PHYS 2603 – Physical Principles of Medical Imaging

Course Description:
This course provides an introduction to physical principles and methods of medical imaging. The course focuses on the ultrasound, x-ray and magnetic resonance imaging. The nature of sound and electromagnetic waves are discussed. Interactions of sound and X-ray radiation with matter relevant for the image formation are considered. Underlying principles of magnetic resonance imaging (MRI) are discussed. An introduction to computed tomography (CT) techniques is provided. The course is a combination of lectures and demonstrations. The course includes a laboratory component.

Prerequisite: RAD 2326 or PHYS 1433

Required Text: Introduction to Physics in Modern Medicine, 2nd edition, S. A. Kane, CRC Press.

Instructional Objectives (Learning Outcomes):
The goal of the course is to introduce students to the scientific principles underlying diagnostic medical imaging methods and technology. The course is designed to provide students with qualitative and quantitative understanding of the nature of sound and electromagnetic radiation as well as the acoustic and electromagnetic properties of matter relevant for image formation. The laboratory component of the course is designed to provide students with opportunities for practical study of the physical principles discussed in lectures.

For the successful completion of this course students should be able to:
1. Describe the main physical characteristics of sound and electromagnetic radiation.
2. Discuss magnetic properties of subatomic particles and their interaction with magnetic fields. Explain basic principles of nuclear magnetic resonance.
3. Describe the image formation and acquisition techniques for ultrasound, X-ray and magnetic resonance imaging, including computed tomography methods.
4. Describe basic structure of ultrasound transducers, X-ray tubes and detectors, and MRI scanners.
5. List the positive and negative sides of each of the three imaging modalities.
6. Understand safety issues associated with each of the imaging modalities.

Assessment:
Students' assessment will be based on class participation, homework assignments, in-class examinations and laboratory reports. The final grade for the course is calculated as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Homework assignments</td>
<td>20%</td>
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<tr>
<td>Midterm exam</td>
<td>30%</td>
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<td>Final exam</td>
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<tr>
<td>Laboratory reports</td>
<td>20%</td>
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Course Outline
Lectures: 2 hours/week
Week 1: Course overview. Wave motion. Chapters 1; 4.1, 4.2
Week 2: Ultrasound. Acoustic Impedance. Transducers. Chapters 4.3-4.6
Week 3: Image formation. Pulse-echo technique. Ultrasound scanners. Chapters 4.7-4.9
Week 5: Electromagnetic waves. Spectrum. Diagnostic X-rays. Chapters 3.3; 5.1, 5.2
Week 6: Interaction of X-rays with matter. X-ray image formation. Chapters 5.3-5.5
Week 7: X-ray tubes and detectors. Applications. Chapters 5.6-5.8
Week 8: Digital radiography. Computed tomography (CT). Chapters 5.9-5.11
Week 9: Midterm Exam
Week 11: Spin precession. Larmor frequency. Free induction signal. Chapters 8.3
Week 12: MRI contrast mechanism. Relaxation times. Spin echoes. Chapters 8.4, 8.5
Week 13: Image formation. Field gradient. Chapters 8.6
Week 15: Final Exam

Laboratory work: 2 hours/week
Week 2: Waves on a string.
Week 3: Acoustic waves.
Week 4: Ultrasonic echoscope.
Week 5: Spectroscopy.
Week 6: Dispersion of light. Index of refraction.
Week 7: X-ray tube.
Week 8: X-ray detector.
Week 9: Radiography with visible light.
Week 10: Computed tomography (CT).
Week 11: Magnetic moment in a magnetic field.
Week 12: Electromagnetic induction.
Week 13: Electron paramagnetic resonance.
Week 14: Simplified MRI. Simulation.
Week 15: Oral presentation.

Academic Integrity Policy Statement
Students and all others who work with information, ideas, texts, images, music, inventions, and other intellectual property owe their audience and sources accuracy and honesty in using, crediting, and citing sources. As a community of intellectual and professional workers, the college recognizes its responsibility for providing instruction in information literacy and academic integrity, offering models of good practice, and responding vigilantly and appropriately to infractions of academic integrity. Accordingly, academic dishonesty is prohibited in The City University of New York and at New York City College of Technology and is punishable by penalties, including failing grades, suspension, and expulsion.

College Policy on Absence/Lateness
A student may be absent without penalty for 10% of the number of scheduled class meetings during the semester as follows:

Class Meets Allowable Absences
1 time/week 2 classes
2 times/week 3 classes
3 times/week 4 classes