COURSE CONTENT

(1) GENERAL INFO

SCHOOL	ENGINEERING		
DEPARTMENT	BIOMEDICAL ENGINEERING		
MSc PROGRAM	BIOMEDICAL ENGINEERING AND TECHNOLOGY		
STUDY LEVEL	POSTGRADUATE, MSc		
COURSE CODE	**BMET201**	SEMESTER	**B**
COURSE TITLE	**Diagnostic Medical Imaging Systems**		

TEACHING	HOURS	ECTS
LECTURES AND WORKSHOPS	39	5

COURSE TYPE	SPECIALIZATION
COURSE REUIREMENTS:	-
TEACHING AND EXAMINATION LANGUAGE:	ENGLISH
IS THIS COURSE OFFER TO ERASMUS STUDENTS	YES (IN ENGLISH)
COURSE WEBPAGE (URL)	https://eclass.uniwa.gr/courses/315/

(2) LEARNING OUTCOMES

Learning outcomes

Course Objectives:
The purpose of this course is to study the basic structure of diagnostic medical imaging systems that use non-ionizing and ionizing radiation. The basic parts (block diagrams) of various diagnostic imaging systems such as Ultrasound and Magnetic Resonance Imaging (MRI) scanners as well as the general radiology (Diagnostic x-ray, Mammography and Computed Tomography-CT) and Nuclear Medical Imaging (γ- camera, SPECT and PET) systems will be analyzed.

In addition, specialized knowledge related to:
-physical principles of ultrasound generation and propagation
-physical principles of magnetic resonance, superconductivity
-Interactions of high energy photons (X-rays and γ-rays) and high-energy particles with matter.
-Interactions of x-ray production and methods of radioisotope production
-types of radioactivity and radiation attenuation through tissues and detectors
-imaging techniques for energy integration detectors (used in x-ray detectors)
-photon counting imaging techniques (used in nuclear imaging, γ-ray detectors) will be provided.

The course includes a laboratory exercise in photon-gamma spectroscopy with a sodium iodide detector NaI:Tl and individual projects and oral presentations on modern and combined medical imaging methods.

Learning Outcomes:
Students will be able to distinguish and compare different methods of various diagnostic Medical Imaging systems, to understand the basic principles of their operation and to evaluate imaging systems knowing the spatial resolution limit of them.

Upon completion of the course, students will have:
1. Deep knowledge of the basic principles of physics regarding ultrasound, magnetic resonance, photon interactions (X-ray and gamma-ray) with matter and high-energy particle interactions with matter.
2. A comprehensive understanding of the scientific field of ionizing and non-ionizing radiation diagnostic medical imaging systems.
3. The ability to describe and distinguish all the individual parts (block diagrams) of described diagnostic medical imaging system.

4. Understand in a deep way the operational principles of each imaging system in order to be able to make a comparative evaluation among them.
5. In addition, students will have developed research abilities and collaborative activities through of a literature/review study and oral presentations, and experimental skills in γ-photon spectroscopy calibration of a sodium iodide (NaI:Tl) scintillator detector.

Achievement of Course Objectives and Learning Outcomes:
To fulfill the above learning outcomes, students will initially be taught physical concepts used in diagnostic non-ionizing radiation imaging such as Ultrasound (US) and Magnetic Resonance Imaging (MRI) systems. The basic parts (block diagrams) that consist of those systems will be analyzed and emphasis will be placed on understanding the common and individual parts of each one.

Next, the ionizing radiation diagnostic imaging systems will be analyzed with emphasis on the techniques used in general radiology (anatomical information) and nuclear medicine imaging systems (functional information).
Special emphasis will be given to the imaging detectors technology used:
-Energy integration techniques (x-ray detectors, CT, Mammography); and
-photon counting techniques (γ-ray detectors, γ-camera, SPECT, PET)

Finally, the course will include an experimental laboratory exercise on gamma ray spectroscopy with a scintillation based sodium iodide (NaI:Tl) detector that students will be learn to calibrate using various radioactive isotopes. Furthermore, literature research/review topics on modern combined imaging methods (such as PET/CT, PET/MRI, whole body PET etc.) will be orally presented by the students.

General abilities

- Search, analysis and synthesis of data and information, using the necessary technologies
- Adaptation to new situations
- Decision-making
- Autonomous work
- Teamwork
- Working in an international environment
- Working in an interdisciplinary environment

(3) COURSE CONTENT

"Physical principles of ultrasound generation and propagation, diagnostic ultrasound imaging systems"
Fundamental concepts of US wave propagation, piezoelectric effect, piezoelectric crystals, ultrasound transducers, types of US imaging: A-mode, B-mode, M-mode, Doppler effect, 3D and 4D imaging, signal analysis and examples of US clinical imaging.

"Physical principles of magnetic resonance, superconductivity, description of magnetic resonance imaging scanners"
Fundamental concepts of magnetic resonance physics, block diagram of MRI scanners, superconductivity effect, MR coils, signal acquisition and analysis, MR imaging methods, magnetic resonance spectroscopy, MR contrast agents and examples of MRI clinical imaging.

"Interactions of photons (X-rays and gamma rays) and high-energy particles with matter"
Interactions of x-ray production, radioisotope production, photoelectric effect, scatter effects, pair production, annihilation effect, radioactivity, types of radioactivity and radiation attenuation in tissues and detectors. Differences among morphological/anatomical and functional imaging.

"Diagnostic X-ray imaging systems"
X-ray tubes, X-ray spectrum, basic structure of a general X-ray imaging systems, mammography, computed tomography systems, fundamental concepts in image science, image reconstruction techniques, image quality and quality control, examples of X-ray clinical medical imaging.

"Nuclear Medicine Diagnostic Imaging Systems"
Radiopharmaceuticals and radioisotopes, block diagram of a gamma camera, single-photon emission computed tomography (SPECT) scanners and positron emission tomography (PET) scanners. Image reconstruction techniques, image quality and quality control, examples of clinical nuclear medical imaging, combined PET/MRI and PET/CT systems. Laboratory exercise on calibration and gamma-ray spectroscopy using a NaI:Tl scintillation detector.

(4) TEACHING AND LEARNING METHODS - EXAMINATIONS

COURSE DELIVERY	Physical presence, face to face at the auditorium or laboratory
USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES	The theoretical part of the course involves the use of a projector for presenting fundamental concepts and is supplemented by the use of the blackboard at the auditorium. The laboratory part of the course will be conducted in the laboratory and includes the calibration of a NaI:Tl scintillation detector with experimental measurements of different radioactive sources by the students as well as a demonstration of the individual parts of the Nuclear Medical Imaging detectors.
TEACHING ORGANIZATION	see table below
STUNDET EVALUATION	50-70% final examination with multiple choice questions, short answer questions, and problem-solving questions. 20-40% technical report and/or hands-on examination in the laboratory. 10-20% Team assignment and oral presentation.

TEACHING ORGANIZATION

Activity	*Semester workload*
Teaching / lectures	39
Lecture material study	30
Unsupervised literature review and preparation of the final project	56
Total	***125***

(5) SUGGESTED LITERATURE

Books, scientific articles and related scientific resources:

[1] Nuclear Medicine Physics/A Handbook for Teachers and students of IAEA, 2014.
[2] Foundations of Biomedical Ultrasound, by R. Cobbold, Oxford University Press, USA (ISBN 13: 978-0195168310).
[3] Diagnostic Radiology Physics, by Dance, D.R., Christofides, S., Maidment, A.D.A., McLean, I.D., Ng, K.H.
[4] Diagnostic Ultrasound Imaging: Inside Out, by T. Szabo, 2nd Edition, Academic Press, Inc. (ISBN 9780123964878).
[5] G. F. Knoll, Radiation Detection and Measurement, John Wiiley and Sons, New York, 1979.
[6] A. G. Webb, "X-ray imaging and computed tomography," in Introduction to Biomedical Imaging, S. V. Kartalopoulos, Ed., pp. 253–274, John Wiley & Sons, New Jersey, 2003.
[7] S. Vandenberghe, P. K Marsden, "PET-MRI: A review of challenges and solutions in the development of integrated multimodality imaging" *Physics in Medicine and Biology*, 60 (4), 2015.

Scientific journals:

[1] BMC Medical Imaging, https://bmcmedimaging.biomedcentral.com/
[2] Medical Physics, https://norcaloa.com/BMIA.

[3] International Journal of Biomedical Imaging, https://www.hindawi.com/journals/ijbi/.
[4] Journal of Medical Imaging, https://www.spiedigitallibrary.org/journals/journal-of-medical-imaging?SSO=1.