Differential equations are all over Physical Sciences, Engineering, Economics, Biology... to describe phenomena of interest. Their systematic study is a major branch of Mathematics.

This course is really two short courses, one in Ordinary Differential Equations (ODE), that is, differential equations of only one variable, and another one in Partial Differential Equations (PDE) for functions of two or more independent variables. This “split” is quite natural: in a nutshell, linear ODE have a finite dimensional space of possible solutions, whereas PDE have an infinite dimensional space of possible solutions, making them a much harder object of study. As we shall study these two topics, there will not be much connection between the two (“energy methods” is one of the few).

For ODE, we shall study some general mathematical questions for initial value problems such as uniqueness of solutions, general structure of solutions, existence of solutions, stability, etc. The treatment here is done in a fairly logical and comprehensive fashion.

Our treatment of PDE is much less comprehensive and we shall basically study three examples in some depth: the Laplace equation, the wave equation and the heat equation. Questions of uniqueness of solutions will be answered in a “reasonable fashion”, but structure questions and existence questions will be beyond this course except for a few simple examples. Emphasis will be on properties that generalize to other (similar) equations, although we shall not have time to pursue these generalizations.

One aim of the class is to introduce you to general mathematical questions and sometimes rather complicated proofs. In this sense, it may be called a “bridge course” between a typical 200-level course and the sometimes very much “theorem-proof” oriented Math courses at the 400-level.

Let us also note that in this course not only will your skills in Calculus (in one and more variables) be in demand, but also your knowledge in Linear Algebra. Such is the nature of study of Differential Equations, drawing on advances from many fields of Mathematics and in turn, inspiring such advances.

As noted before, the mathematical study of differential equations is driven by applications. Regrettably, due to limitations of time, in this course we shall not be able to lecture about such applications. Our two books (and many other), though, contain many examples of where the differential equations come from, for those of you who are interested.

Below is a sketchy week-by-week syllabus. Deviations from it are sure to occur.

**ODE (Brauer and Nohel)**

Aug 25: Introductory examples, motivation.

Aug 28–Sept 1: Notations, Gronwall’s Lemma, Uniqueness (1.6, 1.7, 3.3)

Sept 4–Sept 8: Structure theorems for linear ODE (2.1, 2.2, 2.3, 2.4)
Sept 11-Sept 15: Linear systems with constant coefficients (2.5, 2.6)
Sept 18-Sept 22: Asymptotics behaviour, two dimensional systems (2.7, 2.8)
Sept 25-Sept 29: Existence of solutions (3.1, 3.2, 3.4)
Oct 2-Oct 6: Stability (4.1, 4.2, 4.3)
FALL BREAK
PDE (Zachmanoglou and Thoe)
Oct 11-Oct 13: Introduction (7.1)
Oct 16-Oct 20: Laplace Equation (7.1, 7.4, 7.5, 7.6, 7.7, 7.9, 7.13, 7.16
Oct 23-Oct 27: with bits and pieces from 7.2, 7.3, 7.11, 7.12)... 
Oct 30-Nov 3: ... ctd
Nov 6-Nov 10: The Wave Equation (8.1...8.8)... 
Nov 13-Nov 17: ... ctd
Nov 20: The Heat Equation (9.1...9.4)... 
THANKSGIVING
Nov 27-Dec 1: ...ctd