

Academic Year: ( 2023 / 2024 )

Review date: 19-12-2023

Department assigned to the subject: Bioengineering Department

Coordinating teacher: ABELLA GARCIA, MONICA

Type: Electives ECTS Credits : 6.0

Year : 4 Semester :

**REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)**

Physics, Electronics, instrumentation and Control and Image processing and reconstruction

**SKILLS AND LEARNING OUTCOMES**

RA3: Be able to carry out conceptual designs for bioengineering applications according to their level of knowledge and understanding, working in a team. Design encompasses devices, processes, protocols, strategies, objects and specifications broader than strictly technical, including social awareness, health and safety, environmental and commercial considerations.

RA4: Be able to use appropriate methods to carry out studies and solve problems in the biomedical field, commensurate with their level of knowledge. Research involves conducting literature searches, designing and carrying out experimental practices, interpreting data, selecting the best approach and communicating knowledge, ideas and solutions within their field of study. May require consultation of databases, safety standards and procedures.

RA5: Acquire intermediate/advanced knowledge of engineering and biomedical sciences and demonstrate an understanding of the theoretical and practical aspects and methodology of work in their field of study.

CB1: Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study.

CB2: Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.

CB3: Students have the ability to gather and interpret relevant data (usually within their field of study) in order to make judgements which include reflection on relevant social, scientific or ethical issues.

CB4: Students should be able to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.

CB5: Students will have developed the learning skills necessary to undertake further study with a high degree of autonomy.

CG2: Ability to design, draft and develop scientific-technical projects in the field of biomedical engineering.

CG4: Ability to solve problems with initiative, decision-making, creativity, and to communicate and transmit knowledge, skills and abilities, understanding the ethical, social and professional responsibility of the biomedical engineer's activity. Capacity for leadership, innovation and entrepreneurial spirit.

CG6: Knowledge of current standards, regulations and legislation and ability to apply them to bioengineering projects. Bioethics applied to biomedical engineering.

CG7: Drafting, representing and interpreting scientific-technical documentation.

CG8: Ability to solve mathematical, physical, chemical and biochemical problems that may arise in biomedical engineering.

CG9: Ability to analyse and conceptually design electronic devices to solve problems in biology and medicine.

CG12: Ability to solve mathematically formulated problems applied to biology, physics and chemistry, using numerical algorithms and computational techniques.

CG19: Ability to apply different image analysis and processing techniques, as well as artificial vision to the resolution of problems of biological and medical interest. In particular, the problems of diagnosis by Medical Imaging stand out.

CG21: Ability to analyse complex and multidisciplinary problems from the global point of view of Biomedical Instrumentation.

CT1: Ability to communicate knowledge orally and in writing to both specialised and non-specialised audiences.

CT2: Ability to establish good interpersonal communication and to work in multidisciplinary and international teams.  
CT3: Ability to organise and plan their work, making the right decisions based on the information available, gathering and interpreting relevant data in order to make judgements within their area of study.

## OBJECTIVES

The goal of this course is to provide the students with a comprehensive understanding of medical imaging technology for the different modalities, understanding the essential physics and electronics involved. The clinical applications for every modality will also be covered, including the new hybrid devices that combine the advantages of several techniques.

After the completion of this course the student should be able to understand the processes involved in the image acquisition for every modality, including how every aspect of the acquisition process can influence the final image quality. These concepts will be always learned linked to the clinical applications of every modality, so the student will be capable of understanding the areas in which every technique solves specific clinical needs.

## DESCRIPTION OF CONTENTS: PROGRAMME

### 1. Introduction to medical imaging systems

### 2. X-ray imaging systems

#### 2.1. X-ray production: tubes and generators

#### 2.2. Interaction of radiation with matter

#### 2.3. Conventional radiology

#### 2.4. Special systems: Digital Tomosynthesis, Digital Subtraction Angiography, Dual Energy.

#### 2.5. Computed Tomography

### Nuclear Medicine

#### 3.1. Radioactivity and radionuclide production.

#### 3.2. Planar Image in Nuclear Medicine

#### 3.4. Tomography in Nuclear Medicine: SPECT and PET

### 4. Radiation detectors

### 5. Magnetic Resonance Imaging

#### 5.1. Physical principles

#### 5.2. Instrumentation

#### 5.3. Image acquisition: Sequences

#### 5.4. Localization and reconstruction

#### 5.5. Artifacts

### 6. Ultrasound

#### 6.1. Physical principles

#### 6.2. Transducers

### 7. Radiation Protection: Dosimetry and biology.

### 8. Hybrid systems: PET/CT and PET/MR.

## LEARNING ACTIVITIES AND METHODOLOGY

Teaching methodology will be mainly based on lectures, seminars and practical sessions.

Students are required to read assigned documentation before lectures and seminars. Lectures will be used by the teachers to stress and clarify some difficult or interesting points from the corresponding lesson, previously prepared by the student. Seminars will be mainly dedicated to interactive discussion with the students and short-exams will be passed during the sessions.

Grading will be based on continuous evaluation (including short-exams, practical sessions, and student participation in class and Aula Global) and a final exam covering the whole subject. Help sessions and tutorial classes will be held prior to the final exam.

Attendance to lectures, short-exams or submission of possible homework is not compulsory. However, failure to attend any exam or submit the exercises before the deadline will result in a mark of 0 in the corresponding continuous evaluation block.

The practical sessions may consist on laboratory work or visits to research or clinical centers. A laboratory report will be required for each of them. The attendance to practical sessions is mandatory.

Failure to hand in the laboratory reports on time or unjustified lack of attendance will result in 0 marking for that continuous evaluation block.

## ASSESSMENT SYSTEM

### Continuous evaluation

It accounts for up to 50% of the final score of the subject, and includes three components:

- 1) Practical sessions with PC: The initial steps will be guided during the seminars. The code will be finish at home and upload to AulaGlobal together with a report one week after the last seminar.
- 2) Practical sessions with imaging equipment: They will be assessed through a laboratory reports and/or questionnaires will have to be submitted (AulaGlobal) one week after the session. Attendance is mandatory, other wise otherwise the score will be 0 in the item.
- 3) Student participation (10% of the continuous evaluation mark): It includes contribution to seminars, forum in Aula Global, attitude, homework (quizzes or exercises to be solved in groups or individually), or other activities.

### Final exam

The final exam will cover the whole subject and will account 50 % of the final score. The minimum score in the final exam to pass the subject is 4.0 over 10, notwithstanding the mark obtained in continuous evaluation.

### Extraordinary exams

The mark for students attending any extraordinary examination will be the maximum between:

- a) 100% extraordinary exam mark, or
- b) 50% extraordinary exam mark and 50% continuous evaluation if it is available in the same course.

The minimum score in the extraordinary exam to pass the subject is 4.0 over 10, notwithstanding the mark obtained in continuous evaluation.

### Academic conduct

All exams will be closed-book, closed-notes, no PC or mobile phone, or anything else other than a writing implement and the exam itself. Plagiarism, cheating or other acts of academic dishonesty will not be tolerated. Any infractions whatsoever will result in a failing grade.

<b>% end-of-term-examination:</b>	50
<b>% of continuous assessment (assignments, laboratory, practicals...):</b>	50

## BASIC BIBLIOGRAPHY

- Jerry L. Prince, Jonathan Links Medical Imaging Signals and Systems, Prentice Hall, 2014
- Jirí Jan. Medical Image Processing, Reconstruction and Restoration, CRC Press, November 2, 2005
- Paul Suetens Fundamentals of Medical Imaging, Cambridge University Press, 2009

## ADDITIONAL BIBLIOGRAPHY

- Ray H Hashemi, William G Bradley Jr, Christopher J Lisanti MRI: The Basics, LWW, 2010
- Euclid Seeram Digital Radiography: An Introduction for Technologists, Cengage Learning, 2011
- Frederick W. Kremkau Sonography Principles and Instruments, Saunders, 2010
- Hsieh, Jiang Computed tomography : principles, design, artifacts, and recent advances, Wiley Interscience, 2009
- Jerrold T. Bushberg, J.Anthony Seibert, Edwin M. Leidholdt y John M. Boone The Essential Physics of Medical Imaging, Lippincott Williams and Wilkins, 2011
- Richard R. Carlton, Arlene McKenna Adler Principles of Radiographic Imaging: An Art and A Science, Cengage Learning, 2013
- Robert Gill The Physics and Technology of Diagnostic Ultrasound, High Frequency Publishing, 2012
- Sidney K. Edelman Understanding Ultrasound Physics 4th Edition, E.S.P. Ultrasound, 2012
- Willi A. Kalender Computed Tomography. Fundamentals, System Technology, Image Quality, Applications, Publicis, 3rd edition, 2011