Math 3304 - Introduction to Linear Algebra (Fall 2022)

Instructor: Ross Parker (rhparker@smu.edu)
Course hours: Tu/Th 8:00 - 9:20 am
Location: Hyer Hall 0204
Website: Canvas
Office Hours: Tue 2-3 pm, Wed 3-4 pm, Thu 3-4 pm in Clements Hall 221
Help Sessions (1 hour): Tue 4:30 pm, Wed 5:30 pm, Thu 6:30 pm in Clements Hall 225

Course Description

Linear algebra is the mathematics of systems of linear equations. As an example, the system of two linear equations

$$ax + by = p$$
$$cx + dy = q$$

describes two lines in a two-dimensional plane. In high school algebra, you learned how to determine if these two lines intersect. Linear algebra generalizes this to higher dimensions. It has numerous applications, which include

- Machine learning: how can you reduce a high-dimensional object such as a 1000x1000 pixel color image to something simpler which captures key features of the object?
- Electrical engineering: in a complex analog circuit, how you determine the currents and voltages at any position and point in time?
- Computer graphics: how do you display three dimensional objects on a two-dimensional screen in a convincing way?

The course will cover the following topics: matrices and linear equations, Gaussian elimination, determinants, rank, geometrical notions, eigenvalue problems, coordinate transformations, norms, inner products, orthogonal projections, and Gram-Schmidt and least squares regression. The course will also include computational exercises related to these topics.

Learning goals

By the end of the course, you will be able to

- Write a system of linear equations in matrix form, and then solve that system using Gaussian elimination.
- Define linear independence, and determine if a set of vectors is linearly independent.
- Define a vector space, and solve problems involving subspaces, null spaces, column spaces, and bases.
- Determine the eigenvectors and eigenvalues of a matrix and use them in applications.
- Define the inner product of two vectors, use this to determine the length and orthogonality of vectors, and apply this to least squares regression problems.
- Use MATLAB to compute solutions to problems in linear algebra.

Nuts and Bolts

Class format: This course will be taught in two 80-minute sessions per week. In accordance with current university policy, classes will be taught in-person. For the sanity of everyone involved, there will be a brief break of some form in the middle of each class session. I will incorporate class participation and in-class activities as much as possible. Although I like to think I'm entertaining, no one wants to hear anyone lecture for 80 minutes straight!

Please feel free to interrupt me at any time to ask me to repeat something, clarify a point, request I slow down, fix my handwriting, point out a mistake I have made, etc. I will post surveys a few times throughout the course and welcome your feedback and suggestions for improvement.

- Although I will not formally take attendance, I *strongly* recommend attending class. You will only be able to participate in class activities and ask questions if you attend class.
- I request that during class you refrain from using electronic devices for non course-related purposes. I know that I cannot compete with TikTok and Snapchat for your attention, but I like to think that I am engaging and entertaining, and I will do the best I can to make the time we have together as useful as possible.
- I will post my notes on Canvas (under the Files tab) after each class.
- By popular request (from previous classes), I will devote some time at the end of class on Thursdays to MATLAB. Please bring your laptops to class on Thursdays (but don't use them until the MATLAB portion of class!)
- All exams will be taken during regularly scheduled class time. If you have accommodations for extra time, please contact me to make the necessary arrangements. The final exam must be taken during the block of time scheduled by the university.
- All homework assignments will be submitted electronically via Canvas.
- Office hours will start the second week of class. Please come to office hours for any questions about the course material, the homework, etc. **Important: you do not have to make an appointment for office hours. Just show up!** I am always happy to procrastinate my own research to talk with students. If you would like to meet but cannot attend scheduled office hours, please contact me to schedule an alternative time.

Prerequisites: C- or higher in MATH 1338 or MATH 1340.

Textbook: David C. Lay. *Linear Algebra and its Applications.* Fourth edition (2012) or fifth edition (2016). There is essentially no difference between the two editions except for price. I would highly recommend getting a used copy of the fourth edition and saving yourself a ton of money. For another take on the course material (same general approach, but following a different textbook), you can check out these `lectures` by Gilbert Strang. For an "intuitive", geometric take on linear algebra, check out these amazing `videos` by 3Blue1Brown.

Reading: Reading sections of the textbook is required for the course. Specific reading assignments for each class will be given on the main Canvas page for the course. Reading assignments will be posted at least a week in advance.

Warm-up quizzes: Prior to most class, you must complete a short quiz based on your reading for that topic. These will be completed on Canvas and can be found under the Quizzes tab. These "warm-up" quizzes must be completed before the beginning of class. (Late quizzes will not be accepted). The goal of these problems is for you to think about each topic before class, so that it will be easier to learn during class. If all problems are attempted, the lowest possible grade you can attain on this is a 70. Warm-up quizzes, like reading assignments, will be posted at least a week in advance.

Homework: There will be problem sets due **every Friday**, starting the second week of class. These will be posted at least one week in advance. Homework will involve both standard written problems and computational problems in MATLAB. (See below for information about the computational problems). Homework will be submitted on Canvas and will be due by the end of the day (11:59 pm) on Friday. **Please submit the written problems in your homework as a single PDF file**. If you write your problems on paper, I recommend the CamScanner app to scan them to PDF.

Learning mathematics, like getting to Carnegie Hall, is all about practice, practice, practice. For all assigned problems, you must show all of your work. This means you should display the process used, not just state a final result. Your goal is to convince me you know how to do the problem, not just what the answer is.

You are encouraged to discuss assignments with other students, but you must write up your own solution independently. When you have collaborated with other students, please acknowledge this by adding a note such as "I discussed question X with A and B." If you use any electronic resources, please indicate that as well. Identical or clearly copied assignments will be treated as violations of the honor code.

Do not postpone the problem sets until the last minute, as some answers may not come to you immediately, but then become clear a day later. If you are stuck on a problem, seek help from office hours or discussing with other students. Finally if you are not able to complete a question, write a short note to describe what you tried and what you think may be important. Credit on assignments will come from a serious effort as much as anything else.

Computational problems: Each homework assignment will contain problems which you will complete using the industry standard software package MATLAB. (MATLAB stands for "matrix laboratory", and was developed specifically for linear algebra). SMU has a site license for MATLAB, which means you can install it for free on your computer using the instructions at `https://www.smu.edu/OIT/Services/Info/Matlab`. Please install MATLAB during the first week of class (you do not need to install any of the extra add-ons). If you are having trouble getting MATLAB up and running, do not hesitate to contact me. Instructions for how to submit MATLAB problems on Canvas will be given with the first problem set. Some class time each Thursday will be dedicated to MATLAB.

The MATLAB exercises will parallel the concepts being discussed in class. In addition, they will include more "real-world" applications, including (but not limited to):

- Six degrees of Kevin Bacon
- Modeling market competition using Markov chains

- Heat flow in a metal bar
- Ranking college football teams

Homework grading: Each homework problem will be graded on a five-point holistic scale. Grading for exam problems will be similar. There will be separate grades for the written portion and the MATLAB portion of each homework.

- Excellent (5): Problem shows good effort and understanding and is essentially correct (except perhaps for typos or equivalent). All relevant work is shown.
- Good (4): Problem shows good effort. There are some mistakes but no significant gaps in understanding.
- Satisfactory (3): Problem shows good effort, but there is at least one significant gap in understanding.
- Fair (2): Either problem shows only moderate effort, or there are many significant gaps in understanding.
- Poor (1): Problem was submitted, but minimal effort is shown.
- No credit (0): Problem was not submitted.

Homework policy: Late assignments will in general not be accepted. If you turn in *every assignment*, your lowest homework grade will be dropped.

Midterm exams: There will be two midterm exams, which will be 80 minutes in duration and will be taken during regular class time. The dates of the midterm exams are

- Tuesday, September 27
- Tuesday, November 1

Please contact me if you have an accommodation for extra time to make the appropriate arrangements. The exams will not be cumulative, although you may need to use techniques which were tested on the first exam on the second exam. All students are expected to take exams as scheduled, except as noted below. If you must miss an exam for one of these reasons, or for serious illness or injury, please contact me as soon as possible.

Final exam: The final exam has been scheduled by the university for Monday, December 12 from 8:00 - 11:00 am. (If you have accommodations for extra time, make the necessary adjustments.) By university policy, the final exam must be taken during this block of time. The final exam is cumulative, although it will emphasize material taught since the second midterm.

Exam policy: The following policies will be in effect for the midterm and the final exams.

- You may use a calculator during the exam if you wish, although it is unlikely to be helpful.
- You may use a study sheet for each exam. You must make the study sheet yourself. Study sheets must be one side of a single standard 8.5x11 sheet of paper. You may only write on one side of the paper. You may write whatever you want on it. You will be asked to turn in your study sheet on Canvas along with the exam, i.e. staple it to the back of your exam.

- All answers must be fully justified. You must show all of your work. Remember that your goal is to communicate the result to me in a clear manner so that I can see you understand what you are doing. If I cannot see how you arrived at an answer, even if it is correct, you will receive minimal points. Within reason, arithmetic mistakes will result in only minor point deductions, as long as I can see where you made them.
- You may not use the textbook, class notes, or any other paper references during the exam.

Grades: The grade for this class is computed as follows:

Warmup quizzes	10%
Homework	20% (10% written and 10% MATLAB)
Midterm Exams	40% (20% each)
Final Exam	30%

If your final exam grade is higher than your lowest midterm exam grade, that midterm grade will be replaced with the final exam grade. Letter grades are determined using a standard grading scale.

Communication: Email is the best way to reach me. During the week, I will try to respond within 24 hours (typically much faster!) Email responses may be slower on the weekends, but I will try to reply by Sunday evening. For complex questions, I may ask you to talk with me during office hours.

Anonymous feedback: Anonymous feedback may be provided at any point using the Feedback Box on Canvas.

Diversity Statement

While mathematics, in its idealized form, is objective, the practice and teaching of mathematics is not immune from social issues of race, gender, disability, nationality, and socioeconomic status. Pop culture and the media have not made this any better, from Teen Talk Barbie telling us that "math class is tough" to mathematicians and scientists being portrayed in movies and television as "nerdy white males" such as Tony Stark. I will use the following four axioms by Federico Ardila-Mantilla (San Francisco State University) as a foundation for our time together.

- Axiom 1. Mathematical talent is distributed equally among different groups, irrespective of geographic, demographic, and economic boundaries.
- Axiom 2. Everyone can have joyful, meaningful, and empowering mathematical experiences.
- Axiom 3. Mathematics is a powerful, malleable tool that can be shaped and used differently by various communities to serve their needs.
- Axiom 4. Every student deserves to be treated with dignity and respect.

It is my intent that students from all diverse backgrounds and perspectives be well-served by this course. I am committed to a climate of mutual respect both inside and outside of the classroom. To that end,

- I want you to feel comfortable to ask any question you want, to ask me for clarification, or to ask me to slow down, both in class and in office hours. There are no bad questions!

- I want you to feel comfortable "making mistakes" when participating in class. There will be no judgment on my part. I make mistakes all the time. It is a natural part of the learning process.
- If you feel like your performance in the class is being impacted by your experiences outside of class, please do not hesitate to come and talk with me.
- If something was said in class (by me or anyone else) that made you feel uncomfortable, please talk to me about it. If you prefer to speak with someone outside of the course, the Diversity and Inclusion Officers are an excellent resource.
- If you have a name and/or set of pronouns that differ from those that appear in your official records, please let me know.
- If you have any learning differences that you believe will affect your performance in this class, please come talk to me about how best to accommodate these.
- Anonymous feedback may be provided at any point using the Feedback Box on Canvas.

Honor Code

The SMU Honor Code applies to all homework and exams in this course. Work submitted for evaluation must represent your own individual effort. Any giving or receiving of aid without my express consent on academic work submitted for evaluation shall constitute a breach of the SMU Honor Code.

I take honor code violations very seriously, and will report all violations to the SMU Honor Council. The minimum penalty for a violation is a grade of 0 on the assignment, and the maximum penalty is immediate failure of the course. These penalties are in addition to those imposed by the SMU Honor Council. Examples of honor code violations include:

- Copying homework solutions from any source: online, another student, or a tutor.
- Allowing another student to copy your homework for another student to copy.
- Submitting a Matlab assignment produced by another student as your own.
- Cheating on an exam.

See the SMU Honor Code website for more information.

Disability Accommodations

Students needing academic accommodations for a disability must first register with Disability Accommodations and Success Strategies (DASS). Students can call 214-768-1470 or visit `http://www.smu.edu/Provost/ALEC/DASS` to begin the process. Once registered, students should then schedule an appointment with the professor as early in the semester as possible, present a DASS Accommodation Letter, and make appropriate arrangements. Please note that accommodations are not retroactive and require advance notice to implement.

Religious Observance

Religiously observant students wishing to be absent on holidays that require missing class should notify their professors in writing at the beginning of the semester and should discuss with them, in advance, acceptable ways of making up any work missed because of the absence.

Excused Absences for University Extracurricular Activities

Students participating in an officially sanctioned, scheduled university extracurricular activity should be given the opportunity to make up class assignments or other graded assignments that were missed as a result of their participation. It is the responsibility of the student to make arrangements for make-up work with the instructor prior to any missed scheduled examinations or other missed assignments. (See current Catalog under heading of "Academic Records/Excused Absences.")

Medical Related Absences

To ensure academic continuity and avoid any course penalties, students should follow procedures described by their instructors in order to be provided with appropriate modifications to assignments, deadlines, and exams.