CAAM/STAT 31310, Winter 2026, U Chicago

Foundations of Computational Dynamics: CAAM/STAT 31310

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Dynamical systems, often represented as ordinary differential equations (ODEs) or iterations of functions, are models for variables that change with time. Dynamical systems theory is the study of the structure of all possible solutions of such systems, called orbits or trajectories. When the dynamics is stochastic or deterministic but chaotic, it also makes sense to study the time-asymptotic behavior or *ergodic* properties of orbits. Across science and engineering, several computational questions are asked of dynamical systems such as: i) how sensitive are the orbits and orbit structure of the dynamics to one-time perturbations, to persistent deterministic perturbations, and to noisy perturbations? ii) given some measurements or observations of the dynamics, how do we forecast orbits into the future or predict their statistical moments?, and iii) how can we construct simpler dynamical systems (with fewer variables) that captures their *essential* features? The primary goals of this course are to put such questions in a mathematical language and study rigorous numerical methods for answering them.

We will start with an overview of nonlinear deterministic systems and their numerical analysis, using dynamical systems and ergodic theory. We will then cover analysis, control and learning methods from computational statistics, as applied to dynamical systems. See Canvas or the Github site for a list of topics.

1 General information

- 2 80-minute lectures per week, 3 homeworks, 2 in-class quizzes, 1 final project.
- Class time and location: Tuesdays and Thursdays, 12 pm – 1:20 pm, Kent 103
- Class dates: Jan 6, 2026 – Mar 5, 2026.
- Office hours: 3 pm – 4 pm on Thursdays
- Instructor email: nishac@uchicago.edu

2 Resources (not exhaustive)

Being interdisciplinary, this course will cover select content from multiple textbooks (and also research articles, which will be cited during class), some of which are listed below.

- Introduction to the modern theory of dynamical systems by Katok and Hasselblatt, Cambridge University Press.
- Nonlinear dynamics and chaos by Strogatz, second edition, Westview Press.
- Numerical Solution of Stochastic Differential Equations by Kloeden and Platen, Springer.
- Computational Optimal Transport by Peyre and Cuturi, Foundations and Trends in Machine Learning, 2019.
- Foundations of machine learning by Mohri, Rostamizadeh and Talwalkar, second edition, MIT Press.
- Joel A. Tropp, CMS/ACM 117: Probability Theory & Computational Mathematics, Caltech CMS Lecture Notes 2023-01, Pasadena, December 2023. Link to notes

Lecture notes and handouts will be posted on the Github site as well as the Canvas site for the class.

3 Grading information and late policy

This is a discussion-oriented advanced topics course with no final exam. The grade will be determined by a final project (40%), some homeworks (30%) and two short in-class quizzes (30%). The final project will be a research project on a topic of your choice, related to the course material. I will assist you in the selection of a project and designing its scope, if needed. The final project will be due on the last day of class.

You are welcome to discuss with other students and use online resources, including AI assistants such as ChatGPT and Github CoPilot, to solve the homework questions and for the final project. After that, however, all the submitted work should be your own; no direct copying from anywhere. Please submit LaTeX-ed homework solutions (handwritten solutions are often illegible and will not be graded) on Gradescope as a pdf.

4 List of topics

The syllabus section on Canvas will have a lecture-wise breakdown of topics and be updated throughout the quarter.

5 Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Student Disability Services (SDS). Please meet with me to discuss your access needs in this class after you have completed the SDS procedures for requesting accommodations.

SDS contact information:
Phone: 773-702-6000
Email: disabilities@uchicago.edu.
Website: https://disabilities.uchicago.edu