

# MATH 690ST Real and Artificial Neural Networks

Hours: TuTh 10:00-11:15

## Instructor:

- Professor: Yao Li  
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Office Hours: TBA

**Number of credits: 3**

**Prerequisite:** STAT 515, MATH 331, working knowledge of MATLAB and Python

**Recommended Texts:** Mathematical Foundations of Neuroscience by G. B. Ermentrout and D. H. Terman

## Course Description

The course covers a varieties of biological neuronal network and artificial neural network topics. We will begin with an introduction to mathematical neuroscience, covering mathematical models for single neurons and neuronal networks. We then delve into how artificial neural networks draw inspiration from biological counterparts. Selected topics include the anatomy and function of the primary visual cortex (V1) and its connection to convolutional neural networks (CNNs), as well as machine learning with spiking neural networks (SNNs).

## Course Objectives

This course explores the fascinating relationship between real and artificial neural networks. It is designed for students interested in artificial neural networks and related areas, no prior knowledge of neurosciences is required. By the end of the course, students will have gained essential knowledge of mathematical neurosciences and a deep understanding of the interplay between real and artificial neural networks. This knowledge will equip them to contribute to this rapidly evolving field.

Below is a tentative weekly schedule that is subject to changes

- Week 1: Biology of neurons and Hodgkin-Huxley model
- Week 2-3: Dynamical systems and 2D neuron models
- Week 4-5: Neuronal networks and firing patterns
- Week 6: Integrate-and-fire neuron and firing rate models
- Week 8-9: Artificial neural network and training
- Week 10-12: Primary visual cortex and its connection to convolution neural network (CNN)
- Week 13-14: Learning with spiking neural network and possibly other topics.

The grade will be based on homework assignments and class participation

## Required Work

The required work for the course will 5-6 homework assignments and several classroom presentations

## Class Participation

Your participation is necessary in order to make this course a success. I expect that you will attend every class, will not enter the classroom late, and will complete the reading and the assignments on time. In case of any problems affecting your work, please see me when they happen. I will try to help you. If unable, I will direct you to someone who can help.

## Homework

Homework is an important component of this course. You are expected to express your ideas rigorously, clearly, legibly and completely. Unreadable work, scratching out, etc. will not be graded.

## Presentation

During the semester I will ask each student to give presentations on given research papers or review paper for at least once. The presentation should last 15-25 minutes. Papers will be upload to Moodle 1 week before the presentation.

## Grading

Item	Weight
Homework	50%
Presentation	30%
Classroom Participation	20%
Total	100%

The course score will be converted to a letter grade beginning with these values as cutoffs:

A	A-	B+	B	B-	C+	C	C-	D+	D	F
86	82	78	72	69	65	62	59	55	50	< 50

These cutoffs might be adjusted, but only in the downward direction (to make letter grades higher).

## Drop, Withdrawal, and Incomplete

The last day to drop/add with no record is September 16th. The last day to drop with a W is October 29th.

An incomplete is possible only if all of the following apply: (1) you have a compelling personal reason, e.g., serious illness; (2) your work so far would receive a passing grade; and (3) there is a good chance you will complete the course with a passing grade within the allotted time. Thus, *expecting to fail the class is no reason to ask for an incomplete.*

## Class etiquette statement

- Except for emergency, do not send text messages/emails or make/receive phone calls during lectures.
- If you arrive late to class, sit in the first seat you can find so as not to disturb others, and do not come up to the front of the room to pick up or hand in papers.
- You can use laptops and tablets during class provided that you do not disturb your fellow classmates or my lectures (for example: mute the speaker). They are not allowed during exams.
- Please read *Guidelines for Classroom Civility and Respect*: [http://www.umass.edu/dean\\_students/campus-policies/classroom](http://www.umass.edu/dean_students/campus-policies/classroom)

## Information on In-Class Recordings by Students and Selling of Notes

We have seen a growth over the last couple of years in external vendors (i.e., StudySoup) and other outlets who recruit (and pay) students for their Notes from a class which is then posted for any other student to purchase and use. We have also seen this extend to in-class video recordings of class lectures. Please note that you can only use the notes you take from class for your own personal use, and not share (sell) these notes via an outside vendor or entity without the faculty/instructor's permission. This pertains to in-class recordings as well. **Usage of the notes or in-class recordings in this way without the faculty member's permission is a violation of the faculty member's copyright protection.**

## Accommodation Statement

The University of Massachusetts Amherst is committed to providing an equal educational opportunity for all students. If you have a documented physical, psychological, or learning disability on file with Disability Services (DS), you may be eligible for reasonable academic accommodations to help you succeed in this course. If you have a documented disability that requires an accommodation, please notify me within the first two weeks of the semester so that we may make appropriate arrangements. For further information, please visit Disability Services (<https://www.umass.edu/disability/>)

## Academic Honesty Statement

Since the integrity of the academic enterprise of any institution of higher education requires honesty in scholarship and research, academic honesty is required of all students at the University of Massachusetts Amherst. Academic dishonesty is prohibited in all programs of the University. Academic dishonesty includes but is not limited to: cheating, fabrication, plagiarism, and facilitating dishonesty. Appropriate sanctions may be imposed on any student who has committed an act of academic dishonesty. Instructors should take reasonable steps to address academic misconduct. Any person who has reason to believe that a student has committed academic dishonesty should bring such information to the attention of the appropriate course instructor as soon as possible. Instances of academic dishonesty not related to a specific course should be brought to the attention of the appropriate department Head or Chair. Since students are expected to be familiar with this

policy and the commonly accepted standards of academic integrity, ignorance of such standards is not normally sufficient evidence of lack of intent. <http://www.umass.edu/honesty/>.

## **Title IX Statement**

In accordance with Title IX of the Education Amendments of 1972 that prohibits gender-based discrimination in educational settings that receive federal funds, the University of Massachusetts Amherst is committed to providing a safe learning environment for all students, free from all forms of discrimination, including sexual assault, sexual harassment, domestic violence, dating violence, stalking, and retaliation. This includes interactions in person or online through digital platforms and social media. Title IX also protects against discrimination on the basis of pregnancy, childbirth, false pregnancy, miscarriage, abortion, or related conditions, including recovery. There are resources here on campus to support you. A summary of the available Title IX resources (confidential and non-confidential) can be found at the following link: <https://www.umass.edu/titleix/resources>. You do not need to make a formal report to access them. If you need immediate support, you are not alone. Free and confidential support is available 24 hours a day / 7 days a week / 365 days a year at the SASA Hotline 413-545-0800.