Math 490N: Introduction to Computational Neuroscience

Spring 2004: TuTh 12:30–1:20 and Tu 1:30-2:20 in REC 122.

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Office Hours: { **TuTh** 2:30–3:30 / or by appointment

General Information

Leaders in the National Science Foundation and the National Institutes of Health believe that computational and mathematical methods increasingly will provide the foundation for advances in the biological sciences. This course is intended to provide an introduction to mathematical modeling of the biological processes involved in neuroscience. The course will begin with a brief introduction to differential equations and the basic biology underlying the electrical processes in neurons. Classical systems of differential equations, such as those of Hodgkin-Huxley, FitzHugh-Nagumo, and Morris-Lecar, used to describe firing of action potentials in neurons and their propagation through networks will be developed and analyzed. These ideas and these models describe a diverse set of biological systems and organisms, from action potentials in the giant axon of the squid to control of insulin in pancreatic beta cells to understanding the effect of dopamine in the thalamus of Parkinsons patients. The course will introduce ideas from dynamical systems to understand the behavior of these models, especially the ways in which the behavior changes as the inputs and biological parameters change. Since systems of differential equations of biological importance do not (usually) have closed form solutions, software packages Neuron and XPPAUT will be used to do modeling and computations with the resulting models. The course will emphasize setting up the models of neural systems and interpreting the computed solutions in the context in which the models arose and the dependence of the predicted behavior on the inputs. In particular, the course will include work on phase plane analysis and bifurcations and this work will be supported computationally by XPPAUT. An important goal of the course is to help prepare students to work in an interdisciplinary environment that includes both mathematical and biological scientists.

This course has been approved for graduation credit counting toward the Math major in the Core, CS, and Applied Math options and will count toward a Math minor. See your counselor for further clarification.

Textbooks

The official texts will be:

- *Computational Cell Biology,* by C. P. Fall, E. S. Marland, J. M. Wagner, and J. J. Tyson, editors, Springer, 2002.
- *Non-linear Dynamics and Chaos,* by S. H. Strogatz, Westview Press, 1994.

Reference books that may be useful include:

- *An Introduction to the Mathematics of Biology,* by E. K. Yeargers, R. W. Shonkwiler, and J. V. Herod, Birkhäuser, 1996.
- *An Introduction to Dynamical Systems, Continuous and Discrete,* by R. Clark Robinson, Prentice-Hall, 2004.

The textbooks are on reserve in the Mathematics Library (third floor of the Math Building) now and the other books will be as soon as they can be obtained.

Procedures

Consistent with the goals of the course, much of the work will be done in groups of three or four students. Each group will include at least one biological scientist and at least one mathematical scientist. Except for the midterm and final exam, most of the work of the course will be done in these groups. The organization into groups will occur in the second or third week of the semester.

There will be homework assignments, both computer based and hand written, a written report on a published research paper chosen by the group with my approval, and an oral report on that paper presented to the class. The topics for the the group report and presentation will be chosen during the sixth week of the semester. There will be one midterm test and a final exam during the 16^{th} week of the semester. The midterm and final exam will be different for students in Math 490N and Biol 595N, reflecting the differences in their backgrounds and the material the courses cover.

Homework will count about 25% of the grade, the midterm test about 20%, the written and oral reports will count about 15% each, the final exam about 25%.

Academic Adjustments for Math 490N and Biol 595N

Students who have been certified by the Office of the Dean of Students – Adaptive Programs as eligible for **academic adjustments** should go to MATH 909 and request an *Information Sheet* for this semester that explains how to proceed **this** semester to get these adjustments made in Mathematics courses. It is not the same as last semester. **This should be done during the first week of classes.** Only students who have been certified by the ODOS – Adaptive Programs and who have requested ODOS to send their certification letter to their instructor are eligible for academic adjustments.

Students who are currently undergoing an evaluation process to determine whether they are eligible for academic adjustments are encouraged to find out **now** what procedures they will have to follow when they are certified by requesting the above mentioned Information Sheet from MATH 909.

Large print copies of the *Information Sheet* are available from MATH 909 upon request.

Approximate Course Outline

The course outline will be dynamic, updated as the topics and activities are decided. The details of the course outline will be posted on the course webpage and the webpage will be kept as up to date as possible.

For each date, the first entry is the common class meeting. Entries beginning with (Math) are meetings of Math 490N and entries beginning with (Biol) are meetings of Biol 595N. You are welcome to come to class meetings of both courses if you wish.

Date	*Topic*
1/13	Course Organization, Introduction, Mathematical Models
1/13	(Math) Cells, Neurons, the Nervous System
1/15	Differential Equations
1/15	(Biol) Math Refresher, Some Simple Differential Equations
1/20	More Differential Equations, Phase Portraits
1/20	(Math) Linear Systems and Linearization of Non-linear Systems
⋮	⋮
3/16	SPRING BREAK! No Classes
3/18	SPRING BREAK! No Classes
⋮	⋮
4/20	Group Presentations
4/22	Group Presentations
4/27	Group Presentations
4/29	Written Reports Due
???	**Final Exam** the week of May 3