Physics 122&123

Physics of Medical Imaging: Magnetic Resonance

Spring Semester 2024

2-credit students: Register for PHY 122 only
3-credit students: Register for PHY 122 AND PHY 123

SYLLABUS (Please read carefully)

PHY 122&123 is an interdisciplinary course designed to apply principles of modern physics to the understanding of medical imaging technologies. It is primarily aimed at pre-health, pre-dental, and pre-med students, who typically do not major in physics or engineering. Nonetheless, it also offers a valuable opportunity for physics and engineering students to learn about the application of modern physics in medical diagnostics.

The curriculum builds on the fundamental concepts learned in introductory physics courses, covering topics like electromagnetism, basic quantum mechanics, and nuclear physics. The course will focus on Nuclear Magnetic Resonance (NMR) and nuclear physics-based imaging, technologies crucial to advanced medical diagnostics and research.

Learning Outcomes

We will start looking at the physical principles of NMR. Given its extensive use in medical imaging and spectroscopic analysis, understanding NMR is essential. We will learn how atomic spin directions are organized into a macroscopic magnetization by a magnetic field, and how this magnetization is manipulated using radio-frequency pulses.

A major goal of the course is to understand how T1-, T2-, and Proton Density (PD)-weighted images are created. We will examine the construction of echo sequences, understanding their structure, the reasoning behind their appearances, and the effects of different echo and repetition times on image contrast. We will also explore the molecular and tissue factors that influence T1 and T2 relaxation times in MRI. This understanding is necessary for accurate MRI interpretation. Time permitting, we may also cover additional topics in MRI like inversion recovery, gradient echo, basic gradient echo pulse sequences, or spatial and frequency encoding as well as more advanced techniques like for example fMRI.

Additionally, the course will feature a segment on nuclear imaging. We will look into the use of radio pharmaceuticals in emission imaging and study a range of techniques from simple planar imaging to more complex procedures like Single Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET).

Enrollment in PHY 122 (2 credits) along with the supplemental PHY 123 (1 credit) offers a comprehensive 3-credit experience of this course. Students opting for the 2-credit version will concentrate on MRI.

Instructor

Prof. Paola M. Cereghetti
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Office: LL 410
Office hours: Tuesday, after our 7:55am class. If you would like to meet before class, please e-mail me beforehand, I'm available as early as 7am, both on Tuesdays and Thursdays. For any other time, please e-mail me.

Class Meetings

Tuesdays and Thursdays: From 7:55am to 8:45am in room LL514.

For those enrolled in the 3-credit track, attendance is expected for all sessions during the whole semester. However, if you're a 2-credit student, your classes will span from week 1 through week 9, plus the final week of the semester for end-of-semester presentations. If you are in the 2-credit track and wish to present during week 9, please inform me. We will assess its feasibility, bearing in mind that you will be engaged with fresh content, which will limit the time you have available to prepare your presentation.

Textbook and Class Notes

While there is not a mandatory textbook for this course, I will be drawing from a diverse range of sources and will provide you with the necessary materials. If you are interested in further reading, here are some recommended books on the subject. On medical imaging in general:

Physics of Medical Imaging (3rd edition) by Jerrold T. Bushberg et al.

Introduction to Physics in Modern Medicine (2nd edition) by Suzanne Amador Kane et al.
This text is more basic, but stands out for its clear and concise presentation.

For more technique-specific books on the various imaging methods we will learn this semester:

MRI from Picture to Proton (2nd edition) by D.W. McRobbie et al.

Essentials of Nuclear Medicine Physics, Instrumentation, and Radiation Biology by Rachel A. Powsner et al.

These texts offer a broader and more in-depth exploration of the topics we will cover, and you might find them beneficial for a more comprehensive understanding.

Homework

Homework will be assigned once or twice a week (depending on the topic of Thursday's lesson, you may be given a short homework also on Tuesday). The homework will be in the form of reading assignments and/or problems pertinent to the imaging technique we are learning. Reading and problem solving are designed to help clarify the material, so make sure not to use generative AI to answer questions or solve problems. Homework has to be hand-written on the printed version provided in class.

Attendance

Attendance is mandatory and will count towards your course grade. Should you miss a class for a valid reason or other extenuating circumstances: 1. Let me know, possibly in advance, an e-mail is enough; 2. Make sure that you understand the material you missed and that you catch up with and hand in any missed group activity.

Semester Project

During the semester, you will work on a special topic to be presented at the end of the semester. Presentations for 2-credit students will last 8 minutes, while 3-credit students will have 12 minutes.

Quizzes

We will have in-class quizzes every one or two weeks. The quizzes will be very similar to the activities we will be doing in class, and I will let you know the specific content in advance. There will not be exams or final exams. The quizzes are necessary to motivate students to keep up with the material and build a good foundation to understand more advanced topics. If you miss a quiz for a valid reason, depending on the length, you can make up for it either Tuesday or Thursday before class, or Tuesday after class. If this is not possible, we will figure out something, but please do not make it a habit to miss quizzes, thank you!!

Use of Generative AI

Generative AI is very useful to organize your thoughts and check your English. However, unless in cases when I explicitly say that generative AI can be used for a specific activity or homework, Generative AI of any kind cannot be used. For your own good you should not use generative AI unless prompted. The scope of this class is to learn and retain new concepts and fundamental information in Physics of Medical Imaging, if you use generative AI to respond to homework assignments you will not get the practice that is required to understand the material.

Grading:

Your grade in the course will be determined based on class participation and attendance, homework, quizzes (no hour or final exams), and the quality of your final presentation project as follows:

Participation & Attendance	30%
Homework	20%
Semester's Quizzes	20%
Final Presentation Project:	30%

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.

Student Senate Statement on Academic Integrity

We, the Lehigh University Student Senate, as the standing representative body of all undergraduates, reaffirm the duty and obligation of students to meet and uphold the highest principles and values of personal, moral and ethical conduct. As partners in our educational community, both students and faculty share the responsibility for promoting and helping to ensure an environment of academic integrity. As such, each student is expected to complete all academic course work in accordance to the standards set forth by the faculty and in compliance with the University's Code of Conduct.