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 topics covered in this course will include:

1. Basic over-view of Nonlinear Dynamical Systems and Oscillations in Engineering and Nature
2. Flows on a Line, Stability, Bifurcations
3. Flows on the Circle and Nonlinear Mechanical Systems, Phase locking
4. Linear systems Analysis and Multi-dimensional Flows, Phase Portraits, Nullclines: dynamics and various notions of stability
5. Lyapunov Stability and Instability Theorems
6. Local Analysis: Hyperbolic Fixed Points, Stable Manifold and Grobman-Hartman's Results;

   Nonhyperbolic Fixed Points, Use of Lyapunov Theorems, Invariance Principle
7. Global analysis: Limit Cycles, Dissipative Systems, Gradient Systems, Reversible Systems, Bendixon's Result, Index Theory
8. MIDTERM EXAM
9. Fast and Slow Dynamics, Center Manifolds, Periodic "bursts" in nonlinear systems
10. Weakly Nonlinear Oscillations, Two-timing and Averaging Methods, Van der Pol's Equation
11. Limit Cycles, Subcritical and Supercritical Hopf Bifurcations, Hysteresis in Driven Pendulum, Global Bifurcations of Cycles
12. Infinite Period Biurcations, Homoclinic Bifurcations, Poincare Maps, Linear stability of Periodic Orbits, Floquet Multipliers
13. Coupled Oscillators and Pseudo-periodic Orbits

14. One-dimensional maps, Period doubling, Two-dimensional Maps, Fractals, Baker's and Horse-shoe transformations

15. Lorenz system, Chaos, Lyapunov Exponents, Computational Aspects, Transient Chaos

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

There will be **ONE** midterm exam and a term project. The midterm exam will be around the 7^{th} -8^{th} week of class. Homework will be assigned each week and is required to be turned in exactly a week (to the day) after which it is assigned *before* class starts.