

MATH 635: Analytical and Computational Neuroscience

Fall 2022 Course Syllabus

For further information, please visit the [Course Website](#)

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 2022 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 M is **Monday, November 14, 2022**. 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 16 - 22, 2022 |

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

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.

Important Dates (See: [Fall 2022 Academic Calendar, Registrar](#))

| Date | Day | Event |
|--------------------|---------|------------------------------|
| September 5, 2022 | Monday | Labor Day |
| September 6, 2022 | Tuesday | First Day of Classes |
| September 12, 2022 | Monday | Last Day to Add/Drop Classes |
| November 14, 2022 | Monday | Last Day to Withdraw |
| November 22, 2022 | Tuesday | Thursday Classes Meet |

| | | |
|-------------------------------------|------------------------|------------------------------|
| November 23, 2022 | Wednesday | Friday Classes Meet |
| November 24 to November 25, 2022 | Thursday and Friday | Thanksgiving Recess - Closed |
| November 26, 2022 | Saturday | Saturday Classes Meet |
| December 14, 2022 | Wednesday | Last Day of Classes |
| December 15, 2022 | Thursday | Reading Day |
| December 16 to December 22, 2022 | Friday to Thursday | 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 | |

*Updated by Professor H. Rotstein - 7/12/2022
Department of Mathematical Sciences Course Syllabus, Fall 2022*