Math 332: Applied Differential Equations **2020**
Elementary Differential Equations and Boundary Value Problems, Boyce/DiPrima/Meade,11th
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Course Objectives: *Continue to learn how to do mathematics!* Mathematics is a problem-solving discipline, and we all have room to improve. To develop as problem-solvers, we must focus on technique and not on memorization. In this course, we focus on techniques used to solve differential equations of various types, including both ordinary and partial differential equations. Some of these problems are long! If you understand the basics they are not hard, just lengthy. To reduce some of the repetitive aspects of these problems, we will use Mathematica extensively. However, like all math courses, thinking is the key!

Intended Learning Outcomes: At the end of the course, successful students will be able to

- Approximate solutions of ODEs using numerical methods.
- Apply techniques for finding series solutions of ODEs.
- Apply Fourier Series in a variety of situations.
- Use separation of variables to find solutions of PDEs.
- Analyze Sturm-Liouville problems of various types.
- Use Laplace transforms to solve ODEs.

Attendance Policy: You are responsible for everything done in class, through attendance and sharing class notes with classmates. If you miss a class, e-mail or call me before class is over and explain why. **If you have two unexplained absences, you will be dropped from the course.**

Equipment: We will use Mathematica in class, on homework assignments and on tests. You should get a free copy installed on a laptop or desktop.

Study Problems: You should attempt as many of the exercises in the book as you can. Given the length of some of the problems, there will not be a large number of problems to work, but it is essential that you work enough to become comfortable with the basic manipulations. You do not want to struggle on step 3 of a 14-step problem!

Homework: Throughout the semester, problems will be assigned to hand in with due dates specified. Work these problems neatly and completely. You will be graded on accuracy and ability to communicate your ideas. Most problems will require Mathematica – once you get comfortable with its syntax, you will find it to be a wonderful resource.

Co-Curricular: During the course of the semester, you must attend at least two approved co-curricular events offered by the MCSP department. For each, write a two-paragraph reflection paper, giving a brief summary of the talk and expanding on some aspect of particular interest to you. Reports are due within a week of the talk.

Make-ups: In case of sickness or scheduling conflicts, get in touch with me ASAP.

Academic Integrity: The college policy is fully supported. Tests are closed notes, closed book unless noted. Electronic devices other than computers are not allowed in test situations, and computers may only be used for computation purposes in Mathematica.

I expect you to spend at least 12 hours of work each week inside and outside of class.

Mastery Tests: We will use the mastery testing method. There will be 16 topics to master. Grading of a problem will be either Mastered or not – no partial credit. You may re-try topics that you did not master previously without penalty. Once you have mastered a topic you do not have repeat that topic. Your overall test/exam grade will be based upon how many topics you master. There will be two full test days, with other opportunities in class to repeat topics. Please note that this does not constitute an infinite set of testing opportunities. Due to the lengthy nature of many of the problems, many problems will be take-home problems. **Non-mastered take-home problems may be reworked twice; to get credit, turn in your previous work and a new attempt started from step one. Few mistakes can be tweaked; start over, follow the logic!** The exam is Friday November 20, 1:00-5:00.

Extra Credit: You may earn extra credit in a number of ways. My intent is to encourage you to have fun with mathematics, and that is the grading criterion that I will use – so have fun learning! You may check out from the Roanoke College library and report on "popular" applications of differential equations. You may report on mathematical web sites that have good differential equations demonstrations. You may do extra work on one of the many complex problems we start in class. The main rule here is to do this now; waiting until the end of the semester will distract you from the end-of-semester studying that you need to do.

Grading: The tests-exam mastery grade counts 70% of the final average.
If you master *m* of the 16 topics your mastery grade is $28+4.5m$.
Homework, class participation, and co-curricular reports count 30% of the final grade.
Grades may be curved up based on extenuating circumstances, including improvement as the semester goes on.

A: 93-100 A-: 90-92
B+: 87-89 B : 83-86 B-: 80-82
C+: 77-79 C: 73-76 C-: 70-72
D+: 67-69 D: 63-67 D-: 60-62
F: 59 and below

Mastery Topics

1. Numerical Methods
2. Series Solutions Near Ordinary Points
3. Series Solutions Near Ordinary Points
4. Euler Equations
5. Series Solutions Near Regular Singular Points
6. Two-Point Boundary Value Problems
7. Fourier Series Problems
8. Even and Odd Functions
9. Separation of Variables
10. Heat Conduction Problems
11. Wave Equation Problems
12. Laplace Equation Problems
13. Partial Differential Equations
14. Two-Point Boundary Value Problems
15. Sturm-Liouville Problems
16. Laplace Transforms

Math 332 Schedule (tentative – likely to change!)

Date	Sections	Topics
W 8/19		Epidemiology (COVID)
M 8/23	8.1,3	Numerical Methods
W 8/25	5.1-5.2	Series Solutions Near an Ordinary Point
M 8/30	5.3	Series Solutions Near an Ordinary Point
W 9/2	5.4	Euler Equations
M 9/7	5.5	Series Solutions Near a Regular Singular Point
W 9/9	TEST topics 1-4	
M 9/14	5.6	Series Solutions Near a Regular Singular Point
W 9/16	10.1	Two-Point Boundary Value Problems
M 9/21	10.2	Fourier Series
W 9/23	TEST topics 5-8	
M 9/28	10.3	Fourier Series
W 9/30	10.4	Even and Odd Functions
M 10/5	10.5	Separation of Variables
W 10/7	10.6	Heat Conduction Problems
M 10/12	10.6	Heat Conduction Problems
W 10/14	TEST topics 9-12	
M 10/19	10.7	The Wave Equation
W 10/21	10.7	The Wave Equation
M 10/26	10.8	Laplace's Equation
W 10/28	10.8	Laplace's Equation
M 11/2	11.1	Two-Point Boundary Value Problems
W 11/4	11.2	Sturm-Liouville Problems
M 11/9	6.1-2	Laplace Transforms
W 11/11	6.3	Step Functions
M 11/16	Review	
F 11/20	EXAM	1:00-5:00

Model Reflection Paper

(This is made up, but shows what I'd like to get from you. The two main elements are (1) brief summary of talk and (2) some original thought on the subject.)

The talk on September 7th was by Dr. Sue Dokoo of Pseudo Duke University. Her research is in the game of Sudoku and discussed different aspects of this game. I have seen other people playing it, but did not know the rules or any of the mathematics behind it.

In this game, a 9x9 playing space is provided. An example given was:

		6	2			5	8	
4		2	5					7
				7	8	6		3
5		1		6	7			8
	3						6	
6			8	2		9		1
7		4	3	9				
9					5	2		6
	5	3			1	4		

To "solve" the puzzle, one could just enter numbers in a brute-force kind of way to see if they could get a working configuration. However, sitting in a room full of mathematicians, taking a more analytical approach seemed to be the dominant strategy. Treating this as a constraint-satisfaction problem, you can identify that certain cells must contain specific values. This leads to the conclusion that there is exactly one solution to a "well-formed" Sudoku.

This got me thinking about well-formed Sudoku, and how they are generated in the first place. It seems unlikely that the seeds are randomly assigned, you run the risk of violating set-up rules. A bigger problem is that the seeds may not constrain the possibilities enough to make a unique solution. Another naïve approach might be to take a completed grid and start taking away numbers, but I suspect that you might have a similar issue in terms of necessary constraints.

One that I want to think about is: In forming a viable Sudoku, is it the number of seeds or the placement of seeds that is more critical? I suspect the latter. Also,

- What is the maximum number of seed numbers that can be provided and still result in an ambiguous (unsolvable) puzzle?
- What is the minimum number of seed numbers that can be provided to generate a (uniquely) solvable puzzle?

We were provided two puzzles – one was rated "Easy" the other "Difficult".

- What goes into the rating system?
- Does a difficult puzzle necessarily have fewer seed numbers?
- Is the rating of the complexity somehow determined by the deductive skills required?