Linear Algebra

Concentration Block in Mathematics, Quest University Canada
July 2016

Class Hours: 9:00AM to 12:00PM. Location to be confirmed

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Textbook: *Linear Algebra with Applications*, by Otto Bretscher. This textbook is recommended but not mandatory, and available at the Quest bookstore.

Mathematical applications in the sciences often require the manipulation of many variables at once. Information concerning these variables, coded in matrices and vectors, can be manipulated to produce powerful results in disciplines as diverse as medicine, population dynamics, and meteorology. Students explore some of these applications as motivations for topics such as solving systems of linear equations, matrix and vector operations, linear independence and vector spaces, eigenvalues, and other topics.

Course Evaluation

Problem Sets (6 × 10%)	**60%**
Group Seminars (3 × 5%)	**15%**
Weekend Projects (2 × 5%)	**10%**
Final Project	**15%**

There are four methods of assessment in this course.

- **Problem Sets** will consist of questions based on concepts and ideas that are uncovered during class. Each problem set will consist of five multi-part questions.

- **Group Seminars** will allow you to learn the surprising real-world applications of linear algebra and present them to your peers. Each 15-minute seminar will be conducted in groups of three or four: your group will prepare a 1-page double-sided handout and deliver a ten-minute presentation followed by five minutes of Q&A.

- **Weekend Projects** will be multi-part problems connecting different areas of the course, allowing you to synthesize what you have learned. Think of them as take-home exams.

- **Final Project** work will occur during the last week of the course. Each group will pose a Question and apply Linear Algebra to find a solution. The assessment will consist of a project proposal, a final report, and a ten-minute presentation on the last day of class.

  NOTE: if an assessment is worth x% of the final grade, then it will be marked out of $3x$.

Course Overview

Linear algebra can be most succinctly defined as the study of *vector spaces*, which are sets of objects (called vectors) that allow for typical notions of adding and scaling. You may already be familiar with the idea of a vector as a directed magnitude in space, although in this course this term will mean something much more general. In this course, we will organize disparate ideas and topics into a coherent and systematized theory.

In our effort to understand why this is of interest and importance, we will explore several topics, including systems of equations, matrices, determinants, dimension theory, linear transformations, eigenvalues, eigenvectors, least squares, and linear regression. We will explore the *theoretical* components of linear algebra requiring skills of logic and proof, as well as the *computational* components of linear algebra requiring creative methods in mathematical problem-solving.

Linear algebra is foundational to pure mathematics. By relaxing the axioms of a vector space and generalizing key definitions, the theory of *Abstract Algebra* emerges. *Functional Analysis*, one of the most active areas of 21st century mathematical research, unfolds by extending vector spaces to infinite dimensions.

In addition to the theoretical connections, linear algebra provides the mathematical framework for much of modern engineering, quantum physics, general relativity, dynamical systems, cryptography, computer animation, image compression, social network analysis, and economics. Over the next month, I hope to have you discover why linear algebra really is the "driving engine" of modern mathematics, with deep and important connections to issues that matter to you.

Course Schedule

Day	**Work Due (by 8AM)**	**Topic in Class (9AM to 12PM)**
1	**Diagnostic Quiz**	*Solving Systems of Equations*
2		*Reduced Row Echelon Form*
3	**Problem Set 1**	*Matrix Multiplication*
4	**Seminar 1**	*Matrix Inversion*
5	**Problem Set 2**	*Matrix Inversion*
6	**Weekend Project 1**	*Determinants*
7	**Seminar 2**	*Vectors: Linear Independence*
8	**Problem Set 3**	*Vectors: Subspaces and Dimension*
9	**Seminar 3**	*Vector Spaces*
10	**Problem Set 4**	*Coding Theory*
11	**Weekend Project 2**	*Linear Transformations*
12	**Seminar 4**	*Linear Transformations*
13	**Problem Set 5**	*Linear Transformations*
14	**Seminar 5**	*Eigenvalues and Eigenvectors*
15	**Problem Set 6**	*Eigenvalues and Eigenvectors*
16	**Final Project Proposal**	*Linear Optimization*
17		*Linear Optimization*
18	**Final Project Report**	*Final Presentation*

Course Forum

We have a Moodle page, on which I will post all assessments, handouts, and grades. Please check this page after class each day:

http://moodle.questu.ca/moodle/course/view.php?id=10019

We will also have a class Google Doc for various administrative items, which I ask you to check at least once each day. The URL is:

https://docs.google.com/document/d/11DBRmMqTgKcaWQ2eIneriOjRMmYcD_kcMGoD4ahmgh8/

Course Policies

Assessments:

All assessments are due at **8:00AM** on the day indicated: one hour before the start of class. As I plan to complete some of the marking in the hour before class, your assessment must be in my mailbox by this time. My mailbox is in the Faculty Photocopier Room, on the fourth floor of the Academic Building, across from the President's office.

Any submission that is late, even by one minute, will be subject to a severe late penalty at my discretion (usually 20%). You are allowed *one* exception to this policy, where you are allowed a 24-hour extension to any assessment, with no penalty, provided you have a doctor's note or some other relevant documentation. Additional exceptions will only be given under extenuating circumstances.

I strongly recommend that you have your Problem Set completed and submitted before you leave the Academic Building in the evening, thus avoiding the inconvenience of having to arrive at school early to hand it in.

Attendance:

It is expected that you attend every class. We begin each day at 9:00AM sharp. If you must miss a class for any reason (e.g. illness, family emergency, religious observance), contact me immediately, by e-mail. Regardless of the reason, it is your responsibility to catch up on the material you have missed, and obtain the notes from a classmate (not from me).

Technology:

As a courtesy to me and your fellow students, ensure your cell phone is turned off during class hours (including breakout sessions). In fact, I'd appreciate it if you don't bring your cell phone to class. If you absolutely must bring your phone, leave it in your backpack so that it is not visible to either of us. Also, you will not require your laptop during our in-class activities. Therefore, if you choose to bring your laptop with you, please leave it in your backpack.

Scheduling Meetings:

If you have an Academic Accommodation Plan, please make an appointment to see me on the afternoon of Day 1. Speak to me at the end of class (12PM) or contact me by e-mail, and we will set up a time to meet. I look forward to learning how I can be of service to you.

If you have any other questions or concerns about the course, speak to me at the end of class, or contact me by e-mail, and we will set up a one-on-one meeting at a mutually convenient time.

I will be walking around the 3rd floor of the Library Building between 3PM and 4PM every day between Monday and Thursday. This is where I recommend you work, in case you (and your small group) have any questions on the Problem Set, or any ideas you wish to bounce off of me.

My office hours will typically be on Monday and Wednesday afternoons, but the times will vary; you can sign up for a 15-minute meeting on the class Google Doc. If you need assistance on the Problem Set, please wait until our 3PM get-together; for all other questions/concerns/issues, let's meet individually during office hours.

Please note that I do not have an open-door policy, where students can come by my office at any time. Therefore, do not drop by my office if you do not have an appointment, even if you need "just one minute" to ask a "quick question". No exceptions. Thank you for your understanding.

Grading:

We will use the following scale to convert numerical scores into letter grades:

A	93% – 100%	**C+**	77% – 79%
A-	90% – 92%	**C**	73% – 76%
B+	87% – 89%	**C-**	70% – 72%
B	83% – 86%	**D**	60% – 69%
B-	80% – 82%	**F**	0% – 59%

During our eighteen days together, you will submit six major Problem Sets (180 marks), complete two Weekend Projects (30 marks), deliver three Seminars (45 marks) and complete a Final Project (45 marks). To calculate your final grade, I will add up your marks for these assessments and simply divide by three. As mentioned earlier, if an assessment is marked out of 3x, then it counts x% towards your final grade.

Whenever I return an assessment, I will always post a "model solution" on the Moodle Page. If you wish to respectfully ask why you received a certain mark on a question, you must first carefully review the online model solution that was posted for that question and compare that solution with the comments I have provided for you. If you still disagree with the mark you received, you must e-mail me to request an appointment, and we will set up a time to meet sometime the following day. At this time (and not before), we will discuss your concerns.

As a general rule, please do not debate grades with me. I find it an incredible drain on my time and energy, and prevents me from serving students well.

Plagiarism:

As with all other courses at Quest, you are expected to adhere to the university honour code. In this course, any blatant act of cheating (e.g. finding an online solution to an assignment problem) will receive a zero for the first offense, and an automatic failure for the second offense. In both cases, I will immediately report the incident to the Chief Academic Officer.

So that there is no ambiguity, there are two non-negotiable rules. A violation of either rule constitutes plagiarism.

- Even if you meet with a classmate to discuss an Individual Problem on the Problem Set, the articulation of your thought process (i.e., what you submit to me), must be an *individual* activity, done in your own words, away from others.

- The Problem Sets and Weekend Projects are meant to be demanding, and struggling through a problem is where the bulk of the learning takes place. Your educational experience is cheapened by going online and finding the solution to a problem – even using the Internet to look for a "small hint" is unacceptable. In return, I will be readily available during our daily hour-long get-togethers in the library, and upon request, will also post hints to the Problem Set on our Google Doc. (I have designed the course so that the class Google Doc and Moodle Page are the only online resources you will need!)

One Final Word:

My hope is that through this course, you will discover that Linear Algebra is exciting, beautiful, powerful, and applicable to everything in this world; and that through your efforts over the next three and a half weeks, you will further develop the confidence, critical thinking, and communication skills that will be so essential throughout your life.

Thank you for taking this block in Linear Algebra, and entrusting me to shape your liberal arts education here at Quest University Canada. I am excited to serve as your tutor.