Electrical & Computer ENGINEERING

Carnegie Mellon University Course Syllabus

18-819 E Special Topics in Applied Physics:
Neural Technology, Sensing & Stimulation
Fall Semester, 2012

Course Personnel:

Instructor:

- Shawn Kelly
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  Office hours: TR 1:30 – 3:00, HBH 1205

Teaching Assistant:

- Ashwati Krishnan; ashwatik@andrew.cmu.edu

Course Management Assistant:

- Shannon Lown
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Class Schedule:

- **Lecture**: TR 12:00PM - 1:20PM Doherty Hall 1117
- **Recitation**: F 1:30PM - 2:20PM Doherty Hall 1209

Course Description:
Neural Technology, Sensing, and Stimulation

This course gives engineering insight into the operation of excitable cells, as well as circuitry for sensing and stimulation nerves. Initial background topics include diffusion, osmosis, drift, and mediated transport, culminating in the Nernst equation of cell potential. We will then explore models of the nerve, including electrical circuit models and the Hodgkin-Huxley mathematical model. Finally, we will explore aspects of inducing a nerve to fire artificially, and cover circuit topologies for sensing action potentials and for stimulating nerves. If time allows, we will discuss other aspects of medical device design. Students will complete a neural stimulator or sensor design project.

Specific Goals for the course:
By the end of this course, students should be able to:

- Understand and solve problems relating to:
  - Transport of materials into and out of cells
  - Nerve potentials
  - Models of electrical conduction in nerves

    - Models of mediated transport of ions across nerve membranes
    - The activating function for neural stimulation
    - Stimulating and recording electrode materials, models, and function
    - Stimulating circuit architectures
    - Recording circuit architectures
    - Aspects of the design of an implantable medical device
- Perform analytical tests on an electrode to assess its material properties
- Design and build a circuit to either stimulate or record from neural tissue

Pre-requisites: 18-220 or equivalent, or an understanding of basic circuits, differential equations, and electricity and magnetism. Some review of circuit theory will be provided for those who need it.

Undergraduate Course Area: Applied Physics
Graduate Course Area: Applied Physics (Solid State/Magnetics/Fields)
Undergraduate Course Designation: Coverage

Textbook: (Strongly Recommended)
Cellular Biophysics (Vol. 1 and Vol. 2); Thomas F. Weiss; 1996
These books appear to be out of print, but if the bookstore can't acquire copies, then used versions can be found on Amazon. Also, copies of these books are in the Engineering and Science Library and the Mellon Institute Library.

Course Blackboard: To access the course blackboard from an Andrew Machine, go to the login page at: http://www.cmu.edu/blackboard. You should check the course blackboard daily for announcements and handouts.

Course Wiki:
Students are encouraged to use the ECE wiki to provide feedback about the course at: http://wiki.ece.cmu.edu/index.php.

Grading Algorithm:

10%	Homework
35%	Lab(s) and Project
10%	Quizzes
15%	Midterm
30%	Final

We keep grades on Blackboard. Please review your scores periodically. You have one week after a graded item is returned to request a grade correction.

Homeworks are due at the start of class on the date due. **No late homework accepted**. Discussions about homework in small groups are encouraged. However, homeworks must be written up **individually** and **independently**.

Lab and project information will be handed out partway through the semester.

Tentative Course Calendar

Date	Day	Class Activity
August		
28	Tues	Course Introduction; Overview of cell structure and transport
30	Thurs	Overview of neural medical devices
31	Fri	***No recitation first week***
September		
4	Tues	Diffusion 1
6	Thurs	Diffusion 2
7	Fri	Diffusion wrap-up
11	Tues	Osmosis 1
13	Thurs	Osmosis 2
14	Fri	Osmosis/Diffusion wrap-up
18	Tues	Drift
20	Thurs	Nernst Equation
21	Fri	Cellular resting potential
25	Tues	Cable model of a neuron
27	Thurs	Mediated transport
28	Fri	Review
October		
2	Tues	Mid-term Exam #1
4	Thurs	Hodgkin-Huxley model 1
5	Fri	Hodgkin-Huxley model 2
9	Tues	Myelinated neurons
11	Thurs	Stimulation of neural tissue 1
12	Fri	Hodgkin-Huxley review
16	Tues	Stimulation of neural tissue 2
18	Thurs	Electrode materials
19	Fri	***Mid-Semester Break; No Classes***
23	Tues	Electrode-tissue interface 1
25	Thurs	Electrode-tissue interface 2
26	Fri	Electrode review
30	Tues	Stimulating circuits 1
November		
1	Thurs	Stimulating circuits 2
2	Fri	Stimulation safety
6	Tues	Design project overview
8	Thurs	Recording circuits 1
9	Fri	Recording circuits 2
13	Tues	Neural signal processing
15	Thurs	Implantable device overview
16	Fri	Biocompatible materials
20	Tues	Review
22	Thurs	***Thanksgiving Holiday; No Classes***
23	Fri	***Thanksgiving Holiday; No Classes***
27	Tues	Medical device design
29	Thurs	Medical device entrepreneurship
30	Fri	TBD
December		
4	Tues	Project presentations
6	Thurs	Project Presentations
7	Fri	Review

11	Tues	Final Examinations
13	Thurs	Final Examinations
14	Fri	Final Examinations
18	Tues	Final Examinations

Academic Integrity Policy (http://www.ece.cmu.edu/student/integrity.html**):**

The Department of Electrical and Computer Engineering adheres to the academic integrity policies set forth by Carnegie Mellon University and by the College of Engineering. ECE students should review fully and carefully Carnegie Mellon University's policies regarding Cheating and Plagiarism; Undergraduate Academic Discipline; and Graduate Academic Discipline. ECE graduate student should further review the Penalties for Graduate Student Academic Integrity Violations in CIT outlined in the CIT Policy on Graduate Student Academic Integrity Violations. In addition to the above university and college-level policies, it is ECE's policy that an ECE graduate student may not drop a course in which a disciplinary action is assessed or pending without the course instructor's explicit approval. Further, an ECE course instructor may set his/her own course-specific academic integrity policies that do not conflict with university and college-level policies; course-specific policies should be made available to the students in writing in the first week of class.

This policy applies, in all respects, to this course.

Carnegie Mellon University's Policy on Cheating and Plagiarism (http://www.cmu.edu/policies/documents/Cheating.html) states the following,

Students at Carnegie Mellon are engaged in preparation for professional activity of the highest standards. Each profession constrains its members with both ethical responsibilities and disciplinary limits. To assure the validity of the learning experience a university establishes clear standards for student work.

In any presentation, creative, artistic, or research, it is the ethical responsibility of each student to identify the conceptual sources of the work submitted. Failure to do so is dishonest and is the basis for a charge of cheating or plagiarism, which is subject to disciplinary action.

Cheating includes but is not necessarily limited to:

1. Plagiarism, explained below.
2. Submission of work that is not the student's own for papers, assignments or exams.
3. Submission or use of falsified data.
4. Theft of or unauthorized access to an exam.
5. Use of an alternate, stand-in or proxy during an examination.
6. Use of unauthorized material including textbooks, notes or computer programs in the preparation of an assignment or during an examination.
7. Supplying or communicating in any way unauthorized information to another student for the preparation of an assignment or during an examination.
8. Collaboration in the preparation of an assignment. Unless specifically permitted or required by the instructor, collaboration will usually be viewed by the

university as cheating. Each student, therefore, is responsible for understanding the policies of the department offering any course as they refer to the amount of help and collaboration permitted in preparation of assignments.

9. Submission of the same work for credit in two courses without obtaining the permission of the instructors beforehand.

Plagiarism includes, but is not limited to, failure to indicate the source with quotation marks or footnotes where appropriate if any of the following are reproduced in the work submitted by a student:

1. A phrase, written or musical.
2. A graphic element.
3. A proof.
4. Specific language.
5. An idea derived from the work, published or unpublished, of another person.