions used in interviews; how to open, conduct and conclude an interview. Special emphasis on the journalistic, employment and broadcasting interview. Instructor will use role-playing and videotaping. Students will prepare and conduct simulated interviews. Wills. (ND)

COMM 160. Public Speaking (for IBE Students) (4) every semester
Applying the principles of public speaking to making informative and persuasive presentations effectively. Emphasis on speech composition and effective oral communication skills. This class is limited to students in the Integrated Business and Engineering Honors Program. Ross (HU)

COMM 252. Interpersonal Relationships: Private and Public (4)
In this class, we study theories about effective communication with other theories in personal, social and professional settings. Perceptions, self-disclosure, nonverbal cues, language, and listening are some of the communication elements we identify and analyze in films, role-plays, real-life observations, and a case study. Journal of observations, three short papers, choice of project or term paper, and final essay exam. Wills (SS)

COMM 325. Special Topics in Communication (1-4)
Research and writing or performance involving a topic, medium or issue in journalism, public relations, speech or communication theory not covered in other courses. Prerequisite: nine hours in journalism, public relations or communication and consent of department chair. (SS)

COMM 331. Business and Professional Speaking (4) fall
The principles of oral communication as applied to business and professional situations. Professional presentations, small group interaction and interpersonal communication in the business setting. Prerequisite: junior or senior standing. Ross. (ND)

Languages

Courses are listed alphabetically under Modern Languages and Literature and Classical Studies.

Latin American Studies

The minor in Latin American studies represents an opportunity to explore the language, literature, history, cultures, and socioeconomic problems of our neighbors to the south. It provides a perspective on the problems of other underdeveloped regions of the world, in contrast to most offerings in the humanities and social sciences that usually focus on the mainstream of western culture, notably the United States and Western Europe.

It is worth noting the importance of Latin American cultures in the future of the hemisphere. Latin America is the most rapidly growing part of the world, with a population of nearly 600 million, or twice that of Anglo-America. Several countries, especially Brazil and Mexico, are undergoing rapid industrial expansion. Consequently, besides the personal values to be derived from this curriculum, there are business, governmental, and related career possibilities.

The minor program requires 15 to 16 credit hours, chosen from economics, history, political science, Spanish, anthropology, and I.R. in discussion with the coordinator, Antonio Prieto, Modern Languages and Literature, Maginnes Hall.

Requirements (8 credits).

A. History/Culture (4 credits).
Choose one of the following:

HIST 49	History of Latin America (4)
HIST 50	History of Latin America (4)
SPAN 152	The Cultural Evolution of Latin America (taught in Spanish) (4)

B. Language (4 credits).
Choose one of the following:

SPAN 2	Elementary Spanish II (4)
SPAN 12	Intermediate Spanish II (4)

Elective courses (7-8 credits) chosen from the following courses.

No more than two courses may be taken in any one department:

ANTH 178	Mesoamerican Archeology (3)
MLL 51	Contemporary Hispanic-American Literature (4)
MLL 53	The Hispanic World and Its Culture (4)
HIST 49-50	History of Latin America (4)
HIST 265	Mexico and the Caribbean (4)
HIST 266	Argentina, Brazil and Chile (4)
HIST 368	Seminar in Latin American History (4)

IR 177	International Relations in Latin America (4)
POLS 222	Politics of Developing Nations (4)
POLS 235	Latin American Political Systems (4)
POLS 236	U.S. Foreign Policy and Latin America (4)
POLS 237	Religion and Politics in Latin America (4)
SPAN 263	The Spanish American Short Story (4)
SPAN 265	Spanish and Latin American Cinema (4)
SPAN 320	Literature of the Spanish Caribbean (4)
SPAN 321	Children and Adolescents in Contemporary Spanish American Literature (4)
SPAN 322	The Short Novel in Contemporary Spanish American Literature (4)
SPAN 323	Literature and Revolution in Contemporary Cuba (4)
SPAN 325	Hispanic Literature of the United States (4)
SPAN 342	The New Narrative in Spanish American Literature (4)
SPAN 396	Andean Literature (4)

Law

Professors. Perry A. Zirkel, J.D., LL.M. (Yale), Ph.D. (Connecticut), *University Professor of Education and Law*; George A. Nation III, J.D. (Villanova).

Associate professor. Matthew A. Melone, J.D. (Pennsylvania), C.P.A.

Adjunct professors. Jeanne M. Liedtka, J.D. (Virginia); Patrick F. McCormick, J.D. (Ohio Northern); Jeffrey M. Miller, J.D. (John Marshall); Nancy Schneiderman, J.D. (Harvard).

The following undergraduate law courses are offered through the Perella Department of Finance:

Undergraduate Courses

LAW 101. Introduction to Law (3)
A study of the nature and function of law and the legal system, the study of legal reasoning through the use of the case method.

LAW 111. Criminal Trials and Procedures (1)
The course focuses on criminal law and procedure from actual indictment and/or arrest through and including the appellate procedure. Tactics and strategy within the framework of the various steps of a typical criminal proceeding are discussed. Guest speakers contribute to the course which in the past included Philadelphia police inspectors talking about investigations and polygraphs; an FBI Agent on arrests and Miranda warnings; prominent Philadelphia criminal and trial lawyers; probation officers and others.

Courses numbered 200 and above in the College of Business and Economics are open to sophomores only on petition.

LAW 201. Legal Environment of Business (3)
The study of the legal relationships of business and government, business and society and the individual and society. The case method is used to develop analytical skills. Introduction to contract law and the law of sales underlying the free market system. Prerequisite: ECO 1

LAW 202. Business Law (3)
The law of agency, business organizations, secured transactions, bankruptcy and negotiable instruments. Prerequisite: LAW 201.

LAW 371. Directed Readings (1-3)
Readings in various fields of law, designed for students who have a special interest in a field of law.

LAW 372. Special Topics (3)
Special problems and issues in commercial law.

Course descriptions for the College of Business and Economics graduate courses can be found in this section (Section V) under the heading of *Business and Economics Graduate Courses.*

Management

Professors. Michael G. Kolchin, D.B.A. (Indiana) C.P.M. chair, department of management and marketing.

Associate professors. Theodore W. Schlie, Ph.D. (Northwestern); Robert J. Trent, Ph.D. (Michigan State).

Assistant professors. Robert C. Giambatista, Ph.D. (Wisconsin); Ruihua Jiang, Ph.D. (Western Ontario); Lucinda Lawson, Ph.D. (Texas A&M); Michael D. Santoro, Ph.D. (Rutgers); Qingjiu Tao, Ph.D., (Pittsburgh).

Adjunct professor. Sandra Holsonbach, Ph.D. (Lehigh).

Professor of practice. Dale F. Falcinelli, M.B.A. (Lehigh).

Active emeriti. Richard W. Barsness, Ph.D. (Minnesota); John W. Bonge, Ph.D. (Northwestern); Benjamin Litt, Ph.D. (N.Y.U.).

The Department of Management and Marketing offers an undergraduate management major. Majors may select either the Interfunctional Track (18 credit hours) or the Specialization Track (15 credit hours). Both options require an upper level course in both quantitative methods and organizational behavior. Additional courses build on this foundation. The Management Major often includes elective courses in industrial engineering, computer science and psychology, and care is taken to assure that students are well prepared to take selected specialized courses outside the College of Business and Economics. Faculty advisors collaborate with the individual student to design a curriculum that best serves the student's professional interests.

The Interfunctional Track affords the opportunity to study general business management by taking advanced courses in functional business areas. Students will take cost accounting and corporate financial policy and choose between a marketing course in either new product planning or industrial marketing. The sixth course is an advanced course in either information systems or quality management.

The Specialization Track offers four distinct professional study programs: entrepreneurship, human resources management and supply chain management. The entrepreneurship program is attractive to students intending to start their own businesses or whose families own businesses. Human resources management prepares students for careers in personnel management or for graduate study in industrial relations or employee training and development. Supply chain management focuses on logistics and procurement. In addition to the upper level courses in quantitative methods and organizational behavior, students electing any Specialization Track program of study will choose one of the following advanced courses: purchasing and supply chain management, field study in small business management or personnel management. The remaining two courses are chosen from among advanced courses in economics, industrial engineering, finance, marketing, accounting, and industrial psychology. Faculty advisors will tailor a program of study, drawing upon advanced course work from across the university community.

Management Program and Courses

The Department of Management and Marketing offers an undergraduate management major. Majors will select either the Specialization (15 hours) or Interfunctional (18 hours) track shown below:

Specialization (15 hours)

At least two of the following:

MGT 302	Quantitative Models-Conceptual (3)
SCM 309	Purchasing and Supply Management (3)
MGT 311	LUMAC Management Assistance Counseling (3)
MGT 321	Organizational Behavior Workshop (3)
MGT 333	Personnel Management (3)

Plus up to three of the following:

ECO 234	Labor-Management Relations (3)
ECO 235	Labor Economics (3)
ACCT 324	Cost Accounting (3)
ECO 333	Managerial Economics (3)
ECO 352	Advanced Statistical Methods (3)
ECO 357	Econometrics (3)
FIN 328	Corporate Financial Policy (3)
MKT 319	New Product Planning (3)
MKT 321	Business to Business Marketing (3)
IE 309	Introduction to Information Systems (3)
IE 332	Quality Control (3)
IE 334	Organizational Planning and Control (3)

Courses will be selected in consultation with the faculty advisor to comprise one of the following specialization options: entrepreneurship, human resources management, materials management, and operations management.

Interfunctional (18 hours)

required courses:

MGT 302	Quantitative Models-Conceptual (3)
MGT 321	Organizational Behavior Workshop (3)
ACCT 324	Cost Accounting (3)
FIN 328	Corporate Financial Policy (3)
MKT 319	New Product Planning (3) or
MKT 321	Business to Business Marketing (3)

Plus one of the following:

IE 309	Introduction to Information Systems (3)
IE 332	Product Quality (3)
IE 334	Organizational Planning and Control (3)

For Advanced Undergraduates and Graduate Students

MGT 280. Management of People and Operations (4)
A total quality management perspective of managing people and operations in today's modern organizations. Lectures, case studies, and exercises. Major project required. Prerequisite: junior standing in the College of Business and Economics.

MGT 301. Business Management Policies (3) fall, spring
Case study of business problems and the formulation of policies, strategies and tactics to resolve those problems from the viewpoint of general management. Long-range goal attainment, policy formulation, and administrative implementation for specific functional areas and the total firm. Includes a simulation. Prerequisite: senior standing in the College of Business and Economics, and completion of the college core.

MGT 302. Quantitative Models-Conceptual (3)
Quantitative methodologies and their use in business, economics and related areas. Classical optimization techniques, mathematical programming, linear programming, decision theory, game theory, simulation and network models. Prerequisites: ECO 146, BIS 111.

MGT 306. Entrepreneurship and Business Policy (3) spring
Case study of problems in creating new ventures or managing family-owned businesses. Integrates knowledge acquired in other courses and stresses development of strategic and administrative policies for particular functions and the company as a whole. Prerequisites: senior standing, completion of College of Business and Economics core, and MGT 311, as well as approval of the department chair. Students may not receive credit for both MGT 301 and 306.

MGT 307. Business Communication Skills (3)
Written and spoken communication through letters, memos, reports, and oral presentations. Formal and informal communication networks, and communication processes. Prerequisite: consent of instructor.

MGT 311. LUMAC Management Assistance Counseling (3) fall, spring
A field studies course providing management assistance to small businesses in the Lehigh Valley. Students work in small groups under faculty supervision on a direct basis with owners. Problem solving and experience in applying marketing, accounting, finance, and/or management concepts to business. Prerequisites: junior standing in the College of Business and Economics.

MGT 321. Organizational Behavior Workshop (3)
A workshop course examining individual behavior, interpersonal transactions and behavioral processes in small work groups through motivational analysis, role-playing nonverbal interactions, problem solving and group simulations. Prerequisites: MGT 280, permission of the department chair.

MGT 333. Personnel Management (3)
Analysis and resolution of personnel problems in organizations. Human resource planning, recruitment, selection, orientation, training, appraisal, compensation, and development. Lectures and cases. Prerequisite: MGT 280.

MGT 371. Directed Readings (1-3)
Readings in various fields of management designed for the student who has a special interest in some field of management not covered by the regularly scheduled courses. Prerequisite: consent of the department chair. May be repeated.

MGT 372. Special Topics (1-3)
Special problems and issues in management for which no regularly scheduled course work exists. When offered as group study, coverage varies according to interests of instructor and students. Prerequisite: consent of the department chair. May be repeated.

MGT 373. Management Internship (1-3) summer
A sponsoring faculty member shall direct readings, projects, and other assignments including a comprehensive final report in conjunction with an industry-sponsored internship. The work experience itself, whether paid or unpaid, is not the basis for academic credit. Intellectual development in the context of a field study learning experience will be the determining factor in awarding academic credit. This course cannot be used to satisfy requirements of the Management major. Consent of department chair. Prerequisite: junior standing in the College of Business and Economics and Management major declaration.

Course descriptions for the College of Business and Economics graduate courses can be found in this section (Section V) under the heading of *Business and Economics Graduate Courses.*

Management Science

The management science program is directed toward integrating scientific methods with the functional aspects of organizations by investigating the application of quantitative methodology and systems analysis in the context of decision making, risk analysis, economics and cost analysis, production management, and supply chain logistics. This integration provides the students with a broader perspective toward managerial decision-making in both private enterprise and public administration.

Mid-career professionals and recent graduates with a background in engineering, mathematics, and physical sciences who intend to seek managerial, consulting or systems analyst positions are appropriate candidates. In particular, those candidates who intend to seek positions demanding both technical and management skills find the management science background advantageous in dealing with the complex problems of industrial, commercial, and public service organizations.

The Industrial and Systems Engineering Department administers the management science program. To be admitted to the program a candidate must demonstrate basic competence in calculus, statistics, linear algebra, introductory operations research, accounting, production and economics. A candidate lacking a certain background may be required to take background courses. The minimum program consists of 30 credit hours of course work, of which at least 18 credit hours must be in the 400-level. The ISE graduate faculty coordinator must approve all course work. Upon entering the program, the student must declare an area of concentration listed as follows:

- Operations Research
- Decision and Risk Analysis
- Economics and Cost Analysis
- Production and Operations Management
- Logistics and Supply Chain Management

Each student is required to complete 15 credit hours of core courses, 12 credit hours of courses in the declared area of concentration, and 3-credit hours of approved free elective or completing a management science project. No more than 9 credit hours may be taken from the College of Business and Economics (e.g., including MKT, ECO, GBUS courses).

Core Courses (at least 15 credit hours)

IE 328	Engineering Statistics (3), Prerequisite: Math 23 or equivalent
IE 358	Game Theory (3), Prerequisite: ECO 105 or 115 and 119 and Math 21, 31 or 51
IE 362	Logistics and Supply Chain Management (3), Prerequisite: IE 251 or equivalent
IE 404	Simulation (graduate version of IE 305) (3), Prerequisite: IE 121 and IE 220
IE 410	Design of Experiments (3), Prerequisite:
IE	121 or equivalent
IE 426	Optimization Models and Applications (graduate version of IE 316) (3), Prerequisite: IE 220 or equivalent
IE 429	Stochastic Models and Applications (graduate version of IE 339) (3), Prerequisite: IE 220 or equivalent
IE 458	Topics in Game Theory (3), Prerequisite: 2 semesters of calculus, ECO 412 and
ECO	414, or permission of instructor
MATH 334	Mathematical Statistics (3-4), Prerequisite: MATH 231 or 309

Note: Students who satisfy one or more of the core requirements from previous coursework (e.g., IE 305/404, 316/426, 339/429) may substitute the core requirement by taking additional courses from his/her declared are of concentration. Up to 9 credit hours may be substituted.

Areas of Concentration (at least 12 credit hours)

Each student must declare an area of concentration. No more than 3 credit hours may be taken outside the declared area of concentration.

Area	**Qualified Courses**
Operations Research	**IE** 406, 411, 412, 414, 416, 417, 418, 419, 439, **ECO** 402, 412, 423 **MATH** 312, 338, 340
Decision and Risk Analysis	**IE** 358,458, 409, 410, 416, 419, 439, 442, 446, 451, **MATH** 312, 338, **ECO** 416, 423, 460, 461
Economics and Cost Analysis	**IE** 358, 458, 413, **GBUS** 413, 414, 419*, 420*, 422, **MATH** 467, 468

Production and Operations Management	**IE** 319, 324, 332, 340, 342, 347, 410, 415, 419, 424, 425, 442, 443,445, 448, 449; **GBUS** 413, 450, 481, 483, 485, **ECO** 447, **MSE** 438, 446
Logistics and Supply Chain Management	**IE** 309, 319, 341, 358, 408, 409, 412, 414, 415, 416, 419, 425, 438, 443, 458, **MKT** 321, 325, **GBUS** 450, 481, **ECO** 416, 447, 460, 461

**Daytime section only for students without work experience*

Approved Free Elective or Management Science Project (3 credit hours)

Each student is to complete either an approved free elective relevant to the student's career interest, or complete a project through IE 430 Management Science Project. A faculty member must supervise the project.

Manufacturing Systems Engineering

Program director. Keith M. Gardiner, Ph.D. (Manchester, England), *professor of industrial and systems engineering.*

Program faculty. John P. Coulter, Ph.D. (Delaware), *associate professor of mechanical engineering and mechanics;* Steven L. Goldman, Ph.D. (Boston), *Andrew W. Mellon distinguished professor in the humanities;* Mikell P. Groover, Ph.D. (Lehigh), *professor of industrial and systems engineering*; Parveen P. Gupta, Ph.D. (Penn State), *associate professor of accounting*; Joseph C. Hartman, Ph.D. (Georgia Institute of Technology), *associate professor of industrial and systems engineering*; Roger N. Nagel, Ph.D. (Maryland), *Harvey Wagner Professor of manufacturing systems engineering*; Raymond Pearson, Ph.D. (U. Michigan), *associate professor of materials science and engineering*; Manash R. Ray, Ph.D. (Penn State), *associate professor of accounting*; Theodore Schlie, Ph.D. (Northwestern), *associate professor of management of technology*; Bruce M. Smackey, Ph.D. (Rensselaer), *professor of marketing*; Robert J. Trent, Ph.D. (Michigan State), *associate professor of management*; George R. Wilson, Ph.D. (Penn State), *associate professor of industrial and systems engineering.*

The manufacturing systems engineering program develops engineers who can design, install, operate, and modify systems involving materials, processes, equipment, facilities, logistics and people using leading edge technologies. It integrates systems perspectives with interdisciplinary course offerings from Lehigh's colleges of engineering and applied science, and business and economics.

Complete requirements are listed under Interdisciplinary Graduate Study and Research.

Graduate Courses

MSE 362. (IE 362) Logistics and Supply Chain Management (3)
Modeling and analysis of supply chain design, operations, and management. Analytical framework for logistics and supply chains, demand and supply planning, inventory control and warehouse management, transportation, logistics network design, supply chain coordination, and financial factors. Students are expected to complete industry case studies and a comprehensive final project. Prerequisite: IE 220 and IE 251 or equivalents, or instructor approval.

MSE 421. (GBUS 481) Technology, Manufacturing & Competitive Strategy (3)
Interrelationships among advanced manufacturing management, technology and competitive strategy of the firm. Topics to include industry analysis and competitiveness; competitive strategy formulation and implementation; value chain analysis; manufacturing and technology strategy; manufacturing's contribution to competitive advantage in quality, cost, variety and new product availability; segmentation and substitution; vertical integration.

MSE 423. Product Design/Analysis (3)
Integrated approach to design and analysis of products and systems. Principles for robust design and use of computer-aided engineering to model, evaluate, and enhance design. Case studies and design assignments are major components of this course.

MSE 427. (IE 443) Automation and Production Systems
Principles and analysis of manual and automated production systems for discrete parts and products. Cellular manufacturing, flexible manufacturing systems, transfer lines, manual and automated assembly systems, and quality control systems.

MSE 431. Marketing & the Invention to Innovation Process (3)
Organizational issues and decision-making for capital investments in new technologies. The commercialization process is traced from research and development and marketing activities through the implementation phase involving the manufacturing function. Term project is a commercialization plan for a new manufacturing technology.

MSE 433. Technology and the Factory of the Future (3)
Engineering and technological issues affecting future developments in manufacturing. Topics include flexible automation systems, integration of design and production through the factory data network, intelligent machines, the man-machine interface, and the manufacturing management information system.

MSE 438. Agile Organizations & Manufacturing Systems (3)
Analysis of the factors contributing to the success of manufacturing enterprises in an environment characterized by continuous and unpredictable change. Fundamentals of lean production: aspects of systems design, value stream analysis, flow, set-up and cycle time reduction, kaizen, elimination of waste. Fundamentals of agility: global enterprises, virtual organizations, adapting to change, mass customization, manufacturing flexibility, activity-based management.

MSE 446. International Supply Chain Management (3)
Financial and managerial issues. Evaluation, selection, development and management of suppliers; business models, financial reporting strategies, earnings, quality, risk assessment and internal control, team based new product development. Selected readings, case studies, discussions, lectures, group projects, and presentations.

MSE 451. Manufacturing Systems Engineering Project (1-3)

MSE 490. Manufacturing Systems Engineering Thesis (1-6)

MSE 496. Microelectronics Manufacturing Systems & Technologies (3)
Manufacturing engineering in electronics manufacture: crystal growth, doping, thin film deposition technologies and tooling, pattern generation techniques, contamination control, clean room practices, microelectronics assembly and packaging. Examination of systems design and operation issues.

Marketing

Professors. Richard M. Durand, Ph.D. (Florida), *Herbert E. Ehlers Dean of the College of Business and Economics*; K. Sivakumar, Ph.D. (Syracuse), *Arthur C. Tauck Jr. Professor of International Marketing and Logistics.*

Associate Professors. James M. Maskulka, D.B.A. (Kent State).

Assistant Professors. Ravi Chitturi, Ph.D. (Texas), Franklin Carter, Ph.D. (Carnegie Mellon), Theresa McCarthy, Ph.D. (Tennesee).

Visiting Assistant Professor. Karen Becker Olsen, Ph.D. (Lehigh).

Professor of Practice. Robert Kuchta, M.S. (New Jersey Institute of Technology).

Adjunct. R. Gregory Surovcik, M.B.A. (Lehigh).

The field of marketing offers career opportunities for students in business, economics, liberal arts, engineering, and the physical sciences.

Marketing is pervasive in our society and is a critical function in the promotion of world trade. Creativity and the ability to conduct insightful analyses of competitive business situations are the hallmarks of a well-prepared student who can contribute to a prospective employer's organization. Undergraduates and graduates have been able to secure entry-level positions in a variety of marketing activities with firms in advertising and public relations, retail management, industrial sales and purchasing, bank marketing, marketing research, and new product design. Combining the marketing curriculum with related subjects in international relations, psychology and sociology, engineering, and history can often strengthen a student's capability to grow beyond his or her formal education period. Students are encouraged to explore the potential enhancement of their educational experience through study abroad programs, internships with business, and research projects with faculty members.

Participation in the Marketing Club student organization is an extracurricular activity that offers a professional orientation program and the enjoyment of socializing with other students from across the campus.

The marketing major offered by the Department of Management and Marketing consists of 15 credit hours from the following courses:

Required courses

MKT 311	Buyer Behavior (3)
MKT 312	Marketing Research (3)
MKT 387	Marketing Strategy (3)

Elective courses

Two courses (six credit hours) from the following:

MKT 313	Integrated Marketing Communications (3)
MKT 319	Development and Marketing of New Products (3)
MKT 320	Global Marketing Strategies (3)
MKT 321	Business-to-Business Marketing (3)
MKT 325	Quantitative Marketing Analysis (3)
MKT 331	Electronic Commerce
MKT 332	Sales Management (3)
MKT 348	Management of Marketing Channels (3)
MKT 360	Marketing Practicum (3)
MKT 366	Marketing of Services (3)
MKT 371	Directed Readings (1-3)
MKT 372	Special Topics (1-3)

Undergraduate Courses

MKT 211. Principles of Marketing (3)
Overview of the entire marketing function. A broad-based approach to expose students to the meaning of marketing, the terminology of marketing, the activities involved in marketing, how managers make and implement decisions in marketing, and how they evaluate the results. The role of marketing in the broader society will also be discussed. Prerequisite: ECO 1.

MKT 311. Buyer Behavior (3)
Focuses on the theory and tools necessary to analyze and understand consumers and organizational buyers, in the context of the global information age. Topics covered include, but are not limited to, diffusion of innovations; market segmentation and product positioning; the multiattribute model and the theory of reasoned action; group and individual decision making processes of buyers; and buyer conditioning and learning processes. Lectures, cases and projects. Prerequisite: MKT 211.

MKT 312. Marketing Research (3)
A managerial approach toward conducting and using research for marketing decisions. Focus will be on the relevance and usefulness of systematic research for decision making, the process and steps involved in conducting effective marketing research, analysis and interpretation of the information for decision making, and the presentation of research results to help managers arrive at sound marketing decisions. Particular emphasis will be placed on the context of technological advances in the collection, dissemination, and use of marketing information, the applicability of marketing research principles for a wide variety of organizations and individuals in the global context, and ethical issues involved in marketing research. Prerequisites: ECO 145 and MKT 211.

MKT 313. Integrated Marketing Communications (3)
Focuses on the wide range of areas included in marketing communications and the tools and techniques needed to create an integrated approach. Students are introduced to the broad spectrum of communication messages and the sources that produce them. Students are required to develop and present an integrated marketing communications plan. Prerequisite: MKT 211.

MKT 319. Development and Marketing of New Products (3)
Focuses on the development and marketing of new products and services. Topics covered include diffusion of innovations, new product adoption models, the role of marketing research in various stages of new product development and marketing. Prerequisite: MKT 211.

MKT 320. Global Marketing (3)
Focuses on understanding the process of globalization and its impact on the firm's marketing activities. Topics include changes in the global environment and their impact on marketing activities, development of global marketing strategies based on sound marketing research and the role of technology in global marketing strategies. Prerequisite: MKT 211.

MKT 321. Business-to-Business Marketing (3)
Introduces students to the elements necessary to market a product, service, idea, event, organization, place, information, property, experience, or personality to another business. Students develop and present a complete, integrated business-to-business marketing plan. Prerequisite: MKT 211.

MKT 325 (ECO 325). Quantitative Marketing Analysis (3)
Explores economics and management science approaches to improve marketing decision making and marketing interactions in such areas as strategic marketing, e-marketing, advertising, pricing, sales force management, sales promotions, new products, and direct marketing. The development, implementation, and use of quantitative models are emphasized. Cases are used to illustrate how these models can be applied. Students have the opportunity to learn how to use and evaluate models through spreadsheet-based assignments. Prerequisites: MKT 211, ECO 145, ECO 146, and MATH 21, 31, 51 and 75 and 76.

MKT 331 (BIS 331). Electronic Commerce (3)
This course covers how business and consumers use the Internet to exchange information and complete transactions. Both theoretical concepts and practical skills will be addressed within the scope of the class. Topics include advertising and marketing, ecommerce business and revenue models, online consumer behavior, web site design issues, Internet security, electronic payments, infrastructure issues, privacy issues, and overall electronic commerce strategy. Students will get hands-on experience designing ecommerce web-sites using web authoring software. Prerequisites: BIS 111. MKT 211 or consent of the instructor.

MKT 332. Sales Management (3)
An integrative approach to sales management including formulation of strategically sound sales programs, implementation of sales programs, and evaluation and control of the organization's sales activities. Topics include the role of the sales manager in the divergent demands of multiple constituencies; the development of effective sales organizations; motivating and compensating the sales force; forecasting sales costs and evaluating performance; and coordination of the sales activities with other elements in a firm's marketing program. Prerequisite: MKT 211.

MKT 348. Management of Marketing Channels (3)
Economic, social, and structural aspects of channels will be analyzed. Topics include how channel systems should be formed; an investigation of a variety of channel intermediaries, including franchise systems, distributors, retailers, intermediary "market makers", and gray channels; the role of technology in channel relationships; the interpersonal dimensions of channel relationship management such as conflict management, minority issues, and ethics. Prerequisite: MKT 211.

MKT 360. Marketing Practicum (3)
The marketing practicum combines formal classwork on marketing problem formulation and business communications with an intensive internship or consulting engagement with a business. Students work with client firms to develop individual or team projects, which focus on marketing activities such as market research, strategy development, sales management, and promotion management. Upon completion of the project, students submit a written report and make a formal presentation to clients. Prerequisites: MKT 211, MKT 311 and MKT 312. Cannot be taken concurrently with MGT 311.

MKT 366. Marketing of Services (3)
Focuses on service quality issues and strategies from a customer-focused, business perspective. Gives students an appreciation of the challenges of marketing and managing services and develops strategies for addressing these challenges. Topics include service quality gap analysis; services triangle analysis; 7 p's for services; service-profit chain; service encounter analysis; customer lifetime value analysis; new service development process; service quality dimensions; services guarantees; and demand/capacity management. Prerequisite: MKT 211.

MKT 371. Directed Readings (1-3)
Readings in various fields of marketing designed for the student who has a special interest in some field of marketing not covered in regularly scheduled courses. Prerequisite: consent of the department chair. May be repeated.

MKT 372. Special Topics (1-3)
Special problems and issues in marketing for which no regularly scheduled course work exists. When offered as group study or internship, coverage will vary according to the interests of the instructor and students. Prerequisite: consent of the department chair. May be repeated.

MKT 373. Marketing Internship (1-3) summer
A sponsoring faculty member shall direct readings, projects, and other assignments including a comprehensive final report in conjunction with an industry-sponsored internship. The work experience itself, whether paid or unpaid, is not the basis for academic credit. Intellectual development in the context of a field study learning experience will be the determining factor in awarding academic credit. This course cannot be used to satisfy requirements of the Marketing major. Prerequisite: consent of department chair and junior standing in the College of Business and Economics and Marketing declaration.

MKT 387. Marketing Strategy (3)
Synthesizes the marketing principles introduced in other marketing courses and provides students an integrative framework to marketing decision-making. Lectures and cases. Prerequisite: MKT 311, 312 and senior standing.

Course descriptions for the College of Business and Economics graduate courses can be found in this section (Section V) under the heading of *Business and Economics Graduate Courses.*

Materials Science and Engineering

Professors. G. Slade Cargill, PhD. (Harvard), *chair and Sherman Fairchild Professor;* Alwyn Eades Ph.D. (Cambridge) *associate chair;* Helen M. Chan, Ph.D. (Imperial College of Science and Techno0logy, England) *New Jersey Zinc Professor*; Martin P. Harmer, Ph.D. (Leeds, England), *Alcoa Professor, director of Center for Advanced Materials and Nanotechnology;* Himanshu Jain, ENGR. Sci. D. (Columbia), *Diamond Chair*; Chris Kiely, Ph.D. (Bristol); Charles E. Lyman, Ph.D. (M.I.T.); Arnold R. Marder, Ph.D. (Lehigh), *R.D. Stout Professor;* Raymond A. Pearson, Ph.D. (Michigan); David B. Williams, Ph.D. (Cambridge), *Harold Chambers Senior Professor, Vice Provost for Research.*

Associate Professors. John N. DuPont, Ph.D. (Lehigh); Wojciech Misiolek, Sc.D (U. of Mining and Metallurgy, Krakow, Poland), *Loewy Chair*; Jeffrey M. Rickman, Ph.D. (Carnegie-Mellon).

Assistant Professors. Audrey N. Soukhojak, Ph.D. (M.I.T.) Richard P. Vinci, Ph.D. (Stanford).

Adjunct Professors. Walter L. Brown, Ph.D. (Harvard); W. Thomas Chase, M.A. (New York University); Lisa Friedersdorf, Ph.D. (Johns Hopkins); Brian R. Lawn, Ph.D. (Western Australia); Charles V. Robino, Ph.D. (Lehigh).

Emeritus Professors. Betzalel Avitzur, Ph.D. (Michigan); Sidney R. Butler, Ph.D. (Penn State); Ye T. Chou, Ph.D. (Carnegie Mellon); Richard W. Hertzberg, Ph.D. (Lehigh); Ralph J. Jaccodine, Ph.D. (Notre Dame); Michael R. Notis, Ph.D. (Lehigh); Alan W. Pense, Ph.D. (Lehigh); Donald M. Smyth, Ph.D. (M.I.T); Leslie H. Sperling, Ph.D. (Duke); Robert D. Stout, Ph.D. (Lehigh); S. Kenneth Tarby, Ph.D. (Carnegie-Mellon); David A. Thomas, Sc.D. (M.I.T.); John D. Wood, Ph.D. (Lehigh).

Research engineers and scientists. David W. Ackland; Arlan O. Benscoter.

As science and technology advance in the 2000's and beyond, progress in many fields will depend on the discovery and development of new materials, processed in more complex ways, and with new kinds of properties. It is widely recognized that the progress of history has been divided into periods characterized by the materials that mankind has used, i.e., the stone age, the bronze age, the iron age. Today, materials science and engineering is critical to all other fields of engineering, and advances in these other fields are often limited by advances in materials.

Interest in new materials for solid-state devices, space technology, and superconductivity, as well as a better understanding of the behavior of materials in the design of structures, automobiles and aircraft, plant processing equipment, electrical machinery, etc., have increased the need for people trained in science and technology of materials.

Education for this field of engineering requires basic studies in mathematics, chemistry, physics and mechanics, plus a general background in engineering principles, followed by intensive training in the application of scientific and engineering principles to the development and use of materials in a technological society.

B.S. in Materials Science and Engineering

The undergraduate program is designed to train graduates for research, development, operations, management and sales careers in industry or for graduate study in various specialties of the field, including the manufacture and applications of metals, ceramics, polymers, composites, and electronic materials. While some graduates go directly into materials-producing companies, many serve as engineers in the chemical, electrical, transportation, communications, space, and other industries. A number of students pursue graduate study leading to careers in research and teaching.

Materials Science and Engineering majors have opportunities to gain valuable experience in other, related fields, including other areas of engineering or science, by choosing to concentrate elective courses in one of these areas. Requirements for adding a Minor include at least 15 course credits in that area, which may be taken as technical or free electives in the student's major. It is particularly straightforward for students to obtain a minor in Chemical Engineering, in Manufacturing Engineering, or in Polymer Science and Engineering.

Materials Science and Engineering majors can also participate in undergraduate research at universities in Great Britain and elsewhere during the summer between Junior and Senior years. The Materials Science and Engineering Industrial Option program enables students to gain work experience during the Senior Year. The Materials Science and Engineering Research Option program provides senior undergraduates research experience with Materials Science and Engineering professors and graduate students.

Five-year programs are available to broaden the Materials Science and Engineering undergraduate experience. One of these is the Arts-Engineering Program, in which students can earn both the bachelor of science degree in Materials Science and Engineering and the bachelor of arts degree in some area within the College of Arts and Sciences, such as biology, physics, chemistry, or history. Another is the B.S./M.Ed. Program, which leads (in five years of study and internships) to the B.S. degree in Materials Science and Engineering and a masters degree (M.Ed.) in Education, with elementary or secondary teacher certification.

Minor in Materials Science and Engineering

The Department of Materials Science and Engineering offers minors to students majoring in other subjects. The Department is enthusiastic in its support of students who wish to broaden their education by taking a minor. To obtain a minor in Materials Science and Engineering, a student must complete two required courses (MAT 10, 1 credit, and MAT 33, 3 credits) and four other three-credit courses for a total of 16 credit hours. The four courses may be chosen from a long list of 200 and 300 level courses given by the Department.

Educational Mission

The Materials Science and Engineering undergraduate program's mission is to provide its students an excellent education in a scholarly environment, and to have its graduates acquire the knowledge and experience needed to advance to successful careers and, where appropriate, for graduate study, in materials-related fields.

Educational Objectives

The Materials Science and Engineering undergraduate program's Educational Objectives are that graduates

- have a firm base of knowledge in areas of mathematics, physics and chemistry relevant to materials science and engineering, and be able to apply and extend this knowledge;
- understand relationships among materials structure, properties, processing and performance for metals, ceramics, polymers, composites, and electronic materials; be able to extend this knowledge; and be able to apply it in materials analysis, development, selection, and design;
- be able to function effectively on problem-solving teams and to coordinate and provide leadership for teams, including multi-disciplinary teams;
- be knowledgeable and experienced in using basic laboratory tools, computers, and databases for materials analysis, development, and selection;
- be able to define and solve materials-related problems, including design problems, within economic, environmental, and time deadline constraints;
- develop skills in writing, speaking, reading and listening needed to communicate logically and effectively;
- understand and accept professional and ethical responsibilities, including responsibilities for public safety and workplace safety;
- gain background in history, economics, world cultures and current events to provide a realistic context for their professional activities.

Major Requirements

The recommended sequence of courses is shown below. The standard freshman engineering year is shown in section III. A total of 135 credits or more is required to graduate.

sophomore year, first semester (17 credits)

MATH 23	Analytic Geometry & Calculus III (4)
PHY 21, 22	Introductory Physics II and Laboratory (5)
ECO 1	Economics (4)
MAT 10	Materials Laboratory (1)
MAT 33	Engineering Materials and Processes (3)

sophomore year, second semester (18 credits)

MATH 205	Linear Methods (3)
MECH 2	Elementary Engineering Mechanics (3)
MAT 203	Structure and Characterization of Materials (3)
MAT 205	Thermodynamics and Phase Diagrams (3)
MAT 20	Computational Methods in Materials Science (2)
HSS	Humanities/Social Sciences Elect (4)

junior year, first semester (18 credits)

MAT 201	Physical Properties of Materials (3)
MAT 216	Diffusion and Phase Transformations (3)
MAT 218	Mechanical Behavior of Materials (3)
MAT 101	Professional Development (2)
Elect.	Elective (3)
HSS	Humanities/Social Sciences Elect (4)

junior year, second semester (18 credits)

ENGR 211	Integrated Product Development Projects I (3)
MAT 204	Processing and Properties of Polymeric Materials (3)
MAT 206	Processing and Properties of Metals (3)
MAT 214	Processing and Properties of Ceramic Materials (3)
MAT 210	Macro Materials Processing Lab (2)
MAT 226	Materials Selection in Design (1)
HSS	Humanities/Social Sciences Elective (3)

senior year, first semester (17-18 credits)

ENGR 212	Integrated Product Development Projects II (2)
MAT 302	Electronic Properties of Materials (3)
ECE 81	Principles of Electrical Engineering (4) <u>or</u>
PHY 190	Electronics (3) **or**
MAT 352	Electronics for Materials Science and Engineering (3)
IE 328	Engineering Statistics (3) **or**
MATH 231	Probability and Statistics (3)
ENGR.	Sci. Elect. Engineering Science Elective(3)
HSS	Humanities/Social Science Elective (3)

senior year, second semester (17 credits)

MAT 338	Failure Analysis Reports (2)
CHE 60	Unit Operations Survey (3)
ENGR.SCI.	Elect. Engineering Science Elective (3)
App. Elect.	Approved Elective (3)
Elect	Elective (3)
Elect	Elective (3)

Electives for the sophomore, junior and senior years must be distributed as follows:

Humanities and Social Sciences: 13-15 credit hours.
Free Electives: 9 credit hours in any department.
Approved Elective (3 credit hours) and Engineering Science Electives (6 credit hours) must be selected from a specific list supplied by the Materials Science and Engineering Department. The list includes the Industrial Option and the Research Option.

Industrial Option

MAT 327	Industrial Project (4)
MAT 329	Industrial Project (4)

Research Option

MAT 240	Research Techniques (3)
MAT 291	Undergraduate Research (3)

The Industrial Option introduces students to the work of materials engineers in industry. The emphasis is a team approach to the solution of actual plant problems. The courses are conducted in cooperation with local industries. Three days per week are spent at the plant of the cooperating industry on investigations of selected problems. The option is limited to a small group of seniors, selected by the Department from those who apply. Summer employment is provided when possible for those who elect to initiate the program during the summer preceding the senior year.

The Research Option is offered for students interested in research and development. Financial support may be available for students who elect to initiate a research program during the summer preceding the senior year. The option is limited to a small group of students, selected by the Department from those who apply.

Undergraduate Courses

MAT 10. Materials Laboratory (1) fall
Introduction to experimental methods used to fabricate and measure the structure and properties of materials. Thermal and mechanical processing and properties are emphasized. Specimen preparation and examination by light optical microscopy. Prerequisite: MAT 33 previously or concurrently. Chan.

MAT 20. Computational Methods in Materials Science (2) spring
The use of computers and computational methods to solve problems in materials science and engineering. Students will employ both commercial packages and their own code in order to complete assignments. Students will utilize word processing and display packages to present results of projects. Prerequisite: ENGR. 1 or equivalent. Rickman.

MAT 33. Engineering Materials and Processes (3) fall-spring
Application of physical and chemical principles to understanding, selection, and fabrication of engineering materials. Materials considered include metals, polymers, ceramics, composites and electronic materials. Case studies of materials used range from transportation systems to microelectronic devices. Rickman and staff.

MAT 101. Professional Development (2) spring
Seminar on the role and purpose of engineering in society; the meaning of being a professional; the role of creativity, communications and decision-making in the engineering process; expectations and problems of young engineers; personal goals; choosing a career. Required reading. Written reports based on library research. Prerequisite: junior standing. Lyman.

MAT 107. Special Topics in Materials (1-3)
A study of selected topics in materials science and engineering not covered in other formal courses.

For Advanced Undergraduates and Graduate Students

MAT 201. Physical Properties of Materials (3) fall
Basic concepts of modern physics and quantum mechanics needed for an understanding of electrons in solids. The experimental development leading to wave mechanics is emphasized. Uses of the Schrodinger equation as the basis for the free electron theory of metals and band theory. Optical properties are developed leading to a discussion of lasers. Prerequisites: Phys 21, MAT 33, MATH 205. Jain.

MAT 203. Structure and Characterization of Materials (3) spring
Atomic structure and types of bonding. Crystalline and amorphous states. Crystal structures, and fundamental aspects of crystallography (space lattice, Miller indices, symmetry elements). Crystal defects (point, line and planar). Basic principles of structure determination by x-ray diffraction. Microscopic techniques (light and electron optical), and their application to material characterization. Prerequisites: CHEM 21; MAT 10 and MAT 33 previously or concurrently. Eades.

MAT 204. Processing and Properties of Polymeric Materials (3) spring
The structure-property relationships in polymers will be developed, emphasizing the glass transition, rubber elasticity, crystallinity, and mechanical behavior. Elements of polymer processing. Extrusion of plastics and films, and fiber spinning operations. Prerequisites: MAT 33. Pearson.

MAT 205. Thermodynamics and Phase Diagrams (3) spring
The three laws of thermodynamics. Gibbs free energy and thermodynamic basis for equilibrium. Solution thermodynamics. Binary and ternary equilibrium phase diagrams. Application of thermodynamics to materials problems. Lectures and laboratories. Prerequisite: MATH 23 and MAT 33, previously or concurrently. Vinci.

MAT 206. Processing and Properties of Metals (3) spring
The production and purification of metals, their fabrication, and control of their properties. Includes topics such as precipitation hardening, hot and cold working, and casting. Prerequisite: MAT 216, MAT 218. Marder.

MAT 210. Macro Materials Processing Lab (2) spring
Introduction to the practice of fabrication methods for ceramics, metals and polymers. Includes topics such as melt processing, deformation processing, gas-phase processing, etc. Contains hands-on processing labs and a reverse engineering design project that allows students to examine a particular process in depth. Prerequisite: MAT 204, 206, and 214 taken previously or concurrently.

MAT 214. Processing and Properties of Ceramic Materials (3) spring
General overview of the compositions, properties and applications of ceramic materials. The theory and practice of fabrication methods for ceramics and glasses. Methods of characterization. Selected properties of ceramic materials. Prerequisites: MAT 33. Chan.

MAT 216. Diffusion and Phase Transformations (3) fall
Fundamental diffusion equations; liquid-solid transformations; solid-solid transformations; transformation kinetics; metastable transformations; diffusionless transformations; examples of various transformations in different materials and their effect on properties. Prerequisites: MAT 203, MAT 205. Notis.

MAT 218. Mechanical Behavior of Materials (3) fall
Deformation and fracture behavior of materials. Elastic and plastic behavior, with emphasis on crystallographic considerations. Strengthening mechanisms in solids. Static and time-dependent fracture from microstructural and fracture mechanics viewpoints. Fatigue failure. Prerequisites: MECH 2, MAT 203. Vinci.

MAT 221. (STS 221) Materials in the Development of Man (3) fall
Development of materials technology and engineering from the stone age to atomic age as an example of the interaction between technology and society. In-class demonstration laboratories on composition and structure of materials. Term projects using archaeological materials and alloys. Course intended for, but not limited to, students in the humanities and secondary science education. Engineering students may not use this course for engineering science or technical elective credit. Notis.

MAT 226. Materials Selection in Design (1) spring
Review of different classes of engineering materials and mechanical stress states experienced by structural compo-

nents. Derivation of performance indices. Selection and design of materials based on materials selection charts and performance indices. Application of materials selection concepts to ENGR 211 IPD #1 course. Prerequisites: MECH 2; MAT 33 or consent of instructor. DuPont

MAT 240. Research Techniques (3) fall
Study and application of research techniques in materials science and engineering. Research opportunities, design of experimental programs, analysis of data, presentation of results. Selection of research topic and preparation and defense of research proposal. Restricted to a small number of students selected by the department from those who apply.

MAT 291. Undergraduate Research (3) spring
Application of research techniques to a project in materials science and engineering selected in consultation with the faculty. Normally preceded by MAT 240.

MAT 302. Electronic Properties of Materials (3) fall
The electronic structure of materials, i.e., band and zone theory, is presented from a physical point of view. Electrical conductivity in metals, semiconductors, insulators and superconductors is discussed. Simple semiconductor devices reviewed. Magnetic properties are examined in the context of domain theory and applications are discussed. Optical and dielectric properties of semiconductors and ferroelectrics are considered. Prerequisites: MAT 201, MAT 203. Eades.

MAT 309. Composite Materials (3)
The principles and technology of composite materials. Processing, properties, and structural applications of composites, with emphasis on fiber-reinforced polymers. Lectures and some field trips or laboratories. Prerequisite: MAT 33 or equivalent, MECH 2. Pearson

MAT 310. Independent Study in Materials (1-3)
Provides an opportunity for advanced, independent study of selected topics in materials science and engineering not covered in other formal courses.

MAT 312. (CHE 312, CHEM 312) Fundamentals of Corrosion (3)
Corrosion phenomena and definitions. Electrochemical aspects including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization, and passivity. Non-electrochemical corrosion including mechanisms, theories, and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings, alloys, inhibitors, and passivators. Prerequisite: MAT 205, CHEM 187, or equivalent of either.

MAT 314. Metal Forming Processes (3)
Mechanical metallurgy and mechanics of metal forming processes. Yield criteria. Workability. Friction and lubrication. Engineering analysis of forging, extrusion, wire and tube drawing, rolling, sheet forming and other processes. Recent developments in metal forming. Prerequisite: MAT 206 or consent of instructor. Misiolek.

MAT 315. Physical Properties of Structural and Electronic Ceramics (3)
Structure-property relationships in ceramics. Mechanical behavior including plasticity, hardness, elasticity, strength and toughening mechanisms. Thermal behavior including specific heat, thermal expansion, thermal conduction and thermal shock. Electrical behavior including application of tensors and crystal physics to electroceramics. Prerequisites: MAT 214 or consent of instructor. Harmer.

MAT 317. Imperfections in Crystals (3)
The major types of crystal defects and their role in controlling the properties of materials. Point, line and planar defects, their atomic configurations and experimental techniques to study their characteristics. Emphasis on the role of dislocations and grain boundaries in the control of mechanical properties. Prerequisite: MAT 203 or consent of instructor. Rickman.

MAT 319. Current Topics in Materials Science (3)
Selected topics of current interest in the field of materials engineering but not covered in the regular courses. May be repeated for credit with consent of the department chair. Prerequisite: Consent of department chair.

MAT 320. Analytical Methods in Materials Science (3)
Selected topics in modern analysis and their application to materials problems in such areas as thermodynamics, crystallography, deformation and fracture, diffusion. Prerequisite: MATH 231 or 205. Rickman.

MAT 325. Design, Selection, and Failure Analysis of Engineering Materials (4) fall.
Review of different classes of engineering materials and mechanical stress states experienced by structural components. Failure analysis and prevention of engineering component failure. Introduction to product liability litigation. Problem solution-oriented selection and design of materials with appropriate fabrication, thermal, and surface finish processes. Lectures plus laboratories which require individual design and execution of experiments to solve both materials selection and failure analysis problems. Prerequisites: MAT 204, MAT 206, MAT 214, and MAT 218. Marder.

MAT 327. Industrial Project (4)
Restricted to a small group of seniors and graduate students selected by the department from those who apply. Three full days per week are spent on development projects at the plant of an area industry, under the direction of a plant engineer and with faculty supervision. Misiolek.

MAT 329. Industrial Project (4)
To be taken concurrently with MAT 327. Course material is the same as MAT 327. Misiolek.

MAT 333. (EES 337, CHM 337) Crystallography and Diffraction (3)
Introduction to crystal symmetry, point groups, and space groups. Emphasis on materials characterization by x-ray diffraction and electron diffraction. Specific topics include crystallographic notation, stereographic projections, orientation of single crystal, textures, phase identification, quantitative analysis, stress measurement, electron diffraction, ring and spot patterns, convergent beam electron diffraction (CBED), and space group determination. Applications in mineralogy, metallurgy, ceramics, microelectronics, polymers, and catalysts. Lectures and laboratory work. Prerequisites: MAT 203 or EES 133 or senior standing in chemistry.

MAT 334. (EES 338, CHE 334) Electron Microscopy and Microanalysis (4) fall
Fundamentals and experimental methods in electron optical techniques including scanning electron microscopy (SEM), conventional transmission (TEM)

and scanning transmission (STEM) electron microscopy. Specific topics covered will include electron optics, electron beam interactions with solids, electron diffraction and chemical microanalysis. Applications to the study of the structure of materials are given. Prerequisite: consent of the department chair. Lyman and Kiely.

MAT 335. (CHE 335) Principles of Semiconductor Materials Processing (3)
Description and analysis of the processing steps involved in microelectronic material fabrication. Emphasis will be placed on the chemistry of the fabrication steps, mathematical modeling of the transport and chemical reaction phenomena, and interpretation of experimental methods and data. Prerequisite: a course in thermodynamics and senior standing.

MAT 338. Failure Analysis Reports (2) spring
Application of chemical and mechanical failure concepts, microstructural analysis, and fracture surface characterization to the analysis and prevention of engineering component failures. Conduct laboratory investigations on component failures with written and oral presentations of the results. Prerequisites: Senior standing and MAT 204, MAT 206, MAT 210, MAT 214, and MAT 302. Marder.

MAT 339 Light Metals (3)
Designing mechanical properties of light metals such as aluminum, beryllium, magnesium and titanium through alloying and processing. In depth analysis of strengthening mechanisms and resulting physical properties. Review of typical casting, deformation, powder metallurgy and machining processes applied to these materials. Recent commercial applications in the construction, packaging, aerospace and automotive industries. Prerequisite: MAT 206 or consent of the instructor. Misiolek.

MAT 342. Inorganic Glasses (3) spring
Definition, formation and structure of glass; common glass systems; manufacturing processes; optical, mechanical, electrical and dielectric properties; chemical durability; glass fibers and glass ceramics. Lectures and laboratories. Prerequisite: MAT 33. Jain.

MAT 344. (IE 344) Metal Machining Analysis (3) spring
Intensive study of metal cutting emphasizing forces, energy, temperature, tool materials, tool life, and surface integrity. Abrasive processes. Laboratory and project work. Prerequisite: IE 115 or ME 240 or MAT 206.

MAT 345 Powder Metallurgy (3)
Metal powder fabrication and characterization methods. Powder processing including powder compaction, theory of compacting, press and die design, sintering, and hot consolidation. Microstructure and properties of sintered materials and their relationship to processing conditions. Industrial applications. Emerging powder metallurgy technologies. Prerequisite: MAT 206 or consent of instructor. Misiolek.

MAT 346. Physical Metallurgy of Welding (3)
Operational characteristics of welding processes. Application of solidification and solid state transformation theory to understanding microstructural development in welds, and influence of welding on properties. Metallurgical defects in welds. Computational techniques for predicting heat flow and phase transformations in welds of complex engineering alloys. Laboratory demonstrations. Prerequisites: MAT 216. DuPont.

MAT 348. Materials Science for Electronic Applications (3)
Materials technology for integrated circuit packaging systems. Dielectric, thermal and mechanical considerations; joining methods; resistor and ceramic capacitor materials and incorporation of active devices into packaging systems; multilayer package design and processing. Individualized semester project involving forensic examination of failures using scanning electron microscopy and microprobe analysis. Prerequisite: MAT 201, and MAT 33.

MAT 352. Electronics for Materials Science and Engineering (3) fall
Properties and structures of electronic components including resistors, capacitors, diodes and transistors, a.c. and d.c. circuits, electronic laboratory instruments, circuit analysis and design. Two lectures and one three-hour laboratory per week. Prerequisite: MAT 302 taken previously or concurrently. Cargill.

MAT 367. (CHE 367) Metal Films and Coatings: Processing, Structure, and Properties (3)
Focus will be on the processing, structure, and properties of metal films and coatings. Processing methods will include evaporation, sputtering, chemical vapor deposition (CVD), plasma-assisted CVD, ion implantation, electrodeposition, metal bath solidification, weld overlay, thermal spraying, and diffusion. Characterization of thin films and coatings will be done with the use of sophisticated analytical instrumentation, including spectroscopic methods, microscopy and diffraction techniques. Characterization methods are explored in conjunction with processing techniques and film/coating properties via class assignments that are designed to introduce students to the archival scientific literature. Prerequisite: Senior standing in Chemical Engineering or Materials Science and Engineering, or permission of the instructor(s).

MAT 388. (CHE 388, CHM 388) Polymer Synthesis and Characterization Laboratory (3) spring
Techniques include: free radical and condensation polymerization; molecular weight distribution by gel chromatography; crystallinity and order by differential scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior; morphology and microscopy; surface properties. Prerequisite: Senior level standing in chemical engineering, chemistry, or materials science and engineering, or permission of the instructor.

MAT 393. (CHE 393, CHM 393) Physical Polymer Science (3)
Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline states (including viscoelastic and relaxation behavior) for single-/ and multi-component systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology and behavior. Prerequisite: Senior level standing in Chemical Engineering, Chemistry, or Materials Science and Engineering, or permission of the instructor. Sperling.

MAT 396. (CHEM 396) Chemistry of Nonmetallic Solids (3)
Chemistry of ionic and electronic defects in nonmetallic solids and their influence on chemical and physical properties. Intrinsic and impurity-controlled defects, nonstoichiometric compounds, defect interactions. Properties to be discussed include: diffusion, sintering, ionic and electronic conductivity, solid-state reactions, and photoconductivity. Prerequisite: CHEM 187 or MAT 205 or equivalent.

For Graduate Students

The department offers graduate degrees in Materials Science and Engineering at both masters (M.S. and M. Eng.) and doctoral levels (Ph.D.). Specialized masters degree programs are also available, in Photonics, in Polymers, and in Business Administration and Engineering (MBA&E). The M.S. Degree in Photonics is an interdisciplinary degree for broad training in such topics as fiber optics, lightwave communications, and optical materials, to prepare students for work in industry or for further graduate research at the Ph.D. level. The program requires a total of 30 credits of graduate work, including a 15-credit core of courses in materials, electrical engineering, and physics. The Polymer Science and Engineering Program offers interdisciplinary M.S. and Ph.D. degrees through several departments, including Materials Science and Engineering. The program includes courses in materials, chemical engineering, chemistry, physics, and mechanical engineering. The MBA&E is an interdisciplinary degree program in business and engineering designed primarily for students with an undergraduate degree in engineering and two years or more of relevant work experience. The curriculum consists of an MBA core and electives (23 credits) and engineering core and electives (18 credits), plus other electives and a project which integrates business and engineering (4 credits). Students wishing to have the engineering core in Materials Science and Engineering may enter this program through the Materials Science and Engineering Department.

Special Programs and Opportunities

The department has established specific recommended programs for the M.S., the M.Eng., and the Ph.D., emphasizing the following areas: metals processing and performance, ceramics and glass processing and properties, electronic and photonic materials and packaging, electron microscopy and microstructural characterization, and archaeometallurgy.

These programs are flexible and often interdisciplinary. Advanced level courses can be rescheduled to be held first thing in the morning or late in the day, when off-campus students register.

Major Requirements

The requirements are explained in section IV. A candidate for the M.S. completes a thesis, unless fully funded by industry, in which case a thesis is not required. M.S. thesis research normally represents six of the 30 semester hours required for this degree. Candidates for the M.Eng. complete a three-credit engineering project.

A candidate for the Ph.D. prepares a preliminary program of courses and research, providing for specialization in some field (largely through research) in consultation with the adviser. Prior to formal establishment of the doctoral program by the special committee and its approval by the college, the student passes a qualifying examination that must be taken in the first or second year of doctoral work. The department does not require a foreign language. It does require preparation and defense of a research proposal as a portion of the general examination.

Of the courses listed above only those in the 300 series are available for graduate credit. There are many additional offerings in materials under the listings of other departments.

Most graduate students receive some form of financial aid. Several kinds of fellowships and assistantships are available. This type of aid generally provides for tuition, and a stipend. For details of graduate scholarships, fellowships and assistantships, please refer to section IV.

Research Activities

Graduate students conduct their research in facilities located in the Department or the Center for Advanced Materials and Nanotechnology, or other centers and institutes. The following list describes current Materials Science and Engineering research activities:

Metals Processing and Performance: joining of metals and alloys, laser engineered net shaping, solidification modeling, corrosion and coatings, deformation processing, grain boundary cohesion, bulk metallic glasses.

Ceramics and Glass Processing and Properties: fundamental studies of sintering and grain growth, novel reaction-based processing for bulk and thin film ceramics, microstructure and properties of oxides for environmental coatings, growth of single crystal piezoelectric ceramics, creep and grain boundary chemistry of alumina, dielectric and electrical properties of glasses, corrosion of glass.

Electronic and Photonic Materials and Packaging: electromigration, degradation processes in light-emitting semiconductors, mechanical behavior of thin metal films, reliability of MEMS materials, processing and performance of advanced solder alloys, polymer packaging materials, glass nanostructure and chemistry, glasses for nonlinear optical applications, transparent glass-ceramics, photoinduced phenomena.

Microstructural Characterization: transmission electron microscopy, scanning electron microscopy, nanoscale compositional mapping, cathodoluminescence microscopy and spectroscopy, x-ray microbeam diffraction and fluorescence, x-ray microanalysis, electron-loss spectrometry, extended x-ray absorption and electron energy loss fine structure (EXAFS and EXELFS).

Archaeometallurgy: reconstruction of ancient smelting and fabrication processes, artifact analysis using modern analytical methods, history of materials.

Graduate-Level Courses

MAT 401. Thermodynamics and Kinetics (3) fall
Integrated treatment of the fundamentals of thermodynamics, diffusion and kinetics, as related to materials processes. Laws of thermodynamics, conditions of equilibrium thermodynamics of phase transitions, diffusion in multicomponent systems, and kinetics of phase transformations. DuPont and Eades.

MAT 403. Structure and Properties (3) spring
The underlying principles of the structure of materials and relationship to properties. Crystal structures and

properties, point, line and planar defects and properties, and non-crystalline structure including covalent-ionic, metallic and polymeric glasses and properties. Jain.

MAT 405. Mathematical Methods in Materials Science and Engineering (3) fall
Mathematical and computational skills required for an understanding of materials science principles. The topics to be discussed include vector and tensor calculus, with applications to crystallography and materials properties, solution of differential equations, emphasizing rate equations and the diffusion equation, integral transforms for solving differential equations and computation of scattering intensities, statistics and experimental design, and numerical methods and computer simulation. Cargill and Rickman

MAT 406. Solidification (3)
Structure, theory and properties of liquids. Homogeneous and heterogeneous nucleation theory and experimental results. Solidification phenomena in pure, single and multiphase materials including the nature of the freezing interface, segregation, constitutional supercooling, dendritic growth, crystallographic effects, the origin of defects, crystal growing, zone processes. Prerequisite: consent of the department chair. DuPont.

MAT 408. Transformations (3) fall
The thermodynamic, kinetic and phenomenological aspects of a wide spectrum of solid-state phase transformations. Theories of nucleation, growth and coarsening of second-phase precipitates. Application of the theories to continuous and discontinuous reactions, massive, martensitic and bainitic transformations in metals. Transformations in nonmetallics. Prerequisite: MAT 205 and 216 or equivalent. Marder.

MAT 409. Current Topics in Materials (3)
Recent practical and theoretical developments in materials. This course may be repeated for credit if new material is covered. Prerequisite: consent of the department chair.

MAT 410. Physical Chemistry of Metals (3)
Discussions of reactions involving gases and reactions involving pure condensed phases and a gaseous phase. Ellingham diagrams and equilibria in metal-oxygen-carbon systems. Consideration of the behavior of solutions and methods for determining thermodynamic properties of solutions by experimentation and computation. Prerequisite: MAT 205 or equivalent.

MAT 411. Modern Joining Methods (3)
The foundations upon which the joining processes rest; the present limitations of the various processes; the trends in new developments; the engineering and structural aspects of joining. Prerequisite: MAT 216 and 218 or equivalent.

MAT 412. Magnetic Properties of Materials (3)
Fundamental concepts of magnetism and magnetic properties of ferro- and ferrimagnetic materials. Metallic and nonmetallic materials. Current application areas considered as examples. Prerequisite: Phys 31 or 363 or equivalent.

MAT 413. Formability of Metals (3)
Formability concept. Analysis of the microstructure response to deformation processing parameters including state of stress, state of strain, stain rate, temperature, and friction. Analysis of formability in metal forming processes. Defects. Seminar/discussion format. Prerequisite: MAT 314 or consent of instructor. Misiolek.

MAT 415. Mechanical Behavior of Ceramic Solids (3)
Strength, elasticity, creep, thermal stress fracture, hardness, abrasion and high-temperature deformation characteristics of single- and multi-component brittle ceramic solids. Statistical theories of strength, static and cyclic fatigue, crack propagation, fracture toughness. Correlation of mechanical behavior, microstructure, and processing parameters. Prerequisite: MAT 218 or consent of the department chair.

MAT 416. Atom Movements (3)
Phenomenological and atomistic development of the laws of diffusion and their solution. Influence of gradients of concentration, potential, temperature and pressure. Effects of structural defects on diffusion in metals and nonmetals. Prerequisite: MATH 23 and MAT 205 or the equivalent.

MAT 417. Deformation and Strength of Solids (3)
Topics related to deformation of solids including creep, strengthening mechanisms, annealing of deformed solids, preferred orientation. Primary emphasis is on crystalline materials. May be repeated for credit if different material is covered. Prerequisite: MAT 218 or equivalent.

MAT 418. Fatigue and Fracture of Engineering Materials (3)
Application of fracture mechanics concepts to the fatigue and fracture of crystalline and amorphous solids. Fracture control design philosophies. Metallurgical aspects of fracture toughness and embrittlement susceptibility. Environment-enhanced cracking. Fatigue crack propagation in metals and polymers. Electron fractography. Failure analysis case histories. Prerequisite: MAT 218 or equivalent.

MAT 419. Advanced Physical Metallurgy (3)
Application of physical metallurgy principles to materials systems. Transformation structures and the influence of morphology on properties. Alloy design and heat treatment for improved strength, toughness, creep, corrosion resistance, electrical and magnetic properties. Prerequisite: MAT 325 or equivalent. Marder.

MAT 421. Fracture Analysis (3)
Application of fracture mechanics concepts, microstructural analysis, and fracture surface characterization to the analysis and prevention of engineering component failures. Extensive use of case histories. Introduction to legal aspects of product liability. Prerequisite: MAT 218 or MECH 313 or equivalent.

MAT 423. Advanced Transmission Electron Microscopy (4)
The theory and practice of operation of the transmission and scanning transmission electron microscope. Techniques covered include bright field, high resolution and weak-beam dark field, lattice imaging, diffraction pattern indexing and Kikuchi line analysis. The theory of diffraction contrast is applied to the interpretation of electron micrographs. Specimen preparation techniques. Prerequisite: MAT 334 or equivalent. Lyman, Eades.

MAT 425. Topics in Materials Processing (3)
Topics such as: ceramics, metal, and polymer synthesis and compaction phenomena. Theories of sintering and grain growth. Physical behavior of sintered compacts. Techniques of fiber and crystal growth. Vapor deposition

and ultra-high-purity materials preparation. Desirable preparation: MAT 204 or 206 or 214, and MAT 218. Prerequisite: consent of the department chair.

MAT 427. Advanced Scanning Electron Microscopy (4)
The theory and practice of operation of the scanning electron microscope and electron microprobe. Techniques covered will include high-resolution scanning, quantitative electron probe microanalysis. Electron beam sample interactions, X-ray spectrometry, and electron optics will be discussed in detail. Prerequisite: MAT 334 or equivalent. Lyman, Eades.

MAT 429. Dielectric and Electrical Properties of Ceramics (3)
Basic concepts of dielectric and electrical phenomena in ceramics including dielectric loss, dielectric breakdown, ferroelectricity, piezoelectricity, mixed conduction, and interfacial effects. Physical and materials aspects of technologically important ceramics such as thermistors, varistors, boundary layer capacitors, solid electrolytes, gas sensors, glasses, etc. Prerequisite: MAT 201 or equivalent. Jain.

MAT 430. Glass Science (3)
Definition and formation of glass. Structure of common inorganic (including metallic) and polymeric glass systems. Methods of glass making. Phase separation of devitrification. Physical properties including diffusion, electrical conductivity, chemical durability, and optical and mechanical properties. Special products including glass ceramics, optical fibers, photosensitive glasses, etc. Visit to a glass manufacturing plant may also be included. Prerequisite: MAT 315 or equivalent. Jain.

MAT 431. Sintering Theory and Practice (3)
Science and technology of the sintering of solid-state materials. Driving force and variables. Critical review of the sintering models. Coverage of single phase, multiphase and composite systems. Special sintering techniques such as fast firing, rate controlled sintering, hot pressing and transient second-phase sintering. Sintering of specific ceramic and metal systems. Prerequisite: MAT 214 or equivalent. Harmer.

MAT 432. Theories of Silicon Oxidation (3)
A critical review is given of advanced theories of silicon oxidation. Present accepted theory (Deal-Grove) is inadequate for explaining thin (state-of-the-art) oxides. Course will consider most recent approaches to theory of thin gate insulators. It will also include new experimental approaches that use “impurity gaseous doping” and halogen additions.

MAT 435 Photonic Materials (3)
Scope of photonics, especially in communications. Characteristics of light. Optical properties of metals, semiconductors and insulators. Nonlinear optical properties. Materials for fibers, lasers, detectors, modulators, amplifiers and other components. Prerequisites: MAT 302 or consent of instructor. Jain.

MAT 437. (MECH 437) Dislocations and Strength in Crystals (3)
Theory and application of dislocations. Geometrical interpretation; elastic properties; force on a dislocation; dislocation interactions and reactions; multiplication. Dislocations in crystal structures. Selected topics in strengthening, plastic flow, creep, fatigue and fracture are discussed. Prerequisite: MATH 205 or 231, or MAT 320; MAT 317, or consent of the department chair. Wei.

MAT 443. (CHEM 443) Solid-State Chemistry (3)
Crystal structure, diffraction in crystals and on surfaces, bonding and energy spectra in solids, dielectrics, surface states and surface fields in crystals. Prerequisites: one course in linear algebra and one course in quantum mechanics. Klier.

MAT 458. Materials Design (3)
Analysis of design requirements for materials components. Selection of materials and processes. Study of failures in process and service and application of recent metallurgical and materials engineering knowledge for improved design. Solution and discussion of industrial problems, and outline of experimental approach. Prerequisite: consent of the chair.

MAT 460. Engineering Project (1-3)
In-depth study of a problem in the area of materials engineering or design. The study is to lead to specific conclusions and be embodied in a written report. Intended for candidates for the M.Eng. May be repeated for a total of three credit hours.

MAT 461. Advanced Materials Research Techniques (3)
Study of the theory and application of selected advanced techniques for investigating the structure and properties of materials. May be repeated for credit with the approval of the department chair.

MAT 482. (CHM 482, CHE 482) Engineering Behavior of Polymers (3) spring
A treatment of the mechanical behavior of polymers. Characterization of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analogs. Topics include time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizers, moisture and aging on mechanical behavior. Pearson.

MAT 485. (CHM 485, CHE 485) Polymer Blends and Composites (3) fall
Synthesis, morphology, and mechanical behavior of polymer blends and composites. Mechanical blends, block and graft copolymers, interpenetrating polymer networks, polymer impregnated concrete, and fiber and particulate reinforced polymers are emphasized. Prerequisite: any introductory polymer course or equivalent. Sperling.

MAT 490. Thesis. (1-6)

MAT 499. Dissertation (1-15)

Mathematics

Professors. Huai-Dong Cao, Ph.D. (Princeton), *A. Everett Pitcher Professor*; Donald M. Davis, Ph.D. (Stanford); Vladimir Dobric, Ph.D. (Zagreb, Croatia); Bennett Eisenberg, Ph.D. (M.I.T.); B. K. Ghosh, Ph.D. (London); Samuel L. Gulden, M.A. (Princeton); Wei-Min Huang, Ph.D. (Rochester); Samir A. Khabbaz, Ph.D. (Kansas); Jerry P. King, Ph.D. (Kentucky); Eric P. Salathe, Ph.D. (Brown), *director of the Institute for Biomedical Engineering and Mathematical Biology;* Lee J. Stanley, Ph.D. (Berkeley); Steven H. Weintraub, Ph.D. (Princeton), *chair*; Joseph E. Yukich, Ph.D. (M.I.T.).

Associate professors. Bruce A. Dodson, Ph.D. (S.U.N.Y. at Stony Brook); Garth Isaak, Ph.D. (Rutgers); David L.

Johnson, Ph.D. (M.I.T.); Terrence Napier, Ph.D. (Chicago); Clifford S. Queen, Ph.D. (Ohio State); Susan Szczepanski, Ph.D. (Rutgers); Ramamirthan Venkataraman, Ph.D. (Brown).

Assistant professors. Gautam Chinta, Ph.D. (Columbia); Linghai Zhang, Ph.D. (Ohio State).

Adjunct professor. Howard Fegan, Ph.D. (Oxford).

Visiting assistant professors. Gabriele La Nave, Ph.D. (Brandeis); Dmitry Ostrovsky, Ph.D. (Yale); Alfredo J. Rios Rodriguez, Ph.D. (Rutgers).

Mathematics is a subject of great intrinsic power and beauty. It is the universal language of science, and is essential for a clear and complete understanding of virtually all phenomena. Mathematical training prepares a student to express and analyze problems and relationships in a logical manner in a wide variety of disciplines including the physical, engineering, social, biological, and medical sciences, business, and pure mathematics itself. This is a principal reason behind the perpetual need and demand for mathematicians in education, research centers, government, and industry.

The department offers three major programs leading to the degrees of bachelor of arts in mathematics, bachelor of science in mathematics (with a general mathematics and an applied mathematics option), and bachelor of science in statistics. It also offers several minor programs for undergraduates.

At the graduate level, it offers programs leading to the degrees of master of science in mathematics, master of science in applied mathematics, master of science in statistics, doctor of philosophy in mathematics, and doctor of philosophy in applied mathematics.

The Division of Applied Mathematics and Statistics is a part of the Department of Mathematics.

Calculus Sequences

Many degree programs throughout the university include a mathematics requirement consisting of a sequence in calculus. The Department of Mathematics offers three calculus sequences: MATH 21, 22, 23; MATH 31, 32, 33; MATH 51, 52.

The MATH 21, 22, 23 sequence is a systematic development of calculus. Most students of mathematics, science, engineering, and business will take some or all of this sequence.

As an honors sequence, the MATH 31, 32, 33 sequence covers essentially the same material but in greater depth and with more attention to rigor and proof. This sequence should be considered by students who have demonstrated exceptional ability in mathematics. Students who are contemplating a major in mathematics are strongly encouraged to consider this sequence.

The MATH 51, 52 sequence is a survey of calculus. This sequence is not sufficient preparation for most subsequent mathematics courses. Students contemplating further study in mathematics should consider MATH 21, 22 instead.

MATH 75, 76 is a two-semester sequence that substitutes for MATH 21, covering the same material but at a slower pace.

The MATH 31, 32, 33 sequence will be accepted in place of the other two sequences. MATH 21, 22 will be accepted in place of MATH 51, 52. Credit will be awarded for only one course in each of the following groups: 21, 31, and 51; 22, 32, and 52; 23 and 33. If two courses in the same group are taken, credit will be awarded for the more advanced course; 3x is the most advanced, while 5x is the least advanced.

Undergraduate Degree Programs

The Department of Mathematics offers degree programs in Mathematics and Statistics. These programs have the flexibility and versatility needed to prepare students for a wide variety of careers in government, industry, research and education.

Students in the degree programs in mathematics must satisfy three types of requirements beyond those required by the college: Core Mathematics Requirements, Major Requirements and General Electives. The Core Mathematics Requirement ensures a common core of knowledge appropriate for students in each program. The Major Program Electives consist of courses with specific mathematical or statistical content chosen by the student in consultation with the major advisor to complement the student's interest and career aspirations. With these further breadth and greater depth of knowledge are achieved. The General Electives consist of additional courses chosen from among those offered by the university faculty. Students can use these electives to pursue interests beyond the major, or may use these to expand upon the basic requirements of the degree program. Students are strongly encouraged to use some of these electives to earn a minor in another discipline.

Students in the degree program in statistics must satisfy four types of requirements beyond those required by the college: Required Major Courses, Major Electives, Professional Electives and Free Electives.

Each student is provided a faculty advisor to guide an individual program and supervise the selection of electives.

B.A. in Mathematics

The B.A. program in mathematics emphasizes fundamental principles as well as the mastery of techniques required for the effective use of mathematics. The program provides a solid foundation for those who want to pursue a mathematically oriented career or advanced study in any mathematically oriented field.

Requirements:

College Distribution Requirements		*(32-35 credits)*
Core Mathematics Requirements		*(32-35 credits)*
Calculus	(12 cr)	MATH 21, 22, 23 or MATH 31,32, 33
Introductory Seminar	(3 cr)	MATH 163
Statistics/Probability	(3-4 cr)	MATH 12 or MATH 231
Linear Algebra	(4 cr)	MATH 242
Differential Equations	(3-4 cr)	MATH 205 or MATH 320
Analysis	(4 cr)	MATH 301
Complex Analysis	(3-4 cr)	MATH 208 or MATH 316
Major Requirements	*(10 credits)*	
Algebra	(4 cr)	MATH 243
Electives	(6 cr)	Two courses (at least 6 credits) at or above the 200 level chosen in consulta-

		tion with the major advisor. At most one course may be taken outside the department.
General Electives	*(41-47 credits)*	Chosen in consultation with faculty advisor.

This program requires a total of 121 credit hours.

A student must achieve an average of 2.0 or higher in major courses.

BS in Mathematics

The BS in Mathematics program provides a more extensive and intensive study of mathematics and its applications. Students can pursue the General Mathematics Option or the Applied Mathematics Option. These programs are especially recommended for students intending to pursue advanced study in mathematics or applied mathematics. The General Mathematics Option is recommended for students who wish to pursue mathematics either by itself or in combination with a related field (e.g., physics, computer science or economics). The Applied Mathematics Option provides a broad background in the major areas of applicable mathematics.

General Mathematics Option

Requirements:

College Distribution Requirements	*(32-35 credits)*	
Core Mathematics Requirements	*(32-34 credits)*	
Calculus	(12 cr)	MATH 21, 22, 23 or MATH 31, 32, 33
Introductory Seminar	(3 cr)	MATH 163
Statistics/Probability	(3 cr)	MATH 231 or MATH 309
Linear Algebra	(4 cr)	MATH 242
Differential Equations	(3-4 cr)	MATH 205 or MATH 320
Analysis	(4 cr)	MATH 301
Complex Analysis	(3-4 cr)	MATH 208 or MATH 316
Major Requirements	*(24-25 credits)*	
Algebra	(4 cr)	MATH 243
Electives	(14 cr)	Four courses (at least 14 credits) at or above the 200 level chosen in consultation with the major advisor. At most two courses may be taken outside the department.
Computer Science	(6-7 cr)	Two courses: ENGR 1 and one approved CSE course or two approved CSE courses.
General Electives	*(27-33 credits)*	Chosen in consultation with faculty advisor.

This program requires a total of 121 credit hours.
A student must achieve an average of 2.0 or higher in major courses.

Applied Mathematics Option

Requirements:

College Distribution Requirements	*(32-35 credits)*	
Core Mathematics Requirements	*(33-34 credits)*	
Calculus	(12 cr)	MATH 21, 22, 23 or MATH 31, 32, 33
Introductory Seminar	(3 cr)	MATH 163
Statistics/Probability	(3 cr)	MATH 231 or MATH309
Linear Algebra	(4 cr)	MATH 242
Differential Equations	(4 cr)	MATH 320
Analysis	(4 cr)	MATH 301
Complex Analysis	(3-4 cr)	MATH 208 or MATH 316
Major Requirements	*(23-24 credits)*	
Electives	(17 cr)	Five courses (at least 17 credits) at or above the 200 level chosen in consultation with the major advisor to establish a concentration as described below. At most two courses may be taken outside the department.
Computer Science	(6-7 cr)	Two courses: ENGR 1 and one a approved CSE course or two approved CSE courses.
General Electives	*(28-33 credits)*	Chosen in consultation with faculty advisor.

In consultation with the major advisor, a student must establish a concentration in a particular area of applied mathematics. The courses chosen must have specific mathematical or statistical content and together constitute a coherent program. At most two courses may be taken outside the Department of Mathematics. Students, in consultation with the major advisor, can design a concentration which reflects a particular area of interest or choose to pursue one of the following:

Concentration in Applied Analysis:

Electives must include MATH 230, MATH 322 and MATH 341

Concentration in Discrete Mathematics and Theoretical Computer Science:

Electives must include MATH 251, MATH 329 or MATH 340

Concentration in Probability and Statistics:

Electives must include MATH 309 and MATH 310

This program requires a total of 121 credit hours.

A student must achieve an average of 2.0 or higher in major courses.

B.S. in Statistics

Statistics provides a body of principles for designing the process of data collection, for summarizing and interpreting data, and for drawing valid conclusions from data. It thus forms a fundamental tool in the natural and social sciences as well as business, medicine, and other areas of research. Mathematical principles, especially probability theory, underlie all statistical analyses.

College and university requirements excluding Mathematics (32-35 credit hours)

Required Major courses (45-47 credit hours)

MATH 21, 22, 23/ 31, 32, 33	Calculus I, II, III (12) or Honors Calculus I, II, III (12)
MATH 12/231	Basic Statistics (4) or Probability and Statistics (3)
MATH 43/205/242	Survey of Linear Algebra (3) or Linear Methods (3) or Linear Algebra (4)
MATH 309	Theory of Probability (3)
MATH 310	Random Processes and Applications (3)
MATH 312	Statistical Computing and Applications (3)
MATH 334	Mathematical Statistics (4)
MATH 338	Linear Models in Statistics (4)
MATH 374	Statistical Project (3)

Two approved computing science courses or one approved computer science course and Engineering 1 (6) or (7).

Major Electives (12 credit hours)
At least three courses with specific mathematical or statistical content chosen with the approval of the faculty advisor.

Professional Electives (21 credit hours)
Courses selected from two or three fields of application of statistics and probability.

Free Electives (6-11 credits)
This program requires a total of 121 credit hours.
A student must achieve an average of 2.0 or higher in major courses.

Departmental Honors

Students may earn departmental honors by writing a thesis during their senior year. Students are accepted into the program during their junior year by the department chairperson. This acceptance is based upon the student's grades and a thesis proposal, which the student must prepare in conjunction with a thesis advisor selected by the student. An oral presentation as well as a written thesis are required for completion of the program.

Minor Programs

The department offers minor programs in different branches of the mathematical sciences. Each program requires the courses shown below, and MATH 23 or 33. At most one of the courses in the minor program may also be required in the major program. For substitutions, the student should consult the chairperson.

Minor in Pure Mathematics

MATH 242, 243, 301
MATH 302 or 303 or 307 or 316 or 342

Minor in Applied Mathematics

Two of MATH 205, 208, 230, 231, 242, 320, 323
MATH 322
MATH 341

Minor in Probability and Statistics

MATH 12 or 231
MATH 309
Two of MATH 310, 312, 334, 338

Minor in Actuarial Science

MATH 202, 309 and 310
ECON 129
ACCT 108 or 151

For information on examinations of actuarial societies, students may consult their minor advisor.

Undergraduate Courses

MATH 0. Preparation for Calculus (2) summer-fall
Intensive review of fundamental concepts in mathematics utilized in calculus, including functions and graphs, exponentials and logarithms, and trigonometry. This course is for students who need to take MATH 51 or 21, but who require remediation in precalculus. In particular, students who fail the MATH 51 Readiness Exam must pass MATH 0 before being admitted to MATH 51. The credits for this course do not count toward graduation, but do count on the GPA and current credit count. Prerequisite: department permission.

MATH 5. Introduction to Mathematical Thought (3) spring
Meaning, content, and methods of mathematical thought illustrated by topics that may be chosen from number theory, abstract algebra, combinatorics, finite or non-Euclidean geometries, game theory, mathematical logic, set theory, topology. **(MA)**

MATH 9. Introduction to Finite Mathematics (4) fall
Systems of linear equations, matrices, introduction to linear programming. Sets, counting methods, probability, random variables, introduction to Markov chains. Students may not receive credit for both MATH 9 & 61. **(MA)**

MATH 12. Basic Statistics (4) fall-spring
A first course in the basic concepts and methods of statistics with illustrations from the social, behavioral, and biological sciences. Descriptive statistics; frequency distributions, mean and standard deviation, two-way tables, correlation and regression; random sampling, rules of probability, probability distributions and parameters, parameter estimation, confidence intervals, hypothesis testing, statistical significance. **(MA)**

Note: Students may not have credit for MATH 12 & ECO 145.

MATH 21. Calculus I (4) fall-spring
Functions and graphs; limits and continuity; derivative, differential, and applications; indefinite and definite integrals; trigonometric, logarithmic, exponential, and hyperbolic functions. **(MA)**

MATH 22. Calculus II (4) fall-spring
Applications of integration; techniques of integration; separable differential equations; infinite sequences and series; Taylor's Theorem and other approximations; curves and vectors in the plane. Prerequisite: MATH 21 or MATH 31. **(MA)**

MATH 23. Calculus III (4) fall-spring
Vectors in space; partial derivatives; Lagrange multipliers; multiple integrals; vector analysis; line integrals; Green's Theorem, Gauss's Theorem. Prerequisite: MATH 22 or MATH 32. **(MA)**

MATH 31. Honors Calculus I (4) fall
Same topics as in MATH 21, but taught from a more thorough and rigorous point of view. **(MA)**

MATH 32. Honors Calculus II (4) fall-spring
Same topics as in MATH 22, but taught from a more thorough and rigorous point of view. Prerequisite: MATH 31. **(MA)**

MATH 33. Honors Calculus III (4) fall-spring
Same topics as in MATH 23, but taught from a more thorough and rigorous point of view. Prerequisite: MATH 32. **(MA)**

MATH 43. Survey of Linear Algebra (3) fall
Matrices, vectors, vector spaces and mathematical systems, special kinds of matrices, elementary matrix transformations, systems of linear equations, convex sets, introduction to linear programming. **(MA)**. Students may not receive credit for both MATH 61 & 43.

MATH 51. Survey of Calculus I (4) fall-spring
Limits. The derivative and applications to extrema, approximation, and related rates. Exponential and logarithm functions, growth and decay. Integration. Partial derivatives and extrema. Prerequisite: Passing score on Readiness Exam, or MATH 0. **(MA)**

MATH 52. Survey of Calculus II (3) fall-spring
Trigonometric functions and related derivatives and integrals. Techniques of integration. Differential equations. Probability and calculus. Prerequisite: MATH 21 or 31 or 51. **(MA)**

MATH 61. Linear Algebra for Business and Economics (2) fall-spring
Matrices, solutions of linear systems, linear programming, examples from business and economics, computer solutions. **(MA)**. Students may not receive credit for both MATH 61 & 9, or for both MATH 61 & 43.

MATH 75. Calculus I, Part A (2) fall
Covers the same material as the first half of MATH 21. Meets three hours per week, allowing more class time for each topic than does MATH 21. **(MA)**

MATH 76. Calculus I, Part B (2) spring
Continuation of MATH 75, covering the second half of MATH 21. Meets three hours per week. Final exam for this course is identical to the MATH 21 final. Prerequisite: MATH 75. **(MA)**

MATH 163. Introductory Seminar (3) spring
An introduction to the discipline of mathematics designed for students considering a major in mathematics. The course will provide an introduction to rigorous mathematical reasoning and will survey some area of mathematics. Topics covered will vary. Satisfies the Introductory Seminar requirement.

MATH 171. Readings (1-3) fall-spring
Study of a topic in mathematics under individual supervision. Intended for students with specific interests in areas not covered in the listed courses. Prerequisite: consent of the department chair. **(MA)**

For Advanced Undergraduates and Graduate Students

Courses listed as (3-4) are 3 credits for graduate students and 4 credits for undergraduates. The extra credit will frequently involve some extra workshops or projects.

MATH 201. Problem Solving (1) fall
Practice in solving problems from mathematical contests using a variety of elementary techniques. **(MA)**

MATH 202. Actuarial Exam I (1) spring
Practice in solving problems from the first actuarial exam; problems in calculus and probability with insurance applications. Prerequisites: MATH 23 and 231. **(MA)**

MATH 205. Linear Methods (3) fall-spring
Linear differential equations and applications; matrices and systems of linear equations; vector spaces; eigenvalues and application to linear systems of differential equations. Prerequisite: MATH 22 or 32. (MA)

MATH 207. (CHE 207) Introduction to Biomedical Engineering and Mathematical Physiology (3) fall
Topics in human physiology and mathematical analysis of physiological phenomena, including the cardiovascular and respiratory systems, biomechanics, and renal physiology; broad survey of bioengineering. Independent study projects. Prerequisite: MATH 205. **(MA)**

MATH 208. Complex Variables (3) fall-spring
Functions of a complex variable; calculus of residues; contour integration; applications to conformal mapping and Laplace transforms. Prerequisite: MATH 23 or MATH 33. **(MA)**

MATH 230. Numerical Methods (3) fall
Representation of numbers and rounding error; numerical solution of equations; quadrature; polynomial and spline interpolation; numerical solution of initial and boundary value problems. Prerequisites: MATH 205 (previously or concurrently) and knowledge of either FORTRAN or PASCAL. **(MA)**

MATH 231. Probability and Statistics (3) fall-spring
Probability and distribution of random variables; populations and random sampling; chi-square and t distributions; estimation and tests of hypotheses; correlation and regression theory of two variables. Prerequisite: MATH 23 or MATH 33 or MATH 52. **(MA)**

MATH 234. Fractal Geometry (3-4)
Metric spaces and iterated function systems; various types of fractal dimension; Julia and Mandelbrot sets. Other topics such as chaos may be included. Small amount of computer use. Prerequisite: MATH 23 or MATH 33. **(MA)**

MATH 242. Linear Algebra (3-4) fall
Thorough treatment of the solution of m simultaneous linear equations in n unknowns, including a discussion of the computational complexity of the calculation. Vector spaces, linear dependence, bases, orthogonality, eigenvalues. Applications as time permits. Prerequisite: MATH 23 or 33 or 52. **(MA)**

MATH 243. Algebra (3-4) spring
Introduction to basic concepts of modern algebra: groups, rings, and fields. **(MA)**

MATH 251. Combinatorics (3-4)
Topics selected from enumeration, graphs and networks, Ramsey theory, ordered sets, min-max duality, and designs. Theory will be motivated by applications from operations research and computer science. Prerequisite: MATH 22 or consent of instructor. **(MA)**

MATH 261. (CSE 261) Discrete Structures (3)
Topics in discrete mathematical structures chosen for their applicability to computer science and engineering. Sets, propositions, induction, recursion; combinatorics; binary relations and functions; ordering, lattices and Boolean algebra; graphs and trees; groups and homomorphisms. Prerequisites: MATH 21. **(MA)**

MATH 301. Principles of Analysis I (3-4) fall
Existence of limits, continuity and uniform continuity; Heine-Borel Theorem; existence of extreme values; mean value theorem and applications; conditions for the existence of the Riemann integral; absolute and uniform convergence; emphasis on theoretical material from the calculus of one variable. Prerequisite: MATH 23 or MATH 33. **(MA)**

MATH 302. Principles of Analysis II (3-4) spring
Continuation of MATH 301. Functions of several variables; the implicit function theorem, and further topics with applications to analysis and geometry. Prerequisite: MATH 301. **(MA)**

MATH 303. (Phil 303) Mathematical Logic (3-4) fall
A course, on a mathematically mature level, designed not only to acquaint the student with logical techniques used in mathematics but also to present symbolic logic as an important adjunct to the study of the foundations of mathematics. Prerequisite: non-math majors need Phil 114. **(MA)**

MATH 304. Axiomatic Set Theory (3-4) fall
A development of set theory from axioms; relations and functions; ordinal and cardinal arithmetic; recursion theorem; axiom of choice; independence questions. Prerequisite: MATH 301 or consent of the department chair. **(MA)**

MATH 307. General Topology I (3-4) fall
An introductory study of topological spaces, including metric spaces, separation and countability axioms, connectedness, compactness, product spaces, quotient spaces, function spaces. Prerequisite: MATH 301. **(MA)**

MATH 309. Theory of Probability (3) fall
Probabilities of events on discrete and continuous sample spaces; random variables and probability distributions; expectations; transformations; simplest kind of law of large numbers and central limit theorem. The theory is applied to problems in physical and biological sciences. Prerequisite: MATH 23 or MATH 33 or MATH 52. **(MA)**

MATH 310. Random Processes and Applications (3-4) spring
Theory and applications of stochastic processes. Limit theorems, introduction to random walks, Markov chains, Poisson processes, birth and death processes, and Brownian motion. Applications to financial mathematics, biology, business and engineering. Prerequisites: MATH 309 or MATH 231.

MATH 312. Statistical Computing and Applications (3-4)
Use of statistical computing packages; exploratory data analysis; Monte Carlo methods; randomization and resampling, application and interpretation of a variety of statistical methods in real world problems. Prerequisite: Math 12 or 231. **(MA)**

MATH 316. Complex Analysis (3-4) spring
Concept of analytic function from the points of view of the Cauchy-Riemann equations, power series, complex integration, and conformal mapping. Prerequisite: MATH 301. **(MA)**

MATH 320. Ordinary Differential Equations (3-4) spring
The analytical and geometric theory of ordinary differential equations, including such topics as linear systems, systems in the complex plane, oscillation theory, stability theory, geometric theory of nonlinear systems, finite difference methods, general dynamical systems. Prerequisite: MATH 205, or both MATH 23, 33 and MATH 242. **(MA)**

MATH 322. Methods of Applied Analysis I (3) fall
Fourier series, eigenfunction expansions, Sturm-Liouville problems, Fourier integrals and their application to partial differential equations; special functions. Emphasis is on a wide variety of formal applications rather than logical development. Prerequisite: MATH 205 or consent of the department chair. **(MA)**

MATH 323. Methods of Applied Analysis II (3) spring
Green's functions; integral equations; variational methods; asymptotic expansions, method of saddle points; calculus of vector fields, exterior differential calculus. Prerequisite: MATH 322. **(MA)**

MATH 327. Groups and Rings (3-4) fall
An intensive study of the concepts of group theory including the Sylow theorems, and of ring theory including unique factorization domains and polynomial rings. Prerequisite: MATH 243 or consent of the department chair. **(MA)**

MATH 329. Computability Theory (3-4) spring
Core development of classical computability theory: enumeration, index and recursion theorems, various models of computation and Church's Thesis, uncomputability results, introduction to reducibilities and their degrees (in particular, Turing degrees, or degrees of uncomputability), computable operators and their fixed points. **(MA)**

MATH 334. Mathematical Statistics (3-4) spring
Populations and random sampling; sampling distributions; theory of statistical estimation; criteria and methods of point and interval estimation; theory of testing statistical hypotheses. Prerequisite: MATH 231 or MATH 309. **(MA)**

Mathematics 338. Linear Models in Statistics (3-4) spring
Least square principles in multiple regression and their interpretations; estimation, hypothesis testing, confidence and prediction intervals; analysis, multicollinearity, selection of regression models, analysis of variance and covariance; general linear models, principal component analysis. Use of computer packages. Prerequisite: Math 12 or 231. **(MA)**

MATH 340. (CSE 340) Design and Analysis of Algorithms (3) spring
Algorithms for searching, sorting, counting, graph and tree manipulation, matrix multiplication, scheduling, pattern matching and fast Fourier transforms. Abstract complexity measures and the intrinsic complexity of algorithms and problems in terms of asymptotic behavior; correctness of algorithms. Prerequisites: MATH 22 and MATH 261, or consent of the department chairperson. **(MA)**

MATH 341. Mathematical Models and Their Formulation (3) spring
Mathematical modeling of engineering and physical systems with examples drawn from diverse disciplines. Emphasis is on building models of real world problems rather than learning mathematical techniques. Prerequisite: MATH 205. **(MA)**

MATH 342. Number Theory (3-4)
A survey of elementary and nonelementary algebraic and analytic methods in the theory of numbers. Includes the Euclidean algorithm, Diophantine equations congruences, quadratic residues, primitive roots, number-theoretic functions as well as one or more of the following topics: distribution of primes, Pell's equation, Fermat's theorem, partitions. Prerequisite: MATH 301 or consent of the department chair. **(MA)**

MATH 350. Special Topics (3) fall-spring
A course covering special topics not sufficiently covered in listed courses. Prerequisite: consent of the department chair. May be repeated for credit. **(MA)**

MATH 371. Readings (1-3) fall-spring
The study of a topic in mathematics under appropriate supervision, designed for the individual student who has studied extensively and whose interests lie in areas not covered in the listed courses. Prerequisite: consent of the department chair. May be repeated for credit **(MA)**

MATH 374. Statistical Project (3)
Supervised field project or independent reading in statistics or probability. Prerequisite: consent of the department chair. **(MA)**

MATH 391. Senior Honors Thesis (3) fall-spring
Independent research under faculty supervision, culminating in a thesis presented for departmental honors. May be repeated once for credit. Prerequisite: consent of chair **(MA)**

Graduate Programs in Mathematics

The department offers graduate programs leading to the degrees of master of science in mathematics, applied mathematics, or statistics, and the doctor of philosophy in mathematics or applied mathematics.

To begin graduate work in mathematics a student must present evidence of adequate undergraduate preparation. The undergraduate program should have included a year of advanced calculus, a semester of linear algebra, and a semester of abstract algebra.

M.S. in Mathematics or Applied Mathematics

The master's program demands 30 credit hours of graduate courses with at least 18 hours at the 400 level. With the permission of the chairperson, up to six hours of these courses can be replaced by a thesis. All students in the master's program must also pass a comprehensive examination. The M.S. degree can serve both as a final degree in mathematics or as an appropriate background for the Ph.D. degree.

M.S. in Statistics

This program requires 30 credit hours of graduate courses with at least 18 hours of 400-level STAT or MATH courses. The choice of courses must be approved by the graduate advisor, and up to six hours of coursework may be replaced with a thesis. All students in the program must also pass a comprehensive examination.

The M.S. program in statistics has two tracks. The *statistics* track has recommended courses MATH 309, STAT 412, 434, and 462; electives STAT 410, 438, and 461; and other possible electives STAT 408 and 409, EDUC 411, I.E. 332, 409, and 410, ECO 455 and 463, CSE 411, and MECH 405. The *stochastic modeling* track has recommended courses MATH 309 and 401, and STAT 410 and 463;

electives MATH 341 and STAT 434, 438, and 464; and other possible electives STAT 408 and 409, MATH 402, 407, 430, 467, and 468, ECO 453, CSE 411, MECH 405, and I.E. 316, 339, 409, 416, and 439.

Ph.D. in Mathematics

The plan of work toward the doctor of philosophy degree will include a comprehensive examination and a qualifying examination. The latter tests the student's command of three areas. The combination of areas must be approved by the department. Recent exam areas include algebra, analysis, differential equations, differential geometry, discrete structures, functional analysis, logic and set theory, numerical analysis, probability, statistics, and topology. Other areas of mathematics may be proposed by the candidate and approved by the department. A general examination, a foreign language examination, and the doctoral dissertation and its defense complete the work for the Ph.D. degree.

Each candidate's plan of work must be approved by a special committee of the department. A Ph.D. student is required to have 18 credits of approved graduate level course work beyond the master's level. After completion of 18 credits a student is required to take at least one course per academic year other than Math 409, 410, and 499.

Ph.D. in Applied Mathematics

The plan of work toward the doctor of philosophy degree will include a comprehensive examination and a qualifying examination. The latter tests the student's command of three areas. The combination of areas must be approved by the department. Recent exam areas include analysis, applied probability, differential equations, discrete structures, financial mathematics, linear algebra and linear programming, mathematical biology, mathematical statistics, numerical methods, and statistical methods. Other areas of mathematical and physical sciences may be proposed by the candidate and approved by the department. A general examination, a foreign language examination, and the doctoral dissertation and its defense complete the work for the Ph.D. degree.

Each candidate's plan of work must be approved by a special committee of the department. A Ph.D. student is required to have 18 credits of approved graduate level course work beyond the master's level. After completion of 18 credits a student is required to take at least one course per academic year other than Math 409, 410, and 499.

Graduate Courses

MATH 401. Real Analysis I (3) fall
Set theory, real numbers; introduction to measures, Lebesgue measure; integration, general convergence theorems; differentiation, functions of bounded variation, absolute continuity; Lp spaces. Prerequisites: MATH 302 or consent of department chair.

MATH 402. Real Analysis II (3) spring
Metric spaces; introduction to Banach and Hilbert space theory; Fourier series and Fejer operators; general measure and integration theory, Radon-Nikodym and Riesz representation and theorems; Lebesgue-Stieljtes integral. Prerequisites: MATH 307 and MATH 401.

MATH 403. Topics in Real Analysis (3)
Intensive study of topics in analysis with emphasis on recent developments. Prerequisite: consent of the department chair. May be repeated for credit.

MATH 404. Topics in Mathematical Logic (3)
Intensive study of topics in mathematical logic. Prerequisite: Consent of the department chair. May be repeated for credit.

MATH 405. Partial Differential Equations I (3) fall
Classification of partial differential equations; methods of characteristics for first order equations; methods for representing solutions of the potential, heat, and wave equations, and properties of the solutions of these equations; maximum principles. Prerequisite: MATH 302 or its equivalent.

MATH 406. Partial Differential Equations II (3) spring
Continuation of MATH 405. Emphasis on second order equations with variable coefficients and systems of first order partial differential equations. Prerequisite: MATH 405.

MATH 407. Theory and Technique of Optimization (3)
Linear programming: simplex and revised simplex methods, duality theory; unconstrained optimization by one-dimensional search methods; convexity and Kuhn-Tucker conditions, applications to methods for constrained optimization.

MATH 408. Algebraic Topology I (3)
Polyhedra; fundamental groups; simplicial and singular homology.

MATH 409.(STAT 409) Mathematics Seminar (1-6) fall
An intensive study of some field of mathematics not offered in another course. Prerequisite: consent of the department chair.

MATH 410.(STAT 408) Mathematics Seminar (1-6) spring
Continuation of the field of study in MATH 409 or the intensive study of a different field. Prerequisite: consent of the department chair.

MATH 416. Complex Function Theory (3) fall
Continuation of MATH 316. Prerequisite: MATH 316 or consent of the department chair.

MATH 421. Introduction to Wavelets (3)
Continuous and discrete signals; review of Fourier analysis; discrete wavelets; time-frequency spaces; Haar and Walsh systems; multiresolution analysis; Hilbert spaces; quadratic mirror filters; fast wavelet transforms; computer code; applications to filtering, compression, and imaging. Prerequisite: ECE 108, MATH 205, or consent of instructor.

MATH 423. Differential Geometry I (3)
Differential manifolds, tangent vectors and differentials, submanifolds and the implicit function theorem. Lie groups and Lie algebras, homogeneous spaces. Tensor and exterior algebras, tensor fields and differential forms, de Rham cohomology, Stokes' theorem, the Hodge theorem. Prerequisite: MATH 301, 302, or MATH 243 or MATH 205 with consent of instructor.

MATH 424. Differential Geometry II (3)
Curves and surfaces in Euclidean space; mean and Gaussian curvatures, covariant differentiation, parallelism, geodesics, Gauss-Bonnet formula. Riemannian metrics, connections, sectional curvature, generalized Gauss-Bonnet theorem. Further topics. Prerequisite: MATH 423.

MATH 428. Fields and Modules (3) spring
Field theory, including an introduction to Galois theory; the theory of modules, including tensor products and classical algebras. Prerequisite: MATH 327.

MATH 430. Numerical Analysis (3) spring
Multistep methods for ordinary differential equations; finite difference methods for partial differential equations; numerical approximation of functions. Use of computer required. Prerequisite: MATH 230 or consent of the department chair.

MATH 431. Calculus of Variations (3)
Existence of a relative minimum for single and multiple integral problems; variational inequalities of elliptic and parabolic types and methods of approximating a solution. Prerequisite: MATH 302 or its equivalent.

MATH 435. Functional Analysis I (3) fall
Banach spaces and linear operators; separation and extension theorems; open mapping and uniform boundedness principles; weak topologies; local convexity and duality; Banach algebras; spectral theory of operators; and compact operators. Prerequisites: MATH 307 and MATH 401.

MATH 444. Algebraic Topology II (3)
Continuation of MATH 408. Cohomology theory, products, duality. Prerequisite: MATH 408.

MATH 445. Topics in Algebraic Topology (3)
Selected topics reflecting the interests of the professor and the students. Prerequisite: MATH 444.

MATH 446. Combinatorics (3) fall
Fundamental combinatorial theories and modern techniques interconnecting these theories. Topics selected from: enumeration, Ramsey theory, extremal set theory, hypergraphs, structural and extremal graph theory, polyhedral combinatorics, designs and codes, matroids, ordered sets and lattices. Prerequisite: consent of instructor.

MATH 448. Combinatorics and Graph Theory (3) spring
Fundamental theories and techniques for graphs, ordered sets, hypergraphs, extremal set theory, and matroids. Topics are distinct from those of MATH 446, which is not a prerequisite for this course. Prerequisite: consent of instructor.

MATH 449. Topics in Algebra (3)
Intensive study of topics in algebra with emphasis on recent developments. Prerequisite: consent of the department chairman. May be repeated for credit with the consent of the department chair.

MATH 450. Special Topics (3) fall-spring
Intensive study of some field of the mathematical sciences not covered in listed courses. Prerequisite: consent of the department chair. May be repeated for credit with the consent of the department chair.

MATH 455. Topics in Number Theory (3)
Selected topics in algebraic and analytic number theory. Prerequisites: MATH 316 and MATH 327. May be repeated for credit with consent of the department chair.

MATH 461. (STAT 461) Topics in Mathematical Statistics (3)
An intensive study of one or more topics such as theory of statistical tests, statistical estimation, regression, analy-

sis of variance, nonparametric methods, stochastic approximation, and decision theory. Prerequisites: MATH 334 and MATH 401. May be repeated for credit with consent of the department chair.

MATH 462. (STAT 462) Nonparametric Statistics (3) fall
Order and rank statistics; tests based on runs, signs, ranks, and order statistics; chi-square and Kolmogorov-Smirnov tests for goodness of fit; the two-sample problem; confidence and tolerance intervals. Prerequisite: MATH 231 or 309.

MATH 463. (STAT 463) Advanced Probability (3)
Measure theoretic foundations; random variables, integration in a measure space, expectations; convergence of random variables and probability measures; conditional expectations; characteristic functions; sums of random variables, limit theorems. Prerequisites: MATH 309 and MATH 401.

MATH 464. (STAT 464) Advanced Stochastic Processes (3)
Theory of stochastic processes; stopping times; martingales; Markov processes; Brownian motion; Skorohod imbedding; Brownian bridge, laws of suprema; Gaussian processes. Prerequisites: MATH 309 and MATH 401.

MATH 467. Financial Calculus I (3) fall
Basic mathematical concepts behind derivative pricing and portfolio management of derivative securities. Development of hedging and pricing by arbitrage in the discrete time setting of binary trees and Black-Scholes model. Introduction to the theory of Stochastic Calculus, Martingale representation theorem, and change of measure. Applications of the developed theory to a variety of actual financial instruments. Prerequisites: Math 231 or Math 309 or consent of instructor.

MATH 468. Financial Calculus II (3) spring
Models and mathematical concepts behind the interest rates markets. Heath-Jarrow-Morton model for random evolution of the term structure of interest rates and short rate models. Applications of the theory to a variety of interest rates contracts including swaps, caps, floors, swap-options. Development of multidimensional stochastic calculus and applications to multiple stock models, quantos, and foreign currency interest-rate models. Prerequisites: Math 467.

MATH 470. Proseminar (3) spring
Preparation for entering the mathematics profession. Seminar will concentrate on methods of teaching mathematics, and will include other topics such as duties of a professor and searching for a job. Prerequisite: consent of mathematics graduate advisor.

MATH 471. Homological Algebra (3)
Modules, tensor products, categories and functions, homology functors, projective and injective modules. Prerequisite: MATH 428.

MATH 472. Group Representations (3)
Linear representations and character theory with emphasis on the finite and compact cases. Prerequisite: MATH 428 or consent of the department chairperson.

MATH 490. Thesis

MATH 499. Dissertation
Statistics

STAT 408. (MATH 410) Seminar in Statistics and Probability (1-6) spring
Intensive study of some field of statistics or probability not offered in another course. Prerequisite: consent of the graduate advisor.

STAT 409 (MATH 409) Seminar in Statistics and Probability (1-6) fall
Intensive study of some field of statistics or probability not offered in another course. Prerequisite: consent of the graduate advisor.

STAT 410. Random Processes and Applications (3) spring
See MATH 310.

STAT 412. Statistical Computing and Applications (3)
See MATH 312.

STAT 434. Mathematical Statistics (3) spring
See MATH 334.

STAT 438. Linear Models in Statistics (3) spring
See MATH 338

STAT 461 (MATH 461). Topics in Mathematical Statistics (3)
See MATH 461.

STAT 462 (MATH 462). Nonparametric Statistics (3)
See MATH 462.

STAT 463 (MATH 463). Advanced Probability (3)
See MATH 463.

STAT 464 (MATH 464). Advanced Stochastic Processes (3)
See MATH 464.

Mechanical Engineering and Mechanics

Professors. Herman F. Nied, Ph.D. (Lehigh), *chair*; Philip A. Blythe, Ph.D. (Manchester, England); John P. Coulter, Ph.D. (Delaware); Terry J. Delph, Ph.D. (Stanford); D. Gary Harlow, Ph.D. (Cornell); Ronald J. Hartranft, Ph.D. (Lehigh); Stanley H. Johnson, Ph.D. (Berkeley); Jacob Y. Kazakia, Ph.D. (Lehigh); Edward K. Levy, Sc.D. (M.I.T.), *director, Energy Research Center;* Alistair K. Macpherson, Ph.D. (Sydney, Australia); Sudhakar Neti, Ph.D. (Kentucky); John Ochs, Ph.D. (Penn State); Tulga M. Ozsoy, Ph.D. (Istanbul, Turkey); Donald O. Rockwell, Ph.D. (Lehigh), *Paul B. Reinhold Professor;* Kenneth N. Sawyers, Ph.D. (Brown); Charles R. Smith, Ph.D. (Stanford); Eric Varley, Ph.D. (Brown); Arkady Voloshin, Ph.D. (Tel-Aviv, Israel); Robert P. Wei, Ph.D. (Princeton), *Paul B. Reinhold Professor*.

Associate professors. Meng-Sang Chew, Ph.D. (Columbia); Joachim L. Grenestedt, Ph.D. (KTH, Royal Inst. of Tech., Stockholm, Sweden); Robert A. Lucas, Ph.D. (Lehigh), *associate chair*; Alparslan Öztekin, Ph.D. (Illinois); N. Duke Perreira, Ph.D. (California, Los Angeles).

Assistant Professors. Samir N. Ghadiali, Ph.D. (Tulane).

Emeritus professors. Russell E. Benner, Ph.D. (Lehigh); Forbes T. Brown, Sc.D. (M.I.T.); Fazil Erdogan, Ph.D. (Lehigh); Arturs Kalnins, Ph.D. (Michigan); Jerzy A. Owczarek, Ph.D. (London, England); Ronald S. Rivlin, Sc.D. (Cambridge); Richard Roberts, Ph.D. (Lehigh);

Robert G. Sarubbi, Ph.D. (Lehigh); George C.M. Sih, Ph.D. (Lehigh); Gerald F. Smith, Ph.D. (Brown); Theodore A. Terry, Ph.D. (Lehigh); Dean P. Updike, Ph.D. (Brown).

Educational Mission

The Department of Mechanical Engineering and Mechanics prepares our students to be learners, and agents in both the application and development of technology to better serve the needs of society.

Program Educational Objectives

Mechanical engineering is one of the core disciplines in the P.C. Rossin College of Engineering and Applied Science (RCEAS). The department is committed to serving the overall mission of the RCEAS, and of the University, by providing education and training to undergraduate and graduate students, by developing new knowledge and engineering methodology, and by providing service to industry and society at large. To achieve our Educational Mission, the Department of Mechanical Engineering has established a set of Program Educational Objectives, which are to educate engineers who can:

- Model, formulate and creatively synthesize (i.e design) realistic and practical systems, products, and environments;
- Naturally incorporate basic sciences and the art of mathematics as part of their thinking and problem-solving processes;
- Design, conduct, and analyze experimental tests of practical systems and products;
- Understand and appreciate the technical diversity required to develop new products/processes, and use this understanding to work effectively in multi-disciplinary teams;
- Develop an appreciation of the contemporary world, and be able to contribute to it in a professional and ethical manner;
- Learn how to learn, so that life-long learning becomes second nature.

In concert with these objectives, the academic program of the department seeks to prepare our students to adapt to the rapid advances and changes in technology, and to serve as agents and leaders in effecting these changes, while being cognizant of the needs and concerns of the society at large.

The undergraduate program in mechanical engineering focuses principally on the first five of these objectives, and is configured to prepare our students for employment, and continued professional development and growth. The program provides students with the basic education they will need to function in an engineering environment, pursue graduate studies, continue their professional development and growth, and develop an awareness of the culture and society in which we live. Because of technological innovations and the long-term demands of global competition, the program also seeks to prepare students to adapt to rapid advances and changes in technology, and to provide leadership in effecting these changes, consistent with the sixth educational objective for life-long learning.

Achievement of the six educational objectives is served first through a sound education in mathematics and those physical and engineering sciences that are of greatest relevance to the design and analysis of mechanical systems; second, by exposure to the engineering process (creation, innovation, analysis and judgment) through design courses, projects, laboratories, and a choice of technical electives that permits a degree of specialization; and third, by the development of cultural awareness through courses in humanities and social sciences. Students may take elective courses that transcend traditional disciplinary lines, while satisfying the basic requirements for mechanical engineering.

Design and engineering practices are integrated with the engineering science aspects of the program. Through a broadening of the design sequence to include hands-on manufacturing and multi-disciplinary collaborations, the program seeks to emphasize the integration of design, manufacturing, business, and aesthetics in modern technological enterprises, and to prepare our students to function in an increasingly interdisciplinary environment. Through a comprehensive set of laboratory courses, which ultimately focus on the design and planning of laboratory experiences by the students (rather than carrying out rote experiments), opportunities are provided for students to learn and employ the processes and skills for solving hands-on engineering problems.

B.S. in Mechanical Engineering

Mechanical engineering is one of the broadest of the engineering professions, dealing generally with systems for energy conversion, material transport and the control of motions and forces.

Mechanical engineers may choose from among many different activities in their careers, according to their interests and the changing needs of society. Some concentrate on the conversion of thermal, nuclear, solar, chemical and electrical energy, or on the problems of air, water, and noise pollution. Some concentrate on the design of mechanical systems used in transportation, manufacturing or health care industries or by individual consumers. Some will be working, a decade from now, in fields that do not yet exist. Most will be engaged with concepts involving all four dimensions of space and time.

The curriculum leading toward the bachelor of science in mechanical engineering combines a broad base in mathematics, physical sciences, and the engineering sciences (mechanics of solids, materials, dynamics and fluid, thermal and electrical sciences), including laboratory. Special emphasis is placed on the practice of modern *Integrated Product Development,* combining state-of-the-art computer-aided design and manufacturing methods in a business-oriented framework. Several specific application fields are chosen toward the end of the program in the form of four or more courses elected from a wide variety of 300-level offerings. Courses in mechanical engineering and engineering mechanics are equally available.

The course requirements for a B.S. degree in mechanical engineering are listed below. In addition to required mathematics, physics, chemistry and basic engineering courses, the program includes a minimum of seven courses in humanities and social sciences (see humanities/social sciences), two free electives and five approved electives. The total graduation requirement is 133 credits.

Undergraduate Curriculum in Mechanical Engineering

freshman year (see Engineering, freshman year, Section III)

sophomore year, first semester (16 - 18 credit hours)

ME 10	Graphics for Engineering Design (3)
ME 111	Professional Development (1)
MECH 2	Elementary Engineering Mechanics (3)
MAT 33	Engineering Materials and Processes (3)
MATH 23	Analytical Geometry & Calculus III (4)
	elective (2 - 4)

sophomore year, second semester (16 - 18 credit hours)*

ME 104	Thermodynamics I (3)
MECH 12	Strength of Materials (3)
PHY 21,22	Introductory Physics II and Laboratory (5)
MATH 205	Linear Methods (3)
	elective (2 - 4)

**Co-op students must take ME 21 this semester (17-19 credit hours). See below for Co-op program details.*

junior year, first semester (16 - 18 credit hours)

ME 21	Mechanical Engineering Lab I (1)
ME 231	Fluid Mechanics (3)
MECH 102	Dynamics (3)
ECE 81	Principles of Electrical Engineering (4)
ME 215	Engineering Reliability (3) or
MATH 208	Complex Variables (3) or
MATH 230	Numerical Methods (3) or
MATH 231	Probability and Statistics (3)
	elective (2 - 4)

junior year, second semester (16 - 18 credit hours)

ME 121	Mechanical Engineering Lab II (1)
ME 211	Mechanical Engineering Design I (3)
ME 240	Manufacturing (3)
ME 242	Mechanical Engineering Systems (3)
ME 252	Mechanical Elements (3)
ECE 162	Electrical Laboratory (1)
	elective (2 - 4)

senior year, first semester (16 - 18 credit hours)

ME 212	Mechanical Engineering Design II (2)
	Senior Laboratory (2)
	electives (12 - 14)

senior year, second semester (16 - 18 credit hours)

Senior Laboratory (2)
electives (14 - 16)
Senior Laboratories
Select two out of the following four courses:
ME 207, ME 208, ME 210, and ME 389.

The total number of credits required for graduation is 133. A total of 41 credits in electives must be taken. These electives are of six types:

Mechanical Engineering Electives

a) Humanities/Social Sciences: A total of 17 credits of electives in humanities and social science, which must include ECO 1. (Note that these electives are in addition to the 6 hours of required freshman English.) See description of HSS in Section III of this catalog.
b) ME 321 Introduction to Heat Transfer (3)
c) ENGR. Elective A: One, 3-credit course selected from the following: MECH 302, MECH 305, ME 304, ME 322, ME 331, or ME 343
d) ENGR. Elective B: One, 3-credit course selected from any ME 300 or MECH 300-level course, excluding ME 310
e) ENGR. Elective C: Three, 3-credit courses selected from any ME 300/MECH 300-level course or an engineering/science/mathematics course, as approved by the department chair. ME 310 may be taken once to satisfy this requirement.
f) Free electives: 6 credit hours in any subject area are required

Co-op Program

To participate in the Co-op program you must rank in the top third of the engineering class after three semesters of study and attend a summer program between the sophomore and junior years. See your advisor or contact the Co-op Faculty Liaison for further details.

B.S. in Engineering Mechanics

The curriculum in engineering mechanics is designed to prepare students for careers in engineering research and development, and is especially appropriate for students wishing to specialize in the analysis of engineering systems. In many industries and governmental laboratories there is a demand for men and women with broad training in the fundamentals of engineering in which engineering mechanics and applied mathematics play an important role.

The first two years of the curriculum is the same as that in mechanical engineering. One of the advantages of the curriculum is the flexibility it offers through 18 credits of technical and six credits of personal electives in the junior and senior years. Beyond the sophomore year there are required courses in dynamics, solid mechanics, fluid mechanics, heat transfer, principles of electrical engineering, mathematics, vibrations, and senior laboratories or projects. It is recommended that the electives be chosen either to concentrate in areas such as applied mathematics and computational mechanics, solid mechanics, engineering materials, and fluid mechanics or to obtain further depth in all areas. The academic advisor for the engineering mechanics program will provide guidance in formulating the student's goals and choosing electives.

In addition to the required and elective courses in mathematics, sciences and engineering, the B.S. degree program in engineering mechanics includes a minimum of seven courses in humanities and social sciences (see humanities/social sciences). The total graduation requirement is 131 credits.

Undergraduate Curriculum in Engineering Mechanics

freshman and sophomore years: same as ME curriculum

junior year, first semester (16 - 18 credit hours)

ME 21	Mechanical Engineering Lab I (1)
ME 231	Fluid Mechanics (3)
MECH 102	Dynamics (3)
ECE 81	Principles of Electrical Engineering (4)
MATH 230	Numerical Methods (3)
	elective (2 - 4)

junior year, second semester (16 - 18 credit hours)

ME 121	Mechanical Engineering Lab II (1)
ME 240	Manufacturing (3)
ME 242	Mechanical Engineering Systems (3)

ECE 162	Electrical Laboratory (1)	
MATH 208	Complex Variables (3)	
	electives (5 - 7)	

senior year, first semester (16 - 18 credit hours)
Senior Laboratory (2)
electives (14 - 16)

senior year, second semester (16 - 18 credit hours)
Senior Laboratory (2)
electives (14 - 16)

The total number of credits required for graduation is 131. A total of 44 credits in electives must be taken. These electives are of five types:

Engineering Mechanics Electives

a) Humanities/Social Sciences: A total of 17 credits of electives in humanities and social science, which must include ECO 1. (Note that these electives are in addition to the 6 hours of required freshman English.) See description of HSS in Section III of this catalog.
b) ME 321 Introduction to Heat Transfer (3)
c) ENGR. Mechanics Elective A: Two, 3-credit courses selected from the following: MECH 302, MECH 305, ME 304, ME 322, ME 331, or ME 343
d) ENGR. Mechanics Elective B: Four, 3-credit courses selected from any ME 300/MECH 300-level course or an engineering/science/mathematics course, as approved by the Department Chair
e) Free electives: 6 credit hours of any subject area are required. Typical recommended options:

Applied Mathematics and Computational Mechanics

MECH 305	Advanced Mechanics of Materials (3)
MECH 312	Finite Element Analysis (3)
MATH 309	Theory of Probability (3)
MATH 322	Methods of Applied Analysis I (3)
MATH 323	Methods of Applied Analysis II (3)

Solid Mechanics

MECH 305	Advanced Mechanics of Materials (3)
MECH 307	Mechanics of Continua (3)
MECH 312	Finite Element Analysis (3)
MECH 313	Fracture Mechanics (3)
MATH 322	Methods of Applied Analysis I (3)

Engineering Materials

MECH 305	Advanced Mechanics of Materials (3)
MECH 313	Fracture Mechanics (3)
MAT 218	Mechanical Behavior of Materials (3)
PHY 31	Introduction to Quantum Mechanics (3)
PHY 363	Physics of Solids (3)

Fluid Mechanics

ME 331	Advanced Fluid Mechanics (3)
ME 322	Gas Dynamics (3)
MECH 326	Aerodynamics (3)
MATH 322	Methods of Applied Analysis I (3)

Minor in Aerospace Engineering

The minor in aerospace engineering provides a foundation for students who intend to pursue a career in the aerospace industry. This minor will also provide sufficient technical background in aerospace studies for undergraduates who plan to enter graduate programs in this field. The minor requires a minimum of 17 credits from the following course selection:

Required Courses

MECH 326	Aerodynamics (3)
MECH 305	Advanced Mechanics of Materials (3)
ME 343	Control Systems (3)
MECH 328	Fundamentals of Aircraft Design (3)

Elective Courses

ME 322	Gas Dynamics (3)
ME 323	Reciprocating and Centrifugal Engines (3)
ME 331	Advanced Fluid Mechanics (3)
ME 389	Controls Laboratory (2)
MECH 312	Finite Element Analysis (3)
ME 348	Computer-Aided Design (3)
MAT 309	Composite Materials (3)

Undergraduate Courses in Mechanical Engineering

ME 10. Graphics for Engineering Design (3) fall
Graphical description of mechanical engineering design for visualization and communication by freehand sketching, production drawings, and 3-D solid geometric representations. Introduction to creation, storage, and manipulation of such graphical descriptions through an integrated design project using state-of-the art, commercially available computer-aided engineering software. Lectures and laboratory. (ES 1), (ED 2)

ME 21. Mechanical Engineering Laboratory I (1) fall, spring
Experimental methods in mechanical engineering and mechanics. Analysis of experimental error and error propagation. Introduction to elementary instrumentation. Introduction to digital data acquisition. Prerequisite: MECH 12, previously or concurrently. (ES 1), (ED 0)

ME 104. Thermodynamics I (3) fall, spring
Basic concepts and principles of thermodynamics with emphasis on simple compressible substances. First and second law development, energy equations, reversibility, entropy and efficiency. Properties of pure substances and thermodynamic cycles. Corequisites: MATH 23 and PHY 11. (ES 3), (ED 0)

ME 111. Professional Development (1) fall
Examination of ethical and professional choices facing mechanical engineers. Written and oral communications. Industrial field trips. (ES 0.5), (ED 0.5)

ME 121. Mechanical Engineering Laboratory II (1) fall, spring
A continuation of ME 21 including use of transducers, advanced instrumentation, and data acquisition. Emphasis on experimental exercises that illustrate, and/or introduce material from thermodynamics, and fluid mechanics. Includes proposal writing and interpretation of results. Prerequisites: ME 21, ME 104, and co-requisite: ME 231. (ES 1), (ED 0)

ME 207. Mechanical Engineering Laboratory III (2) fall
Formulation of laboratory experiments through open-ended planning, including decision criteria for laboratory techniques and approaches. Execution of experiments

based on individual plans, followed by assessment of experimental results. Prerequisite: ME 121. (ES 1), (ED 1)

ME 208. Mechanical Engineering Laboratory IV (2) spring
Formulation of laboratory experiments through open-ended planning, including decision criteria for laboratory techniques and approaches. Execution of experiments based on individual plans, followed by assessment of experimental results. Prerequisite ME 121. (ES 1), (ED 1)

ME 210. Laboratory Projects (1-2) fall, spring
Experimental work including planning, design and development of apparatus, data collection and analysis as it pertains to an engineering problem. Progress is reported in the form of several planning and project reports. Prerequisite: Department permission required. (ES 1), (ED 1)

ME 211. Integrated Product Development I (3) spring
Business, engineering and design arts students work in cross disciplinary teams of 4-6 students on conceptual design including marketing, financial and economic planning, economic and technical feasibility of new product concepts. Teams work on industrial projects with faculty advisors. Oral presentations and written reports. Prerequisites: ME 10, MECH 12, ME 104. (ES 0), (ED 3)

ME 212. Integrated Product Development II (2) fall
Business, engineering and design arts students work in cross disciplinary teams of 4-6 students on the detailed design including fabrication and testing of a prototype of the new product designed in the IPD course 1. Additional deliverables include a detailed production plan, marketing plan, detailed base-case financial models, project and product portfolio. Teams work on industrial projects with faculty advisors. Oral presentations and written reports. Prerequisites: ME 211, ME 252, (ME 252 may be taken concurrently). (ES 0) (ED 2)

ME 215. Engineering Reliability (3) fall, spring
Applications of reliability methods to engineering problems. Modeling and analysis of engineered components and systems subjected to environmental and loading conditions. Modeling content encompasses mechanistically based probability and experientially based statistical approaches. Concepts needed for design with uncertainty are developed. Principles are illustrated through case studies and projects. Engineering applications software will be extensively utilized for the projects. Prerequisites: MATH 23 or 33; MECH 12, previously or concurrently.

ME 231. Fluid Mechanics (3) fall, spring
Kinematics of fluid flow and similarity concepts. Equations of incompressible fluid flow with inviscid and viscous applications. Turbulence. One-dimensional compressible flow, shock waves. Boundary layers, separation, wakes and drag. Prerequisite: MATH 205. (ES 2.5), (ED 0.5)

ME 240. Manufacturing (3) spring
Analytical and technological base for several manufacturing processes and common engineering materials. Processes include metal cutting, metal deformation, injection molding, thermoforming, and composites. Process planning, computer-aided manufacturing, manufacturing system engineering, and quality measurements. Design project. Weekly laboratory. Prerequisites: ME 10, MAT 33, MECH 12. (ES 1.5), (ED 1.5)

ME 242. Mechanical Engineering Systems (3) fall, spring
The modeling and analysis of mechanical, fluid, electrical and hybrid systems, with emphasis on lumped models and dynamic behavior, including vibrations. Source-load synthesis. Analysis in temporal and frequency domains. Computer simulation of nonlinear models, and computer implementation of the superposition property of linear models. Prerequisites: MECH 102, MATH 205 and, previously or concurrently, ME 231. (ES 2), (ED 1)

ME 252. Mechanical Elements (3) fall, spring
Methods for the analysis and design of machine elements such as springs, gears, clutches, brakes, and bearings. Motion analysis of cams and selected mechanisms. Projects requiring the design of simple mechanisms of mechanical sub-assemblies. Prerequisites: MECH 12, ME 10 and MECH 102. (ES 1.5), (ED 1.5)

For Advanced Undergraduates and Graduate Students

ME 304. Thermodynamics II (3) fall, spring
Availability and Second Law Analysis. Design of gas and vapor power cycles, and refrigeration systems. Generalized property relations for gases and gas-vapor. Combustion and chemical equilibrium. Design of engineering systems and processes incorporating thermodynamic concepts and analysis. Prerequisite: ME 104. (ES 2), (ED 1)

ME 310. Directed Study (1-3) fall, spring
Project work on any aspect of engineering, performed either individually or as a member of a team made up of students, possibly from other disciplines. Project progress is reported in the form of several planning and project reports. Direction of the projects may be provided by faculty from several departments and could include interaction with outside consultants and local communities and industries. Prerequisite: Department permission required. (ES 1), (ED 2)

ME 312. Synthesis of Mechanisms (3) fall
Geometry and constrained plane motion with application to linkage design. Type of number synthesis. Comparison of motion analysis by graphical, analytical and computer techniques. Euler-Savary and related curvature techniques as applied to cam, gear and linkage systems. Introduction to the analysis of space mechanisms. Prerequisites: MATH 205, MECH 102. Chew. (ES 1), (ED 2)

ME 321. Introduction to Heat Transfer (3) fall, spring
Analytical and numerical solutions to steady and transient one- and two-dimensional conduction problems. Forced and natural convection in internal and external flows. Thermal radiation. Thermal design of engineering processes and systems. Prerequisites: ME 104, ME 231. Neti, Blythe, MacPherson. (ES 2), (ED 1)

ME 322. Gas Dynamics (3) spring
Flow equations for compressible fluids; thermodynamic properties of gases. Normal shock waves. Steady one-dimensional flows with heat addition and friction. Oblique shock waves. Expansion waves. Nozzle flows. Shock tubes; performance calculations and design. Supersonic wind tunnels; diffuser design. Real gas effects. Prerequisites: ME 231, ME 104, MATH 205. Blythe. (ES 2.5), (ED 0.5)

ME 323. Reciprocating and Centrifugal Engines (3) fall
Thermal analysis and design of internal combustion engines (conventional and unconventional), gas turbine engines, air breathing jet engines, and rockets. Components such as jet nozzles, compressors, turbines, and combustion chambers are chosen to exemplify the theory and development of different types of components. Both ideal fluid and real fluid approaches are considered. Prerequisite: ME 104. (ES 2.5), (ED 0.5)

ME 331. Advanced Fluid Mechanics (3) fall
Kinematics of fluid flow. Conservation equations for inviscid and viscous flows; integral forms of equations. Two-dimensional potential flow theory of incompressible fluids with applications. Boundary layers. Introduction to free shear layer and boundary layer stability and structure of turbulence. Transition from laminar to turbulent boundary layers. Separation of flow. Steady and unsteady stall. Secondary flows. Hydrodynamic lubrication. Measurement techniques. Prerequisite: ME 231 or equivalent. Varley. (ES 2.5), (ED 0.5)

ME 340. Advanced Mechanical Design (3) fall
Probabilistic design of mechanical components and systems. Reliability functions, hazard models and product life prediction. Theoretical stress-strength-time models. Static and dynamic reliability models. Optimum design of mechanical systems for reliability objectives or constraints. Prerequisite: MATH 231 or consent of instructor. Harlow. (ES 2), (ED 1)

ME 341. Mechanical Systems (3) spring
Advanced topics in mechanical systems design. Kinematics and dynamics of planar machinery. Shock and vibration control in machine elements. Balancing of rotating and reciprocating machines. Design projects using commercial computer-aided-engineering software for the design and evaluation of typical machine systems. Prerequisite: ME 252. Lucas. (ES 1.5), (ED 1.5)

ME 342. Dynamics of Engineering Systems (3) spring
Dynamic analysis of mechanical, electro-mechanical, fluid and hybrid engineering systems with emphasis on the modeling process. Lumped and distributed-parameter models. Use of computer tools for modeling, design and simulation. Design projects. Prerequisite: ME 242. (ES 2), (ED 1)

ME 343. Control Systems (3) fall
Linear analyses of mechanical, hydraulic and electrical feedback control systems by root locus and frequency response techniques. A design project provides experience with practical issues and tradeoffs. Prerequisite: ME 242 or ECE 125. Johnson. (ES 2), (ED 1)

ME 344 (IE 344, MAT 344) Metal Machining Analysis (3) spring
Intensive study of metal cutting emphasizing forces, energy, temperature, tool materials, tool life, and surface integrity. Abrasive processes. Laboratory and project work. Prerequisite: ME 240 or IE 215 or MAT 206.

ME 348. Computer-Aided Design (3) spring
Impact of computer-aided engineering tools on mechanical design and analysis. Part geometry modeling and assembly modeling using solid representations. Analysis for mass properties, interference, kinematics, displacements, stresses and system dynamics by using state-of-the-art commercially available computer-aided-engineering software. Integrated design projects. Two one-hour lectures and two-hour lab per week. Prerequisites: ME 10, ME 252, ME 242. Lucas, Ozsoy. (ES 1), (ED 2)

ME 350. Special Topics (1-4)
A study of some field of mechanical engineering not covered elsewhere. Prerequisite: consent of the department chair. (ES 1), (ED 2)

ME 360. (CHE 360) Nuclear Reactor Engineering (3) spring
A consideration of the engineering problems related to nuclear reactor design and operation. Topics include fundamental properties of atomic and nuclear radiation, reactor fuels and materials, reactor design and operation, thermal aspects, safety and shielding, instrumentation and control. Course includes several design projects stressing the major topics in the course. Prerequisite: Senior standing in engineering or physical science. Neti. (ES 2), (ED 1)

ME 387. (CHE 387, ECE 387) Digital Control (3) spring
Sampled-data systems; z-transforms; pulse transfer functions; stability in the z-plane; root locus and frequency response design methods; minimal prototype design; digital control hardware; discrete state variables; state transition matrix; Liapunov stability state feedback control (two lectures and one laboratory per week). Prerequisite: CHE 386 or ECE 212 or ME 343 or consent of instructor. Luyben.(ES 3), (ED 0)

ME 389. (ECE 389, CHE 389) Control Systems Laboratory (2) spring
Experiments on a variety of mechanical, electrical and chemical dynamic control systems. Exposure to state-of-the-art control instrumentation: sensors, transmitters, control valves, analog and digital controllers. Emphasis on design of feedback controllers and comparison of theoretical computer simulation predictions with actual experimental data. Lab teams will be interdisciplinary. Prerequisites: Either CHE 386, ME 343, or ECE 212. Johnson. (ES 1), (ED 1)

Undergraduate Courses in Engineering Mechanics

MECH 2. Elementary Engineering Mechanics (3) fall, spring
Static equilibrium of particles and rigid bodies. Analysis of simple truss and frame structures, internal forces, stress, strain, and Hooke's Law; torsion of circular shafts; pure bending of beams. Prerequisites: MATH 22 and Phys 11. (MATH 22 may be taken concurrently). (ES 2.5), (ED 0.5)

MECH 12. Strength of Materials (3) fall, spring
Transverse shear in beams. Mohr's circle for stress. Plastic yield criteria. Deflection of beams. Introduction to numerical analysis of simple structures. Fatigue and fracture. Column buckling. Stresses in thick-walled cylinders. Prerequisites: MECH 2 and MATH 23. (MATH 23 may be taken concurrently). (ES 2), (ED 1)

MECH 102. Dynamics (3) fall, spring
Particle dynamics, work-energy, impulse-momentum, impact, systems of particles; kinematics of rigid bodies, kinetics of rigid bodies in plane motion, energy, momentum, eccentric impact. Prerequisites: MECH 2 and MATH 23. (ES 3), (ED 0)

MECH 103. Principles of Mechanics (4)
Composition and resolution of forces; equivalent force systems; equilibrium of particles and rigid bodies; friction. Kinematics and kinetics of particles and rigid bodies; relative motion; work and energy; impulse and momentum. Prerequisites: MATH 23 and Phys 11. (ES 4), (ED 0)

For Advanced Undergraduates and Graduate Students

MECH 302. Advanced Dynamics (3) spring
Fundamental dynamic theorems and their application to the study of the motion of particles and rigid bodies, with particular emphasis on three-dimensional motion. Use of generalized coordinates; Lagrange's equations and their applications. Prerequisites: MECH 102 or 103; MATH 205. Johnson, Perreira (ES 3), (ED 0)

MECH 305. Advanced Mechanics of Materials (3) fall
Strength, stiffness, and stability of mechanical components and structures. Fundamental principles of stress analysis: three-dimensional stress and strain transformations, two-dimensional elasticity, contact stresses, stress concentrations, energy and variational methods. Stresses and deformations for rotating shafts, thermal stresses in thick-walled cylinders, curved beams, torsion of prismatic bars, and bending of plates. Projects relate analysis to engineering design. Prerequisites: MECH 12, MATH 205. Nied. (ES 2.5), (ED 0.5)

MECH 307. Mechanics of Continua (3)
Fundamental principles of the mechanics of deformable bodies. Study of stress, velocity and acceleration fields. Compatibility equations, conservation laws. Applications to two-dimensional problems in finite elasticity, plasticity, and viscous flows. Prerequisite: MECH 305. Varley. (ES 3), (ED 0)

MECH 312. Finite Element Analysis (3) spring
Basic concepts of analyzing general media (solids, fluids, heat transfer, etc.) with complicated boundaries. Emphasis on mechanical elements and structures. Element stiffness matrices by minimum potential energy. Isoparametric elements. Commercial software packages (ABAQUS, NISA) are used. In addition, students develop and use their own finite element codes. Applications to design. Prerequisite: MECH 12. (ES 1.5), (ED 1.5)

MECH 313. Fracture Mechanics (3) spring
Fracture mechanics as a foundation for design against or facilitation of fracture. Fracture behavior of solids; fracture criteria; stress analysis of cracks; subcritical crack growth, including chemical and thermal effects; fracture design and control, and life prediction methodologies. Prerequisites: MECH 12, MATH 205, or approval of department. Nied, Wei. (ES 2), (ED 1)

MECH 326. Aerodynamics (3) spring
Application of fluid dynamics to flows past lifting surfaces. Normal force calculations in inviscid flows. Use of conformal mappings in two-dimensional airfoil theory. Kutta condition at a trailing edge; physical basis. Viscous boundary layers. Thin airfoil theory. Section design; pressure profiles and separation. Lifting line theory. Compressible subsonic flows; Prandtl-Glauert Rule. Airfoil performance at supersonic speeds. Prerequisites: ME 231 and MATH 208. Blythe, Varley. (ES 2.5), (ED 0.5)

MECH 328. Fundamentals of Aircraft Design (3) spring
Review of aerodynamics; Weight and balance, stability, loads; Basics of propellers; Power and performance; International Standard Atmosphere; Introduction to aerospace composites; Introduction to FAA regulations. Prerequisite: MECH 12. Grenestedt.

MECH 350. Special Topics (3)
A study of some field of engineering mechanics not covered elsewhere. Prerequisite: consent of the department chair.

Graduate Programs

The department offers programs of study leading to the degrees of master of science, master of engineering, and doctor of philosophy in mechanical engineering and computational and engineering mechanics.

Subject to approval, courses from other engineering curricula, such as materials science and engineering, and chemical, electrical, and industrial engineering, together with courses in mathematics and engineering mathematics, may be included in the degree program.

Master of Science in Mechanical Engineering

The M.S. in mechanical engineering requires 24 credit hours of courses and six credit hours of research, which culminates in a thesis. Core courses that must be taken are: ME 442, Mathematical Methods in Engineering I; and either ME 443, Mathematical Methods in Engineering II or ME 413, Numerical Methods in Mechanical Engineering. In addition, three of the following courses must be taken: ME 423, Heat and Mass Transfer; ME 430, Advanced Fluid Mechanics; MECH 408, Introduction to Elasticity; MECH 425, Analytical Methods in Dynamics and Vibrations; and either ME 401, Product Development, or ME 402, Manufacturing. Candidates must also complete a professional quality poster and make a contribution to the department's web page based on their thesis research.

Master of Engineering in Mechanical Engineering

The M.Eng. requires 30 credit hours of graduate work. Audit credits may not be used toward the degree. At least 18 credit hours of courses must be at the 400-level, and 15 of these must be in mechanical engineering and mechanics. At least 18 credit hours of courses must be in mechanical engineering and mechanics, and at least 24 credit hours must be at the 300- or 400-level. No course in mechanical engineering and mechanics below the 300-level may be used towards the M.Eng., but two courses (6 credits) outside the department that are below the 300-level may apply, with approval from a student's advisor and the departmental Graduate Committee.

Master of Science in Computational and Engineering Mechanics

All students pursuing a master's degree in computational and engineering mechanics must take a minimum of 30 credit hours of graduate level work, with not less than 24 of these hours being at the 400 level. Their program must include the following three required courses:

Mathematical Methods I & II	PHYS 428 & 429 or ME 442 & ME 443
Numerical Methods	ME 413

In addition they must take two of the four MEM core courses:

Heat and Mass Transfer	ME 423

Advanced Fluid Mechanics	ME 430
Introduction to Elasticity	MECH 408
Analyt. Meth. In Dynamics & Vibs.	MECH 425

The remaining 15 credits may be taken from any of the graduate courses in MEM and other approved electives. Both thesis and non-thesis options are available.

Doctor of Philosophy in Mechanical Engineering

The Ph.D. program in Mechanical Engineering requires innovative research in collaboration with one or more faculty members, along with the completion of 72 credit hours beyond the bachelor's degree, or 48 beyond the master's, including the core courses. Students entering the program with an exceptional record in the M.S. in mechanical engineering may apply for partial waiver of the core course requirement for purposes of the Ph.D. qualifying examination. Additional course work is determined in consultation with the student's adviser and doctoral committee. Students are admitted to Ph.D. candidacy in mechanical engineering upon attainment of a minimum GPA of 3.35 in five core courses (see core course requirements for Master of Science in Mechanical Engineering) and completion of a General Examination, which is based on assessment and presentation of a research topic. Formal University candidacy for the Ph.D. is granted upon recommendation of the doctoral committee and approval by the engineering college. To complete the Ph.D. degree, the student must present and defend a dissertation before the doctoral committee.

Doctor of Philosophy in Computational and Engineering Mechanics

Students wishing to pursue a Ph.D. in computational and engineering mechanics must take the required core courses:

Mathematical Methods I & II	PHYS 428 & 429 or ME 442 & 443
Numerical Methods	ME 413

They must also take two core courses from the supplemental list given below:

Asymptotic Methods	MECH 419
Integral Equations	EMA 450
Finite Element Methods	MECH 418
Non-deterministic Models in Engr.	MECH 445
Mechanical Reliability	ME 446
Heat and Mass Transfer	ME 423*
Advanced Fluid Mechanics	ME 430*
Introduction to Elasticity	MECH 408*
Analyt. Meth. in Dynamics & Vibs.	MECH 425*

A student must attain a GPA of 3.35 for the five required courses taken. All students who satisfy the GPA requirement will be required to take a three-hour written examination in an area (special topic) of the student's choice. This topic is subject to approval by the computational and engineering mechanics graduate committee. For students who start in the program following their bachelor's degree, the written examination must be taken no later than the beginning of the fourth semester after entry. A student who fails the written examination will be allowed a single retake. The retake examination will be given at the end of the semester in which the examination was first attempted.

In addition, before completion of the degree, a student must have received graduate credit for at least two of the four MEM core courses which are designated by a * in the above list. If desired, these starred courses may be used as part of the Computational and engineering mechanics core, and hence count towards the core GPA requirement.

Research Facilities

The department has a wide range of computational, computer graphics and experimental systems. The department's CAD Lab has over 50 computers that include high-end engineering workstations. The university supports networks of hundreds of PCs as well as links to the Internet with thousands of on-line services.

Experimental facilities include 11 pulsed and continuous laser units for laser diagnostics in the areas of fluid and solid mechanics, four image processing systems, and a number of unique facilities for observing and controlling flow past surfaces and through machines. There are well-equipped laboratories for multi-disciplinary studies of crack growth in deleterious environments and at elevated temperatures of up to 700°C, in conjunction with a number of surface analysis and electron microscopy facilities on campus.

Extensively equipped, interdepartmental robotics controls, and manufacturing laboratories are also available.

Other facilities include the latest mechanical, electrodynamic and servocontrolled hydraulic testing machines, photoelastic equipment, and Moire strain measuring instruments.

Recent Research Activities

Continuum and Solid Mechanics. Formulation of field equations and constitutive equations in non-linear elasticity theories; mechanics of viscoelastic solids and fluids, plasticity theory; generalized continuum mechanics; thermomechanical and electromechanical interactions; analyses and modeling of manufacturing processes; free vibration and dynamic response of elastic shells, elastic-plastic deformation of shells upon cyclic thermal loading, and applications of shell analysis to nuclear power plant components; optical stress analysis; biomechanics of gait; wave propagation; finite amplitude wave propagation.

Fracture Mechanics. Stress analysis of materials containing defects, including viscoelastic, non-homogeneous, and anisotropic materials; analytical and experimental studies and modeling of crack growth under static, periodic, and random loadings and environmental effects; optimizations of fracture control; crack propagation theories for nonlinear material; influence of cracks on the strength of structural members and of interfaces; hydraulic fracture; applications to reliability and durability of composites, structural and microelectronic components, and to processes for resource recovery.

Thermofluids. Structure of turbulent boundary layers, wakes and jets; vortex-solid boundary interactions; boundary layers in compressible flow, including hypersonic regimes; vortex breakdown in internal machinery and in flow past wings; drag reduction in turbulent flows; flow-induced noise and vibration; flutter of blades in axial-flow turbomachinery and of tails and fins on aircraft; unsteady aerodynamic flows past three-dimensional wings and bodies; flow structure and heat transfer at end-wall junctions in rotating machinery and on surfaces of aircraft; flows in micro-hydro-electromechanical systems; convective heat transfer in systems of electronic components; flows through complex components of power generation systems; transport of coal particles; flow and heat transfer in fluidized beds; cycle analysis applied to coal gasifiers; control optimization of heat pumps; laser-Doppler and particle image velocimetry; liquid crystal sensors for heat transfer; Raman spectral techniques applied to two-phase flow; laser diagnostics and image processing of complex flow and heat transfer systems.

Theoretical Fluid Mechanics. Vortex boundary layer interaction, modeling of turbulent boundary layers; geophysical flows such as frontal systems and mountain flows; statistical mechanics of plasmas, liquids and shock waves; finite amplitude waves in stratified gases and liquids; shock wave propagation; non-Newtonian flows in flexible tubes with application to hemorheology; magneto-fluid mechanics; wing theory; thermally driven flows.

Design. Geometric modeling; tolerance analysis and synthesis; assembly modeling; geometric dimensioning and tolerancing; 3-D digitizing; data and information structures; design for manufacturing; design methodology, tools and practices; expert systems in design; industry projects with Integrated Product Development (IPD) focus.

Manufacturing. Free-form surface machining; coordinate measuring machine applications to geometric dimensions and tolerances; Taguchi's method; injection molding; sheet metal fabrication; FEA/FEM applications to plastic deformation of metals; rapid prototyping; intelligent manufacturing incorporating process modeling, sensor subsystems for in situ product quality monitoring, and knowledge-based control for real-time process adaptation; blow molding; composites processing; thermoforming; resin transfer molding; spin coating; electronic packaging.

Systems Dynamics and Controls. Modeling, simulation and control of dynamic systems including: control of unstable processes, programmed logic control experience, compensator design and construction, issues in digital implementation, state-of-the-industrial art experimental equipment, energy methods and bond graph modeling, methods of model identification from experimental data; application to various mechanisms, vehicles, chemical processes, aircraft systems, chemical processes, hydraulic systems, thermodynamic systems, microelectromechanical actuators; application to mechatronics for the integration of mechanical systems, computer control and programming for the design of smart consumer products and intelligent manufacturing machinery.

Stochastic Processes. Modeling of random behavior in mechanical systems; static and time-dependent stochastic fracture mechanics, with particular applications to assessments of reliability and service life prediction.

Engineering Mathematics. General research areas within the division include: Analytical and numerical methods for the solution of ordinary and partial differential equations; industrial applications. Asymptotic methods. Finite element techniques. Wavelets. Non-linear studies; stability and bifurcation. Navier-Stokes equations; boundary layer theory; turbulence modelling. Non-Newtonian fluids; viscometric flows; materials processing. Geophysical flows. Wave propagation; solitons. Combustion phenomena. Continuum mechanics; large deformation analyses; buckling; fracture mechanics. Thermoelasticity. Applied probability and stochastic processes; stochastic differential equations. Statistical mechanics.

Graduate Courses in Mechanical Engineering

Except for core courses, graduate courses are generally offered every third semester. Several courses are offered each year as ME 450 Special Topics. For details, contact the graduate office of the department.

ME 401. Integrated Product Development (IPD) (3) fall

An integrated and interdisciplinary approach to engineering design, concurrent engineering, design for manufacturing, industrial design and the business of new product development. Topics include design methods, philosophy and practice, the role of modeling and simulation, decision making, risk, cost, material and manufacturing process selection, platform and modular design, mass customization, quality, planning and scheduling, business issues, teamwork, group dynamics, creativity and innovation. The course uses case studies and team projects with international partners. Ochs

ME 402. Advanced Manufacturing Science (3) spring

The course focuses on the fundamental science-base underlying manufacturing processes, and applying that science base to develop knowledge and tools suitable for industrial utilization. Selected manufacturing processes representing the general classes of material removal, material deformation, material phase change, material flow, and material joining are addressed. Students create computer-based process simulation tools independently as well as utilize leading commercial process simulation packages. Laboratory experiences are included throughout the course. Coulter/Nied

ME 411. Boundary-Layer Theory (3)

The course is intended as a first graduate course in viscous flow. An introduction to boundary-layer theory, thermodynamics and heat transfer at the undergraduate level are assumed to have been completed. Topics include the fundamental equation of continuum fluid mechanics, the concept of asymptotic methods and low and high Reynolds number flows, laminar boundary layers, generalized similarity methods, two-and three-dimensional flows, steady and unsteady flows and an introduction to hydrodynamic stability. The material is covered in the context of providing a logical basis as an introduction to a further course in turbulent flows.

ME 413. Numerical Methods in Mechanical Engineering (3)

Zeros of functions, difference tables, interpolation, integration, differentiation. Divided differences, numerical solution of ordinary differential equations of the boundary and initial value type. Eigen problems. Curve fitting, matrix manipulation and solution of linear algebraic equations. Partial differential equations of the hyperbolic, elliptic and parabolic type. Application to problems in mechanical engineering.

ME 415. Flow-Induced Vibrations (3)

Excitation of streamlined- and bluff-bodies by self-flutter, vortex, turbulence, and gust-excitation mechanisms. Analogous excitation of fluid (compressible- and free-surface) systems having rigid boundaries. Extensive case studies. Rockwell

ME 420. Advanced Thermodynamics (3)
Critical review of thermodynamics systems. Criteria for equilibrium. Applications to electromagnetic systems. Statistical thermodynamics. Irreversible thermodynamics. Thermoelectric phenomena. Levy

ME 421. Topics in Thermodynamics (3)
Emphasis on theoretical and experimental treatment of combustion processes including dissociation, flame temperature calculations, diffusion flames, stability and propagation; related problems in compressible flow involving one-dimensional, oblique shock waves and detonation waves. Methods of measurement and instrumentation. Staff

ME 423. Heat and Mass Transfer (3) spring
This course is a first graduate course in the basic concepts of heat and mass transfer, providing a broad coverage of key areas in diffusion, conduction, convection, heat and mass transfer, and radiation. Topics covered include: the conservation equations, steady and transient diffusion and conduction, periodic diffusion, melting and solidification problems, numerical methods, turbulent convection, transpiration and film cooling, free convection, heat transfer with phase change, heat exchanges, radiation, mixed mode heat and mass transfer. Neti, Öztekin

ME 424. Unstable and Turbulent Flow (3)
Stability of laminar flow; transition to turbulence. Navier-Stokes equations with turbulence. Bounded turbulent shear flows; free shear flows; statistical description of turbulence. Prerequisite: ME 331. Rockwell

ME 426. Radiative and Conductive Heat Transfer (3)
Principles of radiative transfer; thermal-radiative properties of diffuse and specular surfaces; radiative exchange between bodies; radiative transport through absorbing, emitting and scattering media. Advanced topics in steady-state and transient conduction; analytical and numerical solutions; problems of combined conductive and radiative heat transfer. Prerequisite: ME 321 or CHE 421. Varley

ME 427. (CHE 427) Multiphase Flow and Heat Transfer (3)
Heat transfer and fluid dynamics of multiphase systems. Subcooled, nucleate, and film boiling; bubble nucleation; dynamics of bubble growth and collapse; vapor-liquid cocurrent flow regimes; two-phase pressure drop and momentum exchange, low instabilities; convective-flow boiling; simultaneous heat and mass transfer. Prerequisite: ME 321 or CHE 421. Chen

ME 428. Boundary Layers and Convective Heat Transfer (3)
Navier-Stokes and energy equations, laminar boundary layer theory, analysis of friction drag, transfer and separation. Transition from laminar to turbulent flow. Turbulent boundary layer theory. Prandtl mixing length, turbulent friction drag, and heat transfer. Integral methods. Flow in ducts, wakes and jets. Natural convection heat transfer. Prerequisite: ME 331 or ME 321. Levy

ME 430. Advanced Fluid Mechanics (3) fall
This course is a first graduate course in incompressible fluid mechanics, providing a broad coverage of key areas of viscous and inviscid fluid mechanics. Topics covered include: Flow kinematics, differential equations of motion, viscous and inviscid solutions, vorticity dynamics and circulation, vorticity equation, circulation theorems, potential flow behavior, irrotational and rotational flows, simple boundary layer flows and solutions, and real fluid flows and consequences. Smith, Rockwell

ME 431. Advanced Gas Dynamics (3)
Method of characteristics. Unsteady continuous flow. Unsteady flows with discontinuities. Shock tubes. Detonation waves. Two-dimensional and axisymmetric supersonic flows. Momentum and energy equation of compressible viscous fluids. Prerequisite: ME 322. Blythe

ME 433. (CHE 433, ECE 433) State Space Control (3)
State-space methods of feedback control system design and design optimization for invariant and time-varying deterministic, continuous systems; pole positioning, observability, controllability, modal control, observer design, the theory of optimal processes and Pontryagin's Maximum principle, the linear quadratic optimal regulator problem, Lyapunov functions and stability theorems, linear optimal open loop control; introduction to the calculus of variations; introduction to the control of distributed parameter systems. Intended for engineers with a variety of backgrounds. Examples will be drawn from mechanical, electrical and chemical engineering applications. Prerequisite: ME 343 or ECE 212 or CHE 386 or consent of instructor. Johnson

ME 434. (CHE 434, ECE 434) Multivariable Process Control (3)
A state-of-the-art review of multivariable methods of interest to process control applications. Design techniques examined include loop interaction analysis, frequency domain methods (Inverse Nyquist Array, Characteristic Loci and Singular Value Decomposition) feed forward control, internal model control and dynamic matrix control. Special attention is placed on the interaction of process design and process control. Most of the above methods are used to compare the relative performance of intensive and extensive variable control structures. Prerequisite: CHE 433 or ME 433 or ECE 433 or consent of instructor.

ME 436. (CHE 436, ECE 436) Systems Identification (3)
The determination of model parameters from time-history and frequency response data by graphical, deterministic and stochastic methods. Examples and exercises taken from process industries, communications and aerospace testing. Regression, quasilinearization and invariant-imbedding techniques for nonlinear system parameter identification included. Prerequisite: CHE 433 or ME 433 or ECE 433 or consent of instructor. Johnson

ME 437. (CHE 437, ECE 437) Stochastic Control (3)
Linear and nonlinear models for stochastic systems. Controllability and observability. Minimum variance state estimation. Linear quadratic Gausian control problem. Computational considerations. Nonlinear control problem in stochastic systems. Prerequisite: CHE 433 or ME 433 or ECE 433 or consent of instructor. Staff

ME 442. Mathematical Methods in Engineering I (3) fall
Analytical techniques are developed for the solution of engineering problems described by algebraic systems, and by ordinary and partial differential equations. Topics covered include: linear vector spaces; eigenvalues, eigenvectors, and eigenfunctions. First and higher-order

linear differential equations with initial and boundary conditions; Sturm-Liouville problems; Green's function. Special functions; Bessel, etc. Qualitative and quantitative methods for nonlinear ordinary differential equations; phase plane. Solutions of classical partial differential equations from the physical sciences; transform techniques; method of characteristics.

ME 443. Mathematical Methods in Engineering II (3) spring
Continuation of ME 442.

ME 444. Experimental Stress Analysis in Design (3)
Fundamental concepts of strain measurements and application of strain gages and strain gage circuits. Two- and three-dimensional photoelasticity, stress separation techniques, birefringent coatings, moiré methods, caustics. Use of image analysis in data acquisition and interpretation. Selected laboratory experiments. Voloshin

ME 446. Mechanical Reliability (3)
Design of mechanical engineering systems to reliability specifications. Probabilistic failure models for mechanical components. Methods for the analysis and improvement of system reliability. Effect of component tolerance and parameter variation on system failure. Reliability testing. Prerequisite: MATH 231 or MATH 309. Harlow

ME 450. Special Topics (3)
An intensive study of some field of mechanical engineering not covered in more general courses.

ME 451. Seminar (1-3)
Critical discussion of recent advances in mechanical engineering.

ME 458. Modeling of Dynamic Systems (3)
Modeling of complex linear and nonlinear energetic dynamic engineering systems. Emphasis on subdivision into multiport elements and representation by the bond-graph language using direct, energetic, and experimental methods. Field lumping. Analytical and graphical reductions. Simulation and other numerical methods. Examples including mechanisms, electromechanical transducers, electric and fluid circuits, and thermal systems. Johnson

ME 460. Engineering Project (1-6)
Project work on some aspect of mechanical engineering in an area of student and faculty interest. Selection and direction of the project could involve interaction with local communities or industries. Prerequisite: consent of the department chair.

ME 461. IPD: Design (3)
Industry sponsored Integrated Product Development Project (IPD) projects. The student works with an industry sponsor to do a technical and economic feasibility study of new product development. Selection and content of the project is determined by the faculty project advisor in consultation with the industry sponsor. Deliverables include progress and final reports, oral presentations and posters. Prerequisites: Consent of the department chair and faculty project advisor.

ME 462. IPD: Manufacturing (3)
Industry sponsored Integrated Product Development Project (IPD) projects. The student works with an industry sponsor to create detailed design specifications, fabricate and test a prototype new product and plan for production. Selection and content of the project is determined by the faculty project advisor in consultation with the industry sponsor. Deliverables include progress and final reports, oral presentations, posters and a prototype. Prerequisites: Consent of the department chair and faculty project advisor.

ME 464. Computer-Aided Geometric Modeling (3)
Representation schemes for geometric modeling, computational geometry for curve and surface design, finite-element meshing and NC tool path generation, interfacing different CAD/CAM databases, interactive computer graphics programming. Prerequisite: ME 348 or consent of instructor. Ozsoy

ME 466. Fundamentals of Acoustics (3)
Vibration-induced acoustic radiation, wave equation in planar, cylindrical and spherical coordinates. Sound in tubes, pipes, wave guides, acoustic enclosures. Impedance and source-media-receiver transmission concepts. Noise and its measurements. Ochs

ME 490. Thesis

ME 499. Dissertation

Graduate Courses in Engineering Mechanics

Except for core courses, graduate courses are generally offered every third semester.

MECH 407. Wave Propagation in Solids (3)
Wave propagation in deformable elastic solids; problems in half-space and layered media; application of integral transformations. Delph, Varley

MECH 408. Introduction to Elasticity (3) fall
This course is a first graduate course in solid mechanics. It addresses: kinematics and statics of deformable elastic solids; compatibility, equilibrium and constitutive equations; problems in plane elasticity and torsion; energy principles, approximate methods and applications. Staff

MECH 410. Theory of Elasticity II (3)
Advanced topics in the theory of elasticity. The subject matter may vary from year to year and may include, theory of potential functions, linear thermoelasticity, dynamics of deformable media, integral transforms and complex-variable methods in classical elasticity. Problems of boundary layer type in elasticity; current developments on the micro-structure theory of elasticity. Prerequisites: MECH 409, MATH 208, or consent of the department chair.

MECH 411. (PHY 471) Continuum Mechanics (3)
An introduction to the continuum theories of the mechanics of solids and fluids. This includes a discussion of the mechanical and thermodynamical bases of the subject, as well as the use of invariance principles in formulating constitutive equations. Applications of the theories to specific problems are given. Staff

MECH 413. Fracture Mechanics (3)
Elementary and advanced fracture mechanics concepts; analytical modeling; fracture toughness concept; fracture toughness testing; calculation of stress intensity factors; elastic-plastic analysis; prediction of crack trajectory; fatigue crack growth and environmental effects; computational methods in fracture mechanics; nonlinear fracture mechanics; fracture of composite structures; application of fracture mechanics to design. Prerequisites: MATH 205, MECH 305 or equivalent course in advanced mechanics of materials. Nied, Wei

MECH 415. (CE 468) Stability of Elastic Structures (3)
Basic concepts of instability of a structure; bifurcation, energy increment, snap-through, dynamic instability. Analytical and numerical methods of finding buckling loads of columns. Postbuckling deformations of cantilever columns. Dynamic buckling with nonconservative forces. Effects of initial imperfections. Inelastic buckling. Instability problems of thin plates and shells. Prerequisite: MATH 205.

MECH 416. (CE 464) Analysis of Plates and Shells (3)
Bending of rectangular and circular plates, plates under lateral loads, plates with thermal and inelastic strains, effect of inplane forces, large deflections. Geometry and governing equations of a shell, shells of revolution, membrane states, edge solutions, solution by numerical integration, applications to pressure vessels. Prerequisites: MATH 205; MECH 305 or equivalent course in advanced mechanics of materials.

MECH 417. Mixed Boundary Value Problems in Mechanics (3)
General description of mixed boundary value problems in potential theory and solid mechanics. Solutions by dual series, dual integral equations and singular integral equations. Approximate and numerical methods.

MECH 418. Finite Element Methods (3)
Finite element approximations to the solution of differential equations of engineering interest. Linear and nonlinear examples from heat transfer, solid mechanics, and fluid mechanics are used to illustrate applications of the method. The course emphasizes the development of computer programs to carry out the required calculations. Prerequisite: knowledge of a high-level programming language. Delph

MECH 419. (CHE 419) Asymptotic Methods in the Engineering Sciences (3)
Introductory-level course with emphasis on practical applications. Material covered includes: Asymptotic expansions. Regular and singular perturbations; algebraic problems. Asymptotic matching. Boundary value problems; distinguished limits. Multiple scale expansions. W.K.B. Theory. Non-linear wave equations. Blythe

MECH 424. Unsteady Fluid Flows (3)
Gas dynamics, finite amplitude disturbances in perfect and real gases; channel flows; three-dimensional acoustics; theories of the sonic boom. Motions in fluids with a free surface; basic hydrodynamics, small amplitude waves on deep water; ship waves; dispersive waves; shallow water gravity waves and atmospheric waves. Hemodynamics; pulsatile blood flow at high and low Reynolds number. Models of the interaction of flow with artery walls. Varley

MECH 425. Analytical Methods in Dynamics and Vibrations (3) spring
This course is a first graduate course in dynamics and vibrations. It treats three-dimensional rigid body motion by vector methods and multidegree of freedom systems by variational principles. Discrete modal analysis and continuous modal analysis of one-dimensional systems plus finite-element formulation of numerical problems constitutes about one-third of the course. There is a brief treatment of advanced impact. Use of symbolic computer codes is encouraged. Johnson

MECH 432. Inelastic Behavior of Materials (3)
Time independent and dependent inelastic material behavior. Time independent plasticity. Yield criteria in multi-dimensions, J_2 incremental plasticity in multi-dimensions with associated flow rule. Numerical integration of plasticity equations by radial return and to other methods. Deformation theory of plasticity. Time dependent behavior including linear viscoelasticity and nonlinear creep behavior. Nonlinear material behavior at elevated temperatures. Prerequisite: MECH 408. Delph

MECH 445. Non-deterministic Models in Engineering (3)
Application of probability and stochastic processes to engineering problems for a variety of applications. Modeling and analysis of common non-deterministic processes. Topics are selected from the following: linear and nonlinear models for random systems; random functions; simulation; random loads and vibrations; Kalman filtering, identification, estimation, and prediction; stochastic fracture and fatigue; probabilistic design of engineering systems; and spatial point processes. Prerequisites: advanced calculus and some exposure to probability and statistics. Harlow

MECH 450. Special Problems (3)
An intensive study of some field of applied mechanics not covered in more general courses.

MECH 454. Mechanics and Design of Composites (3)
Mechanics of anisotropic materials. Manufacturing and measurements of mechanical properties. Stress analysis for design of composite structures. Hygrothermal effects and residual stresses. Laminate design, micromechanics of lamina. Bolted and bonded joints. Impact and damage in composites. Lectures and laboratory. Prerequisite: MECH 305 or equivalent course in advanced mechanics of materials. Voloshin

MECH 490. Thesis

MECH 499. Dissertation

Graduate Courses in Engineering Mathematics

Students in the applied mathematics program also have access to the graduate courses listed under mechanical engineering, engineering mechanics, and mathematics, as well as other engineering departments.

EMA 425. Variational Methods in Science and Engineering (3)
Variational problems with one independent variable; Euler-Lagrange equations; methods of solution; space and time dependent fields; null Lagrangians and inhomogeneous Dirichlet data; problems with constraints; symmetries and conservation laws; variational approximation methods, Rayleigh-Ritz, Galerkin, finite element, and collocation. Problems and examples will be drawn from the mechanics of solids, fluids, and related fields. Prerequisite: consent of chair. Staff

EMA 450. Special Topics (3)
An intensive study of some field of engineering mathematics not covered in other courses.

EMA 490. Thesis

EMA 499. Dissertation

Military Science

Professor. LTC William D. Kuchinski, M.S. (RPI), *chair.*

Assistant professors. LTC, USAR, James W. Follweiler, M.S. (Embry-Riddle Aeronautical University); MAJ Robert Haldeman, MSBA (Bucknell University); CPT Jeffrey J. Weinhofer, B.S. (Slippery Rock); CPT Thomas Brede, B.A. (Tarleton State University).

Instructors. MSG Luis Pino, SSG Charleen Acree.

The Department of Military Science, established in 1919, conducts the Army Reserve Officers Training Corps (ROTC) program at Lehigh University. This is one of the oldest ROTC programs in the nation. The Army ROTC program provides a means for students to qualify for a commission as an officer in the Active Army, Army Reserve, or Army National Guard.

The objectives of the military science program are to develop leadership and management ability in each student; to provide a basic understanding of the Army's history, philosophy, organization, responsibilities, and role in American society; and to develop fundamental professional knowledge and skills associated with officership. These objectives are achieved through classroom instruction, leadership laboratories, field trips, role playing, leadership simulations, and individual assessment and counseling. Army ROTC offers a four-year program and a two-year program. The four-year program consists of a two-year basic course and a two-year advanced course. The two-year program consists of the two-year advanced course offered to students with previous military experience, and those who have successfully completed the five-week ROTC Leaders Training Course. Basic course students incur no obligation for service in the Army as a result of taking these courses.

Basic Course. The basic course, normally taken in the freshman and sophomore years, provides training and instruction in leadership, public speaking, and basic military subjects, such as the Army's role and organizational structure, history and philosophy of the Army, basic tactics, land navigation, first aid, group dynamics, and leadership traits and characteristics. Basic course students incur no military obligation

Advanced Course. The advanced course is normally taken in the junior and senior years. The instruction includes management, military skills, advanced leadership and tactics, logistics, administration, military law, ethics, and professionalism, and includes attendance at the ROTC Leadership Development and Assessment Course. Students receive $350 per month subsistence pay during the junior year and $400 per month in their senior year.

To enroll in the advanced course, an applicant completes either the basic course or the five-week Leaders Training Course; or has received basic course credit for previous military experience; or is a nursing student and is accepted for enrollment by the university and the Department of Military Science.

Uniforms and Equipment. All uniforms and equipment needed by the student for military science courses are supplied by the department. Students are charged only for those items not returned when they leave the program.

Transfers. Qualified students transferring from another institution may enter the ROTC program at the appropriate level and year, provided they have received the necessary credits, the recommendation of their former professor of military science (if applicable), and the approval of the university.

Obligation After Graduation. Upon graduation a student will receive a commission as a Second Lieutenant in either the Active Army or the Reserve Forces. If offered active duty, scholarship students serve four years while non-scholarship students serve three. If offered reserve duty, students normally serve six to eight years in a Reserve or National Guard unit.

Graduate Studies. ROTC graduates may request to delay their active service to pursue a full-time course of instruction leading to an advanced degree. Delay does not lengthen the active service obligation unless the degree is obtained at government expense. The three major areas of concentration are medical school, law school, and all other categories.

Course Credit. Students in the College of Arts and Sciences and the College of Business and Economics may substitute military science advanced credits for six hours of electives. In the College of Engineering and Applied Science, six credits of advanced ROTC work are permissible within the normal program of each student, irrespective of curriculum. For curricula that include more than six hours of personal electives in the junior and senior years, inclusion of the more than six hours of ROTC credit with normal programs can be effected only with the approval of academic advisers. All military science credits, including those in the basic course, apply toward the student's overall cumulative grade point average.

Career Opportunities

Individuals are commissioned as officers in the United States Army after completion of the ROTC program and the advanced camp and completion of their bachelors degree requirements. They then qualify in branches (specialties) such as the Corps of Engineers, Infantry, Armor, Aviation, Field Artillery, Air Defense Artillery, Signal Corps, Military Intelligence, Chemical Corps, Ordnance Corps, Finance, Transportation, Military Police, Adjutant General, Quartermaster, Medical Service Corps, or Nursing. Officers work as leaders/managers, specialists, or combinations of the two depending on the assignment.

Programs and Opportunities

ROTC Scholarship Program

This program is designed to offer financial assistance to outstanding young men and women entering the ROTC program who are interested in an Army career. Scholarships provide up to $20,000 annual tuition, a textbook and supplies allowance, and laboratory fees, in addition to pay up to $400 per month for the period the scholarship is in effect. Three-year and two-year scholarships are available to outstanding cadets who are currently enrolled in the four-year ROTC program and are completing their freshman or sophomore year of college. This program is also open to all qualified students who are not currently enrolled in Army ROTC.

Four-year scholarships are open to all students entering ROTC as freshmen. Applications for scholarship must be made to Headquarters, U.S. Army Cadet Command, Fort Monroe, VA by July 15th prior to the high school senior year for early selection, but no later than November 15th for normal application. Applications may be obtained by calling 1-800-USA-ROTC. Application booklets are also available from most high school guidance offices, or may be obtained from the military science department.

Two-Year Program

Students who want to enroll in ROTC after their sophomore year may apply. Applicants must successfully complete a five-week Leaders Training Course (LTC) and have two years of undergraduate or graduate studies remaining. The student is paid for the five-week encampment and receives transportation costs to and from the camp. Additional scholarships are available at this camp.

Physical Facilities

Army ROTC uses areas on and adjacent to the university campus to conduct field training. These locations are excellent for most outdoor activities such as orienteering, patrolling, and survival training. Fort Indiantown Gap Military Reservation, located east of Harrisburg, Pa., and Fort Dix, NJ, located east of Philadelphia, Pa., are used for field training exercises and weapons familiarization during the two annual weekend field exercises. Gettysburg National Park is also visited each year.

Off-campus U.S. Army Training Schools

Cadets may be selected to attend the following U.S. Army Schools: Airborne School (Fort Benning, Georgia), Air Assault School (Fort Campbell, Kentucky), Mountain Warfare School (Ethan Allen Training Center, Vermont), and Northern Warfare School (Fort Greely, Alaska). This off-campus program is fully funded by the U.S. Army. Many other installations throughout the world may be visited through the Cadet Troop Leader Training program. Nursing students may choose to attend the Nurse Summer Training Program at Army hospitals located throughout the United States.

Minor in Military Science

A minor in military science is available in the College of Arts and Sciences. A minor in military science consists of a minimum of 28 credit hours beyond the basic Military Science course and is designed to provide the student with an academic foundation necessary to support continued intellectual growth and stimulate future inquiry in the realm of civil military affairs and military science. Credit hours required are distributed as follows:

Military Science (13)

MS 101	Advanced Military Skills (3)
MS 102	Advanced Leadership (3)
MS 113	Military Command and Staff (3)
MS 114	Officer Responsibilities, Ethics and Military Professionalism (3)
MS 118	Special Military Topics (1)
	History (3)
HIST 110	American Military History (3)

International Relations (3-4)

(Select one course from one of the following categories)
International Relations
Political Science

Written Communications (3)

(Select one course from one of the following categories)
Creative Writing
Scientific Writing
Writing for Mass Communications
English Composition

Human Behavior (3)

(Select one course from one of the following categories)
General Psychology
Sociology
Anthropology
Ethics

Computer Literacy (3)

Commissioning Requirements

Individuals must complete either the two- or four-year programs, attend the advanced camp, receive a college degree, have a cumulative GPA of 2.0, and complete all professional military education requirements to become commissioned officers in the United States Army.

Course Descriptions

Leadership Laboratory is conducted for all students on three Saturdays or Sundays per semester. The Leadership Laboratory provides students the opportunity to demonstrate an understanding of the leadership process and develop fundamental military skills.

Instruction at several levels on a variety of subjects with military application provides the context within which students are furnished opportunities to both teach and lead in a group setting. Responsibility is expanded as the student progresses through the program. In the senior year, the students assume the responsibility for the planning, preparation and conduct of the laboratory. Leadership Laboratory is mandatory for all students enrolled in military science courses.

MS 15. Introduction to Military Science (1) fall
The American Army as an institution, its roots, history, customs and traditions and philosophy of leadership. Emphasis on development and role of a professional officer corps. Includes leadership laboratory.

MS 16. Leadership Assessment and Group Dynamics (1) spring
Role of individual and leader within the group, leadership skills and characteristics. Emphasis on problem solving and application. Includes laboratory and FTX.

MS 23. Topographic Analysis and Land Navigation (2) fall
Maps as tools in basic terrain analysis and as navigational aids and introduction to small unit tactics. Emphasis on application and field exercises at individual and small group levels. Includes leadership laboratory and FTX.

MS 24. Leadership Theory and Management (2) spring
Contemporary theories, traits and principles and small unit tactics development. Leadership philosophies, communications, leader-follower relationships, and leadership problem-solving. Leadership simulations. Includes leadership laboratory and FTX. Note: Credit for this course will count as GPA but not credit passed toward a degree.

MS 101. Advanced Military Skills (3) fall
Essential junior officer skills: advanced land navigation, principles of war, small unit tactical planning, tactics and techniques of the soldier, team leading techniques, oral communications and trainer skills. Emphasizes application and field experience. Includes leadership laboratory and FTX. Prerequisite: permission of department chair.

MS 102. Advanced Leadership (3) spring
Critical examination of leadership qualities, traits and principles with emphasis on military environment. Self, peer, and instructor leadership evaluation. Advanced military skills reinforced. Includes leadership laboratory and FTX. Prerequisite: permission of department chair.

MS 113. Military Command and Staff (3) fall
Role, authority and responsibility of military commanders and staff in personnel, logistics and training management. Staff procedures, problem solving, training methods and oral and written communications skills used in military organizations. Includes leadership laboratory and FTX. Prerequisite: permission of department chair.

MS 114. Officer Responsibilities, Ethics and Military Professionalism (3) spring
Development of the Profession of Arms, its fundamental values and institutions. Ethical responsibilities of military professionals in contemporary American society. Just war theory, international law of war, and American military law. Also covered are current topics to assist cadets in making the transition to the officer corps and service on active duty or in the reserve forces. Includes leadership laboratory and FTX. Prerequisite: permission of department chair.

MS 118. Special Topics for the Army Officer (1) fall, spring
Seminar covering special problems and issues dealing with responsibilities of the commissioned officer as leader, manager, and mentor, not covered in other courses. Prerequisite: permission of the department chair.

Leadership Development and Assessment Course

This is a five-week training program normally conducted at Fort Lewis, WA. Prerequisites are completion of the basic military science courses or their equivalent and MS 101 and 102. The summer camp experience, in coordination with respective engineering curricula, may be used to fulfill the industrial employment requirements of the engineering courses, CE 100, IE 100, and MAT 100

Modern Languages and Literature

Professors. Marie Hélène Chabut, Ph.D. (U.C., San Diego), *French*; David W. Pankenier, Ph.D. (Stanford), *Chinese*; Lenora D. Wolfgang, Ph.D. (Pennsylvania), *French.*

Associate professors. Marie-Sophie Armstrong, Ph.D. (Oregon), *French*; Constance Cook, Ph.D., (Berkeley), *Chinese*; Kiri Lee, Ph.D. (Harvard), *Japanese*; Linda S. Lefkowitz, Ph.D. (Princeton), *Spanish*; Mary A. Nicholas, Ph.D. (Pennsylvania), *Chair, Russian*; Antonio Prieto, Ph.D. (Princeton), *Spanish*; Vera S. Stegmann, Ph.D. (Indiana), *German.*

Assistant Professor. Miren Edurne Portela, Ph.D. (N.C., Chapel Hill), *Spanish.*

Knowledge of other languages opens the door to other cultures, traditions, and perspectives on the world, and promotes deeper insight into one's own language and culture. Proficiency in foreign languages is indispensable in a broad range of professions such as journalism, government, international affairs, law, the armed forces, and business. A bachelor of arts degree with a major in languages provides excellent preparation for professional careers in law, business, and the media. Foreign language study is required for graduate study in many disciplines, as well as for research in science and technology. International experience is personally enriching and enhances career prospects.

Languages offered

Lehigh offers Mandarin Chinese, French, German, Hebrew, Japanese, Russian, and Spanish.

Courses include writing and speaking, reading and listening, literature, civilization, and professional areas such as business and health careers. A number of cultural courses are given in English, but most offerings stress classroom use of the language. Facilities include an International Multimedia Resource Center (IMRC). Within the IMRC in Maginnes Hall are a state-of-the-art multimedia computer lab (Maginnes 470) dedicated primarily to foreign language multimedia and World Wide Web applications and the World View Room (Maginnes 490) in which is shown a regular daily schedule of foreign language news and feature programming received via international satellite TV networks.

Language requirements

The honors major in international relations requires foreign language study. The college scholar program in the College of Arts and Sciences; the major in Russian and Soviet studies, the major in Asian studies, the minors in Latin American studies, Russian area studies, Asian studies, and in military science require language study. Students taking the B.A. in international relations or in foreign careers are expected to study a language. Students choosing a foreign language at an elementary level towards their general studies requirement in the college of engineering must take a minimum of one year (two courses). Some doctoral programs also require foreign language competence, usually assessed by the Department of Modern Languages and Literature.

Advising

Because of the sequential nature of language study and the variety of specializations available, the department pays special attention to student advising. Students whose experience, skills, and placement scores (Advanced Placement or College Board Achievement Test) do not give them a clear indication of their level of placement should consult with their instructor or the department chair. Faculty members responsible for more advanced advising are currently as follows: Chinese minor, Pankenier; Asian studies major and minor, Cook; French major, Chabut; French minor, Armstrong; German major and minor, Stegmann; Russian minor and area studies, major and minor, Nicholas; Spanish major, Prieto; Spanish minor, Lefkowitz.

Major programs

The department offers major programs in French, German, Russian studies, and Spanish. The candidate for the major is expected to demonstrate adequate written and oral command of the language, as well as knowledge of its literature and culture. A period of study abroad is strongly recommended.

Double majors and arts-engineering majors including a language component are well-received by employers. Studies in the two areas are carefully coordinated by major advisers.

Requirements for the major

A minimum of 32 credit hours is required beyond Intermediate II, chosen from Groups A and B below:

Group A: one to four required courses (variable, depending on language major).

Group B: four to seven electives chosen from 100-300 level courses with emphasis on 300-level courses.

For specific course requirements, see each language major adviser.

Language students may count one MLL course taught in English toward the major in French, German, and Spanish.

Requirements for the departmental honors major

Same as for the major plus eight additional hours of advanced courses at the 300 level, dissertation or comprehensive examination (written or oral), and a 3.20 average in the major.

Minor programs

The department offers minor programs in Asian studies, Chinese, French, German, Japanese, Latin American studies, Russian, Russian studies, and Spanish and coordinates these studies with a student's major requirements in any college.

Requirements for the Minor

French, German, Spanish. Sixteen credit hours are required above Intermediate II; one or two courses at the 200 level, one or two courses at the 300 level.

Chinese, Japanese, Russian. A minimum of 16 credit hours.

Related programs

These are available in Asian studies, foreign careers, Jewish studies, Latin American studies, and Russian and Soviet studies. *Recommended related courses.* Students are urged to take elective courses on related subjects, either within or outside the department, as approved by their adviser.

Preliminary Courses.

These may be replaced by other courses when a student qualifies for advanced standing.

Elementary I (4)	Intermediate I (4)
Elementary II (4)	Intermediate II (4)

Advanced courses

Except where otherwise noted, 200- or 300-level courses are open to students having completed eight credit hours beyond Intermediate II. Exceptions require the consent of the instructor.

Language of instruction

All courses are taught in the target language except MLL courses listed under "Foreign Culture and Literature Taught in English." Students thereby become accustomed to considering the language as an active means of communication and not solely as an object of study.

Courses in English

The department offers elective courses in English on literary, cultural, and social subjects listed under "Foreign Culture and Literature Taught in English". These courses may, in most cases, be taken to fulfill preliminary distribution requirements. One of these courses may be included in the major.

Study Abroad and Foreign Study Awards

The department encourages students of foreign languages to spend a summer, a semester, or a full year on an approved program of study abroad. Exchange agreements with partner institutions are continually being developed. The department offers a limited number of travel scholarships for foreign study to qualified students. Applications should be submitted by November 15 for the spring and summer semesters and by April 15 for summer and fall. For credit, transfer students must consult in advance with their major adviser, foreign language adviser, other appropriate departments, the Office of International Education, and when appropriate, the Office of Financial Aid.

Lehigh offers summer programs through the Lehigh Valley Association of Independent Colleges (LVAIC). Programs are offered in Bonn (Germany), Cuernavaca (Mexico), and Seville (Spain) for eight credits each. A faculty member acting as program director accompanies the students. Courses are taught at intermediate and advanced levels by qualified instructors from host institutions. Summer programs sponsored by the Lehigh-LVAIC Center for Jewish Studies include Hebrew in Israel.

Credits and grades are fully transferable under normal LVAIC cross-registration procedures. Interested students should consult with the Department of Modern Languages and Literature, Maginnes Hall.

These courses are offered by Lehigh or under the cooperation agreement with the Lehigh Valley Association of Independent Colleges. Summer or semester study abroad at approved programs may be incorporated into foreign language majors and minors with the permission of the appropriate advisor to a maximum of 16 credits toward the major and eight credits toward the minor.

CHIN, FREN, GERM, JPNS, RUSS, SPAN 91. Language and Culture Abroad I (1-8)
Intensive study of conversation in the language of the country; reading, development of writing skills and selected aspects of the culture. (HU)

CHIN, FREN, GERM, JPNS, RUSS, SPAN 191. Language and Culture Abroad II (1-8)
Intensive study of conversation in the language of the country; rapid review of basic grammar, the reading and analysis of moderately difficult texts, development of rudimentary writing skills, supplemented study of selected aspects of contemporary civilization. Prerequisites: consent of chair and proficiency examination in the target country.

CHIN, FREN, GERM, JPNS, RUSS, SPAN 291. Language and Culture Abroad III (1-8)
Intensive practice of speaking and writing in the language of the country aimed at providing the student with extensive proficiency of expression and the ability to discriminate linguistic usage. Idiomatic expressions and an introduction to stylistics. Reading and analysis of more difficult texts, supplemented by in-depth study of

selected aspects of contemporary civilization. Prerequisites: consent of chair and proficiency examination in the target country.

Foreign Culture and Literature Taught in English

These courses on foreign cultures and comparative topics carry no prerequisites; knowledge of the foreign language is not required.

Language majors may count one MLL course taught in English for credit toward a major requirement. Interested students should consult their language major advisers. **For course descriptions, see under each language area below.**

MLL 23. Lehigh in Russia (1-8)

MLL 27. Russian Classics (4)

MLL 28. The East European Film Experience (4)

MLL 51. Contemporary Hispanic-American Literature (4)

MLL 53. This Hispanic World and its Culture (4)

MLL 68. (ASIA 68) Japanese Language: Past and Present (4)

MLL 73. (ASIA 73, WS 73) Film, Fiction, and Gender in Modern China (4)

MLL 74. (ASIA 74) Chinese Cultural Program (1-8)

MLL 75. (ASIA 75, HIST 75) Chinese Civilization (4)

MLL 76. (ASIA 76, HIST 76) Understanding Contemporary China (4)

MLL 78. (ASIA 78) Asian American Studies (4)

MLL 100 Introduction to International Film (4)
An introduction to international film traditions and theory. We look at the importance of cinema as both art and entertainment and consider the social, political, and economic role of film in national and global contexts. **(HU)**

MLL 124 Negotiating Across Cultures (4)
The world is shrinking! Yet as geographical distances between peoples collapse, our misunderstandings seem to expand. Explore difference, erode barriers, and learn tactics for successfully bridging cultural gaps. Learn the ins-and-outs of cross-cultural communication from specialists in all walks of life and from a diverse array of sources. **(H/S)**

MLL 125. (ASIA 125) Immortal Images: Traditional Chinese Literature in Translation (4)

MLL 127 ORIENTations: Approaches to Modern ASIA (4)
An introduction to East and Southeast ASIA at the turn of the millennium. How do the contemporary societies and traditional cultures of Asian countries differ from the West? What distinguishes our perspectives—on politics, individual liberties, civic responsibility, religious faith, the "pursuit of happiness", etc.? How are Asians represented (or misrepresented) in the West, and how is the trend toward globalization in the "Pacific Century" likely to be affected by the new assertiveness of Asian nations? Pankenier (team taught). **(H/S)**

MLL 140. (ANTH 140, COGS 140, PSYC 140) Introduction to Linguistics (4)
Relationship between language and mind; formal properties of language; language and society; how languages change over time. **(SS)**

MLL 143. German Literature and Culture in Translation (4)

MLL 177. (ASIA 177, HIST 177) China Enters the Modern Age (4)

MLL 231. New German Cinema (4)

MLL 320 Berlin: 1920s to the Present (4)
Literature, culture, and history of Berlin from the Weimar Republic through reunification. **(HU)**

Chinese

Undergraduate Courses in Chinese

CHIN 001. Beginning Chinese Reading and Writing I (2)
Introduction to the Chinese writing system and beginning character acquisition; reading practice with *pinyin* transcription system. (Fall) Co-requisite: CHIN 003 or permission of the instructor. Staff. **(HU)**

CHIN 002. Beginning Chinese Reading and Writing II (2)
Continuation of CHIN 001: continued character acquisition, reading practice in *pinyin* and simple character texts. (Spring) Prerequisites: CHIN 003, CHIN 004 or permission of the instructor. Staff **(HU)**

CHIN 003. Beginning Spoken Chinese I (2)
Introduction to Mandarin Chinese pronunciation, the *pinyin* transcription system, and modern colloquial Chinese; emphasis on oral proficiency. Not open to native speakers. (Fall) Co-requisite: CHIN 001 or permission of the instructor

CHIN 004. Beginning Spoken Chinese II (2)
Continuation of CHIN 003: further practice with text-based dialogues in modern colloquial Chinese; emphasis on oral proficiency. Not open to native speakers. (Spring) Prerequisite: CHIN 002 or permission of the instructor. Staff **(HU)**

CHIN 011. Intermediate Chinese Reading and Writing I (2)
Continued focus on vocabulary/character acquisition and text-based reading and writing exercises using Chinese characters. (Fall) Prerequisites: CHIN 013 or permission of the instructor. Staff **(HU)**

CHIN 012. Intermediate Chinese Reading and Writing II (2)
Continuation of CHIN 011: vocabulary/character acquisition and text-based reading and writing exercises using Chinese characters. (Spring). Prerequisites: CHIN 013, CHIN 014, or permission of the instructor. Staff **(HU)**

CHIN 013. Intermediate Spoken Chinese I (2)
Further development of communicative skills in Chinese using situational dialogues and class discussion; emphasis on oral proficiency. Not open to native speakers. (Fall) Prerequisite: CHIN 004, CHIN 011, or permission of the instructor. Staff. **(HU)**

CHIN 014. Intermediate Spoken Chinese II (2)
Continuation of CHIN 013: further development of communicative skills in Chinese using situational dialogues and class discussion; emphasis on oral proficiency. Not open to native speakers. (Fall) Prerequisite: CHIN 012, CHIN 013, or permission of the instructor. Staff. **(HU)**

CHIN 111. Advanced Chinese Reading & Writing I (2)
Reading, translation, and writing practice using text-based exercises, short stories, essays, and other selected materials. (Fall). Prerequisites: CHIN 014, CHIN 113 or permission of the instructor. Staff. **(HU)**

CHIN 112. Advanced Chinese Reading & Writing II (2)
Continuation of CHIN 111: reading, translation, writing exercises using text-based exercises, short stories, essays, and other selected materials. (Spring). Prerequisites: CHIN 111, CHIN 113, or permission of the instructor. Staff. **(HU)**

CHIN 113. Advanced Spoken Chinese I (2)
Topical discussions and oral presentations in Chinese. (Fall) Prerequisite: CHIN 014, CHIN 111, or permission of the instructor. Staff. **(HU)**

CHIN 114. Advanced Spoken Chinese II (2)
Continuation of CHIN 113: topical discussions and oral presentations in Chinese. (Fall) Prerequisite: CHIN 112, CHIN 113, or permission of the instructor. Staff. **(HU)**

CHIN 251. Special Topics (1-4)
Literary and linguistics topics not covered in regular courses. May be repeated for credit. Prerequisite: consent of the instructor. **(HU)**

CHIN 371. Special Topics (1-4)
Directed study of an author, genre, or period not covered in regular courses. May be repeated once for credit. Prerequisite: consent of the instructor. **(HU)**

Courses Taught in English

MLL 73. (ASIA 73, WS 73) **Film, Fiction, and Gender in Modern China** (4)
Study of the struggle for an individual "modern" entity out of traditionally defined roles for men and women as depicted by Chinese writers and filmmakers. Class, texts, and films in English. Students interested in setting up a corollary Chinese language component may discuss this possibility with the professor. **(HU)**

MLL 74. (ASIA 74) **Chinese Cultural Program** (1-8)
A summer program in China, taught in English. **(HU)**

MLL 75. (ASIA 75, HIST 75) **Chinese Civilization** (4)
The development of traditional Chinese thought, beliefs, technology, and institutions from a historical perspective, from earliest times to China's encounter with the West. **(H/S)**

MLL 76. (ASIA 76, HIST 76) **Understanding Contemporary China** (4)
An overview of recent history, politics, economy, religion, problems of modernization, popular culture, and attitudes. Contemporary Chinese society viewed against the backdrop of tradition and the tumultuous history of twentieth-century China. **(SS)**

MLL 78. (ASIA 78) **Asian-American Studies** (4)

MLL 125. (ASIA 125) **Immortal Images: Traditional Chinese Literature in Translation** (4)
Explore age-old themes in literature as diverse as pre-modern novels, ghost stories, poetry, divination manuals, and medical texts. **(HU)**

MLL 177. (ASIA 177, HIST 177) **China Enters the Modern Age** (4)
The collapse of the imperial order and China's agonizing transformation into a modern nation-state over the past 150 years. The impact of imperialism, war, radical social change, and protracted revolution on Chinese traditions, values, and institutions. **(H/S)**

French

Undergraduate Courses in French

FREN 1. Elementary French I (4) **fall**
Multimedia approach to the study of French. Introduction to French conversation, grammar, and culture. **(HU)**

FREN 2. Elementary French II (4) **spring**
Continuation of FREN 1. Prerequisite: FREN 1 or appropriate achievement test score before entrance, or consent of instructor. **(HU)**

FREN 11. Intermediate French I (4) **fall**
Further acquisition of the fundamentals of French conversation, writing, and culture. Multimedia approach. Prerequisite: FREN 2 or appropriate achievement test score before entrance, or consent of instructor. **(HU)**

FREN 12. Intermediate French II (4) **spring**
Continuation of FREN 11. Prerequisite: FREN 11 or appropriate achievement test score before entrance, or consent of instructor. **(HU)**

FREN 143. Advanced Written French (4)
Intensive practice in written French and introduction to literary criticism. Prerequisite: FREN 12, or achievement test score of 590, or consent of instructor. **(HU)**

FREN 144. Advanced Oral French (4)
Emphasis on comprehension and oral performance of the French language. Student acquires confidence in speaking French through discussions of current issues, articles, novels, movies, and other topics. Required for French majors. Prerequisite: FREN 143 or equivalent. Staff. **(HU)**

FREN 159. The French-Speaking World and its Culture (4)
Cultural, social, and artistic development of France and the French-speaking world. Prerequisite: FREN 143, 144, or consent of instructor. Armstrong, Chabut. **(HU)**

FREN 252. From Romance to Post-Modernism (4)
Representative works from the Middle Ages to the Twentieth Century, including Marie de France, Flaubert, Baudelaire, and Proust. Prerequisite: FREN 143, 144, or consent of instructor. **(HU)**

FREN 269 The Culture of Business
Fundamentals of business in France. Students learn about banking, marketing, advertising, the stock market—how to open a bank account, apply for a job, and what life is like in a French company. Students learn about foreign ventures in France such as Disney and McDonald's. Ideal for someone who wants to intern or work for an international company or a company with a French connection. Taught in English. Prerequisite: FREN 143, 144, or equivalent. **(HU)**

FREN 271. Readings (4)
Study of the works of some author or group of authors, or of a period, or of a literary theme. May be repeated once for credit. **(HU)**

FREN 272. Culture of Business (4)
An exciting new course on the fundamentals of business in France. We will learn about banking, marketing, advertising, the stock market, and many other aspects of business in France. We will learn about foreign ventures in France, such as Disney and McDonald's. We will learn how to open a bank account, apply for a job, and what life is like in a French company. Ideal for someone who wants to intern or work for an international company or a company with a French connection. Taught in French. Prerequisite: FREN 143 or 144 or equivalent. Wolfgang.

FREN 281. French Cultural Program (1-6)
A program in a French-speaking country offering formal language courses and cultural opportunities. **(HU)**

FREN 302. Medieval French Stories (4)
Stories of love, death, revenge, murder, and mayhem. Wolfgang. **(HU)**

FREN 303. Arthurian Romances (4)
Medieval romances of Arthur, Lancelot, and the Holy Grail. Readings and discussion of the first literary works dealing with Arthurian themes. Wolfgang. **(HU)**

FREN 306. Renaissance French Literature (4)
Study of the major writers of the period, including Ronsard, Rebelais, and Montaigne. Wolfgang. **(HU)**

FREN 311. French Classicism
French classical theater, novel, and criticism, with emphasis on Corneille, Racine, Moliere, Pascal, Lafayette, Malherbe, and Boileau. Chabut. **(HU)**

FREN 313. The Age of Enlightenment (4)
The *Philosophes* and *Encyclopédistes* of the eighteenth century, with emphasis on Voltaire, Rousseau, Montesquieu, and Diderot. Chabut. **(HU)**

FREN 316. Nineteenth Century Literature (4)
Study of major nineteenth century novelists and poets. Armstrong. **(HU)**

FREN 318. (THTR 318) Drama in the Twentieth Century (4)
Contemporary French drama with an analysis of its origins and movements. Armstrong. **(HU)**

FREN 320. Contemporary French Fiction (4)
Reading and discussion of contemporary works of fiction (post-1980). Study of how these works fit into the context of French literature and relate more specifically to major literary currents of the twentieth century. Armstrong. **(HU)**

FREN 321. Twentieth-Century French Short Fiction (4)
Examination, within the framework of short fiction, of the major literary currents that have made up twentieth-century literature. Works by Sartre, Camus, de Mandiargues, Robbe-Gillet, Le Clézio, Echenoz, Sallenave, and others. Armstrong **(HU)**

FREN 322. Contemporary French Films (4)
French Films from the late 1950s to the present. Introduction to cinematograhic language and exploration of the issues of gender, power, and madness. Films by Truffaut, J-L Godard, C. Denis, A. Varda, J-J Beineix, E. Rohner, and others. Armstrong **(HU)**

FREN 323. Love and the French Novel (4)
Representative French novels, such as *Tristan et Iseut*, *La Princesse de Clèves*, and *Bonjour Tristesse*. Style, themes, myths, and story patterns are analyzed. **(HU)**

FREN 324. The Outsider in French Fiction (4)
Focus on otherness/difference in French fiction from the eighteenth to the twentieth century. Reading and discussion of short stories and novels by Graffigny, Diderot, Maupassant, Gide, Camus, Duras, Beauvoir, Le Clézio and others. **(HU)**

FREN 327. (WS 327) Women Writing in French (4)
Reading and discussion of works written by women in French. The emphasis is on 19th- and 20th-century writers, such as G. Sand, Colette S. de Beauvoir, M. Duras, and Andrée Chédid. Chabut **(HU)**

FREN 369. Readings (4)
Advanced study of an author, period, or theme. Topics vary. May be repeated once for credit. Prerequisite: consent of instructor. **(HU)**

FREN 370. Internship (1-8)
Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in French-speaking countries. Assigned readings, written reports, and employer performance evaluations are required. Prerequisite: consent of instructor. **(HU)**

FREN 371. Independent Study (1-8)
Special topics under faculty guidance, including honors thesis. May be repeated once for credit. Prerequisite: consent of instructor. **(HU)**

German

Undergraduate Courses in German

GERM 1. Elementary German I (4)
Fundamentals of German; reading and simple texts; simple conversation and composition; vocabulary building. Three class hours plus one laboratory or drill hour each week. No previous German required. **(HU)**

GERM 2. Elementary German II (4)
Continuation of GERM 1, including reading of more advanced texts. Three class hours plus one laboratory or drill hour each week. Prerequisite: GERM 1 or equivalent. **(HU)**

GERM 11. Intermediate German I (4)
Review of grammar, composition, reading of intermediate texts, vocabulary building. Prerequisite: GERM 2, or four units of entrance German or consent of instructor. **(HU)**

GERM 12. Intermediate German II (4)
Continuation of GERM 11. Prerequisite: GERM 11 or consent of instructor; one hour of lab. **(HU)**

GERM 163. German Civilization and Culture (4)
Cultural, historical, and political evolution of German and German-speaking countries in Europe. Prerequisite: GERM 12 or equivalent, or consent of instructor. **(HU)**

GERM 167. Conversation and Composition (4)
Intensive practice in spoken and written German. Prerequisite: GERM 12 or equivalent, or consent of instructor. **(HU)**

GERM 169. Business German (4)
German in business, the professions, international, and social relations. Letter writing, comprehension of technical texts, specialized vocabulary, and grammar review. Prerequisite: GERM 12 or equivalent, or consent of instructor. **(HU)**

GERM 181. German Cultural Program (1-8)
Summer program abroad. Formal instruction in the language and the culture of a German-speaking country. (HU)

GERM 201. Survey of German Literature (4)
Representative works of German literature from the Middle Ages to the present. (HU)

GERM 211 (THTR 211). German Drama (4)
Drama as a literary genre; plays from various periods of German literature. (HU)

GERM 218. (THTR 218) Goethe's "Faust" (4)
Study of Goethe's play with an introduction to the Faust tradition and Faustian themes in modern literature. (HU)

GERM 231. (MLL 231). New German Cinema (4)
Viewing, discussion, and written analysis of selected German films. (HU)

GERM 240. Contemporary Germany (4)
Readings and conversations in German about topics including the social and natural sciences, technology, the environment, politics, daily life, and sports. Practice in spoken and written German. (HU)

GERM 241. German Texts and Contexts (4)
Selected texts in German, as they relate to current debates. Practice in speaking and writing. (HU)

GERM 250. Special Topics (1-4)
Literary and linguistic topics not covered in regular courses. May be repeated for credit. (HU)

GERM 269. Advanced Professional German (4)
A continuation of Business German with an emphasis on specific economic issues affecting contemporary Germany, Switzerland, and Austria. Preparation for the national exam "Certificate for the Professions" and the "International Business German Examination". (HU)

GERM 281. German Cultural Program (1-8)
Study abroad. Formal instruction in German and direct contact with the people and the culture during at least one month in a German-speaking country. Prerequisites: consent of German study abroad adviser. (HU)

GERM 301. German Literature through the Nineteenth Century (4)
Readings of selected literary texts from the Middle Ages, Renaissance, Reformation, Baroque, Enlightenment, Classicism, Romanticism, Realism, and/or Naturalism. (HU)

GERM 305. Modern German Literature (4)
Topics in German literature of the twentieth and twenty-first century. (HU)

GERM 320. (MLL 320.) Berlin: 1920s to the Present (4)
Literature, culture, and history of Berlin from the Weimar Republic through reunification. (HU)

GERM 341. Applied Phonetics and Linguistics (4)
Writing and speaking Standard High German. Study of regional pronunciation, contrasts, dialects. (HU)

GERM 345. German Short Stories (4)
Readings of short prose texts in German. (HU)

GERM 350. Special Topics (1-4)
Literary or linguistic topics not covered in regular courses. May be repeated for credit. Prerequisite: consent of instructor. (HU)

GERM 370. Internship (1-8)
Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in German-speaking countries. Assigned readings, written reports, and employer performance evaluations are required. Prerequisite: GERM 167 or consent of the instructor. (HU)

Courses Taught in English

MLL 143. German Literature and Culture in Translation (4)
A period or theme in German literature or intellectual and cultural history. (HU)

MLL 231. (Germ 231) New German Cinema (4)
Viewing, discussion, and written analysis of German films with English subtitles. (HU)

MLL 320. (Germ 320) Berlin: 1920s to the Present (4)
Literature, culture, and history of Berlin from the Weimar Republic through reunification. (HU)

Hebrew

The department offers courses both separately and in the context of the Jewish studies minor (Section III).

HEBR 1. Elementary Modern Hebrew I (4) **fall**
Classroom and laboratory instruction to develop hearing, speaking, reading, and writing the language. Cultural, ethnic, and religious dimensions of Israeli society. Tapes, textural materials, short stories. No previous study of Hebrew required. (HU)

HEBR 2. Elementary Modern Hebrew II (4) **spring**
Continuation of Hebrew I utilizing the audio-lingual approach. Fundamentals of the language, structure and sounds; the Hebrew verb; reading and vocalized stories; written exercises; tapes; short stories. Prerequisite: HEBR I or its equivalent. (HU)

HEBR 11. Intermediate Modern Hebrew I (4) **fall**
Classroom and laboratory instruction to develop fundamental patterns of conversation and grammar; composition, reading of texts, laboratory work and sight reading; comprehension, speaking, reading and writing of unvocalized materials. Prerequisite: HEBR 2 or consent of instructor. (HU)

HEBR 12. Intermediate Modern Hebrew II (4) **spring**
Continuation of Hebrew 11. Reading of texts, including selected short stories, outside reading and supplementary material; increased emphasis on oral presentation. Prerequisite: HEBR 11 or consent of instructor. (HU)

Japanese

See Asian Studies major and minor.

JPNS 1. Elementary Japanese I (4) **fall**
Introduction to the oral and written language with emphasis on spoken Japanese and syllabaries. Language laboratory. (HU)

JPNS 2. Elementary Japanese II (4) **spring**
Continuation of Japanese 1. Prerequisite: Japanese 1 or equivalent. (HU)

JPNS 11. Intermediate Japanese I (4) **fall**
Continuation of Japanese 2. Structural patterns in both spoken and written languages. 150 kanji (Chinese characters). Prerequisite: JPNS 2 or equivalent. (HU)

JPNS 12. Intermediate Japanese II (4) spring
Continuation of Japanese 11. Prerequisite: Japanese 11 or equivalent. (HU)

JPNS 141. Advanced Japanese I (4) fall
Advanced reading and oral comprehension. Conversation and writing practice. Prerequisite: JPNS 12 or equivalent. (HU)

JPNS 142. Advanced Japanese II (4) spring
Continuation of JPNS 141. Prerequisite: JPNS 141 or equivalent. (HU)

JPNS 290. Special Topics (1-4)
Literary or linguistics topics not covered in regular courses. May be repeated for credit. Prerequisite: consent of instructor. (HU)

JPNS 291. Advanced Japanese and Culture Abroad (1-8)

JPNS 390. Special Topics (1-4)

Courses Taught in English

MLL 68. (ASIA 68) Japanese Language: Past and Present (4)
Historical and contemporary aspects of the Japanese language, including the origins of Japanese in relation to Korean, the influence of Chinese, syntactic features which reflect the hierarchical character of Japanese society, differences in female and male speech, and use of foreign loan words. Prerequisite JPNS 1. (HU)

Russian

RUSS 1. Elementary Russian I (4) fall
Classroom and laboratory, audio, and video introduction to the fundamentals of conversational and grammatical patterns; practice in pronunciation, simple conversation, reading, and writing. (HU)

RUSS 2. Elementary Russian II (4) spring
Continuation of RUSS 1. Prerequisite: RUSS 1 or two years of entrance Russian. (HU)

RUSS 11. Intermediate Russian I (4) fall
Classroom and laboratory practice in conversation. Development of reading and writing skills. Prerequisite: RUSS 2 or three units of entrance Russian or equivalent. (HU)

RUSS 12. Intermediate Russian II (4) spring
Continuation of RUSS 11. Prerequisite: RUSS 2 or 11, or equivalent. (HU)

RUSS 141. Conversation and Composition I (4) fall
Intensive practice in oral and written Russian; laboratory practice in oral comprehension. Readings and discussions on Russian literature and culture. Prerequisite: RUSS 12 or three units of entrance Russian. (HU)

RUSS 142. Conversation and Composition II (4) spring
Continuation of RUSS 141. Prerequisite: RUSS 141. (HU)

RUSS 215. Russian Classics: Russian Literature with Variable Topic and Credit (1-4)
May be repeated for credit. (HU)

RUSS 231. Russian in the Real World I (4)
Readings and conversations about selected nonliterary topics including the social and natural sciences, business, economics, the environment, current political events in Russia and throughout the former Soviet republics. (HU)

RUSS 232. Russian in the Real World II (4)
A continuation of RUSS 231. (HU)

RUSS 251. Special Topics (1-4) fall
Intensive study of literary or linguistic topics. Prerequisite: RUSS 142. May be repeated for credit. Nicholas (HU)

RUSS 252. Special Topics (1-4) spring
Intensive study of literary or linguistic topics. Prerequisite: RUSS 142 or 251. May be repeated for credit. Nicholas (HU)

RUSS 370. Internship (1-8)
Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in Russian-speaking countries. Assigned readings, written reports, and employer performance evaluations are required. Prerequisites: RUSS 141 or 142 and approval of faculty committee on internship. (HU)

RUSS 391. Special Topics (1-4)
Independent study of research under faculty guidance on a literary, linguistic, or methodological topic. May be repeated once for credit. May be used to satisfy the doctoral language requirement. Prerequisites: consent of instructor. Nicholas (HU)

Courses Taught in English

MLL 23. Lehigh in Russia (1-8)
A summer program in Russia, taught in English. (HU)

MLL 27. Russian Classics (4)
Russian classics in translation. May be repeated for credit. (HU)

MLL 28. The East European Film Experience (4)

Spanish

Undergraduate Courses in Spanish

SPAN 1. Elementary Spanish I (4) fall
Basic conversational Spanish illustrating essential grammatical principles. Reading of simple texts and writing. Lab required. (HU)

SPAN 2. Elementary Spanish II (4) spring
Continuation of SPAN 1. Lab required. Prerequisite: SPAN 1 or equivalent. (HU)

SPAN 11. Intermediate Spanish I (4) fall
Limited review of elementary grammar concepts and introduction to more advanced grammar. Emphasis on discussion, reading, and writing about significant topics in the Spanish-speaking world. Students will be required to complete one hour of independent work. Prerequisite: SPAN 2 or equivalent. (HU)

SPAN 12. Intermediate Spanish II (4) spring
Practice and application of previously learned grammar to give maximum exposure to Spanish in contemporary contexts. Materials include articles from current periodicals, video, and literature from Spain and Spanish America, plus one hour of independent work. Prerequisite: SPAN 11 or equivalent. (HU)

SPAN 131. Communicating in Spanish for Medical Personnel (4)
For prospective medical personnel communicating with Spanish-speaking patients. Dialogues, health-care vocabulary. Review of grammar. Language laboratory practice,

plus hospital intensive hour. Prerequisite: SPAN 12 or equivalent. Lefkowitz. (HU)

SPAN 133. Phonetics and Pronunciation (4)
Comparison of Spanish and English sounds; descriptions of Spanish vowels and consonants in their various positions. Oral practice in language laboratory. Special emphasis on accent and intonation patterns. Prerequisite: SPAN 2. (HU)

SPAN 141. Advanced Grammar (4) fall
Intensive review of Spanish grammar with stress on finer points. Analysis of syntax and style. Improvement of grammar through composition. Prerequisite: SPAN 12 or equivalent. Dept. permission required. (HU)

SPAN 142. Advanced Conversational Spanish (4) spring
Conversational practice stressing the building of vocabulary based on literary texts and topics of general interest. Designed to stimulate fluent and spontaneous use of spoken Spanish. Enrollment limited to 15. Prerequisite: SPAN 141 or equivalent. (HU)

SPAN 151. Cultural Evolution in Spain (4) fall
The historical and cultural evolution of Spain. Discussion of major literary works in their cultural and historical contexts. Prerequisite: SPAN 141 or consent of instructor. Lefkowitz. Dept. permission required. (HU)

SPAN 152. Cultural Evolution of Latin America (4)
The historical and cultural evolution of Latin America. Discussion of representative literary works in their cultural and historical contexts. Prerequisite: SPAN 141 or consent of instructor. Prieto. Dept. permission required. (HU)

SPAN 199. Special Topics (3-4)
For students who take a course, not offered at Lehigh, at another institution. May be repeated once for credit. Prerequisite: consent of instructor. (HU)

SPAN 211. Spanish for the Professions (4)
For students with a basic knowledge of Spanish: the language in business, law, international and social relations. Letter writing, comprehension of technical texts, specialized professional vocabulary and review of grammar. Prerequisite: SPAN 141 or equivalent. Dept permission required. (HU)

SPAN 212. Writing Skills (4)
Improving writing proficiency through practice in composition and translation. Prerequisite: SPAN 141 or equivalent. (HU)

SPAN 263. The Spanish American Short Story (4)
Comparative study of the literary problems posed by the work of significant short story writers such as Quiroga, Borges, Cortazar, Ribeyro, and others. Prerequisite: SPAN 152 or equivalent. Prieto. Dept. permission required. (HU)

SPAN 265. Spanish and Latin American Cinema (4)
Oral discussion and written analysis of selected films. Students view films independently. Prerequisite: SPAN 141 or equivalent. Dept. permission required. (HU)

SPAN 290. Special Topics (2-4)
Study of an author or theme, or completion of a special project. Topics may vary. May be repeated once for credit. Prerequisites: SPAN 151 or 152, and consent of instructor. (HU)

SPAN 303. Don Quixote (4)
Reading and critical analysis; two 2-hour sessions. Prerequisite: SPAN 151 or equivalent. Lefkowitz. (HU)

SPAN 305. Spanish Literature of the Middle Ages (4)
Reading and discussion of outstanding works such as El Cid, El Liro de Buen Amor and La Celestina. Topics vary. Prerequisite: SPAN 151. Lefkowitz. (HU)

SPAN 308. The Spanish Novel Since 1939 (4)
The evolution of the novel from post civil war to the present. Reading of Cela, Laforet, Delibes, Rodoreda, and Marse, among others. Prerequisite: SPAN 151 or equivalent. (HU)

SPAN 320. Literature of the Spanish Caribbean (4)
Study of representative works with emphasis on Cuba and Puerto Rico. Writers include Barnet, Carpentier, Sanchez, and Rodriquez Julia. Prerequisite: SPAN 152 or equivalent. Prieto. (HU)

SPAN 321. Children and Adolescents in Contemporary Spanish American Literature (4)
Discussion of narrative techniques and the category of the self as they relate to the images of adolescence and childhood in works by such authors as Vargas Llosa, Reinaldo Arenas, Jose Bianco, Silvinia Ocampo. Prerequisite: SPAN 152 or equivalent. Prieto. (HU)

SPAN 322. The Short Novel in Contemporary Spanish American Literature (4)
Reading and discussion of representative works by Garcia Marquez, Onetti, Rulfo, Bioy Casares, and others. Prerequisite: SPAN 152 or equivalent. Prieto. (HU)

SPAN 323. Literature and Revolution in Contemporary Cuba (4)
Study of works written after 1959 by dissident, non-dissident, and exiled authors (Desnoes, Norberto Fuentes, Benitez Rojo, Cabrera Infante). Prerequisite: SPAN 152 or equivalent. Prieto. (HU)

SPAN 325. Hispanic Literature of the United States (4)
Discussion of fiction, poetry, drama, and film from the main groups in the U.S. Hispanic population. Discussion of Hispanic ethnic identity, bilingualism, and minority issues. Prerequisite: SPAN 152 or equivalent. Prieto. (HU)

SPAN 326. (WS 326) Tradition and Resistance: Women Writers of Latin America (4)
Study of poetry and narrative works by Latin American women writers. Authors include Rosario Ferré, Rosario Castellanos, Elena Poniatowska, Cristina Peri Rossi, among others. Prerequisite: SPAN 152 or equivalent. (HU)

SPAN 342. The New Narrative in Spanish American Literature (4)
Critical evaluation of distinguished works of Spanish American prose fiction of the 1960's and 70's. Readings by Donoso, Fuentes, Garcia Marquez, and Vargas Llosa, among others. Prerequisite: SPAN 152 or equivalent. (HU)

SPAN 379. Internship (2-4)
Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in Spanish-speaking countries or U.S. agencies serving the Hispanic community. Assigned readings, written reports, and employer performance evaluations are required. Prerequisites: SPAN 141 and approval of faculty. (HU)

SPAN 390. Special Topics (2-4)
Study of an author, theme or period. Topics vary. May be repeated once for credit. Prerequisites: SPAN 151 or 152 and consent of instructor. **(HU)**

Courses Taught in English

MLL 51. Contemporary Hispanic-American Literature (4)
Reading and discussion of distinguished Latin American writers: Borges, Garcia Marquez, Cortazar, and Vargas Llosa. **(HU)**

MLL 53. This Hispanic World and its Culture (4)
Characteristics and values of the people of Spain and Latin America in literary works and other material. Hispanic cultural contributions to Western civilization. **(HU)**

Minor in International Film

Description

The minor in International Film affords students the opportunity to examine a wide cross-section of world cinema. It is designed to provide a critical understanding of historical trends and current issues in film across various regions of the world. Covering national cinemas from ASIA, Europe, and Latin America, course offerings will allow students to explore diverse approaches to film that are rooted in the history, culture, and society of different countries in each region.

The minor consists of 16 credits. All students must take a required core course (MLL 100), and the remaining courses are to be chosen from the list of electives below, in consultation with the minor advisor. (One course may be taken outside of the MLL department with the minor advisor's approval.)

Core course

MLL 100. Introduction to International Film (4)

Elective courses

MLL 28.	The East European Film Experience (4)
MLL 73.	Film, Fiction, and Gender in Modern China (4)
FREN 322.	Contemporary French Films (4)
GERM/MLL 231.	New German Cinema (4)
SPAN 265.	Spanish and Latin American Cinema (4)

Minor in International Communication

Description:

The Minor in International Communication is designed for students who have already reached the intermediate level in their language studies and wish to develop international communication skills from a global perspective.

The minor consists of 16 credits. Students must take MLL 90 or 124 as a core course, and one advanced language course in their language (above 100 level), and two other courses from the list of electives below in consultation with the minor advisor. These two courses must be chosen from a region that is different from their language area in order to broaden their communication skills. (One course may be taken outside of the MLL department with the minor advisor's approval.)

Courses:

Required:
Negotiating across cultures (MLL 90 or 124)
One advanced language course (above 100 level)

Electives:

MLL 27	Russian Classics (4)
MLL 53	This Hispanic World and its Culture (4)
MLL 75	Chinese Civilization (4)
MLL 76	Understanding Contemporary China (4)
MLL 143	German Literature and Culture in Translation (4)
MLL 177	China Enters the Modern Age (4)
MLL 195	Lehigh in Spain (4)
FREN 159	The French-speaking World and its Culture (4)
GERM 163	German Civilization and Culture (4)
SPAN 151	Cultural Evolution in Spain (4)
SPAN 152	Cultural Evolution in Latin America (4)

*Lehigh in Martinique (MLL/FREN 198) will be offered in Winter of 2004

Music

Professors. Paul Salerni, Ph.D. (Harvard); Steven Sametz, D.M.A. (Wisconsin) (*Ronald J. Ulrich Chair in Music*); Nadine Sine, Ph.D. (N.Y.U.), *Chair*

Associate Professor. Paul Chou, M.M. (SUNY - Stony Brook) *(Ronald J. Ulrich Chair in Orchestral Music)*

Assistant Professor. William Warfield, M.M. (Manhattan)

Professor of Practice. Eugene Albulescu, M.M. (Indiana)

Lecturers. David Diggs, M.M. (SUNY - Stony Brook); Debra Field, M.M. (Temple)

Adjunct Professors: David Bakamjian, D.M.A. (SUNY-Stony Brook); Helen Beedle, M.M. (New England); Donna McHugh, D.M.A. (Catholic); Albert Neumeyer, M.M. (Trenton); Gene Perla; Dave Riekenberg, M.M.E. (N. Texas State); Tim Schwarz, M.M. (Peabody); James Thoma, M.M. (Juilliard).

Private Instructors: Bass: Carter Henry, Gene Perla; **Bassoon:** Kim Seifert; **Clarinet:** Chris DiSanto; **Flute:** Linda Ganus; **French Horn:** Paul LaFollette; **Guitar:** Richard Metzger, Brett Grigsby (**acoustic**); Bob De Vos, Tom Guarna, Vic Juris (**electric**); **Harp**: Andrea Wittchen; **Oboe**: David Diggs; **Organ**: Tim Harrell; **Piano**: Eugene Albulescu, Helen Beedle, Tim Harrison (**jazz**), Bethany Heller, Kevin McCarter, Donna McHugh, Pat O'Connell, Irmgard Pursell; **Percussion**: Marko Marcinko, Gary Rissmiller, James Thoma; **Saxophone**: David Brandom, Dave Riekenberg; **Trombone**: Michael Christianson; **Trumpet**: Bill Warfield (**jazz**), Lawrence Wright; **Tuba**: Scott Force; **Viola and Violin**: Paul Chou, Tim Schwarz; **Violoncello**: David Bakamjian; **Voice**: Eduardo Azzati, Lise Carlson, Debra Field, Jan Opalach, Lawrence Reppert.

The study of music develops skills which will serve the student well in any career: self-discipline, teamwork, problem solving and leadership. A student graduating with the B.A. degree in music will have a strong foundation in music theory and substantial exposure to western music from the Middle Ages to the present. This curriculum will prepare a student for graduate studies in musicology, music theory, composition, or performance. A music major or minor taken in conjunction with a business major may lead to a variety of careers in arts management or in the recording and music publishing industries. For some a double major or a minor in music will not lead to a career but to a life-long involvement with an art form that gives lasting satisfaction.

The music department also offers significant performance experiences in instrumental and vocal ensembles, large and small, and in private instruction. The Zoellner Arts Center facilities include a Listening Library, practice rooms, a composition and digital class piano studio, a fine recording studio, classrooms and rehearsal rooms. Most importantly, the center boasts its concert facility, Baker Hall. With its 1000-seat capacity and excellent acoustics, it is flexible both on the stage (concert or theater mode) and in seating arrangements. The fully adjustable pit can serve opera or musical theatre, can provide additional seating, or can become an extension of the stage.

Major program

The music program offers **two separate programs,** each earning the Bachelor of Arts degree, the B.A. in Music and the B.A. in Music Composition.

The Bachelor of Arts in Music (36-credit minimum) is for those students who wish to have double majors, who might choose a related field (e.g., arts management, part-time performance careers in orchestras) or who simply want a concentrated exposure to music study. Students choose between **five different concentrations**: performance; history and literature; theory and composition; jazz; conducting. For those who intend to pursue graduate study in music or a performing career, the major program should be viewed as the minimum requirement. Such students should regularly seek the advice of department faculty in expanding their program to suit their particular needs and goals.

Performance Concentration.

Thirteen credits in theory and musicianship skills: MUS 11, 2, 82, 3, 7, 83, 4, 8. Nine credits of music history (any 3 from MUS 233, 234, 235, 236) and eleven credits in lessons, ensembles and recitals, and three credits in music electives. The student must perform a half recital in the junior year, a full recital in the senior year, and juries during the sophomore and junior years.

History Concentration.

Thirteen credits in theory and musicianship skills: MUS 11, 2, 82, 3, 7, 83, 4, 8. Twelve credits of music history (MUS 233, 234, 235, 236) and eleven credits in electives, lessons, and ensembles, of which at least three must be in performance. The students must produce a major research project during the senior year and prepare program notes for department concerts during at least one semester.

Composition and Theory Concentration.

Eighteen credits in theory: MUS 82, 3, 7, 83, 4, 8, 243, 245. Six credits in music history (any 2 from MUS 233, 234, 235, 236) and eight in composition (MUS 253, 254), plus four in lessons or ensembles. Students must produce a substantial composition or theoretical analysis under the direction of department faculty during the senior year. A keyboard test is required to enter composition class.

Jazz Concentration

Thirteen credits in music theory and musicianship skills: MUS 11, 2, 82, 3, 7, 83, 4, 8 plus three credits in Jazz Theory, Music 139. Six credits in Jazz History: MUS 128, 129. A minimum of four credits in Jazz Improvisation, MUS 140 and six in jazz performance: MUS 24, 25, 48. Four credits in music electives. The student must undertake a senior project under faculty direction.

Conducting Concentration

Thirteen credits in music theory and musicianship skills: MUS 11, 2, 82, 3, 7, 83, 4, 8. Nine credits in music history (choose from 233, 234, 235, 236). Four credits in conducting: MUS 321, 322 plus at least two Conducting Internships (MUS 311), of which one must be in orchestra. Six credits of performance electives (lessons and ensembles). A piano proficiency exam must be completed before the end of the sophomore year. The student must undertake a senior project under faculty direction.

The **Bachelor of Arts in Music Composition** is designed for students committed to pursuing music composition beyond the undergraduate level. It is an intensive composition program with a 54-credit minimum.
Twenty-five credits in music theory: MUS 82, 3, 7, 83, 4, 8, 139, 243, 245, 331. Nine credits in music history: MUS 236 plus two from MUS 129, 233, 234, 235. Fourteen credits in composition: MUS 253, 254, two semesters of MUS 353. A minimum of two semesters of MUS 51: LUVME (1 credit each), one semester of conducting, MUS 321 (2 credits) and two credits of music electives. Students will have to pass a piano proficiency exam by the end of the sophomore year. Students will compile a composition portfolio by the end of the senior year.

Minor program

The minor requires a minimum of 17 credits and may include MUS 80 and 90. The program is designed to be flexible but must include MUS 11, 2, 82, 3, and 7, one history or literature course, and two performance courses (MUS 22-79). The student may choose the remaining four credits from department offerings.

Music Option

Although Music and Engineering/Science is not a major in itself, Lehigh attracts many engineering and science students who wish to continue their active involvement in music and the music department. For those students who are interested in pursuing this option, music can be taken as a dual major, minor or elective.

Concert Requirement

Majors and minors must enroll in MUS 100 and attend concerts approved by the music department for a minimum of three semesters.

Departmental Honors

A student must have a 3.5 average in courses in the major to pursue honors. Candidates for departmental honors should submit to the department chair a written proposal, prepared in consultation with a faculty project adviser by the end of the junior year. The project could result in a research paper, a composition or a performance. Upon acceptance of the proposal by the department faculty, the student should register for MUS 350 for one to six credits, which may be taken all at once or over the senior year. The awarding of departmental honors will be contingent on the quality of the completed project.

Private lessons

Lessons in most instruments and voice may be taken for one credit. They must be arranged through the department at set fees that are *not* included in tuition. Please note that registering for lessons cannot guarantee availability due to difficulties in scheduling.

Performing groups

Admission to performing ensembles is by audition (except Choral Union, Symphonic Band and Marching 97), and students receive one credit per semester by registering for the appropriate course number. Although there is no limit to the number of courses in this series that may be taken, students should check with their adviser to determine the number that may be applied toward graduation.

Most department performances take place in Baker Hall, a 1,000-seat theatre in the Zoellner Arts Center.

Course Offerings

Please note that many upper level courses have no prerequisites beyond MUS 10 or 11 and are open to anyone with basic knowledge of musical terminology.

MUS 2. Keyboard Harmony I (1) spring
Beginning piano skills designed to enable the student to use the piano as a tool. Major and minor scales in both hands, forming chords, elementary sight reading. Co-requisite: Music 11. Students may test out upon examination. **(HU)**

MUS 3. Keyboard Harmony II (1) fall
Continuation of MUS 2. Diatonic progressions in major and minor; more advanced sight reading. Students may test out upon examination. Co-requisite: 82. Prerequisite: MUS 2. **(HU)**

MUS 4. Keyboard Harmony III (1) spring
Additional keyboard skills, including progressions with secondary chords, modulations, and sight reading. Students may test out upon examination. Co-requisite: MUS 83. Prerequisite: MUS 3 **(HU)**

MUS 7. Aural Skills (1) fall
Sight singing and ear training through dictation exercises. Rhythm exercises. Co-requisite: MUS 82. Prerequisite: MUS 11 or equivalent. **(HU)**

MUS 8. Aural Skills II (1) spring
Continuation of MUS 7. Co-requisite: MUS 83. Prerequisite: MUS 7. **(HU)**

MUS 10. Basic Skills in Music (2) fall
Rudiments of musical notation, beginning skills in sight singing, ear training, rhythm and keyboard. Intended for anyone who does not plan to major or minor. **(HU)**

MUS 11. Basic Musicianship (2) spring
Development of basic skills in using notation, sight singing and ear training. For intended majors or minors. Co-requisite: MUS 2. **(HU)**

MUS 12: Surveys in Music (3) fall or spring
Varied topics in music for the non-major such as Italian opera, Keyboard Music, the Symphony. Emphasis on developing listening skills and acquaintance with important works in the genre. Staff **(HU)**

MUS 21-79.
Applied music and performance courses may be repeated for graduation credit up to six times in CEAS and CBE. Prerequisite: Admission to Music 22-62 by audition. Music 66, 68, 69, 71-79 have fees.

MUS 21. Marching Band (1) fall. (ND)

MUS 22. Wind Ensemble (1) fall-spring (HU)

MUS 23. Symphonic Band (1) spring (HU)

MUS 24. Jazz Ensemble (1) fall-spring (HU)

MUS 25. Jazz Band (1) fall-spring (HU)

MUS 31. University Choir (1) fall-spring (HU)

MUS 32. Choral Union (1) fall-spring (HU)

MUS 33. Overtones (1) fall-spring. Co-requisite: MUS 31 (HU)

MUS 37. Scenes from Opera and Musical Theatre (1) fall-spring (HU)

MUS 48. Chamber Music Collegium (1) fall-spring. Department Permission. (HU)

MUS 51. LUVME (1) fall-spring (HU)

MUS 61. Lehigh University Philharmonic (1) fall-spring (HU)

MUS 62. Lehigh University Chamber Orchestra (1) fall-spring (HU)

MUS 64. Class Violin for Beginners (1) fall-spring
Class instruction for beginners on violin. Repeatable for credit. Staff **(HU)**

MUS 66. Class Voice for Beginners (1) fall-spring
Group instruction for beginning students of voice, including breathing and vocal production techniques; diction; beginning solo pieces. **(HU)**

MUS 68. Class Piano for Beginners I (1) fall-spring
Instruction for beginning piano students, including rudiments of musical notation in relation to the keyboard; beginning pieces for solo piano and the group.

MUS 69. Class Piano for Beginners II (1) fall-spring
A continuation of MUS 68. After a second semester of class piano, the student should be ready to benefit from private lesson instruction. **(HU)**

MUS 71. Private Piano Study (1) fall-spring (HU)

MUS 72. Private Vocal Study (1) fall-spring (HU)

MUS 73. Private String Study (1) fall-spring (HU)

MUS 74. Private Woodwind Study (1) fall-spring (HU)

MUS 75. Private Brass Study (1) fall-spring (HU)

MUS 76. Private Percussion Study (1) fall-spring (HU)

MUS 77. Private Organ Study (1) fall-spring (HU)

MUS 78. Private Acoustic Guitar Study (1) fall-spring (HU)

MUS 79. Private Electric Guitar Study (1) fall-spring (HU)

MUS 82. Harmony I (3) fall
Exercises in writing in four-part chorale style. Music 3 and 7 must be taken concurrently. Prerequisites: MUS 11 and 2 or equivalent. **(HU)**

MUS 83. Harmony II (3) spring
Continuation of Music 82 including modulation, non-harmonic tones, analysis. Music 4 and 8 must be taken concurrently. Prerequisites: MUS 82, 3, and 7 or equivalent. **(HU)**

MUS 100. Concert Requirement (0) fall, spring
Concerts approved by the department (for majors and minors)

MUS 128. Jazz History I (3) fall
A study of the roots of jazz. Starting in West Africa, the course traces the synthesis of African and European elements to 1945. Musicians covered are Gottshalk, Bolden, Morton, Armstrong, Hawkins, Basie, Ellington and others. Prerequisite: MUS 10 or 11, or permission of instructor. Warfield. **(HU)**

MUS 129. Jazz History II (3) spring
A survey of modern jazz from 1945 to the present. Musicians covered are Parker, Gillespie, Monk, Davis, Coltrane, Hancock, and Coleman. Can be taken independently of Jazz History I, but the first course would be helpful. Prerequisite: MUS 10 or 11, or permission of instructor. Warfield. **(HU)**

MUS 132. Composer and Era (3) fall or spring
Life and development of a composer's style viewed in historical context. Title varies: Bach, Beethoven, Mozart, etc. May be repeated for credit as title varies. Prerequisite: MUS 10 or 11 or equivalent. Sine. **(HU)**

MUS 139. Jazz Theory (3) spring
Study of the music theory that is the foundation of a good jazz solo, composition or arrangement. Study of the modes of the major and melodic minor scale, chord/scale theory using major, melodic minor, diminished, and whole-tone scales. Basic chord progressions, functional analysis of jazz tunes, and ear training are also included. Prerequisites: MUS 82. **(HU)**

MUS 140. Jazz Improvisation (1) fall, spring
Development of skills in improvising music through practice of different scales found in jazz, chord construction, and patterns of figuration found in jazz. May be repeated for credit. Warfield. **(HU)**

MUS 151. Vocal Diction (1) fall or spring
Introduction to the use of the International Phonetic Alphabet. Application to French, Italian, German and English diction using art song repertoire. Preparation of a song in each language. Field. **(HU)**

MUS 161. Production and Marketing of Sound Recordings I (3) fall
A two-semester course providing foundations for organizing a recording project to be carried out by the class, which works in teams. The first course will focus especially on artist negotiations, recording techniques, music publishing and manufacturing. Perla. **(ND)**

MUS 164. Management of Careers in Performing Arts (3)
A one-semester course that provides an overview of what performing artists and managers experience during cycles of career development. Topics include recognition of talent, positioning in the marketplace, creating support structure and attainment of personal goals. Student will be required to apply practical techniques in furthering the career of a chosen artist. Perla **(ND)**

MUS 170. Private Instruction for Performance Concentrators (2)
Lesson fees apply. Repeatable for credit. Restricted to music majors concentrating in performance. **(HU)**

MUS 233. Medieval and Renaissance Music (3) fall, odd
Development of musical style from early Christian chant to the sacred and secular forms of the late 16th century, viewed in cultural contexts. Prerequisite: MUS 11 or equivalent. Sine. **(HU)**

MUS 234. Baroque and Classical Music (3) spring, even
The major genres and composers of the 17th and 18th centuries studied in their cultural context. Prerequisite: MUS 11 or equivalent. Sine. **(HU)**

MUS 235. Romantic Music (3) fall, even
Study of the major composers and their works from late Beethoven to Mahler and Strauss. Prerequisite: MUS 11 or equivalent. Sine. **(HU)**

MUS 236. Twentieth-Century Music (3) spring, odd
Beginning with the major trends at the turn of the century, a study of the important composers and works of the last century to the present. Prerequisite: MUS 11 or equivalent. Sine. **(HU)**

MUS 243. Counterpoint (4) fall
Writing and analyzing pieces in Renaissance and Baroque contrapuntal styles. Prerequisites: MUS 83, 4, and 8 or equivalent. Salerni **(ND).**

MUS 245. Classical and Romantic Forms (4) spring
Analyzing and writing pieces in classical and romantic forms. Exercises in chromatic harmony. Prerequisite: MUS 243. **(ND)**

MUS 251. Special Topics (1-3)
Study of musical topics in history or composition not covered in regular courses. May be repeated for credit as title varies. Prerequisite: consent of the department chair. **(HU)**

MUS 253. Composition I: Electronic and Acoustic Techniques (4) fall
Writing for acoustic and electronic instruments based on 20th-century models. Acoustic orchestration, digital synthesis, effects processing. Use of the computer for score preparation and as a compositional tool. Prerequisite: MUS 83, 4, and 8 or permission of instructor. Salerni. **(ND)**

MUS 254. Composition II (4) spring
Continuation of MUS 253. Prerequisite: 253. Salerni. **(ND)**

MUS 261. Recording Techniques I (3) fall
Recording music in various popular and classical styles using state of the art studio equipment. Topics include microphone choice, placement, mixing, effects processing, digital editing and post production. Prerequisites: MUS 82, 3, and 7 or permission of instructor. **(ND)**

MUS 262. Recording Techniques II (3) spring
Continuation of Recording Techniques I. Prerequisite: MUS 261**(ND)**

MUS 271. Repertoire (2) fall or spring
Survey of literature in a given medium: e.g., piano, vocal, orchestral, choral repertoire. Particular emphasis on performance issues. May be repeated for credit as title varies. **(HU)**

MUS 291. Independent Study (1-3)
Individually supervised work in history or composition, or continuation of projects begun in regular courses. May be repeated for credit. Prerequisite: consent of department chair. **(HU)**

MUS 300. Apprentice Teaching (1-3) (ND)

MUS 311. Conducting Internship (2)
Work under the direction of one of the faculty directors to learn the organization and musical tasks required of

directors as they prepare ensembles for performance. Prerequisites: MUS 322 or permission. Repeatable for credit. Staff **(HU)**

MUS 321. Conducting I (2) fall
Beginning study of conducting techniques, including score reading and preparation, analysis, conducting patterns and gestures. Prerequisite: MUS 83 or permission of the instructor. **(HU)**

MUS 322. Conducting II (2) spring
Continuation of Music 321. Prerequisite: MUS 321. **(HU)**

MUS 331. Advanced Analysis (4) spring
In-depth analysis of music from the Western tradition. Compositions studied to include at least one orchestral piece, one piece with text (song cycle or opera) and one piece using serial procedures. Introduction to Schenkerian analysis. Prerequisites: Music 243 and 245 or permission. Staff **(HU)**

MUS 350. Senior Project (1-6) (ND)

MUS 353. Composition Seminar (3) fall-spring
Seminar review of original compositions alternating with private lessons in composition. The seminar is intended for students doing either independent work in composition or senior projects. Prerequisites: MUS 254. Salerni, Sametz, Warfield. Repeatable for credit. Staff **(HU)**

MUS 370. Recital (1-2) fall-spring
Department permission. **(HU)**

MUS 412. Advanced Choral Conducting and Composition (2) summer
Intensive, week-long seminar/workshop held in conjunction with Oxford University Press. Students elect either composition or conducting track for individual study with international faculty in chosen area. Joint seminars and lab choir rehearsals on choral literature; rehearsals and premieres of student works. Additional seminars with internationally recognized choral directors. New works and repertoire presented in final concert conducted by faculty and participants. Sametz

Philosophy

Professors. Gordon Bearn, Ph.D. (Yale), *William Wilson Selfridge Professor of Philosophy*; Mark H. Bickhard, Ph.D. (Chicago), *Henry R. Luce Professor* in Cognitive Robotics and the Philosophy of Knowledge; Steven Louis Goldman, Ph.D. (Boston), *Andrew W. Mellon Distinguished Professor* in the Humanities; Roslyn Weiss, Ph.D. (Columbia), chair and *Clara H. Stewardson Professor* of Philosophy.

Associate Professors. Robin Dillon, Ph.D. (Pittsburgh); Alexander Levine, Ph.D. (San Diego); Michael Mendelson, Ph.D. (San Diego).

Philosophy is born of discomfort. Whether it is the need to account for the tragedies of circumstance, the incongruities between our assumptions about the world and what experience and science reveal, or the shock of being exposed to hitherto unimagined conceptual alternatives, philosophy arises in those contexts in which serious questions emerge about the adequacy of our most cherished beliefs.

Philosophy is driven by the unsettling awareness that we are not beings who act exclusively on instinct but are instead able to choose from among a variety of ways of thinking about ourselves, the world in which we find ourselves, and our relations with others. Moreover, the beliefs we hold are not merely incidental facts about us like height or eye color. What we believe is often central to our moral identity, the nature of our personal relationships, the manner in which we regard ourselves and treat others, and the happiness and unhappiness that form the emotional contours of our practical lives. Philosophy is born out of our awareness that despite the centrality of our beliefs to our identity as moral beings, the truth of our beliefs can be uncertain, for on virtually any topic there is a variety of possible viewpoints, not all of which can be equally adequate.

In its attempt to ground our beliefs and justify them, philosophy becomes a reflective and critical conceptual activity concerned with foundational questions regarding our deepest assumptions and intuitions about the nature and extent of human knowledge (epistemology), about the nature of reality and the distinction between appearance and reality (metaphysics), about the nature, scope, and grounds of moral value (ethics), and about the nature and theoretical foundations of formal reasoning and valid inference (logic).

The major program in philosophy is designed to provide a broad exposure to all of these areas as well as a strong grounding in the history of the western philosophical tradition. The program emphasizes the close reading and critical evaluation of classic texts from ancient times to the present, and students can expect to develop sophisticated analytic and expository skills that will enable them to engage in original, critical reflection on their own. To this end, the major program involves a combination of required and elective coursework as well as the opportunity to develop and pursue individual interests under faculty supervision. In addition to its regular course offerings, the department also sponsors a variety of activities (e.g. the annual Selfridge Lecture, the Philosophy Forum, the Faculty Seminar, the Philosophy Club, and the annual Reading Party), all of which are designed to complement the course offerings and to promote a university-wide philosophical community.

The major program provides excellent preparation for graduate study in philosophy as well as a solid foundation for any career that places a premium upon clear, careful thinking and rigorous conceptual and expository skills.

For additional information about the faculty, frequency of course offerings, and departmental events, please contact the department for a copy of its brochure.

The Minor Program

The minor in philosophy consists of four courses. The courses must include at least one course at the 200-level or above. Minor programs are planned in conjunction with the departmental advisor who will help the student plan a program compatible with his or her interests. Minor programs may be, but do not have to be, focused in a particular area such as ethics or the history of philosophy or philosophy of mind.

The Major Program

The major program consists of ten courses (38 credits) planned in conjunction with the student's major advisor. In addition to a two semester (6 credits) senior thesis, each major must satisfy the following distribution requirements:

Ethics

1 course from PHIL. 105, 116, or 205

Logic

1 course from PHIL. 114, 260, 265, or 303

History of Philosophy

2 courses from PHIL. 131, 132, 135, 139, 231, 233, 235, 237, or 239

Three of the 10 courses (*not* including the senior thesis) must be at the 200 level or above.

Majors planning to pursue graduate study in philosophy are strongly encouraged to include the following specific courses:

PHIL. 105 Ethics
PHIL. 114 Fundamentals of Logic
PHIL. 131 Ancient Philosophy
PHIL. 135 Modern Philosophy

Senior Thesis

The Senior Thesis (PHIL 390-1) is a year-long, independent project during which philosophy majors, with the consent and under the guidance of a faculty sponsor, investigate a topic of special interest to them. The topic may be historical or non-historical, pure or applied, interdisciplinary or disciplinary; the only constraint is that the student secure the cooperation of a faculty sponsor. During the fall (PHIL 390), the student's energies will be devoted to refining the topic under investigation, working through the bulk of the essential literature, and producing a paper roughly 20 pages in length. During the spring semester (PHIL 391), the student will investigate the same topic more intensively, expanding, revising, and refining the fall paper into a substantial senior thesis roughly 50 pages in length.

Honors

Departmental honors in Philosophy are awarded to those graduating seniors who satisfy the following two criteria: (a) at the time of graduation, their GPA in philosophy is 3.5 or higher, their overall GPA is 3.25 or higher, and (b) their senior thesis is judged by two members of the philosophy department to show sufficient imaginative philosophical accomplishment to merit their receiving Honors in Philosophy.

Undergraduate Courses

PHIL 1. The Examined Life: An Introduction to Philosophy (4)
What makes a life meaningful, what makes it worth living? In pursuit of an answer to this question this course examines many of the basic questions of philosophy: ethical questions about justice and virtue, epistemological questions about the limits of human knowledge, metaphysical questions about what there is. **(HU)**

PHIL 3. (REL 3) Religion, Ethics and Society (4)
Introduction to philosophical and religious modes of moral thinking, with consideration given to ethics in the world religious traditions (family life and role of women, social justice, environment, work, models of ethical ideals). Particular issues examined include abortion, corporal punishment (such as the death penalty), problems in medical ethics, and heavy drinking as a behavioral problem. **(HU)**

PHIL 100. (POLS 100) Introduction to Political Thought (4)
Some of the most significant ancient and modern political theorists: Plato, Aristotle, Machiavelli, Hobbes, Marx, and others. Matthews. **(ND)**

PHIL 101. (POLS 101) Ancient Political Heritage (4)
Important Political thinkers from the pre-Socratics to early, modern political theorists like Machiavelli. Matthews. **(SS)**

PHIL 102. (POLS 102) Modern Political Heritage (4)
Begins where POLS 101 ends; from early modern theorists (e.g. Hobbes) up to contemporary thinkers (e.g. Marcuse). **(SS)**

PHIL 105. Ethics (4)
Examination of right and wrong, good and bad, from classic sources such as Plato, Aristotle, Hume, Kant, Mill and Nietzsche. **(HU)**

PHIL 114. Fundamentals of Logic (4)
Introduction to formal deductive logic, involving the construction of logical proofs in a system of natural deduction with some attention to the philosophy of logic. **(MA)**

PHIL 116. (REL 116) Bioethics (4)
Moral issues that arise in the context of health care and related biomedical fields in the United States today, examined in the light of the nature and foundation of moral rights and obligations. Topics include: confidentiality, informed consent, euthanasia, medical research and experimentation, genetics, the distribution of health care, etc. **(HU)**

PHIL 117. Race and Philosophy (4)
An introduction to the philosophy born of struggle against racism and white supremacy. We will read the work of philosophers, mostly European, who quietly made modern racism possible by inventing the category of race, but we will concentrate on the work of philosophers, mostly of African descent, who for 200 years have struggled to force a philosophical critique of the category of race and the practice of white supremacy. **(HU)**

PHIL 121. Philosophy in Literature (4)
Exploration of philosophical themes through the study of literature and film. Authors may include: Homer, Euripides, Dante, Rimbaud, Sterne, George Eliot, Valery, Joyce, Melville, T.S. Eliot, Rilke, Proust, Musil, Stevens, Cummings, Camus, Sartre, Beckett, Morrison, Barthelme. **(HU)**

PHIL 122. Philosophy of Law (4)
Analysis of the conceptual foundations of our legal system. Special attention devoted to the nature of law and legal obligation, liberty and privacy in constitutional litigation, justice and contractual obligation, theories of punishment in criminal law, and the nature and scope of responsibility in criminal law. **(HU)**

PHIL 123. Aesthetics (4)
Theories, classical and modern, of the nature of beauty and the aesthetic experience. Practical criticism of some works of art, and examination of analogies between arts, and between art and nature. **(HU)**

PHIL 124. (REL 124) Reason and Religious Experience (4)
Critical examination, from a philosophical perspective, of some fundamental problems of religion, the nature of religious experience and belief, reason and revelation, the existence and nature of God, the problem of evil, and religious truth. **(HU)**

PHIL 126. (Hum 126, REL 126) Professional Ethics (4)
An examination of the moral rules and action guides that govern various professions. Professions to be examined will include health (physician and nursing); legal; counseling and psychiatry; engineering; military; clergy; teaching. Attention will be given to modes of ethical reasoning and how those modes are practically applied in professional life and activity. Among issues to be discussed, will be the limits of confidentiality; employer authority; power relationships; obligations to the public; professional rights; sexual boundaries; whistle-blowing; safety and risk; computer ethics; weapons development; discrimination; professional review of ethical infractions. Course will include guest lectures and case studies. Steffen. **(HU)**

PHIL 127. Existentialism (4)
Investigation of the historical development of existentialism from its origins in the 19th century (Kierkegaard, Nietzsche) through its marriage to phenomenology in the early 20th (Heidegger, Sartre, Merleau-Ponty), and out the other side as a vigorous dimension of much literary, psychological, and artistic work produced in the last 50 years. **(HU)**

PHIL 128. Philosophy of Science (4)
Introduction to the structure and methods of scientific investigation. The nature of explanation, confirmation, and falsification. Scientific progress: What is it? Would it be suffocated by obedience to completely rational methods? **(HU)**

PHIL 129. (REL 129) Jewish Philosophy (4)
Consideration of how major Jewish thinkers from the first to 20th centuries confronted questions at the intersection of religion and philosophy: the existence and nature of God, free will, evil, divine providence, miracles, creation, revelation, and religious obligation. **(HU)**

PHIL 131. (CLSS 131) Ancient Philosophy (4)
Historical survey of selected texts and issues in the classical world, from the pre-Socratics through Aristotle, with emphasis on the origins of the western philosophical traditions in ethics, metaphysics, and epistemology. **(HU)**

PHIL 132. (CLSS 132) Hellenistic Philosophy (4)
Historical survey of selected texts and issues in Post-Aristotelian Greek and Roman philosophy from the fourth century B.C. to the third century A.D. Areas of focus may include epicureanism, stoicism, academic and pyrrohnian scepticism, and neoplatonism. **(HU)**

PHIL 133. Medieval Philosophy (4)
Historical survey of selected texts and issues in western philosophy from the fourth to 14th centuries. Attention will be given to the relation between developments in medieval philosophy and major currents in ancient and modern thought. Figures may include Augustine, Eriugena, Anselm, Aquinas, Ockham, and Nicholas of Autrecourt. **(HU)**

PHIL 135. Modern Philosophy (4)
Historical survey of selected texts and issues in 17th and 18th century European philosophy with particular emphasis on developments in epistemology and metaphysics. Attention will be given to the relation of the “modern period” to developments in late medieval philosophy and the rise of the experimental sciences. Figures may include Descartes, Leibniz, Locke, Hume, and Kant. **(HU)**

PHIL 137. (Hum 137, REL 137) Ethics in Practice (1-4)
A variable content course focusing on ethical issues arising in a particular profession, such as law health, business, engineering, military. Variable credit. May be taken more than once. Steffen. **(HU)**

PHIL 139. Contemporary Philosophy (4)
Philosophical thought from the late-19th century to the present; pragmatism, linguistic analysis, existentialism, and Marxism. Truth and knowledge, values and moral judgement, meaning, the place of the individual in the physical world and society, and the impact of the scientific method upon all of these. **(HU)**

PHIL 140. (Asian Studies 140) Eastern Philosophy (4)
Survey of selected texts and issues in the eastern philosophical traditions. Attention will be given to the development and interrelations of these traditions as well as a comparison of western and eastern treatments of selected issues. Areas of focus may include Confucianism, Taoism, and Zen Buddhism. **(HU)**

PHIL 205. Contemporary Ethics (4)
Examination of significant questions addressed by contemporary moral philosophers. Topics vary, but might include: What is a good person? Can a woman be good in the same way as a man? Is morality relative or absolute? Is morality all that important? Prerequisite: PHIL 105 or consent of the instructor. **(HU)**

PHIL 217. Figures/Themes in Race and Philosophy (4)
An investigation of a significant figure in the philosophy of race (e.g. David Walker, W.E.B. DuBois, Alain Locke, Marcus Garvey, Jean-Paul Sartre, Franz Fanon, Aimé Césaire, Cornel West) and/or an investigation of a significant theme in the philosophy of race (Racial Exploitation, Colonialism, Negritude, Afrocentrism, Black Nationalism, African Philosophy, Black Athena). Content Varies. May be taken more than once for credit. **(HU)**

PHIL 220. Knowledge and Justification (4)
Recent work in epistemology. Questions addressed include: If you can’t know whether you are dreaming, how can you know you have two hands? Does knowledge require answers to all possible doubts or only all reasonable doubts? How should we determine the horizon of the reasonable—psychologically or philosophically? **(HU)**

PHIL 223. Figures/Themes in Aesthetics (4)
An investigation of a significant figure in aesthetics (e.g., Burke, Kant, Hegel, Benjamin, Adorno, Goodman, Kivy, Derrida, Deleuze) and/or an investigation of a significant theme in aesthetics (e.g., sensuality, representation, politics, expressionism, cinematic gore, minimalism, architecture, post-modernism). Content varies. May be taken more than once for credit. **(HU)**

PHIL 224. (REL 224) Topics in the Philosophy of Religion (4)
Selected problems and issues in the philosophy of religion. Content varies. May be repeated more than once for credit. (**HU**)

PHIL 226. (WS 226) Feminism and Philosophy (4)
Analysis of the nature, sources, and consequences of the oppression and exploitation of women and justification of strategies for liberation. Topics include women's nature and human nature, sexism, femininity, sexuality, reproduction, mothering. Prerequisite: At least one previous course in philosophy or women's studies. (**HU**)

PHIL 228. Topics in the Philosophy of Science (4)
Themes in the natural, life and social sciences. May be repeated for credit as topic varies. Prerequisite: PHIL 128 or consent of the department chair. (**HU**)

PHIL 231. (CLSS 231) Figures/Themes in Ancient Philosophy (4)
This seminar course will involve in-depth focus upon a major ancient thinker (e.g. Plato, Aristotle, Sextus Empiricus, Plotinus, etc.) or the classical treatment of a particular theme (e.g. "human nature," "the good life," ethical or political theory, etc.). Content varies. May be repeated more than once for credit. (**HU**)

PHIL 233. Figures/Themes in Medieval Philosophy (4)
This seminar course will involve in-depth focus upon a major medieval thinker (e.g. Augustine, Boethius, Maimonides, Bonaventure, Dante, etc.) or the medieval treatment of a particular theme (e.g. the relation of "will" and "intellect," the "problem of universals," ethical or political theory, etc.). Content varies. May be repeated more than once for credit. (**HU**)

PHIL 235. Figures/Themes in Modern Philosophy (4)
This seminar course will involve in-depth focus upon a major 17th or 18th century thinker (e.g. Descartes, Leibniz, Berkeley, Kant, etc.) or the modern treatment of a particular theme (e.g. the nature of "ideas," the roles of experience, reason, and revelation, ethical or political theory, etc.). Content varies. May be repeated more than once for credit. (**HU**)

PHIL 237. Figures/Themes in Nineteenth Century Philosophy (4)
This seminar course will involve in-depth focus upon a major 19th century thinker (e.g. Hegel, Marx, Kierkegaard, Mill, Peirce, Frege, Nietzsche, James, etc.) or the 19th century treatment of a particular theme (e.g. the end of history, revolution, nihilism, authenticity, origins of mathematical logic, infinity, etc.). Content varies. May be repeated more than once for credit. (**HU**)

PHIL 239. Figures/Themes in Contemporary Philosophy (4)
This seminar course will involve in-depth focus upon a major contemporary thinker (e.g. Russell, Whitehead, Husserl, Heidegger, Wittgenstein, Quine, Habermas, Rawls, Rorty, Derrida, Davidson, Foucault, Deleuze, Irigaray, etc.) or the contemporary treatment of a particular theme (e.g. logical positivism, naturalism, non-foundationalism, existential phenomenology, return to virtue, neo-pragmatism, hermeneutics, post-structuralism, post-modernism, neo-kantian political theory, the politics of identity, etc.). Content varies. May be repeated more than once for credit. (**HU**)

PHIL 240. (Asian Studies 240) Figures/Themes in Eastern Philosophy (4)
This seminar course will involve in-depth focus upon a major figure in Eastern thought or upon the Eastern treatment of a particular theme or set of themes. Content varies. May be repeated more than once for credit. (**HU**)

PHIL 250. The Minds of Robots and Other People (4)
Is the nature of thinking illuminated by what computers can do? Is the brain just a complex computer? Could a robot feel pain? Be angry? Recent work in artificial intelligence, psychology, and philosophy. (**HU**)

PHIL 260. Philosophy of Language (4)
Analysis of the nature of the correspondence between the words we use and the world in which we live. Our unifying theme is the quest for an understanding of truth, conceived as a peculiar relation between language and reality. We examine such central notions as meaning and reference, as understood in historically influential philosophical theories of language. (**HU**)

PHIL 265. Philosophy of Mathematics (4)
Survey of metaphysical and epistemological issues from the philosophy of mathematics, with emphasis on the arguments on behalf of mathematical platonism, conventionalism, and psychologism. It is highly recommended that students take PHIL 114 and a year of calculus, or otherwise acquire comparable formal background, prior to this course. (**HU**)

PHIL 273, Ariadne: Internship (2)
An internship devoted to the construction and maintenance of *Ariadne*, an on-line, web-based, undergraduate journal of philosophy. Responsibilities will include research; publicizing the project nationally and locally; reviewing, selecting, and formatting manuscripts for publication; and various other administrative and editorial activities. Some students may also be involved in the initial states of constructing *Dionysos*, an externally refereed, on-line, web-based professional journal of the history of philosophy. Prerequisite: Department permission required: previous coursework in philosophy expected. May be repeated more than once for credit. (**ND**)

PHIL 290. Independent Study (1-4)
Individual philosophical investigation of an author, book, or topic designed in collaboration with a faculty sponsor. Tutorial meetings; substantial written work. May be repeated more than once for credit. Consent of faculty sponsor required. (**ND**)

PHIL 303. (MATH 303) Mathematical Logic (3-4)
A course, on a mathematically mature level, designed not only to acquaint the student with logical techniques used in mathematics but also to present symbolic logic as an important adjunct to the study of the foundations of mathematics. Prerequisite for non-math majors: PHIL 114 (**MA**)

PHIL 364. (POLS 364) Issues in Contemporary Political Philosophy (4)
Selected topics in contemporary political philosophy, such as the Frankfurt school, existentialism, legitimation, authenticity, participatory democracy, and the alleged

decline of political philosophy. May be repeated for credit with consent of the political science chair. **(SS)**

PHIL 367. (POLS 367) American Political Thought (4)
Critical examination of American political thought from the founding of the Republic to the present. Writings from Madison, Hamilton, and Jefferson to Emma Goldman, Mary Daly, Malcolm X, Henry Kariel, and others will be discussed. **(SS)**

PHIL 371. Advanced Independent Study (1-4)
Individual philosophical investigation of an author, book, or topic designed in collaboration with a faculty sponsor. Tutorial meetings; substantial written work. May be repeated more than once for credit. Consent of faculty sponsor required. **(ND)**

PHIL 373. (Hum 373, REL 373) Independent Ethics Project (4)
Supervised ethics research into a topic approved by the advisor for the Humanities Minor in Ethics. An option for completing the ethics minor. For ethics minors only. **(HU)**

PHIL 390. Senior Thesis (2)
The first part of two semesters of intensive research and writing guided by a faculty sponsor in anticipation of completing a senior thesis in philosophy. Individual tutorials; substantial written work. Senior standing as philosophy major and consent of faculty sponsor required. **(ND)**

PHIL 391. Senior Thesis (4)
Continuation and completion of PHIL 390 under the guidance of a faculty sponsor. Prerequisites: PHIL 390; consent of faculty sponsor required. **(ND)**

Physics

Professors. Michael Stavola, Ph.D. (Rochester), *chairperson*; Garold J. Borse, Ph.D. (Virginia), *associate chairperson;* Gary G. DeLeo, Ph.D. (Connecticut), Robert T. Folk, Ph.D. (Lehigh); James D. Gunton, Ph.D. (Stanford); A. Peet Hickman, Ph.D. (Rice); John P. Huennekens, Ph.D. (Colorado); Alvin S. Kanofsky, Ph.D. (Pennsylvania); Thomas L. Koch, Ph.D. (Cal. Tech.), *director, Center for Optical Technologies;* Yong W. Kim, Ph.D. (Michigan); Arnold H. Kritz, Ph.D. (Yale); H. Daniel Ou-Yang, Ph.D. (U.C.L.A.); Jean Toulouse, Ph.D. (Columbia).

Associate professors. Ivan Biaggio, Ph.D., (ETH-Zurich); Volkmar Dierolf, Ph.D. (Utah); Jerome C. Licini, Ph.D. (M.I.T.); Russell A. Shaffer, Ph.D. (Johns Hopkins).

Physics students study the basic laws of mechanics, heat and thermodynamics, electricity and magnetism, optics, relativity, quantum mechanics, and elementary particles. The students also study applications of the basic theories to the description of bulk matter, including the mechanical, electric, magnetic, and thermal properties of solids, liquids, gases, and plasmas, and to the description of the structure of atoms and nuclei. In addition, the student develops the laboratory skills and techniques of the experimental physicist, skills that can be applied in the experimental search for new knowledge or in applications of the known theories.

A majority of physics graduates go to graduate school in physics, often earning the Ph.D. degree. These graduates take university or college faculty positions, or work on research in a variety of university, government, or industrial laboratories. Some students choose employment immediately after the bachelor's degree. They use their many approved and free electives to supplement their science background with applied courses, such as engineering, to develop the skills needed for a position in a particular area.

Because of the fundamental role of physics in all the natural sciences, students also use the physics major as an excellent preparation for graduate study in many other scientific areas, such as: optical engineering, applied mathematics, computer science, biophysics, molecular biology, astrophysics, geology and geophysics, materials science and engineering, meteorology, or physical oceanography. Attractive engineering areas with a high science content include optical communications, aeronautical engineering, nuclear engineering, including both fission and fusion devices; electrical engineering, including instrumentation, electronics and solid-state devices, electrical discharges and other plasma-related areas; and mechanical engineering and mechanics, including fluids and continuum mechanics. The broad scientific background developed in the physics curriculum is also an excellent background for professional schools, such as law (particularly patent law), medicine, and optometry.

Lehigh offers three undergraduate degrees in physics and two undergraduate degrees in astronomy or astrophysics. The three physics degrees are the bachelor of arts with a major in physics and the bachelor of science in physics in the College of Arts and Sciences, and the bachelor of engineering physics in the College of Engineering and Applied Science. The B.A. with a major in astronomy and the B.S. in astrophysics are in the College of Arts and Sciences and are described in the **Astronomy and Astrophysics** section of this catalog.

In addition, there are several five-year, dual-degree programs involving physics: The arts-engineering program (see the **Arts-Engineering** section of this catalog), the combination of the bachelor of science program in the College of Arts and Sciences with Electrical Engineering (described below), and the combination of electrical engineering and engineering physics (see the **Electrical Engineering and Engineering Physics** section of this catalog).

The bachelor of science curriculum in the College of Arts and Sciences requires somewhat more physics and mathematics than the bachelor of arts major, while the latter provides more free electives and three fewer hours for graduation. By making good use of the electives in these programs, either can prepare a student for graduate work in physics or the physical aspects of other sciences or engineering disciplines, or for technical careers requiring a basic knowledge of physics. The bachelor of arts curriculum is particularly useful for those planning careers in areas where some knowledge of physics is needed or useful, but is not the main subject, such as science writing, secondary school teaching, patent law, or medicine.

The bachelor of science in engineering physics curriculum in the College of Engineering and Applied Science requires an engineering concentration in either solid state electronics or optical sciences, in addition to regular physics and mathematics courses. This four-year program prepares students to do engineering work in an overlap area between physics and engineering, which may be engineering in a forefront area in which it is desirable to have more physics knowledge than the typical engineer has, or may be experimental physics which either relies heavily on fore-front engineering or in which the nature of the problem dictates that scientists and engineers will accomplish more working together rather than separately.

A comparison of the curricula in terms of credit hours (minimum credits indicated in major courses and approved electives) in various broad categories is given below.

	College of Arts & Sciences				**College of Engineering**	
	Concentration in:					
	Physics		Astronomy		Solid-State	Optical
	B.A.	B.S.	B.A.	B.S.	Electronics	Sciences
Frshmn English	6	6	6	6	6	6
Coll. Ment. & Sem	4	4	4	4		
Distrb. Courses	*16	*16	*16	16	17	17
Required Prelim & major courses	56	66	53	66	85	78
Apprvd Electives	16	17	12	12	11	18
Electives	23	15	30	20	12	12
Total	121	124	121	124	131	131

**Not including mathematics or science*

The recommended sequences of courses are:

Physics Degree Programs

College of Arts & Sciences

Bachelor of Arts Fall	Spring	**Bachelor of Science** Fall	Spring
Freshman Year			
ENGL 1 (3)	ENGL 2,4 6, 8 or 106, (3)	ENGL 1 (3)	ENGL 2,4, 6, 8 or 10 (3)
PHY 10 or 11 (4)	CHM 21 (4)	PHY 11 (4)	CHM 21 (4)
PHY 12 (1)	CHM 22 (1)	PHY 12 (1)	CHM 22 (1)
MATH 21 (4)	MATH 22 (4)	MATH 21(4)	MATH 22 (4)
Col. Sem. (3)	Dist. Req. (3)	Col.Sem (3)	*ENGR. 1 (3)
Coll. Ment. (1)	Col. Ment (1)		
[16]	[16]	[15]	[15]
Sophomore Year			
PHY 13 or 21 (3-4)	PHY 31 (3)	PHY 21 (4)	PHY 31 (3)
PHY 14 or 22 (1)	Adv.PHY. Lab (2-3)	PHY 22 (1)	PHY 190 (3)
MATH 23 (4)	MATH 205(3)	MATH 23 (4)	MATH 205 (3)
Dist. Req. (6)	Dist. Req. (4)	Dist. Req. (6)	Dist. Req.(3)
	Elective (3)		Elective (4)
[14-15]	[15-16]	[15]	[16]
Junior Year			
Adv. PHY.(2)(7)	Adv.PHY. (6)	PHY 212 (3)	PHY 213(3)
Appr.Elec. (3)	Appr.Elec (3)	PHY 362 (3)	PHY 262(2)
Dist. Req. (3)	Elective (3)	MATH 322(3)	PHY 364(3)
Elective (3)	Jr. Writing (3)	Jr. Writing(3)	PHY 215(4)
		Elective (4)	Elective (4)
[16]	[15]	[16]	[16]
Senior Year			
Adv. PHY. (5)	Appr.Elec (7)	PHY 340 (3)	Appr.Elec.(6)
Appr.Elec. (3)	Electives (8)	ApprElec (8)	Electives (7)
Elective (6)		Dist.Req. (4)	Dist.Req. (3)
[14]	[15]	[15]	[16]
	[121]		[124]

**or an equivalent course in scientific computing*

For the **Bachelor of Arts** curriculum:

At least one of the two advanced physics laboratories (PHY 190, PHY 262) is required.

A total of 18 credits of advanced physics courses (200 or 300 level). At least two of these courses must be at the 300 level.

Approved Electives are subject to the approval of the student's advisor, and should be chosen to provide a coherent program to satisfy the student's goals, such as an interdisciplinary area of science, medical school, law school, teaching certification, science writing, etc.

No more than 6 credit hours of military science may be applied towards the degree.

For the **Bachelor of Science** curriculum:

Approved electives include at least 17 credit hours of physics, physical science, or technical courses. Included in this group must be three of the following courses: PHY 363, 369, (352 or 355), and (348 or 365) and 380. Students planning graduate work in physics are advised to include PHY 273 and 369 among their electives.

No more than 6 credit hours of military science may be applied towards the degree.

P.C. Rossin College of Engineering & Applied Sciences

Bachelor of Engineering Physics

with a concentration in

Solid State Electronics Fall	Spring	**Optical Sciences** Fall	Spring
Freshman Year			
ENGL 1 (3)	ENGL 2,4, 6, 8 or 10 (3)	ENGL 1 (3)	ENGL 2, 4, 6, 8 or 10 (3)
PHY 11 (4)	CHM 21 (4)	PHY 11 (4)	CHM 21 (4)
PHY 12 (1)	CHM 22 (1)	PHY 12 (1)	CHM 22 (1)
MATH 21(4)	MATH 22 (4)	MATH 21(4)	MATH 22 (4)
HSS (3)	ENGR 1 (3)	HSS (3)	ENGR 1 (3)
ENGR 2 (1)		ENGR 2 (1)	
[16]	[15]	[16]	[15]
Sophomore Year			
PHY 21 (4)	PHY 31 (3)	PHY 21 (4)	PHY 31 (3)
PHY 22 (1)	PHY 190 (3)	PHY 22 (1)	PHY 190 (3)
MATH 23 (4)	MATH 205 (3)	MATH 23 (4)	MATH 205 (3)
ECO 1 (4)	MATH 208 (3)	ECO 1 (4)	MATH 208 (3)
ECE 81 (4)	ECE 108 (4)	ECE 81 (4)	ECE 108 (4)
[17]	[16]	[17]	[16]

Junior Year

PHY 212	(3)	PHY 213	(3)	PHY 212	(3)	PHY 213	(3)
ECE 33	(4)	PHY 262	(2)	PHY 362	(3)	PHY 262	(2)
ECE 123	(3)	PHY 215	(4)	OE - Elec	(3)	PHY 215	(4)
MATH 322	(3)	ECE 126	(3)	HSS	(4)	OE - Elec	(3)
HSS	(4)	HSS	(3)	MATH 322	(3)	HSS	(3)
		Elective	(3)			Elective	(3)
	[17]		[18]		[16]		[18]

Senior Year

PHY 340 or ME 104	(3)	HSS or ME 104	(3)	PHY 340	(3)	PHY 355	(3)
PHY 363	(3)	SSE - Elec*	(5)	PHY 352	(3)	Electives	(3)
PHY 362	(3)	Electives	(9)	OE - Elec	(6)	OE -Elec	(6)
SSE - Elec	(6)			Elective	(6)	HSS	(3)
	[15]		[17]		[18]		[15]
			[131]				[131]

*The 11 credit hours of SSE (Solid State Engineering) electives must include ECE 257 or 258 or PHY 273.

**The 18 credit hours of OE (Optical Engineering) electives must include ECE 251 or 252 or PHY 273. Must include at least two of ECE 347, ECE 348, ECE 371, ECE 372.

Other advanced physics or engineering courses may be included among the SSE or OE electives with the approval of the student's advisor.

Combined B.S.(Physics)/B.S.(Electrical Engineering)

The combined arts/engineering programs resulting in bachelors degrees in both physics and electrical engineering may be arranged so that either of the two degrees is completed within the first four years. The suggested curricula are:

Physics-Elec. Engr (Physics first)				*Elec. Engr-Physics* (Electrical Engineering First)			
Fall		Spring		Fall		Spring	
Freshman Year							
ENGL 1	(3)	ENGL 2,4, 6, 8 or 10	(3)	ENGL 1	(3)	ENGL 2,4, 6, 8 or 10	(3)
PHY 11	(4)	CHM 21	(4)	PHY 11	(4)	CHM 21	(4)
PHY 12	(1)	CHM 22	(1)	PHY 12	(1)	CHM 22	(1)
MATH 21	(4)	MATH 22	(4)	MATH 21	(4)	MATH 22	(4)
HSS	(3)	ENGR 1	(3)	HSS	(3)	ENGR 1	(3)
ENGR 2	(1)			ENGR 2	(1)		
	[16]		[15]		[16]		[15]
Sophomore Year							
PHY 21	(4)	PHY 31	(3)	PHY 21	(4)	PHY 31	(3)
PHY 22	(1)	ECO 1	(4)	PHY 22	(1)	ECO 1	(4)
MATH 23	(4)	MATH 205	(3)	MATH 23	(4)	MATH 205	(3)
ECE 33	(4)	MATH 208	(3)	ECE 33	(4)	HSS	(3)
ECE 81	(4)	ECE 82	(1)	ECE 81	(4)	ECE 82	(1)
		ECE 108	(4)			ECE 108	(4)
	[17]		[18]		[17]		[18]

Junior Year

PHY 212	(3)	PHY 213	(3)	PHY 212	(3)	PHY 213	(3)
PHY 362	(3)	PHY 262	(2)	ECE 121	(2)	ECE 126	(3)
PHY Appr Elective	(3)	PHY 264	(3)	ECE 123	(3)	ECE 138	(2)
MATH 322	(3)	PHY 215	(4)	MATH 208	(3)	ECE 136	(3)
HSS	(4)	HSS	(3)	MATH 231	(3)	ECE 125	(3)
		Jr. Writing	(3)	Jr. Writing	(3)		
	[16]		[18]		[17]		[17]

Senior Year

PHY 340	(3)	Elective	(3)	ECE 111	(1)	PHY 264	(3)
PHY Appr. Elective	(3)	PHY Appr. Elective	(5)	ECE Appr. Elective	(3)	ECE Appr. Elective	(6)
ECE 121	(2)	ECE 126	(3)	ECE 251	(2)	PHY 215	(4)
ECE 123	(3)	ECE 138	(2)	PHY 362	(3)	HSS	(4)
HSS	(3)	ECE 125	(3)	Elective	(7)		
Elective	(3)						
	[17]		[16]		[16]		[17]

Fifth Year

ECE 111	(1)	ECE 136	(3)	PHY 340	(3)	PHY 262	(2)
ECE Appr Elective	(3)	ECE Appr Elective	(9)	PHY Appr Elective	(6)	PHY Appr Elective	(5)
ECE 257	(2)	Electives	(3)	MATH 322	(3)	Electives	(8)
MATH 231	(3)			Electives	(3)		
Electives	(6)						
	[15]		[15]		[15]		[15]
			[163]				[163]

EE-EP		*EP-EE*	
Freshman year (see Section III)			
Sophomore year, first semester			
PHY 21	(4)	PHY 21	(4)
PHY 22	(1)	PHY 22	(1)
ECE 33	(4)	ECE 33	(4)
ECE 81	(4)	ECE 81	(4)
MATH 23	(4)	MATH 23	(4)
	[17]		[17]
Sophomore year, second semester			
PHY 31	(3)	PHY 31	(3)
ECE 108	(4)	ECE 108	(4)
ECE 82	(1)	ECE 82	(1)
MATH 205	(3)	MATH 205	(3)
MATH 208	(3)	MATH 208	(3)
ECO 1	(4)	ECO 1	(4)
	[18]		[18]
Junior year, first semester			
ECE 121	(2)	ECE 121	(2)
ECE 123	(3)	ECE 123	(3)
PHY 212	(3)	PHY 212	(3)
MATH 231	(3)	EP-Ap.Elec.	(3)
MATH 322	(3)	MATH 322	(3)
HSS	(3)	HSS	(3)
	[17]		[17]

Junior year, second semester

PHY 213	(3)	PHY 213	(3)
PHY 215	(4)	PHY 215	(4)
ECE 125	(3)	ECE 125	(3)
ECE 126	(3)	ECE 126	(3)
ECE 138	(2)	PHY 262	(2)
HSS	(3)	HSS	(3)
	[18]		[18]

Senior year, first semester

ECE 257	(3)	PHY 340 or	
		ME 104	(3)
PHY 362	(3)	PHY 362	(3)
PHY 363	(3)	PHY 363	(3)
ECE-Ap.Elec.	(3)	EP-Ap.Elec	(3)
HSS	(3)	HSS	(3)
	[15]		[15]

Senior year, second semester

ECE 136	(3)	ECE 138	(2)
ECE-Ap.Elec.	(9)	EP-Ap.Elec	(5)
HSS	(3)	HSS (3)	
Elective	(3)	Electives	(6)
	[18]		[16]

Fifth year, first semester

EP-Ap.Elec	(6)	ECE-Ap.Elec.	(3)
Electives	(6)	MATH 231	(3)
PHY 340 or		ECE 257	(3)
ME 104	(3)		
		Electives	(6)
	[15]		[15]

Fifth year, second semester

PHY 262	(2)	ECE 136	(3)
EP-Ap.Elec	(6)	ECE-Ap.Elec	(9)
Electives	(6)	Elective	(3)
	[14]		[15]
Total Credits	[163]	Total Credits	[163]
Credits in 4 yrs	[135]	Credits in 4 yrs	[132]

EP approved electives**

Fall	**Spring**
PHY 369	PHY 273
PHY 380	ECE 258
PHY 382	ECE 316
ECE 257	ECE 320
ECE 351	ECE 322
ECE 361	ECE 348
ECE 355	
ECE 308	

***Must include ECE 257 or 258 or PHY 273*

Solid State Electronics Concentration

Junior year, first semester (17 credit hours)

PHY 212	Electricity and Magnetism I (3)
ECE 33	Intro. to Computer Engineering (4)
ECE 123	Electronic Circuits (3)
MATH 322	Methods of Applied Analysis (3)
	ASS courses/electives (4)

Junior year, second semester (18 credit hours)

PHY 213	Electricity and Magnetism II (3)
PHY 262	Advanced Laboratory (2)
PHY 215	Mechanics (4)
ECE 126	Fundamentals of Semiconductor Devices (3)
	AS courses/electives (6)

Senior year, first semester (15 credits)

PHY 363	Solid State Physics (3)
PHY 362	Atomic/Molecular Physics (3)
	SSE elective (6)

Senior year, second semester (17 credits)

	SSE electives (5)
	AS courses/elective or SSE elective (3)
	AS courses/elective (7)

Fifth year, first semester

Physics approved electives: three courses selected from PHY 363, 369, (352 or 355), and (346 or 365) and 380.

Students must satisfy both the HSS requirements of the College of Engineering and Applied Science and the distribution requirements, including the junior writing intensive requirement, of the College of Arts and Sciences. Courses appropriate for both may be counted in both categories.

Approved electives are subject to the approval of the student's advisor. Students planning graduate work in physics are advised to include PHY 273 and 369 among their electives.

No more than 6 credit hours of military science may be applied towards the degree.

Astronomy/Astrophysics Degree Programs

(See the Astronomy section in this catalog.)

Research opportunities

A majority of physics, astronomy, and engineering physics majors take advantage of opportunities to participate in research under the direction of a faculty member. Research areas available to undergraduates are the same as those available to graduate students; they are described below under the heading For Graduate Students. Undergraduate student research is arranged informally as early as the sophomore (or, occasionally, freshman) year at the initiation of the student or formally as a senior research project. In addition, a number of students receive financial support to do research during the summer between their junior and senior years, either as Physics Department Summer Research Participants or as Sherman Fairchild Scholars.

The use of electives. The electives available in each of the physics and astronomy curricula provide the student with an opportunity to develop special interests and to prepare for graduate work in various allied areas. In particular, the many available upper-level physics, mathematics, and engineering courses can be used by students in consultation with their faculty advisors to structure programs with special emphasis in a variety of areas such as optical communications, solid-state electronics, or biophysics.

Departmental Honors

Students may earn departmental honors by satisfying the following requirements:

- Grade point average of at least 3.50 in physics courses.
- Satisfactorily completing the following courses (these may be included in the list of approved electives): PHY 369; two of PHY 348, 363 and (352 or 355) and 380; one 400-level physics course.
- Six credits PHY 273 (Research) plus submission of a written report and an oral presentation open to faculty and students.

For students majoring in astronomy or astrophysics, see the **Astronomy and Astrophysics** section of this catalog.

Five-year combined bachelor/master's programs

Five-year programs that lead to successive bachelor and master's degrees are available. These programs satisfy all of the requirements of one of the five bachelor's degrees in physics (B.A., B.S., B.S.E.P.) and astronomy/astrophysics (B.A., B.S.), plus the requirements of the M.S. in physics in the final year. Depending upon the undergraduate degree received, one summer in residence may be required. Interested students should contact the associate chair of physics no later than the spring semester of their junior year for further detail.

The minor program

The minor in physics consists of 15 credits of physics courses, excluding Physics 5 and 7. No more than one physics course required in a student's major program may be included in the minor program. The minor program must be designed in consultation with the physics department chair.

Undergraduate Courses in Physics and Astronomy

PHY 5. Concepts in Physics (4) spring
Fundamental discoveries and concepts of physics and their relevance to current issues and modern technology. For students not intending to major in science or engineering. Lectures, demonstrations, group activities, and laboratories using modern instrumentation and computers. This is a non-calculus course; no previous background in physics is assumed. Three class meetings and one laboratory period per week. No prerequisites. Staff. **(NS)**

PHY 7. (ASTR 7) Introduction to Astronomy (3) fall
Introduction to planetary, stellar, galactic, and extragalactic astronomy. An examination of the surface characteristics, atmospheres, and motions of planets and other bodies in our solar system. Properties of the sun, stars, and galaxies, including the birth and death of stars, stellar explosions, and the formation of stellar remnants such as white dwarfs, neutron stars, pulsars, and black holes. Quasars, cosmology, and the evolution of the universe. May not be taken by students who have previously completed ASTR/PHY 105, 201, or 202. **(NS)**

PHY 8. (ASTR 8) Introduction to Astronomy Laboratory (1) fall
Laboratory to accompany PHY 7 (ASTR 7). **(NS)**

PHY 9. Introductory Physics I Completion (1-2)
For students who have Advanced Placement or transfer credit for 2 or 3 credits of PHY 11. The student will be scheduled for the appropriate part of PHY 11 to complete the missing material. The subject matter and credit hours will be determined by the Physics Department for each student. Students with AP Physics C credit for mechanics will take the thermodynamics and kinetic theory part of PHY 11 for one credit. Prerequisite: MATH 21, 31, or 51 previously or concurrently; and consent of the department. **(NS)**

PHY 10. General Physics I (4) fall
Statics, dynamics, conservation laws, thermodynamics, kinetic theory of gases, fluids. Primarily for architecture, biological science, earth and environmental science students. Prerequisite: calculus (MATH 21, 31, or 51, previously or concurrently). Ou-Yang. **(NS)**

PHY 11. Introductory Physics I (4)
Kinematics, frames of reference, laws of motion in Newtonian theory and in special relativity, conservation laws, as applied to the mechanics of mass points; temperature, heat and the laws of thermodynamics; kinetic theory of gases. Two lectures and two recitations per week. Prerequisite: MATH 21, 31 or 51, previously or concurrently. DeLeo./Licini **(NS)**

PHY 12. Introductory Physics Laboratory I (1)
A laboratory course taken concurrently with PHY 11. Experiments in mechanics, heat, and DC electrical circuits. One three-hour laboratory period per week. Prerequisite: PHY 10 or PHY 11, preferably concurrently. Kanofsky **(NS)**

PHY 13. General Physics (3)
A continuation of PHY 10, primarily for biological science and earth and environmental science students. Electrostatics, electromagnetism, light, sound, atomic physics, nuclear physics, and radioactivity. Prerequisites: PHY 10 or 11 and MATH 21, 31, or 51. Shaffer **(NS)**

PHY 19. Introductory Physics II Completion(1-2)
For students who have Advanced Placement or transfer credit for 2 or 3 credits of PHY 21. The student will be scheduled for the appropriate part of PHY 21 to complete the missing material. The subject matter and credit hours will be determined by the Physics Department for each student. Students with AP Physics C credit for electricity and magnetism will take the optics and modern physics part of PHY 21 for one credit. Prerequisite: 4 credits of PHY 10 or 11, MATH 23, 32, or 52 previously or concurrently; and consent of the department. **(NS)**

PHY 21. Introductory Physics II (4)
A continuation of PHY 11. Electrostatics and magnetostatics; DC circuits; Maxwell's equations; waves; physical and geometrical optics; introduction to modern physics. Two lectures and two recitations per week. Prerequisite: PHY 11; MATH 23, 32, or 52, previously or concurrently. Folk/Hickman. **(NS)**

PHY 22. Introductory Physics Laboratory II (1)
A laboratory course to be taken concurrently with PHY 21. One three-hour laboratory period per week. Prerequisite: PHY 12; PHY 21, preferably concurrently. Folk **(NS)**.

PHY 31. Introduction to Quantum Mechanics (3) spring
Experimental basis and historical development of quantum mechanics; the Schroedinger equation; one-dimensional problems; angular momentum and the hydrogen atom; many-electron systems; spectra; selected applications. Three lectures per week. Prerequisite: PHY 13 or 21; MATH 205, previously or concurrently. Huennekens. (NS)

PHY 91. Measurement and Transducers (1)
Computer-assisted laboratory course, dealing with physical phenomena in mechanics, electricity and magnetism, optics, spectroscopy and thermodynamics. Measurement strategies are developed and transducers devised. Computer simulation, analysis software, digital data acquisition. Prerequisites: PHY 21 and 22 or their equivalent or consent of chairperson. Kim. (NS)

PHY 105. (ASTR 105, EES 105) Planetary Astronomy (4) fall
Structure and dynamics of planetary interiors, surfaces, and atmospheres. Models for the formation of the solar system and planetary evolution. Internal structure, surface topology, and composition of planets and other bodies in our solar system. Comparative study of planetary atmospheres. Organic materials in the solar system. Properties of the interplanetary medium, including dust and meteoroids. Orbital dynamics. Extrasolar planetary systems. Prerequisites: PHY 10 or 11 and EES 21, or departmental permission. DeLeo. (NS)

PHY 110 (ASTR 110) Methods of Observational Astronomy (1)
Techniques of astronomical observation, data reduction, and analysis. Photometry, spectroscopy, CCD imaging, and interferometry. Computational analysis. Examination of ground- based and spacecraft instrumentation, and data transmission, reduction, and analysis. McCluskey. (NS)

PHY 190. Electronics (3) spring
DC and AC circuits, diodes, transistors, operational amplifiers, oscillators, and digital circuitry. Two laboratories and one recitation per week. Prerequisites: PHY 21 and 22, or PHY 13 and 14. Stavola. (NS)

For Advanced Undergraduates And Graduate Students

PHY 201. (ASTR 201) Modern Astrophysics I (4) fall
Physics of stellar atmospheres and interiors, and the formation, evolution, and death of stars. Variable stars. The evolution of binary star systems. Novae, supernovae, white dwarfs, neutron stars, pulsars, and black holes. Stellar spectra, chemical compositions, and thermodynamic processes. Thermonuclear reactions. Interstellar medium. Prerequisites: PHY 10 and 13, or PHY 11 and 21, MATH 22 or 52. McCluskey. (NS)

PHY 202. (ASTR 202) Modern Astrophysics II (4) spring
The Milky Way Galaxy, galactic morphology, and evolutionary processes. Active galaxies and quasars. Observed properties of the universe. Relativistic cosmology, and the origin, evolution and fate of the universe. Elements of General Relativity and associated phenomena. Prerequisites: PHY 10 and 13, or PHY 11 and 21, MATH 22 or 52. McCluskey. (NS)

PHY 212. Electricity and Magnetism I (3) fall
Electrostatics, magnetostatics, and electromagnetic induction. Prerequisites: PHY 21 or 13; MATH 205, previously or concurrently. Huennekens. (NS)

PHY 213. Electricity and Magnetism II (3) spring
Maxwell's equations, Poynting's theorem, potentials, the wave equation, waves in vacuum and in materials, transmission and reflection at boundaries, guided waves, dispersion, electromagnetic field of moving charges, radiation, Lorentz invariance and other symmetries of Maxwell's equations. Prerequisite: PHY 212. Kim. (NS)

PHY 215. Classical Mechanics I (4) spring
Kinematics and dynamics of point masses with various force laws; conservation laws; systems of particles; rotating coordinate systems; rigid body motions; topics from Lagrange's and Hamilton's formulations of mechanics; continuum mechanics. Prerequisites: PHY 21 or PHY 13 and MATH 205, previously or concurrently. McCluskey. (NS)

PHY 262. Advanced Physics Laboratory (2) spring
Laboratory practice, including machine shop, vacuum systems, and computer interfacing. Experiment selected from geometrical optics, interference and diffraction, spectroscopy, lasers, fiber optics, and quantum phenomena. Prerequisites: PHY 21 and 22 or PHY 13 and 14. Dierolf. (NS)

PHY 273. Research (2-3)
Participation in current research projects being carried out within the department. Intended for seniors majoring in the field. May be repeated once for credit. (NS)

PHY 281. Basic Physics I (3)
A course designed especially for secondary-school teachers in the master teacher program. Presupposing a background of two semesters of college mathematics through differential and integral calculus and of two semesters of college physics, the principles of physics are presented with emphasis on their fundamental nature rather than on their applications. Open only to secondary-school teachers and those planning to undertake teaching of secondary-school physics. (NS)

PHY 282. Basic Physics II (3)
Continuation of PHY 281. (NS)

PHY 332. (ASTR 332) High-Energy Astrophysics (3) spring, odd numbered years.
Observation and theory of X-ray and gamma-ray sources, quasars, pulsars, radio galaxies, neutron stars, black holes. Results from ultraviolet, X-ray and gamma ray satellites. Prerequisites: MATH 23 or 33, previously or concurrently, and PHY 21. McCluskey. (NS)

PHY 340. Thermal Physics (3) fall
Basic principles of thermodynamics, kinetic theory, and statistical mechanics, with emphasis on applications to classical and quantum mechanical physical systems. Prerequisites: PHY 13 or 21, and MATH 23, 32 or 52. Toulouse. (NS)

PHY 342. (ASTR 342) Relativity and Cosmology (3) spring, even numbered years.
Special and general relativity. Schwarzschild and Kerr black holes. Super massive stars. Relativistic theories of the origin and evolution of the universe. Prerequisites: MATH 23 or 33, previously or concurrently, and PHY 21. McCluskey. (NS)

PHY 348. Plasma Physics (3)
Single particle behavior in electric and magnetic fields, plasmas as fluids, waves in plasmas, transport properties, kinetic theory of plasmas, controlled thermonuclear fusion devices. Prerequisites: PHY 21, MATH 205, and senior standing or consent of the chairman of the department. Kritz **(NS)**

PHY 352. Modern Optics (3)
Paraxial optics, wave and vectorial theory of light, coherence and interference, diffraction, crystal optics, and lasers. Prerequisites: MATH 205, and PHY 212 or ECE 202. Dierolf. **(NS)**

PHY 355. Lasers and Non-linear Optics (3)
Basic principles and selected applications of lasers and non-linear optics. Topics include electromagnetic theory of optical beams, optical resonators, laser oscillation, non-linear interaction of radiation with atomic systems, electro- and acousto-optics, optical noise, optical waveguides, and laser devices. Prerequisites: PHY 31; PHY 213 or ECE 203, previously or concurrently. Dierolf. **(NS)**

PHY 362. Atomic and Molecular Structure (3) fall
Review of quantum mechanical treatment of one-electron atoms, electron spin and fine structure, multi-electron atoms, Pauli principle, Zeeman and Stark effects, hyperfine structure, structure and spectra of simple molecules. Prerequisite: Phys 31 or CHM 341. Hickman. **(NS)**

PHY 363. Physics of Solids (3) fall
Introduction to the theory of solids with particular reference to the physics of metals and semiconductors. Prerequisite: PHY 31 or Mat 316 or CHM 341, and PHY 340 or equivalent, previously or concurrently. Biaggio. **(NS)**

PHY 364. Nuclear and Elementary Particle Physics (3)
Models, properties, and classification of nuclei and elementary particles; nuclear and elementary particle reactions and decays; radiation and particle detectors; accelerators; applications. Prerequisites: PHY 31 and MATH 205. Kanofsky. **(NS)**

PHY 365. Physics of Fluids (3) spring
Concepts of fluid dynamics; continuum and molecular approaches; waves, shocks and nozzle flows; nature of turbulence; experimental methods of study. Prerequisites: PHY 212 or ECE 202, and PHY 340 or ME 104 or equivalent, previously or concurrently. Kim. **(NS)**

PHY 369. Quantum Mechanics I (3) fall
Principles of quantum mechanics: Schroedinger, Heisenberg, and Dirac formulations. Applications to simple problems. Prerequisites: PHY 31, MATH 205; PHY 215, previously or concurrently. Hickman. **(NS)**

PHY 372. Special Topics in Physics (1-3)
Special topics in physics not sufficiently covered in the general courses. Lecture and recitations or conferences. **(NS)**

PHY 380. Introduction to Computational Physics (3) spring
Numerical solution of physics and engineering problems using computational techniques. Topics include linear and nonlinear equations, interpolation, eigenvalues, ordinary differential equations, partial differential equations, statistical analysis of data, Monte Carlo, and molecular dynamics methods. Prerequisite: MATH 205 previously or concurrently. Borse. **(NS)**

For Graduate Students

The department of physics has concentrated its research activities within several fields of physics, with the result that a number of projects are available in each area. Current departmental research activities include the following:

Solid-state Physics (experimental)
Optical and electronic properties of defects in semiconductors and insulators, electron paramagnetic resonance, ultrasonic attenuation, Raman spectroscopy, luminescence spectroscopy. Properties of thin films, physics of semiconductor devices. Colloidal suspensions and complex fluids.

Solid-state Physics (theoretical)
Electronic properties of defects in semiconductors and insulators, electronic structures, electron-lattice interactions, energy band calculations.

Atomic and Molecular Physics (experimental)
Study of fundamental atom-atom interactions including velocity-changing collisions and diffusion, energy pooling collisions and fine-structure changing collisions. High resolution spectroscopy of bound-bound and bound-free molecular transitions (including photodissociation)

Atomic and Molecular Physics (theoretical)
Collisions of aligned atoms. Charge exchange. Fine-structure changing collisions. Nonlinear optics.

Plasma Physics (theoretical)
Studies of heating, current drive, transport, and plasma diagnostics by transient synchrotron radiation in magnetically confined toroidal plasmas. The research is closely related to ongoing and proposed experiments at major fusion laboratories.

Plasma Spectroscopy
Collisional and collisionless phenomena of very dense plasmas. Laser-produced plasmas.

Nuclear Theory
The few nucleon problem, nuclear structure theory.

Statistical Physics (experimental)
Non-equilibrium fluctuations in gases. Chaotic transitions. Colloidal suspensions and complex fluids. Disordered materials.

Statistical Physics (theoretical)
Kinetic theory, statistical basis of hydrodynamics, non-linear processes, bound states and internal degrees of freedom in kinetic theory. Study of pattern formation in dendritic growth.

Elementary Particles (experimental)
Channeling, device development, and particle jet studies are carried out at Fermilab and Brookhaven.

Elementary Particles (theoretical)
Properties of leptons and vector bosons, weak and electromagnetic interactions. Quark-Glauber calculations of elastic and inelastic scattering.

Non-linear Optics
Theoretical and experimental work in lasers and non-linear optics.

Candidates for advanced degrees normally will have completed, before beginning their graduate studies, the requirements for a bachelor's degree with a major in physics, including advanced mathematics beyond differential and integral calculus. Students lacking the equivalent of this preparation will make up deficiencies in addition to taking the specified work for the degree sought.

At least eight semester hours of general college physics using calculus are required for admission to all 200- and 300-level courses. Additional prerequisites for individual courses are noted in the course descriptions. Admission to 400-level courses generally is predicated on satisfactory completion of corresponding courses in the 200- and 300-level groups or their equivalent.

Facilities for Research

Among the research equipment available in the various experimental physics laboratories are: two electron spin resonance laboratories; a laboratory for optical detection of magnetic resonance; facilities for optical absorption and luminescence studies; ultraviolet, visible, and infrared spectrophotometers; liquid nitrogen, hydrogen, and helium cryogenic equipment; numerous high-power lasers (including a ruby laser, Q-switched Nd:YAG and Nd-glass lasers, several pulsed dye lasers, several argon and Krypton ion lasers, marrowbased CW dye lasers, two tunable CW Ti:Sapphire lasers, and many semiconductor lasers); crystal-growing facilities; a mass-spectrometer, large interferometers, an electron microscope, a high-density plasma source; electronic instrumentation for data acquisition and analysis, including several minicomputers, many microcomputers, and signal averagers.

A 3 MeV Van de Graaff accelerator housed in the Sherman Fairchild Laboratory is used to study radiation defects in solids, to analyze impurity distributions in thin films, to develop instrumentation, and to study channeling and nuclear physics. Also available in materials and electrical engineering laboratories in the Fairchild Laboratory are excellent facilities for the preparation of solid-state materials and the fabrication of solid-state devices; these facilities are heavily used by physics students doing experimental solid-state research.

Graduate Courses in Physics

PHY 411. Survey of Nuclear and Elementary Particle Physics (3)
Intended for non-specialists. Fundamentals and modern advanced topics in nuclear and elementary particle physics. Topics include: nuclear force, structure of nuclei, nuclear models and reactions, scattering, elementary particle classification, SU(3), quarks, gluons, quark flavor and color, leptons, gauge theories, GUT, the big bang. Prerequisite: PHY 369. Shaffer.

PHY 420. Mechanics (3) fall
Includes the variational methods of classical mechanics, methods of Hamilton and Lagrange, canonical transformations, Hamilton-Jacobi Theory. Toulouse.

PHY 421. Electricity & Magnetism I (3) spring
Electrostatics, magnetostatics, Maxwell's equations, dynamics of charged particles, multipole fields. Folk

PHY 422. Electricity & Magnetism II (3) fall
Electrodynamics, electromagnetic radiation, physical optics, electrodynamics in anisotropic media. Special theory of relativity. Prerequisite: PHY 421. Huennekens.

PHY 424. Quantum Mechanics II (3) spring
General principles of quantum theory; approximation methods; spectra; symmetry laws; theory of scattering. Prerequisite: PHY 369 or equivalent. Borse

PHY 425. Quantum Mechanics III (3)
A continuation of Phys 424. Relativistic quantum theory of the electron; theory of radiation. Shaffer

PHY 428. Methods of Mathematical Physics I (3) fall
Analytical and numerical methods of solving the ordinary and partial differential equations that occur in physics and engineering. Includes treatments of complex variables, special functions, product solutions and integral transforms. Gunton.

PHY 429. Methods of Mathematical Physics II (3) spring
Continuation of Physics 428 to include the use of integral equations. Green's functions, group theory, and more on numerical methods. Prerequisite: PHY 428.

PHY 431. Theory of Solids (3)
Advanced topics in the theory of the electronic structure of solids. Many-electron theory. Theory of transport phenomena. Magnetic properties, optical properties. Superconductivity. Point imperfections. Prerequisites: PHY 363 and PHY 424.

PHY 442. Statistical Mechanics (3) spring
General principles of statistical mechanics with application to thermodynamics and the equilibrium properties of matter. Prerequisites: PHY 340 and 369. Toulouse.

PHY 443. Nonequilibrium Statistical Mechanics (3)
A continuation of PHY 442. Applications of kinetic theory and statistical mechanics to nonequilibrium processes; non- equilibrium thermodynamics. Prerequisite: PHY 442. Kim.

PHY 446. Atomic and Molecular Physics (3)
Advanced topics in the experimental and theoretical study of atomic and molecular structure. Topics include fine and hyperfine structure, Zeeman effect, interaction of light with matter, multi-electron atoms, molecular spectroscopy, spectral line broadening atom-atom and electron-atom collisions and modern experimental techniques. Prerequisite: PHY 424 or consent of the department. Huennekens

PHY 455. Physics of Nonlinear Phenomena (3)
Basic concepts, theoretical methods of analysis and experimental development in nonlinear phenomena and chaos. Topics include nonlinear dynamics, including period-multiplying routes to chaos and strange attractors, fractal geometry and devil's staircase. Examples of both dissipative and conservative systems will be drawn from fluid flows, plasmas, nonlinear optics, mechanics and waves in disordered media. Prerequisite: graduate standing in science or engineering, or consent of the chairman of the department. Gunton.

PHY 462. Theories of Elementary Particle Interactions (3)
Relativistic quantum theory with applications to the strong, electromagnetic and weak interactions of elementary particles. Prerequisite: PHY 425. Shaffer

PHY 465. Nuclear and Elementary Particle Physics (3)
Nuclear structure and phenomena; interactions among elementary particles and methods of studying them. Kanofsky

PHY 467. Nuclear Theory (3)
Theory of low-energy nuclear phenomena within the framework of nonrelativistic quantum mechanics. Borse

PHY 471. (MECH 411) Continuum Mechanics (3)
An introduction to the continuum theories of the mechanics of solids and fluids. This includes a discussion of the mechanical and thermodynamical bases of the subject, as well as the use of invariance principles in formulating constitutive equations. Applications of theories to specific problems are given.

PHY 472. Special Topics in Physics (1-3)
Selected topics not sufficiently covered in the more general courses. May be repeated for credit.

PHY 474. Seminar in Modern Physics (3)
Discussion of important advances in experimental physics. May be repeated for credit when a different topic is offered.

PHY 475. Seminar in Modern Physics (3)
Discussion of important advances in theoretical physics. May be repeated for credit when a different topic is offered.

PHY 491. Research (3)
Research problems in experimental or theoretical physics.

PHY 492. Research (3)
Continuation of PHY 491. May be repeated for credit.

Political Science

Professors. Frank T. Colon, Ph.D. (Pittsburgh); Richard K. Matthews, Ph.D. (Toronto), *NEH Distinguished University Professor;* Edward P. Morgan, Ph.D. (Brandeis), *Distinguished University Professor*; Laura Katz Olson, Ph.D. (Colorado), *Chairperson*; Hannah Stewart-Gambino, Ph.D. (Duke).

Associate professors. Frank L. Davis, Ph.D. (North Carolina); Albert H. Wurth Jr., Ph.D. (North Carolina).

Assistant professors. Janet M. Laible, Ph.D. (Yale); Brian K. Pinaire, Ph.D. (Rutgers).

Adjunct professor. Candace K. Briggs, M.A. (East Stroudsburg).

The major in political science is designed to promote understanding of political ideas, institutions and processes and to develop skills in analyzing and evaluating political problems.

A balanced program within the discipline, one that exposes the student to various areas of inquiry in political institutions and political processes as well as in the comparative and philosophical perspectives of political analysis, has been the way in which the goals of the major program generally have been achieved. While the major program outlined below will prove adequate for most student needs, it may be that because of some special factors such as late transfer or unusual interests and/or abilities the outlined program does not accommodate some students. In that case the students may, in consultation with their advisers, develop a major program that in their judgment will more adequately fulfill those needs.

The faculty adviser to the student majoring in political science is designated by the department. The adviser consults with the student and approves the major program. The adviser attempts to help the student relate courses offered by the department to the student's educational goals. The adviser also may act as a resource for the student, and may suggest courses in other disciplines, language courses, and courses in research techniques that may be of benefit.

A variety of experiential opportunities are available to undergraduates majoring in political science. The department, for example, offers a Community Politics Internship every semester that includes opportunities for internship placements in either local government, private agencies or law offices. Students are also encouraged to apply for off-campus internship opportunities, e.g., American University's Washington Semester Program and The Philadelphia Center's Internship in Philadelphia.

Completion of the political science major is considered suitable training for the undergraduate who wishes to go on to law school, to become a social science teacher, or to work as a governmental official, party or civic leader, public affairs commentator, or staff member of a government research bureau. In addition, the business sector continues to provide opportunities in areas such as banking, insurance, and marketing for bachelor of arts graduates with training in the social sciences. Graduate study is advisable for students contemplating certain careers: college teaching, research, or public management, for example.

The three core courses are required. Individual exceptions may be made, for good reasons, by the major adviser with the approval of the department chairman.

Major Requirements

POLS 1	American Political System (4)
POLS 3	Comparative Politics (4)
POLS 100	Introduction to Political Thought (4) or
POLS 101	Ancient Political Heritage (4) or
POLS 102	Modern Political Heritage (4)

Electives

Six elective courses with at least one course from each of the two fields listed below. One of the electives may, with the consent of the department, be in a cognate field.

American Politics, Public Law and Interdisciplinary

POLS 104	Political Sociology (4)
POLS 111	The Politics of the Environment (4)
POLS 115	Technology As Politics (4)
POLS 179	Politics of Women (4)
POLS 230	Movements and Legacies of the 1960s (4)
POLS 232	The Vietnam War in Politics, Media, and Memory (4)
POLS 240	Law and Order (4)
POLS 274	Political Parties and Elections (4)
POLS 302	Comparative State Politics (4)
POLS 306	Public Policy Process (4)
POLS 317	The American Presidency (4)
POLS 326	Democracy Workshop (4)
POLS 328	U.S. Politics and the Environment (4)
POLS 329	Propaganda, Media, and American Politics (4)

POLS 331 Community Politics Internship (4)
POLS 333 Social Psychology of Politics (4)
POLS 351 Constitutional Law (4)
POLS 352 Civil Rights and Civil Liberties (4)
POLS 358 Interest Groups, Factions, and Coalitions in Politics (4)
POLS 359 U.S. Congress (4)
POLS 360 Public Administration (4)
POLS 368 Political Economy (4)
POLS 375 Seminar: Green Policy (4)
POLS 376 Seminar: National Social Policy (4)
POLS 377 Urban Politics (4)
POLS 378 Honors Thesis in Political Science (4)
POLS 379 Honors Thesis in Political Science (4)

Political Theory and Comparative Politics

POLS 100 Introduction to Political Thought (4)
POLS 101 Ancient Political Heritage (4)
POLS 102 Modern Political Heritage (4)
POLS 125 International Political Economy (4)
POLS 132 An Introduction to Canada (4)
POLS 301 Current Political Controversies (4)
POLS 321 Research in Political Science (4)
POLS 323 Public Policy of the European Union (4)
POLS 324 Politics of Western Europe (4)
POLS 325 Nationalism in Comparative Perspective (4)
POLS 335 Latin American Political Systems (4)
POLS 336 U.S. Foreign Policy and Latin America (4)
POLS 337 Religion and Politics in Latin America (4)
POLS 342 Gender and Third World Development (4)
POLS 356 Seminar: Political Philosophy (4)
POLS 364 Issues in Contemporary Political Philosophy (4)
POLS 367 American Political Thought (4)
POLS 370 Seminar: The Citizen versus the Administrative State (4)
POLS 374 Seminar: Third World Issues (4)

Political Science Minor

The minor consists of two of the three core courses listed above (POLS 1, POLS 3, and POLS 100 or 101 or 102) plus any two other political science courses for a total of 16 credits.

Public Administration Minor

The minor consists of POLS 360 plus three other courses chosen in consultation with the adviser for a minimum of sixteen credits.

Political Science Honors

Students must have at least a 3.2 cumulative grade point average, and a 3.3 major grade point average, in order to proceed with departmental honors. Students with honors must complete ten courses in the major, including an independent study focusing on the honors thesis.

Undergraduate Courses

POLS 1. American Political System (4) fall-spring
Constitutional principles; organization and operation of the national government; and dynamics of power within the U.S. political system. (SS)

POLS 3. Comparative Politics (4) fall-spring
The political systems of foreign countries; approaches to the study of comparative politics. (SS)

POLS 100. Introduction to Political Thought (4)
A critical examination of political ideologies: Liberalism, Marxism, Fascism, and Islamism. Matthews (ND)

POLS 101. Ancient Political Heritage (4)
Important political thinkers from the pre-Socratics to early, modern political theorists like Machiavelli. Matthews (SS)

POLS 102. (PHIL 102) Modern Political Heritage (4)
Begins where POLS 101 ends: from early, modern theorists (e.g., Hobbes) up to contemporary thinkers (e.g., Marcuse). Matthews (SS)

POLS 104. (SSP 104). Political Sociology (4)
An introduction to political sociology through an examination of the major sociological questions concerning power, politics, and the state. Covers historical questions concerning state formation, nationalism, social movements, globalization, political culture and participation, and civil society. Includes examples such as racism, welfare reform, campaign financing, coal mining in Appalachia, revolution in Latin America, and the rise of the Nazi party in Germany, and the place of the United States in a global society. Munson (SS)

POLS 111. The Politics of the Environment (4)
A survey of the major environmental, resource, energy and population problems of modern society, focusing on the United States. The politics of man's relationship with nature, the political problems of ecological scarcity and public goods, and the response of the American political system to environmental issues. Wurth (SS)

POLS 115. Technology as Politics (4)
Relationship of technology and technological change with politics and public policy. Review of theories of political significance of technology, including technological determinism, technology assessment, technological progress and appropriate technology. Specific issues in technology with emphasis on U.S. Wurth (ND)

POLS 125. (IR 125) International Political Economy (4)
Principles governing the interaction between the economic and political components of international phenomena. Political causes and consequences of trade and investment. Foreign economic policy in its relationship to domestic economic policy and other aspects of foreign policy. Determinants of foreign economic policy. Prerequisites: Economics 1 or 11 or 12; IR 10. Moon, Barkey (SS)

POLS 132. (Eco., HIST., IR) An Introduction to Canada (4)
An interdisciplinary, team-taught course focusing on history, politics, economics and international relations. Topics covered will include Canada's historical development, recent politics and foreign policy, and economic and trade issues. Special attention will be given to contemporary affairs and to Canada's relations with the United States. (SS)

POLS 179. (WS 179) Politics of Women (4)
Selected social and political issues relating to the role of women in American society. Focuses on such questions as economic equality, poverty, and work roles, the older woman, gender gap, political leadership, reproduction technology, and sexual violence. Olson (SS)

POLS 230. Movements and Legacies of the 1960s (4)
The lessons and legacies of 1960s social and political movements. Students engage with civil rights, black power movements, the New Left, campus protests, the Vietnam war and antiwar movement, the counterculture, women's and ecology movements and assess their connection to democracy, today's world and their own lives. Morgan (**SS**)

POLS 232. The Vietnam War in Politics, Media, and Memory (4)
Examines the meaning of the American war in Vietnam as interpreted and disputed in American politics, the mass media, and private and public memory. Reviews the political history and context of the war, personal experiences and critical perspectives on the war, and characterizations of the war in mainstream news media and popular film. Morgan. (**SS**)

POLS 240. Law and Order. The Politics of Crime and Punishment (4)
This course explores the legal and political consequences of various theories of crime, punishment and social control in the United States. Topics include policing, racial profiling, trial court proceedings and the administration of justice, growing incarceration rates and the prison industry, capital punishment, the jury system, and the nature of legal obligation. Pinaire. (**ND**)

POLS 274. Political Parties and Elections (4)
Study of the organization, functions and behavior of political parties in the United States. Includes voting behavior, campaigns and elections, polling, interest groups, public opinion and the role of the media. Colon (**SS**)

For Advanced Undergraduates and Graduate Students

POLS 301. Current Political Controversies (4)
Selected topical policy issues and alternative approaches to understanding them. Includes the major domestic questions facing the U.S. Emphasis is on debating the current issues of the day. Olson (**SS**)

POLS 302. Comparative State Politics (4)
Analysis of major questions relating to the role of the states in the American federal system and their relationship with the national government. Colon (**SS**)

POLS 306. Public Policy Process (4)
Power relations and their impacts on selected public policy issues, specifically taxation, housing, environment, poverty, energy, the military, and health. Olson (**SS**)

POLS 317. The American Presidency (4)
Role of the executive in the American political process. Includes an analysis of the historical development, selection process, and scope of executive power. Emphasizes domestic and foreign policy initiatives of selected presidents from FDR to today. Prerequisite: POLS 1. Olson (**SS**)

POLS 321. Research in Political Science (4)
Models in the explanation of political phenomena, appropriateness of measurement techniques; construction of research designs; rationale and application of statistical analyses; individual projects involving the construction and testing of models employing a major social science data set. Prerequisite: Consent of the instructor. Davis (**ND**)

POLS 323. Public Policy of the European Union (4)
The institutions and policy-making processes of the European Union. Topics include the creation of the single market and the euro, environmental and agricultural policy, regional development and the policy challenges of eastward enlargement. Prerequisite: POLS 3 or IR 10. Laible

POLS 324. Politics of Western Europe (4)
Comparative discussion of systems of government in Western Europe and of major policy questions facing these states in the post-war era. Topics include the evolution of welfare states, relations with the former Eastern bloc, immigration, and the regionalization and Europeanization of central state authority. Prerequisite: POLS 3. Laible

POLS 325. Nationalism in Comparative Perspective (4)
Examination of major theoretical and policy debates in contemporary studies of nationalism. Focus on the emergence and endurance of nationalist movements in the modern era. Discussion of efforts to evaluate the legitimacy of nationalist claims and to resolve nationalist conflict. Prerequisite: POLS 3. Laible

POLS 326. Democracy Workshop (4)
Student teams enhance the political voice of under-resourced community groups through organization-building, outreach, and policy input at the local level. Weekly seminars on theory and practice of community organizing and its relationship with democracy and power in the United States complement semester-long field placements with community groups and local organizations. Prerequisite: consent of instructor. Morgan (**ND**)

POLS 328. U.S. Politics and the Environment (4)
An examination of contemporary American politics and policy dealing with environmental issues. Current controversies in the legislative and regulatory areas will be covered to examine environmental issues and the political process. Significant portions of the course readings will be taken from government publications. Wurth (**SS**)

POLS 329. Propaganda, Media, and American Politics (4)
The role of propaganda and mass media in sustaining hegemony in the United States. Emphasis on television, advertising and mass culture, public relations, news media, and political propaganda pertaining to U.S. foreign and domestic policy. Students compare critical counter-hegemonic theories to political speeches, documents, news reports, and media encounters that shape much of American political life. Morgan (**SS**)

POLS 331. Community Politics Internship (4)
Integrated fieldwork and academic study. Seminar, research paper, and journal; internship with government and social service agencies, political groups, elected officials, and law offices. May be repeated for credit. Prerequisite: consent of instructor. (**ND**)

POLS 333. (PSYC 333, SSP 333) Social Psychology of Politics (4)
Political behavior viewed from a psychological and social psychological perspective. Prerequisite: Any one of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 5, SSP 21, or department permission. Rosenwein (**SS**)

POLS 335. Latin American Political Systems (4)
Democratic, authoritarian and revolutionary paths to contemporary political issues. Political, economic and social implications of contemporary "democratic" regimes and neo-liberal economic policies. Discussion groups and student presentations on prospects for democratic peace and prosperity in the future. Prerequisite: POLS 3. Stewart-Gambino (**ND**)

POLS 336. U.S. Foreign Policy and Latin America (4)
U.S. historical relationship with Central America, Caribbean and South America with emphasis on economic and military dominance. Contemporary issues such as U.S. invasions of Panama and Grenada, U.S. Cuban relations, the militarization of the "drug war," counterinsurgency. Written analysis of competing U.S. interests across time and regions. Prerequisite: POLS 3. Stewart-Gambino (**ND**)

POLS 337. Religion and Politics in Latin America (4)
Indigenous and "imported" religious structures, the prominent role of the Catholic Church in Latin America, and the recent explosion of Protestant/Pentecostal churches. Emphasis on the intersection of religious belief and power (i.e., gender, local politics, national development, etc.). Short papers integrate material with students' knowledge of religious/political phenomena. Discussion groups analyze philosophical foundations of belief. Prerequisite: POLS 3 and 336. Stewart-Gambino (**ND**)

POLS 342. (WS 342) Gender and Third World Development (4)
Focus on gender implications of contemporary strategies for Third World economic growth, neo-liberalism. How do economic theories affect 'real people?' How do economic theories affect men vs. women? What is the role of people who want to 'help?' Some background in economic theories and/or Third World politics desired, but not required. Prerequisite: POLS 1 or WS 1. Stewart-Gambino (**SS**)

POLS 351. Constitutional Law (4)
An examination of the development of American constitutional law considered in historical and political context. Emphasis is on decisions of the U.S. Supreme Court. Topics include the growth of the Supreme Court's institutional power and the Court's changing interpretations of the federalism, the separation of powers, and constitutional rights. Pinaire (**ND**)

POLS 352. Civil Rights and Civil Liberties (4)
A survey of Supreme Court policymaking pursuant to the Bill of Rights, the Fourteenth Amendment, and federal civil rights statutes. Among the covered topics are changing Supreme Court doctrine concerning freedom of speech and press, religious liberty, criminal procedure, and the due process and equal protection clauses. Pinaire. (**ND**)

POLS 356. Seminar: Political Philosophy (4)
Critical examination of several of the "great books" and/or "great ideas" in political thought. Students will be required to write a major paper and present their work to the class. Matthews (**SS**)

POLS 358. Interest Groups, Factions, and Coalitions in American Politics (4)
The rise of interest group power. Social, economic, and political reasons for groups' increasing influence. Value of different group resources and influence in particular national policy arenas. Types of more, and less, powerful interests, and the implications of this distribution of power for American politics. Davis (**SS**)

POLS 359. U.S. Congress (4)
Elections for the House and Senate and their significance for the way in which Congress functions. The formal structure of party leadership and committees, House and Senate organizational and functional differences, and informal and formal power of legislation and oversight. Congressional relations with the president, bureaucracy, and Supreme Court. Prerequisite: POLS 1. Davis (**SS**)

POLS 360. Public Administration (4)
The nature of administration; problems of organization and management; public personnel policies; budgeting and budgetary system; forms of administrative responsibility. Colon (**ND**)

POLS 364. (PHIL 364) Issues in Contemporary Political Philosophy (4)
Selected topics in contemporary political philosophy, such as the Frankfurt school, existentialism, legitimation, authenticity, participatory democracy, and the alleged decline of political philosophy. May be repeated for credit with the consent of instructor. Matthews (**SS**)

POLS 367. (PHIL 367) American Political Thought (4)
A critical examination of American political thought from the founding of the Republic to the present. Writings from Madison, Hamilton, and Jefferson to Emma Goldman, Mary Daly, Malcolm X, Henry Kariel, and others will be discussed. Matthews (**SS**)

POLS 368. Political Economy (4)
Relationship of democratic politics to government and market, and significance of economic power in the American polity. Economic rationale for the place of the market and economic institutions in polity. Emphasis on information in comparison of economic approaches to public policy and organization (public goods, market failure, and collective action) with traditional political science approaches (group mobilization and conflict, non-decisions and symbolic action). Wurth. (**SS**)

POLS 370. Seminar: The Citizen versus the Administrative State (4)
Administrative power and policy. Constitutional and judicial control of administration. Remedies against improper administrative acts. Major emphasis will be on the United States, with some attention given to analogous issues in other countries. (**SS**)

POLS 374. Seminar: Third World Issues (4)
Focus on Nancy Sheper-Hughes' *Death Without Weeping: The Violence of Everyday Life in Brazil* with discussion of "objectivity" in field research, separation between advocacy and observation, and gendered subjects. Student presentations of research topics in latter part of course, emphasizing professional form and collegial cooperation. Prerequisites: POLS 322, 335, 336, 337, or consent of instructor. Stewart-Gambino (**SS**)

POLS 375. Seminar: Green Policy (4)
Development of guidelines and applications for public policy and political action directed toward environmental sustainability and political feasibility. Focus on problem-solving and policy design, connecting sustainable environmental goals with workable and responsive institutional designs. Prerequisites: POLS 111, 368, or consent of instructor. Wurth (**SS**)

POLS 376. Seminar: National Social Policy (4)
A readings/research seminar on current social policy questions. Course analyzes, from alternatives political perspectives, such issues as Social Security, Medicare, health care, welfare reform, income inequality, and taxation. Students research a specific social issue of their choice. Class discussion on individual research and common readings. Olson **(SS)**

POLS 377. Urban Politics (4)
The structure and processes of city government in the United States; city-state and federal-city relationships; the problems of metropolitan areas; political machines and community power structures; the urban politics of municipal reform; city planning and urban renewal. Colon **(SS)**

POLS 378. Honors Thesis in Political Science (4)
Opportunity for undergraduate majors in Political Science to pursue an extended project for senior honors. Department permission required. **(ND)**

POLS 379. Honors Thesis in Political Science (4)
Continuation of POLS 378. Prerequisite: POLS 378. Department permission required. **(ND)**

POLS 381, 382, 383, 384. Special Topics (1-4)
A seminar on a topic of special interest in a particular political institution, process, or policy. Prerequisite: consent of the department chairperson. **(ND)**

For Graduate Students the department of political science offers a graduate program leading to the master of arts degree. The applicant for admission is required to demonstrate adequate undergraduate preparation. Those seeking full time graduate studies must submit Graduate Record Examination results.

Master of Arts

The master of arts in political science is a 30-credit-hour program that can be accomplished in 12 months by full-time students. A comprehensive examination or thesis is required. The student may take 24 hours of course work and six hours of thesis or may take all 30 credit hours in course work. A graduate-level course in research methods, the American Politics Core, and Comparative Politics Core are required of all candidates for the master of arts degree.

The master of arts program is intended for the student with liberal arts or natural science preparation who has a professional interest in government. The master of arts may be a preparatory step toward doctoral work at another institution or research positions in governmental, institutional or industrial settings or a final degree preparatory for teaching in junior and community colleges.

Graduate Courses

POLS 405. The Budgetary Process (3)
The public budgetary process: competition among interest groups, policy outcomes, intergovernmental relations, and consequences for policy implementation. Davis

POLS 408. American Politics Core (3)
A survey of American politics utilizing readings reflecting a variety of methodological approaches and theoretical perspectives. Readings include but are not limited to works widely regarded as “classics” in American political science.

POLS 413. Modern Political Philosophy (3)
A study of selected modern political philosophers and their continuing effect on politics and political philosophy. Matthews

POLS 415. State and Local Government (3)
Comparative state government, urban politics, intergovernmental relations, regional and local government. Colon

POLS 416. American Environmental Policy (3)
Formation, implementation and impact of environmental policies in the U.S. An examination of the scope of environmental problems, the development of environment as an issue, the role of interest groups and public opinion, the policy-making process, and the various approaches to implementing environmental policy. Special attention to current issues and administrative approaches and to the distinctive character of environmental protection as a political issue. Wurth

POLS 419. Theoretical Issues in American Politics (3)
American contributions to main currents in political philosophy from colonial times to present. Matthews

POLS 421. Research Methods (3)
Models in the explanation of political phenomena, appropriateness of measurement techniques; construction of research designs; rationale and application of statistical analyses; individual projects involving the construction and testing of models employing a major social science data set. Davis

POLS 423. Public Policy of the EU (3)
The institutions and policy-making processes of the EU. Topics include the creation of the single market and the euro, environmental and agricultural policy, regional development and the policy challenges of eastward enlargement. Laible

POLS 424. Politics of Western Europe (3)
Comparative discussion of systems of government in Western Europe and of major policy questions facing these states in the post-war era. Topics include the evolution of welfare states, relations with the former Eastern bloc, immigration, and the regionalization and Europeanization of central state authority. Laible

POLS 425. Nationalism in Comparative Perspective (3)
Examination of major theoretical and policy debates in contemporary studies of nationalism. Focus on the emergence and endurance of nationalist movements in the modern era. Discussion of efforts to evaluate the legitimacy of nationalist claims and to resolve nationalist conflict. Laible

POLS 426. Democracy Workshop (3)
Student teams enhance the political voice of under-resourced community groups through organization-building, outreach, and policy input at the local level. Weekly seminar on theory and practice of community organizing and its relationship with democracy and power in the United States complements semester-long field placements. Prerequisite: consent of instructor. Morgan

POLS 429. Propaganda, Media & American Politics (3)
The role of propaganda and mass media in sustaining hegemony in the United States. Emphasis on television, advertising and mass culture, public relations, news media, and political propaganda pertaining to U.S. foreign and domestic policy. Students compare critical, counter-hegemonic theories to political speeches, documents, news reports, and media encounters that shape much of American political life. Morgan

POLS 430. Movements & Legacies of 1960s (3)
The lessons and legacies of 1960s social and political movements. Students engage with civil rights, black power movements, the New Left, campus protests, the Vietnam war and antiwar movement, the counterculture, women's and ecology movements and assess their connection to democracy, today's world, and their own lives. Morgan

POLS 431. Public Management (3)
The study of bureaucracy and problems of public and nonprofit organization and management; executive leadership; personnel management systems and regulatory administration. Colon

POLS 432. Public Policy Process (3)
Impacts of power relationships on selected public policy areas such as the military, agriculture, housing, environmental, energy, poverty, health, and taxation. May be repeated for credit. Olson

POLS 434. Internship (3)
Internship in private or public agency. May be repeated for credit.

POLS 442. Gender and Third World Development (3)
Issues of international economic development with a particular focus on how gender informs both the academic discourse of development as well as how development policies are gendered in their conception and implementation. Stewart-Gambino

POLS 451. Comparative Politics Core (3)
Theory and concepts in comparative politics. Analysis of applications in studies of Western and non-Western political systems.

POLS 453. Seminar: Media, Propaganda and Democracy (3)
Research seminar on theoretical and applied issues related to democracy vs. political hegemony, as affected by propaganda, the mass media, popular culture, and the capitalist economy. Students will pursue individual research topics linked to common class readings. Weekly paper presentations and critical responses. Morgan

POLS 456. Seminar: Political Philosophy (3)
Critical examination of several of the "great books" and/or "great ideas" in political thought. Students will be required to write a major paper and present their work to the class. Matthews

POLS 458. Seminar: Interest Groups, Factions, and Coalitions in American Politics (3)
The rise of interest group power. Social, economic, and political reasons for groups' increasing influence. Value of different group resources and influence in particular national policy arenas. Types of more, and less, powerful interests, and the implications of this distribution of power for American politics. Davis

POLS 462. Seminar: American Political Thought (3)
Focus on a narrow topic or theorist in the field, e.g., the work of Jefferson, Madison, Hamilton, or Tocqueville. Students will be required to write a major paper and present it to the class. Matthews

POLS 464. Community Fellowship I (3) Fall
15 hours/week in regional agency on specific project relating to regional redevelopment with regularly scheduled contact hours with the faculty advisor. Stewart-Gambino

POLS 465. Community Fellowship II (3) Spring
15 hours/week in regional agency on specific project relating to regional redevelopment with regularly scheduled contact hours with the faculty advisor. Stewart-Gambino

POLS 466. Seminar: American Political Parties (3)
Study of the organization, functions, and behavior of political parties in the United States. Includes voting behavior, campaigns and elections, polling, interest groups, public opinion and the role of the media. Colon.

POLS 467. Legal Problems (3)
This course involves an examination of the role of legal rules, agents, institutions, and values in our society. Primary emphasis will be given to the American legal system, though we will evaluate U.S. principles and politics through a comparative lens as well. Pinaire.

POLS 468. Political Economy (3)
Relationship of democratic politics to government and market, and significance of economic power in the American polity. Economic rationale for the place of the market and economic institutions in polity. Emphasis on information in comparison of economic approaches to public policy and organization (public goods, market failure and collective action) with traditional political science approaches (group mobilization and conflict, non-decisions and symbolic actions. Wurth.

POLS 473. Seminar: Public Administration (3)
Public and nonprofit administrative agencies. Focus on the national government administration, but state, municipal, and nonprofit agencies included. Problems of organization and management; personnel policies; budgeting and financial systems; and forms of administrative responsibility. Colon

POLS 474. Seminar: Third World Issues (3)
Focus on Nancy Sheper-Hughes' *Death Without Weeping: The Violence of Everyday Life in Brazi*l with discussion of "objectivity" in field research, separation between advocacy and observation, and gendered subjects. Student presentations of research topics in latter part of course, emphasizing professional form and collegial cooperation. Prerequisites: consent of instructor. Stewart-Gambino

POLS 475. Seminar: Green Polity (3)
Development of guidelines and applications for public policy and political action directed toward environmental sustainability and political feasibility. Focus on problem-solving and policy design, connecting sustainable environmental goals with workable and responsive institutional designs. Prerequisites: Both POLS 111 and 368 or consent of instructor. Wurth

POLS 476. Seminar: National Social Policy (3)
A readings/research seminar on current social policy questions. Course analyzes, from alternative political per-

spectives, such issues as Social Security, Medicare, health care, welfare reform, income inequality, and taxation. Students research a specific social issue of their choice. Class discussion on individual research and common readings. Olson

POLS 477. (SR 477) Advanced Computer Applications (3)
Uses of computers in social sciences, including data collection, management, analysis, presentation, and decision-making; includes weekly lab.

POLS 481. Special Topics (1-3)
Individual inquiry into some problem of government. Reading, field work, and other appropriate techniques of investigation. Conferences and reports. May be repeated for credit.

POLS 482. Special Topics (1-3)
Continuation of POLS 481.

Psychology

Professors. Mark H. Bickhard, Ph.D. (Chicago), *Henry R. Luce Professor in Cognitive Robotics and the Philosophy of Knowledge;* Diane T. Hyland, Ph.D. (Syracuse)*;* Barbara C. Malt, Ph.D. (Stanford), *chair*.

Associate professors. Susan Barrett, Ph.D. (Brown); Ageliki Nicolopoulou, Ph.D. (Berkeley); Padraig G. O'Seaghdha, Ph.D. (Toronto).

Assistant professors. Michael J. Gill, Ph.D. (Texas, Austin); Laura M. Gonnerman, Ph.D. (USC); Heidi Grant, Ph.D. (Columbia); Gordon B. Moskowitz, Ph.D. (NYU).

Professors of Practice. Timothy Lomauro, Ph.D. (St. John's); Katherine Restuccia, Ph.D. (Widener).

Emeritus professors. George K. Shortess, (Brown); Martin L. Richter, Ph.D. (Indiana); William Newman, Ph.D. (Stanford).

The Psychology Department offers B.A. and B.S. undergraduate degrees, undergraduate minors in general psychology and clinical psychology, and a Ph.D. program.

B.A. Major Program in Psychology

The bachelor of arts in psychology is a social science major requiring approximately 40 credit hours in psychology as described below. Students must also fulfill college and university degree requirements. This flexible program permits development of one or more minors in other fields or the undertaking of a double major. Freshmen who have completed PSYC 1 can enroll in 100-level courses.

Required Core Courses

PSYC 1	Introduction to Psychology (4)
PSYC 110	Statistical Analysis of Behavioral Data (4)
PSYC 210	Experimental Research Methods and Laboratory (4)

Required Breadth Courses
Three 100-level courses, one from three of the following four categories.

A) PSYC 107 Child Development (4)
PSYC 109 (SSP 109) Adulthood and Aging (4)
B) PSYC 121 (SSP 121) Social Psychology (4)
PSYC 153 (SSP 153) Personality (4)
C) PSYC 117 Cognitive Psychology (4)
D) PSYC 176 Mind and Brain (4)

Required Advanced Psychology Seminars

Two Advanced Psychology Seminars are required. Advanced Psychology Seminars are 300-level courses that are offered in a small seminar format. These courses include a significant writing component and utilize primary source readings. Courses that can be used to fulfill this requirement have the Advanced Psychology Seminar designation at the end of the course description.

Additional 300-level Course Requirement

Two additional 300-level courses are required. Students can NOT use PSYC 310, 391, 392, 393 or 394 to fulfill this requirement. All other 300-level psychology courses can be used to fulfill this requirement. Students may opt to take a third or fourth Advanced Psychology Seminar or they may take any of the following courses. These courses fulfill 300-level requirements but not the Advanced Seminar requirement:

PSYC 301	Industrial Psychology
PSYC 305	Abnormal Psychology
PSYC 312	Interpersonal Behavior in Small Groups
PSYC 323	The Child in Family and Society
PSYC 327	Health Psychology
PSYC 328	Educational Psychology
PSYC 333	Social Psychology of Politics
PSYC 335	Animal Behavior
PSYC 338	Phenomenology and Theory of Childhood Disorders
PSYC 354	Psychological Assessment
PSYC 382	Endocrinology of Behavior

Recommended Electives
The bachelor of arts program in psychology is a flexible preparation for a number of fields. With suitable selection of additional courses, students can prepare themselves for graduate study in any subfield of psychology or for careers in areas for which psychology is a desirable and relevant major such as law, social work, marketing, and education.

For graduate programs in developmental, social/personality, cognitive, and clinical psychology, additional coursework in research and statistics is desirable, as is participation in the honors program.

Depending on the specific subfield of interest, many courses in the Departments of Biological Sciences (especially the Behavioral Neuroscience program) and Sociology and Anthropology, in the College of Education, and in the interdisciplinary programs of Cognitive Science, Women's Studies, and Africana Studies may be relevant.

Preparation for programs in health-related areas such as nursing, medicine, and dentistry will include additional coursework in biology, chemistry, and physics. Students should consult with the appropriate pre-professional advisers to determine specific requirements.

Students interested in applying psychology to fields such as law, marketing, social work, or education should consult with faculty in those areas to discuss relevant courses.

The B.S. in Psychology

The bachelor of science in psychology is intended for students seeking a structured behavioral science major. This comprehensive program of study is especially suited as preparation for advanced graduate study in psychology and related fields. The program offers broad scientific training with a concentration in cognitive, developmental, social or clinical psychology. The program may also be attractive to students who are preparing for careers in medicine or health-related fields because it combines the mathematics and natural science courses required for professional study in these fields with exposure to ethics and a specialization in a concentration area such as clinical psychology. Progression through this program is best served through early commitment. This program requires a minimum of 109 credits of the 121 credits required for a bachelors degree.

Requirements for the B.S. in Psychology

University and College Requirements (at least 26 credits):

Arts and Science 1 (1 credit)
College Seminar (3-4 credits)
English Composition (2 courses, 6 credits)

Distribution requirements in two of the following categories (Natural Science, Social Science, or Humanities) (16 credits)

Courses taken for major and collateral requirements can only be used to fulfill one of the three distribution categories (Natural Science, Social Science or Humanities, if two philosophy courses are used to fulfill the Philosophy and Cognitive Science collateral requirement). Students must take additional courses to fulfill the university requirements in the two remaining categories. Collateral courses in mathematics can be used to fulfill the mathematical science distribution category.

The B.S. Program in Psychology: Collateral Requirements (at least 35 credits)

Mathematics: Select 2 courses from MATH 12, 43, or any of the calculus courses (7-8 credits)

Computation and Formal Systems: Select either COGS 140 or PHIL 114 or CSE 12 or 15 (3-4 credits)

Natural Science: Select 3 courses from CHM 21, CHM 75, BIOS 41, EES 31, BIOS 115, BIOS 177, BIOS 276, or PHY 10 (at least 10 credits)

Philosophy and Cognitive Science: Select two courses from COGS 7, PHIL 7, 105, 116, 128, 139, 220, 228, 250, 260 (8 credits)

Social Science: Select two courses from ECO 1, STS 11, 124, 145, 252, WS 101, and ANTH or SSP course which is not cross-listed with psychology (7-8 credits)

Psychology Requirements (48 credits)

Psychology Core Requirements

PSYC 1 Introduction to Psychology (4)
PSYC 110 Statistical Analysis of Behavioral Data (4)
PSYC 210 Experimental Research Methods and Laboratory (4)

Required Breadth Courses

Four 100-level courses, one from each of the four categories.

A) PSYC 107 Child Development (4)
PSYC 109 (SSP 109) Adulthood and Aging (4)
B) PSYC 121 (SSP 121) Social Psychology (4)
PSYC 153 (SSP 153) Personality (4)
C) PSYC 117 Cognitive Psychology (4)
D) PSYC 176 Mind and Brain (4)

Psychology Concentration

Complete the following courses for one of the following concentrations:

A) Cognitive Psychology Concentration
COGS 7 (may not also be used to fulfill collateral requirement)
Select any 2 Advanced Psychology Seminars
Two courses from the following list
- PSYC 307 (Higher Order Cognition)
- PSYC 320 (Psychology of Language)
- PSYC 322 (Language in Atypical Populations)
- PSYC 351 (Cognitive Development in Childhood)
- PSYC 369 (Memory)
- PSYC 373 (Sensation and Perception)

B) Social Psychology Concentration
Complete both 121 and 153
Select any 2 Advanced Psychology Seminars
Two courses from the following list
- PSYC 308 (Seminar in Social Psychology)
- PSYC 311 (The Psychology of Stereotyping, Prejudice, and Discrimination)
- PSYC 313 (Person Perception)
- PSYC 314 (Social Cognition and Social Action)
- PSYC 318 (Seminar in Gender and Psychology)
- PSYC 363 (Personality and Social Development in Childhood)

C) Developmental Psychology Concentration
Complete both 107 and 109
Select any 2 Advanced Psychology Seminars
Two courses from the following list
- PSYC 321 (Language Development)
- PSYC 351 (Cognitive Development in Childhood)
- PSYC 358 (Seminar in Infant Development)
- PSYC 361 (Personality and Social Development in Adulthood)
- PSYC 363 (Personality and Social Development in Childhood)
- PSYC 364 (Narratives, Culture, and Development)
- PSYC 365 (Human Development in Cross-Cultural Perspective)
- PSYC 366 (Seminar in Cognitive Aging)

D) Clinical Psychology Concentration
PSYC 367 (Clinical Psychology: only offered in the summer)
Select any two Advanced Psychology Seminars
Two courses from the following list
- PSYC 305 (Abnormal Psychology)
- PSYC 327 (Health Psychology)
- PSYC 338 (Phenomenology and Theory of Childhood Disorders)
- PSYC 354 (Psychological Assessment)

Department Honors in Psychology

Students in either the B.A. or B.S. degree programs may undertake a program that leads to graduation with department honors. The honors program permits majors of unusual academic ability and interest to explore topics in greater depth than the curricula normally allow. Under faculty supervision, a student normally spends the first semester of the senior year enrolled in PSYC 391 doing library research, learning the appropriate methodology, and preparing a written proposal and oral presentation. In the second semester, while the student is enrolled in PSYC 392, the proposal is implemented, culminating in a written honors thesis and oral presentation.

In the first semester of the junior year, students in either the B.A. or B.S. degree programs may apply for the honors program with the Department Honors Program Director. To be eligible to participate in the honors program, a student must have an overall cumulative GPA of 3.3 and a minimum GPA of 3.3 in courses required for their psychology degree at the time of application. These GPAs must be maintained until graduation.

Minor Programs

General Psychology

The general psychology minor consists of a minimum of four courses in psychology beyond the introductory course (PSYC 1). Students should declare this minor in the psychology department office.

Clinical Psychology

The clinical psychology minor consists of the following courses:

PSYC 153	Personality
PSYC 305	Abnormal Psychology
PSYC 367	Clinical Psychology

And two of the following courses:

PSYC 327	Health Psychology
PSYC 338	Phenomenology and Theory of Childhood Disorders
PSYC 354	Psychological Assessment

This minor is available to Psychology majors, as well as to students from other programs, who desire to augment their training in this aspect of applied psychology. Students should be aware that only one course may be used to jointly fulfill the requirements of a major program and minor program. To complete this minor, students must be prepared to register for at least one summer session since some courses (PSYC 367, 354) are only offered in the summer and other courses have limited enrollment during the academic year. Students interested in this minor should consult the psychology undergraduate coordinator.

Undergraduate Courses

PSYC 1. Introduction to Psychology (4)
Psychology as a science of behavior. Natural science aspects such as learning, sensation-perception, and physiological bases; and social science aspects such as human development, intelligence, and personality. Methodologies appropriate to these areas, and related societal problems. **(SS)**

PSYC 107. Child Development (4)
Survey of theories and research concerning perceptual, cognitive, social, and personality development through infancy and childhood. Prerequisite: PSYC 1 or SSP 1. May not be taken pass/fail. **(SS)**

PSYC 109. (SSP 109) Adulthood and Aging (4)
Social science approaches to the latter two-thirds of life. Cognitive and personality development; attitudes toward aging; social behavior of older adults; widowhood; retirement. Prerequisite: PSYC 1 or SSP 1. May not be taken pass/fail. Hyland. **(SS)**

PSYC 110. (BIOS 110) Statistical Analysis of Behavioral Data (4)
Principles of experimental design and statistical analysis: characteristics of data and data collection; descriptive statistics; hypothesis testing theory and practice; correlation, chi-square, t-test, analysis of variance. Three hours lecture and one hour computer lab. **(ND)**

PSYC 117. Cognitive Psychology (4)
The architecture and dynamics of the human mind: How we acquire knowledge through perception, represent and activate it in memory, and use it to communicate, make decisions, solve problems, and reason creatively. Prerequisite: PSYC 1 or COGS 7. May not be taken pass/fail. **(SS)**

PSYC 121. (SSP 121) Social Psychology (4)
Theories, methods of investigation, and results of research on the way social and psychological processes interact in human behavioral settings. Topics include analysis of self and relationships, dynamics of small groups, attitudes and persuasion, prejudice, prosocial and antisocial behavior. Prerequisite: ANTH 1, ANTH 11, SSP1 or PSYC 1. **(SS)**

PSYC 125. (SSP 125) Social Psychology of Small Groups (4)
Theories and empirical research regarding interpersonal behavior in small groups. Classroom exercises and group simulations. Prerequisite: consent of instructor. Rosenwein. **(SS)**

PSYC 135. (SSP 135, Jour 135) Human Communication (4)
Processes and functions of human communication in relationships and groups. Rosenwein. **(SS)**

PSYC 140. (ANTH 140, COGS 140, MLL 140) Introduction to Linguistics (4)
Relationship between language and mind; formal properties of language; language and society; how languages change over time. No pass/fail option. **(SS)**

PSYC 142. (AAS 142) The Psychology of African Americans (4)
Presentation of a range of writings on the psychology of African Americans; exploration of significant perspectives in understanding the psychological dynamics, popular culture, current research, and cultural implications of Black Americans entering the 21st century. Lectures and discussion. Prerequisite: By the consent of the instructor. **(SS)**

PSYC 153. (SSP 153) Personality (4)
Review and critique of theories of personality and their associated systems of psychotherapy. May not be taken pass/fail. Prerequisite: PSYC 1 or SSP 1. **(SS)**

PSYC 160. Independent Study (1-3)
Readings on topics selected in consultation with a staff member. Prerequisites: PSYC 1 and consent of the department chair. May be repeated for credit. **(SS)**

PSYC 161. Supervised Research (1-3)
Apprenticeship in ongoing faculty research program. Literature review, experimental design, data collection and analysis, and professional writing under faculty

supervision. May be repeated for a maximum of 9 credits. Restricted to pass-fail grading. Prerequisites: PSYC 1 or COGS 7 and consent of sponsor. **(SS)**

PSYC 162. Psychological Field Work (1-3)
Work-study practice including supervised experience in one of several local agencies. Development of familiarity with the operations of the agency and working with individual patients or students. Prerequisites: PSYC 1 plus two additional psychology courses and consent of instructor. **(SS)**

PSYC 176. Mind and Brain (4)
Perception and cognitive neuroscience as the link between mental processes and their biological bases. Visual and auditory perception; the control of action; neuropsychological syndromes of perception, language, memory and thought; neural network (connectionist) models of mental processes. Prerequisite: PSYC 1 or COGS 7. May not be taken pass/fail. **(NS)**

PSYC 210. Experimental Research Methods and Laboratory (4)
Designing, conducting, and reporting psychological experiments. Laboratory exercises, report writing, and a group research project. Prerequisites: PSYC 1 and 110 and consent of department chair. **(ND)**

PSYC 301. Industrial Psychology (4)
Psychological concepts and methods applied to business and industrial settings. Personnel selection, placement and training, leadership, work motivation, job satisfaction and consumer behavior. Prerequisite: PSYC 1. **(SS)**

PSYC 305. Abnormal Psychology (4)
Examines research and theory on the patterns, causes, and treatment of various forms of abnormal behavior. Prerequisite: PSYC 153 or consent of instructor. **(SS)**

PSYC 307. Higher Order Cognition (4)
In depth exploration of selected areas of higher level cognition such as thinking and reasoning, metacognition, expertise, executive processes, language and thought. Prerequisites: PSYC 117 or PSYC 176 or COGS 7 or consent of instructor. O'Seaghdha, Malt. (Advanced Psychology Seminar) (SS)

PSYC 308. (SSP 308) Seminar in Social Psychology (4)
Intensive consideration of selected topics in current theory and research in social psychology. The subject matter varies from semester to semester, and includes such topics as the social psychology of education, the applications of perception and learning theory to social psychological problems, the social psychology of science, and the social environment of communication. May be repeated for credit. Prerequisite: ANTH 1 or SSP 1 or department permission. (Advanced Psychology Seminar) **(SS)**

PSYC 310. Advanced Research Methods in Psychology (4)
Experimental and nonexperimental research design; Sampling and selection from populations; Data exploration; Quantitative and qualitative measurement and analysis; Computer-based data collection; and other specialized topics. Prerequisite: PSYC 210. **(ND)**

PSYC 311. The Psychology of Stereotyping, Prejudice, and Discrimination (4)
We will start by examining the basic cognitive processes that make stereotyping a functional aspect of everyday cognition, and then we will turn toward examining emotional, motivational, and personality differences that affect one's level of prejudice. Finally, we will study the role of social forces in transmitting prejudice (parents, schools, religion, media) and the impact of societal prejudice (discrimination) on those who are the targets of prejudice. The changing face through the decades of how stereotypes, prejudice, and discrimination are measured, expressed, and understood is the focus of the course. Prerequisites: PSYC/SSP 153 or PSYC/SSP 121. Moskowitz. (Advanced Psychology Seminar) **(SS)**

PSYC 312. (SSP 312) Interpersonal Behavior in Small Groups (4)
Intensive consideration of theoretical and methodological issues in the analysis of the development of small groups. Prerequisite: Any one of the following introductory courses: ANTH 1 or SSP 1 or department permission. Rosenwein. **(SS)**

PSYC 313. Person Perception (4)
Psychological processes involved in forming impressions of others. Survey of the factors that influence the way in which we think about the people who make up our social environment and of the laboratory methods with which experimental social psychology investigates person perception. The emphasis is on demonstrating the joint impact of the behaviors performed by others and the biases/expectancies that we bring into the social setting. Prerequisites: PSYC/SSP 153 or SSP/PSYC 121. Moskowitz (Advanced Psychology Seminar) **(SS)**

PSYC 314. (SSP 314) Social Cognition and Social Action (4)
Examines the formation of beliefs about social groups, individuals, the self, and the world. Consequences and validity of those beliefs are considered. Areas of inquiry include stereotypes and prejudice, impression formation processes, the self, attitudes and persuasion, and social influence. Prerequisite: PSYC 110 or SR 111. Gill. (Advanced Psychology Seminar) **(SS)**

PSYC 315. History of Modern Psychology (4)
Origin and development of major theories within perception, cognition, biological, clinical, personality, developmental, learning. 19th and 20th century thought to provide an overview of psychology as a discipline. Prerequisites: two 300-level PSYC courses. (Advanced Psychology Seminar) **(SS)**

PSYC 317. Psychology of Emotion (4)
A selective overview of the scientific study of emotion. Topics will include: historical and modern theories of emotion, physiological and neuropsychological aspects of emotions, evidence that facial expressions of emotion may be universal among humans, and the role of emotion in cognition. Prerequisite: PSYC 110 or consent of the instructor. (Advanced Psychology Seminar) **(SS)**

PSYC 318. (WS 318) Seminar in Gender and Psychology (4)
Gender as shaped by psychological and social psychological processes. Socialization, communication and power, gender stereotypes, methodological issues in sex differences research. Prerequisite: PSYC 210 completed or concurrent or permission of instructor. Hyland. (Advanced Psychology Seminar). **(SS)**

PSYC 320. Psychology of Language (4)
Psychological processes involved in language comprehension, production, and use. Topics include the relation of language to thought; word meaning; speech perception;

language acquisition; sign language. Prerequisite: PSYC 117 or 176 or COGS 7 or consent of instructor. Malt, O'Seaghdha. (Advanced Psychology Seminar) **(SS)**

PSYC 321. Language Development (4)
Descriptive and theoretical accounts of the development of language. Primary focus is on the development of spoken language in infancy and early childhood. Involves observation of children at various stages of language development. Prerequisite: PSYC 107 or 117. (Advanced Psychology Seminar). **(SS)**

PSYC 322. Language in Atypical Populations (4)
Analysis of language function in atypical populations and circumstances. Language deficits throughout the lifespan will be considered, with particular emphasis on their relevance to current linguistic and cognitive science theory. Topics covered include atypical language development (e.g., in Specific Language Impairment, Autism, Down Syndrome, Williams Syndrome) as well as language impairment after brain damage (e.g., stroke) or as a result of progressive degenerative disorders (e.g., Alzheimer's Disease). Prerequisites: PSYC 117 or 176 or COGS 7 or COGS 140. Gonnerman . (Advanced Psychology Seminar) **(SS)**

PSYC 323. (SSP 323) The Child in Family and Society (4)
Influences such as marital discord, family violence, poverty and prejudice on the development of the child from birth through adolescence. Prerequisite: ANTH 1 or SSP1 or department permission. Herrenkohl. **(SS)**

PSYC 327. Health Psychology (4)
An overview of the topic of health psychology. The course presupposes a preventative intervention approach to the problem of assisting healthy individuals to understand the relationship between behavior and health, and to engage those behaviors that promote health. This course will be underpinned with basic science and research on health psychology, but will include an application focus. Prerequisite: PSYC 110. **(SS)**

PSYC 328. Educational Psychology (4)
Overview of historical, contemporary, and emerging issues in the field of educational psychology. Implications of various social, cognitive and behavioral educational-psychological theories for teaching and learning in the classroom. Prerequisite: PSYC 107 or 109 or 117. **(SS)**

PSYC 331. Humanistic Psychology (4)
The literature of and metaphors underlying the humanistic point of view in psychology. These "models of man" are contrasted with models underlying other modes of psychological inquiry. Prerequisites: PSYC 153. (Advanced Psychology Seminar). **(SS)**

PSYC 333. (SSP 233, POLS 333) Social Psychology of Politics (4)
Political behavior viewed from a psychological and social psychological perspective. Prerequisite: ANTH 1, 11, or 12; SSP 1, 5, or 21; PSYC 1, or department permission. Rosenwein. **(SS)**

PSYC 335. (BIOS 335) Animal Behavior (3)
Discussion of the behavior of invertebrates and vertebrates and analysis of the physiological mechanisms responsible for behavioral actions, and adaptive value of specific behavior patterns. Prerequisite: BIOS 31 or EES 31. **(NS)**

PSYC 338. Phenomenology and Theory of Childhood Disorders (4)
The nature, classification, and treatment of childhood disorders. Prerequisite: PSYC 107 **(SS)**

PSYC 351. Cognitive Development in Childhood (4)
Piaget and alternative theoretical approaches. Research on development of memory, comprehension, communication, classification, and social cognition. Prerequisite: PSYC 107, 117, or COGS 7. Barrett. (Advanced Psychology Seminar) **(SS)**

PSYC 354. Psychological Assessment (4)
Basic concepts in the construction, selection, administration, scoring, and interpretation of assessment procedures commonly used in psychology. Selection and evaluation of assessment procedures. Supervised experience administering, scoring, and interpreting assessment procedures. Prerequisites: PSYC 110. **(SS)**

PSYC 356. (SSP 356) Seminar in Personality Psychology (4)
Topics in personality psychology: the self, personality consistency, motivation, psychological adjustment. Prerequisite: PSYC 153 or consent of instructor. (Advanced Psychology Seminar) **(SS)**

PSYC 358. Seminar in Infant Development (4)
Theories and current research focusing on development in the first two years of life. Topics include cognitive, perceptual, language, social, and emotional development, and methods used in infancy research. Prerequisites: PSYCH 107 and consent of department chair. Barrett. (Advanced Psychology Seminar) **(SS)**

PSYC 359. Seminar on Psychological Issues in the Legal System (4)
Contributions of psychological research to understanding the legal system. Social science data on juries, eyewitnesses, mental illness, and the death penalty will be discussed. Conflicts between psychological and legal approaches will be highlighted. Prerequisite: PSYC 110 or consent of instructor. Barrett. (Advanced Psychology Seminar) **(SS)**

PSYC 361. (SSP 361) Personality and Social Development in Adulthood (4)
Theories and current research. Prerequisite: SSP/PSYC 109 or consent of instructor. Hyland. (Advanced Psychology Seminar) **(SS)**

PSYC 363. (SSP 363) Personality and Social Development in Childhood (4)
Issues related to social development (e.g., attachment, social competence), social contexts (e.g., family, day care), and personality development (e.g., sex roles, aggression, temperament) from infancy through adolescence. Prerequisite: PSYC 107 or consent of instructor. (Advanced Psychology Seminar) **(SS)**

PSYC 364. Narratives, Culture and Development (4)
Examines the complex role of narratives - told to and by children, and enacted by children in play - in children's experience and development. Compares and seeks to integrate different approaches in psychology and other disciplines. In the process, we will also be addressing three basic questions: what is narrative, how is it significant, and how should we study it? Prerequisite: PSYC 107. Nicolopoulou. (Advanced Psychology Seminar) **(SS)**

PSYC 365. Human Development in Cross-Cultural Perspective (4)
The formation of mind and personality is shaped in profound ways by the sociocultural contexts within which individuals develop. This course introduces students to basic theoretical and methodological issues and explores important examples of cross-cultural variation and diversity, using comparisons between different societies and between different subcultures within American society. Topics include cognition, language, personality, moral development, socio-emotional development, identity, attachment, and socialization. Materials drawn from anthropology, sociology and education in addition to psychology. Prerequisites: **One** of the following courses **or** consent of instructor: PSYC 107, PSYC 109, PSYC/SSP 121, ANTH 1. (Advanced Psychology Seminar) **(SS)**

PSYC 366. Seminar in Cognitive Aging (4)
Information processing by older adults: perception, attention, memory, speech and text processing and comprehension. The course will also examine the effects on cognitive processing of such diseases as Alzheimer's and Parkinson's. Prerequisite: PSYC 109; PSYC 117 not required but strongly recommended. (Advanced Psychology Seminar) **(SS)**

PSYC 367. Clinical Psychology (4)
The science and profession of helping people overcome psychological problems. Theories of human personality and abnormality in relation to techniques for assessing and treating psychosocial problems and in the light of empirical evidence of validity and effectiveness. Professional issues are also covered. Prerequisites: PSYC 153 and PSYC 305 or consent of instructor. (Advanced Psychology Seminar) **(SS)**

PSYC 369. Memory (4)
The paradoxical power and fallibility of memory in the light of observational, experimental, clinical, and neuroscientific evidence. Potential topics include expert memory; false memory; recovered memory; social transmission; amnesia; memory and personal identity. Prerequisite: PSYC 117 or PSYC 176 or COGS 7 or consent of instructor. O'Seaghdha. (Advanced Psychology Seminar) **(SS)**

PSYC 373. Sensation and Perception (4)
Receptor processes of vision, audition, touch, taste, and smell. Psychological dimensions of such processes leading to consideration of perception as characteristic of organisms. Prerequisite: PSYC 117 or 176 or COGS 7. (Advanced Psychology Seminar) **(SS)**

PSYC 381. Special Topics in Psychology (4)
Topics vary from semester to semester. Topics are presented at an advanced level. Previous course work in psychology is required. May be repeated for credit. **(SS)**

PSYC 382. (BIOS 382) Endocrinology of Behavior (3)
Hormonal effects upon animal and human behavior. Emphasis on neuroendocrinology of steroid hormone involvement in reproductive behaviors. Prerequisite: BIOS 177. **(NS)**

PSYC 391. Thesis (3)
Written report: Literature review and design of project in selected area of psychology. Only open to students in the honors program. Requires consent of the Honors Program Coordinator. **(ND)**

PSYC 392. Thesis. (3)
Execution of project designed in PSYC 391. Final report and oral presentation. Only open to students in the honors program. Prerequisites: PSYC 391 and consent of the Honors Program Coordinator. **(ND)**

PSYC 393. Independent Research (1-3)
Individual research projects designed and executed in collaboration with faculty sponsor. Regular meetings with sponsor to give progress reports and receive feedback. Student reads relevant literature and writes report in APA format. May be repeated for a maximum of 6 credits. Prerequisites: PSYC 210 or 161 and consent of sponsor. **(ND)**

PSYC 394. Senior Research Project (3)
Literature review, design and execution of project in selected area of psychology. Intended for senior majors in psychology. May be repeated for up to 6 credits. Prerequisites: Department permission required. **(SS)**

For Graduate Students

The Department of Psychology offers a distinctive Ph.D. program centered in areas of Human Cognition and Development with specializations in cognition and language, development, and social cognition and personality. Students are trained primarily for positions at universities and in basic or applied research settings. For the most complete and current information visit *www.lehigh.edu/inpsy/gradprogram.html.*

In addition we offer two non-degree Certificate Programs in collaboration with other departments and programs.

The Graduate Certificate in Stereotypes, Prejudice, Discrimination, and Intergroup Relations is administered by the Psychology Department. Information is available via *www.lehigh.edu/inpsy/gradprogram.html.*

The Graduate Certificate in Cognitive Science is administered by the Cognitive Science Program. Information is available at: *www.lehigh.edu/incog/cogscicat.html.*

Requirements for a Ph.D. in the Department of Psychology:

Research

All graduate students are expected to be involved in research throughout their graduate careers. There are also several formal research requirements of the program.

First-Year-Project (PSYC 412). First-year students are expected to choose an adviser and begin to work on a research project as early as possible. A written and oral report of the student's research activities is made to the department. Students entering with an approved Master's thesis are exempt from this requirement.

Master's Thesis. A master's thesis (usually empirical or data-based) is required. An oral presentation of the thesis is made to the department. Students entering with a master's thesis may instead conduct an equivalent non-degree Pre-dissertation Project.

Doctoral Dissertation. This is an original piece of scholarly work usually involving empirical research, although original theoretical or historical research is possible with faculty approval.

Course work

Core courses. All students are required to take one-semester graduate core courses in Cognitive Psychology (PSYC 403), Developmental Psychology (PSYC 402), and Social Cognition (PSYC 406).

PSYC 421 and 422. Statistical Analysis of Psychological Data. These courses represent a two-semester sequence of theoretical and applied statistics and research methodology.

PSYC 430. Graduate Seminars. Students must take at least three graduate seminars, and one additional course approved by the adviser.

PSYC 409 and 410. Professional Seminar. Bookend seminars that cover professional development issues for new and advanced students.

Teaching

Students are encouraged to participate in teaching as appropriate for their training throughout their graduate years. Normally, students begin as teaching assistants and progress to teaching independently.

General Examination

This is required for all doctoral candidates and must be passed at least seven months prior to the awarding of the degree. The sub areas to be covered on the exam are selected by the student in consultation with the student's general exam committee.

Evaluation

Graduate students are evaluated on their performance in coursework, research, teaching, assistantship assignments, and the general examination. The faculty provides each student with a written evaluation of progress in the graduate program annually.

Financial Support

Support is available in the form of teaching and research assistantships, fellowships, and scholarships.

How to Apply

Applications for admission and financial aid may be obtained from the Department of Psychology. While a good undergraduate background in psychology is desirable, promising students with majors other than psychology are encouraged to apply. Completed application forms plus transcripts, letters of recommendation, and a report of scores on the Graduate Record Examination and advanced tests in psychology should be returned no later than February 1 of the year of admission. New students are normally accepted for entrance into the program only for the fall semester.

Graduate-Level Courses

PSYC 402. Developmental Psychology (3)
Survey of theories and research concerning perceptual, cognitive, social, and personality development through infancy and childhood. Prerequisite: Graduate standing or consent of instructor.

PSYC 403. Cognitive Psychology (3)
Survey of theories and research in cognitive psychology. Prerequisite: Graduate standing or consent of instructor.

PSYC 404. (BIOS 404) Behavioral Neuroscience (3)
Theoretical and empirical issues in biopsychology. Prerequisite: Graduate standing or consent of instructor.

PSYC 406. Social Cognition (3)
Theory and research on cognitive processes in personality and social functioning. The self, personality consistency and change, causal attributions, social judgement, goals and self-regulation, and mood and emotion. Topics may vary. Prerequisite: Graduate standing or consent of instructor.

PSYC 409. Professional Seminar I (1).
For students entering the Ph.D. program: Acculturation to graduate school and the Psychology Ph.D. program in particular; professional issues of relevance to individuals at the outset of a research career in psychology. Requirement: Department permission.

PSYC 410. Professional Seminar II (1).
For students nearing graduation: Professional issues of special relevance to Psychology Ph.D. students preparing for academic or nonacademic post-doctoral employment. Requirement: Department permission.

PSYC 412. First Year Research Project. (1-3)
Research project to be completed by June of the first year of the Ph.D. program under the direction of a faculty advisor. May be repeated in second semester of program.

PSYC 415. History of Modern Psychology (3)
Origin and development of major theories in various areas of psychology. Review of 19th and 20th century thought to provide perspective on psychology as a discipline. Newman

PSYC 421. Statistical Analysis of Psychological Data I. (3)
First of a two-semester sequence covering essential issues in statistical analysis as practiced by psychologists. Topics include data description, probability, z and t-tests, general linear model, simple correlation/regression, univariate analysis of variance, chi-square. Emphasis on connecting research designs to appropriate statistical tests, data interpretation, and implementation in statistical packages. Department permission required.

PSYC 422. Statistical Analysis of Psychological Data II. (3)
Second course of the two-semester statistics sequence. Topics include advanced analysis of variance designs, analysis of covariance, multivariate analysis, multiple regression, and analysis of categorical data. Emphasis on connecting research designs to appropriate statistical tests, data interpretation, and implementation in statistical packages. Requirement: PSYC 421.

PSYC 423. (COGS 423) Foundations of Cognitive Science (3)
Survey of fundamental theory and methodologies from artificial intelligence, linguistics, cognitive psychology, philosophy, and neuroscience, as well as salient research problems such as knowledge acquisition and representation, natural language processing, skill acquisition, perception and action, and the philosophical question of intentionality.

PSYC 434. Seminar in Personality (3)
Selected topics in personality theory and research, including personality change, the self, personality consistency, and the relationships among thought, emotion, and behavior. Prerequisite: PSYC 406.

PSYC 443. Seminar in Language Acquisition (3)
Special topics in language acquisition. Content will vary each time the seminar is offered. Prerequisite: PSYC 402 or PSYC 403 or consent of instructor. McRoberts

PSYC 446. Developmental Theories and Special Populations (3)
Traditional developmental theories focus on normative development. children with disabilities have a unique set of experiences that pose special challenges for these theories. In the developmental literature, children with disabilities have sometimes been the focus of studies because they provide a "tests case" for specific theoretical predictions. In this course, we will consider some of these theoretical issues and the insights that have been gained by focusing on special populations. Prerequisite: PSYC 402 or consent of instructor. Barrett

PSYC 448. Seminar in Psychology of Language (3)
Topics in language comprehension and production. Content will vary from year to year. Prerequisite: PSYC 403 or consent of instructor.

PSYC 450. Special Topics in Mathematical Models and Statistics (3)
Selected topics in the application of mathematics to psychological research. May be repeated for credit.

PSYC 460. Special Study (1-9)
Study of some special topic not covered in the regular course offerings. May be repeated for credit.

PSYC 461. Research Seminar (1-9)
Original research designed and executed in collaboration with the faculty. May be repeated for credit.

PSYC 462. Stereotypes, Prejudice, and Discrimination (3)
An in-depth survey of the social psychological literature on stereotypes, prejudice, and discrimination. Topics will include: Origin of stereotypes, mental representation of stereotypes, cognitive and behavioral consequences of stereotypes, inevitability of stereotyping, nature of prejudice in contemporary American society, context-specificity of discriminatory behavior, and theories of intergroup conflict reduction. Prerequisite: PSYC 406 or consent of instructor . Gill.

PSYC 464. Naive Realism in Social Judgment (3)
This seminar examines the variety of unconscious influences that impact on social judgment, with a focus on the cognitive processing mechanisms through which influence is exerted. These influences include contributions to judgment from attitudes, goals, accessible constructs, mind-sets, stereotypes, expectancies, heuristics, and theories about social objects. Prerequisite: PSYC 406 or consent of instructor. Moskowitz.

PSYC 476. Seminar in Cognition (3)
Selected topics in human information processing, including such areas as attention, memory, language and comprehension, and decision-making. Area of emphasis will vary from year to year. Prerequisite: PSYC 403 or consent of instructor.

PSYC 478. (COGS 478) Ontological Psychology (3)
Principles and constraints for the modeling of psychological phenomena: perception, memory, knowing, emotions, consciousness, language, and rationality. Bickhard.

PSYC 480. Seminar in Cognitive Development (3)
Selected topics in cognitive development in infancy and childhood, including such areas as conceptual development, memory development, the development of reasoning abilities, and language acquisition. Emphasis will vary from year to year. Prerequisite: PSYC 402 or consent of instructor.

PSYC 481. Selected Topics in Social and Personality Development (3)
Topics include emotional and sex-role development, peer relations, and social competence. Emphasis will vary from year to year. Prerequisite: PSYC 402 or consent of instructor.

PSYC 482. Seminar in Adult Development (3)
Application of lifespan developmental theory and methodology to personality, social, and cognitive development in adulthood. Prerequisite: PSYC 402 or consent of instructor. Hyland.

PSYC 483. Seminar in Cultural Psychology (3)
Major theoretical approaches and empirical debates in cultural psychology, with a focus on the interplay of individual and sociocultural elements in the formation of mind, the emergence of the self, and the definition and reproduction of culture. Prerequisite: PSYC 402 or consent of instructor. Nicolopoulou

PSYC 484. Psychology of Gender (3)
Major theoretical approaches and empirical debates in the psychology of gender, with a focus on the interplay of nature and nurture in producing gender similarities, gender differences and gender variation in personality, social behaviors, cognitive abilities, achievement, sexuality, and mental health. Methodological issues in gender research. Prerequisite: graduate standing. Department permission required. Hyland

PSYC 490. Thesis Research (1-6).
Master's Thesis or Pre-dissertation Project research directed by committee.

PSYC 499. Dissertation Research (1-15).
Ph.D. dissertation research directed by dissertation committee.

Public Relations

See listings under Journalism and Communication

Quality Engineering

Program. The Master's of Science degree in Quality Engineering (MSQE) is offered by the Department of Industrial and Systems Engineering (ISE). A list of the faculty and descriptions of the courses are included in the catalog description (see catalog index) of the ISE department. The program is designed to accommodate students who are employed full time. Courses are transmitted via satellite to work sites anywhere in the continental USA.

Admission. To be considered for admission to the MSQE program, applicants must have a Bachelor's of Science degree in engineering (any discipline) or in science.

University Requirements. All of the university rules that apply to the awarding of Master's degrees at Lehigh apply to the MSQE, except for the following: no thesis or report or general examination is required. The university rules that do apply to the MSQE are spelled out in the catalog, under the heading "Degree Information" (see catalog index).

Departmental Requirements. All candidates must complete thirty hours of course work—fifteen hours of core courses and fifteen hours of electives. The core courses, which all candidates take, are listed below:

IE 228	Engineering Statistics	(3)
IE 332	Quality Control	(3)
IE 410	Design of Experiments	(3)
IE 422	Measurement and Inspection Systems	(3)
IE 442	Total Quality Management	(3)

Any offered IE or MSE course, if not a core course, is an acceptable elective, and at least nine hours of the electives must be courses, which have prefix IE or MSE. Up to six hours of the electives may be any graduate course or courses that the candidate's advisor approves. The ISE department offers several elective courses, including the following:

IE 415	Manufacturing Management	(3)
IE 445	Assembly Processes and Systems	(3)

Up to six hours of credits earned at other institutions may be used to satisfy degree requirements, if transfer of credits is approved by the registrar.

Religion Studies

Professors. Norman J. Girardot, Ph.D. (Chicago), *University Distinguished Professor*; Kenneth L. Kraft, Ph.D. (Princeton); Michael L. Raposa, Ph.D. (Pennsylvania) *Fairchild Chair of American Studies*; Laurence J. Silberstein, Ph.D. (Brandeis), *Philip and Muriel Berman Professor of Jewish Studies, and Director of the Philip and Muriel Berman Center for Jewish Studies*; Lloyd H. Steffen, Ph.D. (Brown) *Chair*; Lenore E. Chava Weissler, Ph.D. (Pennsylvania), *Philip and Muriel Berman Chair of Jewish Civilization;* Benjamin G. Wright, III, Ph.D. (Pennsylvania).

Assistant Professor. Robert Rozehnal, Ph.D. (Duke).

The religion studies department is committed to the academic investigation of religion as an intrinsic and vital dimension of human culture. The scholarly study of religion is an integral facet of a liberal arts education. The student of religion is engaged in the critical and interpretive task of understanding patterns of religious thought and behavior as aspects of the human cultural experience.

Religion studies is interdisciplinary in that it draws upon humanistic and social scientific modes of inquiry. These include historical, philosophical, sociological, anthropological, and psychological perspectives. Religion studies is a cross-cultural, comparative discipline concerned with the character and significance of the major religious traditions of the world. The student of religion confronts ethical problems and basic issues of value and meaning raised by modern multicultural and technological society.

Major in Religion Studies

The major in religion studies consists of 32 credit hours of coursework (eight courses). Requirements include:

- At least one introductory course (any course numbered below level 10).
- At least one course on a Western religious tradition, and at least one course on an Eastern religious tradition.
- At least four courses at the 100 level or above.
- REL 374 Senior Seminar.

In addition to this minimum distribution, a concentration is recommended in one of the major religious traditions, *or* in a comparative or thematic approach to the study of religion. The concentration should include at least four courses, where that is possible. Language study appropriate to the concentration is also desirable.

Students are particularly encouraged to consider a joint or double major with another major field from any of the three colleges at the university.

Departmental Honors

Religion studies majors are admitted to honors by invitation of the departmental faculty toward the end of the student's junior year. To be eligible, a student must have attained at least a 3.25 average in his or her major program by the end of the junior year. Upon admittance to honors, the student will work out a special program of studies for the senior year with the major advisor, culminating in the writing of a senior essay.

Minor in Religion Studies

The minor in religion studies consists of a total of 16 credits. The specific courses to be taken by each student are to be decided upon jointly by the student and the departmental advisor. Ordinarily, the student will be expected to take one introductory course unless specifically exempted by the department chair.

Course Offerings

REL 1. Sacred Scriptures from Around the World (4)
An encounter with the different sacred books of the world's major religions. Both the books and differing attitudes in these traditions towards sacred books are examined. Books investigated include the Bhagavad Gita, the Analects of Confucius, the Qur'an and the Jewish and Christian Bibles. Wright. **(HU)**

REL 2. Death in Religious Traditions (4)
Introduces students to the study of religion through an exploration of what different religious traditions have to say about the great mystery that we all face, death. Because we all must die, all religions must deal with the challenge and sense of crisis provoked by the deaths of those close to us, of innocent victims of disaster, disease, and crime, and our own imminent deaths. Death thus provides an excellent point of comparison among the various religious traditions. Weissler. **(HU)**

REL 3. (PHIL 3) Religion, Ethics and Society (4)
Introduction to philosophical and religious modes of moral thinking, with consideration given to ethics in the world religious traditions (family life and role of women, social justice, environment, work, models of ethical ideal). Particular issues examined include abortion, corporal punishment (such as the death penalty), problems in medical ethics, and heavy drinking as a behavioral problem. Steffen. **(HU)**

REL 4. How to Study Religion (4)
How do sociologists, psychologists and philosophers answer such questions as: Why and how do religions arise? Why and how do people develop beliefs in God? Where do religious scriptures come from? Why do people ascribe authority to religious traditions? Why has religious faith declined in modern society? Silberstein. **(HU)**

REL 5. Spiritual Exercises East and West (4)
Explores a variety of religious founders" in the history of religions. Girardot. **(HU)**

REL 6. Religion and the Ecological Crisis (4)
Past and present responses to nature in world religions. Contemporary topics include the animal rights debate, ecofeminism, and the development of environmental ethics. Is "the end of nature" at hand? Why is the environment a religious issue? Kraft. **(HU)**

REL 7. Jesus, Buddha, Mao, and Elvis (4)
Comparative and cross-cultural exploration of the nature and meaning of "religious founders" in the history of religions. Girardot. **(HU)**

REL 8. (WS 8) Prehistoric Religion, Art, and Technology (4)
Origins and early development of religions, with focus on interactions of religion, art, and technology in the Paleolithic and Neolithic periods. Special attention to the emergence of patriarchal social forms and the figure of the goddess. Interdisciplinary methods with a consideration of feminist theories of cultural development. Girardot. **(HU)**

REL 9. Spiritual Journeys (4)
A comparative survey of spiritual traveling-from overland pilgrimages to inward journeys in search of truth. Through autobiographies, diaries, poetry and films, students encounter the experiences of seekers from diverse religious traditions, including Hinduism, Buddhism, Christianity and Islam. Rozehnal. **(HU)**

REL 22. (Art 22) Visions of God: 2000 Years of Christian History and Art (4)
An Interdisciplinary course that combines art history and the history of Christianity. From the beginnings of their tradition, Christians have represented their theologies and religious sentiments in visual arts and architecture, and for the same two millennia, a myriad of Christians have learned their Christianity through visual representations. Provides a one-semester survey of the history of Christianity as expressed in the visual arts. Wright/Priester. **(HU)**

REL 60. (ASIA 60) Religions of South Asia (4)
A thematic introduction to the foundational religious traditions of South Asia: Hinduism, Jainism, Buddhism, Sikhism and Islam. Students explore the social and spiritual dimensions of these religious worlds through scripture, ritual practices, narrative and teaching traditions, music and art. Rozehnal. **(HU)**

REL 62. (ASIA 62) Religions of India (4)
Origin, development and meaning of the major forms of Indian religious traditions. Attention to elite and popular forms of Hinduism, Yoga, early Buddhism. **(HU)**

REL 64. (ASIA 64) Religions of China (4)
History and meaning of the major forms of Chinese religion- especially Confucianism and Neo-Confucianism, Taoist mysticism, Buddhism (Ch'an/Zen), and popular religion. Girardot. **(HU)**

REL 65. (ASIA 65) Religions of Japan (4)
A survey of Japan's diverse religious heritage and its impact on contemporary culture. Japanese approaches to the self, the world, and the sacred are considered in comparative perspective. Topics covered include: Shinto, Buddhism, Zen, Confucianism, the way of the warrior, folklore, and postwar movements. Kraft. **(HU)**

REL 67. (ASIA 67) Japanese Civilization (4)
The history and culture of Japan from its origins to the present. Special consideration will be given to the rise and fall of the warrior class, developments in art and religion, the dynamics of family life, and Japan's "economic miracle." Kraft. **(H/S)**

REL 68. Practical Justice: From Social Systems to Responsible Community (4)
Examination of the role of moral and religious values in social systems, including education, the economic system, criminal justice, with particular attention to the problems of poverty, literacy, homelessness and domestic violence. Students engage in volunteer efforts to gain practical experience with those who deliver and receive services in these systems. An action-reflection model (with reference to liberation theology and religious thinkers like M.L. King, Dorothy Day, and Walter Rauschenbusch) is employed to urge reflection on how social systems can be affected and transformed by visions of justice, ethics, religion and social responsibility. Steffen. **(HU)**

REL 73. The Jewish Tradition (4)
Judaism is both a textual tradition and a lived religion. Students read basic Jewish texts—Bible, Talmud, Midrash—and study the ways Jews sanctify the life cycle through rites of passage, and the round of the year through the festival cycle. Silberstein, Weissler. **(HU)**

REL 75. The Christian Tradition (4)
Introduction to the Christian tradition from its early variety and subsequent classical definition in the church councils up to the enlightenment. Special emphasis will be placed on the multiform interpretations of the Christian message. Wright. **(HU)**

REL 76. Reading the Bible in the Contemporary World (4)
Reading passages from the Bible with an eye toward distinguishing and understanding different sorts of questions that can be asked of them and various perspectives that can be adopted when reading them. What are these stories about? What do they mean, when, and to whom? Wright. **(HU)**

REL 77. (ASIA 77) The Islamic Tradition (4)
A thematic introduction to Islamic history, doctrine and practice. Topics include: Qur'an; prophecy and sacred history; ritual practices; community life; legal interpretation; art and aesthetics; mysticism; politics and polemics. Rozehnal. **(HU)**

REL 111. Jewish Scriptures/Old Testament (4)
The religious expression of the Hebrews, Israelites, and Jews as found in the Jewish Scriptures (TANAK/Christian Old Testament). Near Eastern context of Hebrew religion, the Patriarchs, the Exodus, the monarchy, prophecy, Exile and Return. Emphasis on historical, literary, critical problems, and newer socio-historical methods. Wright. **(HU)**

REL 112. The Beginnings of Judaism and Jewish Origins: Jewish Diversity in the Greco-Roman World (4)
The variety of approaches to Judaism in the period following the Babylonian exile through the second century C.E. The literature studied will include Apocrypha, Pseudepigrapha, and the Dead Sea Scrolls. Wright. **(HU)**

REL 114. (CLSS 114) Christian Origins: New Testament and the Beginnings of Christianity (4)
Early Christianity from its beginnings until the end of the second century. Coverage includes the Jewish and Hellenistic matrices of Christianity, traditions about the life of Jesus and his significance, and the variety of belief and practice of early Christians. Emphasis on encountering primary texts. Wright. (HU)

REL 116. (PHIL 116) Bioethics (4)
Moral issues that arise in the context of health care and related biomedical fields in the United States today, examined in the light of the nature and foundation of moral rights and obligations. Topics include: confidentiality, informed consent, euthanasia, medical research and experimentation, genetics, the distribution of health care, etc. (HU)

REL 121. Sources for the Life of Jesus: the Jewish and Christian Context (4)
Ancient sources that claim to provide information about Jesus of Nazareth. Approaches taken to Jesus' life and career; early Christian interpretations of the significance of Jesus; methodology in assessing evidence for the historical Jesus and his message. Wright. (HU)

REL 124. (PHIL 124) Reason and Religious Experience (4)
A critical look, from a philosophical perspective, at some fundamental problems of religion: The nature of religious experience and belief, reason and revelation, the existence and nature of God, the problem of evil, and religious truth. Raposa. (HU)

REL 125. Heresy and Orthodoxy: Varieties of Christianity in the First Three Centuries (4)
Examines the development of Christianity until the end of the third century. Compares the views of different groups about the significance of Jesus. Who were the proto-orthodox? Jewish Christians? Gnostics? What did they think? Why were some branded heretics by others? Wright. (HU)

REL 126. (Hum 126, PHIL 126) Professional Ethics (4)
An examination of the moral rules and action guides that govern various professions. Professions to be examined will include health (physician and nursing); legal; counseling and psychiatry; engineering; military; clergy; teaching. Attention will be given to modes of ethical reasoning and how those modes are practically applied in professional life and activity. Among issues to be discussed will be the limits of confidentiality; employer authority; power relationships; obligations to the public; professional rights; sexual boundaries; whistle-blowing; safety and risk; computer ethics; weapons development; discrimination; professional review of ethical infractions. Course will include guest lectures and case studies. Steffen. (HU)

REL 129. (PHIL 129) Jewish Philosophy (4)
How major Jewish thinkers from the first to the 20th centuries confronted questions at the intersection of religion and philosophy: the existence and nature of God, free will, evil, divine providence, miracles, creation, revelation, and religious obligation. (HU)

REL 132. Hasidic Tales (4)
Examines the mysterious and beautiful tales told by Hasidim, participants in the movement of spiritual revival which arose within 18th century Judaism. Compares Hasidic tales to European fairy tales, and shows how later writers transformed Hasidic narratives to express their own religious or literary meanings. Weissler. (HU)

REL 133. Alternative Religions in the 21st Century (4)
An exploration of alternative religious beliefs and practices in the 21st century. Topics include the new pluralism, adaptations of Asian traditions, goddess religion, and spiritual environmentalism. What distinguishes a religion from a cult? What goes awry when violence is perpetrated in the name of religion? Kraft. (HU)

REL 137. (Hum 137, PHIL 137) Ethics in Practice (1-4)
A variable content course focusing on ethical issues arising in a particular profession, such as law, health, business, engineering, military. Variable credit. May be taken more than once. Steffen. (HU)

REL 138. (WS 138) Women in Jewish History (4)
Contributions of, and limitations on, women at different stages of Jewish history, using both primary sources and secondary material. Experience of modern Jewish women, and the contemporary feminist critique of traditional gender roles. Weissler. (HU)

REL 139. (ANTH 139) Jewish Folklore (4)
Examines the transformation of folk and popular Judaism from the Old World, through the period of immigration to America, to ethnic and later forms of American Jewish culture. Attention paid to concept of folklore revivals and their meanings. Four case studies: folk tales and storytelling, klezmer music, life-cycle rituals, and food. Weissler. (SS)

REL 144. (Art 144) Raw Vision: Creativity and Ecstasy in the Work of Shamans, Mystics, and Artist Outsiders (4)
Comparative exploration of the nature and meaning of religious and artistic experience as reflected in shamanism (both prehistoric and tribal), mystic traditions (especially Taoism and Christianity), and contemporary self-taught artistic visionaries (e.g., Jean Dubuffet, Howard Finster, Mr. Imagination, Lonnie Holley, Norbert Kox). Various disciplinary perspectives will be employed including comparative religions, anthropology, art history, and psychology. Girardot. (HU)

REL 145 (ASIA 145) Islam and the Modern World (4)
Examines how numerous Muslim thinkers-religious scholars, modernists, and Islamists-have responded to the changes and challenges of the colonial and post-colonial eras. Special emphasis is placed on the public debates over Islamic authority and authenticity in contemporary South Asia. Rozehnal. (HU)

REL 146 (ASIA 146) Islam in South Asia (4)
A survey of the dynamic encounter between Islamic and Indic civilizations. Topics include: Islamic identity, piety and practice; art and aesthetic traditions; inter-communal exchange and conflict; the colonial legacy; and the politics of contemporary religious nationalism. Rozehnal. (HU)

REL 150. Judaism in the Modern World (4)
Fundamental themes in the experience of modern Jewry; confrontation with secular culture; crisis of religious faith; Zionism and the renewal of Jewish nationalism;

the problem of Jewish identity in America; and the impact of the Holocaust. Silberstein, Weissler. **(HU)**

REL 152. American Judaism (4)
Diverse cultural and social forms through which American Jews express their distinct identity. Is American Jewry an example of assimilation and decline or creative transformation? What, if anything, do American Jews share in common? Compatibility of Judaism with individualism, pluralism, and voluntarism. How have the Holocaust and the State of Israel shaped the self-understanding of American Jewry? Silberstein. **(HU)**

REL 153. The Spiritual Quest in Contemporary Jewish Life (4)
What factors explain the current growth of spirituality in American Jewish life? How does spirituality differ from conventional religion? What is the impact of Jewish spirituality on contemporary Jewish worship? How does the growth of Jewish spirituality relate to the broader issues of Jewish identity? What accounts for the growing interest in Buddhism among Jews? What is the impact of feminism on Jewish spirituality? How does the growth of spirituality among Jews relate to the growth of spirituality in general American culture? Silberstein **(HU)**

REL 154. (HIST 154) The Holocaust: History and Meaning (4)
The Nazi holocaust in its historical, political and religious setting. Emphasis upon moral, cultural and theological issues raised by the Holocaust. **(HU)**

REL 155. Responses to the Holocaust (4)
A multi-media study of the ways in which writers, artists, film makers, cartoonists, composers, and comics have responded to the horrors of the Holocaust. Among the questions to be considered are: How is it possible to describe and represent the Holocaust in writing? In art? In film? What distinguishes the ways in which this is done by different generations? How is the memory of these events being effectively preserved and transmitted through monuments and museums? What role does the memory of the Holocaust play in the life of contemporary Jews? Silberstein. **(HU)**

REL 156. Israel, Zionism, and the Renewal of Judaism (4)
New interpretations of Judaism, the Jewish community and Jewish history developed by Zionist thinkers. Diverse currents within Jewish nationalist thought and critical responses to Zionist ideology. Silberstein. **(HU)**

REL 157. (HIST 157) Europe in the Age of the Reformation (4)
The breakup of the religious culture of medieval Christian Europe in the reformation movements of the sixteenth century. The origins and varieties of Protestantism; the intersection of religious ideas and politics in Germany, Switzerland, Britain, France, and the Netherlands; the "wars of religion" and the emergence of the European state system. Baylor. **(HU)**

REL 158. (WS 158) Sex and Gender in Judaism (4)
Writings by Jewish feminists reflecting the encounter between Judaism and feminism: prayer and ritual, women rabbis, God, and God language, communal power, the marriage and divorce. Silberstein. **(HU)**

REL 159. Roman Catholicism in the Modern World (4)
A survey of the various intellectual, cultural, political and ecclesiastical developments that have shaped contemporary Roman Catholic life and thought. Raposa. **(HU)**

REL 160. (ASIA 160) The Taoist Tradition (4)
Consideration of the religious and cultural significance of Taoism in its various historical forms. Primary attention will be given to a close reading of some of the most important texts of the early philosophical tradition (*e.g. Tao Te Ching, Chuang Tzu*) and of the later religious tradition (*e.g. Pao P'u Tzu* and other selections from the *Tao Tsang*). Contemporary implications of Taoist thought will also be considered (e.g. "The Tao of Physics", "a Taoist on Wall Street", and "the Tao of Japanese Management"). Girardot. **(HU)**

REL 162. (ASIA 162) Zen Buddhism (4)
History, doctrines, and practices of Zen Buddhism in China, Japan, and the West. Monastic life, notable Zen masters, Zen's cultural impact, and enlightenment. Current aspects of the Zen tradition. (Optional meditation workshop.) Kraft. **(HU)**

REL 164. (ASIA 164, IR 164) Japan's Response to the West (4)
A survey of Japanese history and culture from 1500 to the present, following the theme of Japan's contact with the West. What enabled Japan to modernize and Westernize so successfully? Topics covered include: the expulsion of Christianity, the first samurai mission to the U.S., the postwar American occupation, and contemporary issues. Readings include Japanese novels and short stories (in translation). Kraft. **(H/S)**

REL 167. (ASIA 167) Engaged Buddhism (4)
Examines a contemporary international movement that applies Buddhist teachings and practices to social, political, and environmental issues. Topics include: important thinkers, forms of engagement, and areas of controversy. Kraft. **(HU)**

REL 168. (ASIA 168) Buddhism in the Modern World (4)
Explores contemporary Buddhism in Asia, America, and Europe. Topics include the plight of Tibet, Buddhist environmentalism, and the emergence of a socially engaged Buddhism. How are Westerners adapting this ancient tradition to address present-day concerns? Kraft. **(HU)**

REL 169. (ASIA 169) Classics of Asian Religion (4)
Sacred scriptures of Asia and an introduction to the religions they represent. What do these texts teach about reality, humanity, divinity, and society? How is the path of spiritual practice presented in the different traditions? Prerequisite: one prior course in Religion or Asian studies. Kraft, Girardot. **(HU)**

REL 171 (SSP 171) Religion and Society (4)
An introduction to the sociology of religion. Covers classical and contemporary approaches to defining and studying the role of religion in society. Emphasis on understanding religious beliefs and practices in the United States, the sources and contours of religious change, and the effects of religion on individuals and society. Specific topics include religious fundamentalism, religious conversion, religious practices and authority,

secularization, religion in public life, religion in social change, religious terrorism, and the ways in which religion impacts our personal health, educational attainment, and family life. Munson **(SS)**

REL 174. Contemporary Theology (4)
Major 20th century movements within Christian and Jewish theology understood as responses to the problems of modern times. May be repeated for credit as the subject matter varies. Raposa. **(HU)**

REL 180. (HIST 180) Religion and the American Experience (4)
The historic development of major American religious groups from colonial times to the present; their place in social and political life, and the impact of the national experience upon them. Raposa. **(HU)**

REL 184. (WS 184) Religion, Gender, and Power (4)
Gender differences as one of the basic legitimations for the unequal distribution of power in Western society. Feminist critiques of the basic social structures, cultural forms, and hierarchies of power within religious communities, and the ways in which religious groups have responded. Silberstein. **(HU)**

REL 186. Judaism in Israel and the United States (4)
Explores the differences/similarities in the ideologies, myths and symbols which shape the views of Jews in Israel and the United States on such issues as: the meaning of Judaism, the interpretation of Jewish history, the relationship of religion and peoplehood, and the relationship of democracy and Jewish values. Readings include Amos Oz, A.B. Yehoshua, Haim Hazaz, Leonard Fein, Mordecai Kaplan. Silberstein. **(HU)**

REL 187. Science, Technology, and the Religious Imagination (4)
Impact of the scientific and technological culture on the Western religious imagination. Roots of science and technology in religious ideas and images. Ways of knowing and concepts of experience in religion and science. Raposa. **(HU)**

REL 188. Religion and Literature (4)
Religious themes in the modern novel or the spiritual autobiography. Melville, Tolstoy, Camus, Updike, Walker, and Morrison; or Woolman, Tolstoy, Malcolm X, Wiesel, Frederick Douglass, Sojourner Truth, Kukai. Steffen. **(HU)**

REL 189. Religion and the Visual Arts (4)
To what extent does the process and production of artistic images relate to visionary experience in the history of world religions, and expose a religious dimension in life? In what sense is an artistic vocation similar to the religious vocation of a shaman, prophet, or saint? In what way do artists and religious figures respond to, change, and create the "real" world? Girardot. **(HU)**

REL 213. (CLSS/HIST 213) Ancient Roman Religion (4)
Religious experience of the Roman people from prehistory to end of the empire. Nature of polytheism and its interactions with monotheism (Christianity, Judaism). Theories of religion. Emphasis on primary source materials. **(SS)**

REL 221. (ASIA 221) Topics in Asian Religions (4)
Selected thematic and comparative issues in different Asian religious traditions. May include Buddhism and Christianity, religion and martial arts, Asian religions in America, Taoist meditation, Zen and Japanese business, Buddhist ethics. May be repeated for credit. Girardot, Kraft, Rozehnal. **(H/S)**

REL 222. Topics in Western Religions (4)
Selected historical, thematic, and comparative issues in Judaism, Christianity, and Islam. May be repeated for credit as the subject matter varies. **(HU)**

REL 224. (PHIL 224) Topics in the Philosophy of Religion (4)
Selected problems and issues in the philosophy of religion. May be repeated for credit as the subject matter varies. Raposa. **(HU)**

REL 225. Topics in Religion and Ethics (4)
Analysis of various moral problems and social value questions. Possible topics include: environmental and non-human animal ethics; medical ethics; drug and alcohol abuse; spiritual meaning of anorexia. **(HU)**

REL 228. Theories of Religion (4)
What is religion? Does it have a universal, cross-cultural and trans-creedal essence? Drawing on numerous academic disciples, the course engages the major issues and most influential authors in the academic study of comparative religions. Rozehnal. **(HU)**

REL 230. The Mystical Tradition: Judaism (4)
Explores the history of the quest to know God, through mystical experience or theosophical speculation, as found in Jewish tradition. Examines such issues as the tensions between institutional religion and personal religious experience, between views of God as immanent in the world or transcending it, and between imagery for God and religious experience of God. Weissler. **(HU)**

REL. 247 (ASIA 247) Islamic Mysticism (4)
Sufism, the inner or 'mystical' dimension of Islam, has deep historical roots and diverse expressions throughout the Muslim world. Students examine Sufi doctrine and ritual, the master-disciple relationship, and the tradition's impact on art and music, poetry and prose. Rozehnal. **(HU)**

REL 251. (CLSS 251) Classical Mythology (3)
Myth, religion and ritual in ancient Greece and Rome. Emphasis on primary sources; introduction to ancient and modern theories of myth. Cross-cultural material. **(SS)**

REL 254. (ASIA 254) Buddhism and Ecology (4)
Buddhism's intellectual, ethical, and spiritual resources are reexamined in light of contemporary environmental problems. Is Buddhism the most green of the major world religions? What are the moral implications of actions that affect the environment? Prerequisite: One prior course in religion, environmental studies, or Asian studies. Kraft. **(HU)**

REL 335. (ANTH 335) Religion, Witchcraft and Magic (4)
Addresses broad questions about the roles that religion, magic, and witchcraft play in human life, as philosophical systems of meaning, as useful tools for understanding, and as practical and moral guides for human action. Special focus on the role of witchcraft and magic in the modern world, especially in the lives of disempowered people. Vann. **(SS)**

REL 361. Fieldwork (1-4)
Opportunity for students to work, or observe under supervision, religious organizations or institutions. Consent of chair required. **(ND)**

REL 371. Directed Readings (1-4)
Intensive study in areas appropriate to the interests and needs of students and staff. **(ND)**

REL 373. (HUM 373, PHIL 373) Independent Ethics Project (4)
Supervised ethics research into a topic approved by the advisor for the Humanities Minor in Ethics. An option for completing the ethics minor. For ethics minors only. **(HU)**

REL 374. Senior Seminar (4)
A capstone seminar for departmental majors. Considers the methodologies of religious studies and assesses current issues in the field. Offers opportunities for in-depth work on a particular tradition under the guidance of a faculty member. **(HU)**

REL 375 (SSP 375) The Christian Right in America (4)
What do we know about the Christian Right? Who are they? What do they believe? Where do they come from? Seminar explores answers to such questions through a focus on the history of the Christian Right as well as its ideologies and beliefs, the people who are a part of it, and its evolving relationship to the American political system. Topics include some of the most divisive social issues of our time: abortion, homosexuality, capital punishment, pornography, taxes, education, and the separation of church and state. Munson. **(SS)**

REL 391. Senior Thesis in Religion (4)

Russian

See listing under Modern Languages and Literature.

Russian Studies

Mary A. Nicholas, Ph.D. (Pennsylvania) *program director.*

Professors. Arthur E. King, Ph.D. (Ohio State); Rajan Menon, Ph.D. (Illinois), *Monroe J. Rathbone professor of international relations,* Oles M. Smolansky, Ph.D. (Columbia).

Russian Studies Major

The major in Russian studies is an interdisciplinary program designed to provide students with a broad exposure to the Russian language and to Russian culture. Courses in language, literature, history, politics, foreign policy, and economics, as well as the possibility of study in the republics of the former Soviet Union, are part of the curriculum for this major. The required and elective courses fit in well with a traditional liberal arts education. At the same time, the emphasis on area studies provides students with a focus for their intellectual efforts and a specialization that can be pursued, in graduate school or in a variety of public and private sector careers, after graduation.

The major in Russian studies requires 36 credit hours, distributed as follows:

A. Required Courses

I. Language and Literature: two years of college Russian, course selection based on placement: 16 credit hours.

II. Russian History

HIST 347	Russia to 1855 (4) **or**
HIST 348	Russia since 1855 (4)

III. Russian Politics and Foreign Policy

POLS 261	Soviet and Post-Soviet Politics (4) **or**
IR 168	Diplomacy of USSR, 1917-1991 (4)

B. Elective Courses

The student will select at least three courses from the following list:

IR 167	Diplomacy of Russia to 1917 (4)
POLS 218	Seminar in Post-Soviet Politics (4)
ECO 209	Comparative Economic Systems (3)

Any other Russian language and literature courses.

Other courses approved by the director of the program (e.g., relevant courses offered through LVAIC or at other institutions).

Field Study in the former Soviet Union (e.g., faculty-led study trips offered under special topics or approved study abroad programs).

Any substitutes for required or elective courses must be approved by the director of the Russian studies program.

Russian Studies Minor

The minor in Russian studies is an interdisciplinary program designed to provide a broad range of study of the former Soviet Union. It can be considered the beginning of a specialization in the area that can be continued in graduate school, or a useful area of concentration for certain careers after graduation (e.g., foreign service, governmental employment, business, foreign trade, etc.). The program may also be of general interest to nonspecialist students who wish to do focused work on the culture and society of the former USSR.

The minor in Russian studies requires 18 to 20 credit hours of formal course work, chosen in consultation with the program director, Mary Nicholas, Department of Modern Languages and Literature.

Two semesters of college-level Russian based on the student's level of competence;

Any three of the following:

Any one course in Russian literature or literature in translation (4)

POLS 261	Soviet and Post-Soviet Politics (4)
HIST 347	Russia to 1855 (4)
HIST 348	Russia since 1855 (4)
IR 167	Diplomacy of Russia to 1917 (4)
IR 168	Diplomacy of USSR, 1917-1991 (4)
ECO 209	Comparative Economic Systems (3)
POLS 218	Seminar in Post-Soviet Politics (4)

Special topics courses in other areas such as psychology or sociology and anthropology with permission

Field Study in the former Soviet Union for academic credit under special topics (4)

Other courses approved by the director of Russian studies.

School Psychology

See listings under Education.

Science, Environmental and Technical Writing

See listings under Journalism and Communication.

Science, Technology and Society

Stephen H. Cutcliffe, Ph.D. (Lehigh), *program director.*

Steven Louis Goldman, Ph.D. (Boston), *Andrew W. Mellon Professor in the Humanities.*

The Science, Technology and Society (STS) program is the product of a continuing cross-college effort to create a common ground from which to explore the relations between science, technology and society: between ideas, machines and values.

The STS program serves as a focal point for a wide range of courses that study the natures of science and of technology, and analyze their social and personal implications. It lends coherence and visibility to offerings otherwise dispersed throughout the catalog.

STS Studies Major

The major in science, technology and society studies prepares students for graduate study or for a wide variety of career opportunities including policy analysis, planning, or community relations with public or private sector agencies concerned with the social relations of scientific research and technological innovation. The intrinsically cross-disciplinary character of science-technology-society interactions is reflected in the B.A. requirements. Majors must complete a minimum of 34 credit hours in STS courses, listed below, together with at least 15 credit hours in any traditional academic discipline: engineering, physical or life science, the humanities, or the social sciences. This collateral set of courses should be chosen in consultation with the program director to provide the foundation needed to engage STS studies issues in which that discipline is implicated. The senior seminar and project provide an opportunity for students to integrate the knowledge they have gained and the skills they have acquired, in the course of guided research on a topic of special interest to them. Additional opportunities for student research are available, especially through STS 181: Independent Study.

STS studies is a social science major in the College of Arts and Science, and majors must fulfill the college's B.A. distribution requirements. A detailed description of the STS studies major requirements follows.

Detailed Description of STS Major Requirements

A. Required STS Courses (minimum of 34 hours)

STS 11:	Technology and Human Values (4)
STS 12:	Engineering and Society (4)
HIST 7:	Technology in America's Industrial Age (4) or
HIST 8:	Technology in Modern America (4)
STS/JOUR 124	Politics of Science (4) or
POLS 115:	Technology as Politics (4)
PHIL 128:	Philosophy of Science (4) or
PHIL 228:	Topics in Philosophy of Science (4)
STS 381:	Senior Seminar and Methods (4)
STS 382:	Senior Project (4)

Two additional advanced courses (100 level or higher) from the list of approved STS Studies courses (6-8)

B. Concentration in a complementary discipline (minimum of 15 hours to be chosen in conjunction with STS studies advisor); *or* approved departmental or interdisciplinary program minor; *or* double major.

C. Science and Mathematics Requirement. Students must fulfill the college's regular B.A. distribution requirements of at least eight credits in the natural sciences; and at least three credits in mathematical sciences. At least one of the courses in the natural sciences must also include the associated laboratory course. These courses should be chosen in consultation with the advisor.

STS Studies Minor

The program also offers a minor in science, technology & society studies which is open to all undergraduates. Students electing the minor must take a set of courses totaling a minimum of 15 hours that includes STS 11: Technology and Human Values and electives chosen from the list of all courses eligible for STS studies which follows below. Students should consult with the program director when selecting courses for either the major or the minor.

Science, Technology and Society Courses

STS 11. Technology and Human Values (4)
Impact of technology on society in relation to ethical problems raised by the exploitation of technological innovations. Illustrations from history, social studies, philosophy, literature, and film. Cutcliffe **(SS)**

STS 12. Engineering and Society (4)
An examination, from the perspective of its social context, of engineering as a distinctive problem-solving discipline. The roles of design, modeling, testing, safety analysis, product and client in defining engineering problems and acceptable solutions to them. Goldman, Nagel **(SS)**

STS 117. (HIST 117/WS117) Women, Science and Technology (4)
Explores the impact of technology and science on women's social roles and the contribution of women engineers and scientists to their disciplines. Will focus on the American experience. Among the topics discussed are invention, design, laboratory research, education, engineering, professionalism, labor force participation, office mechanization, household appliances, virtual spaces, childcare and reproduction. Cooper **(SS)**

STS 124. (JOUR 124) Politics of Science (4)
Analysis of the multi-dimensional interaction between the federal government and the scientific community. Explores historical growth of the science-government connection, the scientific establishment both past and present, and the role of scientific advice to the White House and Congress. Also examines scientific ethics, public attitudes toward science, science-society interactions, and case studies of scientific controversies. S. Friedman **(SS)**

STS 141. (ASIA 141) Science and Technology Studies in East Asia (4)
The development of science and technology in East Asia with emphasis on Japan and China. Cultural and religious influences, both internal and external, and interactions with the West, as illustrated by the development of bronze technology, ceramics, and architecture. Factors in Western and Japanese society that have contributed to the rapid growth of Japanese technology as well as limits to future growth of technology in East Asia. **(SS)**

STS 145. (HIST 145) Introduction to the History of Science (4)
The history of modern science, primarily physical and biological, with emphasis on the development of major theoretical models since the seventeenth century. Goldman **(SS)**

STS 181. Independent Study (1-4) fall-spring
Prerequisite: consent of the program director. **(HU or SS)**

STS 221. (MAT 221/ANTH 221) Materials in the Development of Man (3)
Development of materials technology and engineering from the Stone Age to Atomic Age as an example of the interaction between technology and society. In-class demonstration laboratories on composition and structure of materials. Term projects using archaeological materials and alloys. Course intended for, but not limited to, students in the humanities and secondary science education. Engineering students may not use this course for engineering science or technical elective credit. Small **(SS)**

STS 252. (CSC 252) Computers, the Internet, and Society (3)
An interactive exploration of the current and future role of computers, the Internet, and related technologies in changing the standard of living, work environments, society and its ethical values. Privacy, security, depersonalization, responsibility, and professional ethics; the role of computer and Internet technologies in changing education, business modalities, collaboration mechanisms, and everyday life. Nagel **(SS)**

STS 323. (JOUR 323) Controversies (4)
Exploration of science, health, and environmental controversies from the dual perspectives of scientific uncertainty and mass media coverage. Examines genetic engineering and biotechnology, environmental health risks, and human behavior research. Includes discussion of ethical and social responsibilities and interactions of scientists, journalists, and the public. S. Friedman **(SS)**

STS 341. Issues in American Competitiveness: At Home and Abroad (4)
Issues affecting American commercial competitiveness focusing on topics associated with the recent emergence of a new commercial environment in all First World societies. Team taught in a highly interactive setting with industry, public sector, and government experts, in addition to academics from various disciplines and institutions. Students read topical articles and books, participate in team projects and debates, and conduct team research on competitiveness issues they have chosen for a term report. Goldman, Nagel **(SS)**

STS 381. Senior Seminar (4)
In-depth study of selected topics in science, technology, and society with special attention to methodological issues. Subject matter may vary from semester to semester. Intended for STS majors and minors, but open to others. Prerequisite: STS 11 or consent of program director. Cutcliffe **(SS)**

STS 382. Senior Project (4)
Continuation of STS 381. Students conduct and present independent research projects on STS topics of special interest. Prerequisite: STS 381. Cutcliffe **(SS)**

Graduate Courses in STS

(Open to undergraduates by petition only.)

STS 481. Readings in Science, Technology and Society (3)
Readings seminar on selected themes and topics in science, technology, and society. May be repeated for credit with permission of the program director.

Other STS courses.

The following courses, appropriate to STS studies, are offered by various departments. Course descriptions may be found under the catalog entry for the individual department. New courses are frequently added to this list and announced in bulletins published by the STS program. For further information, please contact the program director.

ANTH 221	Materials and the Development of Man—Small
ARCH 107	History of American Architecture—Thomas
ARCH 210	20th-Century Architecture—Zaknic
ARCH/HIST 361	Evolution of High-rise Building Construction—Peters
ARCH/HIST 363	Evolution of Long-Span Bridge Building—Peters
ARCH/HIST 365	Evolution of the Modern Building Process—Peters
ASIA 141	Science and Technology Studies in East Asia—Staff
CHM 5	Chemistry and National Issues—Schray
CLSS 108	Ancient Technology—Small
CLSS/ARCH 204	Ancient City and Society—Small
CSC 252	Computers, the Internet, and Society—Nagel
DES 66	Design History – Snyder & Priester
ECO 311	Environmental Economics—Munley
ECO 314	Energy Economics
EES 3	Global Environmental Change—Meltzer & Zeitler
EES 11	Environmental Geology—Evenson
ES 10	Environment and the Consumer Society—Staff
ENGL 122	Speculative Fiction—Staff
ENGL 187	Themes in Literature: Utopian Literature—Staff
HIST 7	Technology in America's Industrial Age—Smith
HIST 8	Technology in Modern America—Smith
HIST 107	Technology and World History—Smith
HIST 111	Engineering in the Modern World—Smith
HIST 117	Women, Science and Technology—Cooper
HIST 145	Introduction to the History of Science—Goldman
HIST 308	Industrial America Since 1945—Cooper
HIST 315	American Environmental History—Cutcliffe
HIST/ASIA 340	History of Japanese Industrialization Since 1800—Cooper
IR 34	Society, Technology, & War Since the Renaissance—Kaufmann
IR 344	International Politics of Oil—Barkey

JOUR 124	Politics of Science—Friedman
JOUR 125	Environment, Public, and Mass Media —Friedman
JOUR 323	Controversies — Friedman
MAT 221	Materials in the Development of Man—Small
PHIL/REL 116	Bioethics—Staff
PHIL 128	Philosophy of Science—Levine
PHIL 228	Topics in the Philosophy of Science—Goldman
PHIL 250	The Minds of Robots and Other People—Staff
POLS 111	The Politics of the Environment—Wurth
POLS 115	Technology as Politics—Wurth
POLS 328	U.S. Politics and the Environment—Wurth
POLS 375	Green Polity—Wurth
REL 6	Religion and the Ecological Crisis—Kraft
REL 8	Prehistoric Religion, Art, and Technology—Girardot
REL 187	Science, Technology, & the Religious Imagination—Raposa
SSP 160	Medicine and Society—Lasker
SSP 302	The Sociology of Cyberspace—Rosenwein
SSP/JOUR 327	Mass Communication and Society—Rosenwein
SSP 367	Sociology of Science—Rosenwein
THTR/ARCH 161	Theater Design and Engineering—Milet
WS 117	Women, Science and Technology—Cooper

Social Psychology

See listings under Sociology and Anthropology.

Sociology and Anthropology

Professors. James R. McIntosh, Ph.D. (Syracuse), *chairperson*; Raymond Bell, Ed.D. (Lehigh) *emeritus*; Barbara B. Frankel, Ph.D. (Princeton), *Emerita;* John B. Gatewood, Ph.D. (Illinois); Roy C. Herrenkohl, Ph.D. (N.Y.U.) *Distinguished Service Professor*; Judith N. Lasker, Ph.D. (Harvard) *NEH Distinguished Professor*; Robert E. Rosenwein, Ph.D. (Michigan); David B. Small, Ph.D. (Cambridge); Nicola Tannenbaum, Ph.D. (U. of Iowa).Robert C. Williamson, Ph.D. (Southern California), *Emeritus.*

Assistant professors. Heather Johnson, Ph.D. (Northeastern); Ziad Munson, Ph.D. (Harvard), Elizabeth Vann, Ph.D. (Virginia).

The department houses two disciplines, sociology and anthropology. Sociology is concerned with the study of human beings in relationships with others. Anthropology takes a holistic approach to the study of humans today and in the past, in a global, comparative, and multidimensional perspective. Together these disciplines encompass the study of the broadest range of human activities, from the comparative examination of widely divergent past and present cultures and societies, to the inner life of individuals as this influences social behavior, to an examination of the most pressing social issues of our time.

The offerings within the department seek to foster self- and societal awareness as well as an understanding of what it means to be human. Instruction within the department also provides students with the necessary analytic skills to understand and conduct social research. To that end, central to the department's major programs is training in research methods, statistics, and the use of computer applications in social science.

The department offers three bachelor of arts majors: anthropology, sociology and anthropology, and sociology/social psychology. The three programs are parallel in structure and requirements and each consists of 40 credit hours of course work. The sociology and anthropology major is an interdisciplinary program for students desiring a wider familiarity with social science fields, whereas the anthropology and sociology/social psychology majors are for students desiring more traditional, disciplinary programs of study.

Research Opportunities. It is the explicit aim of the department to involve majors, minors and other interested students in the ongoing research activities of faculty members. Second-semester sophomore, junior and senior students interested in a supervised research experience are encouraged to consult with the department chair or talk with the appropriate faculty member. Course credit can be received for research experience.

Internship Opportunities. The department maintains close, working relationships with a variety of social agencies and institutions in the area. Majors can earn course credit by carrying out supervised work in field settings, e.g., hospitals, private and public agencies devoted to social services, courtrooms, prisons, etc. This useful experience allows a student to apply the concepts learned in the classroom to a field setting and to evaluate vocational aspirations and interests.

Senior Thesis. All majors are encouraged to do independent research culminating in a senior thesis; this is especially recommended for students intending to go on to graduate or professional school. The best time to begin discussing possible projects with faculty is during the second-semester of the junior year. The department chairperson should be consulted for further details.

Departmental Honors. To be eligible for departmental honors, students must have at least a 3.3 GPA in the major. In addition, students pursuing honors must take ANTH or SSP 399 and write a thesis during their senior year. Awarding of departmental honors is contingent on both the quality of the thesis, as judged by a department committee, and the candidate's GPA at time of graduation.

B.A. Major Programs

Anthropology

Collateral Requirement (4 credits)

One general course in statistics: MATH 12, ECO 145, PSYC 110, or equivalent. (Note: MATH 12 fulfills the College of Arts and Sciences mathematics requirement.)

Introductory (4 credits)

ANTH 1. Introduction to Anthropology

Disciplinary Core Courses (8 credits)

ANTH 111. Comparative Cultures [fall] or
ANTH 140. Introduction to Linguistics [spring]
and
ANTH 112. Doing Archaeology [spring] or
ANTH 145. Human Evolution (**NS**) [fall, alternate years]

Methodology (4 credits)

SR 111. Research Methods and Data Analysis [fall]

Major Electives (20 credits)

Five additional anthropology courses, at least two of which must be at the 300-level. (Individualized study courses B 300, 393, 394, 395, and 399 B cannot be used to fulfill this requirement; however, one SSP course can be substituted as an Aanthropology@ elective.)

Research, Internship, or Thesis (4 credits)

Preferably during the senior year, majors must complete at least four credits of experiential learning on a subject or in a context relevant to their major. Students may fulfill this requirement in a variety of ways B research, field school, internship, or thesis:

ANTH 300. Apprentice Teaching
ANTH 393. Supervised Research
ANTH 394. Field School
ANTH 395. Internship
ANTH 399. Senior Thesis

Students who intend going on to graduate or professional school are strongly encouraged to do the senior thesis option, and a senior thesis is required for departmental honors.

Sociology and Anthropology

Collateral Requirement (4 credits)

One general course in statistics: MATH 12, ECO 145, PSYC 110, or equivalent.

(Note: MATH 12 fulfills the College of Arts and Sciences' mathematics requirement.)

Introductory (8 credits)

SSP 1	Introduction to Sociology and Social Psychology (4)
ANTH 11	Sociocultural Anthropology (4)

Theory and Methodology (8 credits)

SR 111	Research Methods and Data Analysis (4) fall
SR 381	Development of Social Theory (4) spring

Major Electives (24 credits)

Three additional courses in sociology/social psychology, one of which must be at the 300-level or above, AND three additional courses in anthropology, one of which must be at the 300-level.

(Individualized study courses—300, 393, 394, 395, 395, and 399— cannot be used to fulfill this requirement.)

Sociology/Social Psychology

Collateral Requirement (4 credits)

One general course in statistics: MATH 12, Eco 145, PSYC 110, or equivalent.

(Note: MATH 12 fulfills the College of Arts and Sciences' mathematics requirement.)

Introductory (4 credits)

SSP 1	Introduction to Sociology and Social Psychology (4)

Theory and Methodology (8 credits)

SR 111	Research Methods and Data Analysis (4) fall
SR 381	Development of Social Theory (4) spring

Major Electives (20 credits)

Five additional courses in sociology/social psychology, at least two of which must be at the 300-level.

(Individualized study courses—300, 393, 394, 395, 395, and 399— cannot be used to fulfill this requirement; however, one ANTH course can be substituted as a "sociology/social psychology" elective.)

Research, Internship, or Thesis (4 credits)

Preferably during the senior year, majors must complete at least four credits of experiential learning on a subject or in a context relevant to their major. Students may fulfill this requirement in a variety of ways— research, field school, internship, or thesis:

SSP 300	Apprentice Teaching (4)
SSP 393	Supervised Research (1-4)
SSP 394	Field School (1-8)
SSP 395	Internship (1-4)
SSP 399	Senior Thesis (2-4)

Students who intend going on to graduate or professional school are strongly encouraged to do the senior thesis option, and a senior thesis is required for departmental honors.

Concentrations within the Anthropology Major. Anthropology majors may choose to concentrate in cultural or archaeological anthropology. These optional concentrations in one or the other subfield entail additional constraints on course selection within the major electives@ category, as described below.

Concentration in Cultural Anthropology

Anthropology majors electing to concentrate in cultural anthropology must complete at least four courses in cultural anthropology at the 100-level or above. Regular course offerings that would satisfy this concentration include the following:

ANTH 111. Comparative Cultures
ANTH 120. Culture and Globalization
ANTH 121. Culture and the Environment
ANTH 123. The Cultural Construction of Gender
ANTH 140. Introduction to Linguistics
ANTH 160. Health, Illness, and Healing
ANTH 182. North American Indians
ANTH 184. Cultures of the Pacific
ANTH 187. Peoples of Southeast Asia
ANTH 305. Anthropology of Fishing
ANTH 320. Global Capitalism
ANTH 325. Economic Anthropology
ANTH 330. Food for Thought
ANTH 335. Religion, Witchcraft, and Magic
ANTH 376. Culture and the Individual

Students choosing this concentration are strongly encouraged to use their general education electives to complete at least two physical anthropology/archaeology courses; the equivalent of two years of foreign language study; pursue courses in museum studies, mathematics, computer science, philosophy, religion studies, literature, biology, and geology as specific interests dictate; and take a wide range of courses in the social sciences, generally, such as SSP 1, PSYC 1, POLS 3, IR 10, Eco 1, and history offerings.

Concentration in Archaeological Anthropology

Anthropology majors electing to concentrate in archaeological anthropology must complete at least four of courses in archaeological anthropology at the 100-level or above. Regular course offerings that would satisfy this concentration include the following:

ANTH 112. Doing Archaeology
ANTH 121. Culture and the Environment
ANTH 145. Human Evolution
ANTH 172. North American Archaeology
ANTH 174. Greek Archaeology
ANTH 176. Roman Archaeology
ANTH 178. Mesoamerican Archaeology
ANTH 221. Materials in the Development of Man
ANTH 345. Evolution of the State
ANTH 370. Historical Archaeology
ANTH 377. Archaeology of Death
ANTH 394. Field School (archaeology field school)

Students choosing this concentration are strongly encouraged to use their general education electives to complete at least three courses in cultural anthropology; pursue courses in museum studies, mathematics, computer science, history, and the social sciences as interests dictate; and take a wide range of natural science courses of special relevance to archaeologists.

Minor Programs

Anthropology: ANTH 1, 11, or 12 and four additional courses at 100 level or above in anthropology.

Sociology and Anthropology: One of the following introductory courses: ANTH 1, 11, or 12; SSP 1, 5, or 21 and four additional courses at 100 level or above with at least one in anthropology and one in sociology/social psychology.

Sociology/Social Psychology: SSP 1, 5, or 21 and four additional courses at 100 level or above in sociology/social psychology.

Undergraduate Courses

Anthropology

ANTH 1. Introduction to Anthropology (4) fall and spring
General introduction to the four subfields of anthropology: biological, archaeological, cultural, and linguistic. Class will center around lectures and discussion of ancillary media. Staff. (SS)

ANTH 11. Sociocultural Anthropology (4)
Human behavior in cross-cultural perspective. Variations in kinship reckoning, political organization, economic and religious life in comparative perspective. Particular non-Western peoples: films and readings. (SS)

ANTH 12. Human Evolution and Prehistory (4)
Introductory biological anthropology and prehistory. Adaptive function of human culture and its relation to biological evolution. Mechanisms of evolution, nonhuman primate morphology and behavior, hominid fossil record, cultural beginnings, and survey of world prehistory. (NS)

ANTH 100. Seminar in Anthropology (1-4)
Topics in anthropology. May be repeated for credit. (SS)

ANTH 111. Comparative Cultures (4)
Anthropology is a comparative discipline; through comparisons we learn what is unique to a particular culture, what is shared among a number of cultures, and how trait, idea, practice or belief are related to each other. Students will learn how anthropologists do comparisons and do their own comparative research utilizing both qualitative and quantitative techniques. Tannenbaum. (SS)

ANTH 112. (CLSS 112) Doing Archaeology (4)
Principles of archaeological method and theory. Excavation and survey methods, artifact analysis, dating techniques, and cultural reconstruction. Course includes field project. Small. (SS)

ANTH 120. Culture and Globalization (4)
Examines the relationship between local patterns of culture and the presumably homogenizing forces of globalization. Topics include migration, diaspora, and the politics of identity, the scope and effects of global capitalism and consumerism, tourism, popular culture, the global art market, and cultural authenticity. Vann (SS)

ANTH 121. (CLSS 121, ES 121) Environment and Culture (4))
Impact of environment upon cultural variability and change. Comparative study of modern and past cultures and their environments as well as current theories of human/ environmental interaction. Small. (SS)

ANTH 123. (WS 123) The Cultural Construction of Gender (4)
Comparative study of the meanings and social roles associated with gender. Psychological, symbolic, and cultural approaches. Tannenbaum. (SS)

ANTH 125. Anthropology of Peasant Peoples (4)
Comparative study of peasants—peoples who depend on small-scale agriculture and comprise 80% of the world population. Cultural, political, and economic bases of peasant societies and their future prospects. Tannenbaum (SS)

ANTH 127. (CLSS 127) Early Civilizations (4)
Introduction to early civilizations in the Near East, Mediterranean, Africa, Europe, and New World. Similarities and differences in economics, politics, social organization, and religion. Small. (SS)

ANTH 139. (REL 139) Jewish Folklore (4)
Examines the transformation of folk and popular Judaism from the Old World, through the period of immigration to America, to ethnic and later forms of American Jewish culture. Attention paid to concept of folklore revivals and their meanings. Four case studies: folk tales and storytelling, klezmer music, life-cycle rituals, and food. Weissler. (SS)

ANTH 140. (COGS 140, PSYC 140, MFL 140) Introduction to Linguistics (4)
Relationship between language and mind; formal properties of language; language and society; how languages change over time. (SS)

ANTH 145. Human Evolution (4)
Principles of biological anthropology focusing on the evolution of the human species. Topics include evolutionary theory, nonhuman primate diversity and behavior, the relationship between biology and behavior in evolutionary terms, the hominid fossil record, and genetic variability among contemporary human populations. Prerequisite: ANTH 1 or 11. Students may not receive credit for both ANTH 12 and ANTH 145. Gatewood. (NS)

ANTH 160. Health, Illness, and Healing (4)
Introduction to medical anthropology, a field of study that examines how conceptions of illness and health and methods of healing vary over time and across cultures. Introduces a number of culturally specific approaches to

health and illness, including Western biomedicine, and aims to provide a broad understanding of the relationship between culture, illness, and healing. Vann. (SS)

ANTH 172. North American Archaeology (4) fall
Development of prehistoric North American indigenous population north of Mexico, beginning with earliest evidence of people in the New World continuing up through European contact. (SS)

ANTH 174. (CLSS 174, ART 174, ARCH 174) Greek Archaeology (3)
Ancient Greek culture from the Neolithic to Hellenistic periods. Reconstructions of Greek social dynamics from study of artifacts. Small. (SS)

ANTH 175. Archaeology of Classical Cultures (4)
Course introduces the student to an overview of the archaeology of ancient Greece and Rome from Iron Age to Late Antiquity. Emphasis on aspects of cultural development and change. Small

ANTH 176. (CLSS 176, ART 176, ARCH 176) Roman Archaeology (3)
Cultures of the Roman Empire. Reconstructions of social, political, and economic dynamics of the imperial system from study of artifacts. Small. (SS)

ANTH 178. Mesoamerican Archaeology (4)
Ancient civilizations of Mesoamerica: Olmec, Zapotec, Maya, Toltec, and Aztec. Reconstructions of urban centers, political and economic organizations, and theories of the Mayan collapse. Small. (SS)

ANTH 180. (CLSS 180) Cultures of the Greeks and Romans (4)
Analysis of Greek and Roman Cultures. Focus on kinship, political and economic organization, sexual practices, burial practices, gender construction, religions, art, literature, and warfare. Small. (SS)

ANTH 182. North American Indians (4)
Culture areas of native North America prior to substantial disruption by European influences north of Mexico. Environmental factors and cultural forms. Gatewood. (SS)

ANTH 184. (Asian Studies 184) Cultures of the Pacific (4)
Cultures of the Pacific Islanders prior to substantial disruption by European influences. Culture histories, language families, social organizations, and religions of Australian, Melanesian, Polynesian, and Micronesian peoples. Gatewood. (SS)

ANTH 187. (ASIA 187) Peoples of Southeast Asia (4)
Peoples and cultures of Burma, Laos, Cambodia, Thailand, Malaysia, Singapore, Indonesia, and the Philippines. World view, religion, economy, politics, and social organization. Tannenbaum. (SS)

ANTH 221. (MAT 221, STS 221) Materials in the Development of Man (3) fall
Development of materials technology and engineering from the stone age to atomic age as an example of the interaction between technology and society. In-class demonstration laboratories on composition and structure of materials. Term projects using archaeological materials and alloys. Course intended for, but not limited to, students in the humanities and secondary science education. Engineering students may not use this course for engineering science or technical elective credit. Notis. (SS)

ANTH 305. Anthropology of Fishing (4)
Comparative study of fishing peoples and their technologies. Fishing strategies, control of information, and social organization of marine exploitation in subsistence and modern industrial contexts. Theory of common-property resources and the role of social science in commercial fisheries management. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. Gatewood. (SS)

ANTH 312 The Anthropological Signature of the Past (4)
Course covers the basic tenets of different anthropological analyses of premodern cultures. Emphasis on the archaeological traces of different social constructions in the past. Small. (SS)

ANTH 320. Global Capitalism (4)
Anthropological approach to the forms and effects of global capitalism. Topics include the structure of contemporary global capitalism, including the growth of multinational corporations, flexible corporate strategies, overseas manufacturing, and global branding and marketing; the impact of global capitalism on the environment and on the lives of people in "Third World" countries; consumer culture and the diversity of non-Western consumption practices; alternative capitalist systems, especially Asian capitalisms. Vann (SS)

ANTH 325. Economic Anthropology (4)
Cross-cultural perspectives on the ways people produce, distribute, and consume goods; how these systems are organized; and how they are connected with other aspects of society, particularly political and ideological systems. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. Tannenbaum. (SS)

ANTH 330. Food for Thought (4)
Symbolic and cultural analyses of foods and cuisines. Examines what people eat, who prepares it, what it means, and the social and religious uses of foods historically and cross-culturally. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. Tannenbaum. (SS)

ANTH 335. (REL 335). Religion, Witchcraft, and Magic (4)
Addresses broad questions about the roles that religion, magic, and witchcraft play in human life, as philosophical systems of meaning, as useful tools for understanding, and as practical and moral guides for human action. Special focus on the role of witchcraft and magic in the modern world, especially in the lives of disempowered people. Vann (SS)

ANTH 339. Seminar in Anthropology (4)
Topics in anthropology. Varying semester to semester: human evolution, politics and law, introduction to linguistics, human use of space, anthropology of deviance. May be repeated for credit. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. (SS)

ANTH 345. (CLSS 345) Evolution of the State (4)
Theories of state formation. Comparison of evolutionary trajectories of early states in the Near East, Mediterranean, and New World. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. Small. (SS)

ANTH 370. (HIST 370) Historical Archaeology (4)
This course exams the unique nature of historical archaeology of post contact America. Topics include reconstructing the past through the archaeological and historical record, exhibiting past culture, and capturing the real or imagined past. Course includes fieldwork and visits to famous historical archaeological sites. Small. (SS)

ANTH 371. Special Topics (1-4)
Advanced work through supervised readings. May be repeated for credit. Prerequisite: consent of the department chairperson. (SS)

ANTH 376. Culture and the Individual (4)
Concepts and methods of studying relations between the individual and the sociocultural milieu. Culture and personality language and thought, cross-cultural studies of cognition. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. Gatewood. (SS)

ANTH 377. Archaeology of Death (4)
Course examines what we can determine about the past from human remains. Class will study health, age, and disease from the analysis of human bone, the cultural aspects of burial and funerals, and take part in a field project in Nisky Hill Cemetery in Bethlehem. Small. (SS)

ANTH 393. Supervised Research (1-4)
Conducting anthropological research under the supervision of a faculty member. May be repeated for credit. Prerequisite: consent of the department chairperson. (SS)

ANTH 394. Field School (1-8)
Field school in archaeology or ethnography. Maximum of eight credits for a single season or field experience. May be repeated once for credit.

ANTH 395. Internship (1-4)
Supervised experience involving non-paid work in a setting relevant to anthropology. May be repeated once for credit. Prerequisite: open only to department majors.

ANTH 399. Senior Thesis (2-4)
Research during senior year culminating in senior thesis. Required for anthropology majors seeking departmental honors. May be repeated up to a total of 4 credits. Prerequisite: consent of the department chairperson.

Sociology and Anthropology

SR 41. (WS 41) Human Sexuality (4)
Sexuality and gender roles across the life cycle, including human reproduction, decision-making, and the societal regulation of sexual behavior. (ND)

SR 42. (WS 42) Sexual Minorities (4)
How minority sexual identities have been the subject of speculation, misunderstanding, and sometimes violent attempts at correction or elimination. Sexual orientation, gender role, including transvestitism and "drag," transsexualism, sexism, heterosexism, and homophobia. Emphasis on critical thinking, guest speakers, and discussions. (SS)

SR 100. Seminar in Social Relations (1-4)
Topics in social relations. May be repeated for credit. (SS)

SR 111. Research Methods and Data Analysis (4) fall
Research skills in anthropology, sociology and social psychology. Problem formulation; research design; methods and measures; analysis and interpretation of data. Emphasis on the use of statistics in the research process. (ND)

SR 381. Development of Social Theory (4) spring
Comparative study of social theory. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. (SS)

SR 395. Methods in Observation (4) alternate years
Naturalistic and participant observation in uncontrolled field settings. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. (SS)

SR 399. Senior Thesis (4)
Research during senior year culminating in senior thesis. Required for social relations majors seeking departmental honors. Prerequisite: consent of the department chairperson. (SS)

Sociology/Social Psychology

SSP 1. Introduction to Sociology and Social Psychology (4) fall and spring
Patterns of social interaction, group behavior and attitudes provide a focus on the relationship of the individual to society. Social structure and social change within the institutions of society provide a focus on the relationship of society to the individual. The influences of social class, gender and race are explored at each level of analyses. Theories, methods and research results provide micro and macro models for understanding society. Students who received a C or better in SSP 5 or SSP 21 may not take SSP 1 for credit. Staff. (SS)

SSP 5. Introductory Sociology (4)
Introduction to the sociological perspectives on human behavior and social life. Examines theories and research exploring patterns of relationships between individuals and society, the effects of social structure, culture, and social change on individuals, including the impact of social class, race, and gender. (SS)

SSP 21. (PSYC 21) Social Psychology (4)
Theories, methods of investigation, and results of research in social psychology with emphasis on psychological processes in social behavior, social attitudes, group behavior and social interaction. (SS)

SSP 100. Seminar in Sociology and Social Psychology (1-4)
Topics in sociology and social psychology. May be repeated for credit. (SS)

SSP 103. (AAS 103) Race and Ethnicity (4) fall
Course examines race and ethnicity from a sociological perspective. Focus on the role of the major racial and ethnic communities in modern American society. Explores the roles of race and ethnicity in identity, social relations, and social inequality. Topics include racial and ethnic communities, minority/majority groups, assimilation, prejudice/discrimination, identity, and the social construction of the concept of "race." Johnson (SS)

SSP 104. (POLS 104). Political Sociology (4)
An introduction to political sociology through an examination of the major sociological questions concerning power, politics, and the state. Covers questions concerning state formation, nationalism, social movements, globalization, political culture and participation, and civil society. Includes examples such as racism, welfare reform, campaign financing, coal mining in Appalachia, revolution in Latin America, the rise of the Nazi party in Germany, and the place of the United States in a global society. Munson (SS)

SSP 105. The Social Origins of Terrorism (4)
Examines the social, religious, and political foundations of terrorism by studying the roots of terrorism historically and cross-nationally. We will look at the differing kinds of terrorism, including political terrorism in the Middle East, anti-abortion terrorism in the United States, eco-terrorism, and religious and state terrorism throughout the world. Students will have a chance to better understand the beliefs of terrorists, conditions that produce and sustain terrorism, and the origins of political violence more generally. Munson (SS)

SSP 109. (PSYC 109) Adulthood and Aging: (4)
Social science approaches to the latter two-thirds of the life. Cognitive and personality development; attitudes toward aging; social behavior of older adults; widowhood; retirement. Prerequisite: PSYC 1 or SSP 1. May not be taken pass/fail. Hyland. (SS)

SSP 121 (PSYC 121) Social Psychology (4)
Theories, methods of investigation and results of research on the way social and psychological processes interact in human behavioral settings. Topics include analysis of self and relationships, dynamics of small groups, attitudes and persuasion, prejudice, prosocial and antisocial behavior. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, SSP 21, or PSYC 1. Rosenwein. (SS)

SSP 125. (PSYC 125) Social Psychology of Small Groups (4)
Theories and empirical research regarding interpersonal behavior in small groups. Classroom exercises and group simulations. Prerequisite: consent of instructor. Rosenwein. (SS)

SSP 135. (Jour 135, PSYC 135) Human Communication (4)
Processes and functions of human communication in relationships and groups. Rosenwein. (SS)

SSP 141. Social Deviance and Social Control (4)
Analysis of deviant social systems, supporting factors maintaining them, and societal responses to deviant roles and collectivities. McIntosh. (SS)

SSP 152. Alcohol, Science and Society (4)
Alcohol use and abuse, its historical function in society, moral entrepreneurship, status struggles and conflict over alcohol. Current problems with attention to special population groups and strategies for prevention of alcohol abuse. McIntosh. (SS)

SSP 153. (PSYC 153) Personality (4)
Review and critique of theories of personality and their associated systems of psychotherapy. Prerequisite: PSYC 1 or SSP1. (SS)

SSP 160. Medicine and Society (4)
Health, illness, and the health professions from the sociological perspective. Social epidemiology, social psychology of illness, socialization of health professionals, organization of health care, patient-professional relationships and ethical issues in medical care. Lasker. (SS)

SSP 161. The American Dream: Popular Ideologies in American Society (4)
Is the "American Dream" a myth or reality? This course explores this question and various aspects of basic American values through a sociological lens. The American Dream, meritocracy, and individualism are strongly held beliefs the United States – the "land of opportunity." We will examine the implications, causes, and consequences of these beliefs and other popular ideologies in the context of a highly stratified and increasingly diverse society. The course focuses on how ideologies function to both reproduce and transform society. Johnson. (SS)

SSP 162. AIDS and Society (4)
Impact of the AIDS epidemic on individuals and on social institutions (medicine, religion, education, politics, etc.); social and health policy responses; international experience; effect of public attitudes and policy on people affected directly by AIDS. (SS)

SSP 163. Pass the Peas: Mapping the Blueprint of Hip Hop Culture (4)
The appearance of the hip hop movement can be traced to a specific time and place, the Bronx, New York, 1974. However, hip hop has no single cultural antecedent. To uncover the origins of hip hop culture, one must begin by discovering the richly layered history of African American and Jamaican music of the 20th century. Using this broad canvas, students will discover how young Bronx natives in the 1970s fused elements of past musical styles with their own personal expression. From this point, the course will chart the expansion of hip hop culture from a five borough folk movement to a multi-million dollar entertainment industry in the late 20th century. Staff. (SS)

SSP 165. Contemporary Social Problems (4)
Studies of major problems facing contemporary society. (SS)

SSP 166. (AAS 166) Wealth and Poverty in the United States (4)
Course examines the sociology of wealth and poverty – affluence and disadvantage, "rags and riches" – in American Society. Focus is a critical analysis of the wealth gap, its causes, consequences, and social context. We will consider the roles of wealth and poverty in determining life chances and structuring opportunity, as well as their roles in the perpetuation of social inequality across generations. We will address contemporary debates surrounding public policy, tax laws, anti-poverty programs and other reform efforts aimed at decreasing the gap between the "Haves" and the "Have-Nots." Johnson. (SS)

SSP 171. (REL 171). Religion and Society (4)
An introduction to the sociology of religion. Covers classical and contemporary approaches to defining and studying the role of religion in society. Emphasis on understanding religious beliefs and practices in the United States, the sources and contours of religious change, and the effects of religion on individuals and society. Specific topics include religious fundamentalism, religious conversion, religious practices and authority, secularization, religion in public life, religion in social change, religious terrorism, and the ways in which religion impacts our personal health, educational attainment, and family life. Munson. (SS)

SSP 302. The Sociology of Cyberspace (4)
An examination of social life on the Internet and the World Wide Web. Topics may include sociocultural and psychological aspects of communication in cyber-environments (e.g., email, chat rooms, news groups, MUDS, etc.), interpersonal relationships and group development, the nature of community, the politics of cyberspace (control and democracy), privacy and ethics, and economic dimensions. Examination of past and current case studies. Rosenwein. (SS)

SSP 308. (PSYC 308) Seminar in Social Psychology (4)
Intensive consideration of selected topics in current theory and research in social psychology. The subject matter varies from semester to semester, and includes such topics as the social psychology of education, the applications of perception and learning theory to social psychological problems, the social psychology of science, and the social environment of communication. May be repeated for credit. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. (SS)

SSP 310. (AAS 310, WS 310) Gender, Race, and Sexuality: The Social Construction of Differences (4)
This course will provide the student with an opportunity to engage current debates about the meaning and use of racial and sexual classification systems in society. Using a multi disciplinary approach, we will examine the historical and sociological contexts in which specific theories of racial and sexual differences emerged in the U.S. Additionally, we will explore the ways in which changes in the images have implications on the role racial, gender, and sexual identity plays in our understanding of the relationship between difference and inequality. Prerequisite: SSP 103, or department permission. Staff. (SS)

SSP 312. (PSYC 312) Interpersonal Behavior in Small Groups (4)
Intensive consideration of theoretical and methodological issues in the analysis of the development of small groups. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. Rosenwein. (SS)

SSP 313. Social Movements (4)
Explores the origins, dynamics, and consequences of social movements through both sociological theory and empirical case studies. Covers questions of what constitutes a social movement, where and when social movements arise, who joins a social movement, and how social movements are able to contribute to change. Answers to these questions highlight issues of social movement recruitment and leadership, interactions between movements and the media, the state, and the broader public, ideology, strategies and tactics, and the factors contributing to the success and failure of social movements. Course readings drawn from case studies on civil rights, women's rights, gay rights, the environment, American Indians, abortion, globalization, anti-apartheid, democratization, peace, and Islamic fundamentalism. Munson. (SS)

SSP 314. (PSYC 314) Social Cognition and Social Action (4)
Examines the formation of beliefs about social groups, individuals, the self, and the world. Consequences and validity of those beliefs are considered. Areas of inquiry include stereotypes and prejudice, impression formation processes, the self, attitudes and persuasion, and social influence. Prerequisite: PSYC 110 or SR 111. Gill (SS)

SSP 323. (PSYC 323) The Child in Family and Society (4)
Influences such as marital discord, family violence, poverty and prejudice on the development of the child from birth through adolescence. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. Herrenkohl. (SS)

SSP 324. (JOUR 324). Health, Communication, and the Internet (4)
This interdisciplinary class examines the role of the Internet in changing the way lay people, the mass media and medical organizations think and behave regarding health and medical care. It explores the nature of traditional and online health communication, and highlights online health issues such as access, quality of information, economics, privacy, and ethics. S. Friedman and J. Lasker. (SS) spring

SSP 325. (HIST 325, WS 325) History of Sexuality and the Family in the U.S. (3-4) fall
Social change from early agrarian communities to beginnings of industrialism, emphasizing socio-economic class, family structure, and treatment of women and minority groups. Najar. (SS)

SSP 326. (HIST 326, WS 326) Social Class in American History (3-4) spring
Changing role of women, minority groups, and the family during the industrial era. Development of the modern class structure and the impact of the welfare state. Simon. (SS)

SSP 327. (JOUR 327) Mass Communication and Society (4)
A review of theories and research on the relationship of mass communication to social processes. Intensive analysis of selected media products (e.g., TV news, dramas, and sitcoms; films; print; music videos, etc.). Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. Rosenwein. (SS)

SSP 333. (POLS 333, PSYC 333) Social Psychology of Politics (4)
Political behavior viewed from a psychological and social psychological perspective. Prerequisite: ANTH 1, 11, or 12; SSP 1, 5 or 21; PSYC 1 or department permission. Rosenwein. (SS)

SSP 341. (WS 341) Women and Health (4)
Relationships of women to the medical system. Influence of medicine on women's lives and the impact of the women's movement on health care. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. Lasker. (SS)

SSP 351. (WS 351) Gender and Social Change (4)
Changes in gender roles from social psychological and structural perspectives. Comparative analyses of men and women (including people of color) in the social structure; their attitudes and orientations toward work, family, education, and politics. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. (SS)

SSP 355. Sociology of Education (4)
Course examines the social organization of education as a social institution and the role of schools in society. Focus is primarily on educational processes in the United States. Topics include: IQ, curriculum, tracking, educational inequality, primary/secondary/higher education, private vs. public, informal education and social capital, effects on and of race/class/gender, schools as agents of socialization, educational policy and school reform.

Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. Johnson. (SS)

SSP 356. (PSYC 356) Seminar in Personality Psychology (4)
Topics in personality psychology: the self, personality consistency, motivation, psychological adjustment. Prerequisite: SSP/PSYC 153 or consent of instructor. Williams. (SS)

SSP 361. (PSYC 361) Personality and Social Development in Adulthood (4)
Theories and current research. Prerequisite: SSP/PSYC 109 or consent of Psychology department chair. Hyland. (SS)

SSP 363. (PSYC 363) Personality and Social Development in Childhood (4)
Issues related to social development (e.g., attachment, social competence), social contexts (e.g., family, day care), and personality development (e.g., sex roles, aggression, temperament) from infancy through adolescence. Prerequisite: PSYC 107 or consent of instructor. (SS)

SSP 364. (WS 364) Sociology of the Family (4)
Sociological analysis of families in the United States, including investigations of historical and contemporary patterns. Issues addressed include parenting, combining work and family, divorce and remarriage, family policies. ANTH 363 is recommended in conjunction with this course. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. Staff. (SS)

SSP 366. Sociology of Aging (4)
Residential patterns, social policies and services for the aged. Alternative political strategies, health programs, living arrangements and workplace choices considered. The changing roles of the elderly in American and other societies, and the special problems they face. Impact of changing age structure. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. Lasker. (SS)

SSP 367. Sociology of Science (4)
Review of sociological, social psychological, and anthropological perspectives on science as a cognitive and social enterprise. Analysis of past and contemporary case studies as well as experimental/simulation research. Rosenwein. (SS)

SSP 370. Juvenile Delinquency (4)
The development of delinquent behavior within its social context; an analysis of delinquent gangs and subcultures and the variable patterns of antisocial activity; and the evaluation of institutional controls and treatment of the problem. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. Bell. (SS)

SSP 371. Special Topics (1-4)
Advanced work through supervised readings. May be repeated for credit. Prerequisite: consent of the department chairperson. (SS)

SSP 373. Seminar in Sociology (4)
Intensive consideration of selected topics in contemporary theory or research in sociology. The subject matter varies from semester to semester. May be repeated for credit. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. (SS)

SSP 374. Social Stratification: Race, Class, Gender (4)
This course is an introduction to social stratification. Examines social inequality as an organizing principle in complex societies. Explores the intersection of the "great divides" of race, class, and gender. Through readings from classical sociological theory to cutting-edge literature we embark on a critical analysis of the causes and consequences of social stratification and social mobility in the United States and in a global context. Prerequisite: One of the following introductory courses: ANTH 1, ANTH 11, ANTH 12, SSP 1, SSP 5, or SSP 21. Johnson. (SS)

SSP 375 (REL 375). The Christian Right in America (4)
What do we know about the Christian Right? Who are they? What do they believe? Where do they come from? Seminar explores answers to such questions through a focus on the history of the Christian Right as well as its ideologies and beliefs, the people who are a part of it, and its evolving relationship to the American political system. Topics include some of the most divisive social issues of our time: abortion, homosexuality, capital punishment, pornography, taxes, education, and the separation of church and state. Munson. (SS)

SSP 379. (AAS 379) Race and Class in America (4)
This course focuses on the ways in which race and class intersect in the social, economic, and political structures of American society. Through sociological literature, fiction, non-fiction, film, and other media we will explore the place of race and class in American society. We will examine how race and class operate on a personal, "micro" level, while at the same time operating on a large-scale, "macro" level. Prerequisite: SSP 103, or consent of instructor. Johnson. (SS)

SSP 391. Evaluation Research (4)
Application of social research methods of evaluation of the effectiveness of social programs. Measurement, research design, criteria of effectiveness and decision making. Prerequisite: SR 111 or consent of department chairperson. Herrenkohl. (SS)

SSP 392. Teamwork and Leadership (4)
This course focuses on how teams function in organizational settings, especially in business and industry. Consideration is given to team dynamics and the style(s) of leadership needed to establish and lead teams. Emphasis is placed on both the internal workings of teams and on the external relationships that teams have in organizational settings. Research and theory are drawn from a variety of perspectives and disciplines including social psychology, sociology, and management. Case studies from business and industry are examined. Herrenkohl. (SS)

SSP 393. Supervised Research (1-4)
Conducting sociological or social psychological research under the supervision of a faculty member. May be repeated for credit. Prerequisite: consent of the department chairperson. (SS)

SSP 394. Field School (1-8)
Field school in sociology/social psychology. Maximum of eight credits for a single season or field experience. May be repeated once for credit.

SSP 395 Internship (1-4)
Supervised experience involving non-paid work in a setting relevant to sociology/social psychology. May be

repeated once for credit. Prerequisite: open only to department majors.

SSP 399. Senior Thesis (2-4)
Research during senior year culminating in senior thesis. Required for sociology/social psychology majors seeking departmental honors. May be repeated up to a total of 4 credits. Prerequisite: consent of the department chairperson.

Graduate Courses in Sociology

The Master's Program in Sociology prepares students to apply sociological and social psychological perspectives and methods to the analysis of social problems. Grounded in a strong theoretical and substantive understanding of social institutions, social relations, and social policy, as well as in advanced research and computer skills, students are prepared to be effective and experienced practitioners in the field of applied social research. Specialty areas include: policy studies (health, education, family, diversity, substance abuse, delinquency); human communication (teamwork in organizations, interactional processes, mass communication, personal relationships); and program evaluation.

The program requires 30 hours of course work. Required courses are: Advanced Research Methods; Statistics; Proseminar in Applied Social Theory; Advanced Computer Applications; Research Practicum, either in an agency or firm in the community or with a faculty member; and three electives. All students take a comprehensive exam. Students choose whether to write a thesis or to take an additional six credits of elective courses.

SSP 401. Proseminar in Applied Social Theory (3)
Theoretical perspectives in sociology and their applications to social issues and policy. Issues may include interpersonal dynamics in groups, leadership and team building, race and gender, AIDS and sexuality, organizational structure and process, addictions policy, educational reform. Staff.

SSP 402. Sociology of Cyberspace (3)
The course focus is on case-based discussion in the social psychology and sociology of the Internet and the World Wide Web. Questions of what it means to be an individual online, how relationships develop, the nature of groups, democracy and power, and education are considered. Evaluation is based on short papers related to the cases and assigned readings, both in hard copy and online. Rosenwein.

SSP 411. Advanced Research Methods (3)
Study of quantitative and qualitative methodologies, measurement and research design issues at an advanced level. Specific methodologies include participant observation, survey/interview, laboratory or field methods, content analysis, and focus groups. Prerequisite: SSP 111 or equivalent. Staff.

SSP 413. Research Practicum (3-6)
Supervised research, either with a faculty member or in a community agency, designed to apply research skills to a particular problem as defined by the faculty member or agency in collaboration with the student and supervising instructor. Final paper should demonstrate theoretical understanding, proper application of methodology and data analysis, and results of the project. Staff.

SSP 414. Survey Research (3)
Examination of survey methods, sample design, interview design, training of survey personnel, data management and analysis.

SSP 415. Case Studies of Social Control (3)
Social control leads to social order and also generates social deviance. The processes involved in this dual production are found in the formal institutions of society and in the informal patterns of interaction within groups. Macro and micro level approaches are explored, especially in the drug and alcohol area. McIntosh.

SSP 416. (EDUC 416) Quasi-Experimentation and Program Evaluation (3)
Social science methods for non-laboratory settings. Examination of quasi-experimental research designs, threats to validity, possible controls, and uses in social program evaluation. Non-mathematical presentation. Knowledge of elementary statistics assumed.

SSP 452. Organizing, Community, and Power (4)
Seminar on grassroots and national social movement organizing built around theories of social and political power. Specific topics to be covered include recruitment and media strategies, organizational models, the role of ideology, and movements in the political process. Emphasis will be on practical, applied knowledge of help to practitioners. We will examine examples of both faith-based and race-based organizing, as well as both liberal and conservative social movements. Munson, (SS)

SSP 453. Urban Communities (3)
Reading of classical and contemporary urban theory and community studies in sociology and anthropology. Examination of patterns of social class, power, and social change in urban settings, community organizing and public policy aimed at addressing urban social problems, and evaluation of community interventions. Lasker.

SSP 454. Urban Education: Inequality and Public Policy (3)
Social inequality is found throughout American Society but problems of inequality related to education have perhaps received more attention than those of any other contemporary social institution. Researchers, scholars, journalists, social critics, and observers have studied, written, and talked about educational inequality to an enormous extent. Social service organizations, activists, policy-makers, legal professionals, and government officials have focused massive reform efforts and political agendas to tackle inequality in education. Many sociologists have long viewed education not just as an arena of inequality but as the solution to the widespread inequalities they see reflected in society. Urban education has been an especially complex and controversial subject of scrutiny in recent scholarly and popular debates. This course will focus with a sociological perspective on urban education, inequality, and public policy in the contemporary United States. The first portion of the course examines research and literature relevant to the contemporary social problems of urban education and inequality. The second portion of the course will explore the role of public policy in perpetuating educational inequality, and as a potentially promising solution to it. Johnson.

SSP 461. Seminar in Sociology (1-4)
Topics vary.

SSP 470. Social Theory (3) fall
Major trends in social science theory in historical context. Comparison of the major theoretical perspectives with an emphasis on underlying philosophy and the development of critical capacities in students.

SSP 471. Special Topics (1-3)
Intensive study in an area of sociology that is appropriate to the interests and needs of staff and students.

SSP 472. Special Topics (1-3)
Continuation of SSP 471.

SSP 473. (EDUC 473) Social Basis of Human Behavior (3)
Development of human behavior from a social psychological perspective. Emphasis placed on the impact of society upon school-age children and adolescents. Bell.

SSP 476. Issues in Health Policy Analysis (3)
Sociological analyses of health care and health care policy issues of current concern in American and other societies. Application of analytic frameworks to several majors issues such as organization and financing of services, effects of aging populations on needs, impact of new diseases and of new technologies. Students will analyze selected health care problems faced by local communities. Lasker.

SSP 477. Advanced Computer Applications (3) spring
Uses of computers in social sciences, including data collection, management, and analysis, simulations, and decision-making; includes weekly lab.

SSP 490. Master's Thesis

SSP 492. Advanced Teamwork and Leadership (3)
Examines the development and functioning of teams in the workplace. Includes the purpose of teams, team structure and process, team activities such as decision-making and problem-solving, the organizational context for teams, strategies for implementing teams, and styles of effective team leadership. Research results and case studies are examined. Students participate in illustrative team activities. Herrenkohl.

SSP 495. Methods in Observation (3)
Naturalistic and participant observation in uncontrolled field settings. Students will carry out a field project. Tannenbaum.

Spanish

See listings under Modern Languages and Literature.

Special Education

See listings under Education

Speech

See listings as Communication under Journalism and Communication.

Statistics

See listing under Mathematics

Supply Chain Management

Program director. Robert J. Trent, Ph.D. (Michigan State) *associate professor of management.*

Program faculty. Michael G. Kolchin, D.B.A. (Indiana) *C.P.M., chair, department of management and marketing;* Robert Kutchta, M.S. (New Jersey Institute of Technology) *professor of practice in marketing;* Teresa M. McCarthy, M.B.A. (University of Rhode Island) *instructor of marketing;* Susan A. Sherer, Ph.D. (Pennsylvania) *Kenan Professor of Information Technology Management and program director, business information systems;* Kenneth P. Sinclair, Ph.D. (Massachusetts) *chair, department of accounting;* Gregory C. Tonkay, Ph.D. (Penn State) *professor of industrial and systems engineering;* Todd A. Watkins, Ph.D. (Harvard) *associate professor of economics:* S. David Wu, Ph.D. (Penn State) *chair, department of industrial and systems engineering;* Yuliang Yao, Ph.D. (Maryland) *assistant professor of business information systems.*

Success in today's business environment is driven by competitive advantage and profitability. Customer-focus, value added product differentiation and cost management are the elements associated with industry leaders. The Supply Chain Management undergraduate major at Lehigh University prepares students to understand and manage the processes that distinguish the successful company from its competitors.

The Supply Chain Management major equips students with the knowledge, skills and abilities necessary for success in the complex business environment of the 21st Century. This program:

- Provides solid exposure to supply management, logistics, business-to-business marketing and operations management topics.
- Develops cross-functional team skills by integrating Supply Chain Management students with engineering students in the Integrated Product, Process and Project (IPD) program.
- Emphasizes advanced cost analysis, negotiation, quality management and improvement, logistics network modeling and e-business.
- Integrates core business courses with supply chain major courses.
- Provides field study and experiential learning opportunities in industry.

Supply Chain Management graduates will be prepared to enter industry at a level that accelerates their on-the-job learning and development. Supply Chain Management graduates typically work within four areas, each with its own set of positions and career paths:

purchasing and supply management

transportation and logistics

operations management

inventory management and control

Supply Chain Management Program and Courses

For specific course descriptions please see subject area heading in this catalog. Check index for page number.

Required Major Courses (18 hours)

SCM 309	Purchasing and Supply Management (3)
MKT 321	Business to Business Marketing (3)
IE 168	Production Analysis (3)
SCM 354	Integrated Logistics and Transportation Management (3)
BUS 211	Integrated Product Development

Plus one of the following:

ACCT 324	Cost Accounting (3)
SCM 328	Pricing Concepts and Negotiations (3)

And an optional:

SCM 373	Supply Chain Management Internship (1-3)

In the fall of the student's junior year, we also strongly encourage students to enter the Supply Chain Management program by taking:

SCM 342	Information Systems Applications in E-Business (3) (also cross-listed as BIS 342)

Technology, Interdisciplinary Courses

See listings under Science, Technology and Society.

Theatre

Professor. Jeffrey Milet, M.F.A. (Yale); Augustine Ripa, M.F.A. (Northwestern), *chairperson.*

Associate professor. Drew Francis, M.F.A. (Brandeis) *class of 1961 Professor*; Erica Hoelscher, M.F.A. (Northwestern); Pam Pepper, M.F.A. (Ohio).

Assistant professor. Kashi Johnson, M.F.A. (Pittsburgh).

Adjunct professors. Jacob Campbell, B.A. (DeSales); Jennie Gilrain, B.S. (Allegheny College), (Western Michigan), Professional Training (Jacques Lecoq International School of Theatre, Paris); E. Laura Hausmann, B.F.A. (Boston Conservatory); Christina Keefe, M.F.A. (South Carolina); Joshua Kovar, M.F.A. (Brandeis); Erik T. Lawson; Melissa McLearen, M.F.A. (Virginia); Pamela Richey, M.F.A. (Montana); Raymond Saraceni, M.A. (Villanova).

To study theatre is to examine its many internal disciplines. Acting and directing combine with design, technical theatre, dramatic literature and theatre history to form the body of our art. Students may pursue general theatre studies or focus on particular areas such as performance, design or history and literature. They may major in theatre, minor in theatre or participate strictly in our production program. Students may even complete a minor in theatre from outside the College of Arts and Sciences.

The bachelor of arts degree in theatre is granted after at least 48 credit hours of study. Because we believe that undergraduate theatre education should be broad based with an emphasis on diversity of experience, students are encouraged to take a variety of courses outside the major. Many students complete double majors. Those with the talents and aspirations for a career in theatre have gone to graduate schools offering intense, pre-professional training. Other majors who have not pursued a theatrical career have gone from our program directly into careers in business, social services, sales. Theatre study is an excellent preparation for vocations in which self presentation is important, such as law. The problem solving, analytical and interpersonal skills gained from this discipline are applicable across a wide range of careers. An understanding and appreciation of the complex art of the theatre will enrich a lifetime.

The department's active production program is curricular and promotes collaborative projects involving students, faculty, staff and guest artists. Our large performance facility is the Diamond Theater, a 300-seat thrust theatre housed in the Zoellner Arts Center. The core of our work in this space is dedicated to productions featuring primarily student actors directed by faculty or guest artists. When possible, a highly qualified student may direct or design in this space. In addition to our own productions, we regularly invite outside professional performers and ensembles to work with us and perform. We also operate a lab theatre (Zoellner's Black Box Theater) for student and faculty experimentation. The availability of valuable hands-on experience and the very close working relationships developed between students and faculty uniquely characterize the department of theatre. The department enjoys a special relationship with Bethlehem's professional theatre company, Touchstone Theatre. Performance and administrative internships with the company are available to qualified students and the department and Touchstone often collaborate on workshops and seminars.

Students interested in designing a major or minor in theatre should consult with the department chairperson. Experienced theatre students with questions regarding accurate placement in any theatre course should, likewise, consult with the chairperson.

Lehigh University is an accredited institution of the National Association of Schools of Theatre.

Theatre Major

Through the selection of appropriate electives, students may concentrate their major in one of these areas:

Acting/Directing

Design/Technical Theatre

Theatre History/Dramatic Literature

General Theatre Studies

The major in theatre consists of 48 hours distributed as follows:

Coursework required of all majors, 24 hrs

THTR 60	Dramatic Action, (4)
THTR 87	Design for the Theatre, (4)
THTR 127	The Development of Theatre and Drama from Ritual to Renaissance (4)
THTR 128	The Development of Theatre and Drama from Renaissance to Present (4)
THTR	Acting, any appropriate level (4)
THTR 315	Senior Study (0)
THTR	Production, any two of the following three: 67-Stagecraft (2), 68-Costume construction (2), 69-Stage Electrics (2).

Production Requirement, 8 hrs

Four courses from the following: THTR 20, 21, 22, 23, 25, 26, 27, 28, 30, 31, 35, 42, 45, 47, 175. Advanced courses may be substituted.

Electives, 16 hrs

Four courses carefully selected with an advisor, emphasizing depth or breadth of study.

Recommended electives from other departments:

The departments of art and architecture, English, modern languages and literature, music and others all offer courses of value to a theatre major or minor. Consult with your advisor about enriching your academic career outside the theatre department.

Theatre Minor

The minor in theatre consists of at least 22 hours of course work selected in consultation with a departmental advisor. This includes at least five courses (18-20 hrs) and two active semesters in theatre production totaling at least four credits. Fulfill the production requirement through THTR 67, Stagecraft (2), THTR 68, Costume Construction (2) and/or THTR 69, Stage Electrics or another approved production-oriented course. An approved minor in theatre will include some academic diversity beyond a single curricular area.

Departmental Honors

The exceptional student may elect to pursue departmental honors in the senior year. This student must have a GPA of 3.3 in all theatre courses presented for the major. No later than the fall of the senior year the student, with faculty supervision, elects a special project in a particular area of theatre. This may take the form of preparing to direct a play, researching a role to be performed, preparing a design presentation or researching in an area of theatre scholarship in preparation for the writing of a substantial report. In the next semester, usually the spring of the senior year, the report or project would be executed. The student would enroll in two, four-credit independent study courses, one each senior semester.

The Acting Sequence

Students with little or no prior acting experience should elect Theatre 11, Introduction to Acting, as their first course. Students with some prior acting experience should consult with the department chairperson for accurate placement and waiver of the Theatre 11 prerequisite.

Courses in Theatre

THTR 1. Introduction to Theatre (4)
Foundations of theatre: historical, literary and practical. (HU)

THTR 11. Introduction to Acting (4)
Preparation for scene study and characterization. Recommended for students with little or no prior experience. (HU)

Theatre Production Courses: Theatre 20 through 47

Theatre 20 through 47 are open to all undergraduates by permission and/or audition. These production-oriented theatre courses combine classroom investigation with practical application in theatre department, music department and Zoellner Arts Center productions. Unless otherwise noted, they may not be repeated for credit.

THTR 20. Stage Technology and Production I (2)
Scenic construction materials and techniques. Scenic staging theory, methods and practice. Production assignment in construction and/or crew. Prerequisite: Department permission. Not repeatable for added credit. **(HU)**

THTR 21. Stage Technology and Production II (2)
Theory, methods and practice for advanced or managerial assignments in construction and/or run crew. Prerequisite: Department permission and THTR 20. Not repeatable for added credit. **(HU)**

THTR 22. Stage Properties and Decoration (2)
Creating props and decor for the stage. Production assignment as assistant property master. Prerequisite: Department permission. **(HU)**

THTR 23. Basic Scene Painting (2)
Painting for the stage. Production assignments painting with scenic artist. Prerequisite: Department permission**. (HU)**

THTR 25. Costume Technology & Production I (2)
Costume construction methods and materials. Production assignment in construction or wardrobe. Prerequisite: Department permission**. (HU)**

THTR 26. Costume Technology & Production II (2)
Theory, methods and practice for advanced or managerial assignments in construction and/or run crew. Prerequisite: Department permission and THTR 25. **(HU)**

THTR 27. Lighting Technology & Production I (2)
Computerized lighting systems. Instrumentation and lighting crew participation. Production assignment in light board operation. Prerequisite: Department permission. **(HU)**

THTR 28. Lighting Technology & Production II (2)
Master Electrician assignment. Prerequisite: Department permission and THTR 27. **(HU)**

THTR 30. Sound Technology & Production I (2)
State of the art digital audio technology. Pre-production sound assignments, recording, equipment. Production assignment in sound operation . Prerequisite: Department permission. **(HU)**

THTR 31. Sound Technology & Production II (2)
Sound engineer assignment. Prerequisite: Department permission and THTR 30. **(HU)**

THTR 35. Performance (2)
Performing in a department-approved production. May be repeated for credit. Prerequisite: Department permission. **(HU)**

THTR 37. (MUS 37) Scenes from Opera and Musical Theatre (1)
Performances in opera and/or musical theatre production. May be repeated for credit. **(HU)**

THTR 42. Marketing and Publicity for the Theatre (2)
Theory and practice of marketing and publicity for productions. Prerequisite: Department permission. **(HU)**

THTR 45. Stage Management (2)
Organization, scheduling, coordination of various production specialties. Production assignment as assistant stage manager. Prerequisite: Department permission. **(HU)**

THTR 47. House Management (2)
Front of house coordination, audience services, interface with stage management and production team. Production assignment as house manager. Prerequisite: Department permission. **(HU)**

THTR 54. (CLSS 54) Greek Tragedy (3)
Aspects of Greek theater and plays of Aeschylus, Sophocles, and Euripides in their social and intellectual contexts. Pavlock **(HU)**

THTR 56. Jazz Dance (2)
Jazz dance styles and combinations. May be repeated for credit. Prerequisite: fee. **(HU)**

THTR 57. Modern Dance (2)
Modern dance styles and combinations. May be repeated for credit. Prerequisite: fee. **(HU)**

THTR 58. (CLSS 58) Greek and Roman Comedy (3)
Study of comedy as a social form through plays of Aristophanes, Menander, Plautus, and Terence. Pavlock **(HU)**

THTR 60. (ENGL 60) Dramatic Action (4)
How plays are put together; how they work and what they accomplish. Examination of how plot, character, aural and visual elements of production combine to form a unified work across genre, styles and periods. Recommended as a foundation for further studies in design, literature, or performance. **(HU)**

THTR 67. Stagecraft (2)
Stagecraft, rigging, problem solving, materials and techniques. Practical experience in executing scenery for the stage. **(HU)**

THTR 68. Costume Construction (2)
Techniques of sewing, pattern drafting and fitting. Practical experience in executing costumes for the stage. **(HU)**

THTR 69. Stage Electrics (2)
Theatre lighting techniques, equipment, materials, methods and theory. Practical experience in executing lighting for the theatre. **(HU)**

THTR 77. Ballet (2)
Classical ballet for beginners and those who have had some training. May be repeated for credit. Prerequisite: fee. **(HU)**

THTR 87. Design for the Theatre (4)
Introduction to the process of creating integrated designs in theatre production. The study and practice of the principles of visual representation, historical and conceptual research and the study of theatrical styles. **(HU)**

THTR 111. Theatre Sound (2)
Techniques, materials, and methods of designing sound for theatrical production**(HU)**

THTR 127 (ENGL 127). The Development of Theatre and Drama from Ritual to Renaissance (4)
Survey of Western theatre and dramatic literature from ritual origins to the Renaissance. **(HU)**

THTR 128 (ENGL 128). The Development of Theatre and Drama from Renaissance to Present (4)
Survey of Western theatre and dramatic literature from the renaissance to the present. **(HU)**

THTR 129. History of Fashion and Style (4)
Dress and culture in the Western Hemisphere from prehistory to today. The evolution of silhouette, garment forms and technology. The relationship of fashion to politics, art and behavior. Cultural and environmental influences on human adornment. **(HU)**

THTR 130. Drafting for the Theatre (4)
Theatre drafting techniques and conventions. Material, methods and theory in stage graphics. Model building techniques and practice. An introduction to computer drafting. **(HU)**

THTR 140 (AAS 140). African American Theatre (4)
Studies in African American theatre: literary, and practical and historical. May be repeated for credit. **(HU)**

THTR 144. Directing (4)
Introduction to the theatrical director's art. Research, rehearsal techniques, scene work. Prerequisites: THTR 60, Dramatic Action, and acting experience as determined by the department, or consent of chairperson. **(HU)**

THTR 147. Characterization in Realism (4)
Elements of characterization through scene study in realistic drama. Recommended for students with some prior acting experience, or THTR 11. **(HU)**

THTR 148. Characterization in Expressionism (4)
Elements of characterization through scene study in expressionistic drama. Recommended for students with some prior acting experience, or THTR 11. **(HU)**

THTR 152. Stage Make-up (4)
Theatrical make-up techniques for the actor and designer. **(HU)**

THTR 153. Scene Painting I (4)
Study and practice of basic and advanced methods of painting for the theatre. Includes basic elements and principles of design, color theory, the influence of light, atmosphere and aesthetics for the theatre. **(HU)**

THTR 161. (Arch 161) Performing Arts Venue Design and Technology (4)
Designing theatres. Theatre equipment systems and acoustics. Function and form. ((**HU)**

THTR 175. Special Projects (2-4)
Theatrical topics of current or special interest. Can be repeated for credit. **(HU)**

THTR 181. Theatre Management (4)
Concepts, techniques and practices related to managing the theatrical enterprise. **(HU)**

THTR 185. Production Seminar (1-4)
Practicum in various approaches to theatre production, e.g. performance ensemble. Prerequisite: audition, or consent of the chairperson. Can be repeated for credit. **(HU)**

THTR 211 (Germ 211). Introduction to German Drama (4)
Drama as a literary genre; plays from various periods of German literature. **(HU)**

THTR 218 (Germ 218). Goethe's "Faust" (4)
Study of Goethe's play with an introduction to the Faust tradition. **(HU)**

THTR 230. Drafting for the Theatre II (4)
A continuation of Drafting for the Theatre. Advanced techniques, materials and methods. Computer drafting. Prerequisite: THTR 130, Drafting for the Theatre. **(HU)**

THTR 236. Acting Presentational Styles (4)
Elements of characterization and scene study in presentational dramatic literature from classical through post-modern periods. Prerequisite: 100-level acting course, or consent of chairperson. **(HU)**

THTR 244. Acting Shakespeare (4)
Monologue, scene study and ensemble work from Shakespeare's dramatic and poetic canon. Prerequisite: 100-level acting course, or consent of chairperson. **(HU)**

THTR 245. Advanced Directing (4)
Continuation of Theatre 144. The director's voice. Supervised practical experience. Prerequisite: THTR 144. **(HU)**

THTR 250. Lighting Design (4)
An introduction to the art and practice of lighting design for the stage. History of theatrical lighting design. Recommended prior or concurrent course: THTR 60, Dramatic Action. Prerequisite, THTR 87. **(HU)**

THTR 251. Scene Design (4)
An introduction to the art and practice of scenic design for the stage. History of theatrical scenic design. Recommended prior or concurrent course: THTR 60, Dramatic Action. Prerequisite, THTR 87. **(HU)**

THTR 252. Costume Design (4)
An introduction to the art and practice of costume design for the stage. History of theatrical costume design. Recommended prior or concurrent course: THTR 60, Dramatic Action. Prerequisite, THTR 87. **(HU)**

THTR 253. Scene Painting II (4)
Applied advanced scene painting methods for the theatre. Shop management for the scenic artist. Collaboration with designers and stage technology. Prerequisite: THTR 153. **(HU)**

THTR 260. Design Practicum I (4)
Scenic, costume, lighting or sound design for the theatre. Realized design production assignments and portfolio building. Collaboration, process and presentation. Prerequisite: Any 200-level design course. **(HU)**

THTR 271. Playwriting (4)
The art and practice of writing plays for the stage. **(HU)**

THTR 275. Internship (2-4)
Professionally supervised work in theatres and theatrical organizations in the areas of performance, design, technical theatre, theatre administration and management. May be repeated for credit. Prerequisite: consent of chairperson. (ND)

THTR 315. Senior Study (0)
Seminar for senior theatre majors. Enhancement of current theatre studies while preparing for further theatre studies or activity. Fall only. (ND)

THTR 318. (FREN 318) Drama in the Twentieth Century (3)
Contemporary French drama with an analysis of its origins and movements. Armstrong. (HU)

THTR 328. (ENG 328). Shakespeare (4)
An introduction to Shakespearean drama including comedies, histories, tragedies, and romances. Emphasis on textual study, cultural contexts, and performance strategies. Hawkes, Traister (HU)

THTR 338. Advanced Design (4)
The process of creating integrated designs through aesthetic theory, history of design and studio- based practice. Analysis of whole production process; interpretation of theatrical experience through visual media. Total production evolution, including playwright's aim, director's vision, design concept, rehearsal development and production technology. Prerequisite: THTR 260, Design Practicum I. (HU)

THTR 347. Advanced Characterization in Realism (4)
A continuation of THTR 147 for the advanced acting student. Prerequisite: THTR 147. (HU)

THTR 348. Advanced Characterization in Expressionism (4)
A continuation of Theatre 148 for the advanced acting student. Prerequisite: THTR 148. (HU)

THTR 349. Design Practicum II (4)
A continuation of Design Practicum I. Prerequisite: THTR 338, Advanced Design. (HU)

THTR 351. Advanced Special Projects (4-8)
Independent study in theatre. Prerequisite: consent of the chairperson. Can be repeated for credit. (HU)

THTR 361. Research in Theatre Technology (2-4)
Solving technological problems in theatre. Application of new technologies. May be repeated for credit. Prerequisite: consent of chairperson. (HU)

Urban Studies

Urban Studies Committee. David Curtis Amidon, Jr., M.A. (Penn State), *associate professor of urban studies and director, urban studies program;* Frank T. Colon, Ph.D. (Pittsburgh), *professor of political science;* Thomas J. Hyclak, Ph.D. (Notre Dame), *professor of economics;* Roger D. Simon, Ph.D. (Wisconsin), *professor of history;* J. Bruce Thomas, Ph.D. (Berkeley), *associate professor and chair of architecture;* Ivan Zaknic, M.Arch. and Urban Planning (Princeton), *professor of architecture.*

This is an interdepartmental major program intended for students who seek a broad background in the social sciences and for those with career interests in such fields as business or law, and such specialized areas as city management, architecture and urban planning, human relations, and the helping professions.

Instruction focuses on the process of urbanization, the problems and opportunities arising therefrom, the relationship between cities and economic growth, and public policies relating to cities.

A minimum of 37 credit hours is required, apportioned among two levels of study. Substitutions are possible with approval of the director, who advises all those with majors and minors in urban studies. The director's office is located at 232 Chandler-Ullmann Hall.

Undergraduate Major

I. required preliminary courses (12 credit hours)

US 61	The Study of Urbanization (4)
US 62	Contemporary Urban Issues (4)

one of the following research methods courses

ECO 145	Statistical Methods (4)
MATH 12	Basic Statistics (4)

II. elective courses (25 credit hours)

Any course may be elected from among the following:

ECO 312	Urban Economics (3)
POLS 377	Urban Politics (3-4)
POLS 360	Public Administration (3-4)
HIST 333	American City to 1900 (3-4)
HIST 334	American Urban History (3-4)
SSP 370	Juvenile Delinquency (3)
US 363	Philadelphia: Development of a Metropolis (4)

Up to two Architectural History courses numbered 100 or higher.

Up to two courses may be elected from among the following:

ECO 354	Public Finance: State and Local (3)
POLS 331	Community Politics Internship (3-4)
HIST 326	Social Class in American History (4)
US 125	American Ethnic Groups (4)
US 371/372	Special Topics (1-8)

Participants in off-campus programs, such as the Philadelphia or Washington semesters, may receive credit for up to three elective courses, depending upon the content of those courses, but they must also complete at least four courses in the first group of electives above.

Urban studies minor. The minor consists of US 61 and four or five additional courses from an approved list for a total of 18 credit hours.

Undergraduate Courses

US 61. The Study of Urbanization (4) spring, 2006
Introduction to the study of cities. Emphasis on sources of economic vitality, especially entrepreneurialism, and on causes of social and material decay. Amidon. (SS)

US 62. Contemporary Urban Issues (4) spring, 2005
Analysis of problems, typically including planning, housing, crime, and racial conflict, with strong emphasis on 20th-century New York City. Amidon. (SS)

US 75. Culture Wars (4) every semester
Conservative perspectives on the most divisive issues in American life today including, among others, race, crime, homelessness, family life, feminist and gay/lesbian agendas, and the role of government in the economy. Political bias in the media and the academy. Extensive analysis of feature films. Amidon. (SS)

US 81. Americans from Italy (3)
The immigrant generation seen through autobiographies and fiction. Attitudes of and toward Italo-Americans in recent times, especially as reflected in feature films and in politics. Struggles to preserve traditional values. Amidon. (SS)

US 85. American Jews: Politics and Culture (3) spring
Jewish influences on American higher education and popular culture, with special attention to the movie industry. Sources of Jewish liberalism and leftism. Neoconservatism and other adjustments to the wielding of serious power in American life. Mutual hostilities between secularized Jews and Orthodox Jewry, conservative Catholics, evangelical Christians, and African-Americans. Jewish roles in party politics and journalism. Amidon. (SS)

US 88. The Lost World of Protestant America (3)
Decline of the once-dominant American cultural group in relative size, self-confidence, cohesiveness, and religious conviction. Myth and reality in the work of such figures as Horatio Alger, Zane Grey, Norman Rockwell, and Walt Disney. Individualism, communalism, and constitutional conflict. Seminar format with limited enrollment. Amidon. (SS)

US 125. American Ethnic Groups (4) fall
Immigration to the United States; patterns of conflict and accommodation; emphasis on recent confrontations in New York and Los Angeles. Amidon. (SS)

US 363. Philadelphia: Development of a Metropolis (4) fall
Philadelphia as an experiment in the deliberate creation of a new community; the rise and fall of the Protestant elite; immigration, industrialization, and vigorous growth, 1681-1929; liberalism and the collapse of a great city. Amidon. (SS)

US 371, 372. Special Topics (1-8)
A seminar on a topic of special interest in urban studies. Prerequisite: consent of the program director. (SS)

Women's Studies

Professors. Marie-Helene Chabut, Ph.D. (U.C., San Diego), *professor of French;* Alexander M. Doty, Ph.D. (Illinois), *professor of English;* Jan S. Fergus, Ph.D. (CUNY), *professor of English;* Elizabeth N. Fifer, Ph.D. (Michigan), *professor of English;* Edward J. Gallagher, Ph.D. (Notre Dame), *professor of English*; Lucy C. Gans, M.F.A. (Pratt), *professor of art and architecture*; Thomas J. Hyclack, Ph.D. (Notre Dame), *professor of economics*; Diane T. Hyland, Ph.D. (Syracuse), *professor of psychology;* Judith N. Lasker, Ph.D. (Harvard), *professor of sociology and anthropology;* Laura Katz Olson, Ph.D. (Colorado), *professor of political science;* C. Robert Phillips, Ph.D. (Brown), *professor of history;* Laurence J. Silberstein, Ph.D. (Brandeis), *Philip & Muriel Berman Professor of Jewish Studies and professor of religion studies;* Jean R. Soderlund, Ph.D. (Temple), *professor of history;* Lloyd H. Steffen, Ph.D. (Brown), *University Chaplain and professor of religion studies;* Hannah W. Stewart-Gambino, Ph.D. (Duke) *professor of Political Science;* Nicola B. Tannenbaum, Ph.D. (Iowa), *professor of sociology and anthropology;* Lenore E. Chava Weissler, Ph.D. (Pennsylvania), *Philip and Muriel Berman Chair of Jewish Civilization and professor of religion studies.*

Associate professors. Constance A. Cook, Ph.D., (U.C., Berkeley) *associate professor of modern languages and literature;* Gail A. Cooper, Ph.D. (U.C., Santa Barbara), *associate professor of history;* Robin S. Dillon, Ph.D. (Pittsburgh), *associate professor of philosophy*; Ageliki Nicolopoulou, PhD. (U.C., Berkeley), *associate professor of psychology*; John Pettegrew, Ph.D. (Wisconsin, Madison), *associate professor of history*; Jill E. Schneider, Ph.D. (Wesleyan), *associate professor of biological sciences.*

Assistant professors. Dawn Keetley, Ph.D., (Wisconsin, Madison), *assistant professor of English, Women's Studies, and American Studies;* Monica Najar, Ph.D., (Wisconsin), *assistant professor of history.*

The minor in Women's Studies engages students in the study of two interrelated subjects. The first is an examination of the cultural, historical, and social experiences and contributions of women. The second is an exploration of gender (the social construction of differential identity for males and females) and of the ways in which gender distinctions shape human consciousness and human society.

Nearly all academic disciplines have defined human nature and significant achievement in terms of male experience and have underestimated the impact of gender on social structures and human lives. By contrast, Women's Studies courses attend to women's diverse experiences and perspectives and acknowledge the critical significance of gender. By shifting the focus to women and gender, Women's Studies seeks to provide an alternative paradigm for understanding human experience. Students in Women's Studies courses are encouraged to reevaluate traditional assumptions about human beings, human knowledge, and human culture and society, and to explore non-sexist alternatives for a more fully human social order.

The Women's Studies Program has several major goals: to expand students' understanding of women's present status and rich history; to stimulate a critical examination of the impact of gender roles and stereotypes on social structures and individual lives; to evaluate proposals for alternative arrangements; and to connect issues addressed in the classroom with those raised in personal, political, and cultural contexts. The program challenges students to think beyond the boundaries of traditional gender roles, traditional disciplines, and established institutions. In the best tradition of a liberal arts education, Women's Studies encourages women and men to think critically and constructively, to redesign knowledge, and to gain a better understanding of themselves and their world.

The minor in Women's Studies consists of a minimum of 18 credit hours. Students pursuing the minor are required to take the introductory course (WS 101) and one upper-level course from among those concerned with the theory and practice of Women's Studies. The remaining courses must include at least one course in the arts and humanities and one course in the natural and social sciences. Students arrange their program in consultation with the program director.

Required courses **(6 credit hours)**

WS 101	Introduction to Women's Studies (4)

And one of the following

WS 271	Independent Reading and Research (1-4)
WS 330	Internship in Women's Studies (3)
WS 350	Senior Seminar (3)
WS 373	Internship in Women's Studies (1-3)

Elective Courses (12 credit hours)

WS 8/REL 8	Prehistoric Religion, Art and Technology (4)
WS 41/SR 41	Human Sexuality (4)
WS 42/SR 42	Sexual Minorities(4)
WS 73/ASIA 73/ MLL 73	Film, Fiction, & Gender in Modern China (4)
WS 117/ HIST 117	Women, Science and Technology (4)
WS 121/ ART 121	Women in Art (3)
WS 123/ ANTH 123	Cultural Construction of Gender (4)
WS 124/HIST 124	Women in America (4)
WS 130/ECO 130	Economics of Race and Gender (2)
WS 138/REL 138	Women in Jewish History (4)
WS 145/AAS 145	African American Women Writers (4)
WS 152/CLSS 152/ HIST 152	Women in Antiquity (4)
WS 153/HIST 153	Women in European History, 1500-Present (4)
WS 158/REL 158	Sex and Gender in Judaism: The Feminist Critique (4)
WS 179/POLS 179	Politics of Women (4)
WS 184/REL 184	Religion, Gender, and Power (4)
WS 226/PHIL 226	Feminism and Philosophy (4)
WS 310/SSP 310/ AAS 310	Gender, Race and Sexuality: The Social Construction of Differences (4)
WS 311/ENGL 311	Literature of Women (4)
WS 318/PSYCH 318	Seminar in Gender and Psychology (4)
WS 325/HIST 325/ SSP 325	History of Sexuality and the Family in the U.S. (3-4)
WS 326/SPAN 326	Traditions and Resistance: Women Writers of Latin America (4)
WS 327/FREN 327	Women Writing in French (4)
WS 341/SOC 341	Women and Health (4)
WS 342/POLS.	Gender and Third World Development
WS 351/SOC 351	Gender and Social Change (4)
WS 364/SOC 364	Sociology of the Family (4)
WS 91, 191, 272 291, 371, 381, 382, 391, 392	Special Topics (1-4)

In addition, new courses may be offered annually. Students should check with the director for an updated list.

Undergraduate Courses in Women's Studies

Description of Required Courses (6 credit hours)

WS 101. Introduction to Women's Studies (4)
Placing women's experience at the center of analysis, the course introduces students to the key concepts, theoretical frameworks, and interdisciplinary research in the field of Women's Studies. Examines how gender interacts with race, age, class, etc., to shape human consciousness and determine the social organization of human society. **(HU)**

WS 271. Independent Reading and Research (1-4)
Independent study of selected topics designated and executed in close collaboration with a member of Women's Studies faculty. Students taking this course as a requirement for the minor must elect at least the three-credit option. May be repeated for elective credit. Prerequisite: consent of program director. **(SS/HU)**

WS 330. Internship in Women's Studies (3)
Supervised work in women's organizations or settings, combined with an analysis, in the form of a major paper, of the experience using the critical perspectives gained in Women's Studies courses. Placements arranged to suit individual interests and career goals; can include social service agencies, women's advocacy groups, political organizations, etc. May be repeated for credit. Prerequisites: WS 101 and consent of program director. **(SS)**

WS 350. Senior Seminar (3)
An upper-level seminar that challenges students to systematize insights gained from introductory and elective courses by applying the interdisciplinary methodology of Women's Studies to a focused topic. Subject matter varies semester to semester. Offered by Women's Studies faculty on a rotating basis. May be repeated for elective credit. Prerequisite: WS 101, or consent of program director. **(SS)**

WS 373. Internship in Women's Studies (1-3)
Supervised work in the Women's Studies Center allows students to bring critical perspectives on women and gender into the campus community. Students who wish

to fulfill the internship requirement of the Women's Studies minor must take the Women's Center internship for 3 credits. This course may be repeated for credit up to a maximum of 6 credits. Prerequisites: WS 101 and consent of Women's Center director. **(SS)**

Undergraduate Elective Courses in Women's Studies

Description of Elective Courses (12 credit hours)

WS 8. (REL 8) Prehistoric Religion, Art and Technology (4)
Origins and early development of religions, with focus on interactions of religion, art, and technology in the Paleolithic and Neolithic periods. Special attention to the emergence of patriarchal social forms and the figure of the goddess. Interdisciplinary methods with a consideration of feminist theories of cultural development. Girardot. **(HU)**

WS 41. (SR 41) Human Sexuality (4)
Sexuality and gender roles across the life cycle, including human reproduction, decision-making, and the societal regulation of sexual behavior. **(ND)**

WS 42. (SR 42) Sexual Minorities (4)
How minority sexual identities have been the subject of speculation, misunderstanding, and sometimes violent attempts at correction or elimination. Sexual orientation, gender role, including transvestism and "drag", transsexualism, sexism, heterosexism, and homophobia. Emphasis on critical thinking, guest speakers, and discussions. **(SS)**

WS 73 (ASIA 73, MLL 73) Film, Fiction, and Gender in Modern China (4)
Twentieth century Chinese film and fiction reflect the conflict between male and female traditional and "modern" identities. Students will focus on the issue of the emergence of the individual out of communal culture and link it to the struggle to redefine the roles of men and women in a changing society as depicted by writers and filmmakers from the 1930s up to the present. One topic of discussion will be narrative techniques used to reflect the conflict between self and state or other social conflict. Examples include the manipulation of time, point of view, ideological symbolism, violence and melodrama. Students will compare the common motifs of the oppressed female and impotent male used by modern writers/filmmakers in pre-modern settings. Awareness of censorship, funding, and cultural differences is also part of reading these artistic works. The class is conducted in English with English language materials. Cook. **(HU)**

WS 117. (HIST 117) Women, Science and Technology (4)
Explores the impact of technology and science on women's social roles, and the contribution of women engineers and scientists to their disciplines. Will focus on the American experience. Among the topics discussed are invention, design, laboratory research, education, engineering professionalism, labor force participation, office mechanization, household appliances, virtual spaces, childcare and reproduction. Cooper. **(SS)**

WS 121. (ART 121) Women in Art (3)
Women artists from Renaissance to present. Attitudes toward women artists and their work; changing role of women in art world. Visits to museums and artists' studios. May be repeated for credit, as topic varies. Gans. **(HU)**

WS 123. (ANTH 123) Cultural Construction of Gender (4)
Comparative study of the meanings and social roles associated with gender. Psychological, symbolic, and cultural approaches. Tannenbaum. **(SS)**

WS 124. (HIST 124) Women in America (4)
Roles of women in American society from colonial to present times; attitudes toward women, female sexuality, women's work, and feminism. Cooper, Najar. **(SS)**

WS 130. (ECO 130) Economics of Race and Gender (2)
The question of the role of race and gender in economic decision-making is explored. Various sorts of discrimination are discussed in an economic framework and possible remedies are evaluated. The historical role of race and gender in the economy is also discussed. Prerequisite: Eco 1. Department permission required. **(SS)**

WS 138. (REL 138) Women in Jewish History (4)
Contributions of, and limitations on, women at different stages of Jewish history, using both primary sources and secondary material. Experience of modern Jewish women, and the contemporary feminist critique of traditional gender roles. Weissler. **(HU)**

WS 145. (AAS 145) African American Women Writers (4)
Literature by African American women writers with a focus on the experiences and images of black women in the U.S. Explores the written portraits and voices of 20th century black female novelists and poets, including Hurston, Petry, Morrison, Angelou, and Walker. Levy. **(HU)**

WS 152. (CLSS 152, HIST 152) Women in Antiquity (4)
Interdisciplinary study of women in Greece and Rome. Literary archaeological and historical evidence and approaches. Cross-cultural material. Phillips. **(HU)**

WS 153. (HIST 153) Women in European History, 1500-present (4)
Examines the position of women in Europe since the Renaissance. Particular attention to changing conceptions of women and their roles in society, the evolution of "women's work", the origins, growth and impact of feminism, and gender distinction as reflected in law, politics, popular culture, and leisure. Not open to students who have taken WS 353/HIST 353. **(SS)**

WS 158. (REL 158) Sex and Gender in Judaism: The Feminist Critique (4)
Writings by Jewish feminists reflecting the encounter between Judaism and feminism: prayer and ritual, women rabbis, God and God language, communal power, and marriage and divorce. Silberstein. **(HU)**

WS 179. (POLS 179) Politics of Women (4)
Major social and political issues relating to the role of women in American society. Study of other countries will be included for comparative analysis. Olson. **(SS)**

WS 184. (REL 184) Religion, Gender and Power (4)
Gender differences as one of the basic legitimations for the unequal distribution of power in Western society. Feminist critiques of the basic social structures, cultural forms, and hierarchies of power within religious communities, and the ways in which religious groups have responded. Silberstein. **(HU)**

WS 226. (PHIL 226) Feminism and Philosophy (4)
Analysis of the nature, sources and consequences of the oppression and exploitation of women, and justification of strategies for liberation. Topics include women's nature and human nature, sexism, femininity, sexuality, reproduction, mothering. Prerequisite: one previous course in philosophy or women's studies. Dillon. **(HU)**

WS 342. (POLS 342) Gender and Third World Development (4)
Focus on gender implications of contemporary strategies for economic growth, neo-liberal development models, and mainstream methodologies for field research in Third-World countries. Emphasis on multiple writing assignments, group and individual projects on specific regions and countries, and rigorous research/critical skills. Prerequisite: POLS 3. Stewart-Gambino. **(SS)**

WS 310. (SSP 310, AAS 310) Gender, Race and Sexuality: The Social Construction of Differences (4)
This course will provide the student with an opportunity to engage current debates about the meaning and use of racial and sexual classification systems in society. Using a multidisciplinary approach, we will examine the historical and sociological contexts in which specific theories of racial and sexual differences emerged in the U.S. Additionally, we will explore the ways in which changes in the images have implications on the role racial, gender and sexual identity plays in our understanding of the relationship between difference and inequality. Prerequisite: SSP 103 or department permission. **(SS)**

WS 311. (ENGL 311) Literature of Women (4)
Women's works about women: is literary creativity gender-identified? Are there specifically "feminine" subjects or themes? Besides re-reading some familiar fiction, drama, and poems, introduction to contemporary and often experimental works by less famous writers. **(HU)**

WS 318. (PSYCH 318) Seminar in Gender and Psychology (4)
Gender as shaped by psychological and social psychological processes. Socialization, communication and power, gender stereotypes, methodological issues in sex differences research. Prerequisite: PSYCH 210 completed or concurrent or permission of instructor. Hyland. **(SS)**

WS 325. (HIST 325, SSP 325) History of Sexuality and the Family in the U.S. (3-4)
Changing conceptions of sexuality and the role of women, men, and children in the family and society from the colonial to the post-World War II era. Emphasis on the significance of socio-economic class and cultural background. Topics include family structure, birth control, legal constraints, marriage, divorce, and prostitution. Najar. **(SS)**

WS 326. (SPAN 326) Tradition and Resistance: Women Writers of Latin America (4)
Study of poetry and narrative works by Latin American women writers. Authors include Rosario Ferr, Rosario Castellanos, Elena Poniatowska, Cristina Peri Rossi, among others. Prerequisite: Spanish 152 or equivalent. **(HU)**

WS 327. (FREN 327) Women Writing in French (4)
Reading and discussion of works written by women in French. The emphasis is on 19^{th} and 20^{th} Century writers, such as G. Sand, Colette, S. de Beauvoir, M. Duras, Andree Chedid. Chabut. **(HU)**

WS 341. (SSP 341) Women and Health (4)
Relationships of women to the medical system. Influence of medicine on women's lives and the impact of the women's movement on health care. Prerequisite: Any one of ANTH 1, ANTH 11, ANTH 12, SSP 5, or SSP 21, or department permission. Lasker. **(SS)**

WS 351. (SSP 351) Gender and Social Change (4)
Changes in gender roles from social psychological and structural perspectives. Comparative analyses of men and women (including people of color) in the social structure; their attitudes and orientations toward work, family, education, and politics. Prerequisite: Any one of ANTH 1, ANTH 11, ANTH 12, SSP 5, or SSP 21, or department permission. **(SS)**

WS 364. (SSP 364) Sociology of the Family (4)
Sociological analysis of families in the United States, including investigations of historical and contemporary patterns. Issues addressed include parenting, combining work and family, divorce and remarriage, family policies. ANTH 363 recommended in conjunction with this course. Prerequisite: Any one of ANTH 1, ANTH 11, ANTH 12, SSP 5, SSP 21, or department permission. **(SS)**

WS 91, 191, 272, 291, 371, 381, 382, 391, 392. Special Topics (1-4)
Intensive study of a topic of special interest not covered in other courses. May be cross-listed with relevant offerings in major department or other programs. May be repeated for credit as topic varies. Prerequisite: consent of program director. **(ND)**

VI. An Overview from Past and Present

Lehigh University is independent, nondenominational, and coeducational.

Founded in 1865 as a predominantly technical four-year school, the university now has approximately 4,650 undergraduates within its three major units—the College of Arts and Sciences, the College of Business and Economics, and the College of Engineering and Applied Science—and approximately 2,000 students enrolled in graduate programs offered through the graduate schools in these colleges and in the College of Education. There are undergraduates from nearly every state and U.S. territory and more than 40 foreign nations.

The university is primarily situated on the Asa Packer Campus on the north slope of South Mountain overlooking Bethlehem, Pennsylvania. Sayre Park, the wooded refuge located toward the top of the mountain, is the setting for many living groups. The residences are reached via winding private roads. Many residential units on campus command a panoramic view of the Lehigh Valley. The Appalachians are visible to the west, with an especially good view from The Lookout on the Packer Campus. Both the tower and dining room in Iacocca Hall on the Mountaintop Campus afford panoramic views of the Lehigh Valley. The campus at its highest point is 971 feet above sea level.

A substantial portion of the upper level of Lehigh's campus is maintained as a nature preserve. The preserve supports deer, squirrels, chipmunks, raccoons, wild turkeys and other birds.

Besides the Asa Packer Campus, the university has extensive athletic fields and facilities on the Murray H. Goodman Campus, two miles to the south in Saucon Valley. The university acquired the Mountaintop Campus at the end of 1986. It links the Asa Packer and Murray H. Goodman campuses and brings total land holdings in Bethlehem to 1,600 acres, nearly double the former total.

The board of trustees and university officers have established and enforce policies designed to preserve Lehigh's natural beauty. It is their contention that the environment in which the young adult university student pursues knowledge can make the total educational experience more meaningful, and that the ideal environment is separate and unique from the distractions of the nonacademic community.

There are approximately 400 members of the faculty, teaching a total of more than 2,000 course titles (not all of which are offered every semester). Among faculty members who are tenured and to whom the university has a permanent commitment, nearly all hold the doctorate degree (typically Ph.D. or Sc.D.).

In total, there are more than 2,000 employees of the university, making it the second-largest employer in the community.

History and Purpose

The principal author of the brief history of Lehigh University that follows, Dr. W. Ross Yates, holds the bachelor of arts and master of arts degrees from the University of Oregon, in his native state. He received the doctor of philosophy degree from Yale University and studied in France on a Fulbright Scholarship. He joined the Lehigh staff in 1955 and served as dean of the College of Arts and Science from 1963 to 1972. Today he is professor emeritus of government, and lives in Oregon.

When the sound of the last cannon of the Civil War died away, statesmen, educators, and industrial pioneers marshalled the victorious forces of the North and turned their attention to education. They wanted to increase the number of trained scientists, engineers, and other skilled people so they could transform the vast natural resources of the country into a strong and independent national economy.

Asa Packer was one of the industrial pioneers. He built the Lehigh Valley Railroad and controlled a coal-mining empire in the mountains of eastern Pennsylvania. He knew, as did many others, that a strong national economy depended on more than technical skills. It needed above all people broadly educated in the liberal arts and sciences—people who could combine practical skills with informed judgments and strong moral self-discipline. He kept this in mind when founding and endowing Lehigh University.

The site that Packer chose for his university was a railroad junction across the Lehigh River from Bethlehem, a community founded in 1741 by Moravian missionaries. William Bacon Stevens, Episcopal bishop of the Diocese of Pennsylvania and the first president of the university's board of trustees, in 1869 described the origin of the university as follows:

"In the fall of 1864 an interview was requested of me by the Hon. Asa Packer, of Mauch Chunk (now Jim Thorpe), Pa. He came to my house in Philadelphia, and said that he had long contemplated doing something for the benefit of his State, and especially of the Lehigh Valley. From that valley he said he had derived much of the wealth which GOD had given to him, and to the best interests of that valley he wished to devote a portion of it in the founding of some educational institution, for the intellectual and moral improvement of the young men of that region.

"After conversing with him a little while, and drawing out his large and liberal views, I asked him how much money he purposed to set aside for this institution, when he quietly answered that he deigned to give $500,000. At the time of this interview no one in this country, it is believed, had offered in a single sum such an endowment for a literary institution. It was the noblest offering which an American had ever laid on the altar of learning, and more than equaled many royal donations which have carried down the names of kings as patrons of European universities.

"Filled with profound emotions at the mention of such a gift for such an object, I asked the noble donor what specific plans he had dreamed in his own mind in reference to it. His reply was, "I am not much acquainted with these matters, but you are, and I want you if you will to devise a plan which I can put into effective operation.' I told him that I would make the attempt. I did so. I drew up the outline sketch of such an institution as I thought would give the largest results for the means used, and submitted it in a few weeks to his inspection.

"He examined it with the practical judgment and business habits with which he deals with all great questions, and adopted the scheme as the basis of his future university.

"The first meeting of the Board of Trustees, selected by Judge Packer, met at the "Sun Hotel," in Bethlehem, July 27th, 1865, and began to organize the work before them."

The trustees followed several principles in setting up the university. One was that of combining scientific and classical education. They considered both to be practical. The principle carried forward an ideal of the great 17th-Century Moravian educator, John Amos Comenius. A motto taken from the works of Francis Bacon was used to summarize this principle, namely, *Homo minister et interpres naturae*—man, the servant and interpreter of nature, to use a free translation. That motto lives on at Lehigh, being an element in the university seal.

The trustees chose as first president a man whose education and habits expressed this principle, Henry Coppee. They established five schools, including a school of general literature in addition to four scientific schools of, respectively, civil engineering, mechanical engineering, mining and metallurgy, and analytical chemistry.

Another principle upon which the trustees insisted was that of keeping the size of the student body proportionate to the abilities of the faculty to teach them well. The university would admit only as many freshmen each year as it could be assured of providing with the highest quality of education. In the 19th century the total enrollment never exceeded several hundred students; the size has increased significantly in recent decades, along with the number of faculty members.

The trustees also insisted that Lehigh was to be nondenominational and would have an admission policy based on merit. Competitive examinations were held for applicants for admission. From 1871 to 1891 no tuition was charged, but the national financial crisis at the turn of the century decimated the value of the Lehigh Valley Railroad stock that Packer had given to Lehigh, which was the principal source of income.

At first the student body was entirely male. The contemporary ideological climate would permit nothing else. But around 1916, women were admitted to graduate programs. In 1971, the university opened its undergraduate program to them as well. Today men and women applicants are considered on an equal basis.

From the first, the students were serious-minded. In 1924, Catherine Drinker Bowen, daughter of president Drinker and later a famous biographer, published a brief *History of Lehigh University,* in which she commented:

"Ask any college professor which brand of boy he would prefer to teach, the cigarette brand or the flannel shirt variety. Right here we offer ten to one the flannel shirts. . . Lehigh still holds to the emblem of the flannel shirt—long may it wave! Engineers come to college to work. A writer in the *Syracuse Post* in 1895 spoke truthfully when he said, 'From the first, Lehigh's characteristic has been her earnestness. It is the boast of her graduates, the inspiration of her students. Men go there to learn to take a useful part in the economy of life.' "

The university community was constantly infused with new faculty and students determined to renew and rework the original principles in the light of changing times. The students' ambition and zeal bore fruit; as alumni they carried the university's educational goals into the work of nation-building. And, having received, they gave to perpetuate Lehigh's work of service.

Today, Lehigh University still adheres to Asa Packer's goal of a liberal and scientific education for practical service. Faculty and students work to maintain high quality in instructional programs. Generous support from individuals, foundations, industry, and government help Lehigh to retain high quality of education and faculty while keeping tuition as low as possible. (Tuition covers only a part of the cost of a Lehigh education.)

Presidents of the University

The presidents of Lehigh University are described and their achievements cited in the following paragraphs. The years in parentheses are those served in the presidency.

Henry Coppee (1866-1875). Coppee served as a railroad engineer in Georgia, a captain in the Army during the Mexican War, and taught at West Point and at the University of Pennsylvania before becoming first president in 1866.

Much building was done on the new university campus. A Moravian church on Packer Avenue was remodeled into Christmas Hall; a house for the president was erected on campus; and Packer Hall, the university center, was built.

Coppee lectured in history, logic, rhetoric, political economy, and Shakespeare.

John McDowell Leavitt (1875-1880). Leavitt was an Episcopal clergyman who graduated from Jefferson College and taught at Kenyon College and Ohio University. During his incumbency, the university was divided into two schools, General Literature and Technology. As of 1876, a student could receive two engineering degrees by taking a longer course, and beginning in 1877 the master of arts, doctor of philosophy, and doctor of science degrees were established.

Linderman Library rotunda was completed in 1877. Asa Packer died in May, 1879, and Founder's Day was held in his honor the following October.

Robert Alexander Lamberton (1880-1893). Lamberton, a graduate of Dickinson College, practiced law in Harrisburg, Pa., and was a university trustee when asked to become president. During his administration, students and the community witnessed the first Mustard and Cheese dramatic presentation.

A gymnasium (now Coppee Hall) was erected, and Chandler Chemistry Laboratory was built, now known as Chandler-Ullmann Hall. Lehigh was also building its reputation for academic excellence; the mechanical engineering department was established in 1881 and the Lehigh chapter of Phi Beta Kappa was founded in 1887.

Thomas Messinger Drown (1895-1904). Drown studied medicine at the University of Pennsylvania and went abroad to study chemistry. Thereafter he was professor of chemistry at Lafayette College. In 1895 he assumed the presidency of Lehigh and was greatly interested in furthering the university's development as a technical school.

His first years were difficult ones because the Panic of 1893 decimated the university's stock holdings in the Lehigh Valley Railroad. Nevertheless, Lehigh managed to grow in enrollment, academics, and in physical plant. Williams Hall was completed. The curriculum leading to a degree in arts and engineering was established, as was the department of zoology and biology. New curricula were adopted in metallurgical engineering, geology, and physics.

Drown died in office in 1904. Professor William H. Chandler became acting president.

Henry Sturgis Drinker (1905-1920). Drinker, an 1871 Lehigh graduate, was the only university alumnus ever to become president. In 1907, the alumni endowment fund began, the *Lehigh Alumni Bulletin* was first published in 1913, and the Alumni Association was incorporated in 1917.

Drinker, besides being a lawyer, was a mechanical engineer and had been largely instrumental in solving the problems of constructing the two-mile-long Musconetcong Tunnel, an engineering feat that made possible a railroad line between Easton, Pa., and New York City. He started a tradition of businesslike management of university affairs.

During Drinker's years, more buildings were completed: the original section of Fritz Engineering Laboratory, Drown Hall, Coxe Mining Laboratory, Taylor Hall, Taylor Gymnasium and Field House, Taylor Stadium and Lamberton Hall. Drinker's interest in horticulture led to the planting of many rare trees and plants.

A teacher's course and business administration course were begun in 1909 and in 1918 the university was divided into three colleges, liberal arts, business administration, and engineering—the roots of colleges of today. Army ROTC was established in 1919.

Drinker's daughter, Catherine Drinker Bowen, went on to become a historical writer of note. Her experiences as the daughter of a Lehigh president and occupant of the President's House are recorded in *Family Portrait* (Atlantic Little-Brown).

Drinker resigned in 1920 and Natt M. Emery, vice president, served as chief executive officer until 1922.

Charles Russ Richards (1922-1935). Richards took office in 1922. During his presidency, the first graduate degrees were awarded to women. Lehigh faced a shortage of students from 1929 to 1936 as a result of the Depression, but the newly established office of admission, as well as university scholarships, fellowships, and deferred tuition payments, helped to ease the shortage.

Changing concepts of education were evident in several newly organized academic offerings: philosophy, music, psychology, journalism, history, and fine arts. The majors system was instituted as were the senior comprehensive examinations in the Arts College. The placement bureau, a public relations office, and a student health service were organized.

The Alumni Memorial Building—a memorial to the Lehigh alumni who served in World War I was opened in 1925—and Packard Laboratory was completed in 1929. In the same decade, a major addition to Linderman Library also was completed.

Clement C. Williams (1935-1944). Williams, a civil engineer, was president during an era of unprecedented alumni support. Undergraduate enrollment rose to an all-time high, passing 2,000 in 1938. Richards and Drinker residential houses, and the Ullmann wing adjoining the Chandler Chemistry Laboratory, were built. Grace Hall, the first arena-type facility of any size on campus, was completed in 1940, the gift of Eugene G. Grace, an 1899 graduate, who headed the board of trustees. A Graduate School implemented the programs in the three colleges. Williams retired in 1944, and the university was without a president for approximately two years.

Martin Dewey Whitaker (1946-1960). Dr. Whitaker, who had been director of the Atomic Energy Commission Laboratory at Oak Ridge, Tenn., and had worked in developing the atomic bomb, faced the responsibility of helping the university community readjust to peacetime conditions after World War II.

During his time as president, Lehigh's assets nearly tripled; the endowment more than doubled to $18 million. Many buildings were renovated, and the Dravo House and McClintic-Marshall House residence halls were built. The faculty increased in number by 75 percent and the first endowed distinguished professorships were established.

The Centennial development program was begun in 1959. It raised more than $22 million for faculty salaries and construction that later included Whitaker Laboratory.

An extensive renovation and enlargement project associated with Packer Hall was undertaken in 1957, and, upon completion in 1958, the building became a university center.

Whitaker died in office.

Harvey A. Neville (1961-1964). Dr. Neville was the only faculty member ever elected president. His association with the university began in 1927 as an assistant professor of chemistry. During his three-year term as president, the first phase of the Saucon Valley athletic complex was completed, and Sayre Field was opened atop South Mountain. The Center for Information and Computing Science was established.

Neville, a strong supporter of research who fostered its growth on the campus, died in 1983.

Deming Lewis (1964-1982). Willard Deming Lewis became Lehigh's 10th president after a distinguished career as a space engineer and research administrator.

Dr. Lewis earned three degrees at Harvard and two from England's Oxford University, where he was a Rhodes Scholar in advanced mathematics. In 1941, he joined Bell Telephone Laboratories, and in 1962 he became general manager of systems development with Bellcomm Inc., which engineered systems for the Apollo project that placed the first man on the moon.

Lewis, who died in 1989, received 33 U.S. patents on such devices as microwave antennas and filter and digital error detection systems. He helped write the equations describing a stylus sliding through a warped groove.

During Lewis' tenure as Lehigh president, women were admitted as undergraduate students in 1971. New majors were begun in natural science, biology, social relations, geological sciences, environmental science and resource management, religion studies, computer engineering, computing and information science, applied mathematics, management science, American studies and other fields. Six research centers and seven institutes were established.

Capital campaigns brought in more than $130 million, and construction was completed on Maginnes Hall, Whitaker Lab, Mart Science and Engineering Library, Sinclair Lab, the Seeley G. Mudd Building, Neville Hall, Rathbone Hall dining room, 13 fraternity houses, the Centennial I and Centennial II residential complexes, the Brodhead House residence hall, the Trembley Park student apartments, the Saucon Village Apartments, the Philip Rauch Field House and the Stabler Athletic and Convocation Center. The restoration of Packer Memorial Church was completed, and Packard Lab was renovated.

The original Physics Laboratory is now named in Lewis's honor, as is the indoor tennis center.

Peter Likins (1982-1997). Dr. Likins, who earned a B.S. and Ph.D. from Stanford, and an M.S. from the Massachusetts Institute of Technology, became Lehigh's 11th president in 1982. He sought balanced excellence in undergraduate programs while pursuing focused objectives in graduate study and research.

Under Likins, Lehigh doubled in size with the purchase in 1986 of 742 acres of land and a research complex from Bethlehem Steel Corp. The new Mountaintop Campus links the Asa Packer and Goodman campuses.

Lehigh also added many new buildings and facilities. Perhaps most notable was the $33-million Zoellner Arts Center, which provided a new home to Lehigh's departments of music and theatre and to the University Art Galleries, and made Lehigh a center for the fine arts. The Arts Center and the new Rauch Business Center, home of the College of Business and Economics, were built on the site of Taylor Stadium, which was replaced by Goodman Stadium on Lehigh's athletic campus.

Also during Likins' term, Lehigh built a $20-million, state-of-the-art telecommunications system, the E.W. Fairchild-Martindale Library and Computing Center — one of the most automated libraries anywhere — and the Harold S. Mohler Lab, which honors the former chairman of the board of trustees.

Also dedicated was the Sherman Fairchild Center for the Physical Sciences, which includes the renovated Physics Building (renamed Lewis Lab), and the adjoining Sherman Fairchild Lab.

Lehigh became home to the North East Tier Ben Franklin Advanced Technology Center, which has helped hundreds of new high-technology businesses get started. And the university led the way in establishing the Colonial League, now the Patriot League, in football. The league is committed to the Lehigh tradition of "scholar-athletes."

Financial support grew from $10 million a year to over $24 million. With over half of alumni making gifts, Lehigh ranked among the top Ph.D.-granting schools in percentage of alumni donors.

Likins' term also saw the establishment of the Lehigh Valley Center for Jewish Studies at Lehigh, the Center for Advanced Technology for Large Structural Systems, largest of its kind in North America, and centers in integrated circuits, management studies, chemical process modeling and control, and international studies.

Likins, an expert in spacecraft dynamics and control who has written textbooks in engineering mechanics, was one of 13 science advisers to President George Bush. He came to Lehigh after serving as dean of engineering and provost at Columbia, and left to become president of the University of Arizona.

William C. Hittinger (1997-98). A former chairman of the university's board of trustees, Hittinger became interim president after the departure of Peter Likins. A member of the National Academy of Engineering, Hittinger served for 22 years on the board of trustees. He graduated from Lehigh in 1944 with a B.S. in metallurgical engineering, and received an honorary Doctor of Engineering degree from Lehigh in 1973.

Over a 40-year career in the electronics industry, Hittinger worked for Western Electric Co., National Union Radio Corp., Bell Telephone Laboratories, Bellcomm Inc., General Instrument Corp., and RCA Corp. At Bellcomm, he oversaw systems engineering for NASA's manned spaceflight program, and at RCA, where he became executive vice president, he was responsible for corporate technology, patents, licensing, international business and marketing development, and corporate technology planning.

Hittinger was a member of President Reagan's National Security Telecommunications Advisory Committee from 1982-86. He was also a member of the U.S.-Brazil Presidential Committee on Science and Technology and a member of the board of directors for eight companies.

Hittinger served as national president of the Lehigh Alumni Association 1971-72 and received the prestigious L-in-Life award in 1979. An ROTC student at Lehigh, Hittinger served in the U.S. Army in 1943-46 during World War II, rising to the rank of captain.

During Hittinger's term as chairman of the board of trustees, Lehigh began construction of the Zoellner Arts Center, completed the Ulrich Student Center, aggressively improved its financial aid for undergraduates, and completed the $300 million Campaign for Preserving The Vision. As president, Hittinger realigned the Iacocca Institute into the College of Business and Economics, oversaw the construction of the new Sayre Park Village residential complex, and helped Lehigh move forward during a time of presidential transition.

Gregory C. Farrington (1998-). Dr. Farrington was appointed Lehigh's 12th president in May 1998. He had been dean since 1990 of the School of Engineering and Applied Science at the University of Pennsylvania, where he was responsible for the academic and financial oversight of the school.

Farrington, who earned a B.S. from Clarkson University, and an A.M. and Ph.D. from Harvard, all in chemistry, specializes in solid state electrochemistry. He holds or shares more than two dozen patents and has written or edited books, book chapters and 100 technical papers. Before joining Penn, he was a research chemist for General Electric Co.'s Corporate Research and Development Center in New York state.

At Penn, Farrington established new graduate and undergraduate interdisciplinary degree programs. At Lehigh, he has called on faculty, students, staff and alumni to build a university that rivals the best in America. He will strive to create new interdisciplinary programs and to promote innovative teaching methods that take advantage of new technologies where appropriate while preserving the best of established traditions. He has taken steps to improve relations with Lehigh's neighbors in the City of Bethlehem, and to reduce harmful use of alcohol by students. And he has realigned Lehigh's management structure in an effort to improve service and efficiency and also to strengthen Lehigh's research programs.

Farrington's goals received a significant boost when Peter C. Rossin, a member of Lehigh's Class of 1948, established a $25-million endowment for the engineering college, which was subsequently dedicated as the P.C. Rossin College of Engineering and Applied Science. Rossin's gift is the largest Lehigh has ever received.

Farrington serves on the boards of St. Luke's Hospital in Bethlehem, the Lehigh Valley Economic Development Corp., the Mellon Foundation, Clarkson University and the Wharton-SEI Center for Advanced Studies in Management. He chairs the Materials Research Society Young Investigator Award Committee, and has served as Councilor of the society, chair of the Physical Electrochemistry Committee of The Electrochemical Society, president of the International Society for Solid State Ionics, and editorial board member of *Chemistry of Materials, Solid State Ionics and MultiVersity.*

A native of Bronxville, N.Y., Farrington received an honorary degree from the University of Uppsala in Sweden in 1984 and the prestigious Cannizzaro Gold Medal of the Italian Chemical Society in 1998.

University Campuses

Lehigh University's three campuses are located in Bethlehem, Pa., and comprise 1,600 acres.

Asa Packer Campus. Lehigh's main academic campus, encompassing approximately 360 acres on the north slope of South Mountain overlooking Bethlehem, is a wooded area where most students attend class and live. This contains the original campus of the university.

Murray H. Goodman Campus. During the 1960s, the university acquired extensive acreage in the Saucon Valley just south of South Mountain. Development of one of the nation's finest collegiate athletic complexes has continued since that time. The 500-acre campus now includes the Murray H. Goodman Stadium and other athletic fields, as well as the 6,000-seat Stabler Athletic and Convocation Center, the North East Tier Ben Franklin Advanced Technology Center, the Philip Rauch Field House, the Cundey Varsity House, and the Lewis Indoor Tennis Facility. The campus is named for a major benefactor, Lehigh alumnus Murray H. Goodman, of West Palm Beach, Fla.

Mountaintop Campus. Lehigh bought this campus from Bethlehem Steel Corp. in 1986. It contains 670 acres of woods and a 72-acre research site with 8 buildings, five of which are owned by the University, including a landmark tower building visible for miles around. Acquisition of the facilities—the largest single transaction in Lehigh history—connects the two older campuses. The Mountaintop Campus houses the College of Education; the departments of Biological Sciences and Chemical Engineering; programs in biochemistry, biotechnology, bioengineering, ATLSS (Advanced Technology for Large Structural Systems) center, Energy Research Center, and Ben Franklin incubator companies.

University Buildings

Lehigh has a major collection of 19th-century buildings designed by such prominent architects as Addison Hutton (1834-1916), Edward T. Potter (1831-1904) and the firm of Furness and Evans (Frank Furness, 1839-1912).

The university's newer structures include the Goodman Stadium (1988), the Sherman Fairchild Center for Physical Sciences (1976, 1986), the E. W. Fairchild-Martindale Library and Computing Center (1985), the Stabler Athletic and Convocation Center (1979), the Brodhead House residential facility (1979), the Seeley G. Mudd Building and Neville Hall in the chemistry complex (1975), the Philip Rauch Field House (1975), the Rauch Business Center (1990), the Lewis Tennis Center (1994), and the new Ulrich Student Center in Grace Hall.

Recently completed just east of the Rauch Business Center is the new Zoellner Arts Center, which houses a 1000-seat music auditorium, a 300-seat theatre, a permanent art gallery and museum store, and the departments of music and theatre. A 350-car parking garage is on the same site.

Opened in 1998 in Sayre Park is a new residential complex of three apartment buildings and a community building. This facility is used for upperclass student housing.

Altogether, the three campuses contain 150 buildings with more than 4 million square feet of floor space.

In the following list, the first date after the name of each building indicates the year of construction. The second date indicates the year of a major addition.

Campus Landmarks

Alumni Memorial Building (1925). This edifice of Gothic design, housing the Visitor Center, Admissions and other administrative offices and those of the Alumni Association, represents a memorial to the 1,921 Lehigh alumni who served in World War I and the 46 who died. The building was designed by Theodore G. Visscher, Class of 1899, and James Lindsey Burley, Class of 1894.

E. W. Fairchild-Martindale Library and Computing Center (1985). The high-technology building houses science and engineering holdings and a computer center. Construction was made possible by a major gift from Harry T. Martindale, a 1927 Lehigh graduate, and his wife, Elizabeth, daughter of the late Edmund W. Fairchild, founder of a business-publications and communications empire.

Linderman Library (1877). The rotunda, designed by Addison Hutton, was built as a gift to the university by founder Asa Packer as a memorial to his daughter, Lucy Packer Linderman. The rotunda is surrounded except on the south by a major addition constructed in 1929. The building houses more than 20,000 rare books and volumes related to the humanities and social science. The Bayer Galleria of Rare Books, made possible by a gift from Curtis F. Bayer, '35, was dedicated in 1985.

Packer Memorial Church (1887). The church was the gift of Mary Packer Cummings in memory of her father, founder Asa Packer. It was dedicated on Founder's Day, October 13, 1887. The building was designed by Addison Hutton; the stained-glass window over the main door is attributed to Louis Comfort Tiffany.

President's House (1868). This 21-room residence, designed by Edward Potter, is the home of university presidents and is often used for receptions on special university occasions.

Packer Hall, The University Center (1868). When construction of the building began in 1865, a railroad was built to transport stone to the site. The building, designed originally by Potter, was extensively renovated and enlarged in 1958.

The building was constructed at the expense of the founder, who vetoed a plan to erect it of brick. "It will be built of stone," Asa Packer responded.

Today the building houses student and faculty dining facilities, a food court, deans' offices, the military science (ROTC) department, the Women's Networking Center, a bank office, and conference facilities.

Academic and Research Facilities

Chandler-Ullmann Hall (1883, 1938, respectively). These adjoining buildings formerly were the William H. Chandler Chemistry Building (designed by Hutton) and the Harry M. Ullmann Chemistry Laboratory. Chandler served as acting university president, 1904 and 1905, and taught chemistry from 1871 to 1906. Ullmann served as chairman of the chemistry department. The building has been named a National Historic Chemical Landmark by the American Chemical Society.

The Department of Art and Architecture, division of urban studies, and Department of Psychology are located in Chandler-Ullmann.

Christmas-Saucon Hall (1865 and 1872, respectively). Christmas Hall is the university's oldest building. When Asa Packer acquired the South Mountain site for the university in 1865, a Moravian church was being constructed. The newly formed university took over the building and completed it for use in recitations and as a dormitory and chapel. The name Christmas Hall was chosen in keeping with Moravian religious tradition. In 1872, Saucon Hall was constructed a few feet to the east of Christmas Hall. The buildings were connected with the construction of a "hyphen" in 1926. The building houses the Department of Mathematics and classrooms.

Coppee Hall (1883). The building originally housed classrooms and a gymnasium. It is named in honor of Henry Coppee, first president. The building houses the Weinstock Center for Journalism and Communication.

Coxe Hall (1910). Originally a mining laboratory, the structure is named for Eckley B. Coxe, pioneer mining engineer and trustee of the university. The building was recently renovated for the International Students and Scholars and the English as a Second Language programs and the Global Union.

Drown Hall (1908). The building, designed by Furness and Evans, is a memorial to Thomas M. Drown, president from 1895 to 1904. It is headquarters for the English Department and the Center for Writing, Math & Study Skills.

Fritz Engineering Laboratory (1909, 1955). The laboratory is named for John Fritz, pioneer in the steel industry in the United States and a member of the university's original board of trustees. Fritz provided funds for the original section; a seven-story addition accommodates the university's testing machine, which is capable of applying a five-million-pound load to tension or compression members up to forty feet in length. The hydraulic testing machine is the largest facility of its kind currently in operation in the world. The laboratory is used primarily by the Department of Civil and Environmental Engineering.

Iacocca Hall. (1958, 2003) Known as the tower building, it houses the College of Education, the chemical engineering department, the biological sciences department, as well as a dining room and food service facilities, plus a teleconferencing classroom.

Imbt Laboratories. This is primarily a high-bay research lab space where the ATLSS project was constructed, and where chemical engineering and Energy Research Center have major research facilities. It is also the headquarters of the "Fleet of the Future" program.

Johnson Hall (1955). The building houses the university health service, the counseling service, the chaplain's office, campus police, and the parking services office. Earle F. "Coxey" Johnson, '07, a director of General Motors Corp. and university trustee, provided funding for the structure.

Lamberton Hall (1907). The structure served as the university commons and dining room until the renovation of Packer Hall in 1958. The building honors the memory of Robert A. Lamberton, third president. It most recently housed the music department until its move to the Zoellner Arts Center, and is now the home of the "Moonlight Café".

Maginnes Hall (1970). The multilevel structure is headquarters for the College of Arts and Sciences and also houses the departments of modern languages and literature, history, international relations, political science, and religion studies, as well as the Science, Technology, and Society Program, the Philip and Muriel Berman Center for Jewish Studies, and the Center for International Studies. New classrooms opened on the ground floor in January 2004. The building is named for Albert B. Maginnes, '21, who was a lawyer and university trustee.

Mart Science and Engineering Library (1968). This structure honors the memory of Leon T. Mart, '13, and his son, Thomas, '51. It operates in conjunction with the E. W. Fairchild-Martindale Library and Computing Center.

Seeley G. Mudd Building (1975). This seven-story building houses the chemistry department. The late Seeley G. Mudd was a California medical doctor. The Seeley G. Mudd Foundation, of Los Angeles, made a major gift toward the building.

Neville Hall (1975). This building in the chemistry complex has three auditoriums used for lectures and events. The building is named for Dr. Harvey A. Neville, president from 1961 to 1964, who was a chemist.

Newman Association Center. This Victorian structure, until the mid-1970s used as a private residence, was renovated by the Newman Association and serves as a center for students and as a residence for its director, a Roman Catholic chaplain.

Packard Laboratory (1929). The structure was the gift of James Ward Packard, Class of 1884, the electrical pioneer and inventor of the Packard automobile who served as a university trustee. The first Packard automobile (1898) is displayed in the lobby. The building is the headquarters for the College of Engineering and Applied

Science. It also houses classrooms and laboratories for mechanical engineering and mechanics, for electrical and computer engineering, and computer science and engineering. An auditorium accommodates large classes and various events.

Philosophy Building (1879). This small building just below Packer Memorial Church was constructed as a porter's lodge. Today it houses the philosophy department.

Price Hall. This structure formerly was a brewery named Die Alte Brauerei. In 1912 it was remodeled to serve as a dormitory, and it was named in honor of Henry Reese Price, president of the university board of trustees. It serves as the home of the sociology and anthropology department.

Rathbone Hall (1971). This building's upper level is a major student dining facility, with window walls affording a panoramic view of the Lehigh Valley. The building bears the name of its donor, Monroe Jackson Rathbone, '21, president of the university board of trustees from 1957 to 1973. Rathbone was chairman of the board, Standard Oil Co. (New Jersey), now Exxon Corp., and was a major innovator in the oil industry. The lower level houses the Residential Services Office.

Rauch Business Center (1990). Philip Rauch '33, L.L.D. '79, retired Chairman of the Board and Director of the Parker-Hannifin Corp., made the principal contribution to build this facility. Lehigh's Rauch Business Center was dedicated in 1990 as the state-of-the-art home of the university's College of Business and Economics. The $17.8-million facility has 115,000 square feet of floor space on five stories and features a diverse array of classrooms, auditoria, and conference rooms, and is also home to the Career Services Office.

Sayre Building (1869). Originally known as the Sayre Observatory, the dome that once housed the telescope can still be seen. The Graduate Student Council is headquartered here.

Sherman Fairchild Center for the Physical Sciences (1892, 1976, 1986). The center, completed with help from the Sherman Fairchild Foundation, houses classrooms and laboratories for undergraduate and graduate students in physics, faculty offices and a 260-seat auditorium. The complex includes the Lewis Laboratory, the original five-story stone structure built in 1892, the Sherman Fairchild Laboratory for Solid-State Studies built in 1976, and the 1986 addition comprised of the Oberkotter Auditorium and research laboratories.

Sinclair Laboratory (1970). This facility houses the Center for Optical Technologies, and other research laboratories. It is named for Francis MacDonald Sinclair, and was the gift of his widow, Jennie H. Sinclair.

Whitaker Laboratory (1965). This five-story structure with an adjoining two-level classroom-auditorium section honors the memory of Martin Dewey Whitaker, university president from 1946 to 1960. The building serves the Department of Materials Science and Engineering and Center for Advanced Materials and Nanotechnology. There are laboratories for high-pressure research and reaction kinetics, nuclear studies, analog computation, process control, optoelectronics, high-temperature thermodynamics and kinetics, and fine structures and metallography. The Office of Government Relations is also located in the building.

Wilbur Powerhouse (1908). During most of its life, the building served as a power plant with some early engineering laboratory use. Renovated during the 1970s, it provided performing space for student theatrical productions, until the Zoellner Arts Center was built, and it is now the new home for student shops and project studios for the IPD (Integrated Product Development) program.

Williams Hall (1903). This brick structure was the gift of Edward H. Williams, Jr., Class of 1875. Dr. Williams was a professor of mining and geology. The building contains classrooms and laboratories for the departments of biological sciences and of earth and environmental sciences. A small greenhouse adjoins the building. The building was extensively renovated and a fourth story added in 1956 following a fire.

Zoellner Arts Center (1997). With major gifts from Vickie and Robert Zoellner '54, Dorothy and Dexter Baker '50, and Claire and Theodore Diamond '37, Dagit-Saylor Architects created a 105,000 sq. ft. structure designed to showcase Lehigh's rapidly growing programs in the performing and visual arts as well as the departments of music and theater and 5,000 sq. ft. of exhibition space for the Lehigh University Art Galleries. Baker Hall has a seating capacity of more than 1,000, Diamond Theatre features a thrust stage and seating for 307; and a "black box" theater provides flexible space for experimental productions.

Athletic and Convocational Facilities

Murray H. Goodman Stadium (1988). Joanie and Murray Goodman '48, L.L.D. '88, were the principal benefactors. On October 1, 1988, Lehigh opened the gates to Murray H. Goodman Stadium, located on the Goodman Campus. Capacity is 16,000, and the stadium features a three-tiered press box, and limited chair back seating, with picturesque South Mountain in the background.

Grace Hall (1940). The building is named for its donor, Eugene G. Grace, Class of 1899, who was chairman of Bethlehem Steel Corp. and president of the university's board of trustees, 1924 to 1956. Grace Hall serves as the headquarters and offices for Lehigh intramural and club sports. The upper level houses the newly renovated Ulrich Student Center, including movie theatre, gameroom and mailboxes. The lower level houses the recently renovated Leeman-Turner Arena.

Ulrich Sports Complex (1999). Lehigh chairman of the board of trustees, Ronald J. Ulrich '66, funded the construction of the dual field complex for men's and women's soccer, men's and women's lacrosse, and field hockey. The complex features both natural grass and artificial turf fields, permanent seating, a press box and lighting for night contests. The complex was designed by a group of students enrolled in the University's distinctive ILE (Integrated Learning Experience) program, illustrating the strong partnership between athletics and academics at Lehigh.

Lewis Tennis Facility (1994). An anonymous donor made possible the construction of four indoor tennis courts for recreational use as well as team practice, and is named for former Lehigh President W. Deming Lewis. The building also includes men's and women's locker room facilities.

Philip Rauch Field House (1976). Philip Rauch, '33, L.L.D. '79 made a gift toward the facility. The building has 62,000 square feet of uninterrupted floor space—the equivalent of two football fields—for a variety of athletic activities. It has a six-lane, one-eighth-mile flat track.

Sayre Field (1961). Located atop South Mountain, the field is used for intramural sports.

Stabler Athletic & Convocation Center (1979). This arena provides seating for 6,000 people for concerts, spectator sports, including Lehigh's basketball teams, and other events. University trustee Donald B. Stabler, '30, made a major financial contribution toward the facility.

Taylor Gymnasium (1904 and 1913). This structure was the gift of Charles L. Taylor, Class of 1876, who was a friend and business associate of steel magnate Andrew Carnegie. There are two indoor swimming pools, two basketball courts, the Welch Fitness Center, men's and women's locker rooms, two racquetball and two squash courts, a steam room, a multi-purpose dance/aerobics room, a climbing wall and a Sports Medicine Complex. The athletic department offices are also housed in the Warren (Pete) Musser wing. The Roger Penske Hall of Fame area opened in the spring of '96.

Cundey Varsity House (1963 and 2002). The building, expanded and renovated in 2002, houses a modern weight training facility, sports medicine and equipment areas, team meeting and reception areas, and locker rooms for several varsity teams. The Varsity House is located on the Murray H. Goodman Campus adjacent to the John C. Whitehead Football Practice Facility.

Central Heating/Refrigeration Plant

Central Heating and Refrigeration (1969). This glass-walled building houses three boilers that can be fired by either oil or gas. Other equipment provides chilled water for air conditioning.

Technology Center

125 Goodman Drive (1972). Situated on the Murray H. Goodman Campus in Saucon Valley, the building houses the Lehigh-based North East Tier Ben Franklin Advanced Technology Center, the Manufacturers Resource Center, and the University Relations office.

Residential Facilities

Brodhead House (1979). This structure is the university's first high-rise residential facility. The six-story building includes 4-person suites on the five upper floors, with a dining facility and lobby on the entrance level. The building is named in memory of Albert Brodhead, a member of the Class of 1888 who died in 1933, leaving 51 Bethlehem properties to his alma mater.

Campus Square (2002). In August of 2002, Lehigh opened a 250-bed residential complex that includes the campus bookstore and several retail stores. Air-conditioned, two, three and four-bedroom apartments are complete with full kitchen, private bathroom and fully furnished living room/dining room areas. Attached to the complex is a parking garage for 350 cars for residents' convenience.

Dravo House (1948). This 5-story stone edifice is the university's largest residential facility. It bears the name of two brothers, Ralph M. Dravo, Class of 1889, and Francis F. Dravo, Class of 1887, who founded the Dravo Corp., a Pittsburgh-based international construction company. Both men served as university trustees.

Drinker House (1940). This stone building honors the memory of Henry S. Drinker, Class of 1871, university president from 1905 to 1920.

McClintic-Marshall House (1957). This U-shaped stone structure was built in memory of Howard H. McClintic and Charles D. Marshall, both Class of 1888, who founded the McClintic-Marshall Construction Co. The firm was the world's largest independent steel fabricating firm before its acquisition by Bethlehem Steel Corp. in 1931. It built locks for the Panama Canal and constructed the Golden Gate Bridge in San Francisco Bay.

Richards House (1938). The building honors the memory of Charles Russ Richards, president of the university from 1922 to 1935. The building is constructed of stone in modified Gothic design.

Sayre Park Village (1998). This residential complex is comprised of three apartment buildings and houses students in three- and four-person apartments. Included is a fourth multipurpose community building and outdoor recreation facilities.

Taylor Residential College (1907, 1984). The U-shaped building is one of the earliest concrete structures ever built. It was the gift of industrialist Andrew Carnegie in honor of his friend and associate, university trustee Charles L. Taylor, Class of 1876. The interior of the building was reconstructed and the exterior refinished prior to the facility becoming Lehigh's first residential college in 1984.

Trembley Park (1975). This seven-building undergraduate apartment complex is named in memory of Francis J. Trembley, Lehigh professor and pioneer ecologist.

Warren Square Complex. This cluster of six residence halls is located on Warren Square and Summit Street. They are upperclass facilities and some are used as special-interest houses. Chi Omega sorority is housed in Warren Sq. "E".

Centennial I complex (1965)

Congdon House. Located at the east end of the Centennial I complex. Dr. Wray H. Congdon served as dean of students, dean of the graduate school, and special assistant to the president. Alpha Chi Omega sorority is housed here.

Emery House. It is named for Dr. Natt M. Emery, who was vice president and controller. Pi Beta Phi sorority is housed in Emery.

Leavitt House. The Rev. Dr. John McD. Leavitt was the second president, 1875 to 1879.

McConn House. C. Maxwell McConn was dean of the university from 1923 to 1938.

Smiley House. Dr. E. Kenneth Smiley served as vice president from 1945 to 1964. Kappa Alpha Theta sorority is housed in Smiley.

Thornburg House. Dr. Charles G. Thornburg was professor and head of the Department of Mathematics, 1895 to 1923. Residence and Greek Life staff offices will be located here in the summer of 2004.

Centennial II complex (1970)

Beardslee House. Dr. Claude G. Beardslee was chaplain from 1931 to 1947.

Carothers House. Dr. Neil Carothers was dean of business.

Palmer House. Dr. Philip M. Palmer was dean of the arts.

Stevens House. The Rt. Rev. William Bacon Stevens, of Philadelphia, was Protestant Episcopal bishop of the Diocese of Pennsylvania and first president of the university board of trustees. He was the principal architect of the university's original academic plan.

Stoughton House. Dr. Bradley Stoughton was dean of the engineering college, 1936 to 1939.

Williams House. Dr. Clement C. Williams was president of the university, 1935 to 1944.

Saucon Village Apartments (1974)

The five-building garden apartment complex includes housing for married, graduate, and undergraduate students.

Diamond. Dr. Herbert M. Diamond, professor emeritus of economics, retired in 1964.

Gipson. Dr. Lawrence Henry Gipson, research professor of history, bequeathed his estate to the university to establish the Lawrence Henry Gipson Institute for Eighteenth-Century Studies. Dr. Gipson wrote a monumental 15-volume history, The British Empire before the American Revolution. He won the Pulitzer Prize for volume 10, The Triumphant Empire: Thunderclouds Gather in the West, 1763-1766.

Hartman. Dr. James R. Hartman was chairman of the department of mechanical engineering and mechanics.

More. Dr. Robert P. More, '10, dean of the College of Arts and Sciences, who also taught German for forty years, bequeathed to the university his $746,000 estate, amassed after investing $3,000 in IBM stock. The university child care center is located in this building.

Severs. Dr. J. Burke Severs, of Bethlehem, is distinguished professor emeritus of English. He is a Chaucerian scholar.

Fraternities and Sororities

The university has a strong fraternity tradition, dating back to 1872. Since the admission of undergraduate women in 1971, several sororities have come into being. Some 600 men live in 22 fraternities.

All of the fraternities have houses located on Asa Packer campus. All are chapters of national fraternities.

An alphabetical listing follows. The date of the founding of the chapter is given in the first column. The second column lists the date the chapter occupied its present house; any additional date indicates the most recent addition or major renovation.

Alpha Chi Rho	1918	1968	
Alpha Sigma Phi	1929	1961	
Alpha Tau Omega	1966		
Beta Theta Pi	1891	1968	
Chi Phi	1872	1922	1968
Chi Psi	1893	1916	1955
Delta Phi	1884	1963	
Delta Sigma Phi	1931	1971	
Delta Tau Delta	1874	1985	1959
Delta Upsilon	1885	1968	
Kappa Alpha	1894	1961	
Kappa Sigma	1900	1973	
Lambda Chi Alpha	1926	1973	
Phi Gamma Delta	1921	1968	
Phi Kappa Theta		1966	
Phi Sigma Kappa	1901	1957	1970
Psi Upsilon	1884	1909	1966
Sigma Alpha Mu	1966	1966	
Sigma Chi	1953	1953	
Sigma Phi Epsilon	1907	1963	
Theta Chi	1942	1964	
Theta Xi	1904	1967	

There are nine sororities. All are nationally affiliated. Three reside in the Centennial I Complex, one in Warren Square, and five, Alpha Gamma Delta, Alpha Omicron Pi, Alpha Phi, Delta Gamma and Gamma Phi Beta, reside in Sayre Park. Over 300 women live in sororities.

The sororities are listed with year of establishment at Lehigh in the first column and year of moving into their present house in the second column.

Alpha Chi Omega (Congdon)	1988	1997
Alpha Gamma Delta	1975	2000
Alpha Omicron Pi	1983	2004
Alpha Phi	1975	1996
Chi Omega	2000	2004
Delta Gamma	1982	1987
Gamma Phi Beta	1975	1998
Kappa Alpha Theta (Smiley)	1984	1986
Pi Beta Phi (Emery)	1997	1998

VII. Administration, Faculty and Staff

This section lists the people whose talents and abilities constitute the university's most important resource. Members of the board of trustees contribute their expertise to establish the policies of the university. Also listed are the administration, members of the faculty and staff, and the members of the visiting committees who help to keep courses of instruction current and of maximum value to the students and prospective employers.

Board of Trustees

When only the year of the degree is listed, the degree was awarded by Lehigh University.

Officers of the Board As of December 31, 2003

Members of the Board

Trustees Emeriti

Honorary Trustees

Principal Officers

Educational information (degrees earned and colleges and universities attended) may be found in the alphabetical listing that follows in this section. The highest degree earned is given here. All offices, unless otherwise noted, are located at Bethlehem, PA 18015; the area code, unless otherwise noted, is (610).

Principal Officers

Gregory C. Farrington, Ph.D., president; 758-3157

Roland K. Yoshida, Ph.D., provost and vice president for academic affairs; 758-3605

Mark H. Erickson, Ed.D., vice president for administrative and government affairs; 758-3155

Margaret F. Plympton, M.B.A., vice president for finance and administration; 758-3178

Bonnie N. Devlin, B.A., vice president for advancement; 758-5199

Bradley M. Drexler, B.A., vice president for university relations; 758-4487

Frank A. Roth, J.D., general counsel; 758-3522

Anne S. Meltzer, Ph.D., dean, College of Arts and Sciences 758-4570

Richard M. Durand, Ph.D., Herbert E. Ehlers dean, College of Business and Economics; 758-6725

Sally A. White, Ph.D., dean, College of Education; 758-3221

Mohamed S. El-Aasser, Ph.D., dean, P.C. Rossin College of Engineering and Applied Science; 758-5308

Eric J. Kaplan, Ed.M., dean of admissions and financial aid; 758-3101

Bruce M. Taggart, Ph.D., vice provost for information resources; 758-3025

Steven J. Devlin, Ph.D., vice provost for institutional research; 758-5744

David B. Williams, Ph.D., vice provost for research; 758-6120

John W. Smeaton, Ph.D., vice provost for student affairs; 758-3890

Denise M. Blew, B.S., CMA, CPA, associate vice president for finance and secretary to the board; 758-3179

Jacqueline Matthews, M.S., associate vice president for human resources; 758-3900

Anthony L. Corallo, M.A., associate vice president for facilities services and campus planning; 758-3970

William D. Michalerya, M.B.A., M.Eng., associate vice president for government relations; 758-5483

Joseph D. Sterrett, Ed.D, executive director of athletics; 758-4320

College Offices

College of Arts and Sciences

Maginnes Hall
9 West Packer Avenue; 758-3300
Anne. S. Meltzer, Ph.D., dean
Linda Lowe-Krentz, Ph.D., associate dean, undergraduate
Hannah W. Stewart-Gambino, Ph.D., associate dean
Ingrid H. Parson, Ed.D., associate dean, graduate and research programs

College of Business and Economics

Rauch Business Center
621 Taylor Street; 758-3400
Richard M. Durand, Ph.D., Herbert E. Ehlers dean
Joan DeSalvatore, M.A., associate dean and director, undergraduate program
Kathleen A. Trexler, M.B.A., associate dean and director, MBA program

College of Education

Iacocca Hall
111 Research Drive; 758-3225
Sally A. White, Ph.D., dean

P.C. Rossin College of Engineering and Applied Science

Packard Laboratory
19 Memorial Drive West; 758-4025
Mohamed S. El-Aasser, Ph.D., dean
John P. Coulter, Ph.D., associate dean, graduate program
Richard N. Weisman, Ph.D., associate dean, undergraduate program

Offices and Resources

In this section, only the principal officers are listed. For degree information, consult the alphabetical listing that follows.

Academic Outreach
Henry U. Odi, executive director of academic outreach and special projects

Admissions
27 Memorial Drive West; 758-3100
Eric J. Kaplan, dean of admissions and financial aid

Advancement
27 Memorial Drive West; 758-3120
Bonnie N. Devlin, vice president for advancement

Alumni Association
27 Memorial Drive West; 758-3135
Christopher V. Marshall, executive director

Art Galleries/Museum Operations
420 East Packer Avenue; 758-3615
Ricardo Viera, director/curator

Athletics
641 Taylor Street; 758-4300
Joseph D. Sterrett, executive director of athletics

Ben Franklin Technology Center
125 Goodman Drive; 758-5200
R. Chad Paul, executive director

Bookstore
9 West Packer Avenue; 758-3375
Paula C. Coll, general manager

Budget Office
428 Brodhead Avenue, 758-4204
Stephen J. Guttman, director of budget

Bursar
27 Memorial Drive West; 758-3160
Michael J. King, bursar

Business Services
516 Brodhead Avenue; 758-3840
Barry L. Gaal, associate vice president

Career Services
621 Taylor Street; 758-3710
Donna L. Goldfeder, director

Center for Writing, Math and Study Skills
35 Sayre Drive; 758-3098
Edward E. Lotto, director

Chaplaincy Services
36 University Drive; 758-3877
Rev. Dr. Lloyd H. Steffen, university chaplain, chairperson and professor of religion studies

Child Care Center
5 Duh Drive; 758-5437
Kathy N. Calabrese, director

Community and Regional Affairs
422 Brodhead Avenue; 758-5801

Computing Center (see Information Resources)

Conference Services
63 University Drive; 758-5306
Mary Kay Baker, manager

Controller's Office
524 Brodhead Avenue; 758-3140
Kathleen J. Miller, controller

Corporate and Foundation Relations
27 Memorial Drive West; 758-6845
Kathryn Humphreys, executive director
Joseph J. McKenna, director of corporate relations
Rochelle A. Makela-Goodman, director of foundation relations

Counseling & Psychological Services
36 University Drive; 758-3880
Ian T. Birky, director

Dean of Students
29 Trembley Drive; 758-4156
Sharon K. Basso, dean of students

Development (see Advancement)

Distance Education (see Special Academic Programs)

Environmental Health and Safety
616 Brodhead Avenue; 758-4251
Barbara A. Plohocki, director

Facilities Services and Planning
461 Webster Street; 758-3970
Anthony L. Corallo, associate vice president

Finance and Administration
27 Memorial Drive West; 758-3180
Margaret F. Plympton, vice president
Denise M. Blew, associate vice president for finance and secretary to the board

Financial Aid
218 W. Packer Avenue; 758-3181
Linda F. Bell, director

Fraternity Management Association
219 Warren Square; 758-3888
Elizabeth M. Fisher, executive director

General Counsel
27 Memorial Drive West; 758-3522
Frank A. Roth. Esq., general counsel

Government Affairs
5 East Packer Avenue; 758-5802
Mark H. Erickson, vice president for administrative and government affairs
William D. Michalerya, associate vice president
422 Brodhead Avenue; 758-4802
Vito Gallo, assistant vice president for state relations

Graduate Student Life
Karen H. Huang, director of graduate student life

Health Center
36 University Drive; 758-3870
Susan C. Kitei, M.D., director

Human Resources
428 Brodhead Avenue; 758-3900
Jacqueline Matthews, associate vice president

Institutional Purchasing
516 Brodhead Avenue; 758-3840
Patricia Reich, director

Institutional Research
27 Memorial Drive West; 758-3708
Steven J. Devlin, vice provost for institutional research
Scott M. Knauss, director

Internal Audit
526 Brodhead Avenue; 758-5012
Robert J. Eichenlaub, director

International Students and Scholars
5 E. Packer Avenue; 758-4859
William D. Hunter, director of international education and global union

Library and Technology Services
8A East Packer Avenue; 758-3025
Bruce M. Taggart, vice provost

Mailing and Printing Services
118 ATLSS Drive; 758-5402 (Mailing); 758-5408 (Printing)
Glenn H. Strause, director

Manufacturers Resource Center
125 Goodman Drive; 758-5599
Edith D. Ritter, executive director

Parking Services
36 University Drive; 758-3893
F. Scott Moser, manager

Personnel (see Human Resources)

Police (see University Police)

President's Office
27 Memorial Drive West; 758-3157
Gregory C. Farrington, president

Provost's Office
27 Memorial Drive West; 758-3605
Roland K. Yoshida, provost and vice president for academic affairs

Registrar
27 Memorial Drive West; 758-3200
Bruce S. Correll, registrar

Research and Sponsored Programs
526 Brodhead Avenue; 758-3021
Thomas J. Meischeid, director

Residential Services
63 University Drive; 758-3500
David M. Joseph, director

Risk Management
616 Brodhead Ave.; 758-3899
Richard Freeman, director

Special Academic Programs (Distance Education and Summer Studies)
36 University Drive; 758-3966 (Summer); 758-4373 (Distance)
James A. Brown, director

Sports Communications
641 Taylor Street; 758-3174
Jeff Tourial, director

Student Affairs
29 Trembley Drive; 758-3890
John W. Smeaton, vice provost

Summer Studies (see Special Academic Programs)

Transportation Services
126 Goodman Drive; 758-4410
Christopher J. Christian, director

Treasurer (see Finance and Administration)

University Police
36 University Drive; 758-4200
Edward K. Shupp, chief

University Relations
125 Goodman Drive; 758-4487
Bradley M. Drexler, vice president

Vice Provost for Research
27 Memorial Drive West; 758-6120
David B. Williams, vice provost

Women's Center
Kristen R. Handler, director of women's center

Zoellner Arts Center
420 East Packer Avenue; 758-5323
Elizabeth Scofield, executive director

Faculty and Emeriti

The first date after the name is the date of appointment to continuous service on the Lehigh University faculty or staff; the second date, when the first fails to do so, indicates the date of appointment to the present professional rank**.** Where the name of the institution awarding a high-level degree is not given, the institution is the same one that awarded the previous degree listed.

P.E. indicates certification as a professional engineer; C.P.A. indicates certified public accountant. A.P.R. indicates accreditation by Public Relations Society of America. A.T.C. means certified athletic trainer.

A

John H. Abel, Jr. (1985, 2003), professor emeritus of biological sciences. B.A., Wooster, 1959; M.A., Brown, 1964; Ph.D., 1966.

John W. Adams (1965, 1995), professor emeritus of industrial engineering. B.S., Nebraska, 1952; Ph.D., North Carolina, 1962; CQE.

Eugene O. Albulescu (1997, 2002), professor of practice, music. P.D., Conservatorium of Music (Wellington, NZ), 1988; A.D., Indiana, 1992;, M.M., 1994; B.D., Rongotai (Wellington, NZ), 1997.

Jack A. Alhadeff (1982), professor and head of biochemical sciences. B.A., Chicago, 1965; Ph.D., Oregon Medical School, 1972.

Eugene M. Allen (1967, 1982), professor emeritus of chemistry, B.A., Columbia, 1938; M.S., Stevens Inst. of Tech., 1944; Ph.D., Rutgers, 1952.

Carlos J. Alvare (1984), professor emeritus of art and architecture. B. Arch., Yale, 1947; M.C.P., Pennsylvania, 1954; M. Arch., Yale, 1973.

David Curtis Amidon, Jr. (1965, 1995), associate professor, urban studies. B.A., Juniata, 1957; M.A., Pennsylvania State, 1959.

David J. Anastasio (1986, 1993), associate professor of earth and environmental sciences. B.A., Franklin and Marshall, 1980; M.A., Johns Hopkins, 1984; Ph.D., 1988.

Anne-Marie Anderson (2003), assistant professor of finance. B.S.; U.S. military academy, 1987; M.B.A., Tulso, 1998; Ph.D., Arizona, 2003.

Rosemarie Arbur (1972, 2000), professor emeritus of English. B.A., Nazareth, 1966; M.A., Illinois, 1967; Ph.D., 1972.

Marie-Sophie Armstrong (1986, 1992), associate professor of modern languages and literature. B.A., Institut Superieur d'Interpretariat et de Traduction (France), 1979; B.A., Sorbonne (France), 1979; M.A., Oregon, 1982; Ph.D., 1986.

Mark G. Arnold (2002), assistant professor of computer science and engineering. B.S., Wyoming, 1978; M.S., 1982.

J. Richard Aronson (1965, 1972), William L. Clayton professor of business and economics and director of Martindale Center for the Study of Private Enterprise. B.A., Clark, 1959; M.A., Stanford, 1961; Ph.D., Clark, 1964.

Lloyd W. Ashby (1966, 1971), professor emeritus of education and human services. A.B., Hastings (Nebraska), 1927; M.A., Columbia Teachers, 1935; Ed.D., 1950.

Betzalel Avitzur (1964, 1995), professor emeritus of materials science and engineering. B.S., Israel Inst. of Tech., 1947; Dip., 1949; M.S., Michigan, 1956; Ph.D., 1961.

B

D. Raymond Bainbridge (1972, 2001), professor emeritus of accounting. B.S., Rider, 1963; M.S., Lehigh, 1972; Ph.D., 1978; C.P.A., Pennsylvania, 1971.

Henry S. Baird (2004), professor of computer science and engineering. B.A., Harvard, 1966; M.S., Rutgers, 1976; Ph.D., Princeton, 1984.

Nicholas W. Balabkins (1957, 1994), professor emeritus of economics. Dipl.rer.pol., Gottingen (Germany), 1949; M.A., Rutgers, 1953; Ph.D., 1956.

Linda M. Bambara (1988, 2002), professor of education and human services. B.S., SUNY at Oneonta, 1975; M.S.Ed., SUNY at Binghamton, 1977; Ed.D., Vanderbilt, 1985.

Thoburn V. Barker (1953, 1984), professor emeritus of speech. B.A., Speech, Ohio Wesleyan, 1943; M.A., Columbia, 1951.

Henri J. Barkey (1987, 1999), professor of international relations. B.Sc., City Univ. (London), 1975; M.Sc., Univ. College (London), 1976; Ph.D., Pennsylvania, 1984.

Robert F. Barnes, Jr. (1965, 1995), professor emeritus of philosophy; professor emeritus of computer science. B.S., MIT, 1957; M.A., Dartmouth, 1959; Ph.D., California at Berkeley, 1965.

Susan E. Barrett (1987, 1994), associate professor of psychology. B.A., Clark, 1981; ScM., Brown, 1983; Ph.D., 1987.

Donald D. Barry (1963, 2000), university professor emeritus of political science. B.A., Ohio, 1956; M.A., Syracuse, 1959; Ph.D. 1963.

Richard W. Barsness (1978, 2004), dean emeritus, college of business and economics and university service professor emeritus of management. B.S., Minnesota, 1957; M.A., 1958; M.A., 1960; Ph.D., 1963.

Michael G. Baylor (1976, 1990), professor of history. B.A., Knox, 1964; M.A., Stanford, 1966; Ph.D., 1971.

Barry S. Bean (1973, 1998), professor of biological sciences. B.S., Tufts, 1964; Ph.D., Rockefeller, 1970.

Gordon C.F. Bearn (1986, 2002), professor of philosophy. B.A., Williams, 1977; B.A., Oxford, 1979; Ph.D., Yale, 1985.

Gray E. Bebout (1991, 2003), professor of earth and environmental sciences. B.S., Texas, 1981; M.A., 1984; Ph.D., UCLA, 1989.

Michael J. Behe (1985, 1997), professor of biological sciences. B.S., Drexel, 1974; Ph.D., Pennsylvania, 1978.

Carl R. Beidleman (1967, 1995), DuBois professor emeritus of finance. B.S., Lafayette, 1954; M.B.A., Drexel, 1961; Ph.D., Pennsylvania, 1968.

Peter G. Beidler (1967, 1977), Lucy G. Moses distinguished professor of English. B.A., Earlham, 1962; M.A., Lehigh, 1965; Ph.D., 1968.

Raymond Bell (1966, 2004), university service professor emeritus of education and social relations. Teaching Cert., St. John's (England), 1961; M.A., Temple, 1967; Ed.D., Lehigh, 1971.

Russell E. Benner (1962), professor emeritus of mechanical engineering and mechanics. B.S., Cornell, 1947; M.S., Lehigh, 1951; Ph.D., 1959. P.E., Pennsylvania, 1970.

Rosemary T. Berger (2002), assistant professor of industrial and systems engineering. B.S., William and Mary, 1992; M.S., Northwestern, 1993; Ph.D., 1997.

Ivan Biaggo (2002), associate professor of physics. M.S., Swiss Federal Institute of Technology, 1986; Ph.D. 1993.

Mark H. Bickhard (1990), Henry R. Luce professor in cognitive robotics and the philosophy of knowledge; cognitive science, psychology and philosophy. B.S., Chicago, 1966; M.S., 1970; Ph.D., 1973.

Jerry T. Bidlack (1973, 1995), professor emeritus of music. B.A., Oberlin, 1953; M.A., Boston, 1957.

Mary Jean Bishop (2001), assistant professor of education and human services. B.A., Lebanon Valley, 1984; M.A., Millersville, 1987; Ed.D., Lehigh, 2000..

Glenn D. Blank (1984, 1990), associate professor of computer science and engineering. B.A., Pennsylvania State, 1974; M.A., Michigan, 1975; M.S., Wisconsin at Madison, 1983; Ph.D., 1984.

Rick S. Blum (1991, 2002), professor of electrical and computer engineering. B.S., Pennsylvania State, 1984; M.S., Pennsylvania, 1987; Ph.D., 1991.

Philip A. Blythe (1968, 1970), professor of mechanical engineering and mechanics. B.Sc., Manchester (England), 1958; Ph.D., 1961.

Alec M. Bodzin (1999), assistant professor of education and human services. B.S., Michigan, 1988; M.Ed., George Washington, 1992; Ph.D., North Carolina State, 1999.

Teresa V. Bohlsen (1999), lecturer in spanish, modern languages and literature. B.A., Inst Tech Estudio Superiores, 1964; M.A., University of San Diego, 1984.

John W. Bonge (1972, 2002), professor emeritus of management. B.S., Princeton, 1957; M.B.A., Northwestern, 1959; Ph.D., 1968.

Berrisford W. Boothe (1989, 1996), associate professor of art and architecture. B.A., Lafayette, 1983; M.F.A., Maryland Institute, 1986.

Garold J. Borse (1966, 1977), professor of physics. B.S., Detroit, 1962; M.S., Virginia, 1964; Ph.D., 1966.

Jennifer M. Brill (2002), assistant professor of education and human services. B.S., Boston, 1986; M.Ed., Pennsylvania State, 1995.

Arthur L. Brody (1957, 1989), professor emeritus of psychology. B.A., George Washington, 1951; Ph.D., Indiana, 1956.

Addison C. Bross (1967, 1994), professor of english. B.A., Davidson, 1959; M.A., Duke, 1960; Ph.D., Louisiana State, 1967.

Derick G. Brown (2001), assistant professor of civil and environmental engineering. B.S., Boston, 1986; M.S., California, 1994; M.A., Princeton, 1996; Ph.D., 2000.

Forbes T. Brown (1970, 2004), professor emeritus of mechanical engineering and mechanics. B.S., M.I.T., 1958; M.S., 1958; Mech.E., 1959; Sc.D., 1962.

Josef M. Brozek (1959, 1979), research professor emeritus of psychology. Ph.D., Charles (Prague), 1937.

Stephen G. Buell (1973, 1995), professor of finance. B.S., Lehigh, 1970; M.A., 1971; Ph.D., 1977.

Sidney R. Butler (1969, 1991), professor emeritus of materials science and engineering. B.S., Maine, 1954; M.S., Pennsylvania State, 1956; Ph.D., 1960.

Maria Bykovskaia (2002), assistant professor of biological sciences. M.S., Leningrad (Russia), 1987; Ph.D., Russian Academy of Sciences (Russia), 1992.

C

Huai-Dong Cao (2003), professor of mathematics. B.A., Tsinghua (Beijing), 1981; M.A., Princeton, 1983; Ph.D., 1986.

Hugo S. Caram (1977, 1986), professor of chemical engineering. B.S., Buenos Aires (Argentina), 1967; Ph.D., Minnesota, 1977.

G. Slade Cargill III (1997), chairperson and Sherman Fairchild professor of materials science and engineering. B.S., Georgia Institute of Technology, 1966; S.M., Harvard, 1966; Ph.D., 1969.

Kimberley Carrell-Smith (2002), professor of practice of history. B.A., Wesleyan, 1979; M.A., Delaware, 1981; Ph.D., 1989.

Bobb Carson (1971, 2003), dean emeritus and professor emeritus of earth and environmental sciences. B.A., Carleton, 1965; M.S., Washington, 1967; Ph.D., 1971.

Franklin J. Carter (2004), assistant professor of management and marketing. B.S., Carnegie Mellon, 1978; M.B.A., Wharton, 1982; M.S., Carnegie Mellon, 1994; Ph.D., 1997.

Lynne U. Cassimeris (1992, 1996), associate professor of biological sciences. B.S., Springfield, 1980; Ph.D., North Carolina at Chapel Hill, 1988.

Alfred J. Castaldi (1966, 1987), professor emeritus of education and human services. B.S., Pennsylvania, 1951; M.S., 1956; Ed.D., 1964.

Ward M. Cates (1991, 2001), professor of education and human services. B.A., Duke, 1971; Ed.D., 1979.

Marie-Helene Chabut (1988, 2000), professor of modern languages and literature. Licene de Lettres Modernes, Universite de Toulouse; 1977; Maitrise de Lettres Modernes, 1979; C. Phil., California at San Diego, 1982; Ph.D., 1984.

Helen M. Chan (1986, 1995), professor of materials science and engineering. B.S., Imperial College of Science Tech., 1979; Ph.D., 1982.

Marvin Charles (1970, 1981), professor of chemical engineering. B.S., Brooklyn Polytechnic, 1964; M.S., 1967; Ph.D., 1970.

Manoj K. Chaudhury (1994, 2001), professor of chemical engineering and director of polymer interfaces center. B.S., Calcutta, 1976; M.S., SUNY at Buffalo, 1980; Ph.D., 1984.

John C. Chen (1970), Carl R. Anderson professor of chemical engineering. B.S., Cooper Union, 1956; M.S., Carnegie-Mellon, 1959; Ph.D., Michigan, 1961.

Liang Cheng (2002), assistant professor of computer science and engineering. B.S.E.E., Huazhong (China), 1994; M.S.E.E., Tsinghua (China), 1997; Ph.D., Rutgers, 2002.

Meng-Sang Chew (1992, 1995), associate professor of mechanical engineering and mechanics. B.S., Columbia, 1977; M.S., 1977; M.Ph., 1979; Ph.D., 1980; P.E. Virginia, 1992.

Gautam Chinta (2004), assistant professor of mathematics. B.S., Yale, 1995; Ph.D., Columbia, 2000.

Ravi Chitturi (2003), assistant professor of marketing. B.E., Regional Engineering College at Trichy (India), 1982; M.S., Illinios Institute of Technology, Chicago, 1984; M.B.A., Texas, 1996; Ph.D., 2003.

Paul Chou (1993, 2000), associate professor of music. B.Mus., Indiana, 1983; M.M., SUNY at Stony Brook, 1985.

Shin-Yi Chou (2003), assistant professor of economics. B.A., national Taiwan University, 1994; Ph.D., Duke, 1999.

Ye T. Chou (1968, 1995), New Century Fund professor emeritus of materials science and engineering. B.S., Chung King, 1945; M.S., Carnegie-Mellon, 1954; Ph.D., 1957.

Mooi Choo Chuah (2004) associate professor of computer science and engineering. B.E., Malaya, 1984; M.S., California, 1988; Ph.D., 1991.

Curtis W. Clump (1955, 1988), professor emeritus of chemical engineering. B.S., Bucknell, 1947; M.S., 1949; Ph.D., Carnegie-Mellon, 1954.

Christine L. Cole (1988, 2001), professor of school psychology. B.A., St. Olaf, 1975; M.S., Wisconsin-Madison, 1977; Ph.D., 1982.

Karen M. Collins (1990, 1994), associate professor of accounting. B.S., Salisbury State, 1976; MBA, 1984; Ph.D., Virginia Polytechnic, 1988.

Frank T. Colon (1965, 1980), professor of political science. B.A., Geneva, 1954; M.A., Pittsburgh, 1960; Ph.D., 1962.

Helen L. Columba (1989, 1995), associate professor of education and human services. B.A., Morehead State; M.Ed., Louisville, 1977; Ed.D., 1989.

Constance A. Cook (1989, 1996), associate professor of modern languages and literature. B.A., University of Washington, 1976; M.A., 1980; Ph.D., U.C., Berkeley, 1990.

Gail A. Cooper (1987, 1996), associate professor of history. B.A., California at Santa Barbara, 1975; M.A., 1980; Ph.D., 1987.

John P. Coulter (1990, 2001), associate dean of graduate studies and research for the P.C. Rossin college of engineering and applied science and professor of mechanical engineering and mechanics. B.S., Delaware, 1983; M.S., 1985; Ph.D., 1988.

Kate Crassons (2004), assistant professor of English. B.A., Louisiana, 1996; M.A., Colorado, 1998; Ph.D., Duke, 2004.

David L. Cundall (1975, 1992), professor of biological sciences. B.S., McGill, 1967; M.S., Arkansas, 1970; Ph.D., 1974.

Cassius W. Curtis (1946, 1971), professor emeritus of physics. A.B., Williams, 1928; Ph.D., Princeton, 1936.

Stephen H. Cutcliffe (1976, 2002), professor of science, technology, and society and history; and director of STS program. A.B., Bates, 1968; M.A., Lehigh, 1973; Ph.D., 1976.

Robert B. Cutler (1954, 1979), professor emeritus of music. A.B., Bucknell, 1934; M.A., Columbia, 1935.

D

J. Hartley Daniels (1967, 1991), professor emeritus of civil engineering. B.S., Alberta (Canada), 1955; M.S., Illinois, 1959; Ph.D., Lehigh, 1967. P.E., Alberta (Canada), 1955; P.E., Pennsylvania, 1975.

Donald M. Davis (1974, 1984), professor of mathematics. B.S., M.I.T., 1967; Ph.D., Stanford, 1972.

Frank L. Davis (1987, 1993), associate professor of political science. B.A., Nevada, 1973; M.A., North Carolina, 1980; Ph.D., 1987.

Brian D. Davison (2001), assistant professor of computer science and engineering. B.S., Bucknell, 1991; M.S. Rutgers, 1995: Ph.D., 2001.

Edna S. de Angeli (1963, 1982), professor emerita of classics, B.S., Temple, 1938; M.A., Pennsylvania, 1960; Ph.D., 1965.

James A. Dearden (1989, 2000), professor of economics. A.B., Muhlenberg, 1982; Ph.D., Pennsylvania State, 1987.

Jack A. DeBellis (1964, 2002), professor emeritus of English. B.A., Florida, 1957; M.A., California-Los Angeles, 1959; Ph.D., 1964.

D. Richard Decker (1982, 1984), professor of electrical and computer engineering. B.S., North Carolina State, 1961; M.S., 1963; Ph.D., Lehigh, 1970.

Mary E. Deily (1991, 1995), associate professor of economics. B.A., Maryland, 1979; M.A., Harvard, 1983; Ph.D., 1985.

Gary G. DeLeo (1979, 1996), professor of physics. B.S., SUNY at Fredonia, 1974; M.S., Connecticut, 1976; Ph.D., 1979.

Terry J. Delph (1979, 1989), professor of mechanical engineering and mechanics. B.S., Georgia Inst. of Tech., 1967; M.S., Calif. Inst. of Tech., 1968; Ae.E., 1969; Ph.D., Stanford, 1976.

Volkmar Dierolf (2000), associate professor, physics. M.A., University of Stuttgart, 1987; Ph.D., University of Utah, 1992.

David Diggs (1999), lecturer in music. B.Mus., Oklahoma City, 1969; M. Mus., SUNY, 1974.

Robin S. Dillon (1987, 1993), director of women's studies program and associate professor of philosophy. B.A., Pittsburgh, 1978; M.A., 1981; Ph.D., 1987.

Yujie Ding (2002), associate professor of electrical and computer engineering,. B.S.E.E., Jilin University (China), 1984; M.S.E.E., Purdue, 1987; Ph.D., Johns Hopkins, 1990.

George A. Dinsmore (1955, 1987), professor emeritus of civil engineering. B.E., Yale, 1946; M.S., Colorado, 1955.

Kathryn A. DiPietro (2002), assistant professor of education and human services. B.A., North Florida, 1989; M.E., 1994.

Vladimir Dobric (1987, 2000), professor of mathematics. B.S., Zagreb (Croatia), 1974; M.S., 1980; Ph.D., 1985.

Bruce A. Dodson (1978, 1986), associate professor of mathematics. B.S., Oregon, 1972; M.A., SUNY at Stony Brook, 1975; Ph.D., 1976.

Alexander M. Doty (1986, 2000), professor of english. B.A., Texas-El Paso, 1976; M.A., Illinois-Urbana, 1978; Ph.D., 1984.

Joseph A. Dowling (1958, 1994), distinguished professor emeritus of history. B.A., Lincoln Memorial, 1948; M.A., New York, 1951; Ph.D., 1958.

George J. Du Paul (1992, 1998), professor of education and human services. B.A., Wesleyan, 1979; M.S., Rhode Island, 1983; Ph.D., 1985.

Ian P.H. Duffy (1975, 1989), professor of history. B.A., Oxford (England), 1965; M.A., 1966; Ph.D., 1974.

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Directors and staff members of the university's research centers and institutes are listed. Complete degree information may be found in the faculty and staff alphabetical listings. In some cases, areas of research interest are given.

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Building and Architectural Technology Institute

17 Memorial Drive, East;
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Emulsion Polymers Institute

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Engineering Research Center for Advanced Technology for Large Structural Systems (ATLSS)

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MS, manager-structural laboratories; Richard Sause, Ph.D., co-director-Pennsylvania Infrastructure Technology Alliance (PITA).
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