Introduction to the design of medical instrumentation

Academic Year: (2019 / 2020) **Review date: 15/05/2020 15:23:08**

Department assigned to the subject: Bioengineering and Aeroespace Engineering Department

Coordinating teacher: PEREZ BENITO, DAVID

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 o Digital Signal Processing

OBJECTIVES

The student that successfully finishes this course should understand the biomedical application, specify the user and technical specifications, and provide a complete protocol for the design of a medical instrument, and to analyse the signals and data generated by the the instrument.
Besides, after the completion of this course the student should be able to implement a functioning medical instrument using state-of-the-art electronics and sensor technologies.
Special attention will be paid to safety and regulatory aspects applied to biomedical instrumentation.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Basic concepts on biomedical instrumentation
   - 1.1. Design cycle protocol
   - 1.2. Regulations and marking
2. Electrical safety
   - 2.1. Physiological Effects of Electricity
   - 2.2. Concept of "ground" in biomedical instruments
   - 2.3. Isolated instruments and batteries
3. Origin of Biopotentials. Techniques to record Biopotentials
   - 3.1. Principles of bioelectricity
   - 3.2. Transmembrane Action Potential
   - 3.3. Transmembrane Resting Potential
   - 3.4. Ion Channels, Pumps and Exchangers
4. Electrocardiology. ECG characteristics
   - 4.1. Anatomy and Physiology of the Heart
   - 4.2. Electrophysiological Cardiac Behavior
   - 4.3. Cardiac Transmembrane Action Potential
   - 4.4. The electrocardiogram (ECG)
   - 4.5. Diagnosis based on the ECG
   - 4.6. Recording the ECG
   - 4.7. Invasive Cardiac Mapping Instruments
5. Signal amplification
   - 5.1. Operational Amplifiers and applications
   - 5.2. Output and Input Impedance
   - 5.3. Instrumentation amplifiers
6. Signal filtering
   - 6.1. Frequency domain
   - 6.2. Ideal Filters
   - 6.3. Dealing with the Noise
   - 6.4. Passive Analog Filters

6.5. Active Analog Filters

7. Electrodes and Electrolytes
    7.1. Oxidation and reduction
    7.2. Polarizable and Nonpolarizable Electrodes
    7.3. Electrode Behavior and Circuit Models
8. Sensors: biophysics, design, applications
    8.1. Resistive sensors
    8.2. Capacitive sensors
    8.3. Piezoelectric Sensors
    8.4. Thermocouples
    8.5. Wheatstone Bridge
9. Electroencephalogram and Magnetroencephalogram
    9.1. Action potentials in Neurons
    9.2. Electric and Magnetic Fields in the brain
    9.3. Electroencephalography (EEG)
    9.4. Magnetoencephalography: MEG
    9.5. EEG and MEG signals and applications
10. Electromyogram, electroneurogram, electrooculogram and electroretinogram
    10.1. Electromyogram (EMG): Principles, instrumentation and applications
    10.2. Electroneurogram (ENG): Principles, instrumentation and applications
    10.3. Electrooculogram (EOG): Principles, instrumentation and applications
    10.4. Electroretinogram (ERG): Principles, instrumentation and applications
11. Implantable devices
    11.1. Cardiac Pacemakers
    11.2. Brain Pacemakers
    11.3. Defibrillators.
12. Optical and light based measurement system
    12.1. Basis of Light Propagation in Tissues
    12.2. Light Scattering
    12.3. Light Absorption
    12.4. Optical Contrast Agents
13. Introduction to Digital Signal Processing
    13.1. Analog-to-digital converter
    13.2. Digital Frequency
    13.3. Digital Filtering
    13.4. Changing sampling rate
    13.5. Spectral estimation
14. Applications of Digital Signal Processing
    14.1. Preprocessing signals
    14.2. Automatic detection of events
    14.3. Classification of events
    14.4. Nonlinear analysis of a sequence of events
15. Biomedical signal acquisition and processing with LabView or Matlab
    15.1. Data structures and analysis
    15.2. LabVIEW or Matlab environment
    15.3. Data acquisition with LabVIEW or Matlab

LEARNING ACTIVITIES AND METHODOLOGY

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 discussion with the students and to stress and clarify the most interessing 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 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 will consist on laboratory work and 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

% end-of-term-examination/test:	50
% of continuous assessment (assigments, laboratory, practicals…):	50

Grading:
CONTINUOUS EVALUATION
It accounts for up to 50% of the final score of the subject, and includes three components:
1) Partila exams (10% of the final mark): These exams will take place in a lecture session, and will be announced at least one week in advance. Results of these exams will constitute the core of the continuous evaluation.
2) Practical sessions (25% 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 (15% 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 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.

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.
Percentage of total for grade the end-of-term-examination: 50
Percentage of total for grade the continuous assessment (assigments, laboratory, practicals...): 50

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.