Differential Equations

Fall 2016

MTH 335 Section 101, CRN 3060

**T, R 2:00 – 3:15 T, R Smith Hall 518**

**(Updated 8/21/2016)**

# Instructor: Dr. Bonita A. Lawrence

Office and Lab - 614 Smith Hall

696 – 3040 or 696-3854, lawrence@marshall.edu

Office Hours:  11:00 A.M. – 12:00 A.M M,W

10:00 A.M. – 11:00 A.M. T,R

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 presented below. You can read the full text of these important policies online using the following path: Marshall Home Page - Course Catalogs – Undergraduate Catalogs. At this point, choose the catalog you started under (or any catalog after that).

**University Attendance**

**Policy**: The University Policy that describes excused absences can be found in the Marshall University 2015– 2016 Undergraduate Catalog on pages 85 – 86. Also, see attached document.

**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. The University’s policy concerning academic dishonesty can be found in the Marshall University 2015 – 2016 Undergraduate Catalog on pages 71 - 73.

**Policy for Students with Disabilities:** Marshall University is committed to equal opportunity for all. Students with physical, learning or psychological disabilities should contact the Office of Disabled Students Services (DSS) in Prichard Hall Room 117, 304 696-2271 and provide documentation of their disability. After consultation the DSS coordinator will send a letter to the student’s instructors describing the accommodations the student will need. For more information, go to <http://www.marshall.edu/disabled> or call or visit the office in Prichard Hall.

**Affirmative Action Policy:** In the spirit of equal opportunity for all, Marshall University has an Affirmative Action Policy. This can be found in the Marshall University 2015 – 2016 Undergraduate Catalog on p. 68.

**Inclement Weather Policy:** In the event of bad weather that may prevent us from coming to school, Marshall has a policy that describes how things will be handled. (Prior to last year, during my time at Marshall, the University was only shut down for 1.5 days. However, last spring it was more than a week!) The policy can be found on pp. 69 -70 of the Marshall University 2015 – 2016 Undergraduate Catalog.

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

J. David Logan

Springer

**Course Prerequisites:** The prerequisite for the course is Calculus III (our MTH 231) or permission from the instructor.

**Course Objectives:** This course is a quantitative as well as a qualitative study of dynamic mathematical equations that offer us characterizations of unknown functions known as differential equations. A differential equation describes the relationship between the function of interest and its derivatives. The goal is to determine the function of interest, or equivalently, 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 methods for solving 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 of a differential equation to determine if a particular function is a solution of a given differential equation.

Skill Development: Small group and whole group discussions and development of techniques for determining if a given function is the solution of stated differential equation. Homework exercises assigned daily followed by timely feedback.

Assessment: Evaluation of written and oral presentations of proper application of the definition of a solution to determine if a function is a solution.

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 methods for classifying and determining the appropriate method for solving certain classes of differential equations. Exercises assigned daily followed by timely feedback.

Assessment: Evaluation of written and oral presentations for proper selection and uses of presented techniques with an emphasis on creating a logical argument.

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 how a physical system is modeled. 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. Constructions must include valid reasoning.

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 formal lab reports.

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

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 (**Thursday, December 15, 12:45 – 2:45).**  I will give you a schedule with exam dates and lab dates. 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 University Attendance Policy, 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?**

**August 23, 25 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**

**August 30, September 1 Isoclines and Nullclines**

**A nice application of the Fundamental**

**Theorem of Calculus**

**Boardwork**

**Week 3 Separation of Variables -**

**September 6, 8 A Lovely Technique**

**Some Interesting Physical**

**Models**

**Week 4 First Order Linear Equations**

**September 13, 15 Solving with an Integrating Factor**

**A Nice Theorem – The Structure of**

**the Solution**

**Some Nice Applications**

**Boardwork**

**Week 5 A Qualitative Study**

**September 20, 22 Autonomous Equations**

**Equilibrium Solutions**

**Exam I**

**Week 6 Stability of Equilibrium Solutions**

**September 27, 29 Parameters and Bifurcation of**

**Solutions**

**Initial Value Problems**

**Existence of Solutions**

**Boardwork**

**Week 7 Second Order Equations**

**October 4, 6 The Spring-Mass Problem**

**First trip to the DA Lab**

**Week 8 Second Order Linear Equations-**

**October 11, 13 Constant Coefficients**

**Homogeneous Equations**

**The Eigenvalue Problem**

**Boardwork**

**Week 9 Second Order Linear Equations-**

**October 18, 20 Challenges Associated with Solving the Nonhomogeneous Equation**

**The Method of Undetermined**

**Coefficients**

**Week 10 Resonance**

**October 25, 27 Equations with Variable Coefficients**

**Exam II**

**Week 11 The Cauchy – Euler Equation**

**November 1, 3 Variation of Parameters**

**Boardwork**

**Week 12 A Snappy Transform of Laplace**

**November 8, 10 Properties of the Laplace Transform**

**Boardwork**

**Week 13 Solving DE’s Using the Method of**

**November 15, 17 Laplace**

**Piecewise Continuous Source**

**Functions**

**Boardwork**

**Week 14 Take a Break and Recharge!**

**November 22, 24 Enjoy your family and friends and**

**come back safely!**

**Week 15 The Convolution Property**

**November 29 Linear Systems of DE’s**

**December 1 Second Trip to the DA Lab**

**Week 16 More Cool Models**

**December 6, 8 Review for the Final**

**Boardwork**

**Final Exam: Thursday, December 15, 12:45 P.M. – 2:45 P.M.**

University Class Attendance Policy (Approved by the Faculty Senate, Spring 2015)

Students are expected to attend punctually all class meetings, laboratory sessions and field experiences and to participate in all class assignments and activities as described in the Course Syllabus. Absences are counted from the first class meeting after the student registers. Students registering late are expected to make up all missed assignments in a manner determined by the instructor. Students should be aware that excessive absences, whether excused or unexcused, may affect their ability to earn a passing grade. The instructor of each class shall establish a policy on class attendance and make-up work, and provide the policy to students in the Course Syllabus. This policy must not conflict with university policies, including this policy. Class attendance may be a criterion in determining a student’s final grade in the course if the instructor provides a statement to this effect in the course syllabus.

Students must promptly consult with their instructors about all class absences. Instructors will work with students to identify appropriate documentation and discuss any missed class time, tests, or assignments. A student may not be penalized for an excused absence, provided that the student, in a manner determined by the instructor, makes up the work that has been missed.

Instructors are required to honor University Excused Absences and to provide reasonable and equitable means for students to makeup work missed as a result of those absences. Academic obligations that cannot be made up should be addressed by the course instructor in consultation with the student to ensure that continued enrollment is feasible while there is still an opportunity to drop the course within the established withdrawal period.

This policy excludes academic endeavors that require the completion of a specific number of clock hours, such as clinical experiences, practica, and internships. For those courses, the department chair or program supervisor will determine the maximum number of absences. This policy does not supersede program accreditation requirements.

This policy also excludes laboratory courses that require significant preparation and monitoring. For such courses, departments will determine the minimum number of laboratories a student must complete to pass the course. If a student cannot complete this number of labs, the instructor may recommend that the student withdraw from the class.

If the instructor believes that the number of absences accrued under the terms of this policy (whether excused or unexcused) is such that a student cannot fulfill the learning experience and mastery that a course requires, the instructor may recommend that the student withdraw from the class.