

Fall 2023, Math 4541: Dynamics & Bifurcations I

Class information

- **Lectures:** MW 12:30pm-1:45pm
- **In person class location:** Skiles 254
- **Live lectures and recordings via Zoom:** access via Canvas (Live lectures: "Canvas>Zoom", Recordings: "Canvas>Media Gallery")
 - **NOTE:** This class is on the "in-person" mode, and is NOT hybrid. Live lectures and recordings are offered as an alternative for students who cannot attend the class in person. It is hard to monitor questions from remote participants and therefore, those questions will not be answered in class.
- **Canvas:**
 - **NOTE:** Lecture notes will be posted on *Canvas>Files*.
- **Instructor :** Prof. Hannah Choi (email: hannahch@gatech.edu)
 - Office hours: MW 2pm-3pm (Skiles 265); or by appointment
 - Email policy: I will not answer questions about homework problems via email. Please either use office hours or the Canvas discussion board (do not post answers). For other course related questions, please add the header [MATH 4541] in your email title.

Course information

- **Course Description:** A broad introduction to the local and global behavior of nonlinear dynamical systems arising from maps and ordinary differential equations
- **Prerequisites:** MATH 2403 or MATH 2552 or equivalent.
- **Textbook:** *Nonlinear Dynamics and Chaos with applications to physics, biology, chemistry and engineering* by Steven H. Strogatz, 2nd edition.
 - You can get a free electronic copy of the text book from [Nonlinear Dynamics and Chaos | With Applications to Physics, Biology, \(taylorfrancis.com\)](https://www.taylorfrancis.com). You can access it either via GT Library (using a GT computer system) or via GT log in (Click on "Get Access > With Shibboleth or OpenAthens", search for "Georgia Institute of Technology", then sign into your GT account.)
 - If you have an earlier version of the book and want to keep it, be aware that numeration of sections and exercises may have changed.
- **Group work and Academic Honesty policy:**
 - You are encouraged to discuss and work in groups to solve problem sets.
 - You must write up your own solution and your own code. Copy, pasting, and editing will be considered plagiarism.

Honor code: All students are expected to comply with the Georgia Tech Honor code. Please review the student code of conduct and the [Honor Code](#). Any evidence of cheating or other violations of the Georgia Tech Honor Code will be submitted directly to the Office of Student Integrity

Course topics

1. Introduction to dynamical systems.
2. Flows on the line (1D systems)
3. Solving ODEs w/ a computer
4. Bifurcations in 1-D systems
5. Flows on the circle
6. 2-D linear systems
7. Nonlinear systems in the phase plane
8. Limit cycles
9. Bifurcations in 2D systems
10. Difference equations
11. Logistic maps
12. Fractals
13. Lorenz equations
14. Strange attractors

Grading

- **Homework:** 30%
- **Midterm 1:** 25%
- **Midterm 2:** 25%
- **Final Project:** 20% (10% in-class presentation + 10% final report)

Homework

- 15 points each
- Assigned on Mondays, due next Wednesdays (*except for the HW assignments right before Exams and during Fall Break)
 - Submit electronically via Canvas by Wednesday 11:59pm.
- Homework will be graded statistically. You will receive 5/15 of the credit for handing in a complete assignment (solutions for every problem), and the remaining 10/15 will be for correct solutions to two randomly chosen problems. Late homework is not accepted. Your homework should be neat and readable. The grader is allowed to subtract points (or fractions thereof, at their discretion) for presentation.
- The lowest homework grade will be dropped.
- Late homework is not accepted.

- 105 points total

Exams

- **Midterm Exam 1** : Wednesday 10/11 in class (12:30pm-1:45pm, Skiles 254)
 - Closed book, one single-sided letter-sized (8.5x11 inch) sheet of notes, no calculator
- **Midterm Exam 2** : Monday 11/20 in class (12:30pm-1:45pm, Skiles 254)
 - Closed book, one single-sided letter-sized (8.5x11 inch) sheet of notes, no calculator

Final Project

Each team of 2 students (occasionally 1- or 3-person teams will be allowed) will identify an interesting problem in dynamical systems and bifurcations to do a mini-project. Some project ideas are provided here. You can choose one of the topics suggested (link) or identify a different problem. You should check with Prof. Choi regarding your chosen project topic by Nov 1. Your final project will be graded based on in-class presentations (10 min presentations + 3 mins Q&A).

Note: On rare occasions, the submission of a written final project report (~7 pages) in place of the in-class presentation will be allowed. However, if you would like to choose this alternative format, you should discuss your option by Nov 1 and obtain permission from Prof. Choi. Even if you submit a written report instead of presenting in-class, you should still attend all in-class final presentations of your classmates to receive full credit.

You are required to attend other teams' presentations and strongly encouraged to ask questions during presentations.

Tentative schedule (subject to change actively throughout the semester)

- Please see [Modules](#) for class materials and assignments each week!
 - **Week 1** : 8/21, 8/23
 - **Topics covered:**
 1. Class logistics & Introduction to nonlinear dynamics
 2. 1-D Flows (Strogatz Ch. 2.1-2.7)
 - **Week 2** : 8/28, 8/30
 - **Topics covered:**
 1. Solving ODEs with computer (Strogatz Ch. 2.8)
 2. 1-D Bifurcation (Strogatz Ch. 3.1-3.6)
 - **Mon 8/28:**
 1. **Homework 1 posted (due 9/6)**
 - **Week 3** : 9/4 (No class-Labor Day), 9/6
 - **Topics covered:**

- 1. 1-D Bifurcation (Strogatz Ch. 3.1-3.6)
 - 2. Insect outbreak (Strogatz Ch. 3.7)
 - **Mon 9/4**
 - 1. Homework 2 posted (due 9/13)
 - **Wed 9/6**
 - 1. Homework 1 due (upload via Canvas>Assignment)
- **Week 4 : 9/11, 9/13**
 - **Topics covered:**
 - 1. Flows on the circle (Strogatz Ch. 4.1-4.5)
 - 2. 2-D Linear Systems (Strogatz Ch 5.1-5.2)
 - **Mon 9/11**
 - 1. Homework 3 posted (due 9/20)
 - **Wed 9/13**
 - 1. Homework 2 due (upload via Canvas>Assignment)
- **Week 5 : 9/18, 9/20**
 - **Topics covered:**
 - 1. 2-D Linear Systems (Strogatz Ch 5.1-5.2)
 - 2. Love Affairs (Strogatz Ch 5.3)
 - 3. 2-D Nonlinear Systems (Strogatz Ch. 6.1)
 - **Mon 9/18**
 - 1. Homework 4 posted (due 9/27)
 - **Wed 9/20**
 - 1. Homework 3 due (upload via Canvas>Assignment)
- **Week 6 : 9/25, 9/27**
 - **Topics covered:**
 - 1. 2-D Nonlinear systems (Strogatz Ch. 6.1, 6.7)
 - 2. Limit cycles (Strogatz Ch. 7.0-7.3)
 - **Mon 9/25**
 - 1. Practice midterm & solution posted
 - **Wed 9/27**
 - 1. Homework 4 due (upload via Canvas>Assignment)
- **Week 7 : 10/2, 10/4**
 - **Topics covered:**
 - 1. Relaxation oscillations (Strogatz Ch. 7.5)
 - 2. Limit cycles (Strogatz Ch. 7.6)
 - 3. 2-D Bifurcation (Strogatz Ch 8.1-8.2)
- **Week 8 : 10/9 (No class-Fall Break), 10/11**
 - **Wed, 10/11 :**
 - 1. **Midterm 1 (Ch 1-7, except Index Theory) in class**
- **Week 9 : 10/16, 10/18**

- **Topics covered:**
 1. 2-D Bifurcation (Strogatz Ch 8.1-8.2)
 2. Introduction to Final Project logistics & First In-class Final Project group work session
- **Mon 10/16**
 1. Midterm 1 discussion
 2. Homework 5 posted (due 10/25)
- **Wed 10/18**
 1. First In-class Final Project group work session (2nd half of the class)
- **Week 10 : 10/23, 10/25**
 - **Topics covered:**
 1. 2-D Bifurcation (Strogatz Ch 8.2)
 2. Difference Equations (Strogatz Ch. 10.1)
 - **Mon 10/23**
 1. Homework 6 posted (due 11/1)
 - **Wed 10/25**
 1. Homework 5 due (upload via Canvas>Assignment)
- **Week 11 : 10/30, 11/1**
 - **Topics covered:**
 1. Difference Equations (Strogatz Ch. 10.1)
 2. Logistic Maps and Chaos (Strogatz Ch. 10.2-10.7)
 3. Final project check with the instructor
 - **Mon 10/30**
 1. Homework 7 posted (due 11/8)
 - **Wed 11/1**
 1. Homework 6 due (upload via Canvas>Assignment)
 2. Check with Prof. Choi about the final project topics
- **Week 12 : 11/6, 11/8**
 - **Topics covered:**
 1. Logistic Maps and Chaos (Strogatz Ch. 10.2-10.7)
 2. Fractals (Strogatz Ch 11)
 3. Lorenz Equations (Strogatz Ch. 9)
 - **Mon 11/6**
 1. Homework 8 posted (due 11/15)
 - **Wed 11/8**
 1. Homework 7 due (upload via Canvas>Assignment)
- **Week 13 : 11/13, 11/15**
 - **Topics covered:**

- 1. Strange attractors (Strogatz Ch. 12)
- Mon 11/13
 - 1. Practice midterm & solution posted
- Wed 11/15
 - 1. Homework 8 due (upload via Canvas>Assignment)
- **Week 14** : 11/20, 11/22
 - Mon, 11/20 :
 - 1. **Midterm 2** (Ch 8-12) in class
 - Wed, 11/22 :
 - 1. **Midterm 2 discussion + In-class Final Project group work session**
- **Week 15** : 11/27, 11/29
 - Mon, 11/27 :
 - 1. **Final Project Presentations Part 1**
 - 2. **Final Project Slides upload due 11am** (upload via Canvas>Assignment)
 - Wed, 11/29 :
 - 1. **Final Project Presentations Part 2**
- **Week 16** : 12/4 (*Last day of class*)
 - Mon, 12/4 :
 - 1. **Final Project Presentations Part 3**
 - 2. **Final Project Reports due 11am** (upload via Canvas>Assignment)

Course materials policy

Classes may not be recorded by students without the expressed consent of the instructor unless it is pursuant to an accommodation granted by the Office of Disability services. Class recordings, lectures, homework problems, exam problems, and other materials posted on Canvas are for the sole purpose of educating the students currently enrolled in the course and should not be shared or distributed outside of the class. Students may not record or share the materials or recordings, including screen capturing, unless the instructor gives permission.