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Course Coordinator: S. Uppal.

Email: uppal@math.utoronto.ca.

Office hours: Mondays and Fridays 13:00-14:00, Tuesdays 14:00-15:00 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 MAT188 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 may 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. Please 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, we hope that you appreciate and understand the combination of the two words 'linear' and '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'. Straight or flat things are generally nice and predictable. You’ve no doubt heard the word 'algebra' before and know the algebra of numbers - i.e. the rules of addition and multiplication of numbers. 'Algebra' you may think of, then, as a relation (or relationships). There are other algebras, however, and linear algebra will likely be the second algebra you learn. There will be many new terms introduced to you throughout the term and it will be important that you learn and understand them (not memorize them). Learning linear algebra will be like learning a second language. 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 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, understanding, and writing 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


The strength of the textbook is its early introduction to vector space concepts and definitions; its mid-section exercises which will allow you to test your understanding as you read through the material; and its end of section exercises - there’s a decent 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.


This textbook is at an appropriate level and 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 for this course but would recommend it
only as a secondary source purely for the exercises.


This is the textbook used for the specialist linear algebra MAT240/MAT247 in the Faculty of Arts & Science. 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](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.
- Numerical Labs - 15% of your final grade.
- Midterm Exam I & II - 35% of your final grade (combined). The higher of Midterm I/II will count for 20% of your final grade; the lower 15%.
- 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

Tutorials begin the week of September 19. 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 2hr 30min 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 and times of the midterms are:

- Midterm I - Tuesday October 11, 13:10-15:00.
- Midterm II - Tuesday November 15, 13:10-15:00.

The date of the final exam is to be determined by the Faculty of Applied Science & Engineering and will be scheduled sometime December 9-20.

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 TYPE A, i.e. the exams are closed book, no aids allowed. In particular, phones and calculators are not permitted for exams.

Quizzes

There will be a 10 minute quiz and the end of almost every tutorial (see pages 7-9 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. All quizzes are TYPE A, i.e. the quizzes are closed book, no aids allowed. In particular, phones and calculators are not permitted for quizzes.

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 eight 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.
Numerical Labs

Each student in MAT188 will be scheduled into a biweekly, two-hour lab covering numerical methods using Matlab. Detailed information about the Practical Labs will be available separately and posted on the course webpage. Depending on what section you are enrolled in, Practical Labs begin either the week of September 12 or September 19.

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 nauseam. 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 quiz score.
- Average 8-10 hours (480-600 minutes) of study a week for this course. Being engaged in lectures and tutorials is 200 minutes a week and gets you at least a third of the way there. The remaining time should be spent mainly practicing problems.

Petitions for Missed Term Work, Final Examination, Special Consideration.

- A petition is a formal request for an exception to a Faculty or University rule, regulation, or deadline - most commonly, missing an exam or quiz. Please familiarize yourself with the Faculty of Applied Science and Engineering’s policy regarding petitions here

  http://uoft.me/petitions

Note carefully deadlines and supporting documentation requirements.
Resources

Academic Resources

Academic Advising & Support from the First Year Office:

http://www.undergrad.engineering.utoronto.ca/AdvisingSupport/FirstYearOffice.htm

Here you will find links and information regarding (among other things): Academic Advising, Academic Success, Health & Wellness, International Student Transition Advising, Learning Skills Strategist, Student Rights & Responsibilities, Safety on Campus, and the Code of Behaviour on Academic Matters.

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.

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.

Please familiarize yourself with the University of Toronto’s Academic Integrity policy, you are expected to know the rules:

http://academicintegrity.utoronto.ca/.

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 link above. 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 are experiencing personal challenges that are having an impact on your academic work, please speak to me or seek the advice of the First Year Office.
Weekly Schedule and Suggested Textbook Problems

The textbook problems are divided into four sections: A, B, C, and D. The A problems are standard computational problems with the odd theoretical problem thrown in. The B problems generally duplicate the A problems though in some cases they are not exactly identical to the A problems. Answers to the A problems can be found at the back of the text, and full solutions to the A problems can be found in the Student Solutions Manual. There are no answers available to the B problems. The C problems require the use of a suitable computer program and are questions you may muck about with with Matlab. The D problems are conceptual problems and will ask you to work in general cases, provide short arguments, or invent an example. These questions are important for mastering the ideas/concepts in the course and every student should attempt some of these questions. 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 September 5. **Note:** The first day of lectures is Thursday September 8.

**Lecture:** Euclidean Vector Spaces.
- Introduction to the course.
- Section 1.1: Vectors in $\mathbb{R}^2$ and $\mathbb{R}^3$. A1-10, B1-10, D 1-4.

**Week 2** beginning September 12.

**Lecture:** Euclidean Vector Spaces (continued).
- Section 1.2: Vectors in $\mathbb{R}^n$. A1-7, B1-5, D1-8.

**Week 3** beginning September 19. **Tutorials begin. Quiz 1.**

**Lecture:** Euclidean Vector Spaces (continued).
- Section 1.4: Projections and Minimum Distance. A1-7, B1-7, D1-5.

**Week 4** beginning September 26. **Quiz 2.**

**Lecture:** Systems of Linear Equations.
- Section 2.2: Reduced Row Echelon Form, Rank, and Homogeneous Systems. A1-5, B1-4, D 1-4.

**Week 5** beginning October 3. **Quiz 3.**

**Lecture:** Systems of Linear Equations (continued). Matrices, Linear Mappings, and Inverses.
**Week 6** beginning October 10. **Midterm I.**

**Lecture:** Matrices, Linear Mappings, and Inverses (continued).
- Section 3.2: Matrix Mappings and Linear Mappings. A1-10, B1-11, D1-5.
- Section 3.3: Geometrical Transformations. A1-5, B1-5, D1-5.

**Week 7** beginning October 17. **Quiz 4.**

**Lecture:** Matrices, Linear Mappings, and Inverses (continued).
- Section 3.5: Inverse Matrices and Inverse Mappings. A1-6, B1-6, D1-5.

**Week 8** beginning October 24. **Quiz 5.**

**Lecture:** Determinants.

**Week 9** beginning October 31. **Quiz 6.**

**Lecture:** Determinants (continued). Eigenvectors and Diagonalization.
- Section 5.4: Area, Volume, and the Determinant. A1-6, B1-5, D1-2.

**Week 10** beginning November 7. **Assessment Free Week**

**Lecture:** Eigenvectors and Diagonalization (continued).

**Week 11** beginning November 14. **Midterm II.**

**Lecture:** Orthonormal Bases.
- Section 7.2: Projections and the Gram-Schmidt Procedure. A1-5, B1-5, D1-7
**Week 12** beginning November 21. **Quiz 7.**

**Lecture:** Orthonormal Bases (continued). Symmetric Matrices and Quadratic Forms.


**Week 13** beginning November 28. **Quiz 8.**

**Lecture:** Symmetric Matrices and Quadratic Forms (continued).

- Section 8.3: Graphs of Quadratic Forms. A1-5, B1-6.

**Week 14** beginning December 5. **Note:** The last day of lectures is Wednesday December 7.

**Lecture:** Catch up/Review for Final Exam.