TO: The Engineering Faculty

FROM: The Faculty of the Department of Biomedical Engineering

RE: New Undergraduate-Level Course

The faculty of the Department of Biomedical Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

BME 301 Bioelectricity

Sem. 1. Class 3, cr. 3.

Prerequisite: PHYS 241 and MA 166, or equivalent
Corequisite: BME 305 or ECE 202

Fundamentals of bioelectricity of the mammalian nervous system and other excitable tissues. Passive and active forms of electric signals in both the single cell and cell-cell communication, tissue and systemic bioelectricity, mathematical analysis including Nernst equation, Goldman equation, linear cable theory, and Hodgkin-Huxley Model of action potential generation and propagation.

Reason: The objective of this course is to use fundamental engineering and mathematical tools to understand and analyze basic bioelectricity in the context of the mammalian nervous system. This course teaches students the basic bioelectricity with both biological significance and fundamental mathematical analysis. A solid quantitative understanding of electric phenomenon in the context of the biological system is essential for engineering manipulation of bioelectricity for the purpose of diagnosis, treatment, and beyond.

George Wodicka
Professor and Head

Supporting Documentation:

1. Level: Undergraduate – junior year

2. Course Instructor: Riyi Shi, Peter Doerschuck

3. Course Outline:

Topics in order	***Lectures***
-Basic neurocytology (soma, axon, dendrite neuronal membrane)	*1*
-Basic organization of the nervous system (cell, neuron-neuron, glial-neuron, PNS and CNS	*1*
-Basic functional cellular electricity (capacitance, resistance, battery)	*1*
-Membrane potential and passive electric property of neurons	*1*
-Action potential (generation and propagation, including salutatory)	*1*
-Functional synaptic transmission (chemical vs electrical; IPSP vs EPSP; temporal vs. spatial summation)	*1*
-Large scale, fast and slow electrical properties (EKG, ECG, TEP)	*1*
-Measurement techniques including patch clamp, voltage clamp, current clamp, and intracellular versus extracellular measurements	*1*
-Manipulation of bioelectricity in pathological conditions	*1*
-Use of bioelectricity in biosensors	*1*
-Exam I will be given this week	*1*
-Electrical variable emphasizing values per unit length and per unit area	*1*
-Electrically small cells and lumped RC circuits	*1*
-Electrically large cells and the core conductor model	*2*
-Electrical properties of cell membranes in the lower region	*2*
-Incorporation of cell properties in models of electrically small cell	*1*
-Incorporation of cell membrane properties in models of electrically large cells and the transition from core conductor to cable model	*1*
-Methods for solving the partial differential equation of the cable model impulse responses, and step responses	*2*
-Numerical solution of cable equations	*2*
-Physiological interpretation of cable model solutions	*2*
-Exam II	*1*

Topics in order	***Lectures***
-Experimental background to nonlinear description of cell membrane properties	*2*
-Quantitative description of voltage clamp measurements	*2*
-The Hodgkin-Huxley model	*2*
-Numerical solution of the Hodgkin-Huxley model	*1*
Use of the Hodgkin-Huxley model to explain the behavior of a prototypical axon	*3*
Voltage-current characteristic and passive conductors	*1*
-Exam III	*1*
-Micro anatomy of a mammalian mylinated axon	*1*
-Evidence for sultatory conduction in mylinated axon	*1*
-A model for sultatory conduction	*1*
-Numerical solution of a model for sultatory conduction	*1*
-Use of a sultatory conduction model to explain behavior of a prototypical mammalian axon	*1*
-Summary and future: lumped versus distributed, linear versus nonlinear, and scular versus vector descriptions of electrical phenomena	*1*
-Finals Week **Comprehensive Final**	Total *44*

4. Text: *Cellular Biophysics, Vol. 2-Electrical Properties* by Thomas Fischer Weiss; The MIT Press, Cambridge MA, (1996) and *Principles of Neural Science* by E.R. Kandel, J.H. Schwartz, and T.M. Jessell, McGraw-Hill/Appleton,Lange; 4th ed. (2000).

5. Grading: based on exams, homework, and computational projects.