Introduction to the design of medical instrumentation

Academic Year: (2023 / 2024) **Review date: 18-01-2024**

Department assigned to the subject: Bioengineering Department

Coordinating teacher: RIOS MUÑOZ, GONZALO RICARDO

Type: Compulsory ECTS Credits : 6.0

Year : 3 Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Introduction to bioengineering.
Electronic technology in biomedicine.
Measuring instrumentation.
Signals and Systems or Digital Signal Processing.

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.
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.
ECRT36: Understanding of the process of design and conceptualisation of electronic instruments applied to the resolution of problems in biomedicine. Ability to define the electronic technology and devices to

be used in each case. Understanding of the difficulties and risks involved in the use of electronic devices with live subjects.
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 student who successfully completes this course should be able to understand in depth everything related to the design of a biomedical instrument, what is involved in its biomedical application, be able to describe the user and technical specifications and prepare a complete instrument design and test protocol, as well as analyze the signals and data produced by the instrument.

In addition, upon completion of this course, the student should be able to build a biomedical instrument and demonstrate its operability using modern electronic technologies (microprocessors) as well as various types of sensors.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Introduction to Biomedical Instrumentation
2. Signal Amplification
3. Signal Filtering
4. Electrical Safety
5. Electrocardiology. ECG characteristics
6. Electroencephalography. EEG characteristics
7. Other Biopotential Recordings: EMG, ENG, ERG, EOG
8. Biopotential Amplifiers
9. Electrodes and Electrolytes
10. Sensors: biophysics, design, and applications
11. Introduction to Signal Digitalization
12. Therapeutic and Prosthetic Devices
13. Pressure and Sound Measurements
14. Flow and Volume Measurements
15. Introduction to Optical Measurement Systems

LEARNING ACTIVITIES AND METHODOLOGY

The teaching methodology will be mainly based on lectures, seminars, and practical sessions.
Lectures will be used by the teachers to present the main concepts of the course.
Seminars will be mainly dedicated to interactive discussions with the students and to stress and clarify the most interesting and difficult points. Deliverable exercises and presentations will be done during the sessions.
Grading will be based on continuous evaluation (including a partial exam, practical sessions, and student participation in class and Aula Global) and a final exam. 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 will consist of laboratory work. A laboratory report will be required. Attendance to practical sessions is mandatory. Failure to hand in the laboratory reports on time or unjustified lack of attendance will result in a 0 marking for that continuous evaluation block.

ASSESSMENT SYSTEM

Grading:
Continuous evaluation: It accounts for up to 65% of the final score of the subject, and includes three components:
1) Partial exam (35% of the final mark): This exam will take place in a lecture session, will be announced at least 2 weeks in advance 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 (20% of the final mark): They will be assessed through a laboratory notebook, laboratory reports and/or questionnaires that will be handed in at the end of each practical session. Attendance to at least 80% of the practical sessions is mandatory; otherwise the score will be 0 in this item.
3) Deliverable exercises, student participation, and presentations in the seminar sessions (10% of the

final mark): It includes exercises and homework (quizzes to be solved in groups or individually), other activities, and contribution in sessions.

Final exam: The final exam will cover the second part of the programme and will account for 35 % 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) 50% extraordinary exam mark and 50% 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.

% end-of-term-examination:	35
% of continuous assessment (assigments, laboratory, practicals…):	65

BASIC BIBLIOGRAPHY

- J.G. Webster Medical Instrumentation Application and Design, John Wiley and Sons, Inc..
- L.A. Geddes and L.E. Baker Principles of Applied Biomedical Instrumentation, John Wiley and Sons, Inc..

ADDITIONAL BIBLIOGRAPHY

- A.F. Arbel Analog Signal Processing and Instrumentation, Cambridge University Press.
- J.B Olansen, E. Rosow Virtual Bio-Instrumentation, Prentice Hall PTR.
- L. Cromwell, F.J. Weibell, E.A. Pfeiffer Biomedical Instrumentation and Measurements, Prentice Hall Career & Technology.
- R. Sarpeshkar Ultra Low Power Bioelectronics, Cambridge University Press.