Department of Mathematics & Statistics
Concordia University

MAST 234
Linear Algebra and Applications I
Fall 2023

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Class Schedule: Wednesdays & Fridays, 10:15-11:30 AM.

Office Hours: Wednesdays, 1:30-2:30 PM, or by appointment.

Text: There is no mandatory textbook for this course. All the material will be available in the lecture and work files that will be posted on the MAST 234 Moodle site.

For additional reading and practice, most of the topics covered in this course can be found in the following complementary text:

Fred E. Szabo, Linear Algebra, *An Introduction Using Maple*, Publisher: Academic Press. This textbook will be posted on Moodle in PDF format at no cost to students.

Prerequisites: MATH 204 or equivalent.

Software: ***Maple*** (version 17 or higher) is mandatory for this course. Waterloo Maplesoft is making the ***Maple Student Edition*** available to Concordia students at a special price. In this course, the software is used as a teaching and learning and a computational tool, not as an object of study. However, all activities in this course, such as lectures, problem-solving classes, and assignments, quizzes, the midterm test, and the final examination, are conducted and completed using ***Maple***.

The course material posted in this course is written in ***Maple*** and students are required to use ***Maple*** exclusively in all their work, including assignments, quizzes, and examinations.

Objective: MAST 234 is the first part of the two connected Linear Algebra and Applications courses, the second part being MAST 235. There are two fundamental concepts, vector spaces, and linear transformations, on which this first part is based. In learning these concepts, you will use related Maple constructs such as vectors, matrices, and systems of linear equations.

The objective of MAST 234 is to understand the fundamental concepts of Linear Algebra and to develop conceptual and computational skills that are essential for further study and applications of linear algebra in mathematics, statistics, data science, and other cognate disciplines.

Pedagogy: The weekly classes fall into lectures (conceptual) and applications (computational). The lectures deal with concepts, and their principal properties, illustrated by examples and, whenever appropriate, logical arguments (proofs). The computational complement in which the week's concepts are explored computationally using technology. Problem-solving techniques are illustrated and explored using relevant applications of concepts and tools of linear algebra.

Technology: Linear algebra is a computationally complex subject. Although basic applications deal with easily illustrated concepts, including vectors, matrices, and their properties, the number of arithmetical steps (often addition and multiplications of integers and rational numbers), exceeds the space and time required for manual computation. Fortunately, powerful technological systems have been developed over the last few decades that have largely overcome this obstacle. ***MatLab***, ***Mathematica***, and ***Maple*** are the three dominant computational systems at our disposal. All of them have some of their roots in the problem of dealing with the computational complexity of relatively simply stated linear algebra problems. All registered students have free access to ***Mathematica*** and are recommended to install the software for supplementary use.

In Math 234, the computational system chosen for teaching and learning is ***Maple***. It comes with packages of several linear algebra "commands" that facilitate the computational aspect of the subject and allow us to concentrate on developing conceptual understanding and skills to solve a numerically complex problem.

One of the applications illustrated in this course is the model of an "economy" that is self-sufficient: it has enough interacting industries to match economic output with economic input. The model was developed by Wassily Leontief, a Harvard economist, with the help of a massive but relatively primitive computer capable of solving a linear system based on many linear equations (in matrix form). An extraordinary conceptual and computational achievement for which Leontief received the Nobel Prize in Economic Sciences in 1973. A pared-down model example will be discussed in one of our lectures.

Even though technology plays a significant role in real-world applications of linear algebra, as mentioned, the part of ***Maple*** in this course is primarily computational. Only a limited number of ***Maple*** features are used and will be explicitly documented when needed.

Moodle: All relevant course material, electronic textbooks, lecture notes, computational material, assignments, quizzes, and examinations will be posted on the Moodle course website.

Assignments: Assignments are given and submitted online through Moodle. ***Late assignments will not be accepted.*** Assignments contribute 10% to your final grade.

Working regularly on assignments, class attendance, and working on problems in class is essential for success in this course.

NOTE: Assignment problems will be assigned weekly at the end of the weekly lectures. Examples and problems will be chosen from or based on the listed textbooks, ***Maple Help*** files, and other sources.

Quizzes: Quizzes are given and submitted online through Moodle. They will be scheduled in the second half of Friday lectures and may contain questions about the material covered in the Wednesday lecture of the week in which the quiz is held.

Midterm Test: There will be **one midterm test** based on the material of Lectures 1-6 which will contribute up to 30% to your final grade (see the Grading Scheme). The test will be given in class time on the Friday of Week 7 and must be submitted online through Moodle.

NOTE: It is the Department's policy that midterm test missed for any reason, **including illness,** cannot be made up. If you missed the midterm because of illness **(to be confirmed by a valid medical note)** the final exam can count for 85% of your final grade, and 15% will be contributed by the assignments and quizzes (see the **Grading Scheme**).

Final Exam: The final examination is a 3-hour **closed-book, computer-based *Maple*** examination ***scheduled by the University Examination Office***. Access to resources such as lecture notes, class notes, and similar material is disabled.

Students are responsible for finding out the date and time of the final exam once the schedule is posted by the Examinations Office.

Conflicts with the schedule of the final exam must be reported directly to the Examinations Office, **not to the instructor**.

Students must be available until the end of the final exam period. Conflicts due to travel plans will not be accommodated.

Note: ***There are no supplemental exams for this course.***

Grading Scheme: The final grade will be based on the higher of (a) and (b) below:

(a) 10% for the assignments
5% for the best 2 of 3 quizzes
30% for the midterm test
55% for the final examination

(b) 10% for the assignments
5% for the best 2 of 3 quizzes
15% for the midterm test
70% for the final examination

If the grading scheme for this course includes graded assignments, a reasonable and representative subset of each assignment may be graded. Students will not be told in advance which subset of the assigned problems will be marked and should therefore attempt all assigned problems.

The term work contributes at least 30% to the final grade. Therefore, active participation in classes and continuous work on the course material during the semester is essential for success in this course.

Important Note:	***THERE IS NO "100% FINAL EXAMINATION" OPTION IN THIS COURSE.***

COURSE CONTENTS

Week	Topic	
1	Linear Algebra with Maple	Using Maple Linear equations and linear systems *Applications* Solving linear equations and linear systems
2	Augmented matrices	Augmented matrices (A ∣ b) of linear systems Row reduction of augmented matrices *Applications* Solving linear systems using augmented matrices Linear systems and interpolating polynomials
3	Matrix-vector products	Linear systems as matrix-vector products Ax = B Solving linear systems using matrix-vector products Matrix-vector products as linear combinations *Applications* Leontief input-output systems
Quiz 1 on the material covered in Weeks 1, 2 and 3		
4	Homogeneous systems	Homogeneous linear systems Ax = 0 Solutions of homogeneous systems Linear dependence of vectors Rank and nullity of matrices

5	The spaces R^n	Vectors as n-tuples of real numbers Linearly independent sets of vectors The spans of set of vectors The vector spaces R^n of n-tuples of real numbers Bases of the vector spaces R^n
6	Matrix operations and determinants	Addition and scalar multiplication of matrices Matrix multiplication and matrix transposition Inverses and one-sided inverses of matrices Determinants of square matrices *Applications* Matrix inversion with determinants Matrix inversion with elementary matrices
Quiz 2 on the material covered in Weeks 4, 5 and 6		
7	General vector spaces	Abstraction of the axioms of vector spaces Bases and dimensions of vector spaces *Applications* Polynomial, matrix, and function spaces Row, column, and null spaces of a matrix
MIDTERM TEST on the material covered in Weeks 2 to 6		
8	Linear transformations and their matrix representations	Linear transformations on R^n Domains, codomains, ranges Preservation of linear combinations Composition of linear transformations Matrices for linear transformations
9	Vector coordinates	Coordinate vectors in different bases Coordinate conversion between bases Coordinate conversion matrices
QUIZ 3 on the material covered in Weeks 7, 8, 9		
10	Matrix transformations Eigenvalues and eigenvectors	Linear transformations on vector spaces other than R^n The rank-nullity property of real matrices

		Eigenvalues and eigenvectors of square matrices *Application* Linear transformations and similar matrices
11	Characteristic polynomials Matrix diagonalization	Eigenvalues as roots of characteristic polynomials Eigenbases of vector spaces Diagonalization of matrices using eigenbases *Applications* Solving a differential equation in biology
12	**Review**	**What next?**

Academic Integrity and the Academic Code of Conduct
This course is governed by Concordia University's policies on Academic Integrity and the Academic Code of Conduct as set forth in the Undergraduate Calendar and the Graduate Calendar. Students are expected to familiarize themselves with these policies and conduct themselves accordingly. "Concordia University has several resources available to students to better understand and uphold academic integrity. Concordia's website on academic integrity can be found at the following address, which also includes links to each Faculty and the School of Graduate Studies: https://www.concordia.ca/conduct/academic-integrity.html" *[Undergraduate Calendar, Sec 17.10.2]*

Behaviour
All individuals participating in courses are expected to be professional and constructive throughout the course, including in their communications.

Concordia students are subject to the Code of Rights and Responsibilities which applies both when students are physically and virtually engaged in any University activity, including classes, seminars, meetings, etc. Students engaged in University activities must respect this Code when engaging with any members of the Concordia community, including faculty, staff, and students, whether such interactions are verbal or in writing, face to face or online/virtual. Failing to comply with the Code may result in charges and sanctions, as outlined in the Code.

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Extraordinary circumstances
In the event of extraordinary circumstances and pursuant to the Academic Regulations the University may modify the delivery, content, structure, forum, location and/or evaluation scheme. In the event of such extraordinary circumstances, students will be informed of the change.