

MATH 635: Analytical and Computational Neuroscience

Fall 2021 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 MATH 213, MATH 337, and CS 113 or MATH 240, or departmental approval

Course-Section and Instructors:

Course-Section	Instructor
Math 635-101	Professor H. Rotstein

Office Hours for All Math Instructors: [Fall 2021 Office Hours and Emails](#)

Required Textbook:

Title	<i>An Introductory Course in Computational Neuroscience</i>
Author	P. Miller
Edition	1st Edition (2018)
Publisher	MIT Press
ISBN #	978-0262038256

Recommended Books:	<p>“Mathematical Foundations of Neuroscience” by G. B. Ermentrout & D. H. Terman - Springer (2010), 1st edition - ISBN: 978-0-387-87707-5.</p> <p>“Foundations of Cellular Neurophysiology” by D. Johnston & S. Wu - The MIT Press (1995) - ISBN: 0-262-100053-3.</p> <p>“Dynamical Systems in Neuroscience: The Geometry of Excitability and Bursting” by E. M. Izhikevich - The MIT Press (2007), 1st edition - ISBN: 0-262-09043-8.</p> <p>“Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems” by P. Dayan & L. Abbott - The MIT Press (2001) , 1st edition- ISBN: 0-262-04199-5.</p> <p>“Biophysics of Computation: Information Processing in Single Neurons” by C. Koch - Oxford University Press (1999) - ISBN: 0-19-510491-9</p>
Website:	Course Website

University-wide Withdrawal Date: The last day to withdraw with a **W** is **Wednesday, November 10, 2021**. It will be strictly enforced.

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%
Final 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		

Course Policies: See [Course Website](#)

Exams: There will be one midterm exam/project and one final project/presentation during the final exam period:

Midterm Exam	TBA
Final Exam Period	December 15 - 21, 2021

The final exam will test your knowledge of all the course material taught in the entire course. Make sure you read and fully understand the [Math Department's Examination Policy](#). This policy will be strictly enforced.

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 2021 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](#).

Accommodation of Disabilities: The Office of Accessibility Resources and Services (OARS) 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 Scott Janz, Associate Director of Disability Support Services at [973-596-5417](tel:973-596-5417) or via email at scott.p.janz@njit.edu. The office is located in Kupfrian Hall, Room 201. A Letter of Accommodation Eligibility from the Office of Accessibility Resources and 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 Office of Accessibility Resources and Services (OARS) website at:

<https://www.njit.edu/studentsuccess/accessibility/>

Important Dates (See: [Fall 2021 Academic Calendar](#), [Registrar](#))

Date	Day	Event
September 1, 2021	Wednesday	First Day of Classes
September 4, 2021	Saturday	Saturday Classes Begin
September 6, 2021	Monday	Labor Day

September 8, 2021	Wednesday	Monday Classes Meet
September 8, 2021	Wednesday	Last Day to Add/Drop Classes
November 10, 2021	Wednesday	Last Day to Withdraw
November 25 to November 28, 2021	Thursday to Sunday	Thanksgiving Recess - Closed
December 10, 2021	Friday	Last Day of Classes
December 13 and December 14, 2021	Monday and Tuesday	Reading Days
December 15 to December 21, 2021	Wednesday to Tuesday	Final Exam Period

Course Outline

Week	Topic	Assignment
1	Introduction to Mathematical and Computational Neuroscience Passive membrane properties - The passive membrane equation	See Course Website
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	
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Updated by Professor H. Rotstein - 8/6/2021
Department of Mathematical Sciences Course Syllabus, Fall 2021