ELEC4810 Introduction to Biosensors and Bioinstrumentation

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 2400 OR ELEC 2420

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 (EEG)
        - A. Physiology of the heart
        - B. Dipole concept
        - C. Lead systems
        - D. Electrodes, amplifiers
        - E. ECG instrument design (First lab assignment)
    - 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 (Second lab assignment)
- 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 (Third lab assignment)

6. Clinical Chemistry
   - 6.1 Spectrometry
     - A. Bee-Lambert law
     - B. Light sources
     - C. Wavelength selection: interference gratings
     - D. Photodetection
   - 6.2 Electrochemical sensors
     - A. Potentimetric (pH, P_{co2} electrodes)
     - B. Amperometric (P_{o2} electrode)
   - 6.3 Hematology counting
     - A. Cell counting (Coulter principle)
     - B. Cytometry

Statement of Objectives/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

References:

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%
Lab reports	20%
Midterm Examination	20%
Final Examination	45%