Chemistry 5850: Nonlinear Dynamics
Fall 2005

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Recommended background

- Calculus, differential equations
- Linear algebra, up to eigensystems of matrices

Textbooks

Lectures will be drawn from a variety of sources. Accordingly, there is no set textbook for this course. I recommend that you find a textbook you are comfortable with to use as a reference. However, you will no doubt have to go beyond the material in any one textbook to complete this course.

Here are some textbooks which provide suitable support for this course:

Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering by Steven H. Strogatz

Chaos: An Introduction to Dynamical Systems by Kathleen T. Alligood, Tim D. Sauer, and James A. Yorke

Many other books would of course be suitable. I happen to be familiar with these two, and know that they are still in print.

Additionally, the following book which describes the use of the computer software package `xppaut` (`xpp` for short) would be useful:

Simulating, Analyzing, and Animating Dynamical Systems: A Guide to XPPAUT for Researchers and Students by Bard Ermentrout

I have copies of all of the recommended texts. If you wish to see them before making up your mind, please stop by my office.

Outline

The course was originally organized as a set of twelve two-hour lectures, although the lectures tended to run a bit longer than two hours. This term, the course will be taught in two 75 minute periods each week. This gives us 150 minutes, so we'll have a bit of slack. This will leave you plenty of time to ask questions in class. The lecture notes on the web site will retain the original "twelve lecture" format. Ideally, each "lecture" would be covered in a single week. However, because of the mid-week start and of statutory holidays, we don't have that luxury. In what follows, the word "lecture" should be understood to mean a two-lecture unit covering a single topic.

The lecture notes available on the web site are a complete record of the material to be covered. They won't change much during the term, so go ahead and print them whenever you like. I recommend that you bring them to class and annotate them as you go rather than try to take detailed notes.

The course will emphasize theory, but will use a number of examples drawn from across the sciences. This course is an introductory survey. Accordingly, we won't reach great depth in any area. However, students registered in this course should get a good feel for some of the central ideas and techniques in nonlinear dynamics and for the application of these techniques in the sciences.

Tentative syllabus

Lecture	1	Definition of a dynamical system and related concepts; classification and examples of dynamical systems; phase-plane analysis of ODEs
	2	Local and global stability analysis of ODEs; use of symbolic algebra software
	3	Unstable equilibria, limit cycles, complex dynamics; use of simulation software
	4	Bifurcation analysis; multistability
	5	Invariant manifolds
	6	Singular perturbation theory
	7	Hamiltonian systems
	8	Nonautonomous systems
	9	Maps and differential equations
	10	Stability and bifurcation analysis of maps
	11	Infinite-dimensional dynamical systems; delay-differential equations and their stability analysis
	12	Partial-differential (reaction-diffusion) equations; Turing bifurcations

Evaluation

Each lecture will be accompanied by an assignment. The weighting of each assignment will be proportional to its difficulty and length, and will be announced when the assignment is released. You will usually be given one week to complete the assignment, although I am prepared to be flexible when circumstances warrant. The assignments will emphasize technical aspects of the course, including the use of software (mostly `xpp` and `maple`) to study questions in nonlinear dynamics. Hopefully, you have access to a computer loaded with `maple`. The University has a site license for this software, so having it installed on campus shouldn't be a problem. Moreover, it is available in the university's student computer labs. `Xpp` is free software which you can install on any Unix/Linux computer you have access to. There is also a Windows version, but installing it is a bit more of a chore since you need to install an X server first. Check out the course web site for details on how to get `xpp`. If installing `xpp` turns out to be a problem for you, talk to me and we'll see what we can do.

There will be tests after lectures 6 and 12, the latter held during the exam period. The tests will emphasize conceptual issues, but may also involve small calculations not requiring computer assistance.

Additionally, each student taking the course for credit will be required to present a 50 minute lecture on a topic in nonlinear dynamics or modeling. You should start thinking about topics around the mid-point of the course. Books or research papers can be used for inspiration, and of course I'll be happy to suggest specific lecture topics if you give me an idea of your interests. Your lecture should be on a topic not covered in class. Lectures can either develop a bit of theory we didn't touch, or present an application. Your lecture topic must be approved by the instructor. These student lectures will take place in the last week of classes, after the completion of the regular lectures on Dec. 5. We will need to meet outside of our normal hours to accommodate the student lectures. Times for these lectures will be set later.

Dates and Weights

Test 1	20%	Oct. 24, 3:05 p.m.
Test 2	20%	Dec. 15, 9:00 a.m.
Assignments	30%	
Lecture	30%	Topic approved no later than Nov. 18