BE 567: Nonlinear Systems in Biomedical Engineering
Course Syllabus, Fall 2017

Instructor

Dr. Mary Dunlop
Email: mjdunlop@bu.edu

Office Hours

- Every week: Fri 9-10am, 36 Cummington – Room 307
- Weeks with homework due: Tues 3-4:30pm, 36 Cummington – 2nd Floor Conf. Room
- Or by appointment

Course Schedule

MW 12:20-2:05pm, EPC 204

Webpage and Email

The course webpage is available through Blackboard.
Course announcements will be sent via email to your BU email address.

Textbook

The primary text for the course is:
S. Strogatz. *Nonlinear Dynamics and Chaos*, Westview Press, 2nd Edition.

These textbooks may be useful as references in addition to Strogatz:
D. W. Jordan & P. Smith. *Nonlinear Ordinary Differential Equations: An Introduction to Dynamical Systems*, Oxford Applied and Engineering Mathematics.
L. Perko. *Differential Equations and Dynamical Systems*, Springer.

These books are all available from the library in either e-book or hard copy formats.

Grading and Exams

Grading

Homework: 20%
Project: 15%
Exam 1: 32.5%
Exam 2: 32.5%

Homework

Homework will be assigned roughly biweekly. Full solutions to all problems will be posted the day the homework is returned. Code used for numerical simulations is part of the solution and must be turned in. Course instruction will use Matlab, however you are welcome to use any programming language on homework assignments as long as you include the code.

Late homework is not accepted without prior approval and will receive a score of zero.

For homework grading one problem will be selected at random from each assignment and graded completely. The rest of the problems will be checked for effort with full credit for a reasonable effort and zero credit for no or minimal effort. To facilitate this, please order homework problems sequentially with all parts of the problem together and each problem clearly labeled.

Project

For the course project you will chose a journal article that applies methods from nonlinear dynamics to a biomedical system. Your goal will be to reproduce figures from the paper and, if appropriate, extend the analysis using methods from the class. The project will be approximately the size and scale of a homework assignment.

Exams

There will be two exams of equal weight. The focus of the material for the second exam will be from the second half of the course.

Academic Integrity / Collaboration

Homework: You are encouraged to collaborate with other students on the homework, but the write up must be your own, in your own words. Identical assignments will receive a score of zero. For Matlab problems you can share ideas, but code must be written individually. Any questions about what constitutes an acceptable level of collaboration should be addressed to the instructor.
Project: Code and analysis must be your own. Collaboration and discussion are encouraged.
Exams: No collaboration, calculators, books, or outside materials are allowed. You will be allowed to bring one page (front and back) of handwritten notes with you to the exam.

I encourage you to review the University's policy on Academic Conduct:
https://www.bu.edu/academics/policies/academic-conduct-code/

Cell Phone and Computer Use

Cell phones, laptops, and other electronic devices may not be used in class except for the purposes of taking notes.

Prerequisites

Ordinary differential equations required; linear algebra highly recommended. Course will use Matlab.

Course Overview

This course will teach you how to analyze systems of linear and nonlinear differential equations using dynamical systems methods. Applications will focus on nonlinear biomedical systems.

- Linear Systems
  - Systems of linear differential equations
  - State space
  - Matrix exponential
  - Stability
  - Eigenvalues and behavior of solutions in $\mathbb{R}^2$
  - Diagonalization
  - Jordan form
  - Linear systems with inputs (non homogeneous systems)
- Nonlinear systems
  - Existence and uniqueness
  - Linearization
  - Stable and unstable manifolds
  - Fixed points and their stability
  - Phase portraits of nonlinear systems
  - Lyapunov functions
  - Limit cycles
  - Poincare map
  - Poincare-Bendixson theorem
- Numerical Methods for ODEs
  - Linear systems
  - Nonlinear systems
- Bifurcations
  - Sensitivity analysis
  - Bifurcations of equilibrium points
  - Saddle node, transcritical, and pitchfork bifurcations
  - Hopf bifurcations

Week	Date	Notes
1	9/6/17	
2	9/11/17	
	9/13/17	HW #1 due
3	9/18/17	
	9/20/17	HW #2 due
4	9/25/17	
	9/27/17	
5	10/2/17	
	10/4/17	HW #3 due
6	10/10/17	
	10/11/17	
7	10/17/17	(MJD travel, alternative lecture)
	10/19/17	(MJD travel, alternative lecture)
8	10/23/17	
	10/25/17	Exam #1
9	10/30/17	
	11/1/17	HW #4 due
10	11/6/17	
	11/8/17	
11	11/13/17	
	11/15/17	HW #5 due
12	11/20/17	
	11/22/17	No class (Thanksgiving recess)
13	11/27/17	
	11/29/17	HW #6 due
14	12/4/17	
	12/6/17	
15	12/11/17	Project due
	TBD	Exam #2