Math 638: Continuous Dynamical Systems
Spring 2018

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Text: Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering, 2nd Edition, by Stephen Strogatz, ISBN-10 0813349109

Prerequisites: Mathematics 254 and 337, or 342A and 342B, or MATH 537.

Official Course Description: Dynamical Systems is the study of phenomena that evolve in time. Whether a particular system comes from Biology, Physics, Chemistry, or even the Social Sciences, Dynamical Systems is the subject that provides the mathematical tools for its analysis. This course studies the tools needed to provide deeper understandings of nonlinear phenomena in all of the above areas. The course is intended for senior undergraduate and first year graduate students in Applied Mathematics, Computational Science, Engineering, or Physics. Examples from interdisciplinary areas will be covered. Most of the concepts and examples will be supplemented with Python-based codes. As part of the course, students will be given access to a computer laboratory to complete the computer-based coursework.

Learning Outcomes:

1. Phase Plane Analysis: Students will compute fixed points of nonlinear systems. They will compute the associated eigenvectors and eigenvalues to determine stability. They will compute center-manifolds. They

will compute conserved quantities to find trapping regions. They will use the Poincare-Bendixson theorem, and related topological results, to prove the existence of periodic orbits.

- Course Activity: In class and office hours active-learning exercises.
- Assessment: Student facility with this outcome will be assessed through performance on assignments and exams.

2. Bifurcation Theory: Students will determine when bifurcations occur. Students will categorize different bifurcations, compute their associated normal forms, and describe the impacts of bifurcations in applied problems.

    - Course Activity: In class and office hours active-learning exercises.
    - Assessment: Student facility with this outcome will be assessed through performance on assignments and exams.

3. Approximation Techniques: Students will construct regular expansions, determine when said expansions fail, and then compute multiple-scale expansions to compute complex nonlinear phenomena.

    - Course Activity: In class and office hours active-learning exercises.
    - Assessment: Student facility with this outcome will be assessed through performance on assignments and exams.

4. Chaotic Dynamics: Through an exhaustive examination of the Lorenz system, students will be able to describe chaotic dynamics, determine Lyupanov exponents, and compute strange attractors.

    - Course Activity: In class and office hours active-learning exercises.
    - Assessment: Student facility with this outcome will be assessed through performance on assignments and exams.

5. Numerical Solvers for ODEs: Students will use numerical solvers for ODEs in Python in order to further explore phenomena that is not tractable through classic analytic techniques and to reinforce concepts introduced in other areas of the class.

    - Course Activity: In class and office hours active-learning exercises.
    - Assessment: Student facility with this outcome will be assessed through performance on assignments and exams.

6. Visualization in Python: Students will visualize results in the Jupyter notebook environment so as to develop facility with graphically representing mathematical results.
    - Course Activity: In class and office hours active-learning exercises.
    - Assessment: Student facility with this outcome will be assessed through performance on assignments and exams.

Grading Policy: Your final score will consist of homework (45%), two take home exams (30%), and a final project (25%). Homework is roughly due every week, though please pay attention to the schedule since there are exceptions to this (and every) rule.

Homework Policy: Any work you submit should be as professional as possible. I am not requiring that you type it, but I reserve the right to deduct credit for work that is difficult to read or follow. If you decide to type your work, please feel free to see me for help with LaTeX. You could use Word if you like, but I would not recommend it. Late work is not accepted unless you make arrangements with me in advance.

Project Policy: The project consists of three pieces: a proposal (5%), presentation (10%), and final paper (10%). Guidelines for the project are formalized in separate document which can be found on the Blackboard Course page.

Students with Disabilities: If you are a student with a disability and believe you will need accommodations for this class, it is your responsibility to contact Student Disability Services at (619) 594-6473. To avoid any delay in the receipt of your accommodations, you should contact Student Disability Services as soon as possible. Please note that accommodations are not retroactive, and that accommodations based upon disability cannot be provided until you have presented your instructor with an accommodation letter from Student Disability Services. Your cooperation is appreciated.

Week	Date	Sections
Week 1	01/18	Calculus Review
Week 2	01/23	Ch. 2
	01/25	Ch. 2, HMWK 1 Due
Week 3	01/30	Ch. 3
	02/01	Ch. 3, HMWK 2 Due
Week 4	02/06	Ch. 4
	02/08	Ch. 4, HMWK 3 Due
Week 5	02/13	Ch. 5
	02/15	Ch. 5, HMWK 4 Due
Week 6	02/20	Ch. 6
	02/22	Ch. 6, HMWK 5 Due
Week 7	02/27	Ch. 6
	03/01	Ch. 7 ,Takehome Exam 1 Due
Week 8	03/06	Ch. 7
	03/8	Ch. 7 , HMWK 6 Due
Week 9	03/13	Ch. 7
	03/15	Ch. 7 , HMWK 7 Due
Week 10	03/20	Ch. 7
	03/22	Ch. 7, HMWK 8 Due
Week 11	03/27	Spring Break
	03/29	Spring Break
Week 12	04/03	Ch. 8
	04/05	Ch. 8, Takehome Exam 2 Due
Week 13	04/10	Ch. 8
	04/12	Ch. 9 , HMWK 9 Due
Week 14	04/17	Ch. 9
	04/19	Ch. 9, HMWK 10 Due
Week 15	04/24	Hamiltonian Systems
	04/26	Hamiltonian Systems , HMWK 11 Due
Week 16	05/01	Presentations
	05/03	Presentations
Week 17		Final Project is Due, Have a good summer.