MA 226 –Section B

Differential Equations

Fall 2014

David Deutsch

Class time and location: Tues, Thurs 8-9:30 in CAS 314

Discussion sections:

- B2: W 9-10 in MCS B21
- B3: W 2-3 in MCS B23

Text: Blanchard, Devaney, and Hall: *Differential Equations* (fourth edition), Brooks/Cole Publishing Company, 2012. ISBN number 978-1-133-10903-7.

Course Description: The course is divided into three parts:

- Part 1 – Chapter 1-First Order Differential Equations

  In this first unit we cover sections 1.1-1.9 of chapter 1 and we introduce first order differential equations. We learn key words to classify these equations as linear or nonlinear, autonomous or non-autonomous, and homogeneous or non-homogeneous. We introduce three methods for finding **analytic** solutions to some specific types of equations: separation of variables, method of undetermined coefficients, and integrating factors. We introduce a simple scheme called Euler's Method for finding **numerical** solutions of differential equations. These topics will feel very natural to the students who have completed courses in differential and integral calculus because they are an extension of those classes. What is new and exciting in this chapter is the introduction to a more qualitative understanding of the nature of first order differential equations. Our search for the asymptotic (long term) behavior of the solutions leads to a discussion of several new topics including: slope fields and phase lines, Existence and Uniqueness theorems, the connection between homogenous and non-homogenous equations, and the phenomenon of bifurcation.

- Part 2 – Chapter 2&3 – First Order Systems and Linear Systems

  In this second unit we cover sections 2.1-2.6 of chapter 2 and sections 3.1-3.7 of chapter 3. Systems of differential equations describe the phenomenon of two related quantities that are changing in time. The predator prey model from section 1.1 is an example of the type of systems we will consider. In chapter 2 we are introduced to vector notation that allows us to express a system as a first order homogeneous equation using vectors. In this form it is easy to visualize the behavior of systems by visualizing the behavior of the associated vector field. Also, we can easily extend Euler's Method and the Existence and Uniqueness theorems for systems expressed in a vector form. In chapter 3 we consider the behavior of a very fundamental class of systems known as linear systems. Using matrix notation along with eigenvectors and eigenvalues we will explore the analytic solutions and the qualitative behavior of all possible two-dimensional linear systems.

- Part 3 – Sec 4.1,4.2,4.3, 5.1 and Chapter 6 – Forcing and Resonance, Nonlinear Systems, and Laplace Transforms

  In this third unit we begin by building upon our understanding of the damped harmonic oscillator. Previously, the fate of the damped harmonic oscillator was to tend to the equilibrium rest position after an initial disturbance. In this unit we introduce the idea of a forcing function that can continue to excite the oscillator over time. We study the effects of three types of forcing functions: exponential, polynomial, and periodic. In the case of periodic forcing we will see in section 4.3 the phenomena called resonance whereby a small periodic forcing function can cause infinite amplitude oscillations. In chapter 5 we introduce the idea of linearization of a non-linear system near its equilibrium points so we can better understand the behavior at the equilibrium points. Chapter 6 introduces a very new idea called a Laplace Transform. Laplace Transforms have the ability to transform a differential equation into an algebraic equation. We will begin by showing that this technique produces the same solutions to familiar equations. However, one of the benefits of using Laplace Transforms is that it allows us to work with forcing functions that are not differentiable such as the Dirac delta function. The Dirac delta function models the effect of giving our system an instantaneous jolt of energy. For example, hitting the mass on a spring with a hammer. It is a very important type of forcing function that our methods in chapter 4 cannot address.

Exams:(75%) The three unit exams are scheduled for Tuesday, September 30, Tuesday, November 11, and Tuesday, December 9. The **final exam is scheduled for 9-11 am, Thursday, December 18.** *Please note the date of the final and* **make your travel plans now!** University policy states that you must take the final at the scheduled time. I will drop the lowest of your three unit tests so the best two unit tests will count as 50% of your term grade. The final exam will count for 25% of your term grade so all together exams will make up 75% of your term grade.

Homework:(10%) Homework will be collected and graded weekly beginning Wednesday, September 3. I will drop your lowest two homework scores.

Quizzes:(10%) There will be weekly homework quizzes. Quizzes will be made up of homework problems that have been covered in the previous week. Since the exams are made up primarily of homework-type questions, the purpose of the quizzes is to help you to review your homework. I will always announce which problems you are responsible for on the weekly quiz. I will drop your two lowest quiz scores.

Projects: (5%) Students will be asked to complete two short independent projects. The purpose of the project is to expose you to problems outside the realm of typical homework problems. The first project will be assigned after the first exam and the second project will be assigned after the second exam. Students will be able to work independently or in groups of two or three.

Contact Information:

- David Deutsch (Professor): Office: MCS 265, Email: deutsch@bu.edu
  Office Hours: Tuesday and Thursday 9:30-11 and by appointment.
- (Teaching Fellow) : TBA

Course web page : http://sites.bu.edu/david-deutsch/