Math 2562 Syllabus
Honors Ordinary Differential Equations, 4 Credits
Lecture: TTh, 1:30-2:45, Skiles 249
Recitation: MW, 3:00-3:50, Skiles 368

Instructor

Dr. Howard (Howie) Weiss
Professor of Mathematics
weiss@gatech.edu
Office Hours: M10:30-12, W1-2:30, or by appointment

Teaching Assistant

Mr. Forrest Kieffer
tkieffer3@gatech.edu

1 General Information

Course Description

Our quantitative understanding of the world is often expressed as relationships between rates of change of quantities, such as position and time, chemical concentrations and time, population densities and time, amplitude and space, energy and temperature, etc. Such relationships are expressed in the language of differential equations. In this course we will explore classical, qualitative (dynamical systems), and numerical approaches to understanding solutions of ordinary differential equations.

Linear differential equations can be broken down into parts, each of which can be easily analyzed, and then the effects added together. Nonlinear systems are fundamentally different; their components interact in complicated and often unpredictable ways, Nonlinear systems can exhibit a rich and complicated "zoo" of behaviors, most of which are impossible in linear systems.

Since the vast majority of ODEs in science and engineering are nonlinear and do not possess classical (closed form analytical) solutions, qualitative, and numerical methods are most often used in practice to analyze ODEs. In this honors course we will focus on studying linear systems and then applying this knowledge to study the qualitative behavior of non-linear systems. We will study qualitative methods in greater depth than in Math 2552, and be more rigorous in our study throughout the semester.
Learning Objectives

1. **Learn to model real-world phenomena using ODEs.**

2. For motivation, see famous examples of ODEs from physics, chemistry and biology, learn how ODEs are classified, learn the statements of the fundamental existence and uniqueness of solutions of ODEs and see examples exhibiting pathologies.

3. Learn analytical methods (for separable and linear ODEs) and graphical methods to analyze first order ODEs, including finding equilibrium points and determining their stability. *First exposure to linear stability analysis.*

4. Learn to use Matlab and Mathematica to find analytical solutions.

5. Learn to nondimensionalize ODEs.

6. Learn the importance of bifurcations, how to recognize them, and sketch simple bifurcation diagrams.

7. Learn the Linearity Principle for first order linear systems of ODEs, learn to prove the Jordan Canonical Form in 2 and 3 dimensions and use it to solve first order linear systems of ODEs. Learn to sketch the phase plane, identify the equilibrium points, and determine their stability. *Appreciate the deep relation between linear algebra and linear systems of ODEs, and increase size of student’s linear algebra toolbox.*

8. Learn Euler’s method (and never to use it in practice) and to use Matlab’s suite of numerical ODE solvers and understand the sources of numerical errors, dangers, and best practices.

9. Learn to solve second order linear ODEs with constant coefficients by (i) rewriting them as linear systems and (ii) variation of parameters. Learn how oscillations and resonance arise in linear oscillators.

10. Learn basic properties of Laplace Transforms and their application to solve 2nd order linear ODEs with constant coefficients with non-smooth forcing.

11. Learn to find equilibrium points of nonlinear systems in the plane, use the Hartman-Grobman Theorem to deduce stability, and sketch the phase flow around the equilibrium points. Apply the Stable Manifold Theorem for nonlinear saddles in planar systems. Find conserved quantities, null-clines, and sketch as much of the phase plane as possible for nonlinear ODEs. Key examples include nonlinear oscillators such as the pendulum and Duffing oscillator, Lotka-Volterra competition and predator-prey models.

12. Learn what is chaos and see chaos and bifurcations in forced pendulum and Lorenz system. (1 lecture)

13. Practice clear, concise communication of mathematical ideas.
Pre- and/or Co-Requisites

Grade at least B in the following: MATH 1502 OR MATH 1512 OR MATH 1555 OR MATH 1504 ((MATH 1552 OR MATH 15X2 OR MATH 1X52) AND (MATH 1522 OR MATH 1553 OR MATH 1554 OR MATH 1564 OR MATH 1X53))

2 Course Requirements and Grading

Bi-weekly problem sets (20%), 3 exams (45%), final exam (25%), final project (10%)
Your lowest two homework grades will be dropped.

Your final grade will be assigned as a letter grade according to the following scale: A 90-100%, B 80-89%, C 70-79%, D 60-69%, F 0-59%

Exam 1: 9/24

3 Course Materials

Required Texts

1. Differential Equations, Dynamical Systems, and an Introduction to Chaos, Hirsch, Smale, and Devaney (3rd edition))

2. Ordinary Differential Equations: Basics and Beyond, Schaeffer and Cain (free download from GT library)

Course Website

people.math.gatech.edu/~weiss/math-2562-f18.html

Key subpages
people.math.gatech.edu/~weiss/math-2562-f18-exams.html
people.math.gatech.edu/~weiss/math-2562-f18-homework.html
people.math.gatech.edu/~weiss/math-2562-f18-links.html
people.math.gatech.edu/~weiss/math-2562-f18-lecture-schedule.html
people.math.gatech.edu/~weiss/math-2562-f18-computing.html

Please note that I do not use Canvas or T-Square.
Homework

The only way to learn the material well (and thus receive a good grade) is by solving many problems, and struggling to solve the more challenging ones. Unfortunately, there is no shortcut.

Please read all the relevant sections in the textbooks.

Homework problems will be assigned bi-weekly and will consist of odd number textbook problems, even number textbook problems, and non-textbook problems. Please only submit even numbered textbook problems and all non-textbook problems for grading. Please hand the problems to me before the class begins. You may discuss these problems with other students, but you must independently write up and submit your own solutions. Copying any part of a solution from a book, solutions guide, or website is cheating! Students are expected to abide by the Georgia Tech Academic Honor Code.

Late homeworks will not be excepted, but you may drop your two lowest homework grades. Emailed homeworks will only be accepted with prior agreement of the Instructor - else they will not be accepted.

To receive credit for a solution, you must clearly indicate how you obtained your solution. You will receive no credit without an explanation. Please keep your written answers brief; be clear and to the point. The grader will deduct points for rambling and for incorrect or irrelevant statements. Please do not show arithmetic and most algebra calculations. Your solutions should look like the solutions of examples in the text. If you are asked to show or prove a general result, you will receive no points for numerically verifying the result or proving it for $2 \times 2$ matrices. However, counterexamples can certainly be $2 \times 2$ matrices.

In order to grade as many problems as possible, your submitted problem sets should be printed very neatly in large “font” and stapled. Please do not cross out. Write on only one side of each page, in a single column, and do not use paper that has been torn out of spiral bound notebooks. You may typeset your solutions, but this is not required.

Please either print or submit a screen shot of your code and solution of computer problems.

4 Course Expectations and Guidelines

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech’s Academic Honor Code, please visit catalog.gatech.edu/policies/honor-code/. Any student suspected of cheating or
plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

**Accommodations for Students with Disabilities**

If you are a student with learning needs that require special accommodation, please see me at the beginning of the semester (I will try to help!) and also contact the Office of Disability Services at (404) 894-2563 or disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter.

**Attendance and/or Participation**

It is essential that you come to class on time and ready to work. It is very disruptive when students walk into class late. I strongly recommend class attendance and participation and I will use this activity in determining borderline grades.

**Collaboration and Group Work**

You may discuss homework problems with other students, but you must independently write up and submit your own solutions. Copying any part of a solution from a book, solutions guide, or website is cheating!

**Extensions, Late Assignments, and Re-Scheduled/Missed Exams**

Late homework assignments will not be accepted without an official excuse from the Dean of Students or other university official. However, you may drop your two lowest homework grades. Emailed homeworks will only be accepted with prior agreement of the Instructor and received before the end of class when they are due.

In case that you are unable to take an exam, you need to provide me with an official university excused absence or obtain my written permission before the scheduled exam.

**Student-Faculty Expectations Agreement**

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members
and the student body. See catalog.gatech.edu/rules/22/ for an articulation of some basic expectation that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

**Student Use of Mobile Devices in the Classroom**

You may use laptops or tablets in this class to take notes. Place your phone on mute before class begins. If you must, you may use your cell phone silently during class as long as it is hidden from view. Also, please do not video any parts of lectures.
Resources for Campus Students

In your time at Georgia Tech, you may find yourself in need of support. Below you will find some resources to support you both as a student and as a person.

**Academic support**

- Center for Academic Success success.gatech.edu
- Center for Academic Success 1-to-1 tutoring success.gatech.edu/1-1-tutoring
- Center for Academic Success Peer-Led Undergraduate Study (PLUS) success.gatech.edu/tutoring/plus
- Center for Academic Success Academic coaching success.gatech.edu/coaching
- Residence Life’s Learning Assistance Program (including drop-in tutoring for many 1000 level courses) housing.gatech.edu/learning-assistance-program
- OMED: Educational Services (including group study sessions and tutoring programs) omed.gatech.edu/programs/academic-support
- Communication Center (individualized help with writing and multimedia projects) communicationcenter.gatech.edu
- Academic advisors for your major advising.gatech.edu/

**Personal Support**

- The Office of the Dean of Students: studentlife.gatech.edu/content/services; 404-894-6367; Smithgall Student Services Building 2nd floor
- Counseling Center: http://counseling.gatech.edu; 404-894-2575; Smithgall Student Services Building 2nd floor. Services include short-term individual counseling, group counseling, couples counseling, testing and assessment, referral services, and crisis intervention. Their website also includes links to state and national resources. Students in crisis may walk in during business hours (8am-5pm, Monday through Friday) or contact the counselor on call after hours at 404-894-2204.
- Students’ Temporary Assistance and Resources (STAR): studentlife.gatech.edu/content/need-help (can assist with interview clothing, food, and housing needs)
• Stamps Health Services: https://health.gatech.edu; 404-894-1420 (Primary care, pharmacy, women’s health, psychiatry, immunization and allergy, health promotion, and nutrition)

• OMED: Educational Services: omed.gatech.edu

• Women’s Resource Center: womenscenter.gatech.edu; 404-385-0230

• LGBTQIA Resource Center: gbtqia.gatech.edu/; 404-385-2679

• Veteran’s Resource Center: veterans.gatech.edu/; 404-385-2067

• Georgia Tech Police: 404-894-2500

Personal Support

As a member of the Georgia Tech community, I am committed to creating a learning environment in which all of my students feel safe and included. Because we are individuals with varying needs, I am reliant on your feedback to achieve this goal. To that end, I invite you to enter into dialogue with me about the things I can stop, start, and continue doing to make my classroom an environment in which every student feels valued and can engage actively in our learning community.