G80.2207/G89.2211 – Fall 2024
Mathematical Tools for Neural and Cognitive Science

Course Description

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Brief Description: A graduate lecture course covering mathematical and computational tools for data analysis and modeling of neural and cognitive systems, including the transformations of raw data into a form in which these tools may be utilized, the choice and implementation of the tool, and the interpretation of such analyses. Lectures on each topic will include some mathematical background, derivation of basic results, geometric intuition, and algorithmic implementation, with examples relevant to neural and cognitive science. The course will include biweekly problem sets requiring programming in either MATLAB or Python.

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 NYU departments and other Universities.

Prerequisites: College-level algebra, trigonometry and calculus. Linear algebra and some programming experience is 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 programming 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), filtering, sampling, aliasing and the Nyquist theorem.

III. Probability & Statistical inference (5 weeks): Basic probability, summary statistics, parameter estimation, significance tests, model comparison, decision theory, clustering, model fitting, comparison, and selection.