Syllabus Phys 220: Advanced Physics Lab

Time: Tuesday 1:35-4:15pm, and Thursday 1:35:10-4:15pm.

This is a 3cr. laboratory class and hence you are expected to devote about 9-12hrs per week to this class.

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Contents:

In this class, we will cover the basics and some advanced concepts of experimental physics with a focus on electronics, computer programing, and computerized measurements. We will cover basics electronics such as transistors, OpAmp, A/D converters,…

You will learn in a practical hand-on fashion
- how to program an Arduino board to control stepping motors and to read out various sensors,
- how to write drivers for Python and Labview that let you use the Arduino board as an multi-purpose instrument
- how to program on a higher level in Labview,
- how to evaluate experimental data and compare them to models using Python.
- how to write a scientific paper or report using LaTeX
- how to communicate between different hardware components
- how to use basic instrumentation such as photodiodes, photomultipliers, temperature sensors, digital oscilloscopes, and lock-In amplifiers, stepping motors,….
- how basic electronic components such as transistors, operational amplifiers, solar cells,.. work

The class will be supplemented with in-lab lectures covering basic concepts of electronics, measurements, and data analysis.

The class will be capped with a project in which you will apply all those concepts to design an instrument that tracks the position of the sun and optimize the performance of a solar panel. The course is structured in such a way that you will learn the basic elements first and apply them as you may see fit for your final project.

Required Competencies: Basic Lab Skills as obtained in Phys 12 and 22. Basic Concepts of programming. Computer proficiency.

Final Competencies:
- Able to write programs in Labview, Python, and for the Arduino
- Demonstrate how these programming environments can interact.
- Ability to design and build an automated experiment.
- Ability to handle large data sets.
- Ability to come up with model and fit experimental data to this model.
- Ability to find creative solution with available resources
- Write coherent informative reports that can be understood by physics majors that have not taken the course yet.
- Keep a lab note book

Structure of the Course:
The structure of the course is best described by the goals that we want to achieve. Elements of that will be guided but most of them you will do at your own pace. Guidance will be provided through expected accomplishment for each posted on CourseSite

(1) Study the frequency and phase response of RC circuits using different approaches:
- "by hand" using a function generator and an oscilloscope. Here you will develop strategies how you can exploit the features of the oscilloscope to do that.
- "automatically" by developing a program that lets you set the frequency and read out phase and amplitude of the response.
- "automatically" using a Lock-In amplifier.
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(2) Measure the characteristics of an LED, transistors, and solar-cells. For that we start out doing this essentially by hand step by step but will ultimately do that measurements completely automatically using the Arduino board as a DAQ which is connected to your computer. With the computer we will collect, display, save, and evaluate the data using a higher programming language. We will do this both with Labview and Python. One the way, we need to address the following issues:
- Measure voltages using the Arduino
- How to switch on/off external voltages (transistor)
- How to create a DC voltage using the Arduino (RC circuitry)
- How to isolate the experiment from the Arduino (Operational Amplifier)
- How to write a driver for the Arduino that allows to control it from a computer
- Write programs in Python and Labview that allow to control the experiment, collect data, display data, save data, and fit data to a model.
- Write a paper about the experiment (Latex)

(3) Control of a stepping and servo motor to enable motion control

(4) Final project in which you define your own measurement task, design the experiment, and develop a model that describes the observed behavior.

Degree Requirements: This course is a required course for all Physics majors The course fulfills writing intensive requirement.

LabManual:
No formal lab manual exists yet. Since this is a writing intensive class, it is one of your tasks to collect some of the information needed from the Internet and collect them for future use. We will have some handouts but none of them will be to on the level "Do this, do this,…"
You will need to keep a lab-book to document what you are doing throughout the labs. The outcomes of the experiments are summarized in reports. These reports should be written on a level such that somebody could just use the report and do the respective activity. _In a sense, you are writing a lab manual_

Grades:
The basis for your grades will be your work in the lab as demonstrated in weekly reports and the Final Paper about your projects. The basis for your grade is the demonstration of the final competencies outlined above.

Lab Reports   **50pts**

Since this is a writing intensive course, your reports will be returned for revision. For the grades, the revised version will be most relevant but is expected that you don' t repeat errors that had been pointed out before. Late reports will not be accepted. Due dates will be communicated through the course site assignment. Typically due dates are on Tuesdays. You will receive revisions by Friday. Final Report will be due the following Tuesday, The reports are submitted using course site. The reports are written in the form of a scientific paper, user manuals, program documentations.
See for example https://www.nature.com/scitable/ebooks/english-communication-for-scientists-14053993/118519636#bookContentViewAreaDivID
to learn about what the expectations are

In the writing assignment, it will be specified who the expected reader will be. In no case will it be the instructor.

Labnote Book   **25pts**
A lab note book that describes your activities throughout the course must be kept. Have it signed by instructor once per week. (see document about note books)

Paper about final project: **25pts**
In this paper , you will be evaluated on creativity of your approach, success in executing your approach, defining model for the collected data, discussion of results, quality of paper in terms of structure, referencing, and clarity.

Total: **100pts**

COVID-19 Adjustment to the Course:

Clean your workplace before you start working
Wipe down equipment before and after you have used it.
Never come to the lab when you think you have symptoms

Accommodations for Students with Disabilities
Lehigh University is committed to maintaining an equitable and inclusive community and welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student with a disability must contact Disability Support Services (DSS), provide documentation, and participate in an interactive review process. If the documentation supports a request for reasonable accommodations, DSS will provide students with a Letter of Accommodations. Students who are approved for accommodations at Lehigh should share this letter and discuss their accommodations and learning needs with instructors as early in the semester as possible. For more information or to

request services, please contact Disability Support Services in person in Williams Hall, Suite 301, via phone at 610-758-4152, via email at indss@lehigh.edu, or online at https://studentaffairs.lehigh.edu/disabilities.

The Principles of Our Equitable Community:
 Lehigh University endorses The Principles of Our Equitable Community [http://www.lehigh.edu/~inprv/initiatives/PrinciplesEquity_Sheet_v2_032212.pdf]. We expect each member of this class to acknowledge and practice these Principles. Respect for each other and for differing viewpoints is a vital component of the learning environment inside and outside the classroom..