Jordan University of Science and Technology
Faculty of Engineering
Biomedical Engineering Department

BME 561 Medical Imaging Systems

Course Catalog
3 Credit hours (3 h lectures, Department Elective). This course introduces the physics, instrumentation, the diagnostic methods, signal processing methods, image characteristics and the biological effects in X-ray (projection radiography), X-ray computed tomography, nuclear medicine (SPECT/PET), ultrasound imaging, and magnetic resonance imaging.

Text Book(s)	
Title	Medical imaging: signals and systems.
Author(s)	J. L. Prince and J. M. Links
Publisher	Prentice Hall
Year	2006
Edition	2 nd edition, ISBN 0-13-065353-5

References	
Books	• Fundamentals of Medical Imaging , Paul Suetens, Cambridge University Press, 2009, ISBN: 0521519152, 9780521519151 • Introduction to biomedical imaging, Andrew Roy Webb, Wiley, 2003. ISBN: 0471237663, 9780471237662. • Introduction to Medical Imaging: Physics, Engineering and Clinical Applications, Nadine Barrie Smith, Andrew Webb, Cambridge University Press, 2010. ISBN: 0521190657, 9780521190657.
Software	• Matlab7.0 +: http://www.mathworks.com

Objectives and Outcomes

Objectives	Outcomes
1. Explain the basic principles of x-ray, CT scan, Ultrasound, Nuclear imaging and MRI as an imaging modality.	➢ Understand the general differences between different medical imaging systems. (a, m)
2. Analyze the above mentioned imaging systems in terms of physical mechanisms, data	➢ Comprehend the generation of different signals from different medical imaging system and its interactions with the human body. (a, e, m)

generation and acquisition, image construction, processing and quality.	➢ Know the different imaging parameter for each system. The principle behind them, how to control them and how is this can affect the image appearance. (a, e, m) ➢ Understand the theory and practical construction of every imaging system discussed. (a, e, j, k, m). ➢ Understand the relationship between image parameters for each system and its interaction with human tissues.
3. List strengths and weaknesses associated with every imaging system studied.	➢ Know the specific clinical applications of all imaging systems. The student should be able to choose the best imaging system for specific clinical application. (a, c, f, h, i, j, k)
4. Encourage Long Life Learning, foster team work and enhance students communication skills	➢ Write technical report and give oral presentation on team work project

Topics Covered		
Week	**Topics**	**Chepters in Text**
1	Overview of various medical imaging modalities (Ch. 1); Review of signals and systems basic concepts (Ch. 2); Image quality metrics (Ch. 3)	Chapters 1-3& lectures notes
2-3	Physics of radiography	Chapter 4
3-4	Projection radiography	Chapter 5
4-5	Computed tomography (CT): Instrumentation; Image reconstruction (Radon transform, back projection, filtered back-projection); Image quality.	Chapter 6
6	Digital Radiography	Lecture notes
7-8	The Physics of Nuclear Medicine	Chapter 7
8-9	Planar Scintigraphy	Chapter 8
10-11	Emission Computed Tomography	Chapter 9
12-13	Physics of Ultrasound	Chapter 10
14	Ultrasound Imaging,	Chapter 11
15	Physics of Magnetic Resonance	Chapter 12
16	Magnetic Resonance Imaging (MRI) systems: instrumentation, data acquisition, image reconstruction, image quality. Functional MRI	Chapter 13

Evaluation		
Assessment Tool	**Expected Due Date**	**Weight**
Homework, Quizzes, Project	One week after the problems are assigned	10%
First Exam	According to BME dept. schedule	25 %
Second Exam	According to BME dept. schedule	25 %
Final Exam	According to the University final examination schedule	40 %

Teaching & Learning Methods
- Active learning, where students should be active and involved in the learning process inside the classroom, will be emphasized in the delivery of this course. - Different active learning methods/approaches such as: Engaged Learning, Project-Based Learning, Cooperative Learning, Problem-based Learning, Structured Problem-solving, will be used. - The teaching method that will be used in this course will be composed of a series of mini lectures interrupted with frequent discussions and brainstorming exercises. PowerPoint presentations will be prepared for the course materials. - A typical lecture would start with a short review (~ 5 minutes) using both PowerPoint presentations and the blackboard. This review will also depend on discussions which will gauge the students' digestion of the previous material. Then, the students would have a lecture on new materials using PowerPoint presentations and blackboard. The lecture presentation will be paused every 15 – 20 minutes with brainstorming questions and discussions that will allow the students to reflect and think in more depth about what they learned in that presentation. Then, some example problems will be presented and discussed with the students to illustrate the appropriate problem solving skills that the students should learn. The lecture will be continued for another 15 – 20 minutes, followed by examples and/or a quiz covering the materials taught in the previous two weeks.

Policy	
Attendance	Attendance will be checked at the beginning of each class. University regulations will be strictly followed for students exceeding the maximum number of absences.
Quizzes	Quizzes will be part of this course. No make-up quizzes will be conducted
Student Conduct	It is the responsibility of each student to adhere to the principles of academic integrity. Academic integrity means that a student is honest with him/herself, fellow students, instructors, and the University in matters concerning his or her educational endeavors. Cheating will not be tolerated in this course. University regulations will be pursued and enforced on any cheating student. Lab coat wearing is compulsory during the experiments' conduct.

Contribution of Course to Meeting the Professional Component
➢ Apply knowledge of biological and physical sciences, mathematics, and engineering to solve problems at the interface of engineering and biology. ➢ Design a Biomedical Engineering system, component, and/or process that meet specific needs; and demonstrate understanding of relevant technical, professional, and ethical issues. ➢ Function on multi-disciplinary teams. ➢ Communicate effectively in verbal, written, and graphical formats. ➢ Identify, formulate, and solve Biomedical Engineering problems that address contemporary issues within a global, societal, and economic context. ➢ Recognize the need to pursue continuing educational opportunities in Biomedical Engineering and have the ability to do so.

ABET Category Content	
Engineering Science	2 Credit Hour
Engineering Design	1 Credit Hours

Relationship to biomedical Engineering Program Objectives	
	All of the course objectives contribute to the program objectives.

Medical Imaging Signals and Systems BME 561 Projection Radiography Chapter 5. Lecture Outline â€¢ Instrumentation â€“ X-ray tube configuration â€“ Filtration and restriction of x-ray photons â€“ Compensation and Scatter control â€“ Film screen detector â€¢ Image formation â€“ Geometric effect â€“ Extended source â€“ Detector/film response â€¢ Image quality â€“ Contrast and SNR â€“ Effect of noise and Compton scattering. Overview. Radiographic System. X-ray Tube. X-Ray Tube Components. Solution Manual for Medical Imaging Signals and Systems, 2nd edition, Prince, Links. Signals and Systems 2nd(Simon Haykin).pdf. Signal and systems. Signals and Systems 2nd(Simon Haykin).pdf. Signal and systems. MEDICAL IMAGING. Medical imaging is the technique and process of creating visual representations of the interior of a body for clinical analysis and medical intervention, 32372430 Signals Systems 2nd Edition 1997 Oppenheim Solution Manual 1. DescriÃ§Ã£o completa.Â Chapter 2: signals and systems. 4. where bX c is the greatest integer that is smaller than or equal to X . We also have ZX ZY 1 Î´s2 (x, y) dx dy Pâˆž (Î´s) = lim lim X â†'âˆž Y â†'âˆž 4X Y âˆ'X âˆ'Y ZX ZY X âˆž âˆž X 1 Î´(x âˆ' m, y âˆ' n) dx dy = lim lim X â†'âˆž Y. Medical imaging also establishes a database of normal anatomy and physiology to make it possible to identify abnormalities. Although imaging of removed organs and tissues can be performed for medical reasons, such procedures are usually considered part of pathology instead of medical imaging.Â Medical imaging is often perceived to designate the set of techniques that noninvasively produce images of the internal aspect of the body. In this restricted sense, medical imaging can be seen as the solution of mathematical inverse problems.Â hydrogen nuclei to produce measurable signals, collected through an RF antenna. Like CT, MRI traditionally creates a two dimensional image of a thin "slice" of the body and is therefore considered a tomographic imaging technique. With signal processing as its foundation, Medical Imaging Signals and Systems , Second Edition covers the most important imaging modalities in radiology: projection radiography, x-ray computed tomography, nuclear medicine, ultrasound imaging, and magnetic resonance imaging. Organized into parts to emphasize key overall conceptual divisions, Medical Imaging is most appropriate for engineering students who have taken the prerequisite signals and systems courses as well as elementary probability. This program presents a better teaching and learning experienceâ€"for you and your students. Teach with Understand systems from a signals viewpoint: input signal system or process output signal Jerry L. Prince (Johns Hopkins University) Medical Imaging Signals and Systems August 20, 2009 7 / 412 Introduction to Medical Imaging Systems Overall Perspective A Signal Example Example Input signal: j(x. y) is the linear attenuation coecient for x-rays Process (integration over x variable): g(y) =. j(x. y)dx Output signal: g(y) Jerry L. Prince (Johns Hopkins University) Medical Imaging Signals and Systems August 20, 2009 8 / 412 Introduction to Medical Imaging Systems Possible objectives Possible objec