MATHEMATICS 2250-1
Differential Equations and Linear Algebra
SYLLABUS
Fall semester 2011

when: MTWF 8:35-9:25
where: WEB L104
2250-1 instructor: Prof. Nick Korevaar
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email: korevaar@math.utah.edu
office hours: MW 2:20-3:00, T 10:40-11:30, Th 9:40-10:30, and by appointment
2250-6: Th 8:35-9:25, JFB 103 (except OSH WPRA on September 8)
instructors: Nik Aksamit and Kishalaya Saha
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course home page: www.math.utah.edu/ ∼korevaar/2250fall11

text: *Differential Equations and Linear Algebra*
by C.Henry Edwards and David E. Penney
ISBN = 9780558141066 (custom edition)
ISBN = 9780136054252 (non-custom edition)

prerequisites: Math 1210-1220 (or 1250-1260 or 1270-1280, i.e. single-variable calculus.) You are also expected to have learned about vectors and parametric curves (Math 2210 or Physics 2210 or 3210). Practically speaking, you are better prepared for this course if you've had multivariable calculus (1260, 1280, 2210, or equivalent), and if your grades in the prerequisite courses were above the "C" level.

lecture/section format: MTWF lecture presentations in 2250-1 are complemented by the Thursday section 2250-6. These sections will be a chance to discuss concepts and review homework problems that are due the next day, on Friday at the start of class. Two of the Thursday section dates are reserved for midterm exams.

homework/projects: Homework will be assigned weekly. Your initial assignment is due on the Friday of the first week. After that, assignments will be made on Fridays and be due the following Friday, at the start of class. You will expected to submit written solutions for a subset of the assigned problems. This subset will be specified in the original assignment. In addition, there will be quizzes at the start of Friday classes, covering that week's concepts and all of the homework.The quiz problems will generally require less originality and be less complicated than the more challenging of the homework problems.

You are encouraged to make friends and study groups for discussing homework, although you will each hand in your own solutions to specified problems. (Copying someone elses work is wrong and won't be productive).

There will be several computer projects assigned during the semester, related to the classroom material. They will be written using the software package MAPLE, although you may use MATLAB or other software for your solutions, if you prefer. In addition, you will be asked to use computer software to check various homework calculations throughout the course.

There is a Math Department Computer Lab in the Rushing Student Center at which you all automatically have accounts, and there are other labs around campus where MAPLE, MATLAB, and other software is also available, for example at the College of Engineering and Marriott Library.

There will tutoring center support for the MAPLE in these projects (and for your other homework) as well. There will be introductory sessions to the Math lab and to MAPLE. These will be held in LCB 115, and times will be announced during the first week of classes.

tutoring center: The Math tutoring center is in the Rushing Student Center, in the basement between LCB and JWB on President's Circle. You will be able to find tutors there who can help with Math 2250 homework (8 a.m.- 8 p.m. Monday-Thursday and 8 a.m.- 4 p.m. on Fridays). The page *www.math.utah.edu/ugrad/mathcenter.html* has more information.

exams: There will be two in-class midterms (closed book, scientific calculator only), as well as a final exam. The dates are as follows:

exam 1: Thursday September 29. Probable course material is chapters 1-3.
exam 2: Thursday November 10 . Probable course material is chapters 4-5,10.
Final Exam: 8:00-10:00 a.m. Friday December 16, in our classroom WEB L104. This is the University-scheduled time. The exam will cover the entire course, although the material after the second midterm (Chapters 6-7,9) can be expected to have extra weight.

grading: The Friday quizzes will count for 10% of your total grade. Two quiz scores may be dropped. Each midterm will count for 20% of your grade, the graded course homework and projects will count for a total of 20%, and the final exam will make up the remaining 30% of your grade. Beyond their contributions to your course grades, the real value in carefully working the homework problems and in doing the projects is that mathematics (like anything) must be practiced and experienced to really be learned. **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.

University dates to keep in mind: Wednesday August 31 is the last day to drop this class, Tuesday September 6 is the last day to add it. Friday October 21 is the last day to withdraw. (All of these dates are easy to find from the University home page.)

ADA statement: The American with Disabilities Act requires that reasonable accomodations be provided for students with physical, sensory, cognitive, systemic, learning, and psychiatric disabilities. Please contact me at the beginning of the semester to discuss any such accommodations for the course.

course outline: This course is an introduction to differential equations, and how they are used to model problems arising in engineering and science. Linear algebra is introduced as a tool for analyzing systems of differential equations, as well as standard linear equations. Computer projects will be assigned to enhance the material.

We will cover most of chapters 1-10 in the Edwards-Penney text, in addition to two supplementary sections which cover RLC electrical circuits and additional Laplace transform material.

The course begins with first order differential equations, a subject which you touched on in Calculus. Recall that a differential equation is an equation involving an unknown function and its derivatives, that such equations often arise in science, and that the order of a differential equation is defined to be the highest order derivative occuring in the equation. The goal is to understand the solution functions to differential equations since these functions will be describing the scientific phenomena which led to the differential equation in the first place. In chapters one and two of Edwards-Penney we learn analytic techniques for solving certain first order DE's, the geometric meaning of graphs of solutions, and the numerical techniques for approximating solutions which are motivated by this geometric interpretation. We will carefully study the logistic population growth model from mathematical biology and various velocity-acceleration models from physics.

At this point in the course we will take a four week digression from differential equations, to learn the fundamentals of linear algebra in chapters 3-4. You need a basic understanding of this field of mathematics in order to talk meaningfully about the theory of higher order linear DE's and of systems of linear DE's. Chapter 3 starts out with matrix equations and the Gauss-Jordan method of solution. When you see such equations in high-school algebra you might be thinking of intersecting lines in the plane, or intersecting planes in space, or ways to balance chemical reactions, but the need to understand generally how to solve such equations is pervasive in science. From this concrete beginning we study abstract vector spaces in chapter 4. This abstract theory is useful not only to the understanding of Euclidean space $\mathbf{R}^n$, but it is also the framework which allows us to understand solution spaces to systems of linear differential equations.

In Chapter 5 we will study the theory of second order and higher-order linear DE's, and focus on the ones which describe basic mechanical vibrations and electrical circuits. You may have been introduced to these equations in Calculus or physics mechanics, and we will treat them more completely now, including a careful study of forced oscillations and resonance.

After Chapter 5 we will jump ahead to Chapter 10, the Laplace transform. This "magic" transform converts linear differential into algebraic equations, which you can solve before "inverse-transforming". You will have to see it in action to appreciate it. You will see, for example, that this method gives a powerful way to study forced oscillations in the physically important cases that the forcing terms are square waves or other discontinuous functions. Electrical engineers often use Laplace transform techniques to understand circuits.

To succesfully model more complicated physical systems like shaking in multi-story buildings, one needs the framework of linear systems of differential equations. The linear algebra of eigenvalues and eigenvectors is developed in chapter 6 as a tool for studying systems of DE's in chapter 7, where for example eigenvalues and eigenvectors will be related to fundamental modes for mass-spring systems. We will also understand these systems of DEs from the point of view of Laplace transforms.

Our final course topic is Chapter 9, nonlinear systems and phenomena. This topic ties together many different ideas, as we discuss the stability of equilibria, based on linearization, and consider the geometry of solution trajectories in the phase portrait of autonomous systems. Many of the most interesting (complicated) dynamical systems on earth are non-linear; perhaps the most famous current example of this is global climate change. (We won't be able to study that topic in this course.)

Tentative Daily Schedule

exam dates fixed,
daily subject matter approximated

M	22 Aug	1.1	differential equations and mathematical models
T	23 Aug	1.2	integral as general and particular solutions
W	24 Aug	1.3	slope fields and solution curves
F	26 Aug	1.4	separable differential equations
M	29 Aug	1.4-1.5	and introduction to linear differential equations
T	30 Aug	1.5, EP3.7	cont'd, and circuits supplement
W	31 Aug	2.1	improved population models
F	2 Sept	2.1-2.2	equilibrium solutions and stability
M	5 Sept	none	Labor Day
T	6 Sept	2.2	cont'd
W	7 Sept	2.3	acceleration-velocity models
F	9 Sept	2.4-2.6	numerical methods
M	12 Sept	2.4-2.6	continued
T	13 Sept	3.1-3.2	introduction to linear systems
W	14 Sept	3.1-3.3	matrices and gaussian elimination
F	16 Sept	3.3	reduced row echelon form
M	19 Sept	3.3-3.4	matrix operations
T	20 Sept	3.4-3.5	matrix inverses
W	21 Sept	3.5	continued
F	23 Sept	3.6	determinants
M	26 Sept	3.6	continued
T	27 Sept	4.1-4.2	3-space as a vector space
W	28 Sept	4.2-4.3	n-space, subspaces, linear combinations
Th	29 Sept	1-3.6	EXAM 1
F	30 Sept	4.3-4.4	dependence, independence, bases, dimension
M	3 Oct	4.4	continued
T	4 Oct	4.4	general vector spaces
W	5 Oct	4.4,4.7	continued
F	7 Oct	5.1	introduction to second order differential equations
M	10 Oct	none	Fall break
T	11 Oct	none	Fall break
W	12 Oct	none	Fall break
F	14 Oct	none	Fall break

M	17 Oct	5.2-5.3	general solutions to linear DEs
T	18 Oct	5.2-5.3	homogeneous equations with constant coefficients
W	19 Oct	5.3-5.4	repeated and complex roots
F	21 Oct	5.4	mechanical vibrations
M	24 Oct	5.4, 3.7	and RLC circuits
T	25 Oct	5.5	nonhomogeneous equations and undetermined coefficients
W	26 Oct	5.5-5.6	forced oscillations and resonance
F	28 Oct	5.6	continued
M	31 Oct	5.6, EP3.7	RLC circuits
T	1 Nov	10.1-10.2	Laplace transforms and initial value problems
W	2 Nov	10.2-10.3	partial fractions and translations
F	4 Nov	10.4-10.5	derivatives, integrals and products
M	7 Nov	10.4-10.5	periodic and piecewise continuous input functions
T	8 Nov	EP 7.6	impulses and delta functions
W	9 Nov	4.5-EP7.6	review
Th	10 Nov	4.5-EP 7.6	EXAM 2
F	11 Nov	6.1	eigenvalues and eigenvectors
M	14 Nov	6.1-6.2	diagonalization of matrices
T	15 Nov	6.2-6.3	discrete dynamical systems
W	16 Nov	6.3	applications
F	18 Nov	7.1	existence and uniqueness for first order systems of DEs
M	21 Nov	7.2-7.3	eigenvalue-eigenvector method for linear systems of DEs
T	22 Nov	7.2-7.3	applications of 1st order ODE systems
W	23 Nov	7.4	spring systems
F	25 Nov	none	Thanksgiving
M	28 Nov	7.4	forced undamped spring systems - practical resonance
T	29 Nov	7.5	chains for defective eigenspaces
W	30 Nov	9.1-9.2	introduction to nonlinear systems of differential equations
F	2 Dec	9.1-9.3	linearization near equilibria
M	5 Dec	9.2-9.3	classification of equilibrium solutions; population models
T	6 Dec	9.3-9.4	cont'd, and nonlinear mechanical systems
W	7 Dec	9.4	nonlinear mechanical systems
F	9 Dec	review	entire course
F	16 Dec	FINAL EXAM	entire course, 8-10 a.m., in our classroom