Instructor:

Prof. Steven Strogatz, shs7@cornell.edu
Office: Malott Hall 533
Online office hours: Monday, 2:30 pm -4:00 pm, online on Zoom here
Sign up here to reserve a 15-minute spot for online office hours

Teaching assistants:

Mark Walth, msw283@cornell.edu
Office hours: Wednesday and Thursday, 3:00-4:00, Malott 218

Jiajun Bao, jb2777@cornell.edu
Office hours: Tuesday, 2:00-4:00, Rhodes Hall 657

Textbook:

Strogatz, *Nonlinear Dynamics and Chaos*, 3rd edition.

A PDF copy of the book is available here.

Homework:

Homework is due on Thursday, by 11:00 pm.

You can find the assignments in the Assignments tab on the left hand side of our Canvas.

Submit your homework by scanning it and uploading it on Gradescope.
Soon after the submission deadline, the solutions will be posted in the module for the corresponding week under the Modules tab.

No late homework will be accepted.
You are allowed to miss two homework assignments.
Beyond that, additional missed assignments will count as a zero.

Each homework problem will be graded for completion, not for correctness.
(Completion means a serious, good faith attempt, not a chicken scratch.

Write legibly, and make your logic clear.
Whether or not a problem is considered "complete" is at the discretion of the teaching assistants.)

You should check your own work for correctness by comparing it with the posted solutions.
And Prof. Strogatz and the TAs would be happy to discuss it with you in office hours, if you still have questions.

Grading:

20% Problem sets (assigned every 1-2 weeks)
20% Prelim 1 in class, Sep 25
20% Prelim 2 in class, Nov 6
40% Final exam: Dec 16, 7:00-9:30 pm, Malott 228

Academic Integrity:

Prelims and final exams: You must work alone. You are not allowed to use calculators, computers, phones, or any other electronics.

Homework: To learn the subject, you should try hard to solve the homework problems by yourself and write them up by yourself. But if you want to collaborate with other students, that's OK. You are even allowed to use ChatGPT, Co-Pilot, Gemini, or other generative AI systems. But keep in mind: The prelims and final exam count for 80% of your course grade, and for those, you will be on your own. Wrestling with the homework is your best chance to learn the subject. Use it wisely -- no pain, no gain!

2014 Lectures Online:

If you miss a lecture, or just want to go over something again, you can watch the lectures Prof. Strogatz gave in this course in 2014. They are on Youtube here. This resource may also be helpful on the (hopefully, very few) days when Prof. Strogatz is away for travel.

Topics:

1-D systems and bifurcations (3 weeks)
2-D systems: phase plane analysis, limit cycles and their bifurcations (3.5 weeks)
Lorenz equations and chaos (2.5 weeks)
1-D maps and period doubling route to chaos, renormalization (2 weeks)
Fractals and strange attractors (2 weeks)
More topics and applications if time permits

Lectures:

1. Aug 26. Overview. Logical structure of dynamics [Sections 1.2-1.3 in textbook]
2. Aug 28. One-dimensional flows. Logistic model of population growth [2.0-2.3]
3. Aug 30. Linearization. Impossibility of oscillations. Saddle-node bifurcation. [2.4-2.6, 3.0-3.1]
4. Sep 4. Saddle-node bifurcation (continued). Transcritical and pitchfork bifurcations. [3.1, 3.2, 3.4]
5. Sep 6. Overdamped bead on a rotating hoop [3.5]
6. Sep 9. Overdamped bead (continued) [3.5]
7. Sep 11. Tutorial on non-dimensionalization: Scaling a simple harmonic oscillator [handout]
8. Sep 13. Model of an insect outbreak -- watch this video and read section [3.7]
9. Sep 16. Linear systems [Chapter 5]
10. Sep 18. Fixed points and linearization. Start rabbits vs sheep [6.0-6.4]
11. Sep 20. Finish rabbits vs sheep [6.4]
12. Sep 23. Conservative systems [6.5]
13. Sep 25. Prelim 1
14. Sep 27. Index theory [6.8]
15. Sep 30. Limit cycles, Ruling out closed orbits. Begin Dulac's criterion. [7.0-7.2]
16. Oct 2. Finish Dulac. Begin Poincaré-Bendixson theorem. [7.2-7.3]
17. Oct 4. Finish Poincaré-Bendixson theorem. [7.3]
18. Oct 7. Relaxation oscillator [7.5]
19. Oct 9. Bifurcations in 2-D systems. Hopf bifurcations. [8.0-8.2]

20. Oct 11. Videos: Aeroelastic instabilities. Chemical oscillations. [8.3]
21. Oct 16. Supercritical vs subcritical Hopf bifurcations. Global bifurcations of cycles. [8.2, 8.4]
22. Oct 18. Coupled oscillators and quasiperiodicity [8.6]
23. Oct 21. Chaotic waterwheel video. Conservation of mass equation for waterwheel. [9.0, 9.1]
24. Oct 23. Torque balance equation. Amplitude equations. [9.1]
25. Oct 25. Fixed points of amplitude equations and the Lorenz system. [9.1]
26. Oct 28 Simple properties of Lorenz equations. [9.2]
27. Oct 30. Global stability of origin for r < 1. Liapunov function. [9.2]
28. Nov 1. Chaos on a strange attractor [9.3]
29. Nov 4. Lorenz map. [9.4]
30. Nov 6. UPDATE -- THE PRELIM IS POSTPONED TO FRIDAY
31. Nov 8. PRELIM 2 in class
32. Nov 11. Using chaos to send secret messages. Video. [9.6]
33. Nov 13. Introduction to logistic map. Orbit diagram. [10.0-10.2]
34. Nov 15. Logistic map: analysis. Periodic windows. [10.3, 10.4]
35. Nov 18. Universal aspects of period doubling. [10.6]
36. Nov 20. Introduction to renormalization [10.7]
37. Nov 22. Renormalization (continued) [10.7]
38. Nov 25. Renormalization for pedestrians [10.7]
39. Dec 2. Countable and uncountable sets. Cantor set. [11.0-11.3]
40. Dec 4. Cantor set (continued) [11.3]
41. Dec 6. Other notions of fractal dimension [11.4, 11.5]
42. Dec 9. Picturing the geometry of strange attractors [12.0-12.3]

Students with disabilities:

Your access in this course is very important to me. In order to have adequate time to arrange your approved accommodation, you must request your accommodation letter as soon as possible after approval by SDS.

Once SDS approves your accommodation letter, it will be emailed to both you and me.

Students with exam accommodations:

This course is participating in the SDS Alternative Testing Program (ATP). If you have an approved exam accommodation, you must request it for this course as soon as possible but no later than 7 days before Prelim 1 on September 25. Failure to do so may result in the inability to use your accommodation.

Additionally, be aware of the following:

- After you submit your accommodation letter request, you will automatically be enrolled for all eligible exams and will receive email confirmations for each exam between one and two weeks prior to the exam. You can also review your exam schedule in your SDS Online Services (https://sds.cornell.edu).
- Scheduling for accommodated exams:
    - *Daytime exams:* Students will take accommodated exams at the same time as the general exam. Students with extended time accommodations who have a course immediately following this class have the option to take their exam at 8 a.m. and/or 5 p.m. on the same day.
- All exam logistics will be communicated to you from SDS (look out for emails from sds@accessiblelearning.mail.cornell.edu). Please do not contact me with questions about exam logistics, as I will not be able to answer them. Questions should be sent to sds-testing@cornell.edu.

Coordination of accommodated make-up exams (i.e., for students who have been granted prior permission by me to take the exam on a day other than the scheduled date of the main exam) will be handled by SDS after approval by me. Please see ATP Information for Students for details on how to schedule a makeup exam.