Math 515/Math 488   Spring 2009
Ordinary Differential Equations & Dynamical Systems

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Class Hours: Tuesdays and Thursdays 1:50pm–3:05pm, E1, Rm 241
Office Hours: Tuesdays and Thursdays 10:15am–11:15am or by appointment in E1 Room 115B

This is an introductory course in nonlinear dynamical systems and applications, for graduate and undergraduate students in applied mathematics, engineering and science. This course provides a coherent treatment of the basic ideas, methods and techniques in this exciting area. The emphasis is on understanding and the ability to apply the theory to complex systems. Students will learn nonlinear differential equations along the way, i.e., in the context of mathematical modeling. Throughout the course, many examples of nonlinear differential equations will be used to illustrate basic ideas and methods.

Dynamical systems theory describes the behavior of solutions of nonlinear evolutionary equations. Evolutionary equations are mathematical models of complex phenomena representing the change of processes in time. Dynamical systems theory provides a unified conceptual framework for utilizing general strategies to formulate mathematical models, for investigating nonlinear phenomena described by such models, for quantifying complex behavior, and for devising strategies to control or exploit nonlinear phenomena. Applying the ideas and methods of dynamical systems theory to applications has been a thoroughly interdisciplinary effort.

Topics include:
- Autonomous Dynamics — Equilibrium solutions, linearization and linear stability, asymptotic and Liapunov stability; Phase plane analysis, stable and unstable manifolds, periodic orbits, homoclinic and heteroclinic orbits, bifurcations, generating orbits and exploring dynamics via Matlab;
- Chaotic dynamics — Sensitive dependence on initial conditions, unpredictability, symbolic dynamics, strange attractors, Poincare maps, mechanisms for chaos, detection and quantification of chaos;
- Nonautonomous Dynamics — Cocycles, skew-product flows; periodic, quasiperiodic and almost periodic motions; recurrent motions; exponential dichotomy; invariant manifolds; Lyapunov exponents; and Oseledets multiplicative ergodic theorem.

Pre-requisite: Elementary differential equations, or consent of the Instructor.

Textbook:
J. Guckenheimer and P. Holmes, Nonlinear Oscillations, Dynamical Systems, and Bifurcations of Vector Fields

Reference Books:
P. Holmes, Ninety plus thirty years of nonlinear dynamics: Less is more and more is different. International J. Bifurcation and Chaos 15 (9), 2703-2716.
S. Wiggins, Introduction to Applied Nonlinear Dynamical Systems and Chaos
C. Chicone, Ordinary Differential Equations with Applications