Course Outline for MATH 1104-F (Linear Algebra for Engineering or Science), Winter 2022

Alexander Bors

Basic information on the course:

- **Department/Unit:** School of Mathematics and Statistics (Faculty of Science)
- **Instructor:** Alexander Bors
- **Instructor office location/phone:** Not applicable due to the pandemic – please contact me by e-mail.
- **Instructor e-mail:** `AlexanderBors (at) cunet (dot) carleton (dot) ca`. Whenever possible, I will answer course-related e-mails within one workday. In case I get lots of e-mails with similar questions or questions of general interest, I may answer them by sending an e-mail to all course participants.
- **Office hours (online via Zoom):** Tuesdays, 1:30-2:30pm.
- **TAs for this course:** to be announced.
- **Brightspace page of this course:** `https://brightspace.carleton.ca/d2l/home/59029`.
- **Lectures (live and online via Zoom):** Tuesdays and Thursdays, 11:30am-1pm. The first lecture is on Tuesday, January 11, and the last is on Tuesday, April 12. Lectures will also be recorded and shared in the Carleton Mediaspace.
- **Tutorials:** Tuesdays, 7:30-8:30pm. Tutorials for this section start on January 25th. It is planned that one of the tutorial groups will be held in person and the other groups will be online. However, this will of course depend on how the pandemic evolves over the winter (see also the first paragraph in Section 8).

1 Course description

This course covers the fundamentals of linear algebra, a theory based on the study of systems of linear equations and of linear functions. This is an important theory in its own

right, as many problems ultimately boil down to solving certain systems of linear equations. Moreover, linear algebra is a tool used in many more advanced theories such as calculus (where one of the fundamental ideas is to approximate more complicated functions by linear functions). The ideas and concepts which students learn in this course will reappear in various other contexts throughout their studies.

Contents of the course according to its calendar description: Systems of linear equations, matrix algebra, determinants, invertible matrix theorem, Cramer's rule. Vector space $\mathbb{R}^n$, subspaces, bases. Eigenvalues, diagonalization. Linear transformations, kernel, range. Complex numbers (including De Moivre's theorem). Inner product spaces and orthogonality. Applications.

2 Prerequisites

The prerequisites for this course are "Ontario Grade 12 Mathematics: Advanced Functions", or MATH 0005, or equivalent. Alternatively, the course may be taken after getting special permission by the School.

3 Learning outcomes

By the end of this course, students will

- be able to efficiently and systematically solve various important problems from linear algebra and its applications (such as solving systems of linear equations, switching between implicit and parametric descriptions of subspaces of $\mathbb{R}^n$, finding orthonormal bases of subspaces of $\mathbb{R}^n$ with the Gram-Schmidt method);
- have encountered a range of practical applications of linear algebra (keywords: electrical circuits, balancing chemical equations, linear evolution models);
- be familiar with the connection between linear algebra and geometric concepts (keyword: analytic geometry) as well as applications thereof (such as least-squares problems).

4 Learning Materials

This course will make essential use of the third-party platform MyLab by Pearson. The platform is used for the following two purposes:

- Part of the course evaluation will be held in MyLab, more specifically all forms of evaluation that are machine-graded (i.e., the tests, homeworks and the final exam). The reason why MyLab was chosen over Brightspace for this is because MyLab provides an extensive library of test questions to choose from and allows for a high

degree of randomization (and thus cheating prevention), much higher than what could be achieved within Brightspace with reasonable effort.

- Access to the digital textbook for this course, "Linear Algebra and Its Applications (Sixth Edition)" by D.C. Lay, S.R. Lay and J.J. McDonald, will be through MyLab.

Students will need to buy access to the course in MyLab. Please keep in mind that access to MyLab needs to be purchased separately for each course (e.g., having bought access to MyLab for a calculus course you took earlier would not help you). The only situation where you do not need to purchase access is if you already took MATH 1104 before and your MyLab access from back then has not expired yet. For all other situations, the purchase options are as follows:

- 2-year subscription with access to the digital textbook, $95.
- 2-year subscription without access to the digitial textbook, $60.

More details on the purchasing process and how to access our course after the purchase can be found in a separate PDF provided by Pearson, which is uploaded together with this course outline in Brightspace under "Starting essentials".

5 Evaluation

The evaluation for this course consists of the following parts:

- 2 online tests (in MyLab): 10% of the total grade (5% each). These tests are timed with a duration of 50 minutes, but they can be started anytime during a time window of 1 week each. It is an option to take them during the tutorial of that week, with the corresponding TA providing help with administrative and clarification questions.
- 4 online homeworks (in MyLab): 10% of the total grade (2.5% each). Unlike the tests, these are not timed and can be worked on over the course of a week.
- 3 written assignments (posted and to be uploaded in Brightspace): 45% of the total grade (15% each). Each assignment consists of a list of problems with weighted scores that students need to solve by hand (writing on paper, a tablet device, etc.). The handwritten solutions will then need to be uploaded in Brightspace, to be graded by the TAs. As for the homeworks, students will have a week to work on the assignments.
- 1 online final exam (in MyLab): 35% of the total grade. This will have the same format as the tests, but with a duration of 3 hours. More details, including the date of the final exam, are to be announced.

Some other important remarks concerning evaluation:

- Attendance of the lectures and tutorials is not relevant for the evaluation, but still highly recommended.

- Standing in a course is determined by the course instructor subject to the approval of the Faculty Dean. This means that grades submitted by the instructor may be subject to revision. No grades are final until they have been approved by the Dean.
- Please make sure you are familiar with Carleton's Academic Integrity Policy, available under `https://carleton.ca/registrar/academic-integrity/`. Violations of this policy (including plagiarism, see the next section) are not tolerated and will be reported to the Faculty Dean given evidence.

6 Plagiarism

Not quite without irony, the following important information concerning plagiarism has been copied from `https://carleton.ca/teaching-regulations/appendices/`.

The University Academic Integrity Policy defines plagiarism as "presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one's own." This includes reproducing or paraphrasing portions of someone else's published or unpublished material, regardless of the source, and presenting these as one's own without proper citation or reference to the original source. Examples of sources from which the ideas, expressions of ideas or works of others may be drawn from include but are not limited to: books, articles, papers, literary compositions and phrases, performance compositions, chemical compounds, art works, laboratory reports, research results, calculations and the results of calculations, diagrams, constructions, computer reports, computer code/software, material on the internet and/or conversations.

Examples of plagiarism include, but are not limited to:

- any submission prepared in whole or in part, by someone else;
- using ideas or direct, verbatim quotations, paraphrased material, algorithms, formulae, scientific or mathematical concepts, or ideas without appropriate acknowledgment in any academic assignment;
- using another's data or research findings without appropriate acknowledgement;
- submitting a computer program developed in whole or in part by someone else, with or without modifications, as one's own; and
- failing to acknowledge sources through the use of proper citations when using another's work and/or failing to use quotations marks.

Plagiarism is a serious offence that cannot be resolved directly by the course's instructor. The Associate Dean of the Faculty conducts a rigorous investigation, including an interview with the student, when an instructor suspects a piece of work has been plagiarized. Penalties are not trivial. They can include a final grade of "F" for the course or even suspension or expulsion from the University.

7 Requests for Academic Accommodations

You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

- **Pregnancy obligation:** write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For accommodation regarding a formally-scheduled final exam, you must complete the Pregnancy Accommodation Form, found under `https://carleton.ca/equity/contact/form-pregnancy-accommodation/`.

- **Religious obligation:** write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, see here: `https://carleton.ca/equity/focus/discrimination-harassment/religious-spiritual-observances/`.

- **Academic Accommodations for Students with Disabilities:** The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or `mailto:pmc@carleton.ca` for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website for the deadline to request accommodations for the formally-scheduled exam (if applicable).

- **Survivors of Sexual Violence:** As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit `https://carleton.ca/equity/focus/sexual-violence-prevention-survivor-support/`.

- **Accommodation for Student Activities:** Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation will be provided to students who compete or perform at the national or international level. Write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the

need for accommodation is known to exist. See also https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf.

8 Special Information Regarding Winter 2022 Pandemic Measures

The following paragraphs are copied from the information text on Carleton University's Fall 2021 Pandemic Measures. On top of what is stated there, it should be noted that due to concerns around the new omicron variant of the virus, the university has decided to have all courses be held online during the first three weeks of the term. If this gets extended, it will affect our tutorials, as one tutorial group was meant to be held in person. Our lectures will always be online and thus are unaffected.

All members of the Carleton community are required to follow COVID-19 prevention measures and all mandatory public health requirements (e.g. wearing a mask, physical distancing, hand hygiene, respiratory and cough etiquette) and mandatory self-screening (see https://carleton.ca/covid19/cuscreen/) prior to coming to campus daily.

If you feel ill or exhibit COVID-19 symptoms while on campus or in class, please leave campus immediately, self-isolate, and complete the mandatory symptom reporting tool (see https://carleton.ca/covid19/cuscreen/symptom-reporting/). For purposes of contact tracing, attendance will be recorded in all classes and labs. Participants can check in using posted QR codes through the cuScreen platform where provided. Students who do not have a smartphone will be required to complete a paper process as indicated on the COVID-19 website (see https://carleton.ca/covid19/).

All members of the Carleton community are required to follow guidelines regarding safe movement and seating on campus (e.g. directional arrows, designated entrances and exits, designated seats that maintain physical distancing). In order to avoid congestion, allow all previous occupants to fully vacate a classroom before entering. No food or drinks are permitted in any classrooms or labs.

For the most recent information about Carleton's COVID-19 response and required measures, please see the University's COVID-19 webpage, https://carleton.ca/covid19/, and review the Frequently Asked Questions (FAQs), https://carleton.ca/covid19/faq/. Should you have additional questions after reviewing, please contact mailto:covidinfo@carleton.ca.

Please note that failure to comply with University policies and mandatory public health requirements, and endangering the safety of others are considered misconduct under the Student Rights and Responsibilities Policy, https://carleton.ca/studentaffairs/student-rights-and-responsibilities/. Failure to comply with Carleton's COVID-19 procedures may lead to supplementary action involving Campus Safety and/or Student Affairs.

9 Detailed course calendar

The following is a detailed list of all important events and dates related to this course. The numbers in brackets after each lecture title are the associated textbook sections.

- Week 1 (Jan 10–16):
  - Tu, Jan 11:
    - Lecture 1: Systems of Linear Equations (1.1)
    - Office hour 1
  - Th, Jan 13:
    - Lecture 2: Matrices and Echelon Forms (part of 1.2)
- Week 2 (Jan 17–23):
  - Tu, Jan 18:
    - Lecture 3: The Row Reduction Algorithm (part of 1.2)
    - Office hour 2
  - Th, Jan 20:
    - Lecture 4: Vector and Matrix Equations (1.3 and 1.4)
    - MyLab homework 1 released.
- Week 3 (Jan 24–30):
  - Tu, Jan 25:
    - Lecture 5: Solution Sets of Linear Systems (1.5)
    - Office hour 3
    - Tutorial 1
  - Th, Jan 27:
    - Lecture 6: Linear Independence (1.7)
    - Homework 1 due.
    - MyLab test 1 released.
- Week 4 (Jan 31–Feb 6):
  - Tu, Feb 1:
    - Lecture 7: Applications of Linear Systems (parts of 1.6 and 1.10)
    - Office hour 4
    - Tutorial 2
  - Th, Feb 3:

    - Lecture 8: Linear Transformations (1.8 and 1.9)
    - Test 1 due.
    - Written assignment 1 released.

- Week 5 (Feb 7–13):
  - Tu, Feb 8:
    - Lecture 9: Matrix Operations (2.1)
    - Office hour 5
    - Tutorial 3
  - Th, Feb 10:
    - Lecture 10: The Inverse of a Matrix (2.2)
    - Assignment 1 due.
    - MyLab homework 2 released.
- Week 6 (Feb 14–20):
  - Tu, Feb 15:
    - Lecture 11: Characterizations of Invertible Matrices (2.3)
    - Office hour 6
    - Tutorial 4
  - Th, Feb 17:
    - Lecture 12: Subspaces of $\mathbb{R}^n$ (2.8)
    - Homework 2 due.
- Week 7 (Feb 21–27): Winter break.
- Week 8 (Feb 28–Mar 6):
  - Tu, Mar 1:
    - Lecture 13: Dimension and Rank (2.9)
    - Office hour 7
    - Tutorial 5
  - Th, Mar 3:
    - Lecture 14: Determinants 1 (3.1 and part of 3.2)
    - Written assignment 2 released.
- Week 9 (Mar 7–13):
  - Tu, Mar 8:

    - Lecture 15: Determinants 2 (part of 3.2, 3.3)
    - Office hour 8
    - Tutorial 6
  - Th, Mar 10:
    - Lecture 16: Eigenvectors, Eigenvalues and the Characteristic Equation (5.1 and part of 5.2)
    - Assignment 2 due.
    - MyLab homework 3 released.

- Week 10 (Mar 14–20):
  - Tu, Mar 15:
    - Lecture 17: Diagonalization (part of 5.2, 5.3)
    - Office hour 9
    - Tutorial 7
  - Th, Mar 17:
    - Lecture 18: Introduction to Complex Numbers (Appendix B, more material covered in the lecture notes)
    - Homework 3 due.
    - MyLab test 2 released.

- Week 11 (Mar 21–27):
  - Tu, Mar 22:
    - Lecture 19: Complex Eigenvalues (5.5)
    - Office hour 10
    - Tutorial 8
  - Th, Mar 24:
    - Lecture 20: Inner Product, Length and Orthogonality (6.1)
    - Test 2 due.
    - MyLab homework 4 released.

- Week 12 (Mar 28–Apr 3):
  - Tu, Mar 29:
    - Lecture 21: Orthogonal Sets (6.2)
    - Office hour 11
    - Tutorial 9
  - Th, Mar 31:

    - Lecture 22: Orthogonal Projections (6.3)
    - Homework 4 due.
    - Written assignment 3 released.

- Week 13 (Apr 4–10):
  - Tu, Apr 5:
    - Lecture 23: The Gram-Schmidt Process (6.4)
    - Office hour 12
    - Tutorial 10
  - Th, Apr 7:
    - Lecture 24: Least-Squares Problems and Applications (6.5 and part of 6.6)
    - Assignment 3 due.
- Week 14 (Apr 11–17):
  - Tu, Apr 12:
    - Lecture 25: Course Review
    - Office hour 13
    - Tutorial 11
- Exam period (Apr 14–28): Final exam (exact date and time to be announced).