# Physics 120&121

# Physics of Medical Imaging: Ultrasound and Radiography

FALL SEMESTER 2023

*2-credit students: Register for PHY 120 only*
*3-credit students: Register for PHY 120 AND PHY 121*

## SYLLABUS (Please read carefully)

PHY 120&121 focuses on the ideas and concepts of modern physics as applied in medical imaging techniques, such as ultrasound imaging and radiography. While primarily tailored for pre-health, pre-dental, and pre-med students who may not traditionally major in physics or engineering, the course also welcomes physics and engineering majors eager to learn about this specific application of physics.

We'll begin our exploration with ultrasound imaging. This technique is rooted in the classical physics you've studied in courses like PHY 10&13 or PHY11&21. While this course won't equip you to diagnostically interpret medical images, by the end of our study on ultrasound, you'll be able to grasp key aspects of ultrasound imaging.

After ultrasound, we'll shift our focus to x-ray imaging. We'll first delve into the interactions between matter and radiation, and between matter and particles — these are fundamental for understanding the mechanics of radiographic images. We'll also touch on basic dosimetry concepts. Then, we'll discuss the generation of x-rays and how various parameters can be adjusted to produce the desired x-ray characteristics for different clinical scenarios. This will be more conceptual, you will not be able to operate an x-ray machine after our class! As we progress, we'll touch on more advanced x-ray imaging techniques such as CT-scans, Fluoroscopy, Angiography, and Mammography. To round off the semester, we will acquaint ourselves with the primary techniques in nuclear imaging. This course will not make you a radiologist, but you will gain a good idea for the essential physics behind the production of medical imaging in ultrasound, radiology, and nuclear medicine.

Enrollment in both PHY 120 (2 credits) and the supplemental PHY 121 (1 credit) offers students a comprehensive 3-credit version of this course. However, those students who choose the 2-credit track will be limited to covering ultrasound imaging and a selection of radiography topics.

**Learning Outcomes**

This course builds upon the foundational knowledge students have acquired in introductory physics courses, which covered classical mechanics, electromagnetism, and basic quantum mechanics. Through this curriculum, students will gain an understanding of several medical imaging technologies and delve deeper into topics such as sound propagation, light-matter interaction, particle-matter interaction, and nuances of atomic and nuclear physics. This includes piezoelectricity, generation of high-energy electromagnetic radiation through Bremsstrahlung, atomic structure, photon emission and absorption, and photon-electron interactions like the Compton effect. Although the material is tailored to a 100-level course and will not replace the more advanced content of 200 or 300-level physics courses, it serves as a valuable introduction to these higher-level topics.

**Instructor**

Prof. Paola M. Cereghetti
pmc5@lehigh.edu
Office: LL 410
Office hours: If you'd like to meet before class, please e-mail me beforehand. I'm available as early as 7am. However, I teach PHY 010 from 9:20am to 10:10am on Tuesdays and Thursdays, so I'll have to leave promptly after our class to attend to it. For alternate meeting times, please e-mail me. Thank you!

**Class Meetings**

Tuesdays and Thursdays: From 7:55am to 8:45am in room LL511.

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're in the 2-credit track and wish to present during week 9, please inform me. We'll assess its feasibility, bearing in mind that you'll 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'll be drawing from a diverse range of sources and will provide you with the necessary materials. If you're 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:

*The Physics and Technology of Diagnostic Ultrasound: A Practitioner's Guide* by Robert Gill.

*Radiography in the Digital Age: Physics, Exposure, Radiation Biology* by Quinn B. Carroll.

*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'll 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 before the start of the next class or after the next class while I am teaching PHY 010. 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:

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| 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.