COURSE OUTLINE

THE UNIVERSITY OF BRITISH COLUMBIA

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

MATH 221- 001 - MATRIX ALGEBRA
2022W TERM -1 (SEPT. 6TH, 2022 – DEC. 8TH ,2022)

INSTRUCTOR:

Name: Paul Tsopméné
Contact: paul.tsopmene@ubc.ca (Preferred)
Office Location: SCI 259
Office Hours: Tuesday and Thursday: 10:30am – 12:00pm. I am also available by email or by appointment if these times do not work for you.
Class Location: ASC 130

SCHEDULE:

Lecture: Tuesday and Thursday
Hours: 2:00pm – 3:30pm

LABORATORY COORDINATOR/INSTRUCTOR/TA:

L01:	Name of TA:	Ziyuan Wang	Thursday	8:00am – 9:00am
L02:	Name of TA:	Amirhossein Salamirad	Wednesday	10:00am – 11:00am
L03:	Name of TA:	Amirhossein Salamirad	Monday	4:00pm – 5:00pm
L04:	Name of TA:	Ziyuan Wang	Friday	10:00am – 11:00am

All TAs can be contacted on Canvas.

TEXTBOOK, OTHER REFERENCE MATERIAL, AND CALCULATORS:

Textbook: *Linear Algebra and Its Applications,* by David C. Lay, Steven R. Lay and Judi J. McDonald, 5th edition, Pearson. The textbook is OPTIONAL.
Other Reference Material: As a secondary reference, we are using Chad Davis' notes. This is free and available on Canvas.
Exercise Book: *Matrix Algebra,* by Paul Tsopméné. This is free, and it is available on Canvas. It contains many problems, very detailed solutions, and concept summaries.
Calculators: The use of a scientific calculator (non-graphing, non-programmable) is permitted.

COURSE DESCRIPTION:

Course Website:
Course materials are available at https://canvas.ubc.ca. My primary method of communication is through Canvas messages/emails. Make sure you check this website regularly.

Academic Calendar Entry:
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 103, MATH 142.

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 many areas, including physics, economics and social sciences, natural sciences, computer science, data science, 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, 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, Applications of Determinants (if time permits).
- **Eigenvalues and Eigenvectors:** Eigenvectors and Eigenvalues, The Characteristic Equation, Diagonalization and Applications.

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 nth power of a (diagonalizable) matrix for an arbitrary nonnegative integer n.

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.

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 Tuesday, September 06. Note:** Lectures won't be recorded.

- **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 12.**
Note: The attendance is not mandatory. But **every student must be registered in one of the lab sections**.

LATE POLICY:

Assignments: Late submissions won't be considered. No extensions or make up assignments**.** If an assignment 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**.**

Midterms: 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.

PASSING CRITERIA:

- In order 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%.

Note: 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.

EXPECTATIONS:

You can expect me:

- To start and end class on time.
- To explain a concept or an example as many times as needed until you get it.
- To reply to e-mails within 24 hours on weekdays and 48 hours on weekends.
- To assign homework that adequately covers the material and meets the learning objectives of the course.
- To give exams that accurately reflect the material covered in class and assigned in homework.

I can expect you:

- To read and understand this course outline.
- To come to class on time.
- To be attentive and engaged in class (ask questions when you don't fully understand course material).
- To engage with both the abstract and computational sides of the material.
- To refrain from using laptops, cell phones, and other electronic devices during class.
- To spend an adequate amount of time on the homework each week, making an effort to solve and understand each problem.
- To come to me (or send me an email) if you need help or have any questions (including questions about the assignments).

TENTATIVE COURSE SCHEDULE:

The following course schedule is subject to change.

Lecture #	Topics, Assignments, and Midterms	Date
1	Systems of Linear Equations	Tue, Sept. 6
2	Row Reduction and Echelon Forms	Thu, Sept. 8
3	Using Row Reduction to Solve Linear Systems	Tue, Sept. 13
4	Linear Combinations and Vector Equations	Thu, Sept. 15
	Release Assignment 1	**Fri, Sept. 16**
5	Spanning Sets	Tue, Sept. 20
6	The Matrix Equation Ax=b	Thu, Sept. 22
	Release Assignment 2	**Fri, Sept. 23**
7	Solution Sets of Systems of Linear Equation, Vector Forms	Tue, Sept. 27
8	Linear Independence	Thu, Sept. 29
9	Linear Transformations	Tue, Oct 4
	Midterm 1 (2:00pm—3:15pm, in ASC 130)	**Thu, Oct 6**
10	The Matrix of a Linear Transformation	Tue, Oct. 11
11	Applications of Linear Transformations	Thu, Oct. 13
	Release Assignment 3	**Fri, Oct. 14**
12	Matrix Operations	Tue, Oct. 18
13	Matrix Operations (continued)	Thu, Oct 20
	Release Assignment 4	**Fri, Oct. 21**
14	The Inverse of a Matrix	Tue, Oct. 25
15	Characterization of Invertible Matrices	Thu, Oct. 27
	Release Assignment 5	**Fri, Oct. 28**
16	Applications of Matrix Operations	Tue, Nov. 1
17	Subspaces of R^n	Thu, Nov. 3
	Midterm Break (no classes)	Nov. 7 – 11
18	Basis, Dimension, and Rank	Tue, Nov. 15
	Midterm 2 (2:00pm—3:15pm, in ASC 130)	**Thu, Nov. 17**
19	Introduction to Determinants	Tue, Nov. 22
20	Properties of Determinants	Thu, Nov. 24
	Release Assignment 6	**Fri, Nov. 25**
21	Eigenvalues and Eigenvectors	Tue, Nov. 29

22	Eigenvalues, Eigenvectors, and Diagonalization	Thu, Dec. 1
23	Diagonalization (continued) and Applications	Tue, Dec. 6
24	More Applications of Eigenvalues and Eigenvectors	Thu, Dec. 8

EVALUATION CRITERIA AND GRADING:

Assignments 20%
Midterms 30%
Final Exam 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.

Item	**Weighting**	**Date/Description/Comment**
Assignments	20%	There will be **six assignments** throughout the semester. These will be posted on Canvas on Fridays, and the due date will be next Friday at 11:59 PM. (Assignments will be released on the dates mentioned above.) 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 correctly, and confirm that there are 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.
Midterm #1	15%	The first midterm will be held on **Thursday, October 6**, during class time. I will send you the midterm topics by email about a week before the date of each midterm.
Midterm #2	15%	The second midterm will be held on **Thursday, November 17**, again during class time.
Final Exam	50%	There is a 2.5-hours comprehensive final exam during the final examination period December 11 – 22. **Date: To Be Announced.** This is a cumulative final exam.

Practice Problems: Problems from my exercise book will be regularly assigned for practice. While completing these problems is essential for your success in this course, you do not hand them in for grading. **Note:** Questions in the assignments and midterms, as well as in the final exam, will be similar to those in the exercise book.

IMPORTANT DATES

Tuesday, September 6	Term 1 of Winter 2022 semester starts
Monday, September 19	Last day to withdraw without a W standing
Friday, September 30	National Day for Truth and Reconciliation (no classes)
Monday, October 10	Thanksgiving Day (no classes)
November 7 – 11	Winter session term 1 midterm break (no classes)
Friday, November 18	Last day to withdraw with a W standing
Tuesday, December 8	Last day of classes
December 11 – 22	Final examination period

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

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 W2022 is **Sunday December 11th, 2022, to Thursday December 22nd, 2022**. Except in the case of examination clashes and hardships (three or more formal examinations scheduled within a 24-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.

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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, Dr. John Braun at cmps.depthead@ubc.ca

STUDENT SERVICE RESOURCES

Disability Resource Centre

The Disability Resource Centre ensures educational equity for students with disabilities and chronic medical conditions. If you are disabled, have an injury or illness and require academic accommodations to meet the course objectives, please contact Earllene Roberts, the Diversity Advisor for the Disability Resource Centre located in the University Centre building (UNC 215).

UNC 215 250.807.9263
email: earllene.roberts@ubc.ca
Web: www.students.ok.ubc.ca/drc

Equity and Inclusion Office

Through leadership, vision, and collaborative action, the Equity & Inclusion Office (EIO) develops action strategies in support of efforts to embed equity and inclusion in the daily operations across the campus. The EIO provides education and training from cultivating respectful, inclusive spaces and communities to understanding unconscious/implicit bias and its operation within in campus environments. UBC Policy 3 prohibits discrimination and harassment on the basis of BC's Human Rights Code. If you require assistance related to an issue of equity, educational programs, discrimination or harassment please contact the EIO.

UNC 325H 250.807.9291
email: equity.ubco@ubc.ca
Web: www.equity.ok.ubc.ca

Office of the Ombudsperson for Students

The Office of the Ombudsperson for Students is an independent, confidential and impartial resource to ensure students are treated fairly. The Ombuds Office helps students navigate campus-related fairness concerns. They work with UBC community members individually and at the systemic level to ensure students are treated fairly and can learn, work and live in a fair, equitable and respectful environment. Ombuds helps students gain clarity on UBC policies and procedures, explore options, identify next steps, recommend resources, plan strategies and receive objective feedback to promote constructive problem solving. If you require assistance, please feel free to reach out for more information or to arrange an appointment.

UNC 328 250.807.9818
email: ombuds.office.ok@ubc.ca
Web: www.ombudsoffice.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://investigationsoffice.ubc.ca/
E-mail: director.of.investigations@ubc.ca

Student Learning 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**.
For more information, please visit the Hub's website (https://students.ok.ubc.ca/student-learning-hub/) or call 250-807-9185.

Student Wellness

At UBC Okanagan health services to students are provided by Student 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 Student Wellness for more information or to book an appointment.

UNC 337 250.807.9270
email: healthwellness.okanagan@ubc.ca
Web: www.students.ok.ubc.ca/health-wellness

SAFEWALK

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, see: www.security.ok.ubc.ca