[ELEC4810] [Introduction to Biosensors and Bioinstrumentation] [Fall 2023] [Credits: 4]

Course Description

This course builds on the fundamental knowledge of biosensors and bioinstrumentation. Lectures and hands-on laboratory experiments cover: (1) Basic concepts of biomedical signal analysis; (2) Measurements of bioelectrical, biomechanical and biochemical signals for medical diagnosis and clinical monitoring; (3) Principles of biosensors and biochips; (4) Simple design of new bioinstrumentation and biosensor to solve biomedical problems. Prerequisite(s): ELEC 2200 AND ELEC 2400

List of Topics

1. Introduction: Overview of Course
    - 1.1 Types of medical electronic devices
    - 1.2 General characteristics of biomedical signals
2. Basic Concepts
    - 2.1 Mathematical descriptions of random signals
    - 2.2 Measurement systems fundamentals
        - A. Transduction
        - B. Signal processing methods
        - C. Close loop systems
        - D. Equipment specifications
3. Biopotentials
    - 3.1 Origin: Ionic currents in a single cell
    - 3.2 Action potentials (nerve and muscle)
    - 3.3 Multiple cells: Generation of body-surface potentials
    - 3.4 Electrocardiography (ECE)
        - A. Physiology of the heart
        - B. Dipole concept
        - C. Lead systems
        - D. Electrodes, amplifiers
        - E. ECG instrument design
    - 3.5 Electroencephalography (EEG)
    - 3.6. Electromyography (EMG)
4. Blood Pressure and Flow Measurement
    - 4.1 Physiology of the circulatory system
    - 4.2 Pressure transducers (invasive)
        - A. Strain-gauge (1-,2-,4-arm bridges)
        - B. Inductive
        - C. Capacitive
        - D. Piezoelectric
        - E. Optical
    - 4.3 Non-invasive pressure monitoring
        - A. Manual cuff
        - B. Oscillometric
    - 4.4 Flow measurement
        - A. Indicator-dilution method (dye, thermal)
        - B. Electromagnetic
        - C. Doppler ultrasound

5. Respiratory Monitors
    5.1 Physiology of blood/gas exchange
    5.2 Capnography
    5.3 Oximetry

Lecture Outline

Week 1	Overview of Course; General characteristics of biomedical signals; Mathematical descriptions of random signals; Measurement systems fundamentals
Week 2	Ionic currents in a single cell and rest membrane potential; Action potentials (nerve and muscle)
Week 3	Generation and measurement of body-surface potentials; Physiology of the heart
Week 4	Electrocardiography (ECG); Lead system for ECG measurement
Week 5	Differential amplifiers; ECG instrument design
Week 6	Electromyography (EMG); Electrocardiography (EEG)
Week 7	Electrocardiography (EEG); Electrodes
Week 8	Midterm; Physiology of the circulatory system
Week 9	Fundamentals of Hydraulics; Manual Cuff (Sphygmomanometer)
Week 10	Automated oscillometric measurement;
Week 11	Piezoelectric Transducer; Doppler ultrasonic flowmeters
Week 12	Laser Doppler Flowmeter; Physiology of blood/gas exchange; Oximetry
Week 13	Capnography; Modern wearable biosensors

Laboratory Outline

SEVEN EXPERIMENTS:

1. Bio-signal exploration
2. Electrocardiography (ECG)
3. Electromyography (EMG)
4. Non-Invasive Blood Pressure Measurement
5. Measurement of the Finger Pulse
6. Pulse Oximeter
7. Advanced ultrasound imaging system

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

CO1 - understand the broad role that an electric engineer can play in biomedical engineering
CO2 - describe and analyze biomedical applications from electrical, chemical and mechanical engineering perspectives
CO3 - recognize how engineering and mathematics can be applied to the analysis and constructive manipulation of biological systems and the development of biomedical therapies
CO4 - design a variety of biomedical instruments via comprehensive labs
CO5 - work collaboratively in an interdisciplinary setting
CO6 - undertake more advanced courses in biomedical engineering

Textbook(s):

John G. Webster, *Medical Instrumentation: Application and Design*, 4th edition

Reference Books/Materials:

1. Joseph J. Carr and Johyn M. Brown, *Introduction to Biomedical Equipment Technology*, 4th edition, 2001
2. Joseph. D. Bronzino, *Biomedical engineering and instrumentation: basic concepts and applications*
3. Richard Aston, *Principles of biomedical instrumentation and measurement*
4. Walter Welkowitz, *Biomedical instruments: theory and design*
5. A. Edward Profio, *Biomedical engineering*

Relationship of Course to Program Outcomes:

Please refer to the Report Section 4.3.2 (iii).

Grading Scheme:

Homework	15%
Laboratory	20%
Mid-Term Examination	20%
Final Examination	45%