

**General Info**

*Instructor:* Professor David Grant, grant@colorado.edu

*Office Hours:* M 4-5, W 11:30-1, F 10:30-12, in Math 303 (x2-7208).

*Class Meetings:* MWF 3-3:50 PM in ECCR 131.

*Text:* George F. Simmons, *Differential Equations with Applications and Historical Notes*, second edition (McGraw-Hill). The book is out of print (and the third edition will not be ready in time for us to use) so a course packet for the second edition (containing what we will cover) will be available for purchase at the bookstore by the first day of classes. There are also some used copies of the second edition available online.

*Course website:* <http://euclid.colorado.edu/~grant/courses/3430/>

**Prerequisites.** Multivariable Calculus and Linear Algebra.

**About the course material.**

Without putting too fine a point on it, differential equations describe how the world works. Any system with continuous change is modelled using calculus, and variables are related through their derivatives. Any such relation is a differential equation. This includes Newton's laws of motion and  $E = mc^2$ . As you can imagine, anything this general and important is an old and well-developed branch of mathematics, and this course will only touch upon the tip of the iceberg.

More formally, if  $x$  is an independent variable,  $y$  is an unknown function of  $x$ , and  $y', y'', y''', \dots, y^{(n)}$  denote the first  $n$  derivatives of  $y$  with respect to  $x$ , then an *ordinary differential equation* is some relation:

$$F(x, y, y', y'', y''', \dots, y^{(n)}) = 0,$$

and  $n$  is called the *order* of the equation. Solving such an equation mean finding  $y$  as a function of  $x$ . (Such equations with more than one independent variable are called *partial differential equations* and they are more difficult to analyze and solve: we will not discuss them in this introductory course.) If we want to study  $m$  variables that depend on  $x$ , we need at least  $m$  such equations and these are called *systems of differential equations*.

The "simplest" differential equation is  $y' = f(x)$ . One then solves for  $y$  by integrating  $f$  with respect to  $x$  (so integration is only a very special case of solving a differential equation). Since there are many different techniques for integrating (depending on the form of  $f$ ), you can be assured that there are many different techniques for solving differential equations depending on their form. The feel of solving differential equations is not unlike the feel of algebra where you solve for the missing variable. Only here the task is harder, since you have to solve for a "missing" function, which is only known via an equation relating its derivatives.

Given the difficulty of the task, in this introductory course, we restrict ourselves to certain classes of equations that are more easily analyzed and solved. These are

- 1) First order differential equations.
- 2) Second (and higher) order linear differential equations.

- 3) Systems of first order linear differential equations.  
(A differential equation is called *linear* if it is of the form

$$\sum_{i=0}^n p_i(x)y^{(i)} = 0.$$

Many physical phenomena can be approximated well by linear equations.) These classes include some of most important differential equations found in the physical sciences and engineering. We will solve these equations when we can, but we will also prove theoretical statements showing that solutions exist (and are unique when certain initial conditions are imposed), and learn techniques for solving these equations numerically.

Note that  $e^x$  is a solution of  $y' = y$  and  $\sin x$  and  $\cos x$  are solutions of  $y'' = -y$ , so some of our most useful functions can be described as solutions of differential equations. Hence there is great value in being able to understand properties of solutions of differential equations, even when we can't solve them in terms of functions we already know. We will study how one can often learn qualitative properties of the solutions or express these functions in terms of power series. We will particularly apply these techniques to the solution of *Bessel's Equation*:

$$x^2y'' + xy' + (1 - p^2)y = 0,$$

for some constant  $p$ . The solutions are called *Bessel functions* and are important tools in mathematical physics and other branches of mathematics.

### **Class meetings and assessment.**

This course will meet three days a week. This course will employ aspects of *active learning*, a technique that has proven more successful for student learning than just lecturing in a course. Students spend classtime working on problems, both alone and with a partner, and then sharing ideas with the class. I will probably lecture about two-thirds of the time and have you each actively working about one-third of the time.

For this reason, attendance will be mandatory, and you will be assessed on inclass participation. Also, I will not lecture on everything in the book, so you will be responsible for reading the material in the book before classtime — I will answer questions on the material and go over the main points and do some examples. (The book is excellent and very comprehensible.)

Homework will be assigned weekly, and will be due the following Friday. There will be two hour-long exams during our regular class time and in our usual room. The first will be on Monday, September 26, and the second will be on Monday, October 31. There will be a final exam, in our regular room, from 4:30 till 7 p.m. on Wednesday, December 14. The time has been set in stone by the Dean, so please make sure now that it does not conflict with any of your plans.

Your final grade in this course will be determined by your total score out of 500 possible points. These points are broken down as follows: In class work and participation counts for a total of 50 points and homeworks count for a total of 50 points. The two hour exams will each be worth 100 points, and the final exam will make up the remaining

200 points. The final will, unlike the hour exams, be cumulative, with an emphasis on the material covered after the second exam.

**Friendly advice.**

Do *all* the homework. Don't fall behind: If you have questions, the sooner you ask them the better. I could not find solutions to the problems in the book online, but in case you do, remember that to use that resource is to just cheat yourself out of an important learning experience. In any case, you are expressly forbidden to use any printed or online source for the problems you have to do. You may work on the homework with other students, but you must write-up the solutions yourself, and, in keeping with good academic responsibility, say who you got help from.

**Et Cetera:**

The last day to drop a course without fee or a "W" on your transcript is Sept. 7. Also note that the last day to drop a class in MyCUInfo is Oct. 28.

Please inform me as soon as possible should you need, due to your observance of a religious holiday, to miss an exam, homework, or class. Provided you notify me well in advance, every effort will be made to reach a reasonable accommodation.

If you qualify for accommodations because of a disability, please submit to me a letter from Disability Services in a timely manner so that your needs may be addressed. Disability Services determines accommodations based on documented disabilities. See [www.Colorado.EDU/disabilityservices](http://www.Colorado.EDU/disabilityservices).

The University has an honor code, see <http://honorcode.colorado.edu>. I will expect each student to affix the pledge of the honor code to each exam.

The University of Colorado at Boulder policy on Discrimination and Harassment, the University of Colorado policy on Sexual Harassment and the University of Colorado policy on Amorous Relationships apply to all students, staff and faculty.

See <http://www.colorado.edu/odh>.

Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. See policies at <http://www.colorado.edu/policies/classbehavior.html> and at [http://www.colorado.edu/studentaffairs/judicialaffairs/code.html/# student\\_code](http://www.colorado.edu/studentaffairs/judicialaffairs/code.html/# student_code)