MATH 212: Differential Equations

Spring 2016

Instructor: Dr. Benjamin Purkis

MWTF, 12:15-1:05, Seney 208

Instructor Information:

Email: bpurkis@emory.edu
Office: Pierce 121
Office Hours: Thursday 1-3 or by appointment!
Drop-in policy: If my office door is open, you are always welcome to come in and ask whatever questions you may have. If my office door is closed, you are welcome to knock; I may answer, but I may also ask that you come back at another time. The best way to see me is to come during office hours or email me to set up an appointment.

Course Information and Policies:

Description: Differential equations are an essential tool in modeling real life problems. With applications from population growth, predator-prey models, and harmonic oscillators, differential equations form the language of science. This course will examine many aspects of differential equations and how they may be used to better understand the world around us.

Textbook: *Differential Equations*, 4th Edition, by Blanchard, Devaney, and Hall. You *do not* need the DE Tools Access Code!
Software: *Mathematica*. Instructions for obtaining Mathematica are available at `it.emory.edu/software/mathematica_access%20.html`.

Tentative Content: We will cover chapters 1-4 and 7 of the textbook, including:

1. **First-Order ODEs** - We will introduce modeling via differential equations, including analytic, qualitative, and numerical methods. We will learn about existence and uniqueness of solutions, equilibria and bifurcations, and linear equations.

2. **First-Order Systems** - We will consider modeling via systems, including the geometry of such systems. We will look at analytic methods, Euler's method, existence and uniqueness, and the Lorenz system. We will also consider a second-order equation, the damped harmonic oscillator.

3. **Linear Systems** - We will look at linear systems of ODEs, including the linearity principle and the eigenvalues of such systems. We will then consider second-order linear systems and linear systems in 3 dimensions.

4. **Forcing and Resonance** - We study harmonic oscillators in more detail, including those affected by external forces and undamped oscillators. The phenomena of resonance and steady states will be examined as well.

5. **Numerical Methods** - We consider numerical methods for solving ODEs in more detail, including an in-depth look at Euler's Method and a new method called Runge-Kutta.

6. **Other Topics** - As time allows, we will consider other topics such as Non-Linear Systems of Equations, Laplace Transforms, or Series Solutions.

Prequisites: Calculus II (Math 112). In particular, integration and differentiation are key to this course. You may want to consult a Calculus text occasionally for refreshers.

Course Expectations:

Attendance: While attendance will not be taken directly, it is essential that you come to class on time every day, *having read the sections to be covered.*

Practice: Each class period, practice problems will be assigned and due at the beginning of the following non-Thursday class. These will be odd-numbered problems from the book; you must complete them AND check your solutions. You are encouraged to work with others on these assignments. Practice problems will be graded on a completion basis.

Quizzes: At the end of every Thursday class, you will be quizzed on the previous week's material. There will be 11 quizzes, each worth 12 points. You may drop your lowest quiz grade at the end of the semester. All quizzes are closed book and notes, and *calculators are banned.*

Homework: Written homework assignments will be due on each Friday, with the exception of exam weeks. They will consist of 3-4 problems from the previous week's material. These assignments must be done individually; in particular, copied homeworks will be considered a violation of the Honor Code. Late homeworks will not be accepted under any circumstances.

Projects: Twice during the semester, you will be asked to complete an outside written project. These will be more in-depth explorations of applications with differential equations, and must be typed. These will be graded not only on mathematical correctness, but also your written exposition. I strongly recommend you use LaTeX for these projects; if you do not know what LaTeX is, I'll be happy to help you get started.

Exams: You will have two midterm exams and a final exam this semester. Midterm exams will be during the evening on Thursdays, from 6-8pm. The dates are:

- **Thursday, February 18th, 6-8pm**
- **Thursday, March 31st, 6-8pm**
- Final exam: **Tuesday, May 3 at 9-12am**.

Midterm exams are not cumulative, but the final exam is cumulative. Exams are closed book and notes, and may not be made up for any reason.

Grading: Homework, projects and exams will be graded based on *correctness*, *completeness*, and *legibility*. Practice will be graded on *completeness* alone; however, completeness means a good faith effort to complete the problem, along with work to support that effort. Your grade for this course will be calculated as follows:

1. Practice: 80 points
2. Quizzes: 10 at 12 points each
3. Homeworks: 10 at 12 points each
4. Projects: 2 at 100 points each
5. Midterms: 2 at 120 points each
6. Final: 240 points

Your final grade is out of 1000 points. Grades will be assigned by the following scale:

A	≥ 925	A-	895-924	B+	865-894
B	825-864	B-	795-824	C+	765-794
C	725-764	C-	695-724	D+	665-694
D	600-664			F	≤ 599

Makeups: In general, makeups are not allowed for exams or assignments. However, if you have a valid reason for a makeup exam, inform me as soon as possible. Valid reasons include medical emergency, a death in the family, or religious observations. Extensions will only be granted for emergency situations.

A Word on Technology: Please leave all iPods, MP3 players, netbooks, etc. stowed and off for the duration of the class. Cell phones should be silenced. Return all seats and tray tables to the upright and locked position.

Honor Code: The Honor Code of Oxford College applies to all work submitted for credit in this course. In order to receive credit for your work, you must place your name on it. By placing your name on submitted work, you pledge that the work has been done in accordance with the given instructions and that you have witnessed no Honor Code violations in the conduct of the assignment.

Tentative Schedule: On the following page is a general outline of how the course will proceed. Note this is tentative in the sense that, while the topics covered for the course will not change, the specific topics and activities on a given day may vary.

This syllabus is a guide for effective learning in this class; it is not a legal contract. The instructor reserves the right to modify the syllabus as needed.

Date	Topics	Test	Sections
1/13	Modeling via Differential Equations		1.1
1/14	Euler's Method; Mathematica Intro		1.4
1/15	Analytic Methods: Separation of Variables		1.2
1/20	Qualitative Methods: Slope Fields		1.3
1/21		Quiz 1	
1/22	Existence and Uniqueness	HW 1 Due	1.5
1/25	Equilibria and the Phase Line		1.6
1/27	Bifurcations		1.7
1/28		Quiz 2	
1/29	Linear Equations	HW 2 Due	1.8
2/1	Analytic Methods: Integrating Factors		1.9
2/3	Modeling via Systems of Equations		2.1
2/4		Quiz 3	
2/5	The Geometry of Systems	HW 3 Due	2.2
2/8	The Damped Harmonic Oscillator		2.3
2/10	Decoupled Systems		2.4
2/11		Quiz 4	
2/12	Euler's Method for Systems		2.5
2/15	Existence and Uniqueness for Systems		2.6
2/17	Review for Exam 1		
2/18	**Exam 1, 6-8pm**	Exam 1	
2/19	The SIR Model for an Epidemic	HW 4 Due	2.7
2/22	The Lorenz Equations		2.8
2/24	Linear Systems and the Linearity Principle		3.1
2/25		Quiz 5	
2/26	Straight-Line Solutions	HW 5 Due	3.2
2/29	Linear Systems with Real Eigenvalues		3.3
3/2	Complex Eigenvalues		3.4
3/3		Quiz 6	
3/4	Repeated and Zero Eigenvalues	Project 1 Due	3.5
3/14	Second-Order Linear Equations		3.6
3/16	The Trace-Determinant Plane		3.7
3/17		Quiz 7	
3/18	Linear Systems in Three Dimensions	HW 6 Due	3.8
3/21	Chapter 3 Cleanup		Ch. 3
3/23	Forced Harmonic Oscillators		4.1
3/24		Quiz 8	
3/25	Sinusoidal Forcing		4.2
3/28	Undamped Forcing and Resonance		4.3
3/30	Review for Exam 2		
3/31	**Exam 2, 6-8pm**	Exam 2	
4/1	Amplitude and Phase of the Steady State	HW 7 Due	4.4
4/4	Chapter 4 Cleanup		Ch. 4
4/6	Error in Euler's Method		7.1
4/7		Quiz 9	
4/8	Improving Euler's Method	HW 8 Due	7.2
4/11	The Runge-Kutta Method		7.3
4/13	The Effects of Finite Arithmetic		7.4
4/14		Quiz 10	
4/15	Chapter 7 Cleanup	HW 9 Due	Ch. 7
4/18-4/22	Additional Topics	Quiz 11; HW 10	Ch. 5/6
4/25	Review for Final Exam	Project 2 Due	
5/3	**Final Exam: Tuesday, May 3 9-12am**	Final	