North Carolina School of Science and Mathematics

EE4520 : Biomedical Instrumentation

Course Description: In this course students will learn the basic principles of electronic instrumentation with biomedical examples. Concepts of analog signal processing, filters, and operational amplifiers are explored. Students are exposed to system design concepts such as amplifier design with particular focus on bioelectrical systems such as the cardiovascular and nervous systems. Laboratories reinforce basic concepts and offer the student design opportunities. This course will include a final design project and paper.

Instructor Name or Department:
Letitia Hubbard
Engineering and Computer Science

Course Meeting Pattern:
Residential - 4 days/week: 3 x 50 min + 1 lab x 90 min

Prerequisites/Corequisites:
EE4020 Electrical Engineering OR EE 4080 Biomedical Engineering
Precalculus (MA4000 or higher)

Textbook:
Medical Instrumentation: Application and Design, John G. Webster, 4th Edition

Required Course Materials (including technology):

- All materials for the course (e.g. homework assignments and project descriptions) will be provided through the Canvas Learning Management System.
- Bound composition notebook or spiral notebook for documentation during labs and projects.
- Note-taking materials brought to class on a daily basis.

Course Objectives
In this course students will:

- Study the designs of instruments used to acquire signals from living systems
- Apply knowledge of electrical engineering and science to understand the principles of biomedical electronic circuits.
- Measure and record bioelectric signals using biopotential electrodes
- Design and build bioamplifiers that meet specific criteria and given specifications
- Design filters necessary to condition and isolate a signal
- Analyze and interpret common bioelectric signals and biomedical measurements
- Collaborate and work in teams to complete design projects and labs.
- Integrate information learned about biomedical signals, sensors and instrumentation design to create a medical device on their own.

- Communicate analytical explanations and problem solutions verbally and in writing.

Learning Outcomes
Upon successful completion of this course, you will be able to:
● Describe the components of a basic instrumentation system
● Describe the design and structure of biomedical measurement systems
● Describe and apply the basic mechanisms and principles of sensors to convert physiological events to electric signals in a number of medical instruments
● Understand the origin of biopotentials (e.g. ECG, EEG, EMG, EOG, ERG) and the design and operation of bioelectrodes.
● Describe the basic requirements and features of biopotential amplifiers
● Describe sources of signal artifacts that contaminate biomedical signal acquisition and complicate interpretation
● Interpret and analyze recorded bioelectric signals
● Describe and apply the signal amplification and processing that is common to many medical instruments
● Describe and apply the safety issues, safe design, and safe use of medical instrumentation, and incorporate safety features into design
● Describe situations when CT imaging is preferred to MR imaging
● Design medical instruments, including proper application of signal amplification and processing common to many medical devices
● Demonstrate engineering design through the completion of a medical instrument design project
● Demonstrate effective teamwork and collaboration through the completion of a medical instrument design project

Grading Policy:
<u>Your grade for the course will be calculated as follows:</u>
Quizzes 20%
Homework/In-Class Problem Sets 25%
Labs 35%
Final Project 20%

<u>Grading Scale</u>
A: 90 – 100
B: 80 – 90
C: 70 -80
D: Below 70

Sample Weekly Schedule:

Week	Content	Assessments
Week 1	*Intro to Medical Instrumentation* *Basic Circuits Review* *Medical Devices*	*Circuits Kahoot! Review* *HW: Examples of Circuits in medical devices*
Week 2	*Advanced Circuits Review*	*HW: Advanced Circuits* *Lab: Circuits*
Week 3	*Complex numbers review* *AC Impedance*	*Quiz #1*
Week 4	*Time varying Systems/Transient Analysis*	*HW: AC Impedance/Transient Analysis*
Week 5	*1st & 2nd order instrumentation systems* *Guest speaker*	
Week 6	*Bode plots* *Filters, Rectifiers, Amplifiers*	*HW: Freq. response of RC Circuits* *Lab: Freq. response*
Week 7	*Operational Amplifiers,* *OA design considerations* *Virtual Op Amp simulation*	*HW: Operational amplifiers*
Week 8	*Intro to Iworx* *Op-Amp Circuits in IWorx*	*Quiz #2*
Week 9	*Origin of Biopotentials*	*Lab: Measuring EKG*
Week 10	*Biopotential electrodes* *Biopotential measurements*	*Lab: EKG and signal processing*
Week 11	*Intro to microcontrollers*	*Lab: Arduino Claw*
Week 12	*Final Project intro and work*	*Quiz #3*
Week 13	*Independent Final Project work*	
Week 14	*Independent Final Project work*	
Week 15	*Independent Final Project work*	*Final Project Presentations*