

ECE/NE 410: Neural Circuits and Systems

Meeting time: TR 2:00 – 3:20 pm

Location: 3025 Campus Instructional Facility

Credit hours: 3 undergraduate, 4 graduate

Semester: Fall

Prerequisites: Math 285, CS 101

Instructor Information

Name Professor Yuan Yang

Contact Information yuany@illinois.edu

Office Location: Everitt Lab 3254 or Virtual.

Office Hours: By appointment

Teaching assistant: Mahmood Rajabtabar

Contact Information mr81@illinois.edu

Office Hours and Location: Wednesdays, 4:30 – 5:30 pm, Everitt Lab 2217

Grader: Calla Litteken

Course Description

Introduction to modeling functions of neurons and systems of neurons in the brain. Topics include Boolean signal processing, nonlinear diffusion equations, delay-and-add synaptic signal processing. Integrates information from the structure and physiology from a single neuron up to the assembly of brain circuits. Examples presented to discuss neural circuit and systems include the auditory, and to a lesser extent, visual system. Course concludes with a look at theories of brain function built up from systems of neurons.

Course Objectives

1. Understanding of how lipid bilayers are formed, and their role in physiology.
2. Discussion of channels embedded in lipid layers, that allow ions to be transported across the membrane.
3. Understanding of the history of neuroscience, and the important publications and ideas that evolved starting with Helmholtz's measurements of spike velocity in nerve fibers.
4. Understand the Hodgkin-Huxley model of spike propagation based on their scientific investigation.
5. Formulation of the model of multilayer perceptrons, based on a Boolean vector space.
6. Understanding of features within speech phonemes and how they are characterized using neural circuits.
7. Development of the function and modeling of the inner ear and its processing outcomes.
8. Understanding of the use of psychophysics to help understand brain signal processing models.
9. Discussion of loudness and how it is estimated by the brain, including the intensity JND.
10. Homework sets that discuss the diffusion and wave equations, toward modeling neural spike propagation.

Course Format

- This class meets for two 90-minute lecture periods each week.
- Students are expected to spend 4 hours on average outside of class per week.

Textbook and Reading Materials

- Scott, A. (2002). *Neuroscience: A mathematical primer*. Springer Science & Business Media. A PDF version is provided on the course website.
- Sterling, P., & Laughlin, S. (2015). *Principles of Neural Design*. MIT Press. A PDF version is provided on the course website.
- Scott, A (1977). *Neurophysics*, John Wiley & Sons Inc. A PDF version is provided on the course website.
- Course slides and classroom handout.

Tentative Schedule

Weeks	Topics
1	Introduction to the Nervous System, Neuron Structure and Resting Membrane Potential
2	Action Potential (AP) and Impulse Propagation
3	Electrical Model of Cell Membrane and AP
4	HH Model and Cable Theory
5	Synaptic Transmission
6	Midterm Review
7	Midterm Exam
8	Human Motor System
9	Human Somatosensory System
10	HH Model Simulation (Matlab)
11	Reflexive, Visual and Auditory Systems
12	Brain Signals
13	Selective Topics
14	Fall Break
15	Final Review
16	Final Exam

Course Website

<https://canvas.illinois.edu/>

Grading

	3 Credit	4 Credit
Homework	10%	10%
Midterms	20%	20%
Final	70%	60%
Project for 4 th Credit		10%

*Graduate students taking the course for 4 hours of credit. This additional credit comes from the additional course project and presentation.

Homework and Late Policy

There will be reading and written assignments. There will be five written assignments. Written assignments will be assigned and due the following week on the same weekday before the class.

Homework Formats and Regulations

1. PDF format must be used.
2. Matlab code (.mat) must be attached for programming assignment.
3. File Name "ECE-NE 410 Assign#_Last Name_Frist Name"

Late submission of written assignments will result in a 10% penalty if the submission is made before the homework answers are posted. Late submission will not be acceptable after the standard answers are posted. Exceptions to this policy will only be made if a student communicates with the instructor AT LEAST 24 hours in advance of the original assignment due date or if there is a health or family emergency.

Overall Course Grade

The overall course grade is given on an absolute scale and will not be curved. Concerns about individual assignments or grades should be expressed to the instructor promptly. The regrading request may be made to the instructor with evidence provided by the student. If it is approved, the whole homework or exam will be regraded (rather than only the part where the student has questions). The regraded score may be higher or lower than the initial score, and only one-time regrading is allowed. No regrading is allowed after the final score is posted for the course. This course will be assigning +/- letter grades.

- A+>97%>A>93%>A-
- B+>87%>B>83%>B-
- C+>77%>C>73%>C-
- D+>67%>D>63%>D-
- F<60%

Course Policies

- **Attendance:** Students are expected to attend every class with the exception of pre-authorized absences or unavoidable emergencies. For students who miss the class without a reasonable request or explanation, the final score will be reduced by 1 point per class. For students who join the class after the start, the final score will be reduced by 0.5 points per late arrival as well. If the late or absent due to an emergency, please reach out to the instructor by email before or after the class hours, please don't send any email during the class hours, since that will interrupt the class and other students.
- **Course-related communications:** Course announcements will be sent out via email or Canvas; please check your email and Canvas (<https://canvas.illinois.edu/>) regularly. For general course questions and information, please first consult the syllabus. If your question/issue is still not answered/addressed, please email the course instructor at yuany@illinois.edu.
- **Laptops and mobile devices:** Laptops may be used for course-related tasks only (e.g., to take notes or investigate relevant topics, answer polling questions). Mobile phones should be silent and out of sight during class.

Expectations for Students

- Participate throughout each week.
- Consider and respect others' opinions.
- Complete all assignments on time.
- Discuss concerns privately with the instructor.

Expectations for Instructors

- Be available for face-to-face discussion.
- Respond promptly to students' concerns.
- Grade objectively and promptly return graded assignments.
- Endeavor to accommodate differences in students' learning ability.

Academic Integrity

The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: <https://studentcode.illinois.edu/>.

Academic dishonesty will result in a sanction proportionate to the severity of the infraction, with possible sanctions described in 1-404 of the Student Code (<https://studentcode.illinois.edu/article1/part4/1-404/>). Every student is expected to review and abide by the Academic Integrity Policy as defined in the Student Code:

<https://studentcode.illinois.edu/article1/part4/1-401/>. As a student it is your responsibility to refrain from infractions of academic integrity and from conduct that aids others in such infractions. A short guide to academic integrity issues may be found at <https://provost.illinois.edu/policies/policies/academic-integrity/students-quick-reference-guide-to-academic-integrity/>. Ignorance of these policies is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

Anti-Racism and Inclusivity

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Bias Assessment and Response Team (BART) (<https://bart.illinois.edu/>). Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Disability Related Accommodations

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 333-4603, e-mail disability@illinois.edu or go to <https://www.disability.illinois.edu>. If you are concerned you have a disability-related condition that is impacting your academic progress, there are academic screening appointments available that can help diagnosis a previously undiagnosed disability. You may access these by visiting the DRES website and selecting "Request an Academic Screening" at the bottom of the page.

Family Educational Rights and Privacy Act

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See <https://registrar.illinois.edu/academic-records/ferpa/> for more information on FERPA.

Religious Observances

Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of your religious observances. If a conflict exists, you should notify your instructor of the conflict and follow the procedure at <https://odos.illinois.edu/community-of-care/resources/students/religious-observances/> to request appropriate accommodations. This should be done in the first two weeks of classes.

Sexual Misconduct Reporting Obligation

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: <https://wecare.illinois.edu/resources/students/#confidential>.

Other information about resources