

MATH 345 Differential Equations

Spring 2018

- Instructor:** Dr. Manuela Girotti; office: Weber 223C
email: manuela.girotti@colostate.edu
- Time:** Mon-Tue-Wed-Fri 1:00pm-1:50pm
- Location:** Engineering E 206
- Office hours:** TBA
- Textbook:** *Differential Equations and Their Applications. An Introduction to Applied Mathematics*, by Martin Braun
4th edition, Springer New York, Texts in Applied Mathematics Series #11
ISBN 978-1-4612-4360-1
- Catalog description:** first and second order equations, Laplace transforms, first order systems of equations, numerical methods, applied linear algebra, linearization.
- Overview:** The construction of mathematical models to address real-world problems has been one of the most important aspects of each of the branches of science. It is often the case that these mathematical models are formulated in terms of equations involving functions as well as their derivatives. Such equations are called differential equations. If only one independent variable is involved, often time, the equations are called ordinary differential equations. The course will demonstrate the usefulness of ordinary differential equations for modelling physical and other phenomena.

- Homework:** you will be required to hand in **5 assignments** along the semester.
- The assignments will be posted on the Canvas website with due dates (please, check the Canvas calendar often!) and they reflect the content of the course. No late assignments will be accepted.
- Please, submit your assignment with all the papers stapled together and with your name and CSU ID written on the first page. Use a pen and write clearly. If you are unable to submit a hard copy assignment, you can also scan it and send it to the instructor by email, no later than the due date and due time.
- Discussions and work group are highly encouraged, however the final submission has to be personal and show understanding of the material. Grades will be posted on Canvas.
- Computer Lab:** There will be **2 computer labs on Friday March 30th, 2018 and Friday April 20th, 2018** (regular class on other days).
- On these days the class will meet in **Weber 206**. In the first lab session you will be given a username and a password for the computers in the lab. Please, do not share this information with others.
- The lab classes will be used to visualize concepts seen in class and become familiar with computer software to solve differential equations. In this course we will use mainly Matlab[®] (and Mathematica[®]).
- In addition to the packages mentioned above, many illustrative examples can be found at Addison-Wesley's [Interactive Differential Equations](#) website. You are encouraged to explore these examples as you proceed in the course.
- Midterm exam:** There will be **two midterm exams on Friday March 9th, 2018 and on Monday April 16th, 2018**.
- They will be held during class hours (1pm-1:50pm) in the usual classroom E 206. There will be no make-up test.

Final exam: the final examination will cover material from the entire course. It will be a closed-book exam, no notes are allowed.

The final exam is scheduled for **Tuesday May 8th, 2018 between 4:10pm and 6:10pm**. It will be held in class (room E 206).

If you have time conflicts with other examinations, please notify the instructor as soon as possible.

Grading scheme: The final grade will be built up from the grades coming from assignments, midterm and final exams in the following percentage:

20% assignments,

20% for each of the midterm exams,

40% final exam.

Please, disregard the grading algorithm on Canvas, because it is set automatically and does not respect the grading scheme of this class.

Calculators: unless otherwise stated, basic 4-function calculators and scientific calculators (like Sharp EL 531 and Casio FX 300MS, for example) are permitted in class tests and final examination.

Academic Integrity: as in any other course you will attend, you are required to study and act according to the University Policy on Academic Integrity and the Student Conduct Code (see <http://tilt.colostate.edu/integrity>).

Moreover, bear in mind that the consequences for such misconduct (cheating, etc.) will ultimately fall upon you: this course is a precious opportunity for you to learn something new and valuable. It's an investment on your future. Failing to acquire it will sadly be your loss.

IMPORTANT: note that there is no "100% final exam" option in this course. The term work contributes 40% to the final grade. Therefore, active participation in classes and continuous work on the course material during the semester is essential for success in this course.

Tentative (and ambitious) outline of the course

We will cover Chapters 1-4 of the book. Here is the list of topics:

1. First-order differential equations
 - 1.1. Introduction
 - 1.2. First-order linear differential equations
 - 1.3. The Van Meegeren art forgeries
 - 1.4. Separable equations
 - 1.5. Population models
 - 1.6. The spread of technological innovations
 - 1.7. An atomic waste disposal problem
 - 1.8. The dynamics of tumor growth, mixing problems, and orthogonal trajectories
 - 1.9. Exact equations, and why we cannot solve very many differential equations
 - 1.10. The existence-uniqueness theorem; Picard iteration
 - 1.11. Finding roots of equations by iteration. Newton's method
 - 1.12. Difference equations, and how to compute the interest due on your student loans
 - 1.13. Numerical approximations; Euler's method. Error analysis for Euler's method
 - 1.14. The three term Taylor series method
 - 1.15. An improved Euler method
 - 1.16. The Runge-Kutta method
 - 1.17. What to do in practice
2. Second-order linear differential equations
 - 2.1. Algebraic properties of solutions
 - 2.2. Linear equations with constant coefficients. Complex roots. Equal roots; reduction of order
 - 2.3. The nonhomogeneous equation
 - 2.4. The method of variation of parameters
 - 2.5. The method of judicious guessing
 - 2.6. Mechanical vibrations. The Tacoma Bridge disaster. Electrical networks
 - 2.7. A model for the detection of diabetes
 - 2.8. Series solutions. Singular points; Euler equations. Regular singular points; the method of Frobenius. Equal roots, and roots differing by an integer
 - 2.9. The method of Laplace transforms
 - 2.10. Some useful properties of Laplace transforms
 - 2.11. Differential equations with discontinuous right-hand sides

- 2.12. The Dirac delta function
- 2.13. The convolution integral
- 2.14. The method of elimination for systems
- 2.15. Higher-order equations
- 3. Systems of differential equations
 - 3.1. Algebraic properties of solutions of linear systems
 - 3.2. Vector spaces
 - 3.3. Dimension of a vector space
 - 3.4. Applications of linear algebra to differential equations
 - 3.5. The theory of determinants
 - 3.6. Solutions of simultaneous linear equations
 - 3.7. Linear transformations
 - 3.8. The eigenvalue-eigenvector method of finding solutions
 - 3.9. Complex roots
 - 3.10. Equal roots
 - 3.11. Fundamental matrix solutions; e^{At}
 - 3.12. The nonhomogeneous equation; variation of parameters
 - 3.13. Solving systems by Laplace transforms
- 4. Qualitative theory of differential equations
 - 4.1. Introduction
 - 4.2. Stability of linear systems
 - 4.3. Stability of equilibrium solutions
 - 4.4. The phase-plane
 - 4.5. Mathematical theories of war. L. F. Richardson's theory of conflict. Lanchester's combat models and the battle of Iwo Jima
 - 4.6. Qualitative properties of orbits
 - 4.7. Phase portraits of linear systems
 - 4.8. Long time behaviour of solutions; the Poincare-Bendixson Theorem
 - 4.9. Introduction to bifurcation theory
 - 4.10. Predator-prey problems; or why the percentage of sharks caught in the Mediterranean Sea rose dramatically during World War I
 - 4.11. The principle of competitive exclusion in population biology
 - 4.12. The Threshold Theorem of epidemiology
 - 4.13. A model for the spread of gonorrhoea



A diary of the lectures will be regularly kept on the Canvas calendar with the sections covered in each class. Please, refer to that when preparing for the final exam because that will be the official and ultimate syllabus for the class.

Disclaimer: the instructor reserves the right to make changes to the course outline and course content should this be necessary for academic or other reasons. Every effort will be made to minimize such changes.