Differential Equations - MTH 34, Sec. D01–76932

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Class times and room: Mo, We, 12:00 to 13:50 at CP308.
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Overview of the course.
Understanding and solving differential equations is an essential tool in all the sciences and in mathematics. Most models in any science are based in differential equations (this includes physics, economics, finance, biology...) This course aims to give an understanding of what ordinary differential equations (**ODE**) are, how they are used to model processes in science and some basic tools to solve some of them. **It is important that you master these tools as you will need them in your future studies.** The main topics that we will cover are:

- How to model using differential equations.
- Solutions of differential equations: what they mean analytically, geometrically and numerically.
- Linear equations: how to find analytic solutions.
- First order systems of differential equations: modelling, geometric interpretation and numerical techniques. Finding analytic solutions for some special systems. The harmonic oscillator and forced harmonic oscillator. Resonance.
- Finding solutions using power series. Nonlinear systems: quantitative analysis.
- Laplace transforms: a tool to find analytic solutions to ODE's.

Some resources:

- **Classes:** One purpose of attending classes is to learn faster than if you study on your own with a book. In addition, classes have the advantage of being interactive: you can ask questions. To take full advantage of classes you must do a lot of work on your own before (by reviewing the previous class and looking ahead) and after each class (by making sure that you understood everything and working on the exercises). Otherwise classes are useless.
- **Meetings with the instructor:** If you have not understood something well and need help, or for any other matters concerning the course, you can also talk to the instructor. Please write an e-mail to the address above to arrange a time, or go to office hours.
- **Computer algebra programs:** Students are strongly encouraged to use computer algebra programs (the university has Mathematica; there are also many resources online) in this class. Use them to understand concepts, but not to do computations that you can easily do by hand.

Textbook:

- *Differential Equations,* 3rd *Ed.*, by P. Blanchard, R. L. Devaney, G. R. Hall

Student's responsibilities

- To use the **resources** available (some are above) to attain the main goal: <u>to learn</u>.
- To **prepare** each class by studying the material in the previous class, solving the recommended exercises and reading ahead in the text (or in internet) the material that will be presented.
- To work on many **exercises**, as it is impossible to learn mathematics without doing so. The main purpose of the exercises is not quite to find the answer, but to learn from them. Therefore, if you work in an exercise for a long time without finding a correct answer, do not feel frustrated, instead consider how much you have learned in the process.
- To **ask** questions during classs or tutorials about anything that has not been understood. EVEN IF YOU THINK THAT YOUR QUESTION IS TOO TRIVIAL, I GUARANTEE THAT MANY OTHER STUDENTS WILL BENEFIT FROM THE ANSWER. So when in doubt do your classmates a favor and ASK!

Instructor's responsibilities

- To act as *facilitator* of the learning process of the students, and to assist with any question that students may have about the material.
- To give tests and exams of appropriate difficulty. To grade tests and exams promptly and explain the students the meaning of their grades.

Some Rules

- Cell phones, music devices and laptops are not allowed during class time.
- Tests will not be repeated. The only exception, in some situations, is if the instructor receives notice of the absence (via e-mail or telephone) **on the day of the test or quiz**.

Exams and homeworks:

- There will be three **tests** during the term, **each worth 20%** of the final grade.
- Homework will be **assigned** but **not collected**. It is the **student's responsibility to do the exercises** assigned for each topic and make sure that they are well understood. You can ask questions about the homework during the class. Class participation will count as **extra credit**.
- The **final exam** will count **40%** of the final grade.

Class plan and assigned exercises. MTH 34. Professor Luis Fernández

Use this to prepare each class in advance. Note that dates may change depending on how fast we advance.

DATE	SECTION	MANDATORY EXERCISES
We 9/3	1.1 Modeling via Differential Equations	p. 14: 1, 2, 3, 5, 7, 11, 13–15, 17, 19, 21–23
	1.2 Analytic Technique: Separation of Variables	p. 33: 1–19 odd, 4, 10, 20, 27–30, 36, 39, 41, 42
Mo 9/8	1.3 Qualitative Technique: Slope Fields	p. 47: 1, 3, 6, 7, 9, 11–14, 16–18, 22
We 9/10	1.4 Numerical Technique: Euler's method	p. 61: 1, 2, 5, 6, 7, 11, 14, 16
Mo 9/15	1.5 Existence and Uniqueness of Solutions	p. 71: 1, 3, 5–7, 11, 12, 14, 16
	1.6 Equilibria and the Phase Line	p. 89: 1, 3, 4, 5, 7, 13, 15, 17, 18, 23, 25, 29, 37, 43, 44
We 9/17	1.8 Linear Equations	p. 121: 1, 3, 5, 7, 11, 13, 17, 18, 21, 23, 29
Mo 9/22	1.9 Integrating Factors for Linear Equations	p. 133: 1, 3, 5, 9, 11, 20, 21, 23, 24
We 9/24	NO CLASS	
Mo 9/29	**TEST 1**	
We 10/1	2.1 Modeling via Systems	p. 161: 1-8,11-15,19-24
	2.2 The Geometry of Systems	p. 178: 1-5,7,9,11,12,13,15, 18,19, 21, 23–27
Mo 10/6	2.3 The Damped Harmonic Oscillator	p. 187: 1,5, 9, 10
	2.4 Additional Analytic Methods for Special Systems	p. 194: 1–7 odd, 10, 13
We 10/8	2.5 Euler's Method for Systems	p. 202: 1, 4, 5, 7
	2.6 Existence and Uniqueness for Systems	p. 208: 3, 8, 9, 11
Mo 10/13	NO CLASS	COLUMBUS DAY
We 10/15	3.1 Properties of Linear Systems	p. 258: 4, 5–11 odd, 14–17, 19, 24, 25, 27, 28, 31–35[2]
Mo 10/20	3.2 Straight-Line Solutions	p. 277: 1–7 odd, 11, 13, 15–19, 21, 23
We 10/22	3.3 Phase Planes (Real Eigenvalues)	p. 293: 1–11 odd, 15, 19, 21, 27
Mo 10/27	3.4 Complex Eigenvalues	p. 310: 1-15 odd, 17, 19, 23-26
We 10/29	**TEST 2**	
Mo 11/3	3.5 Repeated and Zero Eigenvalues	p. 327: 1-7 odd, 11–15 odd, 16, 18, 21–23
We 11/5	3.6 Second-order Linear Equations	p. 342: 1–15 odd, 21, 23,26, 29, 34, 40
Mo 11/10	3.7 The Trace-Determinant Plane	p. 358: 1, 2, 3, 5, 9, 11, 12
We 11/12	4.1 Forced Harmonic Oscillators	p. 399: 1, 5, 7, 11, 15, 18–20, 25, 27, 31, 34–37, 40
	4.2 Sinusoidal Forcing	p. 412: 1, 5, 9, 11, 13, 15–19, 23
Mo 11/17	4.3 Undamped Forcing and Resonance	p. 424: 1, 5, 6, 7, 10, 13–17 odd, 21
We 11/19	App. B Power Series Method	p. 748: 1–17 odd
Mo 11/24	5.1 Equilibrium Point Analysis	p. 472: 1, 3, 5–7, 11, 17
	5.2 Qualitative Analysis	p. 487: 1–11 odd
We 11/26	6.1 Laplace Transforms[3]	p. 577: 1–3, 5–9, 12, 13, 15, 20, 24, 27
Mo 12/1	**TEST 3**	
We 12/3	6.2 Discontinuous Functions	p. 585: 1, 2, 3–9 odd, 13, 17, 19
Mo 12/8	6.3 Second-Order Equations	p. 599: 1, 3, 5, 15, 17, 19–21, 27, 29, 31, 33, 34
We 12/10	6.4 Delta Functions and Impulse Forcing	p. 608: 1–9
Mo 12/15	REVIEW FOR THE FINAL	Prepare questions for the review

[1] This section may be deferred until the topic harmonic oscillator is considered in more detail in chapter 4.

[2] Problem 35 is worth emphasizing; the Wronskian is introduced and Abel's Theorem can be discussed here.

[3] Fourier Transforms can be briefly mentioned. We focus on Laplace Transforms.

REMEMBER: The exercises listed correspond to the material that will be covered on the date they are listed.
Before each class, read the section that corresponds to that class and attempt some of the exercises. This way when you hear the explanations in class, you will understand the material much better.