Mathematical Tools for Theoretical Neuroscience

Spring 2024

Check back for updates. Last updated 1/12/2024.
If information here conflicts with any other page (e.g. SSOL, CTN, Vergil), this page takes precedence.

Lecturers:

- Ines Aitsahalia (ifa2108@cumc.columbia.edu)
- Christine Liu (cl4198@cumc.columbia.edu)
- Ben Antin (ba2617@cumc.columbia.edu)
- Krishan Kumar (kk2325@cumc.columbia.edu)
- Erfan Zabeh

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* 12:10pm – 1:25pm
- *Office hours:* TBD
- *Recitations:* TBD

Location: Jerome L Greene Science Center, room L5-084

- Please email cl4198@cumc.columbia.edu if you would like to participate in the course but do not have access to the building.

Webpage: CourseWorks
Credits: 3
Call Num: 18535

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 vector/matrix 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 16	Basics	Functions, inverses, complex numbers	
2	Thu Jan 18	**Linear algebra**	Vectors and matrices	
3	Tue Jan 23	Linear algebra	Matrix operations	HW1 out
4	Thu Jan 25	Linear algebra	Vector spaces	
	Fri Jan 26	Recitation	Lec 1-4 review	
5	Tue Jan 30	Linear algebra	Basis, matrix of a vector	
6	Thu Feb 1	Linear algebra	Linear transformations	
7	Tue Feb 6	Linear algebra	Matrix of a linear transf, change of basis	HW1 due; HW2 out
8	Thu Feb 8	Linear algebra	Eigenvectors	
	Fri Feb 19	Recitation	PCA	
9	Tue Feb 13	Calculus	Limits, derivatives	
10	Thu Feb 14	Calculus	Taylor series	
11	Tue Feb 20	Calculus	Partial derivative, gradient	
12	Thu Feb 22	Calculus	Change of variables: Chain rule, Jacobian	
	Fri Feb 23	Recitation	Integration	HW 2 due
13	Tue Feb 27	Calculus	Directional derivatives, Hessian, Min/Max	HW3 out
14	Thu Feb 29	Calculus	**Convex optimization**, Lagrange	
15	Tue Mar 5	Calculus	Lagrange Multipliers,	
16	Thu Mar 7	Dynamics	ODEs (single variable)	
	Fri Mar 8	Recitation		

	Sun Mar 10			HW3 due
	Tue Mar 12	*No class*	*Spring break / Cosyne*	
	Thu Mar 14	*No class*	*Spring break / Cosyne*	
17	Tue Mar 19	Dynamics	Linear systems (matrix) + Eigenvectors	
18	Thu Mar 21	Dynamics	Fixed points, Nullclines	
19	Tue Mar 26	Dynamics	Linearization	
20	Thu Mar 28	Dynamics	Limit cycles, chaos (buffer)	
21	Tue Apr 2	Signals & systems	Convolution	
	Thu Apr 4	Signals & systems	Fourier series	
	Fri Apr 5	Recitation		HW4 out
22	Tue Apr 9	Probability	Intro Probability: Discrete / combinatorics, counting	
23	Thu Apr 11	Probability	Intro (discrete): Expectation and variance	
	Fri Apr 12	Recitation		
24	Tue Apr 16	Probability	Intro Continuous / Distributions	
25	Thu Apr 18	Probability		
26	Tue Apr 23	Probability		HW6 due; HW7 out
27	Thu Apr 25	Probability		
	Fri Apr 26	Recitation		