ORIGINAL COURSE IMPLEMENTATION DATE:	**July 1994**
REVISED COURSE IMPLEMENTATION DATE:	**September 2015**
COURSE TO BE REVIEWED: **(six years after UEC approval)**	**November 2020**

Course outline form version: 11/22/13

OFFICIAL UNDERGRADUATE COURSE OUTLINE FORM

Note: The University reserves the right to amend course outlines as needed without notice.

Course Code and Number: MATH 438 **Number of Credits:** 3 Course credit policy (105)

Course Full Title: Advanced Linear Algebra
Course Short Title:

Faculty: Faculty of Science **Department (or program if no department):** Mathematics & Statistics

Calendar Description:

Vector spaces; linear functionals; linear operators and their representation; polynomial techniques; orthogonal projection; the adjoint; unitary and orthogonal operators; canonical forms; the singular value decomposition.

Prerequisites (or NONE): MATH 221 and at least two MATH courses 300 level or higher. Note: As of January 2016, prerequisites will change to the following: MATH 221, MATH 265, and at least two MATH courses 300 level or higher.
Corequisites (if applicable, or NONE):

Pre/corequisites (if applicable, or NONE):

Equivalent Courses (cannot be taken for additional credit)
Former course code/number:
Cross-listed with:
Equivalent course(s):
Note: Equivalent course(s) should be included in the calendar description by way of a note that students with credit for the equivalent course(s) cannot take this course for further credit.

Transfer Credit
Transfer credit already exists: ☐ Yes ☒ No
Transfer credit requested (OReg to submit to BCCAT):
☐ Yes ☒ No (Note: If yes, fill in transfer credit form)
Resubmit revised outline for articulation: ☐ Yes ☒ No
To find out how this course transfers, see **bctransferguide.ca**.

Total Hours: 45
Typical structure of instructional hours:

Lecture hours	45
Seminars/tutorials/workshops	
Laboratory hours	
Field experience hours	
Experiential (practicum, internship, etc.)	
Online learning activities	
Other contact hours:	
Total	**45**

Special Topics
Will the course be offered with different topics?
☐ Yes ☒ No
If yes,
Different lettered courses may be taken for credit:
☐ No ☐ Yes, repeat(s) ☐ Yes, no limit

Note: The specific topic will be recorded when offered.

Maximum enrolment (for information only): 36

Expected frequency of course offerings (every semester, annually, etc.): every 2-3 years

Department / Program Head or Director:	Cindy Loten	**Date approved:**	May 28, 2014
Campus-Wide Consultation (CWC)		**Date of posting:**	July 10, 2014
Faculty Council approval		**Date approved:**	October 3, 2014
Dean/Associate VP:	Lucy Lee	**Date approved:**	October 3, 2014
Undergraduate Education Committee (UEC) approval		**Date of meeting:**	November 21, 2014

Learning Outcomes

The focus of this course is on linear transformations, in particular linear functionals and linear operators, and how they may be represented and employed.

Successful students will:

1. Analyze a given linear transformation with the tools of kernel, range, rank and nullity.
2. Demonstrate through arguments and construction of examples and counterexamples how choice of basis affects matrix representation of a transformation and how different such representations are related.
3. Demonstrate via argument and example the effect conditions on a linear operator(s) (for example idempotence or rank) have on matrix representations
4. Use polynomial tools such as the minimal polynomial and characteristic polynomial (among others) to analyze an operator and its representations.
5. Determine if a subspace is invariant under an operator, and how the existence of such subspaces affects matrix representation.
6. Construct the dual of a given basis, and show how a functional may be represented relative to that dual (in the finite dimensional case)
7. Determine if a given operator is diagonalizable, and via argument demonstrate how various conditions (for example on the minimal polynomial or characteristic polynomial or eigenspaces) affect diagonalizability.

Working in inner product spaces:

8. Construct orthonormal bases of subspaces and their orthogonal complements and employ them in applications such as the construction and use of orthogonal polynomials.
9. Construct the orthogonal projection onto a subspace, and demonstrate applications to finite Fourier series and least square approximations. Demonstrate via argument and example the underlying geometric principles of best approximation.
10. Construct the adjoint to a linear operator, and prove elementary statements about the adjoint and its relationship to the operator.
11. Define normal, self-adjoint, unitary and orthogonal operators, prove elementary statements regarding them, and demonstrate the effect these conditions have on the geometry of the eigenvectors, and location of the eigenvalues and matrix representations.
12. Find the singular value decomposition of a transformation and via argument and clearly explain the arguments for the existence of the decomposition. Find the (related) singular value decomposition of a matrix. Construct the pseudoinverse of a transformation. Demonstrate how these tools may be applied in such areas a medical imaging or image compression.
13. Use the symbolic manipulation package Maple to perform relevant computations.

Prior Learning Assessment and Recognition (PLAR)

☒ Yes ☐ No, PLAR cannot be awarded for this course because

Typical Instructional Methods (guest lecturers, presentations, online instruction, field trips, etc.; may vary at department's discretion)

Lectures

NOTE: The following sections may vary by instructor. Please see course syllabus available from the instructor.

Typical Text(s) and Resource Materials (if more space is required, download supplemental Texts and Resource Materials form)

	Author Surname, Initials	Title (article, book, journal, etc.)	Current Edition	Publisher	Year Published
1.	Friedberg, Insel, Spence	Linear Algebra	☒	Prentice Hall	2002
2.	Hoffman Kunze	Linear Algebra	☒	Pearson	1971
3.			☐		
4.			☐		
5.			☐		

Required Additional Supplies and Materials (Eg. Software, hardware, tools, specialized clothing)

Access to Maple software on campus, and access to computer labs for testing.

Typical Evaluation Methods and Weighting

Final exam:	40%	Assignments:	30%	Midterm exam:	30%	Practicum:	%
Quizzes/tests:	%	Lab work:	%	Field experience:	%	Shop work:	%
Other:	%	Other:	%	Other:	%	Total:	100%

Details (if necessary): Students must achieve at least 40% on the final exam in order to receive credit for this course.

Grading system: Letter Grades: ☒ Credit/No Credit: ☐ Labs to be scheduled independent of lecture hours: Yes ☐ No ☒

Typical Course Content and Topics

1. Review of vector spaces, basis, dimension (both finite and infinite dimensional case) over arbitrary fields, but in particular Z_p and C.
2. Linear transformations, null space and range, rank-nullity
3. Direct sum decompositions
4. Representation of transformations, relation between representations, isomorphism between algebra of operators and algebra of matrices.
5. Isomorphism and invertibility of transformations
6. Invariant subspaces
7. Very brief review of determinants
8. Characteristic and minimal polynomials, Cayley-Hamilton theorem.
9. Eigenvalues/vectors, diagonalizability and triangularizability.
10. Linear functionals, dual space, reflexivity, applications e.g. Lagrange polynomials
11. Inner product spaces, orthonormal bases, GramSchmidt process, orthogonal complements
12. Projection on a subspace and applications to finite Fourier series and least squares approximation.
13. The adjoint of an operator
14. Normal and self-adjoint operators and consequences for eigenvalues/vectors
15. Unitary and orthogonal Operators and matrix representations.
16. Singular value decomposition, the pseudoinverse and applications.
17. Time permitting: Jordan Canonical Form