Fall 2018

Math 558: **Advanced ODE and Dynamical Systems**

TTh 2:30 – 4:00 PM,

Instructor: Zaher Hani, (*Office:* 5834 East Hall (EH)), *Email:* zhani@umich.edu,
Website: https://sites.lsa.umich.edu/zhani/.*Office hours:* T-Th 1:00-2:00pm and by appointment.

Prerequisites: Basic Linear Algebra, Ordinary Differential Equations (Math 216 or 316 or equivalent), Multivariable Calculus (Math 215 or equivalent). Some exposure to more advanced mathematics, e.g. Advanced Calculus (Math 451) or Advanced Mathematical Methods (Math 454).

Course Coordinates: TTh 2:30–4:00 pm in 1449 Mason Hall (MH).

Textbook: M. Hirsh, S. Smale, and R. Devaney, *Differential Equations, Dynamical Systems, and an Introduction to Chaos*, 3rd ed., Elsevier. ISBN: 978-0123820105. The UM library has an electronic version which can be freely consulted.

Further Reference and recources: I will often supplement the textbook with material from other sources, like:

1. S. Strogatz, *Nonlinear Dynamics and Chaos*, CRC Press. ISBN: 978-0813349107.
2. C. Chicone, *Ordinary Differential Equations with Applications*, Springer. ISBN: 978-0387307695.
3. V. I. Arnold, *Ordinary Differential Equations*, Universitext, Springer. ISBN: 978-3-540-34563-3.
4. G. Teschl, *Ordinary Differential Equations and Dynamical*, American Math. Society, ISBN: 978-0-8218-8328-0.

Homework: There will be (roughly) weekly homework sets.

Grading: Homework 45%, Midterm 25%, and Final 30%. The final may be a take-home project with informal presentations.

Course Description: This is a course on Ordinary Differential Equations (ODE) and dynamics with an eye towards applications and concrete examples. It emphasizes techniques and results that are useful in applied mathematics, physics, and engineering. Proofs will be supplied, sketched, or at least provided in references. The course will be roughly split into three parts: A) Linear analysis, where we study the dynamics of linear systems, as it is the starting point to understanding the more complicated nonlinear systems; B) Nonlinear Analysis, which will constitute the bulk of the course, and C) Introduction to Chaotic dynamics.

Outline:

A) Linear Dynamics:

- Dynamics in 1D and 1.5D.
- Dynamics in 2D: Phase portraits, dynamical classification.
- Higher dimensional linear systems

B) Nonlinear Dynamics:

- Existence, Uniqueness, and Continuous Dependence on the initial data.
- Analysis of Equilibria and their stability.
- Bifurcation Theory.
- Limit sets and Poincare Map.

C) Introduction to Chaos

- The Lorentz system.
- Discrete dynamical system.

Important Dates

September 4	First day of classes
Octoberm16	Fall recess - No Class
November ?	Midterm (tentatively in one of the first two weeks of November)
November 22,23	Thanksgiving break- No Class
Dec 11	Last day of classes.