APMA 1360: Applied Dynamical Systems (Spring 2020)

Instructor: Ross Parker (ross_parker@brown.edu)
Course hours: MWF 2-2:50pm (no class Fri, Feb 7 and Fri, Mar 20)
Location: Barus & Holley 166
Office Hours: TBA (will conduct online poll)

Course Description

This course gives an overview of the theory and applications of dynamical systems modeled by differential equations and maps. We will discuss changes of the dynamics when parameters are varied, investigate periodic and homoclinic solutions that arise in applications, and study the impact of additional structures such as time reversibility and conserved quantities on the dynamics. We will also study systems with complicated "chaotic" dynamics that possess attracting sets which do not have an integer dimension. Applications to chemical reactions, climate, epidemiology, and phase transitions will be discussed. Specific topics we will cover include (but are not limited to):

- Bifurcation theory: how does the behavior of a system change when a parameter is varied?
- Existence and uniqueness of solutions to ordinary differential equations.
- Dynamical systems in the plane, including periodic solutions and homoclinic orbits.
- Systems with additional structure, including Hamiltonian systems and reversible systems.
- Chaotic dynamics: what is chaos, and how can we quantify it?
- Applications to ecology, climate, mechanics, epidemiology, and other fields based on based on student interest.

Course Objectives

By the end of the course you should be able to

- Describe both qualitatively and quantitatively the dynamics of differential equations in the plane.
- Extract and sketch features of dynamical systems in two and three dimensions.
- Understand and predict qualitative changes in the behavior of dynamical systems as parameters are varied.
- Use dynamical systems as a model for understanding physical phenomena.

Nuts and Bolts

Class format: This course will combine lectures and and work in small groups. You will be expected to follow up outside of class time with reading and working through examples. There will be two midterm exams. There will be a final project instead of a final exam; it will be carried out in groups of 2-4 students and will involve both a written report and a brief in-class presentation.

More information about the final project, including a timeline, will be provided in the first few weeks of the course.

Textbook: There is no required textbook. A good resource is the following text, which is available free through the Brown library.

James Meiss. *Differential Dynamical Systems.* SIAM (2009). `https://login.revproxy.brown.edu/login?url=https://epubs.siam.org/doi/book/10.1137/1.9780898718232`.

Another good book which is fun to read and has many great examples but is less mathematically rigorous is:

Steven Strogatz. *Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering.* Either edition is fine.

Homework: There will be weekly problem sets. These will be posted on Canvas each Wednesday and will be due the following Wednesday by the end of class. Problem sets may submitted in class on the due date, electronically on Canvas, or they may be dropped in the APMA 1360 homework box in 170 Hope St.

For all problems, show all of your work. For a calculation, this means you should display the process used, not just state a final result. For a question given as "Show that something is true", you should write a complete argument. You may discuss assignments with other students, but you must write up your own answer independently. When you have collaborated with other students, please acknowledge this by adding a note such as "I discussed question X with A and B.". The assignments are meant to be part of the learning process and are not tests as such. Allow adequate time and start them well in advance of the due date. Some answers may not come to you immediately, but then become clear a day later. If you are stuck on a problem, seek help from office hours or discussing with other students. I have also set up Piazza for the class. If you have a question on a homework problem, I encourage you to use Piazza so that the entire class can benefit. Finally if you are not able to complete a question, write a short note to describe what you tried and what you think may be important. Credit on assignments will come from a serious effort as much as anything else.

Homework policy: Late assignments generally will not be accepted. That being said, I understand that the unexpected does happen. If you have a serious situation in which you will believe you will be unable to complete your assignment on time, contact me directly as soon as possible to make arrangements.

Exams: There will be two midterm exams, which will be held at the normal class time on

- Friday, February 21
- Wednesday, March 18

Midterm exams will not be given at times other than the scheduled timeslot, except in cases of serious illness, dire emergency, or other major crisis. Documentation will be required. Since I wish to test your mathematical reasoning skills and not how much you can memorize, you are allowed (and strongly encouraged!) to bring a study sheet to each exam. Study sheets must be one standard

8.5x11 sheet of paper; you may use both sides of the paper and may write whatever you want on it.

Prerequisites: APMA 350 (Applied Ordinary Differential Equations) and a course in linear algebra (MATH 520 or 540).

Communication: Email is the best way to reach me. During the week, I will try to respond within 24 hours. Email responses may be slower on the weekends, but I will try to reply by Sunday evening. For complex questions, I may ask you to talk with me after class or come to my office hours.

Grade Distribution:

Problem Sets	30%
Midterm Exams	20% each
Final Project	30%

Time Expectations:

Class time (3 hr/week)	39 hours
Reviewing class material (2 hr/week)	26 hours
Problem Sets (4 hr/week)	52 hours
Midterm exam review (8 hr/exam)	16 hours
Final Project	40 hours
Total for semester	173 hours

Diversity Statement

Mathematics, in its idealized form, is objective. (Important exception: mathematics applied to fields such as the social sciences.) The field of mathematics, however, has long been dominated by white males. Pop culture and the media have not made this any better, from Teen Talk Barbie telling us that "math class is tough" to the stereotypical "nerdy male" mathematicians in movies and television. It is my intent that students from all diverse backgrounds and perspectives be well-served by this course. To that end,

- If you feel like your performance in the class is being impacted by your experiences outside of class, please do not hesitate to come and talk with me.
- If something was said in class (by me or anyone else) that made you feel uncomfortable, please talk to me about it.
- If you prefer to speak with someone outside of the course, the Associate Dean of the College for Diversity Programs, is an excellent resource.
- I will provide a web address at which you can submit anonymous feedback.
- If you have a name and/or set of pronouns that differ from those that appear in your official Brown records, please let me know.

- While I acknowledge that I am part of the patriarchy, I am more than happy to assist with smashing the patriarchy.

Academic Honesty Policy

Norms regarding the quality and originality of academic work are often much more stringent and demanding in college than they are in high school. All Brown students are responsible for understanding and following Brown's academic code, which is described below.

Academic achievement is ordinarily evaluated on the basis of work that a student produces independently. Students who submit academic work that uses others' ideas, words, research, or images without proper attribution and documentation are in violation of the academic code. Infringement of the academic code entails penalties ranging from reprimand to suspension, dismissal, or expulsion from the University.

Brown students are expected to tell the truth. Misrepresentations of facts, significant omissions, or falsifications in any connection with the academic process (including change of course permits, the academic transcript, or applications for graduate training or employment) violate the code, and students are penalized accordingly. This policy also applies to Brown alums, insofar as it relates to Brown transcripts and other records of work at Brown.

Misunderstanding the code is not an excuse for dishonest work. Students who are unsure about any point of Brown's academic code should consult their courses instructors or an academic dean, who will be happy to explain the policy.

Academic Support

Brown University is committed to full inclusion of all students. Please inform me if you have a disability or other condition that might require accommodations or modification of any of these course procedures. You may speak with me after class or during office hours. For more information contact Student and Employee Accessibility Services at 401-863-9588 or SEAS@brown.edu.