MATH 3111 - Linear Algebra 1:00-2:05 MWF, Room: Sci 2200

Instructor: Chris Atkinson
Email: catkinso@morris.umn.edu
Course webpage: `https://ckatkinson.github.io/3111/`
Office: Science 2340
Phone: 589-6321
Office Hours: M 2:05-3:05pm, T 1-2pm, W 9-10am, T 1:30-2:30pm, F 9-10am, or by appointment

Textbook: "Linear Algebra and its applications", fourth edition, by David Lay.

Prerequisites: Math 1102 and perseverance.

Topics covered: See the last two pages of this document. Alternatively, see `http://ckatkinson.github.io/3111/topics.pdf`.

Main themes: In short, linear algebra is the study of vector spaces and linear transformations. A vector space is a type of algebraic structure and a linear transformation is a certain type of function from one vector space to another. Linear algebra has many applications, both in pure and applied mathematics.

The beauty and success of linear algebra comes from the fact that the objects studied by linear algebra are inherently simple. The main geometric objects that linear algebra deals with are lines, planes, and their higher dimensional analogues. Contrast this with calculus where one frequently deals with curves defined by complicated equations that can be difficult to work with. The fact that the objects under consideration are so simple will mean that there will usually be no obstacle to full understanding.

Most of the ideas we'll study in this course use variations on a single technique that you're likely already familiar with. Suppose you have two lines in the xy–plane. Euclidean geometry tells us that the lines either intersect in a single point, are parallel, or coincide. We already know how to decide exactly what's going on in this situation. Our two lines will have equations of the form $ax + by = e$ and $cx + dy = f$ (you can take a line in point–slope or slope–intercept and manipulate it into this form). To understand how the lines intersect (if at all), we simply need to solve the system of linear equations

$$\begin{cases} ax + by &= e \\ cx + dy &= f. \end{cases}$$

You know how to do this, either by the substitution or elimination method. We'll see that if we use only the elimination method, we can make solving this system and more general systems with more variables algorithmic. This technique is *the* main technique that we'll use throughout the course.

After studying the solution sets to more general linear equations and developing some notation to more easily describe these problems, we'll take a step back and look more carefully at what we've done. We'll notice that the solution sets have a very nice structure. This leads to the notion of a vector space. Studying these more abstract mathematical objects will shed light on our previous study of linear equations. When studying how functions between vector spaces behave, we'll find out that what previously seemed to be a notational convenience actually completely describes how vector spaces can be mapped to one another. Again, understanding this connection will shed further light on solving systems of linear equations.

A neat application of understanding how functions between vector spaces behave is Google's PageRank algorithm. A certain matrix factorization can be used for image compression. The tools we develop are used in computer graphics. Time–permitting, we'll discuss these applications and more.

Time commitment: University policy says "one credit is defined as equivalent to an average of three hours of learning effort per week (over a full semester) necessary for an average student to achieve an average grade in the course". Our course is a four–credit course, meeting $3\frac{1}{4}$ hours per week: 4 credits times 3 hours/week/credit - $3\frac{1}{4}$ hours/week in lecture = $8\frac{3}{4}$ hours/week outside class. Thus, you are expected to spend 8 hours and 45 minutes per week working outside of class, reading the textbook and working problems. You should set your sights higher than "average student, average grade", so expect to spend more than $8\frac{3}{4}$ hours a week outside of class.

Details of the class:

- **Course webpage:** All information related to the course will be posted on the course webpage. You should bookmark this link:
  http://ckatkinson.github.io/3111/.
  Visit this page regularly as all announcements and assignments will be posted here.
- **The book:** Before each class meeting, you should quickly read the section of the textbook that we will be discussing in class. The author does a good job of motivating the topics and explaining how they fit together. Your goal on a first read is to get an idea of what the section is about. What are the main definitions? What are the main results? What kind of examples and questions does the author address? During class, I'll give you the human perspective on how to understand the main points. Ideally, you'll go back after class and read the section again in more detail. Learning technical subjects like mathematics is difficult for everyone. You should expect to have to read things more than once to fully understand what is going on.

  The exercises in this textbook are great. There is enough repetition for students to practice the basic computational skills. The more conceptual problems are almost all very approachable. Many textbooks have wacky, mind–bending, tricky problems. This book has almost none of these.
- **Class meetings:** We meet three days per week for 65 minutes. Most days will consist of $15-20$ minutes of structured homework discussion and $45-50$ minutes of lecture. Details are explained below.
- **Homework:**
  - **WeBWorK:** WeBWorK is an online homework system. You can find our section either via the link on the course webpage or by going directly here: http://webwork.morris.umn.edu/webwork2/F18LinAlg_Atkinson/. A few problems will be assigned for each section of the textbook that we cover. These problems will be mostly of a computational nature and are intended to give you practice working though basic examples. These assignments will usually be due one minute before the next meeting of our class.
  - **Practice problems:** I can tell you what to think, but I can't think for you. To learn how to think about linear algebra (or anything else) you need to think about the ideas yourself. To do so, you should work though many example problems.
    The document at https://ckatkinson.github.io/3111/3111-topics.pdf has a list of the sections of the textbook that I plan to cover. In each row, I've listed a selection of

practice problems. After we cover a section in class, you should work through as many of these problems as you need to to master the topic. In addition, when I write the exams, I consider any problem similar to assigned practice problems to be fair game.

Note that some problems are marked with a star (*). These problems are more conceptual or a bit more involved than the ones that are not marked with a star. In each section, the list of problems before the first occurrence of a star are routine, computational problems. You should be sure to learn how to do all types of these problems. You don't necessarily have to repeat types of problems that you've mastered. In almost all sections, the first two starred problems are true–false questions that test your basic understanding of the concepts in the section. I'll definitely be putting similar true–false questions on the exams. The remaining problems typically put together a few ideas or are a bit more involved.

These problems will not be formally collected or graded, but see the following section to see what you will be turning in. You should come talk to me, talk to your classmates, or email me about problems that you need help with.

- **Discussion problems:** After each class meeting, I will post a short subset (usually just two or three) of the practice problems on the course webpage. These are the discussion problems. I expect you to work together in small groups to solve these problems. Working collaboratively allows for you to help each other out when you get stuck and to learn from explaining your thoughts. You should produce a neat write-up to the solution of each of these problems. You should also be prepared to present your solutions to the class.

  During the first $15 - 20$ minutes of class, we will discuss the discussion problems. You will have some time to compare your solutions. I will walk around the class to answer questions, choose presenters, and check that students have completed the work. We will typically have one or two quick presentations of solutions. I will keep track of who has presented. Everyone should expect to present occasionally.

  Each Friday, I will collect your work from discussion problems from the week. You should turn in the neatly written and complete solutions to the problems. These will be graded for completion, correctness, and exposition. I'll also give feedback on your work.

  Your overall grade for the discussion problems will be based both on the problems you hand in and on participation. Participation will be assessed as follows: each student starts with a bank of three *participation points*. There are three different possible *participation infractions*:

  (1) Absence: an unexcused absence during the discussion portion of class.
  (2) Unpreparedness: arriving to the discussion session without having given an honest effort on the discussion problems.
  (3) Non-presentation: refusing to give a presentation.

  A student will lose one participation point if a participation infraction is committed. Lost participation points can be earned back by turning in a complete, neatly written solution set to an **entire section** of practice problems (see list of practice problems). If the list of practice problems includes non–specific directions such as "skip around", your submitted set must include at least 15 problems. I will accept such a set at any point before the last day of instruction. You may only submit a solution set for a given section once (but feel free to submit any number of sections).

  At the end of the semester, the balance of your participation point bank will be used to determine a *participation multiplier* for your discussion problem grade. I will multiply your grade for the collected discussion problems by the participation multiplier. The following table describes how the multiplier will be determined:

Point Balance	Multiplier
3	1.025
$0, 1, 2$	1
-1	0.9
-2	0.75
-3	0.5

- **Lecture:** The remaining time after the discussion will be spent with me talking about the new ideas. I'll help you integrate the ideas you read about into your previous mathematical knowledge and help you understand how to think about the ideas. I'll present some proofs and examples to illustrate the ideas.
- **Exams:** There will be three exams during the semester. The first exam is scheduled for Friday, September 28 (week 5). The second exam is scheduled for Friday, November 9 (week 11). The third exam is scheduled for Friday, December 7 (week 15) The final exam is on Thursday, December 20 from 11:00am-1:00pm. I reserve the right to change the dates of the first three exams, but will most likely stick to the scheduled dates.
- **Grading:** The university's policy for grades can be found at: http://policy.umn.edu/Policies/Education/Education/GRADINGTRANSCRIPTS.html

  I grade homework assignments and exams with the above guidelines in mind using the following numerical scheme. Your overall score will be rounded to the nearest integer. I reserve the right to change the grading scale at any point, but will not increase the requirements for any letter grades.

Letter	Percentage
A	95-100
A-	90-95
B+	86-89
B	83-86
B-	80-83
C+	76-69
C	73-76
C-	70-73
D+	65-69
D	60-64
F	< 60

  If you are taking the course S-N, then you need 70% to earn an S.

  The components of the course will be combined to calculate your grade as follows:

WeBWorK	15%
Discussion problems	15%
Exams	45%
Final Exam	25%

  Although I will not be posting grades online, feel free to ask at any point about where you stand in the course.
- **Extra Credit:** There will be no extra credit.

Univeristy policies: See http://policy.umn.edu/education for the official university policies on education. I will adhere to these policies.

Late work and missed exams: I will only accept late work under exceptional circumstances. Please talk to me as soon as possible if you miss a deadline.

Makeup exams will only be given in the case of legitimate absences as defined by the official university policy: http://policy.umn.edu/Policies/Education/Education/MAKEUPWORK.html. Legitimate absenses must be supported by appropriate documents unless otherwise specified by university policy.

If you have a scheduling conflict and will miss an exam for a documented reason, let me know as far in advance as possible so that we can make arrangements for you to take the exam at another time.

Disability Accommodations:

The University of Minnesota views disability as an important aspect of diversity, and is committed to providing equitable access to learning opportunities for all students. The Disability Resource Center (DRC) is the campus office that collaborates with students who have disabilities to provide and/or arrange reasonable accommodations.

- If you have, or think you have, a disability in any area such as, mental health, attention, learning, chronic health, sensory, or physical, please contact the DRC office on your campus (UM Morris 320.589.6178) to arrange a confidential discussion regarding equitable access and reasonable accommodations.
- Students with short-term disabilities, such as a broken arm, should be able to work with instructors to remove classroom barriers. In situations where additional assistance is needed, students should contact the DRC as noted above.
- If you are registered with the DRC and have a disability accommodation letter dated for this semester or this year, please contact your instructor early in the semester to review how the accommodations will be applied in the course.
- If you are registered with the DRC and have questions or concerns about your accommodations please contact the Coordinator of the Disability Resource Center.

  Additional information is available on the DRC website: http://www.morris.umn.edu/academicsuccess/disability/, or e-mail hoekstra@morris.umn.edu

Here is a link to more policy statements about syllabi: www.policy.umn.edu/Policies/Education/Education/SYLLABUSREQUIREMENTS_APPA.html

Student Learning Outcomes This course is designed to partially satisfy the following *UMM Student Learning Outcomes*: 1a, 1c, 2b, 2e, 2g, 4b, 4c

See http://www.morris.umn.edu/committees/Curriculum/Learning_Outcomes_Approved.pdf