



THE UNIVERSITY OF BRITISH COLUMBIA

Department of Computer Science, Mathematics, Physics and Statistics
Okanagan Campus

MATH 221 - 001
Matrix Algebra
W2021 – T-1
COURSE OUTLINE

Course Information

Instructor: Dr. Paul Tsopméné

E-mail: paul.tsopmene@ubc.ca

Office: SCI 259

Phone: 250-807-8386

Classroom Schedule: Mon & Thu: 5:00 PM – 6:30 PM

Location: ASC 140

Mode of Delivery (Course and Labs): In-Person

Requires In-Person Attendance: Yes

Office Hours: Mon & Thu: 3:00 PM – 4:30 PM. I am also available by email or by appointment if these times do not work for you.

Course Website: Course material on our [Canvas](#) learning management system. My primary method of communication is through Canvas messages/emails. Make sure you check this website regularly.

Textbook & Calculators

Textbook (optional): *Linear Algebra and Its Applications*, by David C. Lay, Steven R. Lay and Judi J. McDonald, 5th edition, Pearson. This is available in the bookstore.

As a secondary reference, we are using Chad Davis' notes. This is free and available on Canvas.

Calculators: The use of a scientific calculator (non-graphing, non-programmable) is permitted.

Calendar Course Description

MATH 221 (3) Matrix Algebra

Systems of linear equations, operations on matrices, determinants, eigenvalues and eigenvectors, diagonalization of symmetric matrices. [3-1-0]

Prerequisite: One of MATH 100, MATH 116.

Corequisite: One of MATH 101, MATH 142.



Course Format

Lectures and labs.

- **Lecture Format:** Each week (excepting holidays) there will be two lectures delivered in person. During a typical lecture, the instructor will present one or more concepts, cover examples, and answer questions. Some lectures will be complemented by out-of-class readings and written assignments. **Our first lecture will hold on Thursday, September 09.**

Note: Although the course will be in-person, **lectures will be recorded and posted on Canvas.**

- **Lab Format:** Most weeks students will meet with their lab section (in-person), and the Teaching Assistant (TA) will answer their questions and/or review and practice course material. Sometimes the TA will cover some interesting applications of matrix/linear algebra. **Labs will start on Monday, September 20.**

Note: The attendance is not mandatory. But **every student must be registered in one of the lab sections.**

Course Overview, Content and Objectives

Course Overview: This course is an introduction to linear algebra, which is a branch of mathematics that studies systems of linear equations and the properties of matrices (plural of matrix). The concepts of linear algebra are extremely useful in physics, economics and social sciences, natural sciences, and engineering. Due to its broad range of applications, linear algebra is one of the most widely taught subjects in college-level mathematics. In this course we will concentrate on the methods of linear algebra and students will be exposed to some formal proofs. We will become competent in solving systems of linear equations, performing matrix algebra, calculating determinants, and finding eigenvalues and eigenvectors. On the theoretical side, we will become comfortable with the vector space R^n and come to understand a matrix as a linear transformation. On the application side, we will see how to use linear systems to solve real-world problems. We will also see how to use determinants to find volumes and eigenvalues and eigenvectors to study/understand some natural phenomena (if time permits).

Contents: Topics include

- **Linear Equations in Linear Algebra:** Systems of Linear Equations, Row Reduction and Echelon Forms, Vector Equations, Matrix Equations, Solution Sets of Linear Equations, Applications of Linear Systems, Linear Independence, Linear Transformations.
- **Matrix Algebra:** Matrix Operations, The Inverse of a Matrix, Characterizations of Invertible Matrices, Subspaces of R^n , Column Space and Null Space, Basis, Dimension and Rank.
- **Determinants:** Introduction to Determinants, Properties of Determinants, Determinants as Area or Volume (if times permits).
- **Eigenvalues and Eigenvectors:** Eigenvectors and Eigenvalues, The Characteristic Equation, Diagonalization and Applications.



Course Objectives: The main objective of this course is to understand the fundamental concepts and computations of matrix algebra. Students should be able to solve a wide array of matrix algebra problems using these concepts and the corresponding calculations.

Learning outcomes

After completing this course, students will be able to:

- Solve systems of linear equations by using matrices (that is, by row reducing the augmented matrix to an echelon form). If a system has at least one solution, students should be able to write the set of solutions in (parametric) vector form.
- Express a linear system as a vector equation as well as a matrix equation.
- Understand the concepts of linear combination and span. In particular, students should be able to show that a given vector is in the span of a set of vectors.
- Understand the concept of linear independence. In particular, students should be able to determine whether a set of vectors is linearly independent or not.
- Find a linear dependence relation among vectors which are not linearly independent.
- Show that a transformation is linear.
- Show that a transformation is not linear.
- Find the image of a vector under a linear transformation.
- Find the standard matrix of a (geometric) linear transformation.
- Understand the concepts of onto and one-to-one. In particular, students should be able to determine whether a linear transformation is onto or one-to-one or neither.
- Understand a matrix as a linear transformation.
- Perform matrix operations – multiply a matrix by a number, add two matrices, subtract two matrices, multiply two matrices, find the transpose of a matrix.
- Determine whether a matrix is invertible or not. If a matrix is invertible, students should be able to find its inverse.
- Use the properties of transposes and matrix inverses to solve matrix equations.
- Use the Invertible Matrix Theorem to prove statements.
- Determine whether a vector is in the column space or the null space of a matrix.
- Find a basis and the dimension of the column space and the null space of a matrix.
- Use the Rank-Nullity Theorem to find the rank or the dimension of the null space of a matrix.
- Compute the determinant of a matrix using various techniques.
- Find the eigenvalues of a matrix.
- Find the eigenvectors of a matrix – find a basis and the dimension of the eigenspace corresponding to an eigenvalue.
- Determine whether a matrix is diagonalizable or not.
- Compute the n th power of a (diagonalizable) matrix for an arbitrary nonnegative integer n .

Evaluation

Assignments (Submit online, Due Friday 11:59 PM)	20%
Midterm 1 (Thursday, October 7 at 5:00 PM in person)	15%
Midterm 2 (Thursday, November 18 at 5:00 PM in person)	15%
Final Exam (Cumulative – TBA, in person)	50%

Final grades will be based on the evaluations listed above and the final grade will be assigned according to the standardized grading system outlined in the UBC Okanagan Calendar.

NOTE:

- **You MUST attain a grade of at least 40% on the Final Exam in order to pass the course.** In the event you do not get at least 40% on the final exam AND your final grade is less than 50%, your final grade will be recorded. In the event you do not attain at least 40% on the final exam AND your final grade is greater than or equal to 50%, a maximum grade of 47% will be recorded.
- The final exam will be given during the regularly scheduled examination period (Dec. 11 – 22, 2021).
- **Passing Criteria:** To pass the course, you must attain a grade of at least 40% on the final exam AND your overall final grade has to be greater than or equal to 50%.
- **Mode of Delivery for Exams:** In-Person

Practice Problems, Assignments, Midterms, and Final Exams

- **Practice Problems:** Every week I will post practice problems on Canvas along with complete solutions. While completion of these problems is essential for your success in this course, **you do not hand them in for grading.**
- **Assignments:** There will be 6 assignments throughout the semester. These will be posted on Canvas on Fridays and the **due date will be on the next Friday at 11:59 PM. To submit your assignment, you will have to upload the assignment as a single .pdf file on Canvas.** Once you submit your work on Canvas, **make sure to go back** to the submission box on Canvas and check that your submission is uploaded properly and confirm no missing pages. Try to complete and submit your work at least 12 hours before the due date. **Remember:** Always start the assigned work early. Do not leave things until the last minute. I will be available for help during my office hours or by emails or by appointments.
Late Policy: Late submissions won't be considered. No extensions or make up assignments. If an assignment/notes is missed for a valid reason (e.g., religious, medical or compassionate reasons, with documentation), the final exam will be weighted more heavily to compensate.
Your worst assignment grade will be dropped from the total.



Assignment #	Will be posted on	Due date
1	September 17	September 24
2	September 24	October 1
3	October 15	October 22
4	October 22	October 29
5	October 29	November 5
6	November 26	December 3

- **Midterms:** There will be 2 midterm exams (80 minutes each).

Midterm 1	Thursday, October 7 at 5:00 PM in person
Midterm 2	Thursday, November 18 at 5:00 PM in person

I will send you the midterm topics by email about a week before the date of each midterm. The midterms will be written during the class time and will be **in person**. It is your responsibility to be present for these tests. **No make-up midterms will be given. If a midterm is missed for a valid reason (e.g., religious, medical or compassionate reasons, with documentation), the other midterm and/or final exam will be weighted more heavily to compensate.**

- **Final Exam:** There is a 2.5-hours comprehensive final exam during the final examination period December 11 – 22. Date: TBA. The final exam will be **in person**. **You MUST attain a grade of at least 40% on the final exam in order to pass the course.**

Important Dates

Tuesday, September 7	Term 1 of Winter 2021 semester starts
Monday, September 20	Last day for withdrawal without receiving a ``W'' standing
Thursday, September 30	National Day for Truth and Reconciliation (no classes)
Monday, October 11	Thanksgiving Day (no classes)
November 8 – 12	Winter session term 1 midterm break (no classes)
Friday, November 12	Last day for withdrawal with a ``W''
Tuesday, December 7	Last day of classes
December 11 – 22	Final examination period

Other calendar dates can be found at <http://okanagan.students.ubc.ca/calendar/>

Course Schedule

Tentative course schedule (this is subject to change).

Lecture #	Subjects, Assignments, Midterms, and Holidays	Date
1	Systems of Linear Equations	Thu, Sept. 9
2	Row Reduction and Echelon Forms	Mon, Sept. 13
3	Using Row Reduction to Solve Linear Systems	Thu, Sept. 16
	Release Assignment 1	Fri, Sept. 17
4	Vector Equations, Linear Combinations, and Spans	Mon, Sept. 20
5	The Matrix Equation $Ax=b$	Thu, Sept. 23
	Release Assignment 2	Fri, Sept. 24
6	Solution Sets of Systems of Linear Equation, Vector Forms	Mon, Sept. 27
	National Day for Truth and Reconciliation (no classes)	Thu, Sept. 30
7	Linear Independence	Mon, Oct 4
	Midterm 1 (80 minutes, will be held during the class time)	Thu, Oct 7
	Thanksgiving Day (no classes)	Mon, Oct. 11
8	Linear Transformations	Thu, Oct. 14
	Release Assignment 3	Fri, Oct. 15
9	The Matrix of a Linear Transformation	Mon, Oct. 18
10	Matrix Operations	Thu, Oct 21
	Release Assignment 4	Fri, Oct. 22
11	Matrix Operations (continued)	Mon, Oct. 25
12	The Inverse of a Matrix	Thu, Oct. 28
	Release Assignment 5	Fri, Oct. 29
13	Characterization of Invertible Matrices	Mon, Nov. 1
14	Subspaces of R^n	Thu, Nov. 4
	Midterm Break (no classes)	Nov. 8 – 12
15	Basis, Dimension, and Rank	Mon, Nov. 15
	Midterm 2 (80 minutes, will be held during the class time)	Thu, Nov. 18
16	Introduction to Determinants	Mon, Nov. 22
17	Properties of Determinants	Thu, Nov. 25
	Release Assignment 6	Fri, Nov. 26
18	Eigenvalues and Eigenvectors	Mon, Nov. 29
19	Diagonalization	Thu, Dec. 2



20	Diagonalization and Applications	Mon, Dec. 6
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Grading Practices

Faculties, departments, and schools reserve the right to scale grades in order to maintain equity among sections and conformity to University, faculty, department, or school norms. Students should therefore note that an unofficial grade given by an instructor might be changed by the faculty, department, or school. Grades are not official until they appear on a student's academic record.

<http://www.calendar.ubc.ca/okanagan/index.cfm?tree=3,41,90,1014>

Final Examinations

The examination period for **W2021 T-1 is December 11 - 22, 2021**. Except in the case of examination clashes and hardships (three or more formal examinations scheduled within a 27-hour period) or unforeseen events, students will be permitted to apply for out-of-time final examinations only if they are representing the University, the province, or the country in a competition or performance; serving in the Canadian military; observing a religious rite; working to support themselves or their family; or caring for a family member. Unforeseen events include (but may not be limited to) the following: ill health or other personal challenges that arise during a term and changes in the requirements of an ongoing job.

Further information on **Academic Concession** can be found under **Policies and Regulation in the Okanagan Academic Calendar** <http://www.calendar.ubc.ca/okanagan/index.cfm?tree=3,48,0,0>

Academic Integrity

The academic enterprise is founded on honesty, civility, and integrity. As members of this enterprise, all students are expected to know, understand, and follow the codes of conduct regarding academic integrity. At the most basic level, this means submitting only original work done by you and acknowledging all sources of information or ideas and attributing them to others as required. This also means you should not cheat, copy, or mislead others about what is your work. Violations of academic integrity (i.e., misconduct) lead to the breakdown of the academic enterprise, and therefore serious consequences arise and harsh sanctions are imposed. For example, incidences of plagiarism or cheating may result in a mark of zero on the assignment or exam and more serious consequences may apply if the matter is referred to the President’s Advisory Committee on Student Discipline. Careful records are kept in order to monitor and prevent recurrences.

A more detailed description of academic integrity, including the University’s policies and procedures, may be found in the Academic Calendar at: <http://okanagan.students.ubc.ca/calendar/index.cfm?tree=3,54,111,0>.

Cooperation vs. Cheating

Working with others on assignments is a good way to learn the material and we encourage it. However, there are limits to the degree of cooperation that we will permit. Any level of cooperation beyond what is permitted is considered cheating.



When working on programming assignments, you must work only with others whose understanding of the material is approximately equal to yours. In this situation, working together to find a good approach for solving a programming problem is cooperation; listening while someone dictates a solution is cheating. You must limit collaboration to a high-level discussion of solution strategies, and stop short of actually writing down a group answer. Anything that you hand in, whether it is a written problem or a computer program, must be written by you, from scratch, in your own words. If you base your solution on any other written solution, you are cheating. If you provide your solution for others to use, you are also cheating.

Copyright Disclaimer

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Grievances and Complaints Procedures

A student who has a complaint related to this course should follow the procedures summarized below:

- The student should attempt to resolve the matter with the instructor first. Students may talk first to someone other than the instructor if they do not feel, for whatever reason, that they can directly approach the instructor.
- If the complaint is not resolved to the student's satisfaction, the student should e-mail the Associate Head, Dr. Sylvie Desjardins at sylvie.desjardins@ubc.ca or the Department Head (PRO TEM), Dr. Andrew Jirasek at andrew.jirasek@ubc.ca

Student Service Resources

Disability Assistance

The Disability Resource Centre ensures educational equity for students with disabilities, injuries or illness. If you are disabled, have an injury or illness and require academic accommodations to meet the course objectives, e-mail us or visit our website for more information.

Web: <http://students.ok.ubc.ca/drc/welcome.html> **E-mail DRC at:** drc.questions@ubc.ca

Equity, Human Rights, Discrimination and Harassment

UBC Okanagan is a place where every student, staff and faculty member should be able to study and work in an environment that is free from human rights-based discrimination and harassment. If you require assistance related to an issue of equity, discrimination or harassment, please contact the Equity Office, your administrative head of unit, and/or your unit's equity representative. **UBC Okanagan Equity Advisor: ph. 250-807-9291**

Web: <https://equity.ok.ubc.ca/> **E-mail:** equity.ubco@ubc.ca



Health & Wellness - UNC 337

At UBC Okanagan health services to students are provided by Health and Wellness. Nurses, physicians and counsellors provide health care and counselling related to physical health, emotional/mental health and sexual/reproductive health concerns. As well, health promotion, education and research activities are provided to the campus community. If you require assistance with your health, please contact Health and Wellness for more information or to book an appointment.

Web: www.students.ok.ubc.ca/health-wellness

Email: healthwellness.okanagan@ubc.ca

Sexual Violence Prevention and Response Office (SVPRO)

A safe and confidential place for UBC students, staff and faculty who have experienced sexual violence regardless of when or where it took place. Just want to talk? We are here to listen and help you explore your options. We can help you find a safe place to stay, explain your reporting options (UBC or police), accompany you to the hospital, or support you with academic accommodations. You have the right to choose what happens next. We support your decision, whatever you decide. Visit svpro.ok.ubc.ca or call us at 250-807-9640

Independent Investigations Office (IIO)

If you or someone you know has experienced sexual assault or some other form of sexual misconduct by a UBC community member and you want the Independent Investigations Office (IIO) at UBC to investigate, please contact the **IIO**. Investigations are conducted in a trauma informed, confidential and respectful manner in accordance with the principles of procedural fairness. You can report your experience directly to the **IIO** by calling 604-827-2060.

Web: <https://investigationoffice.ubc.ca/>

E-mail: director.of.investigations@ubc.ca

The Hub

The Student Learning Hub (LIB 237) is your go-to resource for free math, science, writing, and language learning support. The Hub welcomes undergraduate students from all disciplines and year levels to access a range of supports that include **tutoring in math, sciences, languages, and writing, as well as help with study skills and learning strategies.** **Web:** (<https://students.ok.ubc.ca/student-learning-hub/>) **Ph:** 250-807-9185.

SAFEWALK - Download the UBC SAFE – Okanagan app.

Don't want to walk alone at night? Not too sure how to get somewhere on campus?

Call Safewalk at 250-807-8076 For more information: <https://security.ok.ubc.ca/safewalk/>