UNIVERSITY OF CALIFORNIA
UCMERCED

Syllabus for BIOE065-01: Biocircuits Theory

Fall 2018
Instructor: Sushma Shrinivasan

Designation:	Lower division
Catalog Description:	Basic concepts such as voltage, current, resistance, impedance, Ohm's and Kirchoff's law applied to biological circuits; Basic electric circuit analysis techniques, resistive circuits, transient and steady-state responses circuits and it's application to obtain biophysical and physiological parameters; circuits with DC and sinusoidal sources, steady-state power and three-phase balanced systems, including Laplace and Fourier Transforms applications to solve Circuit Problems in biological systems.
Text Books and Other Required Materials:	Electric Circuits Nilsson & Riedel, 10th Edition. Prentice Hall Instructor notes will be provided as additional course material.
Course Objectives/ Student Learning Outcomes:	By the end of this course, students will be able to: 1. To develop the ability to apply the tools to analyze DC electric circuits in cells and tissues. 2. To understand the energy properties of electric elements and the thermodynamics implications for life development. 3. To understand the techniques to measure voltage and current. Measurements of membrane potential. 4. To understand the basic tools to analyze AC electric Circuits and cells. 5. To use advanced mathematical methods such as Laplace and Fourier transforms and some linear algebra techniques and differential equations to solve electric circuit problems.
Program Learning Outcomes:	
Prerequisites by Topic:	PHYS 09
Course Policies:	Homeworks are typically assigned on Thursday (check CatCourses) and will be due (in class) on the date indicated (typically after one week). Late homeworks will be accepted till the following day)basically a 24-hour extension) but for a reduced credit of 75%. To iterate, feel free to discuss among yourselves to complete the homework problems, but reproducing another person's work is not acceptable. Syllabus for Midterms-1 & 2 will be announced in class as the course progresses, and the final exam will be comprehensive. The class before the exams may be reserved for review of relevant material. In-class surprise quizzes (~ for 5-10 minutes) will be conducted. Make sure to stay updated with canvas on course announcements/material posted.
Academic Dishonesty Statement:	a. Each student in this course is expected to abide by the University of California, Merced's Academic Honesty Policy. Any work submitted by a student in this course for academic credit will be the student's own work. b. You are encouraged to study together and to discuss information and concepts covered in lecture and the sections with other students. You can give "consulting"

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help to or receive "consulting" help from such students. However, this permissible cooperation should never involve one student having possession of a copy of all or part of work done by someone else, in the form of an e mail, an e mail attachment file, a diskette, or a hard copy. Should copying occur, both the student who copied work from another student and the student who gave material to be copied will both automatically receive a zero for the assignment. Penalty for violation of this Policy can also be extended to include failure of the course and University disciplinary action.
c. During examinations, you must do your own work. Talking or discussion is not permitted during the examinations, nor may you compare papers, copy from others, or collaborate in any way. Any collaborative behavior during the examinations will result in failure of the exam, and may lead to failure of the course and University disciplinary action.

Disability Statement: Accommodations for Students with Disabilities: The University of California Merced is committed to ensuring equal academic opportunities and inclusion for students with disabilities based on the principles of independent living, accessible universal design and diversity. I am available to discuss appropriate academic accommodations that may be required for student with disabilities. Requests for academic accommodations are to be made during the first three weeks of the semester, except for unusual circumstances. Students are encouraged to register with Disability Services Center to verify their eligibility for appropriate accommodations.

Topics:

CIRCUIT PARAMETERS AND FUNDAMENTAL LAWS I
Electric charge. Coulomb's law. Electric work. Potential. Potential difference. Electric current. Power. Energy. Resistance. Resistivity. Ohm's law. Kirchoff's law. Branch. Node. Mesh. Circuit elements in series. Circuit elements in parallel. The Goldman parallel conductance model of a cell membrane.

CIRCUIT PARAMETERS AND FUNDAMENTAL LAWS II
Ideal current source. The steady state current clamp technique in spherical cells. Ideal Voltage generator. Internal resistance. Mesh current method. Node voltage method. Thevenin's theorem. Norton's theorem. Superposition's theorem. Concept of cellular electrotone. Capacity. The cellular capacitance. Inductors. The Curtis and Cole paradox for the squid axon. Electromagnetic flux.

WAVEFORMS AND SIGNALS
Periodic and non-periodic signals. Heavyside function. The Heavyside functions as a tool for evaluating ionic conductances. Impulse function. The impulse response: an operational way to define transfer functions of linearize biological systems. Ramp function. Saw-tooth function. Triangular function. Peak value. Peak to peak value. Average value. Effective value (RMS). Sinusoidal and co-sinusoidal signals. Euler's expression. Generic harmonic signal. Amplitude and phase.

INSTRUMENTS
The voltmeter. Internal resistance. The galvanometer. Internal resistance. The Ohmmeter. The Power Meter. The Wheatstone bridge. The impedance bridge. The oscilloscope. Equivalent and random sampling oscilloscopes. The spectrum analyzer.

POWER
Sinusoidal Steady State and Balanced Three Phase Circuits.

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	COMPLEX IMPEDANCE and ADMITTANCE Resistance. Phasorial notation. Capacitive and inductive reactance. Impedance. Impedance diagram. Conductance. The impedance diagram of a spherical cell. Cellular cable analysis using impedance diagrams. Capacitive and inductive susceptance. Capacitance measurements as a way to study cell secretion. Admittance. Series and parallel equivalent circuit. RLC series and parallel circuits.Resonance. CIRCUITS TRANSIENT RESPONSE. ODE RC, RL and RLC circuits. Time constant. Step and impulse response. Passive electrical properties of cells. Transient response of multi-mesh circuits. Time domain solution of a cable equation for a longitudinal cell. The space constant as parameter to define the extent of electrotone in multidimensional tissues. CIRCUITS TRANSIENT RESPONSE. LAPLACE TRANSFORM Studying transient phenomena with the Laplace transform. Circuit analysis in the s (complex variable) domain. Cellular analysis using the Laplace transform. QUADRUPOLE ANALYSYS I Definition of quadrupole and sign convention. Z, y, h, g parameters. Transition Matrix parameters. Symmetry and reciprocity conditions. Two-Port Parameters calculations. Parameters relationship. Parameter conversion tables. Network transformation. Quadrupole applications with controlled voltage and current sources. The neural networks.
Class/laboratory Schedule:	Tuesday & Thursday 1:30-2:45pm in GRAN 145 ; No labs
Midterm/Final Exam Schedule:	Midterm-1 : Tentative date- Sept 26th, 2018, 1:30-2:45pm, in-class Midterm-2: Tentative date- Oct 31st, 2018 1:30-2:45pm, in-class Final Exam: Dec 14th, 2018, 11:30-2:30pm, in-class All exams will be held in GRAN 145 (same room as lecture)
Course Calendar:	
Professional Component:	
Assessment/Grading Policy:	Homework- 25% Midterm 1- 20% Midterm 2- 20% In-class quiz- 5% Finals- 30%
Coordinator:	Sushma Shrinivasan
Contact Information:	sshrinivasan@ucmerced.edu TA : Michael Lun TA Email: mlun@ucmerced.edu
Office Hours:	Instructor: M,T,W,Th 3:30-4:30pm in AOA 143. TA Office Hours: TBA (Announcement will be posted)