# MATH 220 - Linear Algebra Course Outline

**Approval Date:** 12/09/2021
**Effective Date:** 08/12/2022

**SECTION A**

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|---|---|
| **Unique ID Number** | CCC000291468 |
| **Discipline(s)** | Mathematics |
| **Division** | Mathematics |
| **Subject Area** | Mathematics |
| **Subject Code** | MATH |
| **Course Number** | 220 |
| **Course Title** | Linear Algebra |
| **TOP Code/SAM Code** | 1701.00 - Mathematics, General / E - Non-Occupational |
| **Rationale for adding this course to the curriculum** | Nonsubstantive changes to course content and methods of instruction. |
| **Units** | 3 |
| **Cross List** | *N/A* |
| **Typical Course Weeks** | 18 |

**Total Instructional Hours**

| | **Contact Hours** |
|---|---|
| **Lecture** | 54.00 |
| **Lab** | 0.00 |
| **Activity** | 0.00 |
| **Work Experience** | 0.00 |
| **Outside of Class Hours** | 108.00 |

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|---|---|
| **Total Contact Hours** | 54 |
| **Total Student Hours** | 162 |
| **Open Entry/Open Exit** | No |
| **Maximum Enrollment** | |
| **Grading Option** | Letter Grade Only |
| **Distance Education Mode of Instruction** | On-Campus<br>Hybrid |

Entirely Online
Online with Proctored Exams

**SECTION B**

**General Education Information:**

**SECTION C**

**Course Description**

**Repeatability** May be repeated 0 times

**Catalog Description** This course develops the techniques and theory needed to solve and classify systems of linear equations. Solution techniques include row operations, Gaussian elimination, and matrix algebra. Properties of vectors are investigated in two and three dimensions, leading to the notion of an abstract vector space. Vector space and matrix theory are presented including topics such as inner products, norms, orthogonality, eigenvalues, eigenspaces, and linear transformations. Selected applications of linear algebra are included.

**Schedule Description**

**SECTION D**

**Condition on Enrollment**

**1a. Prerequisite(s)**

- MATH 121

**1b. Corequisite(s):** *None*

**1c. Recommended**

- MATH 221

**1d. Limitation on Enrollment:** *None*

**SECTION E**

**Course Outline Information**

**1. Student Learning Outcomes:**

A. Analyze linear systems using matrix methods.
B. Apply basic vector space concepts.
C. Find eigensystems for linear transformations.

**2. Course Objectives:** Upon completion of this course, the student will be able to:

A. Find solutions of systems of equations using various methods appropriate to lower division linear algebra;
B. Use bases and orthonormal bases to solve problems in linear algebra;
C. Find the dimension of spaces such as those associated with matrices and linear transformations;
D. Find eigenvalues and eigenvectors and use them in applications; and
E. Prove basic results in linear algebra using appropriate proof-writing techniques such as linear independence of vectors; properties of subspaces; linearity, injectivity and surjectivity of functions; and properties of eigenvectors and eigenvalues.
F.

**3. Course Content**

1) Techniques for solving systems of linear equations including Gaussian and Gauss-Jordan elimination and inverse matrices;

2) Span of vectors and their geometric description;

3) Applications of linear systems such as network analysis, balancing chemical equations;

4) Matrix algebra, invertibility, and the transpose;

5) Relationship between coefficient matrix invertibility and solutions to a system of linear equations and the inverse matrices;
6) Special matrices: diagonal, triangular, elementary, symmetric and anti-symmetric;

7) Techniques of computing determinants including Cramer's Rule, cofactor expansion, triangular method, and the Sarrus rule;
8) Properties of determinants;
9) Vector algebra for $\mathbf{R}^n$;
10) Real vector space and subspaces;
11) Linear independence and dependence;
12) Basis and dimension of a vector space;
13) Matrix-generated spaces: row space, column space, null space, rank, nullity;
14) Change of basis;
15) Linear transformations, kernel and range, and inverse linear transformations;
16) Matrices of general linear transformations;
17) Eigenvalues, eigenvectors, eigenspace;
18) Diagonalization including orthogonal diagonalization of symmetric matrices;
19) Inner products on a real vector space;
20) Dot product, norm of a vector, angle between vectors, distance between vectors, orthogonal complements and orthogonal projection, orthogonality and orthonormality of vectors in $\mathbf{R}^n$;
21) Angle and orthogonality in inner product spaces; and
22) Orthogonal and orthonormal bases: Gram-Schmidt process.

**4. Methods of Instruction:**

**Discussion:**
**Lecture:**
**Other:** In-class practice problems

**5. Methods of Evaluation:** Describe the general types of evaluations for this course and provide at least two, specific examples.

**Typical classroom assessment techniques**

Exams/Tests --
Quizzes --
Home Work --
Final Exam --

Additional assessment information:

Examples:
The Mathematics Department maintains a commitment to diverse teaching methods in courses emphasizing vital quantitative skills and qualitative reasoning ability. To that end, it is expected that sufficient formative assessments will be given to students that in frequency, length and rigor adequately assess both quantitative skills and qualitative reasoning.

1) An exam including linear transformations where students would be expected to verify appropriate axioms, determine the standard matrix of linear transformations, find the inverse of a matrix, calculate the determinant and use the result to determine if the matrix is

invertible, determine if vectors are linearly independent, solve the matrix equation Ax = b in parametric form and based on that write the geometric description of the solution, solve an application problem involving linear systems, e.g. balancing chemical equations.

2) An exam including vector spaces where the student would be expected to verify axioms for a vector space with standard and non-standard operations, subspaces where students would be expected to verify apropriate axioms, determine whether a set of vectors is linearly independent, find a basis for the null space of a matrix, and perform a change of basis on a vector given two bases.

Letter Grade Only

**6. Assignments:** State the general types of assignments for this course under the following categories and provide at least two specific examples for each section.

A. Reading Assignments
1. Read Section 1.1 from Chapter 1 on linear systems before our next class.

2. Read Section 3.2 Chapter 3 on determinants before our next class and be ready to discuss the difference between the Sarrus rule and cofactor expansion methods.

B. Writing Assignments
Daily online or paper homework assignments from the text such as:

1. Calculating the determinant of a matrix.

2. Diagonalizing a linear transformation.

C. Other Assignments
Other assignments such as research into applications or group projects assigned at instructors' discretion.

**7. Required Materials**

**A. EXAMPLES of typical college-level textbooks (for degree-applicable courses) or other print materials.**

Book #1:

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|---|---|
| Author: | Lay, D., Lay, S., McDonald J. |
| Title: | Linear Algebra and Its Applications |
| Publisher: | Pearson |
| Date of Publication: | 2021 |
| Edition: | 6 |

**B. Other required materials/supplies.**