University of Victoria
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Course Outline
MATH 110: Matrix Algebra for Engineers
Fall 2019

Instructors

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General Course Information

Number of Units 1.5
Note: Credit will be granted for only one of MATH 110, MATH 133, MATH 211, MATH 233A.

Pre-requisites Admission to BEng or BSENG program.

Office Hours and Assistance

	Christopher Eagle	Ismail Belgacem
Monday		
Tuesday	1:30pm-3:30pm (DTB A202)	
Wednesday		
Thursday	8:30am-9:20am (DTB A441)	10:30am-12:20pm (DTB A453)
Friday		

Note: You are welcome to attend the office hours of either instructor. Office hours will begin in the second week of classes. Office hours are subject to change: Please check CourseSpaces for the most up-to-date information.

Drop-in Help The Mathematics & Statistics Assistance Centre is a large space where students can go to work, on their own or in groups, and to discuss math & stats problems. The Centre is staffed with talented Teaching Assistants who are happy to discuss primarily first and second year course material with you. Please see http://www.uvic.ca/science/math-statistics/current-students/undergraduate/msac/ for more information.

Math Club Students in Undergraduate Mathematics and Statistics (SUMS) was founded in 2014 as the reincarnation of a previous undergraduate course union that had been inactive for a few years. Please see http://www.uvic.ca/science/math-statistics/current-students/undergraduate/sums/index.php for more information.

Learning Objectives

Linear algebra is the branch of mathematics concerned with studying "flat" objects, such as lines, planes, and their higher-dimensional analogues. The modern approach to the subject has its roots in the study of determinants (which we will see midway through this course), in the late 17th century, but was primarily developed in the 19th century. Linear algebra forms part of the basic language of many other parts of mathematics, and as such it is ubiquitous in mathematics and the sciences, with applications in general relativity, quantum mechanics, population modelling, economics, and computer search engines, to name just a few. By the end of the term you will have learned the language and techniques of linear algebra, and will be prepared to apply it in your future courses.

You may find that this course has a different flavour than other math courses you have taken, and the material may seem more abstract. Gaining proficiency with these new ideas will help you develop your problem-solving skills and your ability to work with new abstract concepts. In this course the computations you are required to perform are often less complicated than understanding which computations need to be performed and why. In fact, computers are extremely good at carrying out most of the calculations we will see in this course, so computer software is used in many practical applications. To give you an opportunity to see how such software is used, this course includes the use of the MATLAB system in homework assignments.

A complete list of topics to be covered can be found on the schedule at the end of this outline.

Course Material and Online Resources

Textbook Linear Algebra: A Modern Introduction, 4th edition, by David Poole, published by CENGAGE Learning. The 3rd edition is also acceptable, and we will *not* be using the online tools associated with the book.

Course webpage The course webpage will be on `coursespaces.uvic.ca`. We will make frequent use of CourseSpaces to post course announcements, answer student questions, and record student grades. It is your responsibility to read announcements posted on CourseSpaces. If you do not have regular access to your own device that can access CourseSpaces, you can use one of the many computers available to students on campus.

Calculator If a calculator is allowed in tests and examinations in a course offered by the Department of Mathematics and Statistics, then the only acceptable calculator is a Sharp brand calculator with model number beginning EL-510R. The Sharp EL-510RTB may be purchased at the UVic Bookstore or elsewhere for about $15. A calculator **is** permitted in this course.

MATLAB As part of this course you will be required to use the MATLAB software package. The University MATLAB license allows students to install MATLAB on their own computers for free. For more information, visit `https://matlab.engr.uvic.ca/student/`. MATLAB is also installed on many of the computers available for student use at various locations on the UVic campus - a list of locations and hours is at `http://www.uvic.ca/systems/facilities/locationsandhours/index.php`.

Class Meetings

Lectures Lectures meet Tuesdays, Wednesdays, and Fridays, but your time and location depends on your lecture section. We strongly recommend that you prepare for lecture by reading the relevant chapter before coming to class (see the tentative schedule at the end of this outline). Learning linear algebra is like learning a language: The more time you spend with the new definitions and terminology, the more fluent you will become. Do not worry if some of the new ideas or theorems do not make perfect sense on your first reading, this is a normal part of the learning process. Reading ahead will allow you to get the most out of lectures, especially because this course will cover a large amount of material. Attendance in lectures is expected, except in the case of illness, accident, family affliction, or religious observation. You should take notes during lecture; they will not be provided for you.

Tutorials All tutorials meet on Wednesdays, but your time and location depend on your tutorial section. Tutorials will be spent working in small groups on worksheets related to the previous week's lectures. Your tutorial TA will provide the worksheet in tutorial. Your tutorial TA will then facilitate your group's discussion by assigning the groups, asking probing questions, giving hints, occasionally answering questions (sometimes with another question), and having groups explain solutions to each other. You will submit complete solutions to the tutorial worksheets the following week (see below), so participate actively in your tutorials in order to maximize the amount of assistance you get. Because your tutorial TA will collect and mark these solutions, you must attend the tutorial for which you are registered. Usually we will only be able to grade a subset of the assigned questions, but solutions to all questions will be made available after the assignment deadline.

Evaluation and Grading

In this multi-section course, all of the homework and midterms will be set up by the instructors in collaboration and marking will be monitored to ensure consistency across all sections.
Your final percentage grade will be computed according to the following scheme.

Item	Date(s)	Weight
Tutorial Assignments	Most weeks (see schedule near the end of the outline)	8%
Test 1 (45 minutes)	Friday, Sept. 27 (in lecture)	14%
Test 2 (45 minutes)	Friday, Oct. 25 (in lecture)	14%
Test 3 (45 minutes)	Friday, Nov. 15 (in lecture)	14%
Application Project	Due Wednesday Dec. 4 (in tutorial)	5%
Final exam (180 minutes)	TBA	45%

Grading Percentage scores will be converted to letter grades according to the university-wide standard table (`http://web.uvic.ca/calendar2019-09/undergrad/info/regulations/grading.html`).

Tutorial assignments During most tutorials, you will submit complete solutions to the previous tutorial's worksheet. Because your tutorial TA will collect and mark these solutions, you must attend the tutorial for which you are registered. You may work in groups during the tutorial, but **the final product you submit for grading must be your own work**. Talk to your tutorial TA if you are uncertain about how much collaboration is permitted.

A total of 9 tutorial worksheets will be collected. Your lowest tutorial assignment score will be dropped, and nothing is due in the first tutorial (Sept. 11).

MATLAB MATLAB is a computer program capable of performing a wide variety of mathematical tasks; you will use it again in future engineering courses. In the real world most applications of linear algebra involve data sets and matrices that are much too large to be studied by hand, so it is important to know how to have a computer carry out the calculations you need. We are incorporating MATLAB into this course in two ways:

- MATLAB questions on worksheets: Most tutorial worksheets will include a short problem to be completed in MATLAB. These problems are intended primarily to help you learn how to use the MATLAB syntax. You should include solutions to these problems with your tutorial worksheets when you submit them for grading.
- Application Project: Towards the end of the term you will be asked to complete a project in which you apply some of the concepts of this course to a real-world problem. Part of this project will be done by hand, and part will be done using MATLAB.

Tests Each test is 45 minutes long and will take place on a Friday in lecture (see dates above). You must write the tests in the lecture section for which you are registered, and there will be no make-up or alternate test times. Your tests will be returned to you in your tutorial.

Final Examination Off-schedule final examinations (i.e., deferred examinations) are given only in accordance with the university policy as outlined in the Calendar. If you are unable to write a final examination due to illness, accident or family affliction, please refer to the following webpages for detailed instructions how to proceed: `http://web.uvic.ca/calendar2019-09/undergrad/info/regulations/concessions.html` and `http://web.uvic.ca/calendar2019-09/undergrad/info/regulations/exams.html`. Students are **strongly advised not to make plans for travel or employment during the final examination period** as special arrangements will not be made for examinations that conflict with such plans.

Supplemental Examinations. The Department of Mathematics and Statistics does not award 'E' grades or offer Supplemental Examinations in any of its courses.

Accessibility Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations, please feel free to approach your instructor and/or the Centre for Accessible Learning (CAL) as soon as possible. The CAL staff are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations `http://www.uvic.ca/cal`. The sooner you let us know your needs the quicker we can assist you in achieving your learning goals in this course.

Commitment to Inclusivity and Diversity The University of Victoria is committed to promoting, providing and protecting a positive, supportive and safe learning and working environment for all its members.

Policies and Ethics

Specific to Math 110:

Missing tests No make-up tests or alternate test times will be offered. If you are unable to write a test due to serious illness or other valid reason then you must provide adequate documentation to your instructor as soon as possible, no later than 7 days after the missed midterm. In this case your final exam score will replace your missed midterm score.

Missing tutorial assignments If you are unable to submit an assignment in tutorial due to serious illness, religious observance, or other valid reason, then you must provide adequate documentation to your instructor as soon as possible. In this case the assignment portion of your grade will be determined based on the remaining assignments.

Missing MATLAB assignments No extensions will be given for the MATLAB assignments. The instructions will be handed out in tutorial two weeks before each MATLAB assignment is due, and **we strongly recommend starting early**. If you are unable to complete a MATLAB assignment due to a prolonged illness or other valid reason then you must contact your instructor *before* the due date, and provide documentation as soon as possible. In this case the final exam score will replace your missed assignment score. Note that technical difficulties with installing or using the MATLAB system will *not* be accepted as a valid excuse for not submitting a MATLAB assignment on time.

Missing multiple course components If you are unable to complete more than one graded component of the course for acceptable reasons with valid documentation, then you will need to meet with your course instructor to discuss the re-weighting of the remaining course components. Your final exam grade will not be weighted at more than 60% of your course grade.

Re-mark requests If you believe that your work has been incorrectly marked, you must write a short explanation (just a few sentences is enough) and staple it to the front of your work. This request must be submitted to your course instructor **in lecture** no later than the Wednesday after work is returned to the class. Late re-mark requests,

or requests submitted outside of lecture, will not be considered except in the case of absence due to serious illness or religious observance.

Unclaimed work All graded term work in this course will be returned to you during tutorial, so you must attend the tutorial for which you are registered. Any term work that is not collected by the end of the final examination period will be recycled.

Departmental Policies:
(See `https://www.uvic.ca/science/math-statistics/current-students/undergraduate/course-policies/index.php` for more information.)

Attendance The university Calendar states 'Students are expected to attend all classes in which they are enrolled.' (see `http://web.uvic.ca/calendar2019-09/undergrad/info/regulations/attendance.html`). Our courses are conducted on that basis. If you miss an announcement (information concerning midterms, corrections to assignment, etc.) because you did not attend class, you must accept the consequences of not having learned of the change.

Guidelines on Religious Observances Where classes or examinations are scheduled on the holy days of a religion, students may notify their instructors, at least two weeks in advance, of their intention to observe the holy day(s) by absenting themselves from classes or examinations. Instructors will provide reasonable opportunities for such students to make up work or missed examinations.

Academic Integrity Academic integrity is intellectual honesty and responsibility for academic work that you submit individual or group work. It involves commitment to the values of honesty, trust, and responsibility. It is expected that students will respect these ethical values in all activities related to learning, teaching, research, and service. Therefore, plagiarism and other acts against academic integrity are serious academic offenses.

The responsibility of the institution

Instructors and academic units have the responsibility to ensure that standards of academic honesty are met. By doing so, the institution recognizes students for their hard work and assures them that other students do not have an unfair advantage through cheating on essays, exams, and projects.

The responsibility of the student

Plagiarism sometimes occurs due to a misunderstanding regarding the rules of academic integrity, but it is the responsibility of the student to know them. If you are unsure about the standards for citations or for referencing your sources, ask your instructor. Depending on the severity of the case, penalties include a warning, a failing grade, a record on the students transcript, or a suspension.

It is your responsibility to understand the University's policy on academic integrity: `http://web.uvic.ca/calendar2019-09/undergrad/info/regulations/academic-integrity.html`

How to Succeed in This Course

Practice regularly Linear algebra is very different from most of the mathematics you learned in highschool, and it comes with a new vocabulary and a large number of new ideas. The best way to master linear algebra is to practice regularly. See below for a list of recommended textbook problems. While we will not be collecting these problems, they are an excellent way to make sure you are fully understanding the course material. We strongly recommend that you work on textbook problems as the course progresses - cramming before the tests is very unlikely to be successful in this course. A list of recommended problems is provided on the next page of this outline.

Visit CourseSpaces There is a forum set up for class discussion, which the instructors will monitor fairly regularly. Feel free to *answer* questions there as well as ask them; the instructors will chime in if we spot any errors. If you have a question about course policies, it is almost certain to be answered in an announcement (or this course outline) – so please check before emailing!

Check your progress Read the feedback your TA gives you on your tutorial assignments – that is a good indication of how your test solutions will be marked. Make a habit of providing a justification for each step of your work - we are much more interested in *how* you found your answer than the final answer itself. Keep an eye on the CourseSpaces grade book to see your current expected grade in the course.

Contact the instructors Your instructors are available to provide you with assistance, either in their office hours or by email. It is difficult to communicate the material of this course by email, so we strongly prefer that questions about course content be asked in person, during office hours. Due to the number of students enrolled in each lecture, if you ask a question by email whose answer already appears in the Course Outline or in a post on CourseSpaces we will probably just send you a link. Our reply time will depend on many factors. Please be aware that we might keep very different hours than you do! If you will see your instructor in the next 48 hours, you might get a faster reply by asking your question in person.

Start preparing early If you are able to maintain a constant moderate level of work then you will not have intense weeks where it is hard to keep up with your workload. Begin reviewing for the tests a week or two ahead of time, by re-working tutorial worksheets and textbook problems.

Course Survey

We value your feedback on this course. Towards the end of term you will have the opportunity to complete a confidential course experience survey (CES) regarding your learning experience. The survey is vital to providing feedback to us regarding the course and our teaching, as well as to help the department improve the overall program for students in the future. When it is time for you to complete the survey, you will receive an email inviting you to do so. If you do not receive an email invitation, you can go directly to `http://ces.uvic.ca`. You will need to use your UVic NetLink ID to access the survey, which can be done on your laptop, tablet, or mobile device. We will remind you nearer the time, but please be thinking about this important activity, especially the following three questions, during the course.

1. What strengths did your instructor demonstrate that held you learn in this course?
2. Please provide specific suggestions as to how the instructor could have helped you learn more effectively.
3. Please provide specific suggestions as to how this course could be improved.

In addition to the formal feedback at the end of the course, your instructors also welcome your comments throughout the term.

Recommended exercises

Learning mathematics requires practice, and you should expect to need more practice than the tutorial worksheets alone can give you. For that reason, we very strongly recommend completing additional problems from the resources provided here.
We will be maintaining a collection of recommended exercises, along with their solutions, at `http://www.math.uvic.ca/~eaglec/Math110/`. Each week your tutorial worksheet will indicate the related exercises from this collection.
In addition to the exercises above, the course textbook has many excellent practice problems. The exercises listed below refer to the 4th edition of the course textbook. If you have an earlier edition the question numbers may be different, and you are encouraged to check with someone using a more current edition to make sure you are working on appropriate problems.

Section	Exercises
1.1	1, 3, 5, 7, 9, 13, 15, 17, 19, 21
1.2	3, 9, 15, 17, 19, 23, 25, 33, 41, 59, 65
1.3	1, 5, 7, 9, 13, 15, 18, 19, 23, 27, 29, 35, 37, 43
2.1	1, 2, 3, 5, 8, 9, 15, 17, 21, 24, 27, 29, 33, 35, 39, 41
2.2	1, 3, 5, 7, 13, 19, 21, 23, 25, 27, 29, 33, 35, 37, 43
2.3	1, 3, 5, 7, 11, 15, 21, 23, 27, 29, 43, 46, 47
3.1	1, 3, 5, 7, 9, 11, 13, 15, 21, 23, 29, 35, 40
3.2	1, 3, 5, 7, 9, 11, 13, 15, 23, 25, 27, 35, 36, 37, 39, 45, 47
3.3	1, 5, 7, 9, 11, 13, 17, 19, 23, 27, 34, 39, 43, 53, 59
3.5	1, 3, 5, 7, 9, 11, 13, 15, 17, 18, 21, 23, 25, 27, 29, 31, 35, 39, 40, 41, 42, 46, 51
3.6	1, 5, 7, 9, 13, 15, 19, 21, 23, 25, 33, 37
4.1	1, 3, 5, 7, 11, 13, 15, 17, 23, 25, 27, 29, 35, 37
4.2	1, 3, 7, 10, 11, 15, 23, 27, 31, 32, 33, 35, 39, 45, 47
4.3	1, 5, 9, 11, 13, 15, 19, 21, 23, 25
4.4	1, 3, 5, 7, 9, 13, 15, 17, 19, 23, 25, 27, 29, 33, 39, 45
5.1	1, 3, 5, 7, 9, 15, 19, 27, 28, 29, 31, 37
5.2	1, 3, 5, 7, 9, 13, 17, 21, 25, 27
5.3	1, 3, 5, 7, 9, 10, 11, 12, 14, 15, 16, 17, 18, 21
5.4	1, 3, 5, 7, 9, 11, 13, 14, 17, 19, 21, 23, 24
Appendix C	See practice problems on CourseSpaces

We recommend that you do practice problems as soon as possible after we cover the relevant sections in lecture. The lecture schedule and topics on the next page are approximate and subject to change. Note that this course will **not** include the material in the textbook regarding binary vectors or algebra over $\mathbb{Z}_p$.

Note: The schedule on the following pages is **approximate**. We may, at times, cover material at a different speed than is indicated in this table. The best way to know where we are in the course content is to attend class regularly.

Week of	**Lecture**	**Tutorial**	**Important Dates**
Sept. 2	1.1, 1.2 Introduction to vectors	No tutorial	First day of classes Wednesday, Sept. 4
Sept. 9	1.2, 1.3 Dot products Length Lines and planes	Tutorials begin **Due**: Nothing **Returned**: Nothing **Handed out**: Worksheet 1	
Sept. 16	1.3, 2.1, 2.2 Lines and planes Linear systems	**Due**: Worksheet 1 **Returned**: Nothing **Handed out**: Worksheet 2	
Sept. 23	2.3 Linear independence Span	**Due**: Nothing **Returned**: Worksheet 1 **Handed out**: Worksheet 3	**Test 1** Friday, Sept. 28 (in lecture)
Sept. 30	(See final page for textbook references) Introduction to linear transformations Matrices as linear transformations Introduction to matrix algebra	**Due**: Worksheet 3 **Returned**: Test 1 **Handed out**: Worksheet 4	
Oct. 7	(See final page for textbook references) Matrix multiplication Composition of linear transformations Transpose	**Due**: Worksheet 4 **Returned**: Worksheet 3 **Handed out**: Worksheet 5	Thanksgiving Day Monday, Oct. 7
Oct. 14	(See final page for textbook references) Invertibility Determinants The Fundamental Theorem	**Due**: Worksheet 5 **Returned**: Worksheet 4 **Handed out**: Worksheet 6	

Continued on next page.

Week of	**Lecture**	**Tutorial**	**Important Dates**
Oct. 21	3.5 Subspaces of $\mathbb{R}^n$ Basis Dimension and rank	**Due**: Nothing **Returned**: Worksheet 5 **Handed out**: Worksheet 7	**Test 2** Friday, Oct. 25 (in lecture)
Oct. 28	3.5, Appendix C, 4.1, 4.3 More on subspaces Coordinates Complex numbers Eigenvalues and eigenvectors	**Due**: Worksheet 7 **Returned**: Test 2 **Handed out**: Worksheet 8	
Nov. 4	4.3, 4.4 More on eigenvalues and eigenvectors Similarity Diagonalizability	**Due**: Worksheet 8 **Returned**: Worksheet 7 **Handed out**: Worksheet 9	
Nov. 11	No new material No classes Monday-Wednesday	No tutorial	**Test 3** Friday, Nov. 15 (in lecture)
Nov. 18	5.1, 5.2 Orthogonality in $\mathbb{R}^n$ Orthogonal matrices Orthogonal complements	**Due**: Nothing **Returned**: Worksheet 8 & Test 3 **Handed out**: Worksheet 10	
Nov. 25	5.2, 5.3 Orthogonal projections Gram-Schmidt algorithm	**Due**: Worksheet 10 **Returned**: Nothing **Handed out**: Worksheet 11	
Dec. 2	5.4 Orthogonal diagonalizability The Spectral Theorem	**Due**: Application Project **Returned**: Worksheet 10 **Handed out**: Nothing	Last day of classes Wednesday, Dec. 4

Chapter 3 textbook references

We will be covering some of Chapter 3 in a different order than the textbook. The material is about the algebraic operations on matrices. Each operation can be viewed from the point of view of computation, matrix algebra, and linear transformations. The textbook presents computations in Section 3.1, matrix algebra in Section 3.2, and linear transformations in Section 3.6. We will cover all of the material from those sections, but we will treat the operations one at a time, and present all three aspects of each operation in turn. Below is a list of page numbers corresponding to each topic. If it becomes unclear where we are in the material, either ask your instructor or post on the CourseSpaces discussion forum.

- **Week of 30 September, 2019**
  - Definitions: 138-139, 211-214
  - Addition, subtraction, and scalar multiplication: 140-141, 154
  - Matrices as linear transformations: 214-219
- **Week of 7 October, 2019**
  - Multiplication and composition: 141-145, 149-150, 158-159, 219-221
  - Transpose: 150-152, 159-161
- **Week of 14 October, 2019**
  - Inverses and invertibility: 163-178, 221-223
  - Determinants: Section 4.2