ECE590 and ECE499 – Spring of 2008
Neural Engineering

Objective: This course gives an overview of Neural Engineering for graduate and senior undergraduate students with Engineering or Neuroscience backgrounds. The sequence of classes is designed to cover from fundamentals of Neurophysiology through applications of neural prosthesis devices such as retinal and cochlear implants. Other important aspects of Neural Engineering to be discussed include the brain-machine interface, instrumentation for interfacing electronics to the nervous system, and sensors for neural research.

Prerequisites: While there is no formal prerequisite, it is expected that the students show interest in these areas, and that they acquire the necessary knowledge throughout the semester, either by interaction with the instructor and other students, or through the reading of support textbooks.

Main Textbook: Neural Engineering, ed. Bin He, Bioelectric Engineering Series, vol. 3, 2005. ISBN 0-306-48609-1.

Pertinent journal papers will be emailed to students periodically.

Supplementary texts:

- Kandel, E.R., Principles of Neural Science, McGraw-Hill, 2000, ISBN 0838577016.
- Purves, D, Augustine, G.J, et al. (eds), Neuroscience, Sinauer Assoc., 1997 (or newer edition). ISBN 0878937471.
- Khandpur, R.S., Biomedical Instrumentation, McGraw-Hill, 2005. ISBN 0071447849.

Obs. Don't buy any of the supplementary textbooks: they are meant as a guide for you to know which areas the course will cover. Some (if not all) of these books will be on reserve in Fenwick.

Course structure: the course consists of weekly lectures, homework, and two exams. Exams will be closed book and closed notes. Students are to bring a calculator every class, including exam days. A paper presentation is due by the end of the semester (see details below). Participation in class will be considered as part of the grade; the hope is that most of the sessions will be of great interest to students and arouse discussion in class, either in the form of possible projects in neural engineering, or as analysis of previously emailed journal papers.

Grade:

Midterm	30%
Final exam	30%
Participation in class and homework	20%
Paper	20% (judged by your classmates)

Paper:

- Subject to be selected by each student within first 2 weeks of class. (Talk to the instructor.)
- 20min presentation (with slides) in the end of the semester
- main literature source(s) have to be available to other students 2 weeks before the presentation
- Other students will grade you. Grades will be based on: clarity of explanation; creativity; knowledge of the subject and background; consistency; quality of presentation.

Homework is due at the beginning of class. Late homework assignments will be graded according to the following criteria: up to 24h late: 80% of total grade; from 24 to 48h late: 60% of total grade; from 48 to 96h late: 60% of total grade. No homework accepted after 96h.

Exams: Absence from exams must be justified.

Course outline (Spring 2008):

1. Jan 24th :

Introduction.
Discussion of syllabus.
Fundamentals of Neurophysiology. Neuron; membrane.
Broad definition of a neural prosthesis; development; market; history.
Design criteria for a prosthetic device; bottlenecks.
Brainstorming with students: why “Neural Engineering”.
HW#1a (pick your topic for project after looking at literature and book)
HW#1b (paper from Nature or Science, questions/discussion).

2. Jan 31st : (HW#1 due)

Charge passage to and from the brain.
Metals for use in implants.
Fundamentals of data analysis for implanted materials (electrochemistry and histology).
Applications: cochlear implant.
HW#2 (Microelectrodes paper)

3. Feb 7th : (HW#2 due)

Interfacing electronics to the body.
High pass and low pass electrodes
Drug delivery and neurochemical analysis
HW#3

4. Feb 14th : (HW#3 due)

Fabrication methods for implantable prosthesis.
Sieve probes, shank probes, brain slice applications (non implantable)

HW#4

5. Feb 21st : (HW#4 due)
Brain-machine interfaces.
Practical implementations and modeling.
HW#5

6. Feb 28th : (HW#5 due)**:**
Neurorobotics.
Pre-midterm review.

7. March 6th :
Midterm (chapters 1 through 4 of textbook)

March 13th – no class, Spring break.

8. March 20th:
Electrical Stimulation of neurons.
Effects of electric fields on transmembrane potentials.
HW#6

9. March 27th: (HW#6 due)
Neural signal processing; Learning; Plasticity
HW#7

10. April 3rd : (HW#7 due)
Neural implant examples: retinal and cochlear
HW#8

11. April 10th : (HW#8 due)
Modeling neurons. Hodgkin Huxley. Timestamps. Firing rates.
HW#9

12. April 17th: (HW#9 due)
Neuronal system identification
HW#10

13. April 24th : (HW#10 due)
Seizure prediction
HW#11

14. May 1st : (HW#11 due)
Final projects due. Presentations. Pizza.

15. May 8th :
Final exam.