MA 574; Spring 2007
Applied Nonlinear Dynamics
T,R: 9:30-11:00, MCS 148

Description: Attractors and invariant measures for nonlinear dynamical systems. Measures of chaos like Lyapunov exponents. Time series analysis. Parametric excitation. Multiple time scales and singular perturbation theory. Dynamics and synchronization of coupled neuronal oscillators. Nonlinear dynamics in cellular and molecular biology. Analytical dynamics of mechanical systems and modal analysis, including methods for high modal density limits. Strong emphasis on applications to realistic biological and mechanical systems.

Outline

This course is designed to introduce students to advanced ideas in the qualitative theory of ordinary differential equations and dynamical systems. There will be a strong emphasis on applications, particularly on models drawn from mathematical biology.

Grading: Grades will be based on homework assignments, due about every two weeks, on two midterm exams and on a 5-10 page paper related to one of the main topics of the course. This should be basically a literature review, focusing on two or three papers chosen in consultation with the instructor. The topic of your paper will be due the week after spring break. During the last week of the course each person will be asked to give a short presentation on their paper the paper itself the last day of class. These will contribute to your final grade according to the breakdown:

Each midterm: 20%
Final paper: 20%
Homework: 40%

Your work in this course is governed by BU's Academic Conduct Code

http://www.cs.bu.edu/ugradprogram/conduct.html

which you are expected to be familiar with and abide by. However, I encourage you to work together on the homework assignments since I feel that this is the best way to learn this material. After you have discussed and worked through the problems each person should then write up his or her own solutions. If you have any questions about whether or not some sort of collaboration is permissible please don't hesitate to come and talk it over with me.

Important dates for the semester (such as the last date to add or drop a course) are available at: http://www.bu.edu/reg/dates/

Text: An Introduction to Dynamical Systems; Continuous and Discrete, by R. Clark Robinson, publ. Pearson Ed. Inc. (2004).

In addition, particularly for the sections dealing with applications, I will often place additional readings on reserve in the Sci. and Eng. Library.

Office Hours:

Mon: 2-4 pm
Tues: 11-12 pm
Thurs: 11-12 pm

I encourage you to come to my office hours if you have any questions about the course. If you want to speak with me, but are unable to come to see me at any of my regular office hours, please let me know and we can schedule a mutually convenient time.

OUTLINE

Week 1: Linear Systems (Chapter 1)

Weeks 2-3: Nonlinear System (Chapters 2-5)

- Flows
- Phase portraits
- Nullclines
- Stability of Fixed Points
- Lyapunov Functions
- Limit Sets

Weeks-4-5: Multiple Time Scales (External Readings)

- Asymptotic Expansions
- Matching

Weeks 6-7: Discrete Dynamical Systems (Chapter 8, §9.1, §12.1, §12.2)

- Fixed Points
- Periodic Orbits
- Stability

Week 8: Periodic Orbits in Continuous time Dyn. Systems (Chapter 6)

- Poincaré Bendixson Theorem
- Stability of periodic orbits

Weeks 9-10: Mathematical models of neurons (External Readings)

- The Hodgkin-Huxley equations
- The Fitzhugh-Nagumo model
- Oscillations in neural models

Weeks 11-12: Chaotic Behavior in Dynamical Systems (§7.1, §13.4, §7.6, §13.4 Chapter 14)

- Attractors
- Lyapunov Exponents
- Fractal Dimensions

Week 13: Time-series and Attractor Reconstruction (External Readings)