UNICUSANO
ROME

Code: ING-INF/06 **Credits:** 9
Matter: Biomedical Electronics
Main language of instruction: Italian
Other language of instruction: English

Teaching Staff

Head instructor
Prof. Ivan Bernabucci - ivan.bernabucci@unicusano.it

Introduction

1. Objective of the course :

The course is intended to provide the students with the fundamental tools to understand the generation mechanisms of the main biosignals of different nature, the operating principles of the acquisition devices, and the primary circuit solution for the signal conditioning. The most important biopotentials (electrocardiography, electromiography, electroencephalograpy) will be investigated, describing the generation mechanisms at the level of the membranes of the excitable cells and aiming to understand their characteristics near the sampling positions. The student will acquire the competences to correctly design the acquisition system of these signals. The course teaches about the effects of the passage of the electrical current in the human body, showing the electrical safety measures commonly adopted in healthcare environments to reduce the risks related to direct or indirect contacts.

Objectives

2. Course Structure:

The course is focused on the following goals:

- To illustrate the concept of biomedical signal
- To illustrate the measurement devices for mechanical quantities in the biomedical area of investigation
- To present competencies about the generation mechanisms of the most common biopotentials
- To provide the tools for the correct acquisition and conditioning of the biomedical signals

- To show the risks derived from the passage of electric current in the human body

Competencies:

As prerequisites, to attend the course the student must have passed the courses of **Digital Electronics** (Elettronica Digitale) and **Electronics II** (Elettronica II).
Notions and concepts of Electronics and Signal Theory are extremely important for this course.

At the end of the course the student will have the following competencies:

Knowledge and Understanding
The student will obtain the knowledge of the main biomedical quantities and of their generation processes.
He/She will also understand the operating principles of the acquisition devices of biosignals of different nature, together with the mechanisms of generation of the biopotentials and of the excitable cells. The student will know the risks coming from the passage of electric current in the human body.

Applying knowledge and understanding
The student will understand how to dimension the different parts of a biosignal acquisition system, knowing how the single parts (amplification, filtering, A/D conversion) of this system will interact and transform the biomedical signal, and which are the related problems. The activities of the course are intended to apply the acquired knowledge on solving practical problems using elaboration software (Octave, Python).

Making judgments
At the end of the course the student will be able to select the appropriate devices and the correct solutions for the conditioning of the specific biomedical signals according to their characteristics and typologies. He/She will be able to dimension the different blocks of the acquisition systems for biomedical signals, knowing how these different blocks effect the final result.

Communication skills
The student will gain a correct and comprehensive scientific language skills that will allow him/her to correctly communicate the

acquired knowledge using proper technical terms.

Syllabus

3. Programme of the course:

The course material is composed by the audio-video lessons and the sldies.
Self-assessment asynchronous tests are provided to the students in order to let them evaluate their preparation and the acquired knowledge from every lesson.
The interactive didactics is performed in the forum of the “virtual classroom” and includes 2 Etivity.
The course of Biomedical Electronics is based on 9 formative credits and the total load of study is about 220 hours:
180 hours for the visualization and the study of the on line material (50 for the visualization and assimilation of the contents of the video lessons, 10 hours for the guided exercises and the self-assessment test at the end of each module, 120 of autonomous study)
40 hours of interactive didactics for the elaboration and the delivery of 2 Etivity. With an average load of study of 4 hours/day, the student will be able to attend the exam after 55 days of study comparable to 2 months.

Module 1 - Characteristics of biomedical instrumentation (4 video-recorded lessons – 12 hours, 0.5CFU, 3 days) in which the following topics are tackled: introduction to the bioengineering and role of the biomedical instrumentation – description of the main biomedical quantities of interest – description of the characteristics of the biomedical instrumentation and specifics of acquisition systems – sensors and transducer in biomedical scope.

Module 2 – Devices for measurement of mechanical and thermal quantities in biomedical scope (8 video-recorded lessons – 33 hours, 1 Etivity of 20 hours, 2.2CFU, 13 days) in which the following topics are tackled: basic notions of applied electronics - force and pressure measurements – thermal measurements – devices for kinematic and dynamic analysis of the human movement – applications.

Etivity 1 – Force Platforms: Solutions for the selective measurement of the different force and moment components.

Module 3 – Fundamentals of electro-physiology (6 video-recorded lessons – 26 hours, 1CFU, 7 days) in which the following topics are tackled: cell membrane - generation of resting membrane potential - generation of action potential - operating principles of the electrodes for the bipotentials sampling – circuit model of the electrodes.

Module 4 – Processing of the biomedical signals (8 video-recorded lessons – 33 hours, 1.35CFU, 8 days) in which the following topics are tackled: conditioning blocks – frequency components of a signal – filtering – filtering typologies – project of active filters – Shannon sampling theorem – sampling of a signal – quantization of a signal.

Module 5 – Biopotentials (12 video-recorded lessons – 42 hours, 1 Etivity of 20 hours, 2.6CFU, 15 days) in which the following topics are tackled: basic notions of physiology – generation mechanisms of the electrocardiographic signal ECG – characteristics of the ECG signal – instrumentation for the acquisition of the ECG signal – applications – notions of muscles physiology - generation mechanisms of the electromyographic signal EMG - characteristics of the EMG signal - instrumentation for the acquisition of the EMG signal – applications – notions of central nervous system physiology - generation mechanisms of the electroencephalographic signal EEG – characteristics of the EEG signal – instrumentation for the acquisition of the EEG signal – applications.

Etivity 2 – Digital elaboration of biosignals in Octave. Filtering the biomedical signals from noise components.

Module 6 – Interaction between electric current and human body (8 video-recorded lessons – 33 hours, 1.35CFU, 8 days) in which the following topics are tackled: effects of electric current on the human body - impedance model of the human body – microshock and macroshock – electric safety – regulations.

Evaluation system and criteria

The exam is a written test: 1 open question about a specific theory concept of the course (10 points), 2 numerical/design exercises (10 points) and a list of multiple choices questions, which can be of

theoretical or numerical nature (12 points). The duration of the written test is about 90 minutes. The maximum score is 32 points equivalent to 30 e lode. The questions of the exam refer all the topics of the course.
The students can use simple calculators, and it is FORBIDDEN the use of any textual or visual support related to the course. All the material necessary for the execution of the exam, and especially of the numerical exercises, is included in the text of the exam.

Bibliography and resources

4. Materials to consult:

The didactics material in the platform is divided in 6 modules. They cover the program and each of them contains slides, texts and video lessons.

5. Recommended bibliography:

F. P. Branca. “Fondamenti di Ingegneria Clinica, vol.1”. Springer Verlag. J. D. Bronzino. “The Biomedical Engineering Handbook, vol.1”. CRC Press.