New York City College of Technology
The City University of New York
Department of Physics

Syllabus PHYS 2603

Course Title

Physical Principles of Medical Imaging

Course Description

We will discuss the physical principles underlying medical imaging, the methods and technology used to noninvasively obtain information about the human body for diagnostic and therapeutic purposes. The focus is on ultrasound, X-ray and magnetic resonance imaging (MRI). We will discuss the nature of sound and electromagnetic radiation as well as the acoustic and electromagnetic properties of matter relevant for image formation. We will also discuss the principles of computed tomography, a technique used to create three-dimensional images of the internal organs. In addition, we will study the basic structure of ultrasound transducers, X-ray tubes and detectors, and MRI scanners. The laboratory component of the course is composed of experiments which provide opportunities for practical study and applications of the principles discussed in the lectures.

Required Text

Introduction to Physics in Modern Medicine, 2nd edition
Author: Suzanne Amador Kane
Publisher: CRC Press
ISBN: 9781584889434

Recommended reading will be listed on Blackboard and discussed in class.

Grading and Attendance Policies

Grading is based on class participation and attendance, homework assignments, in-class examinations and performance of laboratory experiments. The homework will contain reading and problem-solving assignments from the textbook and other sources. There will be one in-class midterm and one in-class final exam. The laboratory component consists of experiments which students perform in groups. The final grade for the course is calculated as follows:

Homework assignments	10%
Midterm exam	30%
Final exam	30%
Laboratory experiments	30%

The letter grade will be assigned according to the following:

A	93-100	C+	77-79.9
A-	90-92.9	C	70-76.9
B+	87-89.9	D	60-69.9
B	83-86.9	F	0-59.9
B-	80-82.9		

In accordance with college policy, the number of permissible absences is two for lectures and one for labs. Additional absences may result in a "WU" grade.

Weekly Lecture Calendar

Week	Topic	Assignment
1	Course overview. Wave motion. Sound waves. Ultrasound.	Ch. 1; 4.1, 4.2
2	Pulse-echo principle. Acoustic impedance. Transducers.	Ch. 4.3-4.7
3	Image formation. Ultrasound absorption. Ultrasound scanners.	Ch. 4.8-4.9
4	Image quality and artifacts. Safety. Applications of ultrasound.	Ch. 4.10-4.17
5	Electromagnetic waves. Spectrum. Diagnostic X-rays.	Ch. 3.3; 5.1, 5.2
6	Interaction of X-rays with matter. X-ray image formation.	Ch. 5.3-5.5
7	X-ray tubes and detectors. Medical applications.	Ch. 5.6-5.8
8	Digital radiography. Computed tomography (CT).	Ch. 5.9-5.11
9	Midterm Exam	
10	Magnetism. Nuclear magnetic resonance. Radio frequency (RF) waves.	Ch. 8.1-8.3
11	Spin precession. Larmor frequency. Free induction signal.	Ch. 8.3
12	MRI contrast mechanism. Relaxation times. Spin echoes.	Ch. 8.4, 8.5
13	Image formation. Field gradient.	Ch. 8.6
14	Applications. Artifacts. Safety.	Ch. 8.7-8.11
15	Final Exam	

Laboratory Experiments

Lab	Topic
1	Introduction
2	Ultrasonic echoscope and ultrasonic transducers
3	Acoustic impedance
4	Ultrasound absorption
5	Ultrasound imaging: B-scans
6	Fluorescence of a luminous screen due to X-rays
7	Energy spectrum of an X-ray tube
8	Attenuation of X-rays: the absorber material and thickness dependence
9	Attenuation coefficient: dependence on the atomic number Z
10	X-ray computed tomography (CT)
11	Basic NMR signal acquisition
12	Spin lattice (longitudinal) relaxation
13	Spin-echoes and spin-spin relaxation
14	Magnetic resonance imaging in 1D
15	Final

Course-specific learning outcomes

Upon completion of this course a student will be able to:

1. Describe the physical principles of ultrasound, x-ray and magnetic resonance imaging methods.
2. State the basic principles of the tomographic techniques used in computed tomography.
3. List the positive and negative sides of each of the three imaging modalities.
4. Discuss basic safety issues relevant for each of the three imaging modalities.

General education learning outcomes

Upon completion of this course a student will be able to:

1. Describe the elements of the scientific method and its significance to scientific discoveries, the development of models, and the formulation of scientific theories.
2. Employ pictorial, graphical and mathematical methods to simplify and solve problems relevant to real-world applications.
3. Acquire and practice basic laboratory skills including gathering, analyzing and interpreting data.
4. Practice communication and writing skills in class discussions, preparation of written laboratory reports, and independent project work.
5. Practice collaborative work during laboratory activities.

Pathways learning outcomes

Upon completion of this course a student will be able to:

1. Describe the elements of the scientific method and its significance to scientific discoveries, the development of models, and the formulation of scientific theories.
2. Employ pictorial, graphical and mathematical methods to simplify and solve problems relevant to real-world applications.
3. Acquire and practice basic laboratory skills including gathering, analyzing and interpreting data.
4. Practice communication and writing skills in class discussions, preparation of written laboratory reports, and independent project work.
5. Practice collaborative work during laboratory activities.

Accessibility Statement

City Tech is committed to supporting the educational goals of enrolled students with disabilities in the areas of enrollment, academic advisement, tutoring, assistive technologies and testing accommodations. If you have or think you may have a disability, you may be eligible for reasonable accommodations or academic adjustments as provided under applicable federal, state and city laws. You may also request services for temporary conditions or medical issues under certain circumstances. If you have questions about your eligibility or would like to seek accommodation services or academic adjustments, please contact the Center for Student Accessibility by phone 718-260-5143, or online at http://www.citytech.cuny.edu/accessibility/ .