Biomedical Instrument (BME 580)

Instructor: Moo-Yeal Lee, Ph.D.
Office: FH439
Office hours: Friday 1:00 – 3:00 pm
Lecture hours: Tuesday & Thursday, 6:00 – 7:50 pm
Class room: MC308
Prerequisite(s): Graduate standing in chemical and biomedical engineering, chemistry, physics or permission of instructor. An introduction to the functions and applications of biomedical sensors and instruments used in biomedical research and health care industry. Demonstrations on a few instruments provided in laboratories.

Course Description:

Recent advances in biomedical research and health care industry have been accelerated by a variety of instruments, which cover diagnostic, therapeutic, and clinical laboratory instruments. This course will introduce the basic principles and design issues of biomedical sensors for biomedical applications as well as basic anatomical and physiological features of the human body for important biomedical instruments used in the health care industry. The objective of this course is to understand the background, working principles, functions, and applications of the major bioinstrumentation available to study biological systems. The course will cover techniques that are used to monitor biomedical interactions at the molecular, cellular, or tissue level, as well as interactions at the entire human body level. The guiding principle of this class is to give a well-rounded overview of current biomedical instrumentation either for fundamental research or for clinical applications. In addition, students will be provided a guided tour of instrumentation facilities and several instrument demonstrations available at CSU.

* Cell phone use in class is strongly prohibited.

Course Materials:

Textbooks

1. Biomedical Device Technology: Principles and Design, Anthony Y. K. Chan, Charles C. Thomas Pub Ltd, (2008)
2. Introduction to Biomedical Engineering Technology, Second Edition, Laurence Street, CRC Press (2011)

Reference books

1. Medical Instrumentation: Application and Design, Fourth Edition, John G. Webster, John Wiley & Sons, Inc. (2009)
2. Medical Imaging: Essentials for Physicians, Anthony B. Wolbarst, Patrizio Capasso, and Andrew R. Wyant, Wiley-Blackwell (2013)

These books are only suggestions and there is no need to purchase them. The material covered in the course will be drawn from these books and other sources, and lecture notes will be provided to students.

Grading Policy:

Students are expected to attend lectures, participate in discussion, answer oral quizzes, complete assignments on time, take mid-term and final examinations, present student projects in the class, and submit reports on student projects. All scores on class attendance/participation, quizzes, exams,

assignments, and student projects will be based on 100 points. The final score will be calculated by the percentage given below.
- Class attendance: 4%
- Class participation: 4%
- Oral quiz: 7%
- Midterm exam: 30%
- Final exam: 30%
- Instrument demonstration report and homework: 10%
- Student project: 15% - presentation (10%) + report (5%)

In terms of student projects, three students in one group will play a role as a manager who participates in the process of purchasing a biomedical instrument and makes a decision on which one to purchase. They are expected to submit a project report (ranging from 10 – 15 pages) and a PowerPoint slide deck (up to 20 min presentation and 10 min Q&A) to upper-level managers (i.e., the instructor and fellow students), which should include the title of report and the name of group members, a table of contents, executive summary, introduction, basic principles of the sensor/instrument, the names of commercial manufacturers, different features and biomedical applications, recommendation for purchase (i.e., your conclusions), and literature cited. Both the instructor and students will evaluate the student projects. Since this is a master student-level course, all students will be graded in the same manner. The final grade will be determined by a grading guideline chosen by the instructor. The following grading guideline exemplifies the relationships between the final score calculated from the formula above and the letter grade assigned. Final grades will be balanced between the grading guideline and a student grade distribution.
- A: 90 - 100
- A-: 85 - 89
- B+: 80 - 84
- B: 75 - 79
- B-: 70 - 74
- C: 50 - 69

Topical Outline:
1. Introduction
   a. History of medical devices
   b. Classification of biomedical instruments
   c. Important anatomical and physiological features of the human body
2. Concepts in signal measurement, processing, and analysis
3. Transducers for biomedical applications
   a. Pressure and force transducers
   b. Temperature transducers
   c. Motion transducers
   d. Flow transducers
   e. Optical transducers
   f. Electrochemical transducers
4. Biopotential electrodes
5. Biopotential amplifiers
6. Electrical safety and signal isolation
7. Diagnostic devices
   a. Heart: electrocardiogram (ECG) monitor
   b. Circulatory system and blood: blood pressure measurement, pulse oximeter

c. Respiratory system: pulmonary function analyzer
    d. Nervous system: electroencephalogram (EEG) monitor, muscle/nerve stimulator
    e. Digestive system: endoscope
    f. Sensory organs: otolaryngo/ophthalmoscope
    g. Reproduction: fetal heart detector, fetal monitor
    h. Skin, bone, muscle, miscellaneous: thermometer, bone densitometer
8. Diagnostic imaging
    a. X-rays: computed (axial) tomography (CT or CAT) scanner
    b. Magnetic resonance imaging (MRI) scanner
    c. Positron emission tomography (PET) scanner
    d. Diagnostic ultrasound
9. Therapeutic devices
    a. Heart: defibrillator, pacemaker
    b. Circulatory system and blood: artificial heart, ventricular assist device, heart–lung machine, sequential compression device, automatic tourniquet, intravenous fluid administration pump
    c. Respiratory system: ventilator
    d. Nervous system: anesthetic machine, electroconvulsive therapy machine
    e. Renal system: hemodialysis, peritoneal dialysis, lithotriptor
    f. Sensory organs: phacoemulsifier, ophthalmic laser
    g. Reproduction: bilirubin therapy system, infant incubator, infant resuscitator
    h. Skin, bone, muscle, miscellaneous: electrosurgery machine, surgical laser, surgical ultrasound, microscope, sterilizer, physiotherapy equipment
10. Case study of medical devices
11. Student project presentation

Instrument Demonstration
There is a lab component in this class. Students will have a great opportunity to learn in-depth knowledge of biomedical instrumentation via a demonstration from real world experts. Through the instrument demonstration, students will learn fundamental principles of the following instruments that are routinely used in hospitals, biomedical labs, R&D centers, and industries. After each demonstration, students are expected to write a report (2 - 3 pages) in terms of basic principles of the instrument, operational procedures, and biomedical applications.
    1. Scanning electron microscope (SEM) by Dr. Orhan Talu
    2. Confocal microscope by Dr. Sailen Barik
    3. Optical motion capture, EMG, accelerometers, and force plates by Dr. Antonie J. (Ton) van den Bogert
    4. Atomic force microscopy (AFM) by Dr. Chandrasekhar Kothapalli
    5. Physiology measurement instruments by Dr. Kenneth E Sparks
    6. Microplate reader, high-content imaging (HCI) system, and robotic liquid dispensing system by Dr. Moo-Yeal Lee

*Specific demonstration schedules will be announced later.