# University of Toronto
# Department of Mathematics
# MAT224H1F, Linear Algebra, 2025

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*Note: Updated office hours will be posted on Quercus (http://q.utoronto.ca) See Instructor Information).*

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# Course Overview

## Course Description:

Fields, complex numbers, vector spaces over a field, linear transformations, matrix of a linear transformation, kernel, range, dimension theorem, isomorphisms, change of basis, eigenvalues, eigenvectors, diagonalizability, real and complex inner products, spectral theorem, adjoint/self-adjoint/normal linear operators, triangular form, nilpotent mappings, Jordan canonical form.

## Prerequisites:

MAT221H1(80%)/ MAT223H1/ MAT223H5/ MATA22H3/ MATA23H3/ MAT240H1/ MAT240H5

## Course Objectives:

Not every matrix is diagonalizable but it can be upper-triangularizable. The ultimate goal of the course is to learn Jordan canonical form, which is a certain upper-triangular form. Learning the contents of the course description is necessary to achieve the goal. By the end of course you have

- learned the goal.
- learned to communicate concepts of linear algebra in a proof-oriented setting.
- developed ability to read abstract theories.

## Course Text:

A Course in Linear Algebra, David B. Damiano and John B. Little

## Teaching Mode:

3hrs lectures per week.
1hr tutorial per week (starting on **Sep 11**)

## Technical Requirement:

In order to participate in this course, students will be required to have:

- Reliable internet access. It is recommended that students have a high speed broadband connection (LAN, Cable, or DSL) with a minimum download speed of 5 Mbps.
- A computer satisfying the minimum technical requirements (https://www.viceprovoststudents.utoronto.ca/covid-19/tech-requirements-online-learning/

If you are facing financial hardship, you are encouraged to contact your college or divisional registrar (https://future.utoronto.ca/current-students/registrars/) to apply for an emergency bursary.

## Evaluation

All term tests and the final exam will be in-person and closed-book unless there is a notice of change on Quercus. You must bring your UofT Photo ID to the term tests and the final exam.

### Mark Breakdown :

- 10 tutorial work (10%): choose 8 best scores
- 9 assignments (10%): choose 7 best scores
- 2 tests (cumulative) (40%): drop the lowest score
- Final Exam (cumulative) (40%)

### Assignments :

- The assignment questions and schedule will be available on Quercus.
- Crowdmark will be used for assignment submission.
- No late submission will be accepted.
- Full marks will be given to all assignments submitted on time regardless of correctness but related to the questions.

## Tentative Test Date and Time

| Test | date | Tentative time |
|---|---|---|
| Test 1 | Oct 15<br>Wednesday | Regular Sitting 6:10pm, 100mins<br>Alternative Sitting: TBA |
| Test 2 | Nov 5<br>Wednesday | Regular Sitting 6:10pm, 100mins<br>Alternative Sitting: TBA |
| Final Exam | TBA<br>during the final exam period | TBA |

## Tutorial Procedure

1. The first tutorial will take place on Sep 11.
2. There will be a tutorial quiz at every tutorial. 1 full marks will be given upon submission regardless of correctness.
3. The procedure of tutorial with schedule will be posted on the course website on Quercus.

## Course Policies

**Missed Test or Assignment:**

1. Alternative sittings will be provided on the test date for the students who have a test or class conflict with the regular sitting time.
2. Students who cannot be present for a test because of **serious illness** must contact their instructors **as soon as possible, and no later than one week after returning to class.** They must also report their absence through **online absence declaration on Acorn** under the Profile and Setting menu.
3. Besides illness only very serious reasons can be considered as valid excuses for missing an evaluation. If a student misses one of the tests with a valid reason, the student's test is worth 30%.; the final exam is worth 50% For more information on this, consult the Academic Calendar.
4. There is no make-up assignment or test.

**Remarking policy :**

If a test is submitted for remarking, the entire test may be remarked, allowing the possibility that a student may receive a lower mark on any or all questions. Requests for remarking tests must be submitted by email to (TBA, available later) within 1 week of the date when test results are released via crowdmark (for full-answer questions). For example, if test results are released on Oct 20, the deadline for requesting remarking is Oct 27, 11:59pm. More detailed information about remarking will be available on the announcement and by email near the release date.

**Email Policy:**

1. Should you have a question that is not answered on the course site (please check there first!) please note that all communications with the Course Instructor or TA's must be sent from your official utoronto email address, with the course number included in the subject line. If these instructions are not followed, your email may not be responded to.
2. No math questions will be answered by e-mail.
3. All questions related to administration should be sent to **mat224h1f.a@course.utoronto.ca**

## Institutional Policies and Support

**Academic Integrity:**

All suspected cases of academic dishonesty will be investigated following procedures outlined in the Code of Behaviour on Academic Matters (https://governingcouncil.utoronto.ca/secretariat/policies/code-behaviour-academic-matters-july-1-2019).

If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, please reach out to your Course Instructor. Note that you are expected to seek out additional information on academic integrity from me or from other institutional resources (for example, the University of Toronto website on Academic Integrity http://academicintegrity.utoronto.ca/).

**Accessibility:**

The University provides academic accommodations for students with disabilities in accordance with the terms of the Ontario Human Rights Code. This occurs through a collaborative process that acknowledges a collective obligation to develop an accessible learning environment that both meets the needs of students and preserves the essential academic requirements of the University's courses and programs.

Students with diverse learning styles and needs are welcome in this course. If you have a disability that may require accommodations, please feel free to approach your Course Instructor and/or the Accessibility Services office as soon as possible. The sooner you let us know your needs the quicker we can assist you in achieving your learning goals in this course.

Link to Accessibility Services website:
https://studentlife.utoronto.ca/department/accessibility-services/

**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.

**Important Academic Dates & Deadline:**

The academic dates include enrolment dates, drop deadlines, exam periods, petition deadlines and more. https://www.artsci.utoronto.ca/current/dates-deadlines/academic-dates

**Other Academic and Personal Supports:**

- Writing Centre https://writing.utoronto.ca/writing-centres/arts-and-science/
- U of T Libraries https://onesearch.library.utoronto.ca/
- Feeling Distressed? https://studentlife.utoronto.ca/task/support-when-you-feel-distressed/

## MAT224H1F Schedule of Lectures

Not every matrix is diagonalizable but it can be upper-triangularizable on complex vector space. The ultimate goal of the course is to learn Jordan canonical form, which is a certain upper-triangular form. Learning the contents of the course description is necessary to achieve the goal.

| Chapter | Sections | Main Topics |
|---|---|---|
| Chapter 1 | 1.1 – 1.6<br>(Sep 2-11) | **1.1** :vector space<br>**1.2** :subspace<br>**1.3** :span set, direct sum<br>**1.4** and **1.5** :linear independence and dependence, homogeneous system<br>**1.6** :bases and dimension |
| Chapter 2 | 2.1 – 2.7<br>(Sep 16-Sep 30) | **2.1** :linear transformation<br>**2.2** :matrix associated with linear transformation<br>**2.3** :kernel, image, dimension theorem<br>**2.4** :injective and surjective linear mapping, applications of the dimension theorem<br>**2.5** :composition of linear transformations<br>**2.6** :inverse of linear transformation<br>**2.7** :change of basis |
| Chapter 3 | 3.1 – 3.3<br>(Oct 2) | 3.3.8-3.3.11 |
| Chapter 4 | 4.1 – 4.6<br>(Oct 7-Oct 21) | **4.1** :eigenvalues and eigenvectors<br>**4.2** :diagonalization<br>**4.3** :orthogonal, orhonormal<br>**4.4** :orthogonal projection and basis, Gram-Schmidt orthogonalization process<br>**4.5** :symmetric matrix and its properties<br>**4.6** :diagonalization and spectral decomposition of symmetric mapping,<br>application: conic sections |
| Chapter 5 | 5.1 – 5.3<br>(Oct 23, Nov 4-6) | **5.1** :complex numbers, n-th roots<br>**5.2** :determinant, eigenvalue, eigenvectors, diagonalization on complex vector space<br>**5.3** :Hermitian inner product, adjoint linear transformation,<br>diagonalization of self-adjoint linear transformation |
| Chapter 6 | 6.1 – 6.4<br>(Nov 11-Nov 27) | **6.1** :invariant subspace, triangularization, Cayley-Hamilton Theorem<br>**6.2** :canonical basis of finite dimensional vector space with respect to nilpotent mapping,<br>canonical form(a upper-triangular form) for nilpotent mapping<br>**6.3** :generalized eigenspace and eigenvectors, Jordan block, Jordan canonical form<br>**6.4** :computing Jordan form |

Note: some suggested textbook examples and exercises will be available on the course website on Quercus.