Medical instrumentation and devices

Academic Year: (2023 / 2024) **Review date: 19/12/2023 14:27:15**

Department assigned to the subject: Bioengineering Department

Coordinating teacher: VAQUERO LOPEZ, JUAN JOSE

Type: Electives ECTS Credits : 6.0

Year : 4 Semester :

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Mandatory:
- Introduction to the design of biomedical instrumentation
- Electronic technology in biomedicine
- Measuring Instrumentation
- Systems and Signals
- Control Engineering

Recomended
- Physics I, II and III
- Differential Equations
- Robotics

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.
CG20: Ability to design instruments for medical applications, from surgical instruments to micro and nanometric biosensors.
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

This is a project-based course in which the student will acquire a comprehensive understanding of the design of medical, surgical and interventional instrumentation. The students will have to apply their previous knowledge (electronics, signal processing, physiology, etc.) to design and build and validate functional medical devices that will be introduced during the course.
The lectures and seminars will serve to guide the construction of the instrumenst, and this will be done by means of different examples introduced in the guided practices.

DESCRIPTION OF CONTENTS: PROGRAMME

The program will cover descriptions, analysis and study cases related to medical devices, instruments and signal processing for application like the ECG and the EEG, light sensors for biomedical instrumentation, advanced electronics for laboratory instrumentation, diagnose and therapy, prosthesis, image-assisted treatment and therapy monitoring in real time, mathematical and computational models to aid diagnosis and to assist surgical devices with real time control and expert systems for image guided interventions among other.
This is the specific syllabus implementation:

1. Introduction
2. Basic electronics
   a. Bioengineering applications
3. Radiation Detectors
   a. Semiconductor light detectors
   b. Radiation Detectors Signal Processing
4. Image Guided Interventions
   a. Image Guided Interventions and tracking systems
   b. Patient to image registration
   c. Point-based rigid registration
5. Therapeutic devices: Radiotherapy
   a. Intro to External Radiotherapy
   b. Radiotherapy
6. Parameter Estimation
7. Application in Neurology
8. Hearing aids and cochlear implants
   a. Audio and speech processing
9. Final system design
10. Laboratory Practices
    a. Serial Port
    b. Radiation Detectors
    c. Pulseoximetry
    d. Image Guided Interventions

LEARNING ACTIVITIES AND METHODOLOGY

This is a project-based course in which the student has to deal with medical devices that will be tested and evaluated. To support the project design, the teaching methodology will be mainly based on lectures that will introduce the fundamental concepts, seminars where the device design will be analysed, and practical sessions in the laboratory. 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. Seminars will be mainly dedicated to interactive discussion with the students and short-exams will be passed during these sessions. Tutorship regime will be announced in Aula Global.

ASSESSMENT SYSTEM

% end-of-term-examination/test:	30
% of continuous assessment (assigments, laboratory, practicals…):	70

CONTINUOUS EVALUATION ASSESSMENT: 65% of the final mark, includes:
1) Partial exam (30% of the final mark): This exam will take place in a lecture session and will cover approximately half of the programme. If the grade is >=4.0, the students do not need to take the exam on this part in the final.
2) Practical sessions (25% of the final mark): They will be assessed through a questionnaire at the end of the practical sessions. Attendance to at least 80% of the practical sessions is mandatory; otherwise the score will be 0 in this item.
3) Exercises in class (10% of the final mark): It includes exercises and quizzes to be solved in class about previous lectures/seminars
4) Final project presentation (5% of the final mark)

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.

Final exam: The final exam will cover the second part of the programme and will account for 30% of the final score. Additionally, the students will have another opportunity to pass the exam on the first half. 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) 60% extraordinary exam mark and 40% continuous evaluation if it is available in the same course.

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.

BASIC BIBLIOGRAPHY

- J.G. Webster Principles of Applied Biomedical Instrumentation, John Wiley and Sons, Inc., 2009

- Leif Sörnmo, Pablo Laguna BIOELECTRICAL SIGNAL PROCESSING IN CARDIAC AND NEUROLOGICAL APPLICATIONS, Elsevier Academic Press, 2005

ADDITIONAL BIBLIOGRAPHY

- G.D. Baura Medical Device Technologies, Academic Press, 2012

- Richard C. Aster, Brian Borchers, Clifford H. Thurber Parameter Estimation and Inverse Problems, Academic Press, 2013

- Robert B. Northrop Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation, CRC Press, 2012