

Georgia Institute of Technology & Emory University  
Coulter Department of Biomedical Engineering

BMED 7610 - COMPUTATIONAL NEUROSCIENCE  
CREDITS: 3-0-3

*Fall 2026 - TuTh 12:30-1:45*  
*Location: TBD*

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office hours: by appointment

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**Overview:** Information about how we sense, think, and move is represented by electrical activity within the nervous system, where the language of communication is often referred to as the *neural code*. This course provides an overview of the underlying biological processes that give rise to neural activity, the code by which information is represented and transformed in sensory and motor systems, and how this relates to decision making and action. Topics will span from detailed biophysics; to neural data and statistics; to machine learning, population dynamics, and control.

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**Course Philosophy:** Neuroscience is a field that draws from many different disciplines and lines of thinking, from molecular and cellular biology, to psychology, to philosophy, to engineering, physics, math, and computer science, and more! It takes all kinds of people, from different backgrounds and training, to really attack these problems. So, whether you have studied neuroscience before, or if this is your first class, if you think you have nothing to offer the discussion, you're wrong! The hardest questions in neuroscience are often the most "naive", with an emphasis on the quotation marks. So, read, think, ask questions, argue, and figure out what you know and what you don't know, and do something about it! Learn something from your classmates and instructors, and teach them something too!

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### Course Objectives

- Become comfortable with the basic biology of neuroscience
- Think of phenomena and mechanisms in terms of models
- Acquire data analytic skills frequently utilized in neuroscience
- Become comfortable with the concepts of neural dynamics and neural control
- Translate the math into numerical implementation
- Start to appreciate the questions being asked in the field

### Course Modules - ALL DATES SUBJECT TO CHANGE

#### Course Introduction: August 25, 2026

#### I. Neurons, Synapses, & Circuits (~ 8 class meetings, Aug 27 - Sep 22)

- Basic cell biophysics
- Simple neuron models
- Review of system dynamics
- Active conductance & the Hodgkin-Huxley model
- Synapses and synaptic models

- Synaptic plasticity: observations, models, learning?
- Neural circuits: why does wiring matter?

### **Homework Set 1, Presented September 15**

## **II. Neural Data, Population Coding, & Modeling (~ 9 class meetings, Sep 24 - Oct 22)**

- Visual system and measuring neural activity
- Review of relevant topics in probability and statistics
- Spike trains and spike train statistics
- Statistical models of spike generation
- Firing rate models
- Spike triggered analysis
- Optimization and estimating parameters from data
- Information theoretic approaches
- Population dynamics and dimensional reduction

### **Homework Set 2, Presented October 8**

### **Homework Set 3, Presented October 29**

### **Final Project Working Session - October 15**

## **III. Neural Control (~ 7 class meetings, Oct 27 - Nov 24)**

- Control strategies of the nervous system
- Linear systems
- Control theory basics
- Linear control in the state space
- Control of neurons, neural circuits, and neural populations

### **Final Project Working Session - Nov 5**

### **Final Project Presentations - Dec 1, Dec 3, Dec 8**

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## **Prerequisites**

- It is expected that students enrolling in this course have previous coursework that covers the following topics: calculus, physics, some linear algebra, rudimentary neuroscience, signal processing, probability and statistics, time/frequency domain analysis, linear systems

## **Course Website**

- The Canvas website will be used for the course materials
- Homework sets will be available in pdf format posted on the website
- Check the site often for announcements, homework, and reading assignments
- The syllabus will be dynamic (changing as the course proceeds)

## **Reading**

- Text: P. Dayan and L. Abbott, *Theoretical Neuroscience*, MIT Press, 2001
- Handouts will be periodically posted on the course website

## **Code**

- The course will utilize Python as a computational tool to reinforce the analytical aspects
- Homework will rely on the use of Python-based Google Colab Notebooks
- Links to Python and Google Colab tutorials will be posted on the course website

## Homework

- Homework will be done in assigned groups and presented during a class session
- Each homework assignment will consist of 3-4 problems that all groups are expected to complete
- The solutions for each problem should be written as a Google Colab notebook which includes code, figures, and written exposition. Only one solution is required for each group
- On the day of presentations, groups will be assigned to present a single homework problem to the class. This means that not all groups will present for a given homework set
- Presentations should be 10-15 minutes long, with some time for questions
- Grading is based on completion of the Google Colab notebook as well as evaluation of the presentations by peers and instructors

## Projects

- Projects will be done in groups of 2-3 students, depending on class size
- There will be several “Project Working Sessions” for finding group members, brainstorming project ideas, and providing status updates
- Some potential final project topics will be provided (see course website for more information) or groups can come up with their own topic
- There will be both a final presentation and a written final report
- The final presentations will be presented in 3 sessions at the end of the course

## Grading

- Homework (40%), Final Project (45%), Individual (15%)
- Individual is a combination of performance in group, and participation in general.
- Students will work in groups on homework sets and on final projects.

## Use of Generative Artificial Intelligence (AI) Tools

You may use generative AI programs, e.g. ChatGPT, to help generate ideas and brainstorm. You should be aware that the material generated by these programs may be inaccurate, incomplete, biased or otherwise problematic. Also, use of these tools may stifle your own independent thinking and creativity.

Generative AI derives its output from previously created texts from other sources that the models were trained on yet doesn't cite sources. Per GaTech's Honor Code, you may not submit any work generated by an AI program as your own. This includes code for the homeworks, the homework problems themselves, and especially the final projects. However, you are permitted and encouraged to use these tools to generate ideas, help you see how to solve problems, search for things, etc.

If you include material generated by an AI program, it should be cited like any other reference material (with due consideration for the quality of the reference, which may be poor). When/if you use AI platforms in your assignments, please write a note to clarify where in your process you used AI, include the prompt used to generate the material, and which platform(s) you used. See this article for how to cite AI properly: How to cite ChatGPT <https://apastyle.apa.org/blog/how-to-cite-chatgpt>

## Your well-being

- Your instructors, and the BME department as a whole, care about student mental health. While your instructors can be a resource, we also want to make sure you are aware of the formal resources for receiving mental health assistance in BME and at GT. More information about these resources can be found here: <https://mentalhealth.gatech.edu/>

- Mental Health Care & Resources – The Center for Mental Health Care and Resources (CMHCR) is the best place to engage with mental health care at GT. They are found in the Smithgall Student Services Building and can also be reached at 404-894-2575. Their normal hours of operation are 8am to 5pm Monday through Friday. CMHCR can connect you with services including individual or group counseling, academic or personal support services, assessment and testing for learning disabilities, and other mental health providers. They can help you find the right resources for a crisis, an acute issue, or a longer-term concern.
- BME Satellite Counselor – In addition to the Center for Mental Health Care’s centralized services, BME hosts a counselor, Kate Silverio, in Room 1105 of the Whitaker Building (in the back of the academic office). The Satellite Counselor offers 15 min appointments (in-person or virtual) during which students can discuss a brief or specific, non-emergency concern, and/or learn about mental health resources on campus. To schedule with the Satellite Counselor, please email her ([kate.silverio@studentlife.gatech.edu](mailto:kate.silverio@studentlife.gatech.edu)).
- Crisis Services - If you require immediate support for mental health difficulties you have several options: During business hours (8 a.m.-5 p.m.). Call 404-894-2575 or go to Suite 238 in the Smithgall Student Services Building. Outside of business hours, call 404-894-2575 and select the option for the after-hours counselor. In an emergency, call Georgia Tech Campus Police at 404-894-2500 on campus or 911.