G80.2207/G89.2211 – Fall 2016
Mathematical Tools for Cognitive and Neural Science

Course Description

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Audience: The course is targeted for CNS and Psychology doctoral students, but is often attended by master's students and postdocs, as well as students from other departments, and other Universities.

Brief Description: A graduate lecture course covering mathematical and computational tools necessary to solve data analysis and modeling problems, the transformations of raw data into a form in which these tools may be utilized, and the interpretation of such analyses. Lectures on each topic will include some mathematical background, derivation of basic results, and examples relevant to neural science. The course will include weekly problem sets based on the MATLAB software package.

Prerequisites: University-level algebra, trigonometry and calculus. Linear algebra and some programming experience in MATLAB are helpful, but not required.

Format: The course consists of two 2-hour lectures per week, and a computer lab session roughly every other week. The course includes a sequence of 5-6 homework assignments, primarily in the form of computer exercises, to examine the lecture topics in the context of concrete and realistic problems. These are *essential* for learning the material. Grades are based primarily on homework, but also take into account attendance and participation.

Course materials: There is no textbook. Supplementary reading materials will be handed out in class. All materials will be available from the course web site:

`http://www.cns.nyu.edu/~eero/math-tools/`

Topics:

I. Linear Algebra & Least Squares (4 weeks): vector spaces, projection, matrices, singular value decomposition, least-squares regression, Principal Components Analysis, total-least-squares regression, linear discriminants.

II. Linear Systems Theory (4 weeks): Convolution and Fourier Transforms (1D and multi-D), sampling, Nyquist theorem.

III. Uncertainty & Statistics (5 weeks): Basic probability, estimation, bias/variance, significance tests, bootstrapping, cross-validation, model comparison, decision theory / signal detection theory, general linear models, stochastic models of neurons, experiments and data analysis with stochastic stimuli (e.g. reverse correlation).