PSYC 5553 INTRODUCTION TO NONLINEAR DYNAMICS Fall 2023

Monday 1:25 – 4:25 PM, Bousfield 394 (Theoretical Neuroscience Lab)

Prerequisites: PERMISSION OF INSTRUCTOR

Professor: Dr. Edward Large, Department of Psychological Sciences and Department of Physics

Office: Bousfield 186C

Email: edward.large@uconn.edu

Office Hours: Monday & Tuesday, 10:00-11:00

Required Reading
Strogatz, S. H. (1994). Nonlinear Dynamics and Chaos: With Applications To Physics, Biology, Chemistry, And Engineering. Reading, MA: Addison-Wesley.

Background
Should Have – Algebra and Calculus
Good to Have – Differential Equations and Linear Algebra

Software
Matlab (for simulations)
Mathematica / Maple / Wolfram Alpha (for analysis)

Course Description
This course aims to provide an introduction to nonlinear dynamical systems, the type of mathematics that is used to model physical, biological, psychological, and engineered systems including fireflies, neurons, networks, human perception-action, robotics, and social systems. It introduces students to the major concepts of dynamical systems, including state space, stability, and bifurcation theory. Emphasis is on exploration of systems via computer simulation and mathematical analysis. Familiarity with algebra and the calculus is assumed, but all needed techniques will be reviewed during the course.

In the first semester, you will learn the mathematics, beginning with simple systems, and ultimately arriving at some pretty complicated ones. We use "Nonlinear Dynamics and Chaos" by Strogatz. Students will also receive instruction in basic Matlab programming. There is also an optional second semester, in which each student will apply what was learned in the first semester to a modeling project related to their own research.

Our goal will be to make it through Chapter 8 of the textbook. Depending on the our progress, we may make it to some more advanced topics, such as Chaos. Mastery of this material will put the student in an excellent position to create and understand

dynamical systems models of real phenomena of current interest in physiology, biology, engineering, neuroscience, and psychology, and to read and understand models published in the literature.

Method of Instruction
It will be a flipped classroom. Students read the material and work on the homework at home. In class we spend most of the time working problems together and learning how to simulate dynamical systems. We will use Matlab, and this will be a good opportunity for those who wish to learn Matlab. Is is OK to program in another language, like Python if you already use it, but in class we will program in Matlab. We will also learn to use Mathematica / Wolfram Alpha for mathematical analysis. I tailor lectures, problem-solving sessions, and live coding sessions to the backgrounds of the students in the current semester's class. In that sense, no specific background is assumed.

Grading
• Weekly homework (60%). Problems from the book and simulations in Matlab.

• Final (40%): Take home exam distributed at the last class, due one week later.

Homework problems and the final exam should be handed in electronically as pdf documents. This will provide experience formatting equations and figures suitable for publication.

Attendance and Class Participation
It is important to attend all lectures and ask question to understand the materials taught.

Classroom etiquette
All electronic communication devices – e.g., cell-phones – MUST be OFF during all lectures and tests. Computers are allowed and necessary for live coding sessions.

Reasonable Accommodation Statement for Makeups
Reasonable accommodation will be made for students participating in a religious observance or in University-approved activities, including athletic or scholastics teams, musical and theatrical performances and debate activities.

Policy Against Discrimination, Harassment and Inappropriate Romantic Relationships: The University is committed to maintaining an environment free of discrimination or discriminatory harassment directed toward any person or group within its community – students, employees, or visitors. Academic and professional excellence can flourish only when each member of our community is assured an atmosphere of mutual respect. All members of the University community are responsible for the maintenance of an academic and work environment in which people are free to learn and work without fear of discrimination or discriminatory harassment. In addition, inappropriate Romantic relationships can undermine the University's mission when those in positions of authority abuse or appear to abuse their authority. To that end, and in accordance with federal and state law, the University prohibits discrimination and discriminatory harassment, as well as inappropriate Romantic relationships, and such behavior will be met with appropriate disciplinary action, up to and including dismissal from the University.

More information is available at http://policy.uconn.edu/?p=2884.

Sexual Assault Reporting Policy
To protect the campus community, all non-confidential University employees (including faculty) are required to report assaults they witness or are told about to the Office of Diversity & Equity under the Sexual Assault Response Policy. The University takes all reports with the utmost seriousness. Please be aware that while the information you provide will remain private, it will not be confidential and will be shared with University officials who can help.
More information is available at http://sexualviolence.uconn.edu/.

Course Outline

Ch 1: Introduction and Overview

All sections

Ch 2: Flows on the line All sections

Tutorial on Matlab
Numerical integration of dynamical systems

Ch 3: Bifurcations
Special lecture on Taylor Series
All sections (although, we may skip 3.3 and 3.5 depending on time)

Ch 4: Flows on the circle
All sections except 4.6

Ch 5: Linear systems
Special lecture on Linear Algebra (Eigenvectors & Eigenvalues) All sections

Ch 6: Phase plane
All sections except 6.6

Ch 7: Limit cycles All sections

Ch 8: Bifurcations revisited All sections except 8.5

If Time: Chs 9 & 10