Course Syllabus - Nonlinear Dynamics and Chaos

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Course Content

Required Texts: *Chaos: An Introduction to Dynamical Systems*, by Alligood, Sauer and Yorke, 2000.

We will cover the material in Chapters 1-9 of the text. Additional topics may be covered as time permits. You will also be assigned additional readings from other sources and projects during this course. It is the intent that this course will be fun, interesting and shed light on some current topics in applied mathematics.

What is Chaos?

Many simple nonlinear deterministic systems can behave in an apparently unpredictable and chaotic manner. Chaos was not fully appreciated until the widespread availability of digital computers for numerical simulations and the demonstration of chaos in various physical systems. The study of chaotic systems has undergone explosive growth in the past two decades. The ideas of chaos have been very fruitful in such diverse disciplines as biology, economics, chemistry, engineering, fluid mechanics, and physics.

A dynamical system is one whose evolution is deterministic: its future motion is determined by its current state and its past history. A chaotic dynamical system is characterized principally by its sensitivity to initial conditions. A well known example of this is the weather. Small changes in weather patterns can result in large changes later on.

Historically, Henri Poincaré (1854-1912) was instrumental in providing the fundamental notions of dynamical chaos as can be found at the University of Maryland Chaos site: http://www-chaos.umd.edu/misc/poincare.html:

> The idea of dynamical chaos was first glimpsed by Poincaré when he entered a contest sponsored by the king of Sweden. One of the questions in this contest was to show rigorously that the solar system as modeled by Newton's equations is dynamically stable. The question was nothing more than a generalization of the famous three body problem, which was considered one of the most difficult problems in mathematical physics. In essence, the three body problem consists of nine simultaneous differential equations (all linear, each of second order). The difficulty was in showing that the general solution converges since any solution will be given in terms of infinite series. While Poincaré did not succeed in giving a complete solution, he made such a major headway in attacking the problem that he was awarded the prize anyway. The distinguished Weierstrass, who was one of the judges, said, "this work cannot indeed be considered as furnishing the complete solution of the question proposed, but that it is nevertheless of such importance that its publication will inaugurate a new era in the history of celestial mechanics."
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> To show how visionary Poincaré was, it is perhaps best if he described the Hallmark of Chaos - sensitive dependence on initial conditions - in his own words:
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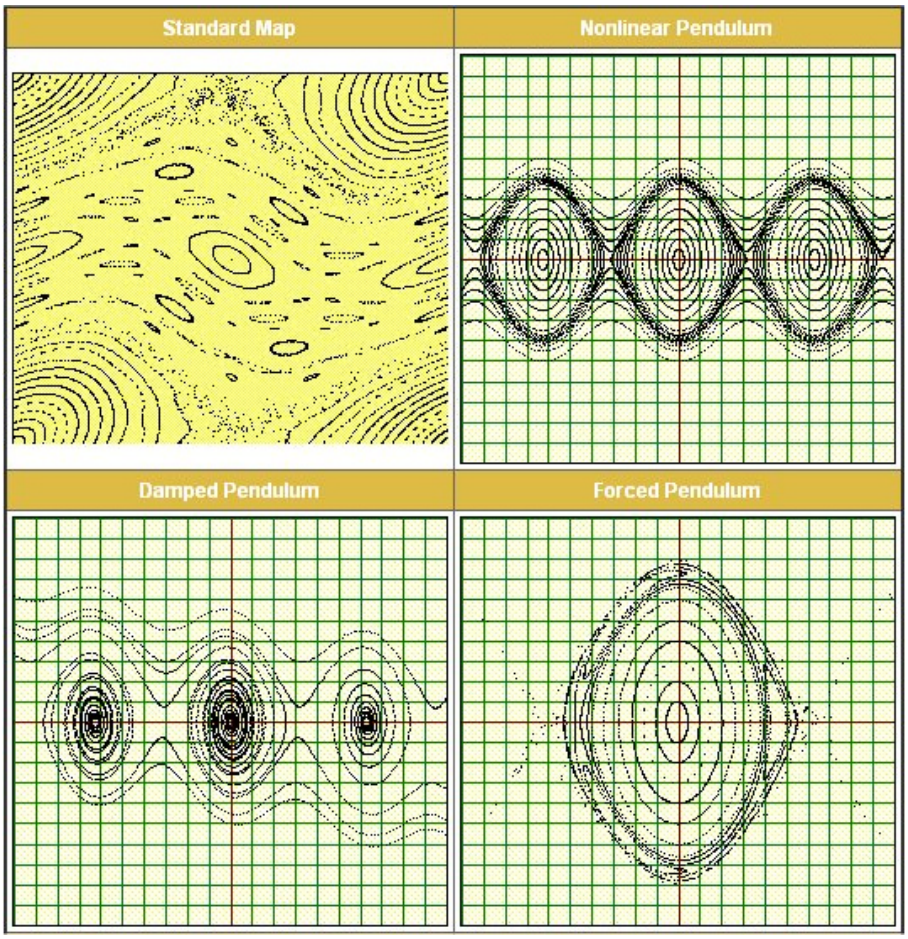
> *If we knew exactly the laws of nature and the situation of the universe at the initial moment, we could predict exactly the situation of that same universe at a succeeding moment. but even if it were the case that the natural laws had no longer any secret for us, we could still only know the initial situation approximately. If that enabled us to predict the succeeding situation with the same approximation, that is all we require, and we should say that the phenomenon had been predicted, that it is governed by laws. But it is not always so; it may happen that small differences in the initial conditions produce very great ones in the final phenomena. A small error in the former will produce an enormous error in the latter. Prediction becomes impossible, and we have the fortuitous phenomenon*. - in a 1903 essay "Science and Method"



Group Work

In this course you will occasionally work with other students to complete a task. For many of you group work will be a new experience. In order to make this experience both productive and enjoyable, we offer the following suggestions:

- Start the project as soon as it is assigned. Do not put it off until the last minute. Some of the assignments will take time and working in a group may require more time due to scheduling difficulties.
- Read over the entire assignment, carefully before discussing or completing any part of it.
- Initially, you may have no idea as to how to get started. Don't panic! Discuss the project with the group and generate some ideas. Assign tasks to each member (leader, recorder, computation, analysis, author, editor.)
- Projects are not always as straightforward as standard homework assignments. You may need to make some assumptions and later justify these assumptions, indicating how they affect your results.
- The final report should be thoughtful, well-written and neatly organized. It should summarize your approach to the problem, present your results and conclusions, and be furnished with full explanations.
- If you have investigated the project as far as possible and still have questions, or there is a need for clarification of some point, then discuss them with your instructor before writing the report.

Web Pages/Email:

This syllabus as well as a variety of other relevant information for this class will be posted on the internet. You are encouraged to log onto this page at least weekly and send email to your instructor. You can also email the instructor for hints to homework questions, after working on them. (I will try to get back to you with an answer within a day. Sometimes the hints may be posted on the web page.)

You will find other useful materials, such as links to tutorials, sample problems, etc. provided by people at other universities. Those proficient with the web may explore and find other sites, which we can add to our resources. So, watch for additions, changes, and announcements for the class.

Course Requirements:

Homework: Homework assignments will be assigned periodically and you will be told when the work is due. There will be a penalty of 5% for each class that it is late**.**

Project: Several projects will be assigned during the course. A major project will be carried out during the second half of the semester. This will be a group effort, but the individual student grade will be based upon the efforts, accuracy, promptness exhibited in carrying out their part of the project. The end result will be a webpage and a 10-15 minute presentation during the allotted final time: **December 12th, 7:00-10:00.**

Exams and Grades:

There will be three exams for this course. The material and the tentative dates for the exams are given below:

Exam	Chapters	Date
1	Ch 1-3	Oct 3
2	Ch 4-5, 13	Oct 31
3	Ch 7-9	Nov 21

Your final grade will be based on the following

Three Exams	60%
Homework	20%
Projects	20%

90-100	A
80-89.5	B
70-79.5	C
60-69.5	D

In some cases borderline grades may be modified by a plus, or a minus, if the instructor determines that such grades are earned.

Academic Honor Code: "The University of North Carolina at Wilmington is committed to the proposition that the pursuit of truth requires the presence of honesty among all involved. It is therefore the institution's stated policy that no form of dishonesty among its faculty or students will be tolerated. Although all members of the university community are encouraged to report occurrences of dishonesty, each individual is principally responsible for his or her own honesty." Student Handbook. *(This includes plagiarism, bribery and cheating.)*

Student Disabilities: UNCW Disability Services supplies information about disability law, documentation procedures and accommodations that can be found at http://www.uncw.edu/stuaff/disability/. To obtain accommodations the student should first contact Disability Services and present their documentation to the coordinator for review and

verification.

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