DEPARTMENT OF MATHEMATICAL AND COMPUTATIONAL SCIENCES
UNIVERSITY OF TORONTO MISSISSAUGA

MAT223H5S LEC0104
Linear Algebra I
Course Outline - Winter 2025

Class Location & Time	Tue, 09:00 AM - 10:00 AM Thu, 01:00 PM - 03:00 PM MN 1270 Thu, 06:00 PM - 08:00 PM ZZ TBA
Instructor	Alexander Rennet
Office Location	
Office Hours	
E-mail Address	alex.rennet@utoronto.ca
Course Web Site	https://q.utoronto.ca
Co-Instructor	Jonathan Herman
Office Hours	TBA
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Co-Instructor	Jaimal Thind
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Course Description

Systems of linear equations, matrix algebra, determinants. Vector geometry in R2 and R3. Complex numbers. Rn: subspaces, linear independence, bases, dimension, column spaces, null spaces, rank and dimension formula. Orthogonality, orthonormal sets, Gram-Schmidt orthogonalization process, least square approximation. Linear transformations from Rn to Rm. The determinant, classical adjoint, Cramer's rule. Eigenvalues, eigenvectors, eigenspaces, diagonalization. Function spaces and applications to a system of linear differential equations. The real and complex number fields.

Prerequisite: Grade 12 Advanced Functions (MHF4U) and Grade 12 Calculus and Vectors (MCV4U or MAT102H5).
Exclusion:

MAT240H5 or MAT223H1 or MAT240H1 or MATA22H3 or MATA23H3

(SCI)
Distribution Requirement: SCI

Students who lack a pre/co-requisite can be removed at any time unless they have received an explicit waiver from the department. The waiver form can be downloaded from here.

Detailed Course Description

Course Structure

The main purpose for the course structure outlined below is to use peer-reviewed, evidence-based pedagogical tools in the classroom to help you **deeply understand complex material** and develop your ability to **think like a mathematician.**

Weekly Cycle

A weekly cycle (Monday to Sunday) in this course consists of several components:

1. **Pre-Class Reading:** You will complete a short reading before class, which will include specific learning objectives to meet, and practice exercises to help you meet them.

2. **PCRA:** After completing the reading you will take a pre-class quiz on Quercus to check that you are prepared to learn new material in class this week. This and the reading are to be completed by **Monday evening before** the week's classes begin.

3. **In-Class Activities:** Class time will be spent helping you learn the more subtle and confusing parts of the course, and

actively work on problems. Sometimes material in these activities will be 'new' (not covered in the pre-class readings) and in general, they will build-off of the readings.

4. **Asynchronous Activites:** Each week there will be a short activity for you to complete on your own at home. It is typically paired with a video discussing the activity. Typically these either add a small bit of new material, give you a different perspective on something done that week, or give you an opportunity (e.g through more examples) to reinforce a concept from that week's material.

5. **Tutorials:** Each week (except two) in tutorial you will work on a worksheet (not marked) and have a chance to ask questions. **All tutorials are in person.**

6. **Take-Home Assignments:** Outside of class you will work on assignments to help you practice what you've learned and solidify your knowledge.

7. **Weekly Guide:** To help you keep track of what you need to do for each week, we will provide you with a "Weekly Guide" on the course page that outlines the week's work cycle, and gives you direct links to each of the components you need to complete.

Delivery Modes:

- **LEC 0102 (Herman)** will be **fully in-person** (all three hours of lecture are in-person).
- **LEC 0104 (Rennet)** will have **one hour of synchronous online lecture (Tu 9-10),** and **two hours of in-person lecture (Th 13-15)**.
- **LEC 0105 (Thind)** will have **synchronous online lectures** (all three hours on Zoom).
    - Zoom links for LEC104 & LEC105 will be on the course webpage.
- **All tutorials are in-person only.**
- **All tests will be in-person for all students (no exceptions).**
- **The final exam is in-person only (again, no exceptions).**

Learning Outcomes

Course Goals

In this course we will study Linear Algebra and some of its applications.

- Students will learn about connections between, and different perspectives on algebraic objects and tools such as linear systems, matrices, transformations and subspaces.

- Students will do this by mastering procedural tasks involving these objects and tools, but also by analyzing and solving problems related to the conceptual underpinnings of these objects and tools.

- Rigorous mathematical proof is lightly introduced, and students will be expected to determine if a mathematical statement (related to the course content) is true or false and justify their answer with some rigour.

- Students will also be introduced to writing mathematics with an audience of peers in mind, and will be expected to reflect on their written work with those peers.

- Students will also gain an appreciation of a few of the many applications of linear algebra outside of mathematics; this is partly to help students understand the mathematical framework for those applications, but also to inspire students to continue their study of linear algebra and mathematics.

Learning Outcomes

Upon completion of this course...

- Students should be able to apply various algorithms and procedures to solve a variety of computational problems.

- Additionally, students should (with respect to key terminology and notation from linear algebra) be able to:

    - Recognize and express the meaning of said terminology and notation.
    - Recall the statements of key theorems and definitions.
    - Interpret a novel definition or statement which involves terminology or notation.
    - Reformulate a statement involving some of the terminology and/or notation using different terminology and/or notation, including passing from algebraic to geometric interpretations and vice-versa.

- With respect to an extensive list of linear algebraic objects, (such as vectors, matrices, linear systems, transformations, subspaces, etc) be able to:
    - Create examples which have and/or lack various combinations of properties.
    - Visualize or graphically depict those objects (where applicable) including detail about relevant features they may have.
    - Verify that a statement or claim about such objects is true using a brief mathematical argument, or prove that the statement is false by applying the previous skill to create an appropriate counterexample.

- Be able to apply the computational and analytical skills listed above to solve problems involving familiar and novel applications.

- Have begun to develop their ability to learn new mathematics by reading written mathematics; in particular by reading and actively interacting with a set of "scaffolded" readings specifically-designed for this course.

- Be able to write short mathematical explanations geared towards an audience of peers, and receive and effectively respond to feedback on this work from their peers.

Textbooks and Other Materials

First of all, if in doubt about what to work on at any point, consult the WEEKLY GUIDES on our course webpage.

That said, the following are the **four** sources for the course material (all of which will be made available on the course website):

1. Weekly **Pre-Class Readings**
2. Weekly **In-Class Activities**
3. Weekly **Asynchronous Activities**
4. **Course Textbook**

The first three are your **primary resources**, the course textbook is a **secondary source.**

- The textbook is "*Linear Algebra with Applications, Open Edition*", by Nicholson, and it is an "Open Educational Resource" (i.e. free).
- **We will post the pdf on Quercus for you to download**
    - A slightly newer version is also available for free download at:https://lyryx.com/linear-algebra-applications/
    - Sadly, this newer version omits the practice problems from each section.

- The pre-class readings are numbered (e.g. "1.3", "2.1") to correspond to the course textbook, and care has been taken to make the other course materials match the textbook, including using the same notation and terminology.
- The course textbook is a *secondary* source because it often covers the same material in *more* detail than we need (e.g. including proofs of theorems we will use) or covers topics we will not cover in the course.
- The textbook includes *many* **additional practice problems** it includes for each section and solutions to some of them.
    - A curated **list of suggested problems** from the textbook will be posted to the course webpage. If a question is not on this list, it may refer to topics not covered in our course.

Assessment and Deadlines

Type	Description	Due Date	Weight
Other	Pre-Class Readiness Assessments ("PCRA") - 11, best 10 count	On-going	5%
Other	In-Class Polling	On-going	5%
Assignment	Take-Home Assignments (five)	On-going	5%
Term Test	Test #1	2025-02-06	20%
Term Test	Test #2	2025-03-13	20%
Final Exam		TBA	45%

	Total	100%

More Details for Assessment and Deadlines

Term Tests

- There will be two **in-person** Term Tests.
- Term Tests will take place during the **Thursday 6-8pm** time slot for **all students**.
- Test dates will **not** overlap with **MAT232** tests.
- **By registering for this class, you agree to be available 6-8pm on these dates:**
  - **Test #1 - February 6, 2025**
  - **Test #2 - March 13, 2025**
  - **Make-Up Test - March 20, 2025** (see Missed Term Work below for more information)

Note: the "ZZ TBA" Thursday 6-8 timeslot is **only** for test writing, and is only used on the dates specified above. You do **not** have a class or anything else to do with this course scheduled on Thursdays 6-8 other than the tests mentioned above.

Final Exam

The final exam of the course will take place during the examination period in April, and will be 3 hours long, and will cover all the material from the course.

The date, time, and location of the exam will be arranged by the UTM Registrar's Office. More information will be posted here: https://metis.utm.utoronto.ca/examschedule/finalexams.php

Take-home Assignments:

There will be **five take-home assignments**.

- Each take-home assignment will have two componenents: **online** and **written**.
  - The **online** component will be done on a platform called **WebWork.** It is worth 20% of the assignment mark.
  - The **written component** will be completed on paper (or typed, written on a tablet, etc) then uploaded and submitted via **Crowdmark**. It is worth the remaining 80% of the assignment mark.
  - Generally, not every problem in the written component will be marked, as we do not have resources to do this. However, solutions and/or a marking rubric will be posted to Quercus.
  - Please familiarize yourself with **WebWork** and **Crowdmark** as soon as possible in the semester (see the course website for more information).
- The due dates are the following **Sundays** (**except A5, which is due on the last day of classes, a Friday):
  - **A1 - Week 3 - January 26**
  - **A2 - Week 6 - February 16**
  - **A3 - Week 8 - March 9**
  - **A4 - Week 10 - March 23**
  - **A5 - Week 12 - April *4***
  - The deadline is **11:59pm**, i.e. just before midnight.
- Each student has access to a single (one-time) **36-hour extension** for their choice of one of these assignments - please see the "Penalties for Lateness" section below for more information.
- Other details (what questions to do, how to submit your work) will be posted on the course webpage.

PCRA - "Pre-Class Readiness Assessments"

Each week ***before*** the week's classes begin, you will complete a short **Quercus quiz** based on the **pre-class reading.**

- This quiz is meant to help ***you*** assess how well you understood the reading and how well prepared you are for the week's classes.
- You should answer the quiz questions to the best of your ability, so that you get a sense of what you need help with.
- You will have **unlimited attempts** until the due date.
- Only **completion** of the quiz matters for your final mark, and only your scores for ten PCRA will count.
  - *For example, if you complete nine of the eleven PCRA quizzes, you will get (9/* ***10****)*5 = 4.5 points out of 5 towards*

your final mark.
- Late PCRA submissions will not be accepted (no exceptions.)

In-Class Polling Questions

Each week in class, you will complete some number of polls in lecture.

- These will help you and your instructor check your understanding of basic concepts from the week's material.
- These are also marked for **completion only,** and are worth 5% of your final mark.
- To earn a full 5% you must participate in a minimum of 90% of the polls.
    - *For example, if you complete 72% of all of the polling questions done in your LEC section this semester, you would receive (72 / **90**)*5 = 4.5 points out of 5 towards your final mark.*
- We will use the **MathMatize** platform for this. Instructions for setting up a MathMatize account will be posted on the course page.
    - Please note that you will need to bring a device which can connect to the internet to class to complete these questions (e.g. smart phone, tablet, laptop).
    - If you do not have access to such a device, please contact the course coordinator.
- No make-up polling or additional opportunities will be provided to make-up missed polling. This is why we only count 90% of the polls done (see above).
- You must complete in-class polls in your registered LEC section.

Penalties for Lateness

Each student may request a **36-hour extension** for **ONE take-home** assignment this semester.

- If you wish to use this extension, you must **follow the instructions posted on the course webpage to use this one-time extension**; otherwise your assignment will receive a mark of 0.
    - In short, it starts notifying the correct person: the **Assistant Coordinator**, Shiqi (Stella) Chen, at sqstella.chen@mail.utoronto.ca

- Outside of these extensions, **late assignments are not accepted** (anything submitted after the deadline will simply receive a 0, typically with **no exceptions**.)
- There are no extensions for the PCRA, or in-class polling questions.
- The missed test policy is in the next section below.

Procedures and Rules

Missed Term Work

I'm going to miss Test #1 or #2 - what do I do?

- If you miss Test #1 and/or Test #2, you do **NOT** need to submit any documentation, declare your absence on ACORN nor provide any documentation whatsoever.
- **You will automatically be eligible to write the Make Up Test, no questions asked.**

I missed Test #1 or #2 and now I'm also going to miss the Make-Up Test - what do I do?

- I you are eligible to write the Make Up Test but miss it or do not write it, you must provide valid documentation (Verification of Illness or Injury Form), submitting it to the the **Assistant Coordinator**, Shiqi (Stella) Chen, at sqstella.chen@mail.utoronto.ca **by midnight (11:59pm) on March 28th.**
- ***PLEASE NOTE: you may NOT use the ACORN Declaration of Absence Tool for the Make Up Test*** (Each course can select one assessment which is excluded from use of this tool. In our course, that assessment is the Make Up Test.)

How will missing a test affect my final mark?

The marking scheme will be adjusted as follows for students who have missed a test:

- **One missed test:** You are eligible to write the Make-Up Test, and the Make-Up Test mark will replace the missed test mark, with your final mark otherwise calculated normally.

- **Two missed tests:** You are eligible to write the Make-Up Test, and the Make-Up Test mark will replace one missed test

mark.
    - The Make Up test will therefore be worth 20% of your final mark.
    - The Final Exam will be worth 65% of your final mark.

- **Missed Make-up Test:** There will be no second make up test, regardless of the reason. If you miss the make up for a (documented) valid reason, then the relevant weight will typically be transferred to the final exam.

It is highly recommended that you write the regular term tests if you are able to.

- Please reach out to the course coordinator, or an academic advisor if you are missing substantial amounts of class, so that we can try to help you get back on track, offer support and guidance about how best to proceed in the course, and/or point you towards relevant supports.
- If you miss the make up test, without providing valid documentation, you would typically receive a mark of 0 on the make up test.

What will the Make-Up Test consist of?

The material on the Make Up Test will be different than the material on Test 1 and Test 2. In particular, the Make Up Test takes place after Test 2, and will cover material up to and including Week 9, whereas Test 2 takes place in Week 9 and covers material up to and including Week 8 only.

Missed Final Exam

Students who cannot complete their final examination due to illness or other serious causes must file an online petition **within 72 hours of the missed examination**. Late petitions will **NOT** be considered. Upon approval of a deferred exam request, a non-refundable fee is required for each examination approved. See the Office of the Registrar Administrative Fees for Services page for more information.

Academic Integrity

Academic integrity is essential to the pursuit of learning and scholarship in a university, and to ensuring that a degree from the University of Toronto Mississauga is a strong signal of each student's individual academic achievement. As a result, UTM treats cases of cheating and plagiarism very seriously. The University of Toronto's Code of Behaviour on Academic Matters outlines behaviours that constitute academic dishonesty and the process for addressing academic offences. Potential offences include, but are not limited to:

In papers and assignments:

1. Using someone else's ideas or words without appropriate acknowledgement.
2. Submitting your own work in more than one course, or more than once in the same course, without the permission of the instructor.
3. Making up sources or facts.
4. Obtaining or providing unauthorized assistance on any assignment.

On tests and exams:

1. Using or possessing unauthorized aids.
2. Looking at someone else's answers during an exam or test.
3. Misrepresenting your identity.

In academic work:

1. Falsifying institutional documents or grades.
2. Falsifying or altering any documentation required, including (but not limited to) doctor's notes.

All suspected cases of academic dishonesty will be investigated following procedures outlined in the Code of Behaviour on Academic Matters. If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, you are expected to seek out additional information on academic integrity from your instructor or from other institutional resources.

Plagiarism Detection

Normally, students will be required to submit their course essays to the University's plagiarism detection tool for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their essays to be included as source documents in the tool's reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of this tool are described on the Centre for Teaching Support & Innovation web site

(https://uoft.me/pdt-faq).

Students may wish to opt out of using the plagiarism detection tool. In order to opt out, contact your instructor by email no later than two (2) weeks after the start of classes. If you have opted out, then specific information on an alternative method to submit your assignment can be found below.

Informed Consent – Email Lists

As a student enrolled in this course, you understand that you are providing your implicit consent to be included in an email list for the department to send you non-essential information from time to time. If you do not wish to be included in such an email list, please request to be removed by contacting one of the Academic Advisors & Undergraduate Program Administrators. Their information can be found on the MCS Website Contact Us page .

Final Exam Information

Duration: 3 hours

Additional Information

Copyright Policy. Course materials prepared by the instructor are considered by the University to be an instructor's intellectual property covered by the Copyright Act, RSC 1985, c C-42. These materials are made available to you for your own study purposes, and cannot be shared outside of the class or "published" in any way. Lectures, whether in person or online, cannot be recorded without the instructor's permission. Posting course materials or any recordings you may make to other websites without the express permission of the instructor will constitute copyright infringement. Please note, posting HW and/or test questions to online forums outside of our course discussion board constitutes a copyright violation, and may also constitute an academic offence.

Privacy & Course Videos - Notice of video recording and sharing (Download and re-use prohibited).

For those students enrolled in LEC 0104, 0105 (the ones with some or all online LEC time):During online lecture in these sections, including your participation, will be recorded on video and will be available to students in the course for viewing remotely after each session. Course videos and materials belong to your instructor, the University, and/or other sources depending on the specific facts of each situation, and are protected by copyright. In this course, you are permitted to access session videos and materials for your own academic use, but you should not download, copy, share, or use them for any other purpose without the explicit permission of the instructor. For questions about recording and use of videos in which you appear please contact your instructor.

Tech Requirements for LEC 0104, 0105. The minimum technological requirements for taking part in online courses can be found in U of T's "Student Tech Requirements for Online Learning". Please have a look at this to ensure you have the technology that you'll need to succeed while taking courses online.

In addition to the minimium requirements included in the link above, in this course we recommend:

- A camera or scanner. (For digitizing assessments - while you can type your work, many find this a better solution for mathematics.)
- Speakers/Headphones and a Microphone. (If you will be taking part in "live" course components.)
- A video camera. (If you will take part in "live" course components - this will help facilitate working in small groups during LEC.)

Additionally, you will need to set up your "UTM Zoom Account" (as opposed to any personal Zoom account); visit https://utoronto.zoom.us/ before your first class to get that set up. Access to online classes will be restricted to those with U of T Zoom accounts.

Generative AI. - The use of generative AI is not allowed in MAT223H5S. Note that:

- The knowing use of generative artificial intelligence tools, including ChatGPT and other AI writing and coding assistants, for the completion of, or to support the completion of, an examination, term test, assignment, or any other form of academic assessment, may be considered an academic offense in this course.

- Representing as one's own an idea, or expression of an idea, that was AI-generated may be considered an academic offense in this course.

- Students may not copy or paraphrase from any generative artificial intelligence applications, including ChatGPT and other AI writing and coding assistants, for the purpose of completing assignments in this course.

- This course policy is designed to promote your learning and intellectual development and to help you reach course learning

outcomes.

Help & Suggestions for Success.

If you need help there are many resources available to you. Please come and ask us for help as soon as you need it. Try not to let yourself fall behind. Here are some suggestions for succeeding in this course, including some options that may be helpful if you feel you need additional help/support. However, all of these suggestions apply equally to all students: in fact, making use of the following resources is the hallmark of a **successful** student!

- All course staff have office hours, which are posted on the course page, and at the top of this document.
- We will make extensive use of the course discussion board. Instructors and TAs have extra hours allocated to checking in on the discussion board, and most questions posted should be answered in less than 24h. (Usually faster than that, but evenings and weekends may result in slower response times.)
- You will have opportunities to ask questions in Tutorials.
- The Academic Skills Centre also has much to offer: https://www.utm.utoronto.ca/asc/.
- Additionally, see the "Support Services & Resources" section of the course page for links to a wide variety of supports and resources available to UTM students.

Email Policy

Before you send an email to course staff, please check if the answer to your question is in the syllabus or on the discussion board.

If your question is administrative or about course policy, please email the course coordinator (Alex Rennet - alex.rennet@utoronto.ca) rather than your instructor.

All emails to course staff should come from your "utoronto" email account, and contain "MAT223" in the subject heading.

You can typically expect a response to your email within approximately 24 hours (excluding weekends and holidays or other university closures).

Last Date to drop course from Academic Record and GPA is March 10, 2025.

Equity, Diversity and Inclusion

The University of Toronto is committed to equity, human rights and respect for diversity. All members of the learning environment in this course should strive to create an atmosphere of mutual respect where all members of our community can express themselves, engage with each other, and respect one another's differences. U of T does not condone discrimination or harassment against any persons or communities.