

Syllabus for Math 2250-004 Differential Equations and Linear Algebra

Fall 2016

Instructor Professor Nick Korevaar

email korevaar@math.utah.edu

office LCB 204, 801.581.7318

office hours T 9:45-10:45 a.m. in LCB 204; W 4:30-6:00 p.m. and H 10:40-11:40 a.m. in WEB 1622.

Lecture MTWF 8:35-9:25 a.m. MWF in JWB 335, T in JFB 103

Laboratory sections with Patrick Webb, webbp@gmail.com

2250-005 H 8:35-9:25 a.m. JTB 120

2250-006 H 9:40-10:30 a.m. JTB 120

with Qing Xia, xia@math.utah.edu

2250-007 H 7:30-8:20 a.m. LCB 222

2250-008 H 8:35-9:25 a.m. LCB 215

Course websites

Daily lecture notes and weekly homework assignments will be posted on our public home page.

<http://www.math.utah.edu/~korevaar/2250fall16>

I expect you to bring copies of the lecture notes to class, as they are an outline for the topics we will cover and the problems we will work out in class. Most students find that using and annotating the notes is helpful in understanding the class material. Some lecture material is included in the notes and there are also large open spaces in which we will work out examples together. My goal is to have class notes posted by noon the day before class. This should give ample time for you to print them out. Printing for math classes is free in the Math Department Rushing Student Center, in the basement of LCB.

Grades will be posted on our CANVAS course page; access via Campus Information Systems.

Textbook *Linear Algebra & Differential Equations with Introductory Partial Differential Equations and Fourier Series*, ISBN-13: 978-1-269-42557-5.

This text is a hybrid of the three texts: *Differential Equations and Linear Algebra* 3rd Edition, by Edwards and Penney; *Applied Partial Differential Equations with Fourier Series and Boundary Value Problems*, 5th edition, by Haberman; *Elementary Linear Algebra*, by Edwards and Penney. You should definitely buy this version of the text if you plan to take the 4th semester in the new engineering math sequence, Math 3140, or the PDE course Math 3150. If your math courses will terminate with Math 2250, then the 3rd edition *Differential Equations and Linear Algebra* text by Edwards-Penney will suffice. (This was the text for Math 2250 thru summer 2013.)

Final Exam logistics: Friday December 16, 8:00-10:00 a.m., in our MWF classroom JWB 335.

Catalog description for Math 2250: This is a hybrid course which teaches the allied subjects of linear algebra and differential equations. These topics underpin the mathematics required for most students in the Colleges of Science, Engineering, Mines & Earth Science.

Prerequisites: Math 1210-1220 or 1310-1320 (or 1250-1260 or 1311-1321, i.e. single-variable calculus.) You are expected to have learned about vectors and parametric curves in one of these courses, or in Math 2210 or Physics 2210 or 3210. Practically speaking, you are better prepared for this course if you've had elements of multivariable calculus in courses such as 1320, 1321, or 2210 and if your grades in the prerequisite courses were above the "C" level.

Grading

Math 2250-004 is graded on a curve. **note:** In order to receive a grade of at least "C" in the course you must earn a grade of at least "C" on the final exam. To see historical distributions of grades in my Math 2250 classes you can look at my old course home pages, on the exam pages.

Details about the content of each assignment type, and how much they count towards your final grade are as follows:

- **Homework (15%):** Homework from roughly three textbook sections is due every Friday at the beginning of class, based on lecture sections covered through the preceding Wednesday. All assignments will be

posted on our public page, the Friday before they are due. Several problems per section will be randomly selected for grading. Two of a student's lowest homework scores will be dropped. Only hard-copy assignments will be accepted—no digital copies—and no late homework will be accepted.

- Quizzes (5%): At the end of most Friday classes, a short 1-2 problem quiz will be given, taking roughly 10 minutes to do. The quiz will cover relevant topics from the week's lectures, homework, and lab section work. Two of a student's lowest quiz scores will be dropped. There are no makeup quizzes. You will be allowed and encouraged to work together on these quizzes.
- Super Quizzes (5%) : Two Fridays prior to each exam, a more extensive quiz will be given, consisting of 3-5 problems and taking roughly 30 minutes to complete. The super quiz will cover material from the preceding weeks.
- Midterm exams (30%): Two class-length midterm exams will be given, On Friday September 30 and Friday November 11. Review for the exams will occur either in lecture or in the lab sections, in the days before the exams. No midterm scores are dropped.
- Final exam (30%): A two-hour comprehensive exam will be given at the end of the semester. As with the midterms, a practice final will be posted. Please check the final exam time, which is the official University scheduled time. It is your responsibility to make yourself available for that time, so make any arrangements (e.g., with your employer) as early as possible.
- Lab (15%): Every week a Teaching Assistant (TA) -directed lab section will be held. In Lab, the TA will hand out problem worksheets and will facilitate student-led group work. The worksheet problems will provide guided practice with both basic methods, as well as longer in-depth problems with physical and engineering applications. Some of the problems will be from the homework due on Fridays. Others will be handed in separately before the start of class on Wednesdays. Credit will be given for both lab attendance and completed Wednesday worksheets. Students should expect that worksheets will take additional time outside of lab to finish completely. None of the lab worksheet grades will be dropped. The TA's will be available for additional office hours in WEB 1622.

Strategies for success

- Attend class and lab regularly.
- Read the relevant text book sections and lecture note outlines *before* you attend class.
- Ask questions and become involved.
- Plan to do homework daily; try homework on the same day that the material is covered in lecture; do not wait until just before homework and lab reports are due to begin serious work.
- Form study groups with other students.

Students with disabilities

The University of Utah seeks to provide equal access to its programs, services and activities for people with disabilities. If you will need accommodations in the class, reasonable prior notice needs to be given to the Center for Disability Services, 162 Olpin Union Building, 581-5020 (V/TDD). CDS will work with you and the instructor to make arrangements for accommodations. All information in this course can be made available in alternative format with prior notification to the Center for Disability Services.

Learning Objectives for 2250

The goal of Math 2250 is to master the basic tools and problem solving techniques important in differential equations and linear algebra. These basic tools and problem solving skills are described below.

The essential topics

Be able to model dynamical systems that arise in science and engineering, by using general principles to derive the governing differential equations or systems of differential equations. These principles include linearization, compartmental analysis, Newton's laws, conservation of energy and Kirchoff's law.

Learn solution techniques for first order separable and linear differential equations. Solve initial value problems in these cases, with applications to problems in science and engineering. Understand how to approximate solutions even when exact formulas do not exist. Visualize solution graphs and numerical approximations to initial value problems via slope fields.

Become fluent in matrix algebra techniques, in order to be able to compute the solution space to linear systems and understand its structure; by hand for small problems and with technology for large problems.

Be able to use the basic concepts of linear algebra such as linear combinations, span, independence, basis and dimension, to understand the solution space to linear equations, linear differential equations, and linear systems of differential equations.

Understand the natural initial value problems for first order systems of differential equations, and how they encompass the natural initial value problems for higher order differential equations and general systems of differential equations.

Learn how to solve constant coefficient linear differential equations via superposition, particular solutions, and homogeneous solutions found via characteristic equation analysis. Apply these techniques to understand the solutions to the basic unforced and forced mechanical and electrical oscillation problems.

Learn how to use Laplace transform techniques to solve linear differential equations, with an emphasis on the initial value problems of mechanical systems, electrical circuits, and related problems.

Be able to find eigenvalues and eigenvectors for square matrices. Apply these matrix algebra concepts to find the general solution space to first and second order constant coefficient homogeneous linear systems of differential equations, especially those arising from compartmental analysis and mechanical systems.

Understand and be able to use linearization as a technique to understand the behavior of nonlinear autonomous dynamical systems near equilibrium solutions. Apply these techniques to non-linear mechanical oscillation problems and other systems of two first order differential equations, including interacting populations. Relate the phase portraits of non-linear systems near equilibria to the linearized data, in particular to understand stability.

Develop your ability to communicate modeling and mathematical explanations and solutions, using technology and software such as Maple, Matlab or internet-based tools as appropriate.

Problem solving fluency

Students will be able to read and understand problem descriptions, then be able to formulate equations modeling the problem usually by applying geometric or physical principles. Solving a problem often requires specific solution methods listed above. Students will be able to select the appropriate operations, execute them accurately, and interpret the results using numerical and graphical computational aids.

Students will also gain experience with problem solving in groups. Students should be able to effectively transform problem objectives into appropriate problem solving methods through collaborative discussion. Students will also learn how to articulate questions effectively with both the instructor and TA, and be able to effectively convey how problem solutions meet the problem objectives.

Week-by-Week Topics Plan

Topic schedule is subject to slight modifications as the course progresses, but exam dates are fixed.

- Week 1:** 1.1-1.4; differential equations, mathematical models, integral as general and particular solutions, slope fields, separable differential equations.
- Week 2:** 1.4-1.5, EP 3.7, 2.1-2.2; separable equations cont., linear differential equations, circuits, mixture models, population models, equilibrium solutions and stability.
- Week 3:** 2.2-2.4; equilibrium solutions and stability cont., acceleration-velocity models, numerical solutions.
- Week 4:** 2.5-2.6, 3.1; numerical solutions cont., linear systems; Super quiz over chapters 1-2.
- Week 5:** 3.1-3.4; linear systems, matrices, Gaussian elimination, reduced row echelon form, matrix operations.
- Week 6:** 3.5-3.6; matrix inverses, determinants, review; **Midterm exam 1 on Friday September 30** covering material from weeks 1-6.
- Week 7:** 4.1-4.4; vector spaces, linear combinations in \mathbb{R}^n , span and independence, subspaces, bases and dimension.
- Week 8:** 4.4, 5.1-5.3; second-order linear DEs, general solutions, superposition, homogeneity and constant coefficients.
- Week 9:** 5.4-5.6; mechanical vibrations, pendulum model, particular solutions to non-homogeneous problems; Super quiz.
- Week 10:** 5.6, 10.1-10.3; forced oscillations and practical resonance, Laplace transforms, solving IVPs with transforms, partial fractions and translations.
- Week 11:** 10.4-5; Unit steps, convolutions; **Midterm exam 2 on Friday November 11**, covering weeks 7-11 material.
- Week 12:** EP 7.6, 6.1-6.2, 7.1; impulse functions, eigenvalues and eigenvectors, diagonalization, intro to first-order systems of ODE's.
- Week 13:** 7.2-7.4; Matrix systems of DEs, eigenanalysis, spring systems, forced undamped systems, practice resonance.
- Week 14:** 7.4, 9.1-9.3; Equilibria, stability, phase portraits for non-linear systems, ecological models; Super quiz
- Week 15:** 9.3, 9.4; population models, nonlinear mechanical systems, review.
- Week 16:** Finals week: comprehensive **final exam Friday December 16, 8:00-10:00 a.m. in MWF classroom JWB 335. This is the University scheduled time.**