EGR 8306 Nonlinear Dynamics

Term:	Fall 2005
Instructor:	Dr. "Nat" C. Nataraj
Classes:	Thursdays, 6:10 – 8:20
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Course Description

The dynamics of systems as diverse as from the areas of mechanical, electrical, fluid, biological, chemical and financial, are generally described by nonlinear models. All these systems exhibit complex phenomena that cannot be understood from linearized mathematical models which are often used in practical engineering. These complex phenomena such as bifurcations, instabilities, and chaos are often observed and cannot be ignored. Moreover, they are fascinating and impossible to predict using linearized models.

This course is an introduction to the broad area of nonlinear dynamics. We will use both analytical and computational techniques in order to provide a unified treatment. We will mostly focus on systems governed by ordinary differential equations but briefly touch upon difference equations and partial differential equations as well. Numerous practical applications will be explored.

Prerequisites/Co-requisites

Graduate engineering mathematics, exposure to computer programming.

Text

Strogatz, S. H., 1994, "Nonlinear Dynamics & Chaos," Westview Press. ISBN 0-7382-0453-6.

Suggested additional reference material is as follows.

- E. Atlee Jackson, 1991, "Perspectives of Nonlinear Dynamics: Volumes 1 and 2," Cambridge Press.
- Nayfeh, A. H., & Mook, 1979, "Nonlinear Oscillations."
- Nayfeh, A. H., 1981, "Introduction to Perturbation Techniques," John Wiley & Sons.

- Struble, R. A., 1962, "Nonlinear Differential Equations," McGraw-Hill.
- Gilmore, R., 1981, "Catastrophe theory for scientists and engineers," Dover Publications.
- Brauer, F., and Nohel, J. A., 1969, "The qualitative theory of ordinary differential equations," Dover Publications.
- Hale, Jack K., 1963, "Oscillations in nonlinear systems," Dover Publications.
- Butenin, N. V., 1965, "Elements of the theory of nonlinear oscillations," Blaisdell Publishing Company.
- Coddington, E. A., and Levinson, N., 1955, "Theory of Ordinary Differential Equations," McGraw-Hill.
- Nataraj, C., Research Notes.

Grading:

Homework will be assigned every week and should be submitted promptly for grading and subsequent discussion. In addition, small computer projects will be assigned.

An individual term project will be required of each student. The project topic may be either selected by the student, with approval, or be specified by the instructor. It is initiated at the mid-term date and is due in the last class week.

The semester grade is based on the following relative weights.

Homework	15%
Tests (two)	20%
Computer projects	30%
Final Exam (comprehensive)	35%

Grades:

F $<$ 65% C- $<$ 70% $<$ C $<$ 75% $<$ C+ $<$ 80%$<$ B- $<$ 82% $<$ B $<$ 85% $<$ B+ $<$ 87% $<$ A- $<$ 90% $<$ A

Course Syllabus

- Review of linear system theory; linearization, stability, numerical solutions
- The nonlinear pendulum; limit cycles
- Phase plane analysis and Poincare maps
- Stability concepts
- Periodic solutions; jump phenomena; parametric excitation
- Asymptotic methods; multiple scales and averaging
- Floquet theory
- Bifurcation theory
- Chaotic oscillations; numerical tools
- Practical applications