Syllabus for Georgia Institute of Technology's BMED 4400:

NeuroEngineering Fundamentals

Real World Curriculum
Last update: 1/7/13

This is a unique lab+lecture course that allows you to enhance your problem-based learning (PBL) skills by designing your own cutting-edge experiments with advanced ideas and equipment identical to those used in the Laboratory for Neuroengineering and elsewhere at Georgia Tech. Emphasis will be on teamwork, thinking, and self-directed inquiry. You will learn all about where brain tissue and technology meet. The course is designed to give you skills useful in the Real World, and attempts to emulate the grad school experience.

Course Objectives:
- *To become conversant in all of the fields where technology and neural tissue meet, in both clinical and basic research settings.*
- *To hone self-directed inquiry skills through the design and execution of laboratory experiments.*
- *To build and work with actual neuroengineering research hardware and software.*
- *To learn to document lab work in an enduring, useful lab notebook.*
- *To learn and apply modeling and data analysis tools to real data obtained during lab.*
- *To hone group skills, working as small teams in and out of the lab.*
- *To learn practical neurophysiology.*
- *To develop an appreciation of neural dynamics, including sensory-motor integration and closed-loop feedback.*

Pre-requisites: BMED 4752 (Introductory Neuroscience) and BMED 3110 (Physiology lab, or equivalent) strictly enforced.

2 hours lecture, *6 hours lab per week* (3 hours supervised, 3 hours YOU MUST SCHEDULE). (Auditing of lectures is OK with instructor permission; There is no room for guests or auditors in the labs)

Instructor:
Dr. Steve Potter <steve.potter@bme.gatech.edu>
(404) 385-2989 (Office); (404) 542-2228 (cell/home)
Office: 3110 Whitaker; Office Hours: after lecture or by appointment
"No questions are too dumb to ask"

Various *Special Guest Lecturers* will be presenting their research and methodology.

TA: Seth Koenig <skoenig@gatech.edu>
Administrative Assistant: Alyceson Andrews, (404) 894-1359, rm. 3114 Whitaker

Class Meeting Times:
Lectures: Monday, Wednesday 2:05-2:55 ES&T L1205.
Lab Orientation lectures: These will introduce lab topics and allow discussion and planning of experiments.
Neuroengineering Fundamentals Lectures: These will be relatively independent of the labs, covering the Big Picture of Neuroengineering. Many will be given by guest lecturers doing neuroengineering.

Class Discussion/PBL: Several lecture periods will be used for discussing and refining your experiments.

Laboratory: Whitaker Basement Cell Culture Room 0243 and physiology room 0246.
Supervised Labs: Thursdays, 4:35-7:25.
Unsupervised labs: YOU are responsible for scheduling ~3 hours/week with your teammates, as needed.

Textbooks: If you took IntroNeuro, you already have the Purves book. If not, you need to get Purves, *Neuroscience*, 5th Edition or another good neurobiology text. We will also be reading and discussing parts of *"Neuroethics"* edited by Martha Farah (~$25 on Amazon http://amzn.com/0262514605).

LECTURES

(See Class Schedule, which is subject to change)

The "lectures" should be thought of as discussions, including brainstorming and troubleshooting. Your questions and interruptions for discussion and input are always welcome.

Topics to be covered or reviewed:
The nervous system, its inputs and outputs;
Basic cellular neurobiology;
Neuron activity, neurodynamics, oscillations and bursts;
Neuromorphic engineering: VLSI silicon (electronics) models of neural systems;
Neural interfacing for sensory and motor prosthetics;
Neural interfacing for treatment of disease (functional stimulation);
Neural interfacing for in vitro brain models;
Real-time neural data analysis and feedback;
Neurally-controlled robots;
Diagnostic neural interfacing and functional neuroimaging;
Optical recording and stimulation in research and in the clinic;
Neural tissue engineering, repair and regeneration.

LAB

The Laboratory component will emphasize feedback and the dynamics of neural systems. We will use neuronal networks grown in vitro as the "experimental subject". This involves multi-neuron recording and stimulation with multi-electrode arrays (MEAs). Your self-designed projects will be based on actual research problems being pursued in the Potter lab and elsewhere.

The Lab Module will incorporate electronics construction, programming, cell culture, electrophysiology, literature searching, experimental design, data visualization and analysis, scientific notebook writing and oral presentation. You will build on problem-based learning (PBL) skills in small groups. *You are expected to seek help from me or the TA when things don't work. You may not give up on something without my permission! I can not emphasize this enough. Re-read the last two sentences!*

LAB NOTEBOOKS

"If it's not in your notebook, it didn't happen." -Jerry Pine, inventor of MEAs.

Every student must keep a detailed lab notebook as a Google Document. Create an account on Google if you don't already have one. Share your notebook with me and the TA with Google Docs or Google Drive; I'm stevepwork@gmail.com. The target reader is a new grad student who is trying to follow where you left off. Make it clear, readable, well written and annotated, organized (include a table of contents, sections with headings, dates for all entries, etc.) Explain what you learned when things worked, AND when they didn't. Plenty of things won't work, but don't consider them "failures" because you always learn something. The more detail you include, the better. Deep thinking and analysis are *expected*. Because much of your research and lab work will be done as a team, it is important that you note on each day's page whether this is your own work or that of a teammate. All of your personal efforts and contributions in creating group proposals, presentations, and reports must be reflected here. Your notebooks should include not just lab activities, but also your outside research and group meetings. Each paper you read should have a summary of important points. Read previous semesters' Good Notebook Examples!

GRADING

Nearly half of your grade will be for lab performance and accomplishments, **judged primarily by your lab notebook and peer evaluations**. Deadlines are important in the Real World. Late work will not be accepted. Attendance to all lecture and lab sessions is REQUIRED. I have worked hard to create for you a useful and interesting class, and the Special Guests have donated their time to your education. Your total points will be reduced by 2 for each unexcused absence. Excuses require doctor's or Dean's note, or letter of invitation (for interviews, etc.).

Points Breakdown

Weekly Quizzes and homework	15
Midterm exam	15
Presentation 1	5
Presentation 2	5
Lab Notebook 1	15
Peer Evaluations 1	5
Lab Notebook 2	15
Peer Evaluations 2	5
Comprehensive Final exam	20
Total points	100

Everyone in the group will receive the same score for the group's presentation, so it would be to your advantage to make sure all parts of it are well prepared, not just your part.

The Exams will mainly cover topics in the Required Readings and Lectures, but may include concepts learned in the labs. They will be short answer and essay format. They will emphasize integrating information learned over the semester, and deep thinking, as opposed to memorization of factoids.

Grading will be absolute, not curved, so each of you has a chance to get whatever grade you are willing to earn.

Points
90-100: A Excellent Performance
Goes above and beyond goals set by professor and TAs. Notebooks are very well-written and useful to others. Teammates call you a leader. Outside-class inquiry is done often, including digesting material into notes, and tutoring teammates. All course material is absorbed, processed, and used to create novel (not taught in class) and consistent ideas relating to NeuroEngineering. Material learned in the lab and from outside inquiries is combined well with lecture and text material. Writing is excellent.

70-89.9: B Good Performance
Accomplishes all goals set by professors and TAs. Works well on a team. Learns from failure well. Notebook has most of the information expected and is readable. The most important points of the course are absorbed, processed, and presented well enough to show proficiency in NeuroEngineering. Some lecture or reading materials are forgotten or not well understood. So-so or poor integration with material learned in lab or from outside inquiries. Writing is good.

50-69.9: C Fair Performance
Does enough to get by. Sometimes disappoints fellow team members. Inadequate outside inquiry needed for labs. Doesn't ask for help. Some important points were mentioned but not adequately described or integrated with other points. Little attempt to think independently or to combine ideas learned. Some required material was forgotten, never studied, or misunderstood. Writing is poor.

30-49.9: D Very Poor performance
One or more of: Failure to credit others' work; Very poor writing; Little or no effort in combining ideas learned; Poor understanding of several important NeuroEngineering ideas; Poor attendance.

0-29.9: F Fail
Evidence of foul play; Poor attendance; Missed or unfinished assignments; A detriment to your team.

Your input is requested!
This is a course that depends on very tricky technology and unpredictable biology, so you should not expect everything to go smoothly. Just like in the Real World! Read and follow the *Advice from Former Students* pdf (on Tsquare). Any suggestions you may have for improvements are appreciated. Pass them on to the instructor, TA, or anonymously via CIOS.

Honor Code
Students are expected to adhere to the Georgia Tech Honor Code, which means, in the team-effort context, that you must cite all work by your teammates or others by name, and put your name on work YOU did. Any material you obtain from readings of the text or the literature must include the **full** citation. You are responsible for reading and following the honor code: http://www.honor.gatech.edu/plugins/content/index.php?id=9

Extra Credit
Unlike with IntroNeuro BMED4752, this class does not have Extra Credit. I prefer you spend your extra effort on doing excellent inquiry and lab research, fixing up your notebook, and interacting well with your team. Come see me if you need help with any of those!