

Chaos and Dynamical Systems (MATH-UA 264)

My Information: My name is Jose Diaz-Alban. You are welcome to call me Jose (as long as it's done respectfully), otherwise Professor, or Professor Diaz-Alban are also fine. Some additional info:

- Email: jad241@nyu.edu
- Office: 620 WWH (also labeled CIWW).
- Office hours: Wednesday 1:00-2:30pm room 446. Thursday 1:30pm-3:30pm room 406. Office hours are being held in 60 5th Ave. room Other times available by appointment.

Course Information: This is Chaos and Dynamical Systems. The course meets M/W from 11:00am-12:15pm in room 201 WWH.

The prerequisites are Calculus 2 and Linear Algebra. Topics will include dynamics of maps and of first order and second-order difference/differential equations: stability, bifurcations, limit cycles. Geometric viewpoint, including phase planes, will be stressed. Chaotic behavior will be introduced in the context of one-variable maps (the logistic), fractal sets, etc. Applications will be drawn from physics and engineering.

There is also a recitation on Friday from 12:30pm-1:45pm in room 201 WWH. The recitations start February 2. Note that I am your recitation instructor.

Textbook The book we plan to use for the course is

Alligood, Sauer, Yorke: *Chaos: An Introduction to Dynamical Systems*.

This text is available for free for NYU users via the following link

<http://link.springer.com/book/10.1007%2Fb97589>

Some additional references

1. Devaney: *An Introduction to Chaotic Dynamical Systems*.
2. Strogatz: *Nonlinear Dynamics and Chaos*.
3. Hirsch, Smale, Devaney: *Differential Equations and Dynamical Systems and an Introduction to Chaos*. This text is available for free for NYU users via the following link

<https://www.sciencedirect.com/science/book/9780123820105>

I will be placing all of the references available for reserve in the Courant Library (located on the 12th floor of WWH).

Schedule With the array of academic backgrounds composing this course, it's hard to give a precise schedule. Nevertheless, I will try.

- Week 1. Introduction to dynamical systems. Review of some Calculus and Analysis results (pages 8-15 in Devaney).
- Week 2. Maps, fixed points and their stability (sinks and sources), cobweb plots, the family of logistic maps. This is chapter 1 material in the textbook.
- Week 3. Periodic orbits of maps and their stability, bifurcations in the logistic map. This is chapter 1 material in the textbook.
- Week 4. The doubling map, itineraries, sensitive dependence on initial conditions, the tent map, conjugacy, first definition of chaos. This is chapter 1 material in the textbook.
- Week 5. Two dimensional maps, stability of fixed points via linearization, stable and unstable manifolds. This is chapter 2 material in the textbook.

- Week 6. Further examples of 2-D maps, Lyapunov exponents, chaotic orbits, basin of attraction. Note that we transition from chapter 2 material to chapter 3 material in the textbook.
- Week 7. Fractals (Cantor set) and fractal dimension, chaos in two dimensional maps, chaotic attractors. This is chapter 4, 5, 6 in the text. A second definition of chaos is given.
- Week 8. Spring break.
- Week 9. Introduction to continuous-time systems, review of linear ODE, examples of nonlinear ODE. This is chapter 7 in the textbook.
- Week 10. Periodic orbits and limit sets, Poincare-Bendixson theorem. This is chapter 8 in the textbook.
- Week 11. Examples of chaos in 3-D systems, the Lorenz attractor. This is chapter 9 in the textbook.
- Week 12. Stable manifolds, crises. Chapter 10 in the textbook.
- Week 13. Bifurcations in differential equations, types of bifurcations. This is chapter 9 in the textbook.
- Week 14. Cascades, Feigenbaum's constant.
- Week 15. TBA.
- Week 16. Monday May 7 last day of Class. Review. Questions.

Remark:

1. Note that the order in which chapter 1 material is presented in the syllabus (or textbook) may ultimately be different than the order presented in class. Moreover, I will be working from the Devaney text from time to time. I will certainly let you know when to refer to his textbook.
2. It's clear that I will not be covering all of the material from chapters 4, 5, 6 in week 7. I will update the syllabus sometime in week 4 to discuss week 7 in more detail.
3. I may find myself covering bifurcations must earlier than week 13. If I do, I will be doing it for discrete time systems, and I will follow the Devaney textbook.
4. Note that week 15 is left blank for the moment. It will most likely be filled in with material from previous weeks since I am bound to get behind with the course material.

Homework/Exams/Grades

Homework: Homework will be given weekly (usually after Wednesday's class) and collected in recitation. Your first homework will be due Feb 2. No late homework. Late homework is defined to be homework that is submitted 10 minutes after recitation has begun. Homework is 10% of your grade.

Quizzes: From time to time we will have quizzes in the recitation. The content on the quiz will be announced at least 1 week in advance. Quizzes will be 10% of your grade. Moreover, I will let you know the material that is going to appear on the quiz.

Midterm: There will be two midterms. The first midterm is scheduled for Monday March 5. I will cover up to (and including) the material covered on February 28. Midterm 1 will be worth 20% of your grade. The second midterm is scheduled for Monday April 23. While it will emphasize continuous time systems, it will also contain questions concerning discrete time systems. Midterm 2 will be worth 25% of your grade. Note that the dates to midterms 1 and 2 are subject to change.

Final: This exam is cumulative. Date TBA (this is a university set date). The final exam will be 35% of your grade.

Your letter grade will be assigned according to the cutoffs below.

Cutoff	Letter grade
93	A
90	A-
87	B+
83	B
80	B-
75	C+
65	C
50	D

These cutoffs might be adjusted, but only in the downward direction (to make letter grades higher). **DO NOT ASK ABOUT THE CURVE. LIKE EVER!**

Class/Recitation:

Attendance is mandatory. Arriving on time to class matters. If this is an issue for you, this is not the course for you. Attendance and arriving late will be recorded starting Wednesday February 7. I will not make it an issue if you miss class twice and/or late twice (note that recitation counts). Every absence(after 2) from classes will result in a 1% decrease in your overall grade percentage that I compute at the end of the semester. Every time you are late (after 2) to class will result in a .5% decrease in your overall grade. How do I define late? If you come to class and find me lecturing, then you are late (I will never start class prior to 11am). Note that if you are 20+ minutes late, I will consider it an absence. Lastly, about recitation. Let's say you come to recitation 5 minutes late. Yes, your homework will be accepted, but keep in mind you are still late to class.