NJIT New Jersey's Science & Technology University

THE COLLEGE OF SCIENCE AND LIBERAL ARTS

THE DEPARTMENT OF MATHEMATICAL SCIENCES

MATH 635: Analytical and Computational Neuroscience
Fall 2020 Course Syllabus

NJIT Academic Integrity Code: All Students should be aware that the Department of Mathematical Sciences takes the University Code on Academic Integrity at NJIT very seriously and enforces it strictly. This means that there must not be any forms of plagiarism, i.e., copying of homework, class projects, or lab assignments, or any form of cheating in quizzes and exams. Under the University Code on Academic Integrity, students are obligated to report any such activities to the Instructor.

COURSE INFORMATION

Course Description: This course will provide an intermediate-level mathematical and computational modeling background for small neuronal systems. Models of biophysical mechanisms of single and small networks of neurons are discussed. Topics include voltage-dependent channel gating mechanisms, the Hodgkin-Huxley model for membrane excitability, repetitive and burst firing, single- and multi-compartmental modeling, synaptic transmission, mathematical treatment of 2-cell inhibitory or excitatory networks. In this course, the students will be required to build computer models of neurons and networks and analyze these models using geometric singular-perturbation analysis and dynamical systems techniques.

Number of Credits: 3

Prerequisites: MATH 211 or 213, MATH 337, and CS 113 or MATH 240, or departmental approval

Course-Section and Instructors

Course-Section	Instructor
Math 635-001	Professor H. Rotstein

Office Hours for All Math Instructors: Fall 2020 Office Hours and Emails

Required Textbook:

Title	*An Introductory Course in Computational Neuroscience*
Author	P. Miller
Edition	1st
Publisher	MIT Press (2018)
ISBN #	978-0262038256
Website	http://web.njit.edu/~horacio/IntroCompNeuro/IntroCompNeuroF20.html

University-wide Withdrawal Date: The last day to withdraw with a **W** is **Monday, November 9, 2020**. It will be strictly enforced.

RECOMMENDED BOOKS

- *Mathematical Foundations of Neuroscience* by G. B. Ermentrout & D. H. Terman – Springer (2010), 1st edition - ISBN: 978-0-387-87707-5.
- *Foundations of Cellular Neurophysiology* by D. Johnston & S. Wu – The MIT Press (1995) - ISBN: 0-2621000533.
- *Dynamical Systems in Neuroscience: The Geometry of Excitability and Bursting* by E. M. Izhikevich – The MIT Press (2007), 1st edition – ISBN: 0-262090438.
- *Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems* by Peter Dayan and Larry F. Abbott. The MIT Press, 2001. ISBN 0-262041995.
- *Biophysics of Computation - Information processing in single neurons* by Christof Koch. Oxford University Press, 1999. ISBN 0-195104919.

POLICIES

DMS Course Policies: All DMS students must familiarize themselves with, and adhere to, the Department of Mathematical Sciences Course Policies, in addition to official university-wide policies. DMS takes these policies very seriously and enforces them strictly.

Grading Policy: The final grade in this course will be determined as follows:

Homework, Quizzes & Class Participation	40%
Midterm Exam / Project	30%
Project / Presentation	30%

Your final letter grade will be based on the following tentative curve.

A	90 - 100	**C**	70 - 74
B+	85 - 89	**D**	60 - 69
B	80 - 84	**F**	0 - 59
C+	75 - 79		

Attendance Policy: Attendance at all classes will be recorded and is **mandatory**. Please make sure you read and fully understand the Math Department's Attendance Policy. This policy will be strictly enforced.

Exams: There will be one midterm exam held in class during the semester.

Midterm Exam	TBA
Final Exam Period	December 15 - 21, 2020

Makeup Exam Policy: There will be **NO MAKE-UP QUIZZES OR EXAMS** during the semester. In the event an exam is not taken under rare circumstances where the student has a legitimate reason for missing the exam, the student should contact the Dean of Students office and present written verifiable proof of the reason for missing the exam, e.g., a doctor's note, police report, court notice, etc. clearly stating the date AND time of the mitigating problem. The student must also notify the Math Department Office/Instructor that the exam will be missed.

Cellular Phones: All cellular phones and other electronic devices must be switched off during all class times.

ADDITIONAL RESOURCES

Math Tutoring Center: Located in the Central King Building, Lower Level, Rm. G11 (See: Fall 2019 Hours)

Further Assistance: For further questions, students should contact their instructor. All instructors have regular office hours during the week. These office hours are listed on the Math Department's webpage for Instructor Office Hours and Emails.

All students must familiarize themselves with and adhere to the Department of Mathematical Sciences Course Policies, in addition to official university-wide policies. The Department of Mathematical Sciences takes these policies very seriously and enforces them strictly.

Accommodation of Disabilities: Disability Support Services (DSS) offers long term and temporary accommodations for undergraduate, graduate and visiting students at NJIT.

If you are in need of accommodations due to a disability please contact Chantonette Lyles, Associate Director of Disability Support Services at 973-596-5417 or via email at lyles@njit.edu. The office is located in Kupfrian Hall, Room 201. A Letter of Accommodation Eligibility from the Disability Support Services office authorizing your accommodations will be required.

For further information regarding self identification, the submission of medical documentation and additional support services provided please visit the Disability Support Services (DSS) website at:

- https://www.njit.edu/studentsuccess/accessibility/

Important Dates (See: Fall 2020 Academic Calendar, Registrar)

Date	Day	Event
September 1, 2020	T	First Day of Classes
September 5, 2020	S	Saturday Classes Begin
September 7, 2020	M	Labor Day
September 8, 2020	T	Monday Classes Meet
September 8, 2020	T	Last Day to Add/Drop Classes
November 9, 2020	M	Last Day to Withdraw
November 25, 2020	W	Friday Classes Meet
November 26-29, 2020	R - Su	Thanksgiving Recess - University Closed
December 10, 2020	R	Last Day of Classes
December 11 & 14, 2020	F & M	Reading Days
December 15 - 21, 2020	T - M	Final Exam Period

Course Outline

Week	Topic	Assignment
1	Introduction to Mathematical and Computational Neuroscience	See course website
	Passive membrane properties – The passive membrane equation	
2	Ordinary differential equations (ODEs): Review of analytical methods	“
	Ordinary differential equations (ODEs): Review of numerical methods and Matlab	
3	Dynamics of the passive membrane	“
	The passive membrane equation	

4	Integrate-and-fire models	“
	The Hodgkin-Huxley model	
5	Hodgkin-Huxley type models with additional ionic currents	“
	The cable equation	
6	Introduction to dynamical system methods for neural models	“
	Reduced one- and two-dimensional neural model	
7	One-dimensional neural models: Phase-space analysis	“
8	Two-dimensional neural models: Phase-space analysis I	“
9	Two-dimensional neural models: Phase-space analysis II	“
10	Sub-threshold oscillations: Two and Three dimensional models	“
	Bursting	
11	Synaptic dynamics	“
12	Overview on network dynamics	“
13	Student Presentations	“
14	Student Presentations	“
15	Student Presentations	“