Differential Equations

Spring 2018

MTH 335 Section 202, CRN 3962

**T, R 5:00 – 6:15, Smith Hall 516**

**(Updated 1/7/2018)**

# Instructor: Dr. Bonita A. Lawrence

Office and Lab - 614 Smith Hall

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Office Hours:  10:00 A.M. – 11:30 A.M. M, W

2:00 P.M. – 3:00 P.M. M, W

Or by appointment: If you are not able to come for office hours because you have other commitments, please let me know and we will find a good time that will work for both of us.

**General University**

**Policies:** By enrolling in this course, you agree to the University Policies. You can read the full text of these important policies online at the Marshall website at MU Academic Affairs: University Policies (URL: http://www.marshall.edu/academic-affairs/policies ).

**Attendance Policy**:

I expect you to be in class every day you are physically able. It is your responsibility to determine what you missed, in the event you are unable to attend class. Requesting notes from a colleague would be wise. You will be able to find your assignments at the Blackboard site for our class.

**Academic Dishonesty Policy:** I expect you to do your own work. You can certainly discuss the homework problems with your colleagues but what you present to me for any type of assessment must be your own. When you follow the proof technique of another author, the proof must be written up in your own words.

**Policy for Students with Disabilities:** Marshall University is committed to making all programs, services, and activities fully accessible to students with disabilities. The purpose of the Office of Disability Services Program is to provide the educational and physical accessibility support necessary for students to achieve their academic goals and to promote as much independence as possible on the part of the students with disabilities. Students with disabilities who require accommodations must contact the Office of Disability Services ( <http://www.marshall.edu/disabled> ).

**Course Description from Catalog:** First and second-order ordinary differential equations. Applications include vibrations and electrical circuits. Laplace transform, approximate solutions, orthogonal functions, Fourier series; partial differential equations including heat, wave, and Laplace equations.

**Course Prerequisites:** The prerequisite for the course is a grade of C or better in Calculus III (our MTH 231) or permission from the instructor.

**Textbook:** A First Course in Differential Equations, 3rd Edition

J. David Logan

Springer

**Course Objectives:** This course is a quantitative as well as a qualitative study of dynamic mathematical equations, differential equations, that offer us characterizations of unknown functions. The differential equation describes the relationship between the function of interest and its derivatives. The goal is to determine the function of interest, or the solution to the differential equation. We will begin with some discussion about what defines a differential equation and what it means to have a solution. We will discuss techniques for solving certain classes of ordinary differential equations. One very useful method we will investigate allows us to solve a differential equation that contains a discontinuous external forcing function, for example. This method uses a transform known as the Laplace Transform. Of interest to many of you may be our discussion of using differential equations to model physical phenomena. This allows us to use mathematics to create a dynamic equation that can simulate the physical system it is modeling. From this model, we can make observations and predictions of future states of the system.

Some fundamental analytical methods for solving particular classes of differential equations will be discussed and applied, including an extensive study of second order differential equations. From there we will investigate linear systems of equations and from this knowledge, look into the behavior of nonlinear systems, if time permits.

You will have the opportunity to use the Marshall Differential Analyzers, located in my lab in Smith Hall, Room 614, to study the behavior of solutions of differential equations. After you learn a bit about how the machine models mathematical equations, you will set up problems on the machine and solve them and analyze the solution.

Success in the course will be measured by your success at meeting the following objectives.

The ability to:

1. Understand what is required for a given function on a prescribed interval to be a solution to particular differential equations.

Learning Outcome: Utilize the definition of the solution to differential and determine if a particular function is a solution of a given differential equation.

Skill Development: Small group and whole group analysis of classical proofs and their application to exercises. Exercises assigned daily followed by timely feedback.

Assessment: Evaluation of written and oral presentations of analyses for validity and logical flow.

1. Classify certain ordinary differential equations and understand how the presented methods can be used to solve them.

Learning Outcome: Choose the appropriate method and solve certain models that belong to particular classes of differential equations.

Skill Development: Small group and whole group discussions of classifications and methods for solving certain differential equations. Exercises assigned daily followed by timely feedback.

Assessment: Evaluation of written and oral presentations for proper selection and uses of presented techniques.

1. Analyze qualitative nature of a solution of an ordinary differential equation (or system of ordinary differential equations) without the benefit of an explicit solution.

Learning Outcome: For a given equation, find the equilibrium solutions and determine stability, possible bifurcation points, and asymptotic behavior of solutions.

Skill Development: Small group and whole group discussions of the qualitative nature of solutions. Exercises assigned daily followed by timely feedback.

Assessment: Evaluation of written and oral presentations of analyses of the qualitative nature of solutions of differential equations.

1. Recognize the relationships between physical systems and differential equations that are used to model them.

Learning Outcomes: Describe the connection between a physical system and a given model used to study it. Create a mathematical model from the known behavior of a physical system.

Skill Development: Small group and whole group discussions of the qualitative nature of solutions. Exercises assigned daily followed by timely feedback.

Assessment: Evaluation of written and oral presentations of the construction of mathematical models from a given physical system.

1. Understand the mechanics of the differential analyzer and how it can be used to model differential equations. .

Learning Outcome: Program and solve a differential equation using the Marshall Differential Analyzer and analyze your results.

Skill Development: Small group and whole group laboratory experiences in the Marshall Differential Analyzer Lab. Lab experience supported and enhanced by formatted lab reports.

Assessment: Evaluation of lab reports describing setup and output of the differential analyzer and analysis of what the output offers.

1. Present all of your mathematical analyses clearly in both written and oral form. Organization and logical flow will be the secrets to success in meeting this objective.

Learning Outcome: Presentation of written or oral discussions in a valid and logical format.

Skill Development: Small group and whole group discussions of the organization of information when presenting the solution to exercises that involve modeling physical phenomena, solving the associate differential equation and analyzing the results.

Assessment: Evaluation of all written assignments and oral presentations at the board for validity and logical flow.

1. To recognize and appreciate various approaches to the same problem.

Learning Outcome: Construction of at least two different valid and logical approaches to a given problem.

Skill Development: Small group and whole group discussions with peers of various approaches to exercises.

Assessment: Evaluation of solutions of exercises that require the use of more than one approach to an exercise presented in both written and oral form.

**Grading Procedure:** You grade will be calculated using the following percentages:

Challenge of the Week 15%

Boardwork 5 %

Lab Exercises 5 %

2 Chapter Exams 50 %

Final Exam: 25%

There will be four exams during the semester, including the final exam (**Tuesday, May 1, 5:00 – 7:00).**  A schedule with exam dates and lab dates can be found at the end of this document. In the event you are not able to take the exam on the scheduled date because of serious circumstances, (see General Undergraduate Catalog, p. 124, for the list of excused absences) please contact me before the scheduled exam time so that we can plan a time for you to take the exam early.

I will assign homework almost every class period. If you have questions about the homework, come and visit me during office hours. If you have a particular exercise that you still have questions about, ask at the beginning of class. I will ask to you present some of your fine works of art at the board for my enjoyment as well as that of your peers. This is what I call “Boardwork”. You must visit the board at least twice during the semester to get full credit for your boardwork. I will give you the opportunity to show me regularly how you are progressing with your homework through what I call the “Challenge of the Week”. This will be an in-class exercise with a couple of problems you do on your own.

Your final grade will be determined using the following scale:

90% - 100% A

80% - 89% B

70% - 79% C

60% - 69% D

0% - 59% F

My best advice (It’s free!) is for you to keep up with your reading and homework assignments.

**Attendance Policy:** I expect you to be in class every day you are physically able. It is your responsibility to determine what you missed in the event you are unable to attend class. Requesting notes from a colleague would be wise. I am happy to give you information about any assignments you missed. If you miss an exam or a deadline for an assignment and your absence is excused (See General University Policies at link mentioned on page 1 of this document), you have one week after the date of the excused absence to make it up.

**Have a great semester and let me know if I can help you. If I can’t answer your question, I’ll find someone who can!**

**Cheers!**

**Dr. Lawrence**

**Tentative Program of Events for MTH 335**

**Class Days Topics and Events**

**Week 1 What is a DE?**

**January 9, 11 Why Study?**

**Some Integration and Differentiation**

**Techniques – A Bit of a Review**

**An Intro to First Order**

**DEs with some nice models**

**What is a solution?**

**Week 2 The Geometry of Solutions**

**January 16, 18 A nice application of the Fundamental**

**Theorem of Calculus**

**Boardwork**

**Week 3 Separation of Variables -**

**January 23, 25 A Lovely Technique**

**Some Interesting Physical**

**Models**

**Boardwork**

**Week 4 First Order Linear Equations**

**January 30, February 1 Solving with an Integrating Factor**

**A Nice Theorem – The Structure of**

**the Solution**

**Some Nice Applications**

**Boardwork**

**Week 5 A Qualitative Study**

**February 6, 8 Autonomous Equations**

**Equilibrium Solutions**

**Exam I**

**Week 6 Stability of Equilibrium Solutions**

**February 13, 15 Parameters and Bifurcation of**

**Solutions**

**A Look at Classical Mechanics**

**Initial Value Problems**

**Existence of Solutions**

**Boardwork**

**Week 7 Second Order Equations**

**February 20, 22 The Spring-Mass Problem**

**First trip to the DA Lab**

**Week 8 Second Order Linear Equations-**

**February 27, March 1 Constant Coefficients**

**Homogeneous Equations**

**The Eigenvalue Problem**

**Boardwork**

**Week 9 Second Order Linear Equations-**

**March 6, 8 Challenges Associated with Solving the Nonhomogeneous Equation**

**The Method of Undetermined**

**Coefficients**

**Boardwork**

**Week 10 Resonance**

**March 13, 15 Equations with Variable Coefficients**

**Exam II**

**Week 11 Spring Break!**

**March 19 - 23 Enjoy!**

**Week 12 The Cauchy – Euler Equation**

**March 27, 29 Variation of Parameters**

**Boardwork**

**Week 13 A Snappy Transform of Laplace**

**April 3, 5 Properties of the Laplace Transform**

**Boardwork**

**Week 14 Solving DE’s Using the Method of**

**April 10, 12 Laplace**

**Piecewise Continuous Source**

**Functions**

**Boardwork**

**Week 15 The Convolution Property**

**April 17, 19 Linear Systems of DE’s**

**Second Trip to the DA Lab**

**Week 16 More Cool Models**

**April 24, 26 Boardwork**

**Final Exam: Tuesday, May 1, 5:00 P.M. – 7:00 P.M.**