Syllabus for NBIO136b

Jonathan Cannon

Instructor: Jonathan Cannon, office TBA, tel: 314-749-6902, email: cannon@brandeis.edu.
Office hours: Mon 2pm-3pm, Wed 11am-12pm, or by arrangement

TA: Mark Zielinski, office: Bassine 303, email: mcz@brandeis.edu.
Office hours: Fri 10am-11am or by arrangement

Course website on Latte.

Class time: Tuesday and Thursday 3:30-5:00

Book: Dayan and Abbott, Theoretical Neuroscience

Overview:

Welcome to Computational Neuroscience! This course will be an exploration of several of the major questions in neuroscience from a mathematical/computational perspective. In particular, we will focus on the questions:

- How can we find meaning in the electrical neuronal activity observed in the brain?
- How do the physical mechanisms in the brain give rise to the observed patterns of activity?
- How can neurons perform the tasks necessary for (animal/human) life?

This course of instruction is offered with two principal goals:

- Students will become conversational in the language of computational/theoretical neuroscience.
- Students will become familiar with the capabilities, limitations, and philosophical challenges of CN.

In class:

Let's make a deal. I will work hard to plan class time that is not just me talking at you and showing you slides. There will be discussions, group work, and several classes spent in the computer lab in which Mark and I can give you personalized help. I will be highly responsive to any feedback on how to make class time as engaging as possible. In exchange, *I ask that you not have laptop screens in front of you during class.* An old-fashioned notebook (or, if necessary, a tablet computer in old-fashioned notebook mode) should be sufficient for note-taking.

Reading assignments:

Regular work for this course will consist largely of reading from the required textbook, supplementary materials, and published papers. Reading assignments will be posted on the website along with several questions designed to guide your reading. I will ask you to bring brief answers to these questions and one question of your own into class.

Coding assignments:

There will also be several coding assignments. We will be writing our code in the Matlab language/environment. Matlab is available in the Goldfarb and Farber computer clusters here on campus, and is also available in many research laboratories. Students who don't have easy access to Matlab in one of these locations can install Matlab using the university's site license. If you have not worked in Matlab before, *and especially if you have not coded before,* you should work through the tutorial online here: `http://www.mathworks.com/help/matlab/getting-started-with-matlab.html`. We will start the first two coding assignments together in the computer lab to make sure you're on your feet.

Major grades:

There will be three "major grades" during the semester:

- A data analysis paper, in which you use techniques learned in class to make sense of spiking data
- A cumulative in-class midterm
- A final project in which you present independent research on a topic of your choice and its connections to the course material

Grading policy:

Grades will be calculated from reading assignments (20%), coding assignments (25%), and the three major grades (15% each). Answers to reading questions will not be accepted late. Maximum credit available for a coding assignments or major grade will decrease exponentially after its due date with a half-life of three days:

$$g = \bar{g}\left(2^{\frac{-[t-\tau_{due}]_+}{3}}\right)$$

(where g is your final fractional grade, $\bar{g}$ is your fractional grade before late penalty, t is the time since the Big Bang in earth days, τ_{due} is the due time, and $[\cdot]_+$ denotes $max(\cdot, 0)$.)

Questions:

Almost all of the information that enters our brain enters by a process that can be characterized as "active sensing." Rats whisk and sniff; bats echolocate; babies stick things in their mouths. In short, *effective learning requires active participation.*

Every reading assignment will require you to formulate questions about your reading. In class, any time is a good time for a question. When students refrain from asking questions, it's often for one of two reasons:

1. *They are worried about wasting class time.* Let me worry about that – I take full responsibility for choosing which questions to answer at length and which to take "offline."
2. *They are embarrassed that their question may be "stupid."* Every brain is born unique, and each is shaped by the unique collection of stimuli with which it interacts. I generally consider a brain "smart" to the extent that it is engaged in active sensing, regardless of background or skill set. It is your responsibility to make sure you get an answer to your "stupid" question, and it's my job to help you do that, either in class, in office hours, or online.

Tentative schedule
(assignment list is not complete; due dates may be subject to change.)

Th, 8/27	Course overview and discussion	
Unit 1:	**The informative neuron**	
Tue 9/1	Analysis of spike trains	
Thu 9/3	Modeling neuron responses	
Tue 9/8	Spike trains in the computer lab	
Thu 9/17	Analysis of oscillations	Due: Spike train lab
Tue 9/22	Decoding neuron responses	
Thu 9/24	Information theory	
Thu 10/1	TBA	
Unit 2:	**The dynamic neuron**	
Tue 10/6	ODEs and passive membranes	Due: Data analysis paper
Thu 10/8	Active conductances	
Tue 10/13	Hodgkin-Huxley models in the computer lab	
Thu 10/15	The zoo of neuronal behavior	
Tue 10/20	Integrate-and-fire reduction	Due: Hodgkin-Huxley lab
Thu 10/22	Rhythm and synchronization	
Tue 10/27	Rate models	
Thu 10/29	Rate model dynamics	
Tue 11/3	TBA	
Thu 11/5	MIDTERM	
Unit 3:	**The learning and computing neuron**	
Tue 11/10	Rate model computations	
Thu 11/12	Unsupervised learning	
Tue 11/17	Classical conditioning	
Thu 11/19	Attractor-based memory	
Tue 11/24	Categorization	
Tue 12/1	TBA	Due: Final project
Thu 12/3 TBA		
Tue 12/8	TBA	