Department of Mathematics & Statistics
Concordia University

MAST 234
Linear Algebra and Applications I
Fall 2021

Preface: **Due to exceptional circumstances, this course will be taught and all assessments will be done completely ONLINE.**

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Office Hours: Tuesdays, 12:00-14:30. Thursdays, 12:00-14:00. Available In-Person and Online.

Text: *Linear Algebra, Theory and Applications*, by W. Cheney & D. Kincaid, 2nd Edition. Publisher: Jones & Bartlett.
The textbook will be available at:
https://www.bkstr.com/concordiastore/home
Note: Students should order textbooks as early as possible, especially for printed versions in case books are backordered or there are any shipping delays.

Prerequisites: MATH 204 or equivalent is a prerequisite for this course.

Objective: This is the first part of the two connected *Linear Algebra and Applications* courses, the second part being MAST 235. There are two major concepts, *Vector Spaces* and *Linear Transformations,* on which this first part is based. In learning these concepts we will use related constructs such as *vectors*, *matrices* and *systems of linear equations*. The objective of the course is to master your understanding and skills in these key concepts of Linear Algebra that will be critical for further Linear Algebra courses in your curriculum.

Pedagogy: Classes start with a lecture introducing the principal concepts of the topic considered that day, followed by problem solving by students. Mathematical issues that arise during problem solving are discussed in class.

Software: *MAPLE (version 17 or higher)* is mandatory for this course. The Waterloo's *Maplesoft* is making "MAPLE Student's edition" available to Concordia students at a special price. In this course the software is only used as a computational tool, ***not* as an object of study** in itself. All assignments, quizzes, the midterm test and the final examination are done using *MAPLE*.

Assignments: Assignments are given and submitted online through Moodle. Late assignments **will not** be accepted. Assignments contribute 10% to your final grade (see the Grading Scheme). *W*orking regularly on the assignments, as well as class attendance and working on the problems in the class, is essential for success in this course.

Midterm Test: There will be **one midterm test**, based on the material of weeks 1-5 (see the *CONTENTS* below). The test will contribute up to 30% to your final grade (see the Grading Scheme). It will be held online during class time on **Tuesday, February 23, 2021**.

NOTE: It is the Department's policy that tests 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 the quizzes. *Please talk to me as soon as possible for any absence for any organization concerns, and for assistance in preparation therein.*

Final Exam: The Final Examination will be 2 hours long written using Maple. 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 are to 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 (see the schedule below)
30% for the class test
55% for the final examination

(b) 10% for the assignments
5% for the best 2 of 3 quizzes
15% for the class 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.

IMPORTANT: **NOTE** that there is **NO "100% FINAL EXAM"** option in this course.
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. *If you have any concerns about your participation, please email me as soon as possible to discuss options and make a participation plan moving forward.*

Disclaimer: The instructor reserves the right to make changes to the course outline and course content should this be necessary for academic or other reasons. Every effort will be made to minimize such changes. *All changes will be clearly noted on the course Moodle, and sufficient notice will be given to all students.*

CONTENTS

Week	Textbook	Topics considered	Recommended problems
1	**Section 1.1** LINEAR SYSTEMS& MATRICES	• Review of systems of linear equations. o Matrix form of a system o Matrix of the system; augmented matrix o Elementary Row Operations o Row Echelon Form o Row equivalent matrices o Solutions for a system of linear equations; systems with parameters	Gen.Ex. 1.1 # 5, 23, 35, 39
2	**Section 1.2** VECTORS, MATRICES, SPANS	• Review of vectors and matrices o Vectors in R^n. Linear combination of vectors o Matrix-vector products • Span of a set of vectors • Consistency of systems of linear equations in terms of span of columns of the matrix	Gen.Ex. 1.2 # 11, 15, 19, 25
3	**Section 1.3** HOMOGENEOUS SYSTEMS	• Homogeneous systems of equations , and the Null Space of a matrix • The rank of a matrix • Nontrivial solutions of a homogeneous system. • Linear dependence of vectors and homogeneous systems of equations	G.Ex. 1.3 # 5, 9, 13, 21, 25
4	**Sections 2.1, 2.4, 5.1** VECTOR SPACES and SUBSPACES	**QUIZ 1** (on the material covered in previous weeks) • Examples of Vector Spaces o n-tuples (R^n)& Euclidean vector spaces o Polynomials as vectors o Other examples (Matrices, Functions) • Generalization: the axioms of a vector space. • Properties of vector spaces (Theorems 2.4: 1-5) • Linear Independence in general vectors spaces. • Vector Subspaces: Definition, Properties, Examples	G.Ex. 2.1: # 1, 7, 11, 13, 23 G.Ex. 2.4 # 7,15,27,33, 35 G.Ex. 5.1 # 1,3,5,11,15,29
5	**Section 3.1** OPERATIONS ON MATRICES, DETERMINANTS	• Operations on matrices o Multiplication of matrices: column and row patterns o Special matrices • Determinants (an overview) • Properties of invertible square matrices	G.Ex. 3.1 #11, 19, 41, 47, 51

6	**Section 3.2** MATRIX INVERSE (Left & Right)	**MIDTERM TEST** (based on material of **Weeks 1-5**) • Left and Right Inverses of non-square matrices, properties	G.Ex. 3.2 # 9, 11, 19, 21
7	**Section 2.3** LINEAR TRANS-FORMATIONS IN R^n	• Linear transformations in R^n o Domain, Co-domain, Range: definition and examples o The Linearity properties: definition and examples o Matrices and linear maps: Theorems 1-3. o Composition of linear mappings (Theorem 2.3.8)	G.Ex. 2.3 # 3, 7, 9, 11, 21, 15, 25, 43
8	**Section 5.2** BASIS, DIMENSION & COORDINATES	• Basis for a vector space & Dimension o Spans, Minimal spanning sets & Dimension o Unique representation of a vector in a given basis o Theorems 5.2: 8, 9, 10, 11, 12, 13.	G.Ex. 5.2: # 1, 5, 7, 15, 17, 21, 41
9	**Section 5.3** COORDINATE SYSTEMS	**QUIZ 2** (on the material covered in Weeks 5, 6, 7 and 8) • Coordinate vector, Coordinatization • Coordinates in different basis • Transition matrices from one basis to another.	G.Ex. 5.3: # 1, 2, 3, 5, 7, 11, 21, 23, 32, 41, 47
10	**Section 5.3** LINEAR MAPS (GENERAL) LINEAR MAPS &MATRICES	• Linear transformations in abstract vector spaces, other than R^n • Rank-Nullity Theorem (section 5.2, #17 & #18) • Linear transformations and basis in the domain and co-domain. o Theorem 2 (section 5.3) • Matrix representation of a linear transformation • Matrices of linear mappings of a vectors space into itself o Similar matrices, Theorem 5 (sec. 5.3)	G.Ex. 5.3 # 15, 17, 27, 31, 33, 49, 51
11	**Section 6.1** LINEAR OPERATORS & EIGENTHEORY	**QUIZ 3** (on material covered in Weeks 8, 9, 10) • Introduction to Eigentheory o Eigenvectors and eigenvalues of matrices (sec. 6.1) o Definition of eigenvectors and eigenvalues of a linear operator (sec. 6.1) o Eigenvalues of a linear operator are the eigenvalues of any of its matrix representations	G.Ex. 6.1 # 15, 23, 29, 31, 37, 45
12	**Section 6.1** EIGENTHEORY and DIAGONA-LIZATION	• Diagonalizable matrices and diagonalizable linear operators o Definition (sec 6.1) o Conditions of diagonalizability: basis of eigenvectors. o Theorem 3 and its Corollaries	G.Ex. 6.1: # 33, 52, 66, 71
13	**REVIEW**	Review Classes	

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: concordia.ca/students/academic-integrity."
[Undergraduate Calendar, Sec 17.10.2]

Use of Zoom
Note: Zoom is included as an institutionally-approved technology. This means we have been assured of the privacy protections needed to use freely within the classroom)

Zoom will be used in this course to facilitate learning at a distance. It may be used to record some or all of the lectures and/or other activities in this course. If you wish to ensure that your image is not recorded, speak to your instructor as soon as possible.

Also, please note that you may not share recordings of your classes and that the instructor will only share class recordings for the purpose of course delivery and development. Any other sharing may be in violation of the law and applicable University policies, and may be subject to penalties.

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.

Intellectual Property
Content belonging to instructors shared in online courses, including, but not limited to, online lectures, course notes, and video recordings of classes remain the intellectual property of the faculty member. It may not be distributed, published or broadcast, in whole or in part, without the express permission of the faculty member. Students are also forbidden to use their own means of recording any elements of an online class or lecture without express permission of the instructor. Any unauthorized sharing of course content may constitute a breach of the Academic Code of Conduct and/or the Code of Rights and Responsibilities. As specified in the Policy on Intellectual Property, the University does not claim any ownership of or interest in any student IP. All university members retain copyright over their work.

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.