Differential Equations

Spring 2016

MTH 335 Section 201, CRN 4078

**MW 2:00 – 3:15 T, R Smith Hall 531**

**(Updated 1/10/2016)**

# Instructor: Dr. Bonita A. Lawrence

Office and Lab - 614 Smith Hall

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

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

11:00 A.M. – 12:00 P.M. T,R

**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,

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 fantastic mathematical expressions that offers us a characterization of an unknown function, a 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 particular classes of differential equations will be discussed and applied followed by 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.

You will be among the first to use the Marshall Differential Analyzer, located in my lab in Smith Hall, Room 311, to study differential equations. You will have the opportunity to 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 (**Thursday, May 5, 12:45 – 2:45).**  A schedule with exam dates and lab dates is included 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, let’s discuss them at the beginning of class or 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?**

**January 12, 14 Why Study?**

**Modeling with DE’s.**

**How is a solution defined?**

**Finding and verifying solutions of particular DE’s.**

**Week 2 Classifications of DE’s.**

**January 19, 21 Uniqueness, Existence and**

**the Interval of Existence –**

**A Useful Theorem**

**Boardwork**

**Week 3 Slope Fields, Nullclines, and Isoclines**

**January 26, 28 Pure Time Equations and the**

**Fundamental Theorem of Calculus I**

**and II.**

**Particle Dynamics**

**Boardwork**

**Week 4 The Spring Mass Equation**

**February 2,4 Separation of Variables Method**

**The Autonomous DE – A Study of the**

**Malthus Model**

**Dimensionless Models**

**Boa**

**Week 5 Equilibrium Solutions**

**February 9, 11 Stability and Bifurcation**

**Exam I**

**Week 6 Reactors and Circuits**

**February 16, 18 Solving First Order Linear Equations**

**Interesting Applications**

**Boardwork**

**Week 7 Approximate Solutions**

**February 23, 25 Error Analysis**

**Intro to Second Order Linear Equations**

**First trip to the DA Lab**

**Week 8 Second Order Linear Equations-**

**March 1, 3 Constant Coefficients**

**Homogeneous and Nonhomogeneous**

**Boardwork**

**Week 9 Second Order Linear Equations-**

**March 8, 10 Variable Coefficients**

**The Cauchy-Euler Equation**

**Boardwork**

**Week 10 Variation of Parameters**

**March 15, 17 Higher Order Linear Equations**

**Exam II**

**Week 11 Spring Break!!**

**March 21 – 25 Have some fun and return to school safely!**

**Week 12 Properties of the Laplace Transform**

**March 29, 31 Solving DE’s with Laplace**

**Boardwork**

**Week 13 Convolution**

**April 5, 7 Piecewise Continuous Source**

**Functions**

**Boardwork**

**Week 14 Impulsive Source Functions**

**April 12, 14 Linear Systems of DE’s**

**Qualitative Behavior**

**Second Trip to the DA Lab**

**Week 15 Linear Orbits**

**April 19, 21 Nonlinear Models**

**More Cool Models**

**Boardwork**

**Week 16 Linearization and Stability**

**April 26, 28 More cool models**

**Boardwork**

**Final Exam: Thursday, May 5, 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.