

# Math 2250-10: Ordinary Differential Equations and Linear Algebra Fall 2015

<b>Time &amp; Location</b>	10:45-11:35 AM, <b>MWF in WEB (Warnock Engineering Building) L103, T in WEB 2230</b>
<b>Instructor</b>	Chris Miles
<b>Contact</b>	Office hours: <b>T 9:45-10:45 AM, Th 1:00-2:00 PM</b> or <b>always available by appointment</b> Office location: LCB (LeRoy Cowles building) 326 Email: miles@math.utah.edu Website: www.math.utah.edu/~miles
<b>Lab information</b>	Instructors: Huachen Chen (hchen@math.utah.edu), Chee Han Tan (tan@math.utah.edu) Section 11: Th 9:40-10:30 AM in <b>WBB (William Browning building) 207</b> Section 12: Th 10:45-11:35 AM in <b>WBB 207</b>
<b>Textbook</b>	<i>Linear Algebra &amp; Differential Equations</i> , by Edwards & Penney, ISBN: 9781269425575.  The above textbook is a custom printed edition for this course, along with the next courses in the sequence, Math 3140/50. If you plan on taking either of these courses, then you should buy this custom printed edition, which can be found at the bookstore.  If you do not plan on taking these courses for whatever reason, then the 3 <sup>rd</sup> edition, <i>may</i> suffice. If you go this route, <b>it is at your own risk</b> , as I do not know the magnitude of the changes between the editions.
<b>Course website</b>	Canvas will be used regularly for this course. Checking the site often for updates is strongly recommended. It can be access via my website or at: <a href="http://utah.instructure.com/courses/348396">utah.instructure.com/courses/348396</a> .
<b>Technology</b>	<b>Calculators will not be allowed on quizzes or exams</b> , but the use of technology is strongly encouraged otherwise. Students are <i>not</i> expected to have prior programming experience, but will be required to run snippets of code that will be provided in lecture and lab. These snippets provide an essential aid to the theory. The code will be in some mix of MATLAB, Maple, and Mathematica.
<b>Grading</b>	The grade for each student will be calculated by the following breakdown:  homework (10%) + lab (15+5=20%) + quizzes (15%) + 2 exams (2x15=30%) + final (25%).  <b>Attendance to the lab section is required</b> , and will count for 5% of a student's total grade. The remaining 15% of the lab grade will be determined by the lab submissions that will be graded. The policies, grading criteria, and expectations of the lab will be communicated by the lab instructor the first week. Questions about the content or grading of the lab should be directed toward the lab instructor.  Homework assignments will be given either at the end of class or on Canvas. A subset of the problems will be selected to be turned in weekly (likely every Wednesdays) and will be <b>graded for both completeness and correctness</b> , but all of the problems assigned are recommended to the student to attempt and are considered "fair game" for material on exams and quizzes. Questions about homework can be asked in lecture <i>prior</i> to the homework being due. <b>Late homework will not be accepted.</b>  Quizzes will be every Friday unless noted otherwise. They will be approximately 15-20 minutes in length and given at the beginning of class. They will cover the material discussed in class since the previous quiz. <b>There will be no make-up quizzes but the lowest quiz grade will be dropped from every student's score.</b>  There will be two in-class mid-term exams. They are tentatively scheduled for the <b>weeks of September 28<sup>th</sup> and November 9<sup>th</sup></b> . Exact dates will be announced closer to the exam and will be determined based on the pace of the course. <b>There will be no make-up exams.</b>

**Final exam** All students are expected to take the comprehensive final exam and **cannot** pass the course without taking it. The room will be announced during the last week of classes. All students are expected to arrange their personal schedule to allow them to take the exam at this time. Students with conflicts should speak to the instructor as soon as possible but unless it is an absolute emergency no student will be allowed to take the final exam early. Note the time:

**FINAL EXAM: TUESDAY, DECEMBER 15, 2015 10:30 – 12:30 AM**

**Resources** The math department offers free drop-in tutoring for students. The center is located underneath the walkway between LCB and JWB and can be accessed by entering either building. They are open M-Th 8:00 AM-8:00 PM and F 8:00 AM-6:00 PM.

**Cheating** If a student is caught cheating on any homework, quiz, or exam, they will automatically receive a 0 for that assignment. Depending on the severity of the cheating, they may fail the class.

**Course objectives** 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:

**Tools and skills**

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 a series of transformations that include utilizing the methods of calculus. Students will be able to select the appropriate calculus operations to apply to a given problem, execute them accurately, and interpret the results using numerical and graphical computational aids.

Students will 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 articulate how problem solutions meet the problem objectives.

### **ADA statement**

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.

### **Schedule**

**Week 1:** §1.1-1.4 — math models, general/particular solutions, slope fields, separable equations.

**Week 2:** §1.4-1.5, §2.1-2.2 — linear equations, circuits, mixture models, population models.

**Week 3:** §2.2-2.4 — equilibria, stability, acceleration-velocity models, numerical solutions.

**Week 4:** §2.5-2.6, §3.1 — numerical schemes, linear systems;

**Week 5:** §3.1-3.4 — linear systems, matrices, Gaussian elimination, reduced row echelon form

**Week 6:** §3.5-3.6 — matrix inverses, determinants. **midterm exam 1 on material from weeks 1-5**

**Week 7:** §4.1-4.4 — vector spaces, linear dependence, span, subspaces, bases and dimension.

**Week 8:** §5.1-5.3 — 2<sup>nd</sup> order DEs, general solutions, superposition, homogeneity, constant coefficients.

**Week 9:** §5.4-5.6 — mechanical vibrations, pendulums, solutions to non-homogeneous problems.

**Week 10:** §5.6, §10.1-10.3 — forced oscillations, resonance, Laplace transforms.

**Week 11:** §10.4-5 — unit steps- convolutions, **midterm exam 2 on material from weeks 6-10.**

**Week 12:** §6.1-6.2, §7.1 — impulse functions, eigenvectors/values, 1<sup>st</sup> order systems.

**Week 13:** §7.2-7.4 — matrix systems, eigen-analysis, spring systems, forced undamped systems.

**Week 14:** §7.4, §9.1-9.3 — equilibria, stability, phase portraits, ecological models.

**Week 15:** §9.3-9.4 — population models, nonlinear mechanical systems.

**Week 16:** finals week

*Note:* This syllabus is **not** a binding legal contract. It may be modified at the instructor's discretion at any time, but all adjustments will be announced.