Mathematical Tools for Theoretical Neuroscience (NBHV GU4359)

Spring 2025

Check back for updates. Last updated 1/13/2025.
If information here conflicts with any other page (e.g., SSOL, CTN, Vergil), this page takes precedence.

Lecturers:

- Christine Liu (cl4198@cumc.columbia.edu)
- Ines Aitsahalia (ifa2108@cumc.columbia.edu)
- Adithya Gungi (ag4472@columbia.edu)
- Krishan Kumar (kk3525@cumc.columbia.edu)
- Amol Pasarkar (app2139@columbia.edu)

Faculty Contact: Prof. Ken Miller* kdm2103@columbia.edu

*(*Please contact Prof. Miller to sign add/drop forms and other items which require faculty permission)*

Time:

Lectures: Tuesdays and Thursdays 12:10 PM – 1:25 PM
Office Hours: TBD
Recitations: TBD

Location:

Jerome L Greene Science Center, Room L5-084
Please email Rozanna Yakub (ry2185@cumc.columbia.edu) if you would like to participate in the course but do not have access to the building.

Webpage:

CourseWorks

Credits: 3

Description

An introduction to mathematical concepts used in theoretical neuroscience aimed to give a minimal requisite background for NBHV G4360, Introduction to Theoretical Neuroscience. The

target audience is students with limited mathematical background who are interested in rapidly acquiring the vocabulary and basic mathematical skills for studying theoretical neuroscience, or who wish to gain a deeper exposure to mathematical concepts than offered by NBHV G4360. Topics include single- and multivariable calculus, linear algebra, differential equations, signals and systems, and probability. Examples and applications are drawn primarily from theoretical and computational neuroscience.

Prerequisites

Basic prior exposure to trigonometry, calculus, and/or vector operations at the high school level.

Registration

Undergraduate and graduate students: Must register** on SSOL.

Audit Interest Form/CourseWorks Access Request: Link

Grading

- **50% Homeworks** (approximately bi-weekly)
- **50% Participation** (attendance, asking/answering questions, office hours, comments on notes, etc.)
- **Extra Credit:** +1% on your next homework assignment for finding a typo and +10% for finding an error in the typed lecture notes. (Please add comments directly to the posted files.)

Schedule*

(**Subject to change. Some advanced topics may be dropped if we need more time to cover the basics**)

#	Date	Topic	Notes	HW
1	Tue Jan 21	Basics	Functions, inverses, complex numbers	
2	Thu Jan 23	Linear Algebra	Vectors and matrices	
3	Tue Jan 28	Linear Algebra	Matrix operations	HW1 out

4	Thu Jan 30	Linear Algebra	Vector spaces	
	Fri Jan 31	Recitation	Lec 1-4 review	
5	Tue Feb 4	Linear Algebra	Basis, matrix of a vector	
6	Thu Feb 6	Linear Algebra	Linear transformations	
7	Tue Feb 11	Linear Algebra	Matrix of a linear transf., change of basis	HW1 due; HW2 out
8	Thu Feb 13	Linear Algebra	Eigenvectors	
	Fri Feb 14	Recitation	PCA	
9	Tue Feb 18	Calculus	Limits, derivatives	
10	Thu Feb 20	Calculus	Taylor series	
11	Tue Feb 25	Calculus	Partial derivative, gradient	
12	Thu Feb 27	Calculus	Change of variables: Chain rule, Jacobian	
	Fri Feb 28	Recitation	Integration	HW2 due
13	Tue Mar 3	Calculus	Directional derivatives, Hessian, Min/Max	HW3 out
14	Thu Mar 5	Calculus	Convex optimization, Lagrange	
15	Tue Mar 10	Calculus	Lagrange Multipliers	
16	Thu Mar 12	Dynamics	ODEs (single variable)	

	Fri Mar 13	Recitation		HW3 due
17	Tue Mar 17	Dynamics	Linear systems (matrix) + Eigenvectors	
18	Thu Mar 19	Dynamics	Fixed points, Nullclines	
19	Tue Mar 24	Dynamics	Linearization	
20	Thu Mar 26	Dynamics	Limit cycles, chaos (buffer)	
21	Tue Mar 31	Signals & Systems	Convolution	
	Thu Apr 2	Signals & Systems	Fourier series	
	Fri Apr 3	Recitation		HW4 out
22	Tue Apr 7	Probability	Intro Probability: Discrete/combinatorics, counting	
23	Thu Apr 9	Probability	Intro (discrete): Expectation and variance	
	Fri Apr 10	Recitation		
24	Tue Apr 14	Probability	Intro Continuous / Distributions	
25	Thu Apr 16	Probability		
26	Tue Apr 21	Probability		HW6 due; HW7 out
27	Thu Apr 23	Probability		
	Fri Apr 24	Recitation		

For any questions or concerns regarding the course, please reach out to Prof. Miller (listed above) or visit the CourseWorks webpage. You may also contact the lecturer of the section directly.

Important Policies:

- **Academic Integrity:** All students are expected to adhere to University policies of academic honesty.
- **Attendance:** Regular attendance is highly recommended to succeed in this course. Participation is a significant component of your grade.
- **Late Submissions:** Homework assignments submitted after the deadline may be subject to a grade penalty unless prior arrangements are made. Extensions requested before the due date will be accepted.
- **Accessibility Statement:** We are committed to providing an inclusive and accessible learning environment for all students. If you require accommodations, please contact the Office of Disability Services at disability.services@columbia.edu as early as possible to discuss your needs. All requests for accommodations will be handled confidentially and in accordance with university policies. We value diverse perspectives and strive to create a space where all students feel welcomed and supported. Discrimination or harassment of any kind will not be tolerated. If you encounter any issues related to inclusion, please reach out to the faculty contact.

We look forward to a fun semester exploring the mathematical foundations of theoretical neuroscience!