



MATH-221 – Elementary Linear Algebra

University Arts and Science

Effective Term & Year: Fall 2022

Course Outline Review Date: 2026-03-01

Program Area: Math and Sciences

Description:

This course is intended for students who are pursuing a Bachelor of Science (with a major in Computing, Mathematics, or Physics) or Applied Science (Engineering) degree. Topics include: systems of linear equations and matrices, matrix arithmetic, determinants, vectors, products of vectors, lines and planes in 2- and 3-space, Euclidean vector spaces, real vector spaces, inner product spaces, eigenvalues and eigenvectors, diagonalization, linear transformations, kernel, range, similarity, approximation and quadratic forms. Linear algebra is used extensively in Computer Science, Engineering, Mathematics, Applied Mathematics, and Physics.

Program Information:

This course is required for majors in Math, Physics, and Engineering. It is required for students pursuing the Engineering Certificate who want to transfer into Engineering at the University of British Columbia or the University of Victoria. This course can also be used as an elective in several University Studies Programs. Refer to the College Program Guide for additional information.

Delivery Methods: On-campus (Face-to-Face)

Credit Type: College of the Rockies Credits

Credits: 3

Course type/s: Sciences

Instructional Activity and Hours:

Activity	Hours
Classroom, Directed Studies or Online Instruction	45
Seminar/Tutorials	
Laboratory/Studio	
Practicum/Field Experience	
Co-op/Work Experience	
Other	
Total	45

Course Requisites:

- Complete all of the following
 - Completed at least 1 of the following:
 - [MATH104](#) – Integral Calculus (3)
 - [MATH103](#) – Differential Calculus (3)
 - Except students enrolled in first year Engineering. (MATH 103 for first year Engineering students may be taken concurrently).

Flexible Assessment: Yes

In some cases students may be able to apply for recognition of prior learning outside the classroom. This flexible assessment process provides equivalent course credit. It is a rigorous process that may include external evaluation, worksite assessment, demonstration, standardized test, self-assessment, interview, products/portfolio, and challenge exam, or other measures as appropriate. Tuition fees apply. Contact an education advisor for more information.

Course Transfer Credit:

For information about receiving transfer credit for courses taken at either British Columbia or Alberta institutions, please see <https://www.bctransferguide.ca/> or <https://transferalberta.alberta.ca> . For more transfer credit information, please visit <https://www.cotr.bc.ca/Transfer>

All requests for course transfer credit from institutions in British Columbia or elsewhere should go to the College of the Rockies Enrolment Services office.

Textbook Resources:

Textbook selection varies by instructor and may change from year to year. At the course outline effective date the following textbooks were in use:

Possible texts used by this course include (but are not limited to):

- Linear Algebra with Applications (2019), Open Edition, Keith Nicholson, Creative Commons License (CC BY-NC-SA)
- A First Course in Linear Algebra (2017), Open text, Ken Kuttler, Creative Commons License (CC BY)

Please see the instructor's syllabus or check COTR's online text calculator <https://textbook.cotr.bc.ca/> for a complete list of the currently required textbooks.

Learning Outcomes:

Linear algebra is required for students wishing to go on in Computer Science, Economics, Engineering, Mathematics, Applied Mathematics, and Physics.

At the completion of Math 221, a successful student will be able to:

- Solve systems of linear equations using Gaussian and Gauss-Jordan elimination;
- Perform matrix arithmetic including inverting matrices;
- Calculate determinants using row reduction or cofactor expansion;
- Use Cramer's rule and understand its role in theoretical proofs;
- Understand vectors in 2- and 3-space, dot and cross products, lines and planes;
- Generalize the above to more than three dimensions;
- Understand the axiomatic approach to vector spaces including subspaces, linear independence, bases and dimension, rank and nullity;
- Understand the axiomatic approach to inner product spaces including orthonormal bases, orthogonal projections (including least squares and Fourier series) and orthogonal matrices;
- Use eigenvalues and eigenvectors to perform orthogonal diagonalization. Work with quadratic forms; and
- Understand the concept of linear transformation, kernel and range, and similarity.

This course should help students:

- Use written and oral communication skills effectively, employing methods appropriate to message and context;
 - Think clearly and critically, fusing experience, knowledge and reasoning into considered judgment; and
 - Identify, interpret, and solve problems, effectively implementing and evaluating proposed strategies.
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Course Topics:

1. Systems of linear equations

- a) Gaussian elimination
- b) Matrices
- c) Matrix arithmetic; inverses

2. Determinants

- a) Properties of the determinant function
- b) Evaluating determinants by row reduction
- c) Cofactor expansion
- d) Cramer's rule

3. Vectors on 2- and 3-space

- a) Vector arithmetic
- b) Dot product
 - i) norm of a vector
 - ii) projections
- c) Cross products
- d) Lines and planes in 3-space

4. Euclidean vector spaces

- a) Euclidean n-space
- b) Linear transformations $R^n \rightarrow R^n$

5. Real vector spaces

- a) Axioms
- b) Subspaces
- c) Linear dependence
- d) Basis and dimension

e) Row space, column space, null space

f) Rank and nullity

6. Inner product spaces

a) Axioms

b) Angles and orthogonality

c) Orthonormal bases

i) Gram—Schmidt process

d) Best approximations

i) Least squares

ii) Fourier series

e) Orthogonal matrices; change of basis

7. Eigenvalues and eigenvectors

a) Diagonalization

i) Quadratic forms

- Conic sections
- Quadric surfaces

b) Orthogonal diagonalization

8. Linear transformations

a) Kernel and Range

b) Inverse linear transformations

c) Similarity

See instructor's syllabus for the detailed outline of weekly readings, activities and assignments.

Evaluation and Assessments

Assessment Type: On-Campus (face-to-face)

Assessment Type	% of Total Grade
Assignments/Quizzes	20%
Midterm Tests	30%
Final Exam	50%
Total	100%

Grade Scheme

A+	A	A-	B+	B	B-	C+	C	C-	D	F
>=90	89-85	84-80	79-76	75-72	71-68	67-64	63-60	59-55	54-50	<50

Pass requirements: None

Evaluation Notes: A grade of “D” grants credit, but may not be sufficient as a prerequisite for sequential courses.

Exam Attendance:

Students must attend all scheduled exams at the appointed time and place. Instructors may approve an alternate exam to accommodate an illness or personal crisis. Department heads will consider other written requests. Any student who misses a scheduled exam without prior approval will receive a “0” on the exam.

Academic Policies:

College of the Rockies policies related to courses can be found at <https://cotr.bc.ca/about-us/college-policies/> and include the following:

- Policy 2.4.3 Students with Documented Disabilities
- Policy 2.4.4 Student Conduct (plagiarism, other cheating, behavioral misconduct)
- Policy 2.5.8 Academic Performance
- Policy 2.5.3 Grade Appeal
- Policy 2.4.9 Student Concerns Re Faculty

Course Changes:

The College of the Rockies updates course outlines regularly to meet changing educational, employment and marketing needs. The instructor will notify students in writing of any updates to this outline during the semester. The instructor reserves the right to revise, add or delete

material while meeting the learning outcomes of this course outline.