AME 522 Nonlinear Dynamical Systems, Vibratons and Chaos

Units: 4.0

Fall 2022—Mon, Wed—Time: 12:00-1:50pm

IMPORTANT:

Location: OHE 136

Instructor: Carlos Pantano

Office: OHE 430L

Office Hours: by appointment (COVID restrictions may apply)

Contact Info: pantanor@usc.edu

- Allow 24 hours for email responses during weekdays.
- Please use your USC email account for all communication.

Teaching Assistant: TBD

Office: TBD

Office Hours: TBD

Contact Info: TBD

IT Help: https://viterbigrad.usc.edu/technical-support/

Contact Info: dentsc@usc.edu; (213) 740-2881

Course Description

The purpose of this course is to introduce the methods of analysis and simulation used in the description of nonlinear mechanical, chemical, and biological, systems, and in general nonlinear dynamical systems. The topics covered in this course includes:

1. Basic over-view of Nonlinear Dynamical Systems and Oscillations in Engineering and Nature
2. Flows on a Line, Stability, Bifurcations; Flows on the Circle and Nonlinear Mechanical Systems, Phase locking
3. Linear systems Analysis and Multi-dimensional Flows, Phase Portraits, Nullclines: dynamics and various notions of stability; Lyapunov Stability
4. Lyapunov Stability and Instability Theorems
5. Local Analysis: Hyperbolic Fixed Points, Stable Manifold and Grobman-Hartman's Results; Nonhyperbolic Fixed Points, Use of Lyapunov Theorems, Invariance Principle
6. Global analysis: Limit Cycles, Dissipative Systems, Gradient Systems, Reversible Systems, Bendixon's Result, Index Theory
7. MIDTERM EXAM (Week of September 28th)
8. Fast and Slow Dynamics, Center Manifolds, Periodic "bursts" in nonlinear systems; Weakly Nonlinear Oscillations, Two-timing and Averaging Methods, Van der Pol's Equation
9. Limit Cycles, Subcritical and Supercritical Hopf Bifurcations, Hysteresis in Driven Pendulum, Global Bifurcations of Cycles
10. Infinite Period Bifurcations, Homoclinic Bifurcations, Poincare Maps, Linear stability of Periodic Orbits, Floquet Multipliers
11. Coupled Oscillators and Pseudo-periodic Orbits; Lorenz system, Chaos, Lyapunov Exponents, Computational Aspects, Transient Chaos
12. One-dimensional maps, Period doubling, Two-dimensional Maps, Fractals, Baker's and Horse-shoe transformation

Prerequisite(s): NA

Co-Requisite(s): NA

Concurrent Enrollment: NA

Recommended Preparation: Undergraduate courses in vector and tensor calculus, and partial differential equations.

Course Notes

This course will make extensive use of the Desire2Learn (D2L) USC Viterbi course management platform. All lecture notes and videos will be made available online through this website. The system will also be used to manage the homework submission process. Each homework assignment will have its own Dropbox to which the students can upload solutions. The D2L system will also be set up with a discussion forum for the homework assignments. Students are encouraged to use this for peer-to-peer discussions. The instructor and TA will monitor these discussion forums.

Please familiarize yourself with the D2L system as soon as possible.
https://courses.uscden.net/d2l/home

Technological Proficiency and Hardware/Software Required

Basic use of mathematical and plotting software (e.g., Matlab, Mathematica) will be required for some homework assignments.

Textbook and Other Resources

Nonlinear Dynamics and Chaos by Steven Strogatz

Some Reference Texts:

Dynamical Systems, by D. Arrowsmith and C. Place
Nonlinear Systems, by P. Drazin
Differential Equations and Dynamical Systems, by L. Perko
A Treatise on Analytical Dynamics, by L.A. Pars
Nonlinear Oscillations, Dynamical Systems and Bifurcation of Vector Fields, by J. Guckenheimer and P. Holmes
Nonlinear Systems, by H. Khalil

Grading: 30% Homework
30% Midterm Exam
40% Final Exam
There will be **ONE** Midterm Exam, and a Final Exam.
The midterm exam will be around the 6th week of class.

Assignment Submission Policy

- You can discuss homework problems with each other, but your solutions must be your own.
- Please indicate on your homework assignment if you have worked with another student.
- Assignments that are late will be penalized 25% for each day after the due date (see weekly schedule).
- All exams will be open-notes.
- Please notify the instructor at least 1 week ahead of time if you are unable to attend an examination or meet a homework deadline.

Grading Timeline

Graded assignments will be returned to students one week after submission.

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems:

Student Health Counseling Services - (213) 740-7711 – 24/7 on call
engemannshc.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 – 24/7 on call
engemannshc.usc.edu/rsvp
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) | Title IX - (213) 740-5086
equity.usc.edu, titleix.usc.edu
Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

Bias Assessment Response and Support - (213) 740-2421
studentaffairs.usc.edu/bias-assessment-response-support
Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

The Office of Disability Services and Programs - (213) 740-0776
dsp.usc.edu
Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710
studentaffairs.usc.edu/ssa
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101
diversity.usc.edu
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
dps.usc.edu, emergency.usc.edu
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps.usc.edu
Non-emergency assistance or information.