PURDUE UNIVERSITY

WELDON SCHOOL OF
BIOMEDICAL ENGINEERING

BME 301 Bioelectricity

Course Syllabus

Location: BMED 1001
Time: Tuesdays and Thursdays from 12 noon to 1.15pm

Professor: Eugenio Culurciello
Office hours: Purdue Blackboard Discussions is the best to communicate and share questions with instructor, TA, and all fellow students. Please check if your questions have been listed before posting a new one. E-mail for appointments on Fridays 4-5 PM MJIS 2031. euge@purdue.edu Please use BME301 in subject!

Teaching Assistant: Rebecca Bercich
Office hours: Tuesdays 7:00-9:00 PM MJIS 2083
rbercich@purdue.edu Please use BME301 in subject!

Course objective: In this course you will acquire an intuition and understanding about the means through which biological systems generate electrical signals, and how they can be recorded and induced with manufactured devices.

Description: In this course you will use fundamental engineering and mathematical tools to understand and analyze basic bioelectricity and circuit theory in the context of the mammalian nervous system. A second objective is to instill in you an appreciation for the similarities between electricity in biology and in silicon circuits, enabling you to begin interfacing the two in simple recording and stimulating experiments. A solid quantitative understanding of electric phenomenon in the context of the biological system is essential for designing many devices for biomedical diagnosis, treatment, and beyond. BME 301 will give you the theoretical framework you need to begin exploring electrophysiological devices with biomedical engineering applications. Neural network models and learning techniques will be used to model cortical sensory processing of neural circuits. These tools will be cemented through hands-on experiments in BME 305, a separate lab course with extensive wet-lab and circuit prototyping components.

This course will cover the following topics (in order):

- Introduction to the nervous system, with an overview of neurons, glia, basic central and peripheral nervous system organization, and simple neural circuits (e.g. vestibulo-ocular reflex, stretch, etc…)
- Chemical basis of electrical signals. Derivation of membrane resting potential, ion channels, Nernst and Goldman equations. Action potentials with both saltatory and passive conduction. Types of neurotransmitters along with both direct and indirect modulation pathways.
- Electrophysiological recording techniques including: patch-clamp, voltage-clamp, extracellular electrodes etc…
- Electrical models of cells in standard resistor and capacitor component terms. Means of modeling current flows through cellular circuits using both Matlab and SPICE. Incorporation of discrete passive and active components into the model to simulate the presence of electrodes, amplifiers, etc…
- The Hodgkin-Huxley model of the action potential. It's validation in the giant squid axon, and what it tells us about temperature dependence as well as sensitivity to causal, nonlinear, and sub-threshold oscillatory effects.
- Recording and stimulating bioelectric signals using operational amplifiers in both theory and practice. Issues that arise in biological experiments as well as clinical practice. What this tells us about op-amp selection or design.
- Neural networks models, learning and training

Text book: Neuroscience, Purves et al. 5th or 4th edition, with 3rd edition also suitable.

Computing Tools: We strongly believe in open-source software for academic and research purposes. We suggest all students to learn and use Linux operating systems and learn the foundation of Unix in your spare time. Python with packages numpy, scipy, matplotlib are the recommended tools. An easy to install distribution is Sage http://www.sagemath.org/. Grade bonuses will be given to all students using these tools.

Exams: All exams will be closed-book, closed-notes, no calculators, or anything else other than a writing implement, the exam itself, and your brain.

Homework: All homework will be due at the beginning of class after seven calendar days from the day they were assigned. Generally they will be assigned on the last day of the week (Thusday) and will be due at the beginning of class on the following Thursday irrespective of holidays.

Academic conduct: Plagiarism, cheating or other acts of academic dishonesty will not be tolerated. Any infractions whatsoever will result in immediate expulsion from the course and a failing grade for the semester.

Grading:

Weekly homework	10%
Semester project	20%
Exam 1	20%
Exam 2	20%
Final Exam	30%
Total	**100%**

Grade Scale:

GPA	Grade	Percentage
4	A	≥93
3.7	A-	92 – 90
3.3	B+	89 – 87
3.0	B	86 – 83
2.7	B-	82– 80
2.3	C+	79 – 77
2.0	C	76 – 73
1.7	C-	72 – 70
1.3	D+	69– 67
1	D	66– 60
0	F	≤59.99%

Emergency planning: In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. Here are ways to get information about changes in this course: Contact the professor, or the TA.

Students with special needs: If you have a disability of any kind that could affect your work for the course, please contact me by email or in person as soon as possible, so that we can arrange appropriate accommodations in consultation with Purdue's Disability Resource Center.