MATH 2250-001, Differential Equations and Linear Algebra, Spring 2018

Instructor: Nathan Willis  
Class Meetings: Monday, Tuesday, Wednesday, and Friday at 7:30-8:20 in CSC 208  
Lab Instructor:  
Lab Meetings: Thursday in JTB 140 from 7:30-8:20 AM (Section 002) or 8:35-9:25 AM (Section 003)  
Nathan’s Email: willis@math.utah.edu  
Lab Instructor’s Email:  
Nathan’s Office Hours: TBD.  
Lab Instructor’s Office Hours: TBD.  
Final Exam: Monday April 30 2018 from 8:00-10:00 AM in CSC 208  
Canvas: Canvas will be used for posting course announcements, homework assignments, grades, files and any relevant supplementary material. You are also welcome to make use of the Canvas discussion board to discuss course problems or topics. You can access the Canvas page through CIS or by logging in at utah.instructure.com. Students should check the Canvas page regularly for course information and resources. Email notifications and correspondence will be sent to the student’s UMail address ([u-number]@utah.edu); this email account must be checked regularly.  
Grading: The following are the grade components and the percentage each contributes to a student’s final grade:  

- **Homework Assignments (20%)** - Roughly three textbook sections are due every Friday (with the exception of exam weeks) at the end class. The homework will typically cover lectures through to the preceding Friday. If you click on a homework assignment, you will see listings of problems. After the homeworks are turned in three problems will be chosen to be graded, each out of 5 points. There will also be 5 points given for completing all problems. Making each homework out of 20 points. Two of a student’s lowest homework scores will be dropped. Homework will only be accepted in class, no electronic copies. No late homework will be accepted. Late is considered anytime after I leave the classroom on the day the assignment is due.  

- **Quizzes (5%)** - At the end of every Wednesday class, a short 1-2 problem quiz will be given, taking roughly 10-15 minutes to complete. The quiz will cover relevant topics covered since the previous Wednesday. Two of a student’s lowest quiz scores will be dropped.  

- **Lab (20%)** - Every Thursday a Teaching Assistant- (TA) directed lab section will be held. These lab sections will have smaller class sizes, consisting of working on lab worksheets. The lab worksheets will tend to cover longer, more in-depth problems than that found in homeworks and exams, and will sometimes require use of instructor-supplied Maple or Matlab software to complete. The TA will be there to help guide students through the problems. Completion of worksheets will require work outside of the lab hour. The lab work serves the the goal of learning complete problem solving fluency (see below), where students will develop skills to solve problems involving multiple coordinated skills, including interpretation and identification of relevant variables and unknowns, operationalization of the question into a series of executable methods, and interpretation and communication of results. The lab represents 20% of the class time every week, and consequently 20% of your total grade. Attendance to the lab and participation in the lab is mandatory and attendance/participation will be taken each week by the TA. Credit will be broken out into 5% lab attendance and 15% for well-written lab worksheet-reports.  

- **Midterm Exams (30%, 15% each)** - Two 50-minute midterm exams will be given in class on select Fridays (February 16th and March 30th). A practice exam will be posted a week prior to the
midterm that will cover the same material. Review of the practice exam will occur in the lab before the exam.

- **Final Exam (25%)** - A two-hour comprehensive exam will be given **Monday April 30 2018 from 8:00-10:00 AM in CSC 208**. As with the midterms, a practice final will be posted a week prior.

Final course letter grades will be determined as follows: If X is your course percentage weighted according to the above, then \( \{ X \geq 93\% \Rightarrow A, X \geq 90\% \Rightarrow A-, X \geq 87\% \Rightarrow B+, X \geq 83\% \Rightarrow B, X \geq 80\% \Rightarrow B-, X \geq 77\% \Rightarrow C+, X \geq 73\% \Rightarrow C, X \geq 70\% \Rightarrow C-, X \geq 67\% \Rightarrow D+, X \geq 63\% \Rightarrow D, X \geq 60\% \Rightarrow D-, X < 60\% \Rightarrow E \} \). The instructor retains the right to modify this grading scheme during the course of the semester; students will, of course, be well notified of any adjustments.

**Additional Resources**

- **Tutoring Center & Computer Lab** - There is free tutoring in the T. Benny Rushing Mathematics Student Center (room 155, the lower level between JWB and LCB), as well as a computer lab. For more information see http://www.math.utah.edu/ugrad/tutoring.html

- **Private Tutoring** - University Tutoring Services, 330 SSB. There is also a list of tutors at the math department office JWB 233.

**Technology**: Calculators will not be allowed on quizzes or exams. Students are not expected to have prior programming experience, but will be required to run portions of code that will be provided in lecture and lab. The code will use the following programs: MATLAB, Maple, and Mathematica. These programs are great resources to check homework assignments prior to submitting them for evaluation. I encourage you to review your work before instructor evaluation.

**Expected Learning Outcomes:**

- **Basic 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.
  
  - Manage to utilize 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, 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 utilize 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.

Important Dates:

Classes begin ................................................................. Monday, January 8
Last day to add without a permission code ........................................... Friday, January 12
Last day to drop (delete) classes ......................................................... Friday, January 19
Last day to add, elect CR/NC, or audit classes ........................................... Friday, January 19
Midterm 1 ................................................................. Friday, February 16
Last day to withdraw from classes ....................................................... Friday, March 2
Midterm 2 ................................................................. Friday, March 30
Last day to reverse CR/NC option ....................................................... Friday, April 20
Classes end ................................................................. Thursday, April 24
Final Exam ............................................................ Monday, April 30

Student Responsibilities: All students are expected to maintain professional behavior in the classroom setting, according to the Student Code, spelled out in the Student Handbook. Students have specific rights in the classroom as detailed in Article III of the Code. The Code also specifies proscribed conduct (Article XI) that involves cheating on tests, plagiarism, and/or collusion, as well as fraud, theft, etc. Students should read the Code carefully and know they are responsible for the content. According to Faculty Rules and Regulations, it is the faculty responsibility to enforce responsible classroom behaviors, and I will do so, beginning with verbal warnings and progressing to dismissal from and class and a failing grade. Students have the right to appeal such action to the Student Behavior Committee. http://regulations.utah.edu/academics/6-400.php
**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 & Access, 162 Olpin Union Building, 801-581-5020. CDA will work with you and the instructor to make arrangements for accommodations. All written information in this course can be made available in alternative format with prior notification to the Center for Disability & Access.

**Addressing Sexual Misconduct:** Title IX makes it clear that violence and harassment based on sex and gender (which includes sexual orientation and gender identity/expression) is a civil rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, color, religion, age, status as a person with a disability, veteran's status or genetic information. If you or someone you know has been harassed or assaulted, you are encouraged to report it to the Title IX Coordinator in the Office of Equal Opportunity and Affirmative Action, 135 Park Building, 801-581-8365, or the Office of the Dean of Students, 270 Union Building, 801-581-7066. For support and confidential consultation, contact the Center for Student Wellness, 426 SSB, 801-581-7776. To report to the police, contact the Department of Public Safety, 801-585-2677(COPS).

**Student Names and Personal Pronouns:** Class rosters are provided to the instructor with the student’s legal name as well as 'Preferred first name' (if previously entered by you in the Student Profile section of your CIS account). While CIS refers to this as merely a preference, I will honor you by referring to you with the name and pronoun that feels best for you in class, on papers, exams, group projects, etc. Please advise me of any name or pronoun changes (and update CIS) so I can help create a learning environment in which you, your name, and your pronoun will be respected. If you need assistance getting your preferred name on your UIDcard, please visit the LGBT Resource Center Room 409 in the Olpin Union Building, or email bpeacock@sa.utah.edu to schedule a time to drop by. The LGBT Resource Center hours are M-F 8am-5pm, and 8am-6pm on Tuesdays.
Course Roadmap Week-by-Week (Subject to Change):

<table>
<thead>
<tr>
<th>Week</th>
<th>Dates</th>
<th>Sections</th>
<th>Material</th>
</tr>
</thead>
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| 1    | 1/8-1/12    | 1.1, 1.2, 1.3, 1.4 | Differential equations  
Mathematical models  
Integral as general and particular solutions  
Slope fields  
Separable differential equations  |
| 2    | 1/16-1/19   | 1.4, 1.5, 2.1, 2.2 | Separable equations continued  
Linear differential equations  
Circuits, mixture models, and population models  
Equilibrium solutions and stability  |
| 3    | 1/22-1/26   | 2.2, 2.3, 2.4 | Equilibrium solutions and stability continued  
Acceleration-velocity models  
Numerical solutions  |
| 4    | 1/29-2/2    | 2.5, 2.6, 3.1 | Numerical solutions continued  
Linear systems  |
| 5    | 2/5-2/9     | 3.1, 3.2, 3.3, 3.4 | Matrices and matrix operations  
Gaussian Elimination  
Reduced Row Echelon Form  |
| 6    | 2/12-2/16   | 3.5, 3.6 | Matrix inverses  
Determinants  
**Midterm 1 on Friday**  |
| 7    | 2/20-2/23   | 4.1, 4.2, 4.3, 4.4 | Vector spaces  
Linear combinations in $\mathbb{R}^n$  
Span and linear independence  
Subspaces, bases, and dimension  |
| 8    | 2/26-3/2    | 5.1, 5.2, 5.3 | 2nd-order linear differential equations  
General solutions  
Superposition, homogeneity, and constant coefficients  |
| 9    | 3/5-3/9     | 5.4, 5.5, 5.6 | Mechanical vibrations and pendulum model  
Particular solutions to non-homogeneous problems  
Forcing and resonance  |
| 10   | 3/12-3/16   | 10.1, 10.2, 10.3 | Laplace transforms  
Solving IVPs with transforms  
Partial fractions and translations  |
| 11   | 3/19-3/23   |           | **SPRING BREAK**  |
| 12   | 3/26-3/30   | 10.4, 10.5 | Unit steps  
Convolutions  
**Midterm 2 on Friday**  |
| 13   | 4/2-4/6     | 6.1, 6.2, 7.1 | Eigenvalues and eigenvectors  
Diagonalization  
1st-order systems of ODE  |
| 14   | 4/9-4/13    | 7.2, 7.3, 7.4 | Matrix systems  
Eigenanalysis  
Spring systems and forced undamped systems  
Practical Resonance  |
| 15   | 4/16-4/20   | 9.1, 9.2, 9.3 | Equilibria and stability  
Phase portraits for non-linear systems  
Ecological models  |
| 16   | 4/23-4/24   | 9.4 | Nonlinear mechanical systems  |