

Special Topics: Intro to Computational Neuroscience
Course Prefix and Number: MATH 4804 NSC
Term: Fall 2026
Credit Hours: 3

Instructor Information

Instructor: Hannah Choi

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General Course Information

Description

This course provides an introduction to computational neuroscience, focusing on mathematical model-based approaches used to understand neural dynamics and computations across single cells and networks of neurons. The course is designed for both students with mathematical and computational backgrounds interested in neuroscience, as well as for students with neuroscience backgrounds interested in mathematical models. Some basic knowledge and familiarity with Python, MATLAB, or other programming languages will be useful.

Course Learning Outcomes

Upon successful completion of this course, you should be able to:

- Understand core topics in computational neuroscience including neuronal spiking, learning and memory, and encoding/decoding in neural populations, along with related mathematical concepts
- Analytically and computationally implement neuronal models at different levels, including single neuron spiking models, rate-based models, and neuronal networks.
- Simulate various neuronal models using Python, MATLAB, or other programming languages

Course Topics

- Modeling single neurons
 - [Reviews on mathematical concepts] Review of ODEs & numerical solutions
 - Conductance-based models and leaky-integrate-and-fire models
 - [Reviews on mathematical concepts] Review of dynamical systems

- Bistable neural systems
- Modeling synapses
- Neural variability and coding
 - Spike train variability & firing rates
 - Single neuron & population tuning
 - [Reviews on mathematical concepts] Review of basic probability & Baye's theorem
 - Encoding & Decoding
 - Entropy and mutual information
 - Modeling spike train variability with Poisson process
 - Modeling a neuron with noisy synaptic input
- Modeling networks of neurons
 - Mean-field approximations
 - Feedforward networks
 - Recurrent networks
- Synaptic plasticity, learning, and memory
 - Hebbian learning, STDP
 - Associative memory & Hopfield network
 - Feedforward artificial neural networks & deep neural networks

Pre- &/or Co-Requisites

- Familiarity with coding (MATLAB, Python, or other).
 - Python: Please install/use the latest python distribution which is open-source and free.
 - MATLAB: Georgia Tech offers free MATLAB to students. Please check <https://software.oit.gatech.edu/Links to an external site.> to have a student version of MATLAB installed on your computer.
- Math 2552 or equivalent (concurrent enrollment is satisfactory). Students with a strong background who have not completed this course may reach out to the instructor to inquire about the possibility of an override.

Required Course Materials

"[Modeling Neural Circuits Made Simple with Python.](#)" by Robert Rosenbaum.

- NOTE: The book can be found on the publisher's website where an **open access** is available by clicking on "Open access" and then "Other open access edition": <https://mitpress.mit.edu/9780262548083/modeling-neural-circuits-made-simple-with-python/>.
- There will be additional materials outside of the textbook offered as lecture notes in class.

Grading Policy:

Grading

- **Homework:** 50%
- **Midterm Exam (in-class):** 25%
- **Final project:** 25%
 - Presentation (in class) + Slides + Attendance on presentation days (15%)
 - Written Report (10%)

Grading Scale

- **A:** 90% - 100%
- **B:** 80% - 89%
- **C:** 70% - 79%
- **D:** 60% - 69%
- **F:** 0% - 59%

Description of Graded Components

Homework

- Assigned on Wednesdays, due in 1.5 weeks on Mondays (*There may be some exceptions. Please check the detailed weekly schedules & modules on Canvas.)
 - Submit electronically via Canvas by 11:59pm of the due date.
- Late assignments will incur a (10%) penalty for each day it is late, up to 6 days after the original deadline-- homework submissions that are late for 1-week or more after the deadline will NOT BE ACCEPTED. This penalty does not apply to excused late submissions.
- Your homework should be neat and readable. The grader is allowed to subtract points (or fractions thereof, at their discretion) for presentation.
- You are not allowed to use generative AI beyond asking for simple notations and formats (See below for class policy regarding Generative AI below). Homework submissions will be scrutinized for the use of generative AI. Homework submissions with a substantial use of generative AI will incur 0 point.

In-Person Midterm Exam

- See Canvas class schedule for the midterm exam date. The midterm exam will take place in class.
- Closed book
- No calculator or any other electronics allowed.
- One double-sided letter-sized (8.5x11 inch) sheet of notes is allowed.

Final Project

Each student will identify a published research article of interest to them, understand the paper, and propose a research "plan" that builds on the paper. Note that you do NOT need to actually carry out the proposed research plan-- you only need to construct a convincing and sound research proposal by identifying an interesting research question and designing relevant methods. There will be bonus points if you perform some of the proposed analyses/simulations and show preliminary results. At the end of the semester, you will turn in a maximum 6-page written proposal (including figures) and present both the paper and the proposed research to the class.

- **Presentation**
 - Scheduled during the last two classes.
 - Attendance at both presentation days required (1 point each)
 - Slide submission due on the first presentation day by 3pm.
- **Written Report**
 - Submission of the written report to Canvas due on the last day of class by 11:59pm. No late submission will be accepted unless excused by the instructor.

Course Policies

Attendance and/or Participation

While this is an in-person course and regular attendance is expected, your presence will not directly impact your final grade—with one exception. Attendance is mandatory for both days of final project presentations. Failure to attend these sessions will result in a grade deduction for the final project (unless excused by the instructor).

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. Review [Georgia Tech's Honor Code](#) and the student [Code of Conduct](#).

Any student suspected of cheating or plagiarism on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Core IMPACTS

Not applicable.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, [contact the Office of Disability Services](#) (404-894-2563) as soon as possible to make an appointment

to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Student-Faculty Expectations Agreement

At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. [The Student-Faculty Expectations](#) articulate some basic expectations that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Collaboration, Group Work, and Use of Generative AI

Working together on problem sets is encouraged. However, the work you turn in on problem sets should be your own understanding, code implementations, and calculations. **Any evidence of cheating, plagiarism, or other violations of the Georgia Tech Honor Code will be submitted directly to the Office of Student Integrity.** All students are expected to comply with the Georgia Tech Honor code (See Academic Integrity).

Course materials policy

Classes may not be recorded by students without the expressed consent of the instructor unless it is pursuant to an accommodation granted by the Office of Disability services. Class recordings, lectures, homework problems, exam problems, and other materials posted on Canvas are for the sole purpose of educating the students currently enrolled in the course and **should not be shared or distributed outside of the class.** Students may not record or share the materials or recordings, including screen capturing, unless the instructor gives permission. Violations **will be submitted directly to the Office of Student Integrity.**

Generative AI

Do not use generative AI to write your code in this course. **Submitting AI generated code is plagiarism and it is a serious academic offense.** Writing code is hard. Cheating is tempting. While it may seem like an easy way out of a challenging task, you are only cheating yourself of the opportunity to develop a solid foundation when you use generative AI for a course like this that teaches you the basics. There are many resources where you can find help: the Matlab & Python documentation, StackExchange, to name a few. These resources can provide explanations as well as examples of working code. Understanding what is happening in an example and applying it to your own particular problem is an important part of the active learning process

- **Allowed use:**
 - Asking for notations and formats (e.g. "How do you enter a matrix in Python?")
 - Debugging snippets of code
- **NOT allowed:**
 - Asking a generative AI to write your code (e.g. "Write Python code to numerically solve these differential equations: ...")

Campus Resources for Students

Undergraduate Student Academic Success Resources:

A list of resources for undergraduate students' academic success and information about advising can be found at [Success at Tech](#).

- Academic Support: Academic Success and Advising (a unit in the Office of Undergraduate Education & Student Success) provides free support for your courses. Students can attend scheduled supplemental review (PLUS) sessions, stop by Drop-In Tutoring, or schedule a one-on-one appointment through Knack. To explore what options work best for you, please visit us online at success.gatech.edu/tutoring, email us at tutoring@gatech.edu, or come see us at Clough Undergraduate Learning Commons, Suite 283.