Syllabus for Math 2250-10
Differential Equations and Linear Algebra
Spring 2015

Instructor: Professor Grant B. Gustafson

Email: `ggustaf@math.utah.edu`

Lecture: MWF, 8:00 to 9:25 am, WEB 1230 (Duke Lecture Room)

Problem Session: Tuesday, 8:00 to 9:35 am, WEB 1250 (Stockham Lecture Room).

Laboratory: Thursday 8:35 am in AEB 310 or 9:40 am in LCB 323, as registered.

Course Web Site: `http://www.math.utah.edu/~gustafso/`

Office and phone: JWB 113, 801-581-6879

Office hours: After class daily works. Appointments welcome! See the JWB 113 posted hours, duplicated online at `http://www.math.utah.edu/~gustafso/doorcardS2015.pdf`.

Final Exam: WEB 1230, Wednesday May 6, 2015, 7:15 am until 10:15 am.

Textbook: Linear Algebra and 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: Edwards and Penney, *Differential Equations and Linear Algebra 3rd Edition*; Edwards and Penney, *Elementary Linear Algebra*; R. Haberman, *Applied Partial Differential Equations with Fourier Series and Boundary Value Problems, 5th edition.* ISBN numbers below.

Prerequisites: Math 1210 and 1220 or the equivalent (Calculus I and II). This is first-year Calculus, with a very brief introduction to linear differential equations. Engineering programs fulfill the requirement with Engineering Calculus 1310-1320 and Accelerated Engineering Calculus 1321. In addition, background is required in planar curves, velocity and acceleration vectors from Physics 2210 or Math 2210 (Calculus III), or their equivalent courses. The co-requisite is Physics 2210, with actual use of physics minimal. There is use made in the course of partial derivatives, the Jacobian matrix and the chain rule in several variables.

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, then please notify the Center for Disability Services, 162 Olpin Union Building, 801-581-5020 (V/TDD). CDS will work with you and your instructors. All information in this course can be made available in alternative format with prior notification to the Center for Disability Services.
A personal note: I will make accommodation. Please tell me what is needed and I will complete the CDS paperwork. Call 801-581-6879, email to `ggustaf@math.utah.edu` or visit JWB 113.

Course Design

This course will cover essential knowledge of differential equations and linear algebra as used in engineering applications. The course is structured into four lecture hours per week (80 min each day MWF) and one Lab hour per week.

The work you will complete in Math 2250 consists of fourteen (14) weekly homework packages, fourteen (14) weekly take-home quizzes and fourteen (14) weekly Thursday labs. Homework and quizzes are turned in on Wednesday. Labs are turned in on Thursday. There are two (2) midterm exams on Friday, 80 minutes each, fixed dates Mar 6, Apr 17, and a comprehensive 120-minute final exam on Wednesday May 6.

Exceptions to the due dates and exam dates will be posted at the course web site. In addition, email will be sent to the email address recorded (by you) at the Registrar's web site. This includes unpredictable events, especially unplanned no-lecture days and university-excused snow days.

Learning Objectives for 2250

A 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 mechanical energy and Kirchhoff's circuit laws.

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, including linear combinations, span, independence, basis and dimension, to understand the solution space to linear algebraic equations, linear scalar differential equations, and linear systems of differential equations.

Understand initial value problems for first order linear differential equations, and corresponding initial value problems for higher order linear differential equations and systems of nonlinear differential equations.

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

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

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 of mechanical systems and electrical networks.

Understand and be able to use linearization as a technique to classify the behavior of nonlinear autonomous dynamical systems near equilibrium solutions. Apply linearization, phase portrait analysis and stability theorems to a system of two first order non-linear differential equations. Examples include nonlinear models for interacting populations, the nonlinear pendulum and hysteresis in the Van der Pol oscillator.

Develop your ability to communicate modeling and mathematical explanations and solutions, using computer software such as Maple, Matlab, Mathematica/Maxima and internet-based computational tools.

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

Strategies for Success

Recommendations from Course Organizers

- Read the relevant text book sections *before* attending class. Ask questions and become involved.
- Work on the homework daily.
- Know how grades are computed at the start of the semester and plan accordingly.

- Create or join a study group with your classmates.
- Utilize the **Mathematics Tutoring Center** in building LCB.
- Visit the instructor and the TA during office hours.

My Recommendations

The above recommendations apply. In addition:

- Scan a section quickly to identify the main ideas and methods. As you read, catalog the worked examples.
- Read each assigned problem, as though it was a worked example. Add the problem types to the catalog of worked examples, details delayed. Especially, closely examine **all** recommended problems, not just the ones to be submitted. This is reading, not problem solving.
- Determine the easy problems from the list. Find a path for solving them, without writing anything. Mark the more difficult problems, to be solved later.
- Chase down the details. Background courses like algebra and calculus require a focused, channeled review when a problem knocks you down. This plan reduces the number of bruises in future weeks.

Tutoring: The Math Department Tutoring Center is located in building LCB, in the **Math Center**. It is open for free tutoring from 8 AM to 8 PM on Mon-Thu, and Friday from 8 AM to 6 PM. The center is closed weekends and semester holidays. The times and specialities of available tutors are recorded at web address

`www.math.utah.edu/ugrad/tutoring.html`.

Texts:

Hybrid for 2250 and 3140: *Linear Algebra and Differential Equations with Introductory Partial Differential Equations and Fourier Series*, ISBN-13: 978-1-269-42557-5. The bookstore sells this hybrid edition, which bundles Edwards-Penney 3/E with Haberman 5/E, the latter for courses 3140 and 3150. This is the official required textbook.

Supplements: Sections 3.7 and 7.6 will be used, from the Edwards-Penney text *Differential Equations and Boundary Value Problems*, the current Math 2280 textbook, any edition. These sections cover *electrical circuits* and extra *Laplace transform* material. Copies will be made available of these two short sections.

Alternative text: *Differential Equations and Linear Algebra*, by C.H. Edwards Jr. and David E. Penney, 2009 Third Edition, ISBN-10: 0-13-605425-0. New problems and text material appear in the third edition. The bookstore may not stock it. The hybrid book includes all chapters of this textbook.

Online References: Site `http://www.math.utah.edu/~gustafso/` has pdf and text documents that can be printed from a modern web browser. Author: G.B. Gustafson. The notes and slides may be freely viewed and printed. The typeset material is from Gustafson's 900 page book, *Applied Differential Equations and Linear Algebra*, Copyright 1999-2015, as yet unpublished.

Student Solution Manual: The Edwards and Penney text *Differential Equations and Linear Algebra, 3/E* has a separately purchased student solution manual. Some textbook bundles from the publisher include the solution manual.

Cliff's Notes: Title *Differential Equations*, Cliff's Notes series, contains concise examples and readable explanations of topics found in the Edwards-Penney text.

Illegal copies: It is illegal to xerox a whole textbook. It is illegal to download a PDF copy of a whole textbook. These sentences are inferred from university copyright policy, online at `http://regulations.utah.edu/research/7-013.php`.

Computer Tutorials:

Assumed is a passive knowledge of one or more computer algebra systems `Maple`, `Matlab` with `Maxima`, `Mathematica`. The computer code examples are supplied only in `Maple`. Unique translated `Maple` code examples will be posted, awarded with extra credit.

Persons without the passive knowledge of `Maple` and `unix` may attend one of the *tutorials* on the subject offered during the first two weeks of the term. The organizer for these tutorials is Aryn DeJulis, 801-585-9478, `dejulis@math.utah.edu`. The dates and times are available at the tutoring web address `www.math.utah.edu/ugrad/tutoring.html`.

Grading:

Final grades will be based on weighted components, as follows.

Weight	**Graded Component**
30%	Written midterm examinations.
30%	Written final examination.
20%	Textbook problems and computer problems.
10%	Quizzes.
10%	Thursday Lab, Z. Zhu.

Written In-Class Exams:

There are two (2) midterm written in-class exams and a 2-hour written in-class final exam. Exams are graded by G. B. Gustafson and assistants.

Exams have different presentation requirements, and none of the textbook problem exposition ideas apply. Basically, in-class exam solutions are expected to be a first draft.

A **sample exam** is supplied a few days before an in-class exam. Exam problems are modeled after the assigned textbook exercises. Computer problems do not appear on in-class exams.

Please bring pencils and eraser. Paper will be supplied. No books, tables, notes, phones or calculators on exam day.

Midterm Exams. Each of the two (2) midterm exams has equal weight, 15% of the semester total, which is half the final exam weight of 30%. The official time allowed for a class meeting is 80 minutes. To get extra time on exam day, the exam papers are distributed 35 minutes early and collected 5 minutes late, for a total exam period of 120 minutes.

An actual midterm exam has the same topics and number of problems as the sample midterm exam.

Final Exam. Two hours are reserved by the university for the written final exam, which is weighted as two midterm exams, representing 30% of the semester total.

The university published final exam time for an 8:05 MWF class is Wednesday May 6, 8-10 AM in the regular classroom. Effort is made to provide 60 more minutes of exam time, 7:15am to 10:15am.

The final exam is comprehensive. About 35% of the exam covers the last three chapters the course. The remaining 65% covers all other chapters. The actual final exam has the same topics and number of problems as the sample final exam.

Oral Exam:

There is no oral exam. Makeup exams may have an oral exam requirement, details negotiated.

Quizzes:

The quizzes are take-home, supplied online at the course web site, links in the Weekly Calendar. Updates and changes to the quiz problems stop one week before the calendar due date.

An assistant will grade quiz problems, using the rules for grading of an exam problem, possible score 0 to 100 on each problem. See **Exam Grading Practices**, *infra.* A certain number of quiz problems will be forgiven, the total number decided at the end of the semester.

Hand-written Problems and Computer Labs:

There will be 130 items used for grading during the semester, including textbook problems and computer labs. They will be graded by an external assistant employed by Aryn DeJulius. The weight of the 130 items is 20% of the semester total. They are collected weekly in stapled packages, a total of 14 packages.

Textbook problems to be submitted for grading are listed at the end of this document. Collaboration is encouraged. Please submit your own handwritten solutions.

Study guide problems are not collected for grading. Unique contributed study guide solutions created by class members will be posted, the effort earning extra credit, which can cancel missed homework and lab scores.

Exposition suggestions exist for written presentation of textbook problems. A full accounting of *format ideas* contributed by Utah students appears on the internet course page as *format ideas for submitted work*. Kindly steal ideas and implement them as your own, as they apply to your written work, both textbook problems and computer labs.

Computer Projects:

The projects will be written by hand. Assist is expected from a computer algebra software package. Examples will use computer algebra system `Maple`. There is a Math Center Computer Lab in the lowest floor of building LCB at which registered students automatically own accounts. Math accounts can login from other hosts, the Math Center Lab being only one possibility. Drop-in mathematics tutoring in the Math Center starts the first week of the semester. Drop-in computer help in the Math Center Computer Lab starts in the second week.

Withdrawal:

It is the Math Department policy, and mine as well, to grant any withdrawal request until the University deadline. Registered students may initiate a withdrawal by starting the registrar's paperwork that is required. My job is the signature. I promise that withdrawal requires **no explanation** and **no appearance**.

Grading Scale:

```
A  = 95-100, A- = 90-94,
B+ = 85-89,  B  = 80-84, B- = 75-79,
C+ = 70-74,  C  = 65-69, C- = 60-64,
D+ = 55-59,  D  = 50-54, D- = 45-49,
E  = 0-44.
```

Exam Grading Practices. The scale is used religiously for the grading of exams. Graders mark a problem with a letter grade and then they convert the letter grade into a numerical credit from a table of credits.

For example, if part (b) of problem 3 is marked as 30 percent of the problem, then the grader will convert a letter grade of `C+` for problem 3(b) into a credit of between 70 and 74 percent of 30 points towards the total of 100 for problem 3. Possible credits for a `C+` on problem 3(b) would be either 21 or 22 out of 30, at the option of the grader.

Final Letter Grade. Final grades are computed from the grading scale to a letter, using the following components and credits. The basic formula driving the choice of percentages is 60 percent exams and 40 percent homework and labs.

Component	**Percent Credit**	**Problem Count**	**Grading Total Score**
Exam 1	15	Eight	800
Exam 2	15	Eight	800
Final Exam	30	Nine	900
Homework and Computer	20	One Hundred Thirty	13000
Quizzes	10	Fourteen	1400
Thursday Lab	10	Fourteen	1400

Scoring on homework, labs and exams uses a scale of 0 to 100, per problem, the same as the grading scale. The following examples illustrate how the grades on papers are converted to a final grade.

Example 1. A score on Exam 1 of 94 is a letter grade of `A-`. The credit earned towards the final grade is 94 percent of 15, which equals 14.1.

Example 2. A score on the Final Exam of 91 is a letter grade of `A-`. The credit earned towards the final grade is 91 percent of 30, which equals 27.3.

Example 3. Homework earned 100 each on 110 items and 50 each on 9 items for a total of 11450 out of 13000 possible. This is an average of 88 percent which is a letter grade of `B+`. The credit earned towards the final grade is 88 percent of 20, which equals 17.6.

Example 4. Assume midterm scores of 94, 88 percent, final exam 91 percent, homework 88 percent, quizzes 75 percent and Thursday lab 90 percent. The total credits toward the final grade are

$$14.1 + 13.2 + 27.3 + 17.6 + 7.5 + 9.0 = 88.7$$

which rounds up to 89, for a final letter grade of $B+$.

The final letter grade of $B+$ or $A-$ is decided by considering exam performance first and effort expended second. In this case, the final exam at 91 percent was clearly an $A-$, therefore the score of 89 is promoted to 90 with final grade $A-$. If the final grade had rounded to 88 percent, then the final letter grade issue is difficult. Borderline cases can require phone, office or email communication to resolve. Please act immediately, if your semester record is borderline.

Computer Assist

Computer code examples are supplied in Waterloo's `Maple` computer algebra system. Examples are duplicated when possible for the MathWork's `Matlab` numerical workbench.

A passive knowledge of `Maple`, `Matlab/Maxima` or `Mathematica` is assumed from about the second week of the course. If you are new to computer algebra systems and numerical workbenches, then explore the online tutorial links at the course web site.

Further help with computers can be obtained in the Math Center, director Aryn Dejulius. Her web page is `www.math.utah.edu/ugrad/tutoring.html`. Contact info: office MC 155A in building LCB next to the Math center, phone 801-585-9478, email `dejulis@math.utah.edu` .

Persons without computer training and no technology-assist experience can survive through Chapter 2 with a graphing calculator and Microsoft's `Excel`. These tools are useful also for those with programming talent. Everyone should learn some examples for `Wolfram Alpha`, which answers natural language questions. The internet-based application `alpha` is found by Google search from an internet browser.

LCB Math Center

Free tutoring is available in the LCB tutoring center 8:00 a.m. to 8:00 p.m. daily, except until 6:00pm on Friday, closed weekends and semester holidays. Some maple help is available. Only a few of the tutors are capable of helping you on computer projects or on 2250 homework problems. The work hours of those individuals can be found by browsing the **Math Center web page**, located in the undergraduate link at `http://www.math.utah.edu/`

Grading Details

- **Take-Home Quizzes (14), total 10%**: A **Stapled package** is due on Wednesday, for the weekly take-home quiz delivered the previous week. Quiz problems are graded exactly like exam problems.
- **Thursday Lab (14), total 10%**: Teaching Assistant (TA) **Ziwen Zhu** will direct a lab session every Thursday. A **lab project** (called a worksheet) is distributed in the lab and the

TA will lead student group work. The lab project problems will provide guided practice with basic methods and longer in-depth problems with physical and engineering applications. A minor number of problems will use computer assist. Credit is applied to your record for lab attendance and the completed worksheet. Lab projects take additional time outside of class to finish. Additional office hours are available in the conference room WEB 1622, with hours and staffing posted in the *Announcements* at the course web site.

- **Homework packages (14), total 20%**: About three textbook sections of **textbook exercises** are due every Wednesday in a **stapled package**, based on lecture sections covering through the preceding Friday. At the end of this syllabus appear listings of the assigned problems, with graded exercises boxed. Other problems are study guide problems.

  The possible score on a problem is 0, 50, 100. If there are obvious mistakes or missing problems, then the grader looks at all problems in detail. Otherwise, the grader scans the easier problems and grades the difficult ones in more detail.

- **Midterm exams (2), total 30%**: Two 80-minute midterm exams will be given on select Fridays, fixed dates Mar 6, Apr 17. The exam may be started at 7:30 am to allow for extra time. A practice exam with solutions will be posted a week prior to the midterm. Questions about the practice exam may be asked in the lecture, in the lab section, during office hours, by email and telephone.

- **Final exam (120 minutes), total 30%**: A 120 minute comprehensive exam will be given at the end of the semester. A practice final will be posted a week prior. Please check the final exam date and time (time extended by one hour) against your schedule:

  Final Exam: WEB 1230, Wednesday 6 May, 2015, 7:15 am until 10:15 am.

  It is your responsibility to make yourself available for that time. Please make any arrangements (e.g., with your employer) as early as possible.

- **Rank-in-Class** is determined only by the exams. Rank 1 is the best, determined by sorting high to low on the exam average

$$\text{Exam}_{\text{Ave}} = 100\left(\frac{30}{100}\left(\frac{\text{Midterm}_1 + \text{Midterm}_2}{2}\right) + \frac{30}{100}(\text{Final})\right).$$

  There is no influence on class rank from homework, take-home quizzes or Thursday labs.

Midterm Exam Details

The exams are modeled after the sample midterm exam, which is supplied on the web site, updated at least one week before the exam date. Available on the web page are old exams and solution keys, including all midterm and final exams for the last three years. You may print these for reference. The final exam has a separate study guide, also available at the site.

Books, tables, notes, cell phones, tablets, earphones and calculators are not allowed on exam day.

An in-class Midterm exam has different presentation rules, and none of the textbook problem ideas suggested will apply on exam day. Basically, the in-class exam is a first draft. No answer checks are expected. Answers count 25% and details count 75%.

Final Exam Details

Two hours are reserved for this written exam. As published by the university:

8:05 class: Wednesday, May 6, 2015 at 7:15am until 10:15am in the regular classroom.

The final exam is comprehensive. It covers explicitly all chapters 1 to 10 except chapter 8, with weight distributed evenly across the 9 chapters. A study guide consisting of problem types by chapter plus several final exam solution keys for previous final exams appear at the web site. There is explicit contact on the final exam with chapter 1 and 2 topics, but there are no matching problems on final exam online solution keys dated 2013 or earlier.

Please bring pencils, eraser and a university ID. Paper will be supplied. No notes, calculators, tables, books or aids of any kind.

Due Dates, Extra Credit, Late Work, Withdrawal

Due Dates are updated dynamically at a link on page

`http://www.math.utah.edu/~gustafso/s2015/2250/index2250S2015.html`.

Please prepare submitted work according to the tentative schedule of due dates. The actual due date is the same date, or one class day later, as documented on the web site. This adjustment is needed for snow days and unforseen events, so it happens infrequently.

Email Notification is sent for due dates, exam reviews and exam dates during the semester. This service depends on your email address being up to date.

Look up your campus information data by visiting the registrar's campus WWW site (where you add classes). Find out your email address, then test it by emailing a message to yourself. To update the information, return to the registrar's site and edit your personal data.

When is Work Late?

Work is considered late and therefore unacceptable when the stack of papers exits 113 JWB and goes to the grader. Papers not in the stack get a zero recorded for the assignment.

Zero scores can be erased by submitting unique solutions to study guide problems or extra credit problems. These problems also have due dates, but different from the weekly packages.

Are you an exception? Please ask, rather than assume anything. Depend on extra credit problems (see below) to make up for work not submitted on schedule. The same advice applies, if submitted work earns a grade of 50% or 0. While a zero generally means no work was submitted, a grader sometimes rejects a paper completely and marks it as zero, as though nothing was submitted. You'll get the paper back and hopefully an explanation.

Grader Duties

The state of submitted work is locked at the point the grader gets the stack. A grader's job is to filter out the good work from the bad work and record the result. This record is never appended, it is only corrected for errors.

Lowest Scores Dropped

The lowest ten (10) homework problems are dropped from consideration in order to expedite mediation of missing work. There is no distinction between a problem from the textbook, an Extra Credit problem, a computer-assisted problem, or an allowed unique solution to a study guide problem. All earn the same credit.

Too Many Zero Scores

If you have more than fifteen (15) zero scores, then please email **ggustaf@math.utah.edu** or call 801-581–6879 to discuss the situation and options for completing the work.

Withdrawal

It is the Math Department policy, and mine as well, to grant any withdrawal request until the University deadline. This promise also means that such a withdrawal requires no explanation. Withdrawals are always initiated by the registered student. All paperwork is the duty of the student. My job is the signature.

Extra credit instructions

Extra credit problems are only available in PDF format at the course web site. They do not appear in the textbook or in this syllabus. It is possible, because of them, to earn 100% credit on each homework. Grades on extra credit problems are 100 and 0.

Study guide unique solutions can be submitted according to the same deadlines as extra credit. Unique solutions are posted with extra credit applied to the solver's record.

Location. The web site `http://www.math.utah.edu/~gustafso/` has a 2250 link to PDF files for all extra credit problems, one PDF file for each chapter.

Rule 1: Extra credits from Ch1 to Ch5 apply only to that chapter. These chapters are collected on April 10.

Rule 2: Extra credits from Ch6 to Ch10 apply to any missing score. These chapters are collected at the last class meeting. The last possible moment to submit them is Friday May 1 (during the final exam period), under the door JWB 113.

Which problems should I work? For chapters 1 to 5, you can choose within a given chapter whichever extra credit problems that you want to submit. Just because you missed `1.2-2` is no reason to work `XC1.2-2`: choose any extra credit problem from chapter 1.

To illustrate **how credit is applied**, suppose that chapter one has 15 homework problems and 5 extra credit problems. Consider this record:

Problem Count	Score	
9	100	successful problems
3	50	problems with demerits
3	0	failed problems
4	100	successful extra credit

Then the average on chapter one is the smaller of $(9 * 100 + 3 * 50 + 4 * 100)/15 = 96.67$ and 100. A fifth extra credit problem could add 100 to the total, then the average is 100%.

Another example:

> Standard problems might total 1600 for a chapter, which is the count for 16 problems. Extra credit problems could potentially add 5 times 100 or 500. If 1350 was earned on standard problems, plus 300 on extra credit, then the total earned is $(1350 + 300)/16 = 103.125$. This total is truncated to 100, because you may earn no more than 100% for a chapter.

Labels for Submitted Work. Please submit extra credit problems with a special label. To illustrate, extra credit problem **1.2-12** would be submitted with label **XC1.2-12**. Your name on the top of the page and the course 2250-10 is sufficient, no ID number required. Study Guide solutions submitted for possible extra credit must be unique to ones already posted. Kindly label them with a special label, e.g., label **SG1.2-12**.

Deadlines. There are two deadlines for submitting extra credit work: April 10 for chapters 1 to 5, and May 1 (during final week) for chapters 6 to 10X. The extra credit stack is delivered on these dates to a grader. The records are locked by the grader and never appended, only corrected. Without the help of graders, the extra credit cannot be counted. Please adhere to the schedule, it is absolute.

Purpose of the Textbook Problems

The *purpose* of the problems is to practice doing mathematics, that is, to write out in detail the solutions to problems. A textbook problem is generally an engineering–style "crank" problem, usually devoid of proofs. The process:

- **Understand the Problem**. Understanding usually involves reading the *problem notes* and the textbook. Answers may not be provided. You may get an outline of the solution in class or on the WEB, to increase the probability that the project gets completed on schedule. Problems are discussed in class in finer detail, often with the aid of computer slides, which are mirrored at the web site as PDF files. Slides cover a similar problem or sometimes the exact problem considered in the project.
- **Background Reading**. To solve a problem, a second opinion of the theory and method is essential. It might be that you can flesh it out of your book's examples, the college algebra text, the calculus text or some engineering mathematics book. No matter, go to a source that works for you. This is *reading* and not a tutorial.
- **Scratch Paper Write–up**. The initial creation of a solution is the essence of the learning process. Everyone learns by repetition, and here is where you do it. Use a pencil and a big eraser, lots of paper, and flesh out a first draft at full speed. Don't submit this draft!
- **Final Copy**. The final copy of the solution uses the scratch paper draft as raw material to *present* the details of the solution. As such, it is more than a collection of formulas on paper. There is no strict requirement, except that *neatness* and *completeness* are a must.
- **Final Copy Format Ideas**. The most successful format to date was invented by several engineering mathematics students over the years 1990–2014. This format is described in some detail below and also in the internet document *format ideas for submitted work.*

Suggestions for Improving Written Work

1. Use engineering paper or plain white paper. Lined notebook paper and graph paper are not acceptable for mathematics, because they introduce flaws in vertical white space.
2. Reports are hand-written in pencil. They start with a problem statement followed by the book's answer or by a final answer summary. Supporting material appears at the end, like a tax return.
3. Every report has an answer check. For problems with textbook answers, it is usual to see "*the answer matches the textbook*," or briefly **B.O.B.**, for *back of book*. For problems without a textbook answer, a full answer check is expected.
4. Mathematical notation is on the left, text on the right, about a 60% to 40% ratio. One equal sign per line. Justify equations left or align on the equal signs.
5. Text is left-justified on the right side. It includes explanations, references by keyword or page number, statements and definitions, references to delayed details, like long calculations, graphics and answer checks.
6. Items **1**, **2**, **3** are expected elements of a report. Freely modify suggestions **4** and **5**. They are ideas and suggestions, not rules.

Cooperative efforts are allowed and encouraged. Kindly produce individual handwritten reports. There is no penalty for getting help from others – it is encouraged. This includes tutorial staff in the Math Center LCB, teaching assistants and fellow students.

English language deficiencies are tolerated but not excused. Graders prefer short, precise English comments. If English is your second language, then try to improve your writing skills: (1) shorten comments and (2) use specific references to the textbook.

Presentation is expected to improve throughout the 15 weeks of the course. You are not expected to be an expert in the first week. Correctness of answers will be checked. The problem notes might contain answers plus a solution outline. In class, further details are communicated. Your job is to *improve* on the initial start into the solution. Add the particulars, make comments, and chase down the details from algebra and calculus. College algebra and calculus skills need constant and careful review. Writing up the solution identifies the stumbling blocks and forces a review of background material.

References are expected. After the first occurrence, omit the citation. It is appropriate to refer to the previous assignment on which the citations originated.

Week-by-Week Guide of Textbook Sections and Homework Due

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

Abbreviations:

> **EP** = Edwards-Penney 2010, Differential Equations and Linear Algebra 3/E
> **EPbvp** = Edwards-Penney 2008, Differential Equations and Boundary Value ... 4/E
> **EPH** = Edwards-Penney-Haberman hybrid textbook 2013 (the required textbook)
> **DE** = Differential Equation
> **ODE** = Ordinary Differential Equation
> $\boxed{12}$ = Means problem 12 is to be submitted for grading.

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WEEK 1, Jan 12-16
======
1.1; differential equation, mathematical model.
1.2;  integral as a general or particular solution.
1.3; slope field.
1.4; separable differential equation.
Take-home Quiz1 and Homework HW1 due next Wednesday.

WEEK 2, Jan 19-23
======
Monday Holiday, Martin Luther King. No classes.
1.5; linear differential equation.
3.7 EPbvp; LR and RC circuits. RLC later.
2.1, 2.2, 2.3; mixture model, population model, cascades, equilibrium solution,
stability, acceleration-velocity models.
Take-home Quiz2 and Homework HW2 due next Wednesday.

WEEK 3, Jan 26-30
======
2.3; escape velocity, Jules Verne problem.
2.4, 2.5, 2.6; numerical solutions.
Take-home Quiz3 and Homework HW3 due next Wednesday.


WEEK 4, Feb 2-6
======
3.1, 3.2, 3.3; linear systems, matrices, Gaussian elimination;
3.4; reduced row echelon form.
Take-home Quiz4 and Homework HW4 due next Wednesday.

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WEEK 5, Feb 9-13
======
3.5; matrix operations, matrix inverses.
3.6; determinants.
Take-home Quiz5 and Homework HW5 due next Wednesday.

WEEK 6, Feb 16-20
======
Monday Holiday, President's Day. No classes.
4.1; vector spaces, linear combinations in R^n.
4.2; span and independence.
4.3; subspaces.
Midterm Exam 1, on Mar 6, covers topics from Week 1 to Friday of Week 6.
Take-home Quiz6 and Homework HW6 due next Wednesday.
Study Sample Exam 1 for Friday, Mar 6.

WEEK 7, Feb 23-27
======
4.4; bases and dimension.
4.7; abstract vector spaces and solution space of a DE.
5.1, 5.2; second-order linear DE, general solutions, superposition.
Take-home Quiz7 and Homework HW7 due next Wednesday.
Study Sample Exam 1 for next Friday.

WEEK 8, Mar 2-6
======
5.3; constant coefficients.
5.4; mechanical vibrations, pendulum model.
5.5; particular solutions to non-homogeneous problems.
EPbvp 3.7; circuits.
Take-home Quiz8 and Homework HW8 due next Wednesday.
Mar 6: Friday Midterm Exam 1 over Weeks 1, 2, 3, 4, 5, 6.

WEEK 9, Mar 9-13
======
5.6; forced oscillations, resonance and mechanical vibrations.
10.1, 10.2, 10.3; Laplace transforms, solving a DE with transforms.
Take-home Quiz9 and Homework HW9 due next the Wednesday after Spring Break.

WEEK 10, Mar 15-22 is Spring Break. No classes.
=======
No Quiz 10. No HW 10. No Thursday Lab meeting.

WEEK 11, Mar 23-27
=======
10.4; partial fractions and translations.
10.5; Unit step, ramp, convolution.
EPbvp 7.6; impulse response.
Take-home Quiz11 and Homework HW11 due next Wednesday.

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WEEK 12, Mar 30 to Apr 3
=======
6.1; eigenvalues and eigenvectors.
6.2; diagonalization
6.3; power method.
7.1; intro to first-order systems of ODE.
April 17: Midterm Exam 2 will cover Weeks 7 to 12, including section 7.1.
Take-home Quiz12 and Homework HW12 due next Wednesday.
Study Sample Exam 2.

WEEK 13, Apr 6-10
=======
7.2; Matrix systems of DE
7.3; eigenanalysis method, spring systems, forced undamped systems.
Take-home Quiz13 and Homework HW13 due next Wednesday.
Study Sample Exam 2.

WEEK 14, Apr 13-17
=======
7.4; systems and practical resonance.
9.1; equilibria, stability.
9.2; phase portraits for non-linear systems.
Take-home Quiz14 and Homework HW14 due next Wednesday.
Study Sample Exam 2.
Friday Apr 17: Midterm Exam 2 over Weeks 7, 8, 9, [Week 10=break], 11, 12.

WEEK 15, Apr 20-24
=======
9.3; populations and ecological models;
9.4; nonlinear mechanical systems,
Take-home Quiz15 and Homework HW15 due by next Friday 1 May under the door JWB 113.
Study Sample Final Exam

WEEK 16, Apr 27-28
=======
Sample Final Exam.
Comprehensive Final Exam review.
Study Sample Final Exam

WEEK 17
=======
Finals week: Comprehensive final exam, Wed May 6, 7:15-10:15 a.m. in WEB 1230.

Homework Exercises

Packages are due on Wednesday, the week after they are assigned. For example, the HW package for Week 1 is due Wednesday of Week 2. Week 10 is Spring Break: no HW10, no Quiz10.

HW 1

1.1: 1, 4, 5, 6, 9, 15, 19, 27, 29, 30, 32, 33, 34
Reading. Required background.

1.2: 1, $\boxed{2}$, $\boxed{4}$, 5, $\boxed{6}$, 7, 9, $\boxed{10}$, 13, 15, 16, 18, 21, 22, 24, 26, 29, 31, 32, 33, 35, 40, 41

1.3: 2, 3, 5, 6, $\boxed{8}$, 10, 11, 13, $\boxed{14}$, 23, 25, 26, 33

1.4: 2, 3, 4, $\boxed{6}$, 9, $\boxed{12}$, 13, $\boxed{18}$, 19, 20, 21, $\boxed{22}$, $\boxed{26}$, 36, 41, 42, 45, 46, 49, 51, 56, 59

HW 2

1.5: 1, 7, $\boxed{8}$, $\boxed{10}$, 13, $\boxed{18}$, $\boxed{20}$, 21, 23, 24, 33, $\boxed{34}$, 36, 39

3.7 EPbvp: 1, 2, $\boxed{4}$, 7 [RC and LR circuits only]

2.1: 1, 3, 4, 6, $\boxed{8}$, 10, 12, $\boxed{16}$, 22, 23, 33, 37

2.2: 5, 7, 8, 9, $\boxed{10}$, 11, 15, 17, $\boxed{18}$

2.3: 2, 3, 9, $\boxed{10}$, 13, 14, 17, 18, 19, $\boxed{20}$, $\boxed{22}$, 24

2.3: 25: escape velocity

HW 3

2.4: 2, 3, 4, $\boxed{6}$, 10, 12, 17 Euler's method

2.5: 3, 4, 5, $\boxed{6}$, 10, 12 improved Euler or Heun

2.6: 3, 4, 5, $\boxed{6}$, 10, 12 Runge-Kutta
Submitted as a computer project.
Instructions are at the course web site: numericalDEproject-S2015.pdf

HW 4

3.1: 1, 4, 6, 7, $\boxed{8}$, 9, 11, $\boxed{12}$, $\boxed{16}$, 17, 19, 23, 24, $\boxed{26}$, 27, 28, 29, 32, 33, 34

3.2: 7, 8, 9, $\boxed{10}$, 13, $\boxed{14}$, 15, 17, 20, 21, $\boxed{24}$, 25, 29, 30

3.3: $\boxed{10}$, 11, 13, 17, 19, $\boxed{20}$, 33, $\boxed{34}$, 35

HW 5

3.4: 3, 5, 7, 10, 11, 13, 16, 19, 21, $\boxed{22}$, 27, $\boxed{30}$, 31, 32, 33, 34, 35, $\boxed{36}$, 39, $\boxed{40}$, 44

3.5: 5, 7, $\boxed{14}$, 17, 23, 25, $\boxed{26}$, 33, 43, $\boxed{44}$ or $\boxed{\text{Xc3.5-44a}}$

3.6: 3, 5, $\boxed{6}$, 11, 17, $\boxed{20}$, 21, 25, 29, $\boxed{30}$, 33, 30, 31, 37, $\boxed{40}$, 51, 53, $\boxed{60}$

HW 6

4.1: 1, 7, 9, 11, 15, 16, $\boxed{18}$, $\boxed{20}$, 22, 23, 25, 26, 27, $\boxed{32}$, 33-36

4.2: 3, $\boxed{4}$, 5, $\boxed{6}$, 7, 9, 11, 15, 17, $\boxed{18}$, 21, 24, 27, $\boxed{28}$, 29

4.3: 1, 3, 6, 8, 9, 10, 11, 16, 17, $\boxed{18}$, 23, $\boxed{24}$, 25, $\boxed{34}$

HW 7

4.4: 5, $\boxed{6}$, $\boxed{12}$, 21, $\boxed{24}$, 31

4.5: 6, 9, 15, 19, 23, 24, 28: No lecture, not due.

4.6: 2, 3, 5: No lecture, not due.

4.7: 7, $\boxed{10}$, 11, $\boxed{12}$, 19, $\boxed{22}$, 25, 26

5.1: 1, 6, 10, 11, 12, 14, 17, 18, 27, 33, $\boxed{34}$, $\boxed{36}$, 37, $\boxed{38}$, 39, $\boxed{40}$, 41, $\boxed{42}$, 43, $\boxed{46}$, $\boxed{48}$, 53

5.2: 1, 2, 5, 8, 11,13, 16, $\boxed{18}$, 19, 20, 21, $\boxed{22}$, 23, 25, 26

HW 8

5.3: 3, 7, $\boxed{8}$, 9, $\boxed{10}$, 11, $\boxed{16}$, 17, 23, 27, 31, $\boxed{32}$, 37, 40

5.4: 3, 4, 5, 6, 10, 11, 15, 17, 19, $\boxed{20}$, 21, 33, $\boxed{34}$

3.7 EPbvp: 1, 2, 4, 7, $\boxed{12}$, 15, $\boxed{18}$, 19 [electrical circuits]

HW 9

5.5: 2, 3, 5, $\boxed{6}$, 10, 11, $\boxed{12}$, 19, 21, $\boxed{22}$, 25, 27, 29, 31, 34, 39, 43, 45, 47, 51, 52, $\boxed{54}$, 57, $\boxed{58}$, 59

5.6: 3, $\boxed{4}$, 5, 7, $\boxed{8}$, 9, $\boxed{11}$, 13, 15, 17, $\boxed{18}$, 20, 21, 22

10.1: 1, 3, 7, 9, 11, 13, 17, $\boxed{18}$, 19, $\boxed{22}$, 23, 27, $\boxed{28}$, 29, 31, 40

HW 10

HW 10 does not exist. Spring Break. No Quiz 10. No Lab 10. HW9 due Wednesday after the break.

HW 11

10.2: 3, 7, 9, $\boxed{10}$, 15, $\boxed{16}$, 17, 19, $\boxed{20}$, 21, 23, $\boxed{24}$, 35, 37

10.3: 3, $\boxed{6}$, 7, 9, $\boxed{12}$, 13, 17, $\boxed{18}$, 20, 23, 27, 28, 29, 30, 32, 34, 37

10.4: $\boxed{2}$, 3, 9, 13, 15, 17, $\boxed{22}$, 23, 26, 27, 29, 30, $\boxed{36}$, 37

10.5: 3, $\boxed{4}$, 7, 9, 11, 13, $\boxed{14}$, 21, $\boxed{22}$, 25, 27, $\boxed{28}$, 31, 33, 34, 37

7.6 EPbvp: 2, 5, 6, $\boxed{7}$, $\boxed{8}$, 11, $\boxed{12}$, 18, 21, $\boxed{22}$ [impulses and Laplace]

HW 12

6.1: 3, 7, 9, $\boxed{12}$, 13, 15, 17, 19, $\boxed{20}$, 21, 25, 27, 29, 31, $\boxed{32}$, 33, $\boxed{36}$, 37

6.2: 3, $\boxed{6}$, 9, $\boxed{20}$, 21, 23, 24, $\boxed{26}$, 27, $\boxed{28}$, 29, 31, 33, 37

HW 13

7.1: 1, 3, 2, 5, 7, $\boxed{8}$, 11, 12, 15, 17, $\boxed{20}$, 21, 24, 26

7.2: 1, 3, 7, 9, $\boxed{12}$, 13, $\boxed{14}$, 16, 23, 25

7.3: 3, 7, $\boxed{8}$, 11, 13, $\boxed{20}$, 21, 29, $\boxed{30}$, 31, 34, 36, 39, 43, 45, 49

HW 14

7.4: 2, 3, $\boxed{6}$, 8, 9, 12, 13, 14, 16, 17, 18, 21, $\boxed{24}$

9.1: 3, $\boxed{4}$, 5, 7, $\boxed{8}$, 11, 15, 17, $\boxed{18}$

9.2: $\boxed{2}$, 5, 7, 9, $\boxed{12}$, 13, 17, 19, 21, $\boxed{22}$, 23, 29

HW 15

9.3: 5, 7, $\boxed{8}$, $\boxed{9}$, $\boxed{10}$, 11, 18, 19

9.4: 1, 3, $\boxed{4}$, $\boxed{8}$, 9, 10, 11, 13, 14