COURSE CATALOG FORM

Course Code: BMED4512				**Course Name**: Medical Imaging			
Semester	**Lc + T + L**	**Credit**	**ECTS**	**Language**	**Category**	**Instructional Methods**	**Pre Requisites**
7	(3+0+0)	3	5	English	Core	Lecture	ELEC2501
Course Objectives	This course aims to provide an introduction to the physics and engineering of the major imaging modalities in current use in hospitals. These are X-rays, including computed tomography (CT), ultrasound, magnetic resonance imaging (MRI), radionuclide imaging. It is offered at an introductory level; the only prerequisites are statistics, mathematics, MATLAB experience, and an introduction to electricity, optics, ultrasound, and magnetism. The course is a combination of lectures and demonstrations using MATLAB with an emphasis on a take-home project. The course aims at different medical imaging modalities and their limitations and advantages.						
Course Content	Fundamentals of medical imaging. Medical image processing. X-ray imaging and Computed Tomography (CT). DSA Imaging. Fluoroscopy. Mammography. Magnetic PET/SPECT Imaging, Resonance Imaging (MRI). Ultrasound Imaging. Color Doppler echocardiography.						
Course Learning Outcomes	1. Explain the basic knowledge of the commonly used and emerging biomedical imaging modalities 2. Recognize safety aspects of imaging with ionizing and non-ionizing radiation. 3. Describe the classical NMR physics, Bloch equations, signal detection concepts, signal acquisition: FID and echo techniques, Multi-dimensional Fourier imaging, and k-space. Signal, contrast, and noise of MRI 4. Discuss the physics of acoustics (waves and wave propagation) and ultrasound pressure field formation. Clear overview to image formation using array technology, focusing, advanced beamforming, 5. Provide small practical assignments in the fundamental analytical and computational tools as image registration, mathematical morphology, texture analysis, pattern recognition using MATLAB						
ISCED Category of the course	52 – Engineering						
Textbook	Medical Imaging Signals and Systems, Jerry Prince, Jonathan Links, Pearson, 2nd ed., 2015.						
Other References	Digital image processing for medical applications, G. Dougherty, Cambridge, 2009. Introduction to Medical Imaging, N.B. Smith and A. Webb, Cambridge, 2010. Introduction to Biomedical Imaging, A. Webb, Wiley, 2003.						

COURSE PLAN

Week	**Topics**
1	Fundamental principles of medical imaging modalities. Energy sources and tissue properties captured in medical imaging. General image characteristics (Imaging System Performance). Imaging Performance Measures (Rose Model)
2	Specificity, sensitivity and the receiver operating characteristic. (ROC) curve Spatial Resolution Line Spread Function of Medical Imaging Systems. X-Ray Computed Tomography and DSA Point Spread Function and Modulation Transfer Function.
3	Signal-to-Noise Ratio of a medical image. Image Contrast. Contrast-to-noise Ratio. Wiener Spectrum. 2-D Convolution of the image. Dynamic Range and Resolution. 2D Fourier Transform Image Filtering using MATLAB. Low-pass and high pass filtering using masks
4	Backprojection, sinograms, Radon Transform, filtered back-projection and inverse of 2D Fourier Transform with MATLAB implementations.

5	X-Ray Matter Interaction, Lambert-Beer's Law, Image Intensifier, X-Ray 2D Planar Imaging, Noise in X-Ray Imaging, X-ray Detectors. Fluoroscopy, Mammography, Digital Subtraction Angiography (DSA), Computed Tomography, Reconstruction of multi-slice helical CT scans
6	Digital X-ray tomosynthesis. Tomosynthesis Reconstruction Methods. Radiation and Effective Dose. Safety aspects of imaging with ionizing and non-ionizing radiation associated with imaging modalities and understand the types of diagnostic problems that each modality can address.
7	Midterm
8	Radiation doses from common planar radiography and CT scans Performance of Different X-Ray Detector Technologies Nuclear medicine: Planar scintigraphy, SPECT and PET/CT Preprocessing algorithm program PET/CT PET/CT Fusion Radioactivity and radiotracer half-life Compton scattering
9	The physics of acoustics (waves and wave propagation) ultrasound pressure field formation, including reflection, diffraction, and scattering. Image formation using array technology, focusing, advanced beamforming, 3-D ultrasound, and plane-wave imaging techniques, The concept of speckle noise, speckle statistics, and its relation to tissue morphology and techniques for speckle reduction and image enhancement
10	Midterm II/Take-home Project
11	Classical NMR mode: nucleus in a magnetic field, rotating reference frame & resonance, Bloch equations, signal detection concepts, signal acquisition: FID and echo techniques, Multi-dimensional Inverse Fourier imaging, and k-space. Signal, contrast, and noise of MRI, Basic sequence design
12	The single-coil acquisition process of MR data. The multiple-coil acquisition process of MR data, noise distribution function in MRI. MR Specifications, Diffusion Tensor Imaging, Tractography. Closed bore MRI scanner architecture and Electromagnets. A high-field open MRI system. GE/Siemens and other Medical Systems. Gradient coils and Spinal phased array coil Cardiac MRI MRI Safety.
13	Provide small practical assignments in the fundamental analytical and computational tools as image registration, mathematical morphology, texture analysis, pattern recognition using MATLAB.
14	Project Oral Presentations

COURSE ASSESMENT AND ECTS WORK LOAD

ACTIVITIES	**Quantity**	**Time (h)**	**Work Load**
Lectures	14	3	42
Final Exam (Preparation included)	1	15	15
Quizzes	1	10	10
Homework	1	10	10
Midterm Exams (Preparation included)	1	15	15
Project (Report, Presentation)	1	20	20
Out class working time	1	20	15
		Total Work Load	127
		ECTS Credits (Total Work Load / 25)	5

PROGRAM OUTCOMES - COURSE OUTCOMES RELATIONS		
PO	**Program Outcomes**	**CO**
1	**1.1.** Adequate knowledge in fundamentals of mathematics (algebra, differential equations, integrals, probability etc), science (physics, chemistry, biology etc.) and computer science (programming and simulation);	1,3,4
	1.2. ability to use theoretical and applied knowledge in these areas in complex engineering problems.	1, 5
2	**2.1.** Ability to identify, formulate, and solve complex engineering problems;	2, 3, 4, 5
	2.2. ability to select and apply proper analysis and modeling methods for this purpose.	2, 3, 4, 5

Revision Date	Prepared by	Approved by
30/01/2022	Asist. Prof. Rüştü Murat Demirer	Prof.Dr. Ahmet Aksen