Advanced Differential Equations

Spring 2015

MTH 616 Section 201

**T,R 11:00-12:15 SH 518**

(Updated 1/22/2015)

# Instructor: Dr. Bonita A. Lawrence

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Office Hours: 2:00 P.M. – 3:30 P.M. T,R

10:00 A.M. – 11:30 A.M. M,W

Or a time that we can find that

works 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 2013 – 2014 Undergraduate Catalog on pages 83 – 84.

**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 2013 -2014 Undergraduate Catalog on pages 69 – 70.

**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 2013 - 2014 Undergraduate Catalog on p. 66.

**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. (Note that I have been here for 12 years and we have only shut down school one day during this time.) The policy can be found on pp. 67 -68 of the Marshall University 2013 – 2014 Undergraduate Catalog.

**Course Description from Catalog:** Differential equations are studied qualitatively. Topics include the existence and uniqueness of solutions and the behavior of solutions including the stability of nonlinear systems, periodic solutions, and approximation using perturbation methods.

**Course Prerequisites:** There is no formal prerequisite for this course. I will assume that you have had the first course in advanced calculus and a proof techniques course. If this is not the case, please come to talk to me about your previous training. It is helpful if you have had an undergraduate course in ordinary differential equations. This is a 600 level course and I am assuming that your mathematical maturity is at such a level that you can read, discuss and learn.

**Course Objectives:** This course is a qualitative study of these lovely mathematical equations that offers us a characterization of unknown function. We will use the nature of the expression and classical results that have been developed through the centuries to describe the behavior of the unknown function under various conditions. The standard undergraduate course in differential equations presents methods for solving various types of DE’s. This semester we will focus more on whether or not a solution actually exists and how it behaves. We will study the qualitative behavior of solutions, including topics such as stability of nonlinear systems, existence of periodic solutions, and finding approximations using perturbation methods.

Success in the course will be measured by your success at meeting the following learning outcomes:

1. *Learning Outcome:* Apply the results (and the proof techniques used) found in classical theorems in differential equation theory.

*Skill Development:* Individual and group analysis of classical theorems and their proofs. Topics under consideration include a broad spectrum of results concerning existence and uniqueness of solutions of differential equations and differential inequalities, approximations for solutions and continuous dependence of solutions on initial conditions. This includes homework, boardwork and Excursions. Exercises will be assigned daily and followed up by timely feedback.

*Assessment:* Evaluation of written and oral presentations for proper applications of the results of classical theorems and the expansion of these ideas to related results. The proper use of proof techniques found in classical theorems will also be evaluated.

1. *Learning Outcome:* Expand understanding of qualitative properties of first order differential equations to higher order systems of differential equations.

*Skill Development:* Individual and whole group development and analysis of the structure required for the study of higher order systems of differential equations. Topics discussed include existence and uniqueness of solutions, properties of linear systems, and Activities include homework, boardwork and Excursions. Exercises will be assigned daily and followed up by timely feedback.

*Assessment:* Evaluation of written and oral presentations for proper use of proofs techniques from your first course in differential equations, construction of proofs for results related to systems of differential equations and use of these results to find solutions of systems of differential equations.

1. *Learning Outcome:* Construct (as well as recreate) formal proofs of propositions and theorems that address concepts discussed during the course of the semester.

*Skill Development:* Individual and whole group constructions of logical and valid proofs of theorems and propositions concerning topics addressed during the course of the semester. Activities include homework, boardwork and Excursions. Exercises assigned daily followed by timely feedback.

*Assessment:* Evaluations of written and oral presentations of proofs for proper logic and validity.

1. *Learning Outcome:* Present your work clearly and concisely in both written and oral form. Organization and logical flow will be the secrets to success in meeting this objective.

*Skill Development:* Individual, small group and whole group creation of proofs of stated propositions. Daily exercises with review the following day.

*Assessment:* Evaluation of all written assignments and oral presentations by both professor and colleagues for clarity and concise language. This includes homework, boardwork and Excursions.

1. *Learning Outcome:* Program and run the differential analyzer to solve a variety of differential equations.

*Skill Development:* Small group and whole group laboratory analysis of how the mechanics of the differential analyzer models mathematics and hands-on setup of particular models on the machine. These studies will take place in the Marshall Differential Analyzer Lab. Lab experience supported and enhanced by formal written lab exercises.

*Assessment:* Evaluation of lab reports for proper descriptions of the required programming and the associated output of the differential analyzer and analysis of what information the output offers us.

1. *Learning Outcome:* Construct at least two different valid and logical approaches to a given problem.

*Skill Development:* Individual, small group and whole group discussions with peers and presentations for peers of multiple approaches to the same problem. Exercises assigned daily followed by timely feedback.

*Assessment:* Evaluation of solutions for the proper use of more than one approach to an exercise presented in both written and oral forms. This includes homework, boardwork and Excursions.

This will be a spiritual (and spirited) study of differential equations.

**Textbook:** An Introduction to Ordinary Differential Equations

Ravi P. Agarwal and Donal O’Regan

Springer

This book has an interesting format in that it is a collection of lectures. Read the material carefully and more than once. Create your own mental picture of what is being described. Look at it from your own perspective. I have found this to be the best way to understand sometimes complex ideas.

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

Homework: 20%

Boardwork: 20%

Midterm Exam: 30%

Final Exam: 30%

I want contribute to your quest to be a lifelong learners. To achieve this goal, I have planned the following format for our class time:

I will assign topics for each of you to study and present to your peers and to me. As you present, I will offer additional ideas and clarification of concepts that may be a bit cloudy. I think you will enjoy the experience.

There will be two tests during the semester, a midterm and a final exam is on **Thursday, May 5, 10:15 A.M. – 12:15 P.M**. In the event you are not able to take the exam on the scheduled date because of very serious circumstances, (see Graduate Catalog, pp. 47-48, 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.

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.

A Tentative Schedule of Events for Advanced Differential Equations

Week 1 A Review of What it Means to be a Solution of a

January 13,15 Generalized Differential Equation

Some Historical Notes

Boardwork

Week 2 Exact Equations and Their

January 20, 22 Solutions

The Use of Integrating Factors for Finding Solutions

Boardwork

Week 3 A Study of Elementary First Order Equations

January 27, 29 Using the Theory of Exact Equations

Boardwork

Week 4 A Review of Methods for Solving First and Second

February 3, 5 Order Linear Equations

Boardwork

Week 5 Preliminary Theory Required

February 10, 12 for the Development of Existence

and Uniqueness Results

Boardwork

Week 6 Constructing a Solution Using the Fine Work

February 17, 19 of Picard – Successive Approximations

Boardwork

Week 7 When Does a Solution Exist?

February 24, 26 A Collection Results That Offer Us Existence

The Work of Cauchy and Peano

Boardwork

Week 8 When a Solution Exists, When is it Unique?

March 3, 5 A Collection of Uniqueness Results

Mid-Term Exam