Computational and Mathematical Neuroscience
MATH 559/BIOINF 800, Fall 2010

Meeting times: T,Th 8:30-10am, EH 4088

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Office Hours: M 9-10am, T,Th 10-11am and by appointment

CTOOLS Website: MATH 559 001 F10
Class email address: math559f10@ctools.umich.edu

Textbook: No required textbook. Readings will be posted on course webpage. Readings and homework problems will be selected from a number of different texts including:

1. Mathematical Foundations of Neuroscience by G.B. Ermentrout and D.H. Terman (Springer 2010). PDFs of all chapters available at springer.com.
2. Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems by P. Dayan and L. Abbott (MIT Press, 2005).
3. Foundations of Cellular Neurophysiology by D. Johnston and S.M. Wu (MIT Press 1995).
4. Biophysics of Computation by C. Koch (Oxford University Press, 1999).
5. Methods in Neuronal Modeling, C. Koch and I. Segev, eds. (MIT Press, 1999).
6. MATLAB for Neuroscientists: An Introduction to Scientific Computing in Matlab by P. Wallisch (Elsevier/Academic Press 2009). Available online from UM library.

Homework: Bi-weekly homework assignments including analytical and numerical-based problems. Late homework will be grudgingly accepted.

Course project: A modeling project will be due Monday, December 20. Oral presentations of projects to be given in class November 30, December 2, 7 and 9.

Grading: Homework 50%, modeling project 40%, class participation 10%

Numerics: Numerical implementation and analysis of the models presented in the lectures will be an integral part of the course. You may use a numerical package of your choice. I can offer support and demonstration code for Matlab and XPP/XPP-AUT (http://www.math.pitt.edu/~bard/xpp/xpp.html).

Topics covered:

Sept 7,9: Introduction, biophysics of ion flow, Nernst and Goldman-Hodgkin-Katz equations

Sept 14,16: Circuit model of neuronal membrane, passive membrane properties, integrate-and-fire model

Sept 21,23: Hodgkin-Huxley equations

Sept 28,30: Cable and compartmental models, propagation of action potentials

Oct 5,7: Cable and compartmental models continued, other ion channels

Oct 12,14: Probabilistic models of single ion channels

Oct 21: Reductions of the Hodgkin-Huxley model, Morris-Lecar model, phase plane analysis, linear stability of equilibrium points

Oct 26,28: Morris-Lecar model continued, bifurcation analysis

Nov 2,4: Synaptic currents, neuronal networks

Nov 9,11: Excitatory and inhibitory neuronal networks, noisy neuron models

Nov 16*,18: Noisy neuron models continued, neural encoding and decoding

Nov 23: Neural encoding and decoding

Nov 30, Dec 2,7,9: Presentations of projects