Brandeis UNIVERSITY

Math 123a: Principles of Mathematical Modeling

Fall 2025

Instructor: Yangyang Wang (yangyangwang@brandeis.edu)
Time: T, F 11:10 am -12:30 pm
Class Location: Gerstenzang: 122

Student Hours: T, F, 2:10-3:10 pm, Goldsmith 302
Office location: Goldsmith 302

Prerequisites

It is assumed that students are proficient in linear algebra, calculus and differential equations. The pre-requisite courses are thus MATH 15, 20 and 37.

Course Materials

The course will be mostly based on selected chapters from the following references:

- Otto & Day: A biologist's guide to Mathematical Modeling in Ecology and Evolution
- Devaney: An introduction to chaotic dynamical systems
- Strogatz: Nonlinear Dynamics and chaos.

These textbooks are not required - they are useful references.

Introduction and Objectives

Mathematical equations provide a very powerful approach to understand natural and social phenomena. Since ancient times, scientists have used mathematical models to describe natural phenomena as diverse as gravitation, electro-magnetism, competition for survival of ecological species, evolution, games, economics, financial markets and brain's physiology, to cite a few. Mathematical models sometimes have shed new light for understanding those natural phenomena, and reciprocally, questions arising in other scientific disciplines raised complex, sometimes largely open mathematical problems that deserve new theories.

This course is an introduction to mathematical modeling. Through a number of examples, this course will provide a view on the approach of the applied

mathematician, review a few classical models in biology and ecology, present methods allowing their theoretical study, as well as a few open problems they raise.

The objectives of the course are to provide the students with main concepts in mathematical modeling and methods used by applied mathematicians to study these equations and obtain a better understanding of the phenomena described, particularly using dynamical systems theory, calculus, stability analysis and bifurcations.

Class sessions will include two oral presentations per student. The course will emphasize developing oral communication skills for effectively conveying mathematical modeling concepts and their real-world applications.

Tentative Course Topics

Understanding and building mathematical models
Introduction of classical models in biology and ecology
Discrete-time models / dynamical systems
Continuous-time models / dynamical systems
Fixed points, equilibrium, periodic solutions, bifurcations
Pattern formation and morphogenesis

Learning goals:

- Learning what represents a mathematical model of a natural phenomenon,
- Learning how to develop a mathematical model
- Understanding classical models such as prey-predator models in ecology
- Being able to analyze the dynamics of discrete-time dynamical systems
- Being able to analyze continuous-time dynamical systems and periodic dynamics
- Being able to effectively communicate different mathematical modeling approaches and their applications to real-world problems through oral presentations and written report.

Course Work and Grading

- **Homework**: 30% of total grade.

- Collaboration and discussion on homework are encouraged but you must write up your solutions independently of your classmates.
- Late Homework Policy: Unless under exceptional circumstances (e.g. medical emergency), late assignments will not be accepted. However, the two lowest scores will be dropped.

• **Midterm**: 30% of total grade

• **Presentations (15%) and Final project (25%):** 40% of total grade

- Each student will give two presentations: one during the first half of the semester and one towards the end (the Final Project Presentation)
- The format and guidelines for the presentations will be provided later in the semester

• **Participation**
- A bonus of up to 5 points will be granted for significant participation, including active engagement in class discussions, asking questions, and other relevant contributions.

Learning Expectations and Resources

This course will be conducted in-person. However, in the event of campus closures such as snow days or other disruptions, it may transition to remote instruction through Zoom. **In-person attendance is expected** (unless accommodations have been cleared with me beforehand.

Success in this course is based on the expectation that students will spend a minimum of 9 hours of study time per week in preparation for class (reviewing class materials, homework, preparation for exams and projects, etc.).

Undergraduate students from SAS with financial need should contact Student Financial Services to discuss options available to purchase equipment and other technology and supply needs. GSAS students should contact Monique Howell in GSAS.

Accommodations

Brandeis seeks to create a learning environment that is welcoming and inclusive of all students, and I want to support you in your learning.

If you think you may require disability accommodations, you will need to work with Student Accessibility Support (SAS) (781-736-3470, access@brandeis.edu). You can find helpful student FAQs and other resources on the SAS website, including guidance on how to know whether you might be eligible for support from SAS. If you already have an accommodation letter from SAS, please provide me with a copy as soon as you can so that I can ensure effective implementation of accommodations for this class. In order to coordinate exam accommodations, ideally you should provide the accommodation letter at least 48 hours before an exam.

Instructor's Note:

Course policies, grading and topics may be adjusted as necessary. Any changes will be communicated promptly.

Important Policies and Resources

Academic Integrity

Every member of the University community is expected to maintain the highest standards of academic integrity. A student shall not submit work that is falsified or is not the result of the student's own effort. Infringement of academic integrity by a student subjects that student to serious penalties, which may include failure on the assignment, failure in the course, suspension from the University or other sanctions. Please consult Brandeis University Rights and Responsibilities for all policies and procedures related to academic integrity. Students may be required to submit work via TurnItIn.com or similar software to verify originality. A student who is in doubt regarding standards of academic integrity as they apply to a specific course or assignment should consult the faculty member responsible for that course or assignment before submitting the work. Allegations of alleged academic dishonesty will be forwarded to the Department of Student Rights and Community Standards. Citation and research assistance can be found at Brandeis Library Guides - Citing Sources.

Breaks

Class meetings of 90 minutes include a 10-minute break, while class meetings of 180 minutes include two breaks, at the instructor’s discretion.

Classroom Health and Safety

- Register for the Brandeis Emergency Notification System. Students who receive an emergency notification while attending class should notify their instructor immediately. In the case of a life-threatening emergency, call 911. As a precaution, review this active shooter information sheet.
- Brandeis provides this shuttle service for traveling across campus or to downtown Waltham, Cambridge and Boston.
- On the Brandeis campus, all students, faculty, staff and guests are required to observe the university's policies on physical distancing and mask-wearing to support the health and safety of all classroom participants. Review up to date COVID-related health and safety policies regularly.

Course Materials/Books/Apps/Equipment

If you are having difficulty purchasing course materials, please make an appointment with your Student Financial Services or Academic Services advisor to discuss possible funding options, including vouchers for purchases made at the Brandeis Bookstore.

Library

The Brandeis Library collections and staff offer resources and services to support Brandeis students, faculty and staff. Librarians and Specialists from Research & Instructional Services, Public Services, Archives & Special Collections, Sound & Image Media Studios, MakerLab, AutomationLab, and Digital Scholarship Lab are available to help you through consultations and workshops.

Privacy

To protect your privacy in any case where this course involves online student work outside of Brandeis password-protected spaces, you may choose to use a pseudonym/alias. You must share the pseudonym/ alias with me and any teaching assistants as needed. Alternatively, with prior consultation, you may submit such work directly to me.

Student Support

Brandeis University is committed to supporting all our students so they can thrive. If a student, faculty, or staff member wants to learn more about support resources, the Support at Brandeis webpage offers a comprehensive list that includes these staff colleagues you can consult, along with other support resources:

- The Care Team
- Academic Services (undergraduate)
- Graduate Student Affairs
- Directors of Graduate Studies in each department, School of Arts & Sciences

- Program Administrators for the Heller School and International Business School
- University Ombuds
- Office of Equal Opportunity.