Math 1110 Differential Equations, Fall 2012: Syllabus

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Office hours: M 3-4pm, W 2-3pm, or by appointment.

Description: Differential equations are among the most powerful mathematical tools for modeling how systems change in time. While these 'systems' come from a wide range of fields including physics, chemistry, electrical engineering, biology, climate science, economics and pure mathematics, they may nevertheless be treated on a common footing using tools we will develop in this course.

In spite of this unification however, the resulting theory is by no means simple! We'll see that even very simple systems can exhibit an extraordinarily complex range of behaviors, including (most famously) the phenomenon known as chaos.

Though there are many different approaches to analyzing and solving differential equations, we take a 'dynamical systems' point of view and focus on the study of qualitative behaviors of systems such as stability, limit sets, bifurcations and chaos rather than explicit solution techniques (which tend not to be applicable outside of very specialized situations). The treatment will be rigorous and proofs will be given.

The only formal prerequisite is differential calculus, which we will rely on quite heavily. As we go along we will also develop a considerable amount of linear algebra; though no prior exposure to this is required, it may be beneficial.

Text: *Differential Equations, Dynamical Systems, and an Introduction to Chaos*, by Hirsch, Smale, & Devaney. 2nd Ed (ISBN 978-0-12-349703-1), or 3rd Ed (ISBN 978-0-12-382010-5).

The official textbook is the 2nd edition, used copies of which are in stock at the bookstore. The recently released 3rd edition has been updated to include some additional examples, but is otherwise almost the same. Either one will be fine for this class.

Exams:

- Midterm 1: Friday Oct. 12, in class.
- Midterm 2: Friday Nov. 16 or Monday Nov. 19, in class.
- Final: TBA

Approximate lecture schedule:

Lectures	Topic
1-3	Intro to ODE, first order and linear vs. non-linear equations, logistic equation with harvesting.
4-6	Systems of equations, reduction of order, planar systems.
7-11	2D linear algebra, eigenvalues and eigenvectors, classification of planar linear systems.
12-17	Higher dimensional linear algebra and systems, matrix exponential. Midterm 1.
18-20	Nonlinear dynamical systems, existence/uniqueness, equilibria and linearization.
21-23	Bifurcations, nullclines, systems of special type (gradient and Hamiltonian systems).
24-26	Limit sets and the Poincaré map.
27-32	Applications from biology, mechanics, electrical engineering, etc. Midterm 2.
33-36	The Lorentz system, intro. to chaos and discrete dynamical systems.

Course Policies:

- **Grading:** Your final grade will depend on approximately bi-weekly homework assignments and three exams (2 midterms and a final). Letter grades will be awarded on a curve based on your total numerical score computed using the percentages below. Your lowest homework score will be dropped, and the final will be cumulative.

Homework	40%
Midterm 1	20%
Midterm 2	20%
Final Exam	30%

- **Homework:** Homeworks may be turned in during class, or turned in to the appropriate box in the math department mailroom, **by 4pm on the due date.** Collaboration on homework assignments is allowed, and indeed encouraged. This means discussing problems, solution techniques, and comparing individual answers, **not copying answers.** Each student must write up their own homework individually. **Please cite your collaborators and references used (apart from the textbook) on your homework assignments.**

- **Missed/Late assignments and exams:** Late homework will not be permitted, except in cases of emergency accompanied by a note from the Dean's office. If you have a conflict, please arrange to turn in your assignment early, or use it as your lowest homework score to be dropped. A missed exam may be made up only in the case of an emergency; the make up will be an oral exam and may be more difficult than the original.

- **Grade disputes:** Please check over your exams and assignments when they are returned to you for any grading mistakes (they happen!) and I will be glad to correct them. **Grade disputes will be considered for one week following the return of an assignment.** After one week, the grade is set.

Tips for success:

- **Read the relevant material before class.** I will put sections of the book corresponding to each lecture on the website a day or so beforehand. You don't need to fully understand everything, but you'll find that having some familiarity with the subject of the lectures beforehand is extremely helpful, and you'll definitely get more out of each lecture this way.

- **Be your own teacher.** You are the person in the best position to identify which things you understand well and which things you feel a little hazy about. Try taking the role of instructor and see if you could explain the material to someone else (or yourself) and you'll quickly find out which things you are confused about. While confusion is a (the?) natural state of learning mathematics (if you're not confused about something you probably aren't doing interesting mathematics!), don't let it persist — work to become 'unconfused'! (That way you can move on to be confused about something new...)

- **Come to office hours.** This is an invaluable time to get unconfused. Identify those things you don't understand very well, and ask me about them — professors like to explain things! I'm also happy to discuss mathematics in general or anything else.

- **Think about and do math!** Really understanding mathematics takes time and practice. The homework assignments are meant to give you an opportunity to dig into the material and develop your skills and intuition. While your lowest homework grade will be dropped (since everybody has a bad and/or crazy week at some point), not spending *any* time thinking about a particular assignment is a Bad Idea, as is waiting until the night before to begin. You will get the most out of the homework by starting early and letting the problems roll around in your brain for a while. Sometimes the best mathematical insights come while you're walking down the street (or in the shower!) after you've put a problem in the back of your mind.