# COURSE: MATH 850, FALL 2014

## ADVANCED ORDINARY DIFFERENTIAL EQUATIONS AND DYNAMICAL SYSTEMS

INSTRUCTOR: Prof. Milena Stanislavova

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TIME AND PLACE: MWF 10:00-10:50, 564 Snow

OFFICE HOURS: MWF 1-2pm, 525 Snow

TEXT: Gerald Teschl, Ordinary Differential Equations and Dynamical Systems, 2012, Graduate Studies in Mathematics, V.140, AMS

PREREQUISITES: Math 320 or 321, Math 765, Math 790

A graduate level course in Ordinary Differential Equations and their applications in mathematical physics. In the first part of the class we will cover the classical results in the theory including existence, uniqueness and regularity of solutions, continuous dependence on initial data and parameters, and extendability of solutions, the fundamental theory for linear systems (global existence theorems, solution by operator exponentiation), the structure of solutions for autonomous linear systems. We will emphasize the connection to applied mathematics and will try to introduce some modern techniques whenever possible. In the second part we will introduce stability theory and nonlinear systems, invariant manifolds and periodic orbits. Bifurcation theory, Melnikov's method and the Smale horseshoe and Smale-Birkhoff's homoclinic theorem will be covered at the end.

HOMEWORK: There will be 5 graded assignments for the semester and a final assignment, which will determine your grade.

## TENTATIVE TOPICS

1. Classical Theory: existence, uniqueness and regularity of solutions, continuous dependence on initial data and parameters, and extendability of solutions.
2. Linear Dynamics: the fundamental theory for linear systems (global existence theorems, solution by operator exponentiation), the structure of solutions for autonomous linear systems, analysis in the constant coefficient (autonomous) case, Jordan normal forms and associated stability conditions, the periodic-coefficient case and Floquet theory.
3. Boundary value problems and Sturm-Liouville theory.
4. Dynamical Systems and Stability Theory: definitions, examples, and counterexamples of various notions of stability, the method of Lyapunov functions, and stability via linearization, Poincare map.
5. Nonlinear Systems – Local Theory: flows and linear approximation, critical points and hyperbolicity, stable and unstable manifold theorems, the Hartman-Grobman theorem, the center manifold theorem and Carr's theorem, normal form theory, and analysis of gradient and Hamiltonian systems.

6. Nonlinear Systems – Global Theory: important invariant sets (periodic, homoclinic, and heteroclinic orbits, etc.) and their associated invariant manifolds, the Poincare map and the orbital stability of periodic orbits, Poincare-Bendixson theorem for planar systems.

7. Periodic Solutions and Chaos: stable and unstable manifolds, Melnikov's method, center manifolds and the Lyapunov-Schmidt reduction, the Smale Horse-shoe and Smale-Birkhoff homoclinic theorem.

**OTHER SUGGESTED BOOKS:**

1. Ordinary Differential Equations with Applications by Carmen Chicone
2. Differential Equations and Dynamical Systems by Lawrence Perko