Approval: 9th Senate Meeting

Course Name: Biomedical Systems

Course Number: EE 516

Credits: 2.5-0.5-1-4

Prerequisites: IC 110 Engineering Mathematics (IC110), IC 161 Applied Electronics

Intended for: UG/PG

Preamble:

The study of biological systems changed dramatically over the past few decades from observational to systemic view. Presently systems in biology are modelled and analysed using concepts developed in electrical engineering. Also from an elaborate set of diagnostic practices followed in large health care centers, medicine has now reached to a level at which most diseases can be detected at homes using the notion of point of care testing. It is therefore essential to develop knowledge in biomedical engineering, stepping out of the conventional treatment of it as just measurement and instrumentation practices in biomedicine. The course aims to provide the senior undergraduate and graduate students a system theoretic point of view to biomedical phenomenon with definite abstractions developed in electrical engineering.

Course outline:

This course will introduce aspects of biomedical engineering from a systems perspective. The overarching pedagogical goal is to elucidate the bidirectional interaction between biological systems and quantitative models. Specifically, the course intends to describe biological systems can be described using engineering principles and use engineering principles to extract information from biological systems. These goals will be underpinned with calculus-based mathematical descriptions. The computational approaches used for diagnostic estimations will be explained. Professional ethical issues relating to Biomedical Engineering systems will also be covered.

Teaching Objectives (based on Bloom's Taxonomy):

A student who completes this course will be able to:

1. *Describe* what biomedical engineers do in their professional activities.
2. *Familiarize* themselves with the basic components that constitute biological systems (at organs and systems level)
3. *Understand* and *apply* generalizable engineering concepts to describe many types of systems found in biology and medicine. Systems include physiological systems (organs and systems level), bioelectronics systems, sensing and transducing systems, computational systems, etc.
4. *Analyze* physiological systems and design engineering systems to measure various pathophysiological parameters.

Course modules:

1. Introduction to Biomedical Systems 4L

Introduction to System Science - Notion of dynamic systems: modeling and simulation using MATLAB - Biomedical systems as dynamic systems - Compartmental modeling of biological systems - Eye movement model - Muscle model - Classical system identification

2. Anatomy and Physiology 6L

Introduction-Cellular organization – Tissues - Major organs and systems - Homeostasis

3. Modelling of human body

5L

Cardiovascular model, Lung model, Nervous System model, Muscular system model

4. Biomedical sensing

11L

Bioelectric phenomena - Origin of bio-potentials - Bio-potential measurements – ECG, EEG, EMG, ERG, ENG – Notion of system identification - Chemical biosensors – electrochemical sensors and chemical fibro-sensors - Notion of ion selective field effect transistor (ISFET) and immunologically sensitive field effect transistor (IMFET) - Fundamentals of light propagation in biological tissue - Biophysical measurement techniques using light – photoplethysmography - Acoustic biosensors – phonocardiography - Photo-acoustic bio-signals – estimation of blood glucose.

4. Bio-signal processing 6L

Characterization of bio-signals – morphological, statistical and transform features - Frequency domain representation of bio-signals - Noise characteristics - Noise reduction by Ensemble Averaging and Linear Time Invariant A Posteriori - filtering techniques - Signal averaging - Wavelet transform - Compression of bio-signals - lossless and lossy compression

5. Biomedical embedded systems 8L

Choice of embedded core - Notion of Internet of Things as extended to biomedicine - Embedded processing for disease diagnosis – Wearable biomedical embedded systems - Point of care testing devices - Diagnostic processing for detection and classification of diseases - Computational intelligence techniques for disease diagnosis - Classification of cardiac, neuromuscular, neurological and hematological diseases - Memory management issues for diagnostic processing - Power reduction techniques in diagnostic systems

6. Moral and ethical issues in developing Biomedical Systems 2L

Morality and ethics - Two moral norms: beneficence and nonmaleficence - Human experimentation - Regulation of medical device innovation - Ethical issues in feasibility studies - Ethical issues in treatment use

7. Course Project:

A 6 weeks project where the student will develop a practical biomedical system going through the problem formulation, analysis, design and development phases.

Text books:

1. J. Enderle, S. Blanchard, J. Bronzino, “Introduction to Biomedical Engineering”, Elsevier Academic Press, 2009.
2. R. Begg, D.T.H. Lai, M. Palaniswami, “Computational Intelligence in Biomedical Engineering”, CRC Press, 2008.

Reference books:

1. L. Sornmo, P. Laguna, “Bioelectrical Signal Processing in Cardiac and Neurological Applications”, Elsevier Academic Press, 2005.

2. J.G. Webster, “Medical Instrumentation: Application and Design”, John Wileyand Sons, 2003.