USC University of Southern California

AME 522

Nonlinear Dynamical Systems, Vibrations, and Chaos

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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 wish-list of 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

Course Text: 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/Term Project
There will be **ONE** Midterm Exam, and a Term Project/Final Exam (TBD).
The midterm exam will be around the 6^{th} week of class.

Homework Policy: 1. All students are encouraged to confer with anyone on how to solve the homework problems. The aim for each student is to learn the material in multiple ways.
2. Each student will write-up his/her homework that is submitted INDEPENDENTLY, i.e., *without* anybody else's help.
3. Homework will be assigned about each week and it is required to be turned in exactly on the specified day it is due. Late homework will not be graded
4. All students MUST turn in their homework *before* class starts on the day it is due. Every attempt will be made to return graded homework back to the students in the week following its submission.

Office Hours: Thursday 1:00-2:00 PM

Teaching Assistant (TA): Mr. Nami Mogharabin Email: namimogh@usc.edu
TA Office Hours: Mondays, Tuesdays, Fridays, 3:30:-4-15 PM

Class Policy: 1. If a student is found cheating on the homework, the student will be given a warning. If found to be cheating again the student will get a zero on the 30% set aside for the homework grade for the entire course.
2. A student found cheating on any exam will get an 'F' grade on the course.