MATH 76.03: Evolutionary Dynamics

Winter '23

Instructor:	Olivia Chu	**Office:**	Haldeman 258
Email:	Olivia.J.Chu@dartmouth.edu		

Course Pages:

1. https://math.dartmouth.edu/~m76w23/ (not yet active)
2. Canvas – will be updated regularly throughout the term

Course Time: MWF 10:10am-11:15am (x-hour Th 12:15pm-1:05pm) in Kemeny Hall 004.

Office Hours: Wednesdays from 2-3pm, and by appointment, starting Jan 11th, in Haldeman 258.

- **Note:** The Haldeman Center is connected to Kemeny Hall, and Haldeman 258 is located inside the Neukom Institute suite on the second floor. The suite is generally locked, so someone will need to let you in when you arrive.

Course Description: Evolutionary dynamics is the mathematical study of evolutionary processes permeating every corner of biology. This course is intended for both upper-level undergraduate students and graduate students who are interested in applying mathematics to real-world problems. It will cover important topics related to cooperation, opinion dynamics, infectious diseases, and cancer, and introduce mathematical techniques and stochastic modeling approaches needed to tackle such problems.

ORC Prerequisites: Math 3, Math 20, and Math 23, or approval of the instructor. Programing skills helpful, but not required.

Suggested Textbooks:

- Nowak, M. A. (2006). Evolutionary Dynamics: Exploring the Equations of Life. Harvard University Press.
- Sigmund, K. (2010). The Calculus of Selfishness. Princeton University Press.

Grading Policy and Formula: Four Problem Sets (40%), Final project on a topic of your choice (50%), Attendance & Participation (10%).

Final Project: The final project is a research project, which will require significant use of quantitative methods, concepts, and ideas learned in class (e.g. game theory models, statistical analyses, simulations).

- Students are encouraged to work in groups of up to 2 individuals.
- Students will prepare a final report ($\sim$ 15 pages) written in the format of a scientific research paper, as well as give a flash talk about the work to the class. Each presentation is limited to 15 minutes.

- Approximately 4 weeks are given to complete the final project/final essay.
- The instructor will suggest project ideas in the third week, but students are allowed (and encouraged) to propose their own, which has to be approved by the instructor in the fourth week at the latest.

Important Dates:

No class	January 6th, 2023
Class during x-hour	January 12th, 2023
No class (MLK Jr. Day)	January 16th, 2023
Class during x-hour	January 19th, 2023
Final project proposal due	January 30th, 2023
Homework problem sets	biweekly (every other week)
Final project presentations	March 3rd and 6th, 2023
Final project report due	March 10th, 2023
Add/drop period	January 4th-17th, 2023
Final day to drop a 4th course	February 14th, 2023
Final day to withdraw from a course	February 21st, 2023

Tentative Course Outline:

Week 1: Overview

- Evolutionary games: introduction & overview
- Stability concepts: Nash Equilibrium vs. Evolutionarily Stable Strategy
- Replicator equations and their connection with ecological dynamics

Week 2: Evolution of cooperation

- Social dilemmas of cooperation
- Rules for cooperation

Week 3: Evolutionary games

- Repeated games
- Beyond pairwise interactions: multi-person games

Week 4: Evolutionary graph/set theory

- Finite populations
- Spatial games
- Games on dynamical social networks

Week 5: Evolution of strategies in phenotype space

- Adaptive dynamics
- Evolutionary branching

Week 6: Opinion dynamics

- Adaptive network models
- Data applications of adaptive voter models

Week 7: Disease dynamics and public health

- Epidemiological models
- Population heterogeneity
- Vaccination dilemma

Week 8: Cancer evolution and treatment

- Clinically relevant models of cancer
- Predicting treatment responses
- Cancer treatments

Week 9: Final project presentations

Jupyter Server: There is now a dedicated Jupyter notebook server for undergraduate use, where anyone can log in with a NetID. Accounts don't have to be created in advance. The service is at `https://euclid.dartmouth.edu` and it's a basic Jupyter install, with Python and Sagemath kernels.

Honor Principle: Collaborations (giving and receiving assistance) during closed-book exams and quizzes are strictly prohibited. Any form of plagiarism is not allowed in the final project. If you have questions, please ask the instructor first and always refer to the Academic Honor Principle (`https://students.dartmouth.edu/community-standards/policy/academic-honor-principle`).

Student Accessibility and Accommodations: Students requesting disability-related accommodations and services for this course are encouraged to schedule a phone/Zoom meeting with the instructor as early in the term as possible. This conversation will help to establish what supports are built into the course. In order for accommodations to be authorized, students are required to consult with Student Accessibility Services (SAS) – online at `https://students.dartmouth.edu/student-accessibility/students/where-start/apply-services`; by phone at 603-646-9900; via email at student.accessibility.services@dartmouth.edu – and to request an accommodation email be sent to the instructor. We will then work together with SAS if accommodations need to be modified based on the learning environment. If students have questions about whether they are eligible for accommodations, they should contact the SAS office. All inquiries and discussions will remain confidential.

Student Religious Observances: Dartmouth has a deep commitment to support students' religious observances and diverse faith practices. Some students may wish to take part in religious observances that occur during this academic term. If you have a religious observance that conflicts with your participation in the course, please meet with me as soon as possible – before the end of the second week of the term at the latest – to discuss appropriate course adjustments.

Mental Health and Wellness: The top priority of this course is students' health and well-being. The class will ensure that everyone is free of pressure and anxiety. The academic environment at

Dartmouth is challenging, our terms are intensive, and classes are not the only demanding part of life. There are a number of resources available on campus to support students' wellness, including the undergraduate dean (https://students.dartmouth.edu/undergraduate-deans/), Counseling and Human Development (https://students.dartmouth.edu/health-service/counseling/about), and the Student Wellness Center (https://students.dartmouth.edu/wellness-center/). The instructor encourages students to use these resources to take care of themselves throughout the term, and to come speak with the instructor if they experience any difficulties.

COVID Information: Please visit https://covid.dartmouth.edu/ for the most up-to-date COVID information and policies. If students have symptoms of COVID, they should take a rapid test and wear a face mask when around others. Currently (at the start of this winter quarter), face masks are not required in the classroom (unless someone has tested positive for COVID-19 in the prior 10 days and has tested out of isolation on Day 5 or Day 7). However, students are encouraged to wear a face mask if they feel more comfortable doing so and to get in touch with the instructor if they have any special circumstances relating to COVID-19. Students will not be penalized for missing class due to COVID, and the instructor will work together with the student to come up with a plan to make up any missed work.

Late Policy: As we are amid a once-in-a-century pandemic, please request appropriate accommodations if you expect delays in turning in your assignments. Otherwise, by "deadline", we really mean it. On the condition of accepting the penalty for turning in the final project report late (5% each additional day), however, an extension of maximum 4 days will be granted on a case-by-case basis. In exceptional circumstances, students with disabilities should inform the instructor of their accommodation requests well in advance, so that the instructor will have sufficient time to work with Student Accessibility Services to provide appropriate accommodations.