MATH 1370: *Introduction to Computational Neuroscience.*

Class Meeting Location and Times: TuTh, 4:00-5:15, 525 Thackeray Hall Hall.
Instructor: Dr. Brent Doiron;

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office hours By appointment.

web: http://www.math.pitt.edu/∼bdoiron will contain homework assignments and related announcements.

Course description:

Computational neuroscience is devoted to applying numerical and theoretical techniques to contemporary problems in both cellular and systems neuroscience. The first aim of this course is to give a broad introduction to several mathematical models of neurons and networks of neurons, with an emphasis on how these models have advanced the understanding of the nervous system. The second aim is to introduce contemporary mathematical representations of how neurons perform computations, with an emphasis on neural coding. The final goal is to integrate these two approach, offering a new technique set to explore neural computation.

The approximate course material, in the order it is to be presented, is :

1. Electrical circuit model of a cellular membrane. The Hodgkin-Huxley model of action potential generation. Influence of various ionic channels on action potential generation.

2. Reduced models of action potential generation (Fitzhugh-Nagumo model) with a phase-plane description of action potential dynamics. Transitions between excitable and oscillatory dynamics. Mathematical analysis of bursting.

3. Synaptic inputs and models of synaptic plasticity.

4. Stochastic neuroscience I: Diffusion approximation of pre-synaptic input, stochastic neuron models, neural variability and balanced vs. unbalanced inputs, integrate-and-fire neuron models.

5. Stochastic neuroscience II: Point processes, spike train statistics, spectral measures of spike train response.

6. Neural coding: Neural decoding, parameter estimation by population codes, Fisher information.

7. Mean field models and population activity. Wilson-Cown firing rate models.
8. Balanced cortical networks and internally generated neural variability.
9. Competition models, Attractor networks, and the Hopfield model.
10. Neural models of working memory and decision making.

Official course text:
I will be posting relevant articles on my webpage to supplement the text, these will be mentioned in classes as they are posted. Other recommended (but not required) source material can be found in these texts:

Mathematics for Neuroscientists. Fabrizio Gabbiani and Steven Cox, Academic Press, 2010

Theoretical Neuroscience. Peter Dayan and Larry Abbott, MIT Press, 2001

Dynamical Systems in Neuroscience Eugene Izhikevich, MIT Press, 2006.

Biophysics of Computation Christof Koch, Oxford University Press, 1999.

Spikes: Exploring the Neural Code Fred Rieke, David Warland, Rob de Ruyter van Stevenick, William Bialek, MIT Press, 1997.

Stochastic Processes in the Neurosciences Henry Tuckwell, SIAM Press, 1988.

Spiking Neuron Models Wulfram Gerstner and Werner Kistler, Cambridge University Press, 2002.

Mathematical Physiology Mathematical Physiology, Springer-Verlag, 1998.

Grading:

Assignments: The course will have 5-6 assignments. Each assignment will involve a significant MATLAB component and further analysis to be done by the student. The assignment grade will compose **60%** of the course grade.

Course Project: The students will complete a research project, where the methodology introduced in class will be applied to a neuroscience-motivated problem of interest. In large part the project may be to replicate, and possibly expand in some small direction, results from a preexisting modeling study already published. Students will submit a single paragraph proposal with a beginning reference list by the mid-term point. The instructor must approve this proposal before work on the project should begin. A 15-20 page report (double spaced with figures) will be due the last week of the term, and a 10-15 minute presentation will be given by the students in that same week. The students will be encouraged to work in pairs and submit a single report and present their project as a team. A sample list of potential projects will be given in the first few weeks of the term; of course students are encouraged to propose projects of their own design. Further details will be given later in the term. The combined project grade will be **40%** of the course grade.

Teaching assistant and recitations:
The course will have a dedicated teaching assistant (Youngmin Park; yop6@pitt.edu). Youngmin will have weakly office hours (math assistance center Mondays 9-11am, Thursdays 9-11am), where students can obtained individualized help. Youngmin will also be giving one recitation per assignment (approximately 7 days before the due date), covering key techniques in MATLAB that will aid students that require assistance in coding basics.

Homework policies: I strongly recommend that you complete the homework problems; very few students can learn this material without doing so and they can significantly impact your course grade. Students are welcome to work together on homework. However, each student must turn in his or her own assignments, and *no copying from another student's work is permitted.* Deadline extensions for homework will not be given. If you realize that you have a serious conflict that may prevent your submitting an assignment on time, please talk to me as far in advance as possible. I also encourage you to come talk to me about homework problems if you'd like additional feedback.

Disability concerns: If you have a disability for which you are or may be requesting accommodation, you are encouraged to contact both your instructor and Disability Resources and Services (DRS), 216 William Pitt Union, (412) 648-7890/(412) 383-7355 (TTY), as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course.

Academic integrity: The University of Pittsburgh Academic Integrity Code is available at http://www.fcas.pitt.edu/academicintegrity.html. The code states that "A student has an obligation to exhibit honesty and to respect the ethical standards of the academy in carrying out his or her academic assignments." The website lists examples of actions that violate this code. Students are expected to adhere to the Academic Integrity Code, and violations of the code will be dealt with seriously.