Department of Mathematics, University of Toronto
MAT223H1S - Linear Algebra I
Winter 2016

Lectures & Administrative Information

Section	Time	Lecture Room	Instructor	Office
L0101	W1-3, R2	SS 2118	T. Bazett	HU 912
L0201	T1-3, R1	MP 203	S. Uppal	PG 112
L0301	TR1, F11	MP 202	Y. Qing	BA 6103
L0401	TWR12	MP 103	T. Bazett	HU 912
L0501	T1, R1-3	MP 102	L. Garcia Martinez	BA 6168
L5101	T6-9	MP 102	N. Garcia-Fritz	BA 6103
L5201	W6-9	GB 220	X. Shen	HU 1012A

Course Coordinator: S. Uppal.

Email: uppal@math.utoronto.ca.

Office hours: Tuesdays 3:10-4:00pm, Wednesdays 5:10-6:00pm, Thursdays 4:10-6:00pm or by appointment. If you would like to book an appointment outside my regularly scheduled office hours, please send me an email indicating the times you are available to meet. Also, please give at least 24 hours notice for appointments so that there is suitable time to make arrangements.

Email Policy & Etiquette

We will respond to emails as soon as possible, usually within 24-48 hours (except on weekends). Several days before an exam is always a particularly busy time and it may take us longer to respond. If your situation is urgent, it's best to speak with us in person either before or after class or during office hours.

- **Put MAT223 in the subject line, use your UofT email, and always identify yourself**.
- **Be specific**. We're better able to help you the more specific you are. If your question is complex or lengthy and requires multiple back-and-forth emails, we will ask you to to come office hours, or make an appointment, instead.
- **Check the syllabus and Blackboard first**. If the answer to your question(s) is available in the syllabus or on Blackboard, we will not respond to your email.
- **Be professional**. Please use an appropriate tone, level of formality, and review what you've written before sending your email. Email, in the context of the class and communication with instructors, is professional correspondence and we expect you to treat it as such.

Brief Course Description & Goals

This is an introductory course in linear algebra over $\mathbb{R}^n$. By the end of the course, you should appreciate and understand the combination of the two words 'linear' + 'algebra'. For now, you may understand 'linear' to mean anything 'straight' or 'flat' e.g. the equation of a line represents something 'straight'; the equation of a plane represents something 'flat'. You've surely heard the word 'algebra' before and know the algebra of numbers - i.e. the rules of addition and multiplication of numbers. Linear algebra will be the second algebra you learn and will be like learning a second language. There will be many new terms introduced to you throughout the term and it's important to really learn and understand (not memorize) them. You will be required to know precise definitions and statements of theorems, be able to solve standard computational problems in each section covered, understand all theoretical concepts involved, and be able to do simple, short proofs of particular statements. Always keep in mind that in linear algebra **concepts are as important as computations**.

It is hoped that by the end of the course you will have

- become fluent in linear algebra over $\mathbb{R}^n$ and some of its applications.
- become comfortable reading and understanding precise mathematical statements, definitions, and proofs.
- sharpened your problem solving, reasoning, and writing skills.

You will see some superb material in this course. If you run into some trouble along the way, please do not hesitate to contact your instructor or TA for help. See the weekly schedule on page 8 & 9 of this document for a full list of topics covered.

Textbook and Reading Material

Required: We are using a custom textbook for this course consisting of select chapters from Keith W. Nicholson : *Linear Algebra with Applications, 7th ed.* ISBN-13: 978-1-25-945514-8. The textbook is available for purchase from the UofT Bookstore only. A *Solution Manual* is not available but there are solutions to the odd numbered questions in the back of the text.

The strength of the textbook lies in its set of exercises - there's a good mix of computational and theory problems in each section. We suggest, however, that lectures be your primary source of information and the textbook a secondary source.

Recommended: Jeffery Holt: *Linear Algebra with Applications.* ISBN: 978-0-716-7866-72

This textbook is at an appropriate level but the set of exercises in this text aren't as strong as Nicholson's. It is suitable for the material we cover but there are times when the author uses non-standard notation and definitions, notably his definition of row-echelon form of a system of linear equations. We have used this textbook in previous years and it's the textbook used for the engineering version of this course, MAT188.

Recommended (advanced): Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence: *Linear Algebra, 4th ed.* ISBN:978-0-130-08451-4

This is the textbook used for the specialist linear algebra MAT240/MAT247. A solid, well written text, with good problems but advanced for this course. For those of you looking to delve deeper, this is the text to read.

Course Webpage

The website for this course is accessible through http://www.portal.utoronto.ca

Please check the website frequently for course announcements and materials. All announcements posted are considered to have been announced to the class and not having read or seen an announcement **is not** an accepted reason for not following guidelines or missing deadlines. You may configure your preferences on portal to receive email notification as soon as an announcement has been posted.

Marking Scheme

Your final grade will be calculated by the following formula:

- Quizzes - 10% of your final grade.
- Midterm Exam I & II - 50% of you final grade (combined). The higher of Midterm I/II will count for 30% of your final grade; the lower 20%.
- Final Exam - 40% of your final grade.

Your raw scores for each piece of term work will be recorded on Blackboard. Please check regularly that your marks have been recorded accurately. If there are any discrepancies, please email the course coordinator immediately - **do not** wait for weeks to go by - at uppal@math.utoronto.ca. You will, of course, need evidence that your grade is not recorded correctly.

Course Components

Lectures

You will get the most out of lectures if you come to really engage with the material as opposed to just taking notes (or not). Try to make sense of individual topics and their connections to other topics and how to translate seemingly abstract concepts into simple terms. If you do choose to take notes, I suggested re-writing and revising your notes the same day, while concepts are still fresh in your mind.

While cell phones are not prohibited in lecture, **recording or taking pictures in class is strictly prohibited without the consent of your instructor**. Please ask before doing.

Tutorials

Every student should be registered in one tutorial section. You may register in one of the tutorial time slots through ROSI/ACORN by the end of the first week of classes. After that, look for and follow the instructions on Blackboard about enrolling in a tutorial. By the end of the second week of classes tutorial groups and locations will be posted on the course website.

Tutorials begin the 3rd week of classes. Tutorials are an integral part of the course and should be regarded as just as important as lectures. During your tutorials your TA will discuss 'Tutorial Problems' which will be posted on the course website each Friday and will be discussed in your tutorial the following week. The problems are meant to develop your skills, deepen your understanding, and to help prepare you for the exams. It's important then that you practice early and often, identify what you're having the most trouble

with and ask questions.

As with lectures, **recording or taking pictures in tutorial is strictly prohibited without the consent of your TA**. Please ask before doing.

Midterms & Final Exam

There will be two 1hr 50min minute midterm exams and one 3hr final exam common to all sections of the course. Each midterm will emphasize material not already tested but may build on previous material. The final exam will be cumulative.

The dates of the midterms are:

- Midterm I - Friday February 12, 4:10-6:00pm. An early sitting is available from 2:10am-4:00pm for those with a legitimate conflict.
- Midterm II - Friday March 18, 4:10-6:00pm. An early sitting is available from 2:10am-4:00pm for those with a legitimate conflict.

The date of the final exam is to be determined by the Faculty of Arts & Science but will be scheduled sometime April 12-29.

If you have a legitimate conflict and need to register for the early sitting of the exams, please read and follow the instructions that will be posted on Blackboard roughly two weeks before the date of each midterm.

Each midterm exam and the final exam may contain multiple choice questions, short answer questions, theory questions, precise definitions and statements of theorems. Exact details about exam content and format will be posted on the website roughly two weeks before the date of each midterm. Midterms and the final exam are closed book and no calculators or other aids are allowed.

Quizzes

There will be a 10 minute quiz and the end of almost every tutorial (see pages 8 & 9 for the schedule). The quiz will consist of one question, possibly with multiple parts based on the suggested problems/tutorial problems for that week. Students are expected to provide their own paper to write the quiz. The marking for each quiz will be out of 4.

A good performance on a quiz is not necessarily an indication of your mastery of a concept, or that you are prepared for exams. They do, however, help you identify any emerging gaps in your understanding.

There will be nine quizzes in total but only your best seven quizzes will count toward your quiz grade. The material for the quiz will be posted on the course website each Friday before your tutorial the following week.

There will be no make-up quizzes.

Tips to do well

- Attend every lecture and tutorial.
- Come to lecture and tutorial prepared. For lectures, this means reviewing the material from the previous week, and reading the relevant sections in the textbook beforehand. Be active while reading - write definitions and statements of theorems and note any concepts that are unclear and any questions you may have. You can then either bring them up in lecture or see if the lecture has answered your questions. For tutorials, this means attempting the Tutorial Problems in advance. The key is to discover what you do and don't know and where there are gaps in your understanding. Once you look up a solution, or have someone show you a solution, you lose out on this valuable insight.
- Practice, practice, practice. Learning linear algebra is like learning a new language, to master it requires consistent practice. Once you've read the textbook and reviewed your notes, you won't gain much by re-reading them ad nauseum. Practice problems as much as you can. Practice early and often rather than cramming in short bursts.
- Learn, don't memorize. Learning is an active process; memorizing is passive.
- Form study groups. You will learn from one another, through both your expertise and your mistakes.
- Ask questions. Lots of them. If you're stuck on a problem and don't know where to begin, a good starting point is to identify the keywords and ask yourself "what does this mean?".
- Complete **all** the term work. Consistently, the top marks for the course are earned by students who don't defer any exams and write all the quizzes, even though we drop your lowest two quiz scores.
- Average 8 hours (480 minutes) of study a week for this course - 1/5th of a full time job. Being engaged in lectures and tutorials is 200 minutes and gets you almost halfway there. The remaining time should be spent mainly practicing problems.

Course Policies

Missed Exams

- You will be assigned a grade of 0 for any midterm exam you do not write unless you submit a University of Toronto Verification of Student Illness or Injury form - http://www.illnessverification.utoronto.ca/getattachment/index/Verification-of-Illness-or-Injury-form-Jan-22-2013.pdf.aspx - within one week after the date of the exam.
- The form must have all the required fields properly filled out and it must list the doctor's OHIP number.
- The form must clearly state that on the date of the exam you were unable to write. Accordingly, it's expected that you will have met your doctor on the date of the exam. Illness before the exam is not sufficient grounds for not writing the exam nor is the claim that you would have performed "sub-optimally". The form **cannot just report that you told the doctor after-the-fact that you were ill previously**.
- The form must be original and completed by a qualified medical doctor - **not** an acupuncturist, chiropractor, or other health care professional.
- Once you submit your form, it will be reviewed before it will be accepted. Part of the review process may include following up with your doctor, your college registrar, or the undergraduate chair of the math department. It is an academic offence to feign illness to miss an exam.

- If you do miss either Midterm I or II for a legitimate reason that you can document, and your documentation is accepted, then your final exam will account for 65% of your final grade, and the midterm exam you do write will account for 25% of your final grade.

Quizzes

- **Each student must attend their assigned tutorial group to write their quiz otherwise your grade will be recorded as 0**.
- Medical notes are not necessary/will not be accepted for missing a quiz since we drop your lowest two quiz scores in calculating your quiz grade.
- Under no circumstances will the weight of any quiz be transferred to the final exam.

Academic Resources

Accessibility Needs

The University of Toronto is committed to accessibility. If you require accommodations for a disability, or have any accessibility concerns about the course, the classroom or course materials, please contact Accessibility Services - http://www.studentlife.utoronto.ca/ - as soon as possible.

Writing and English Language Instruction

For information on campus writing centres and writing courses, please visit http://www.writing.utoronto.ca/.

FREE English language instruction with the ELL Program will start in Winter 2016. The Communication Cafe offers drop-in discussions, presentations, and debates, along with learning about Canadian culture starting January 11, 2016 - no registration necessary. Sessions are facilitated by writing centre instructors. Also, registration is open NOW for Reading eWriting, online writing practice with a writing centre instructor starting January 15, 2016. For more information about the English Learning Language (ELL) program, please visit http://www.artsci.utoronto.ca/current/advising/ell.

Other Resources

Student Life Programs and Services: http://www.studentlife.utoronto.ca

Academic Success Centre: http://www.studentlife.utoronto.ca/asc

Health and Wellness Centre: http://www.studentlife.utoronto.ca/hwc

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Academic Integrity

Academic integrity is fundamental to learning and scholarship at the University of Toronto. Participating honestly, respectfully, responsibly, and fairly in this academic community ensures that the U of T degree that you earn will be valued as a true indication of your individual academic achievement, and will continue to receive the respect and recognition it deserves.

Familiarize yourself with the University of Toronto's Code of Behaviour on Academic Matters

http://www.governingcouncil.utoronto.ca/policies/behaveac.htm.

It is the rule book for academic behaviour at the U of T, and you are expected to know the rules.

The University of Toronto treats cases of academic misconduct very seriously. All suspected cases of academic dishonesty will be investigated following the procedures outlined in the Code. The consequences for academic misconduct can be severe, including a failure in the course and a notation on your transcript. If you have any questions about what is or is not permitted in this course, please do not hesitate to contact me. If you have questions about appropriate research and citation methods, seek out additional information from me, or from other available campus resources like the U of T Writing Website. If you are experiencing personal challenges that are having an impact on your academic work, please speak to me or seek the advice of your college registrar.

Weekly Schedule and Suggested Textbook Problems

As a general rule, you should try to solve as many problems as possible and in a timely fashion. The more problems you do, the better your understanding will be.

Your instructor may be slightly ahead or behind this schedule. **This schedule is subject to change**.

Week 1 beginning January 11.

Lecture: Systems of Linear Equations.

- Introduction to the course.
- Section 1.1: Solutions and Elementary Operations. **# 1-17**.
- Section 1.2: Gaussian Elimination. **# 1-15**.

Week 2 beginning January 18.

Lecture: Systems of Linear equations (continued), Matrix Algebra.

- Section 1.3: Homogeneous Equations. **# 1-7, 11, 12**.
- Section 2.1: Matrix Addition, Scalar Multiplication, and Transposition. **# 1-22**.

Week 3 beginning January 25. **Tutorials begin. Quiz 1**.

Lecture: Matrix Algebra (continued).

- Section 2.2: Equations, Matrices, and Transformations. **# 1-23**.
- Section 2.3: Matrix Multiplication. **# 1-10, 14-24, 27-36**.

Week 4 beginning February 1. **Quiz 2**.

Lecture: Matrix Algebra (continued).

- Section 2.4: Matrix Inverses. **# 1-42**.
- Section 2.5: Elementary Matrices (optional) - omit Smith Normal Form. **# 1-10, 13, 17-20**.

Week 5 beginning February 8. **Midterm Exam I. Quiz 3**.

Lecture: Matrix Algebra (continued). Vector Geometry.

- Section 2.6: Linear Transformations. **# 1-25**.
- Section 4.1: Vectors and Lines. **# 1-27**.

Week 6 beginning February 22. **Quiz 4**.

Lecture: Vector Geometry (continued). The Vector Space $\mathbb{R}^n$.

- Section 4.2: Projections and Planes - omit Determinant Form of the Cross Product **# 1-25, 32-34, 37-39, 41-45**.
- Section 5.1: Subspaces and Spanning. **# 1-23**.

Week 7 beginning February 29. **Quiz 5**.

Lecture: The Vector Space $\mathbb{R}^n$ (continued).

- Section 5.2: Independence and Dimension. **# 1-20**.
- Section 5.3: Orthogonality. **1-14, 16-18**.

Week 8 beginning March 7. **Quiz 6**.

Lecture: The Vector Space $\mathbb{R}^n$ (continued). Determinants and Diagonalization.

- Section 5.4: Rank of a Matrix. **# 1-15, 18**.
- Section 3.1: The Cofactor Expansion. **# 1-26**.

Week 9 beginning March 14. **Midterm Exam II, Quiz 7**.

Lecture: Determinants and Diagonalization (continued)

- Section 3.1: The Cofactor Expansion. **# 1-26**.
- Section 3.2: Determinants and Matrix Inverses - omit Adjugates, Cramer's Rule, and Polynomial Interpolation. **# 1-7, 10-14, 16-18, 20 (b)-(d), (i)-(k), 25-27**.

Week 10 beginning March 21. **Quiz 8**.

Lecture: Determinants and Diagonalization (continued).

- Section 3.3: Diagonalization and Eigenvalues - omit Linear Dynamical Systems their Graphical Descriptions. **#1-4, 6-27**.
- Section 5.5: Similarity and Diagonalization - omit Complex Eigenvalues. **#1-13**.

Week 11 beginning March 28. **Quiz 9**.

Lecture: Orthogonality.

- Section 8.1: Orthogonal Complements and Projections - Section will be posted on Blackboard. **#1-17**.

Week 12 beginning April 4.

Lecture: Orthogonality (continued).

- Section 8.1: Orthogonal Complements and Projections (continued) - Section will be posted on Blackboard. **#1-17**.
- Catch Up/Review for Final Exam.