COURSE TITLE
Neural Signals (BMES 477/710)

LOCATION
PISB 104

LECTURE
Tuesday 5:00 pm – 6:20 pm
Thursday 5:00 pm – 5:45 pm

LAB
Thursday 5:45 pm – 6:20 pm

INSTRUCTOR
Catherine R. von Reyn, PhD
crv33@drexel.edu
Office Hours: Friday 2:00 pm - 3:00 pm or by request
Bossone 601 or Zoom (via email request)

TA
Haley Croke
hrc43@drexel.edu
Office Hours: TBD
Location: TBD

DESCRIPTION
This course introduces the theory and analysis of neural signals. In the first half of the course, students will learn the biophysical basis of action potential generation, generator potentials, and synaptic potentials and the current engineering strategies used to measure these neural signals. Additionally, students will learn the Hodgkin-Huxley description of action potential generation, equivalent circuit representation of neurons, and be able to derive and employ the fundamental equations to model individual neurons and circuits. In the second half of the course, students will learn current theories behind how neurons encode information and how this information can be acquired and decoded for engineering uses. Students will be required to derive equations describing these processes and apply computational algorithms to simulate and analyze real neural data.

COURSE PURPOSE WITHIN A PROGRAM OF STUDY
The purpose of this course is to establish a student's initial foundation in neuroengineering. It serves to build upon a student's prior knowledge of mathematics, computer science, and biology to model and predict the functional outcomes of neural processes. It also provides an introduction to neural data acquisition and active projects in neural data analysis to develop a skillset that is utilized (and expanded) in subsequent neuroengineering/neurotechnology courses.

PREREQUISITES
Graduate standing or Neuroengineering concentration.
In addition, this course requires knowledge in the following areas: basic probability theory (stochastic processes), linear algebra, differential equations, basic electronic circuit analysis, and MATLAB programming.

REQUIRED TEXT
An Introductory Course in Computational Neuroscience. Paul Miller. MIT Press, ISBN 9780262038256
https://mitpress.mit.edu/books/introductory-course-computational-neuroscience

SUPPLEMENTAL REFERENCES

Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems. Peter Dayan and Larry Abbott. MIT Press, ISBN 9780262541855

Spikes: Exploring the Neural Code. Fred Rieke, David Warland, Rob de Ruyter van Steveninck, William Bialek. MIT Press, ISBN 9780262681087

Principles of Neural Science. Eric Kandel, Thomas Jessell, James Schwarz, Steven Siegelbaum, A.J. Hudspeth. McGraw-Hill, ISBN 978-0071390118

Additional journal articles will be available on Bb Learn one week prior to class.

SUPPLEMENTAL TECHNOLOGIES
MATLAB
Zoom

WEB RESOURCES
As indicated in Bb Learn.

COURSE URL
Course uses Bb Learn management system.

COURSE LEARNING OUTCOMES
1. Learn the biophysical mechanisms behind neural signaling and the models used to describe these mechanisms.
2. Use programs to model generator potentials, equilibrium potentials, action potentials, chemical signaling, and electrical signaling.
3. Understand cable theory of passive dendritic activity.
4. Derive the Hodgkin-Huxley description of action potential generation including understanding calcium spike generation.
5. Use compartmental models to simulate neural activity.
6. Learn how networks of neurons organize.

GRADING AND REQUIREMENTS

Assignments (35%):

Lab Assignments: Students will be required to attend lab and learn to apply and generate MATLAB functions for neural simulations and data analysis. Lab assignments include questions based on the theory and application of these functions. Assignments not finished during the lab period must be completed as homework. ***Lab assignments are given on Tuesday and are due on Monday at 11:59PM*** unless stated otherwise.

Reading Assignments: Students will be required to write commentaries on journal articles. Commentaries must be 300 words or less and should highlight the key finding(s) of the article and address issues/limitations for interpreting data presented in the article. ***Reading assignments are posted on Monday and are due before class on Thursday*** unless stated otherwise.

No late assignments will be accepted.

Quizzes (10%): A brief quiz will be given every Thursday at the beginning of class. Quizzes will cover topics from past lectures and reading assignments.

Midterm Exam (25%): A midterm exam will be given during the ***second lecture of week 6***. The problems will include mathematical modeling and short answer questions.

Modeling Paper (30%): Students will be required to investigate a topic in neural engineering that applies neural models learned in this course. Students will select one paper with a modeling component that addresses the topic. Students will evaluate this model by running the code themselves. Students will then modify the code to ask their own specific question and report the results. They will then submit their working code and a paper (limited to 5 pages) that includes the following:

1. Intro (5%):
    a. the underlying biological questions asked by the authors and asked by the student
2. Methods (10%):
    a. the mathematical model being used to solve these questions
    b. how the mathematical model has been derived or altered to represent the biological system (what did the authors alter and then what did the student additionally alter)
3. Results (10%):
    a. a summary of the authors' results
    b. the results generated by the student (need to include figures)
4. Discussion (5%):
    a. the student's evaluation of whether the model has been applied appropriately and the model limitations
    b. the overall impact of the research paper as well as the overall impact of the student's modeling work

Topics and selected papers are due the day of the midterm and the final paper with working code is due TUESDAY on the week of exams.

GRADING SCALE

Score %	<63	63-66	67-69	70-72	73-76	77-79	80-82	83-86	87-89	90-92	93-96	97-100
Letter Grade	F	D	D+	C-	C	C+	B-	B	B+	A-	A	A+

GRADING CRITERIA

Assignments, final papers, and exams will be graded out of 100 points. Quizzes will be graded out of 10 points. The final paper will be evaluated based on the student's ability to understand the derivations, applications, and limitations of mathematical models of biological systems.

SUBMISSION INFORMATION

All assignments are to be submitted through Bb Learn unless stated otherwise.

INSTRUCTOR FEEDBACK

Assignments are to be graded and returned within two weeks of submission. The instructors and TAs will respond to emails within 24 hours.

COURSE POLICIES

- Course communications will be through Bb Learn. Students are responsible for checking their email and the course site for assignments and communications.
- All assignments and papers must be completed individually.
- Any act of academic dishonesty, including but not limited to plagiarism and cheating, will be strictly prosecuted and may result in a 0 for the assignment, an F for the course, or any other appropriate action.

UNIVERSITY POLICIES

Academic Integrity, Plagiarism, Dishonesty and Cheating Policy

http://www.drexel.edu/provost/policies/academic_dishonesty.asp

Student with Disability Statement:

https://drexel.edu/disability-resources/support-accommodations/student-family-resources/

Course Add/Drop Policy:

http://www.drexel.edu/provost/policies/course-add-drop

Course Withdrawal Policy:

https://drexel.edu/provost/policies-calendars/policies/course-coop-withdrawal/

Initial Course Participation (ICP):

Class attendance is critical to your success as a student. Missing classes may impact your class success and your federal financial aid.

Changes to a Course:

It is the prerogative of the faculty member to make course modifications during the term when necessary, at her/his discretion. Changes will be communicated to students at least 24 hours in advance, except when inclement weather or emergency situations arise.

COURSE SCHEDULE

WEEK	DATE		TOPIC	TEXT CHAPTERS	ASSIGNMENT
1	26-Sep	T	Intro, Nernst and Goldman; Lab	1.1-1.3; 2.1	Lab 1 Due 10/02
	28-Sep	Th	Equivalent Circuits	2.2	Quiz 1
2	3-Oct	T	Cable Theory		Lab 2 Due 10/09
	5-Oct	Th	Lab		Quiz 2
3	10-Oct	T	Action Potentials, Channels and Currents		
	12-Oct	Th	Integrate and Fire Model; Lab	2.3-2.7	Quiz 3
4	17-Oct	T	Hodgkin and Huxley Model	1.4.1; 4.1-4.6	Lab 3 Due 10/23
	19-Oct	Th	Compartment Based Models; Lab	4.7-4.9	Quiz 4
5	24-Oct	T	Synapses	5.1-5.3	
	26-Oct	Th	Synaptic Plasticity	8.1-8.3	Commentary 1 Due 10/30
6	31-Oct	T	Networks; Review for Midterm	5.5-5.8	
	2-Nov	Th	MIDTERM		Topic and Modeling Paper Due
7	7-Nov	T	Recording Methods: Electrodes; PSTH	3.1	Lab 4 Due 11/13
	9-Nov	Th	The Somatosensory System		Quiz 7
8	14-Nov	T	Spike Train Statistics; Lab	3.1-3.7	Lab 5 Due 11/20
	16-Nov	Th	Auto and Cross Correlations		Quiz 8
	21-Nov	T	No Class		
	23-Nov	Th	No Class		
9	28-Nov	T	Information Theory; Lab	1.4.3	
	30-Nov	Th	Population Codes		Quiz 9
10	5-Dec	T	Place Cells and Decoding		Commentary 2 Due 12/06
	7-Dec	Th	Recording Methods: Imaging		

Final Modeling Paper Due Exam Week