Math 3890-02: Dynamical Systems
MWF 12:10–1:00pm in SC 1210
Spring 2019

Instructor: Prof. Spencer Dowdall

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Office Hours:
Mondays 2:00–3:30pm
Thursdays 2:00–3:30pm
and by appointment

Course Information

Dynamical systems is an active area of mathematics that has close connections to many topics including analysis, number theory, geometry, topology and probability. Dynamics is the study of systems that deterministically change over time, with the goal of obtaining quantitative and qualitative understanding of their evolution and long-term behavior. Despite being deterministic, sensitivity to small perturbation often gives rise to extremely complex and even chaotic behavior, even in the most basic dynamical systems. This course will give a broad introduction to the topic by developing explicit examples and exploring general features shared by different systems. We will begin with one-dimensional transformations, such as circle homeomorphisms and expanding maps, and progress to more general systems including horseshoe maps and toral automorphisms. This will lead us to topics including Julia sets, structural stability, Markov partitions, symbolic dynamics, entropy, and classification of dynamical systems up to conjugacy.

Warning: This is a rigorous, proof-based mathematics course. You will be required to understand theorems and their proofs, and discover and write proofs on your own.

This is also a *new course* that is still under development in certain respects. The content, direction, and even format of the course are flexible and may adapt over time in accordance with the background, enthusiasm, and receptivity of the audience. Your feedback throughout the semester is highly appreciated and may be taken into account while shaping the course.

Prerequisites: Math 2501 or both 2300 and either 2410 or 2600 are the bare minimum prerequisites. It is recommended that students be familiar with topology (e.g. Math 3200) and/or analysis (e.g. Math 3100). You should know the basics of mathematical logic, sets, functions, and proofs.

Text: The textbook for the course is *A First Course in Dynamics with a Panorama of Recent Developments* by Boris Hasselblatt and Anatole Katok. Much of what we cover is discussed in this book, though we will take a different approach in emphasizing concepts and selecting the order of topics. The supplemental recommended text is *Dynamical Systems* by Shlomo Sternberg. This text focuses on a more narrow selection topics, but often treats them with more detail. One final additional resource is the book *An introduction to Chaotic Dynamical Systems, 2nd Edition* by Robert Devaney.

Course webpage: https://math.vanderbilt.edu/dowdalsd/Sp2019math3890/
View the webpage for course information (including this document), current announcements, instructor information, homework assignments, and the current schedule of topics. Grades for completed assignments will be available in Brightspace.

Grading: Final grades will be computed according to the following breakdown:
Homework–30%, Class Participation–15%, Midterm Exam–27%, Final Exam–28%.

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* *This syllabus is dated **January 14, 2019** and will be followed as closely as possible, but the instructor reserves the right to modify or supplement it as needed. The most up-to-date version is available on the course website.*

If you get above a 90/80/70/60 you are guaranteed to earn at least some sort of A/B/C/D. However, final grades may be curved with more generous letter grade cutoffs.

Midterm Exam: There will be a midterm exam given in class on Monday **February, 25**. There may also be a take-home component to this exam.

Final Exam: Comprehensive Oral Final Exams will be administered during exam week.

Homework: Homework assignments will be given in class and posted to the course webpage. Assignments will generally be due at the beginning of class on Wednesdays. Solutions should look *professional* and be *neat*, *legible*, and *stapled*. Assignments that do not conform to these guidelines may be returned ungraded and considered late under the policy below. Students are encouraged to type their solutions using LaTeX. I consider homework an essential part of this class. It is often said that the best way to learn mathematics is to do mathematics. To succeed in this class you should take the homework seriously and think carefully—and independently—about each problem.

Student Presentations: Classes on Fridays will often be devoted to student presentations of solutions to problems from the previous assignment. All students will be given the opportunity to present; the schedule of who-presents-what will be determined in advance on Wednesdays. Presentations are expected to be well-prepared and clearly delivered. The quality of these presentations and student's willingness to volunteer will factor into the *participation* portion of the final grade.

The purpose of these presentations is to provide practice in communicating complex ideas in a precise manner and to foster discussion among class participants. Presenting mathematics in front of an audience greatly solidifies ones own understanding of the material. Please be respectful of each other during these presentations and make only constructive or helpful comments when needed.

Collaboration Policy: Students are encouraged to work together on homework assignments. However, a student *should not present as their own work solutions to which they did not make substantial contribution*. Collaborators in a solution should be acknowledged. To clarify: It is okay to talk to each other about the homework and work out solutions together. But each student must *write up their solutions independently and in their own words*. It is not okay for one student to copy another student's write-up even if both students worked on the solution. In particular, it is not okay to share electronic files of solutions. Copying answers from another student or source, sharing electronic files, or allowing your answers to be copied will be considered a violation of Vanderbilt's Honor Code.

Late Homework Policy: It is your responsibility to have your homework turned in during class on the day it is due. This is the case even if you are unable to attend the class yourself. I will accept late homework turned in during regularly scheduled office hours the following day; however in this case the assignment will receive **at most 85%** of the score otherwise obtained, and you will also have to present on the blackboard a problem of my choosing. I will not accept any late homework after 3:30pm on the day after the due date.

Attendance: Attendance is very important for this class; I strongly encourage you to actively participate by asking questions and engaging in class discussion. Attendance is expected for each class meeting, and students are responsible for all announcements, assignments, and material covered in class. See the College of Arts & Science policy on 'Class Attendance' in the Undergraduate Catalog.

Registration deadlines: The Open Enrollment Period ends on Monday, January 14th. This is the deadline for students to add a course or to make other changes in YES. Between January 15th and January 21st, any withdrawals or adjustments in level or in grading status must be completed using the add/drop form. If only the "DROP" section of the form is filled out, the instructor may sign the form. If a student wishes to make any change that involves lling in the ADD section of a drop/add

form (whether or not it also involves lling in the DROP section), then the student must see the DUS (John Rafter) or the Assistant DUS (Jakayla Robbins) in person. Per Math Department policy, the only change to a math course that will be approved is a change to the level of the course (e.g. switching from Math 1301 to Math 1300 or vice versa).

Important Dates:

- **Monday, January 14th** – Last day to unconditionally add a class
- **Monday, January 21st** – Last day to drop a class with no entry on the record
- **Monday, January 21st** – MLK Day (No classes)
- **Monday February 26** – In-class Midterm Exam
- **March 4th-8th** – Spring Break (No classes)
- **Friday March 15th** – Last day to withdraw from a course (with a grade of W)
- **Monday, April 22nd** – Last day of classes

Honor Code: Vanderbilt's Honor Code governs all work in this class. All work submitted for credit must be the student's own and should reflect the student's own understanding of the material.

Accommodations: If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Access Services Center (`www.vanderbilt.edu/student-access/`). They will determine with you what accommodations are appropriate and communicate them to the instructor. This service is confidential.

Web Resources: The American Mathematical Society maintains a very useful page (`www.ams.org/outreach/undergrad.html`) for undergraduate mathematics majors that contains information on summer programs, graduate studies, clubs, undergraduate journals, competitions, careers, and much more.