I. INTRODUCTION

A. Linear Algebra is a three semester-hour course. This course introduces and provides models for application of concepts of vector algebra. Topics include finite dimensional vector spaces and their geometric significance; representing and solving systems of linear equations using multiple methods, including Gaussian elimination and matrix inversion; matrix determinants; linear transformations; quadratic forms; eigenvalues and eigenvector; and applications in science and engineering.

B. This is a specialty course for an Associate in Science degree with a major in Mathematics.

C. Prerequisite: A grade of C or better in MATH 2414, Calculus II.

II. LEARNING OUTCOMES

Upon successful completion of this course, Linear Algebra, the student will be able to:

A. Be able to solve systems of linear equations using multiple methods, including Gaussian elimination and matrix inversion. (F3, F4, F12)

B. Be able to carry out matrix operations, including inverses and determinants. (F3, F4)

C. Demonstrate understanding of the concepts of vector space and subspace. (FF7, F8, F10, F12)

D. Demonstrate understanding of linear independence, span, and basis. (F4, F9, F12)

E. Be able to determine eigenvalues and eigenvectors and solve problems involving eigenvalues. (F3, F4, F10, F11, F12)

F. Apply principles of matrix algebra to linear transformations. (F3, F4, F8, F10)

G. Demonstrate application of inner products and associated norms. (F3, F4, F10, F11, F12)

III. INSTRUCTIONAL MATERIALS

The Instructional materials identified for this course are viewable through www.ctcd.edu/books
III. COURSE REQUIREMENTS

A. Assignments are given in MyMathLab and are due as scheduled by your instructor. The instructor will monitor students’ progress in completing the assignments.

B. Students are expected to attend every class, to arrive at each class on time, and remain in class for the entire period. Instructors may choose to lower a student's grade because of tardiness.

IV. EXAMINATIONS

A. Examinations will be given at appropriate points during the semester. Each examination will be announced in class in advance. There will be three examinations (including the final).

B. Students who miss an exam should discuss with the instructor the circumstances surrounding the absence. The instructor will determine whether a make-up exam is to be given. It is necessary to make an appointment with the instructor for a make-up exam.

V. SEMESTER GRADE COMPUTATIONS

A. The semester average is derived from the homework, quizzes, unit exams, and comprehensive final exam in MyMathLab in accordance with the weights below:

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>15%</td>
</tr>
<tr>
<td>Quizzes</td>
<td>15%</td>
</tr>
<tr>
<td>Unit 1 Exam</td>
<td>20%</td>
</tr>
<tr>
<td>Unit 2 Exam</td>
<td>20%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>30%</td>
</tr>
</tbody>
</table>

You must take the final exam and score at least 50% to pass the course.

B. Final grades will follow the grade designation below:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Class Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>“A”</td>
<td>90 to 100</td>
</tr>
<tr>
<td>“B”</td>
<td>80 to 89</td>
</tr>
<tr>
<td>“C”</td>
<td>70 to 79</td>
</tr>
<tr>
<td>“D”</td>
<td>60 to 69</td>
</tr>
<tr>
<td>“F”</td>
<td>0 to 59</td>
</tr>
</tbody>
</table>

VI. NOTES AND ADDITIONAL INSTRUCTIONS
A. **Withdrawal from Course:** It is the student's responsibility to officially drop a class if circumstances prevent attendance. Any student who desires to, or must, officially withdraw from a course after the first scheduled class meeting must file an Application for Withdrawal or an Application for Refund. The withdrawal form must be signed by the student.

An Application for withdrawal will be accepted at any time prior to Friday of the 12th week of classes during the 16-week fall and spring semesters. The deadline for sessions of other lengths is as follows.

<table>
<thead>
<tr>
<th>Session</th>
<th>Deadline for Withdrawal</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-week session</td>
<td>Friday of the 9th week</td>
</tr>
<tr>
<td>10-week session</td>
<td>Friday of the 7th week</td>
</tr>
<tr>
<td>8-week session</td>
<td>Friday of the 6th week</td>
</tr>
<tr>
<td>6-week session</td>
<td>Friday of the 4th week</td>
</tr>
<tr>
<td>5-week session</td>
<td>Friday of the 3rd week</td>
</tr>
</tbody>
</table>

The equivalent date (75% of the semester) will be used for sessions of other lengths. The specific last day to withdraw is published each semester in the Schedule Bulletin.

Students who officially withdraw will be awarded the grade of "W" provided the student's attendance and academic performance are satisfactory at the time of official withdrawal. Students must file a withdrawal application with the college before they may be considered for withdrawal.

A student may not withdraw from a class for which the instructor has previously issued the student a grade of "F".

B. **An Incomplete Grade:** The College catalog states, "An incomplete grade may be given in those cases where the student has completed the majority of the course work but, because of personal illness, death in the immediate family, or military orders, the student is unable to complete the requirements for a course..." Prior approval from the instructor is required before the grade of "I" is recorded. A student who merely fails to show for the final examination will receive a zero for the final and an "F" for the course.

C. **Cellular Phones and Beepers:** Cellular phones and beepers will be turned off while the student is in the classroom or laboratory.

D. **Americans With Disabilities Act (ADA):** Disability Support Services provide services to students who have appropriate documentation of a disability. Students requiring accommodations for class are responsible for contacting the Office of Disability Support Services (DSS) located on the central campus. This service is available to all students, regardless of location. Explore the website at [www.ctcd.edu/disability-support](http://www.ctcd.edu/disability-support) for further information. Reasonable accommodations will be given in accordance with the federal and state laws through the DSS office.
E. Civility: Individuals are expected to be cognizant of what a constructive educational experience is and respectful of those participating in a learning environment. Failure to do so can result in disciplinary action up to and including expulsion.

F. Advanced Math Lab: The Math Department operates an Advanced Mathematics Lab in Building 152, Room 145. All courses offered by the Math Department are supported in the lab with appropriate tutorial software. Calculators are available for student use in the lab. Students are encouraged to take advantage of these opportunities. See posted hours for the Advanced Math Lab.

G. Office Hours: Full-time instructors post office hours outside the door of the Mathematics Department (Building 152, Room 223). Part-time instructors may be available by appointment. If you have difficulty with the course work, please consult your instructor.

VII. COURSE OUTLINE

A. Lesson One: Linear Equations in Linear Algebra (Chapter 1)
   1. Learning Outcomes: Upon successful completion of this lesson, the student will be able to:
      a. Define a system of linear equations.
      b. Perform row reduction on matrices to reduce them to echelon forms.
      c. Create vector equations.
      d. Solve matrix equations in the form $Ax = b$.
      e. Find solution sets of linear systems.
      f. Use applications of linear systems.
      g. Define linear independence.
      h. Use introductory linear transformations.
      i. Find the representative matrix of a linear transformation.
      j. Explore linear models in business, science, and engineering.
   2. Learning Activities:
      a. Listen to classroom lecture and discuss exercises. (F5, F6, F7, F8)
      b. Read pages of assigned chapter. (F1)
      c. Work problems as assigned by the instructor. (F2, F7, F8, F9, F10, F11, F12)
   3. Lesson Outline:
      a. Section 1.1 – Systems of Linear Equations
      b. Section 1.2 – Row Reduction and Echelon Forms
      c. Section 1.3 – Vector Equations
      d. Section 1.4 – The Matrix Equation $Ax = b$
      e. Section 1.5 – Solution Sets of Linear Systems
      f. Section 1.6 – Applications of Linear Systems
      g. Section 1.7 – Linear Independence
      h. Section 1.8 – Introduction to Linear Transformations
      i. Section 1.9 – The Matrix of a Linear Transformation
      j. Section 1.10 – Linear Models in Business, Science, and Engineering

B. Lesson Two: Matrix Algebra (Chapter 2)
1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
   a. Complete matrix operations.
   b. Find the inverse of a matrix.
   c. Understand the characteristics of invertible matrices.
   d. Create partitioned matrices.
   e. Understand matrix factorizations.
   f. Understand the Leontif input-output model.
   g. Explore applications to computer graphics.
   h. Define subspaces of $\mathbb{R}^n$.
   i. Define dimension and rank.

2. **Learning Activities:**
   a. Listen to classroom lecture and discuss exercises. (F5, F6, F7, F8)
   b. Read pages of assigned chapter. (F1)
   c. Work problems as assigned by the instructor. (F2, F7, F8, F9, F10, F11, F12)

3. **Lesson Outline:**
   a. Section 2.1 – Matrix Operations
   b. Section 2.2 – The Inverse of a Matrix
   c. Section 2.3 – Characterizations of Invertible Matrices
   d. Section 2.4 – Partitioned Matrices
   e. Section 2.5 – Matrix Factorizations
   f. Section 2.6 – The Leontif Input-Output Model
   g. Section 2.7 – Applications to Computer Graphics
   h. Section 2.8 – Subspaces of $\mathbb{R}^n$
   i. Section 2.9 – Dimension and Rank

C. **Lesson Three:** Determinants (Chapter 3)
   1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
      a. Define determinants.
      b. Use the properties of determinants.
      c. Use Cramer’s rule, find volume, and apply linear transformations.

2. **Learning Activities:**
   a. Listen to classroom lecture and discuss exercises. (F5, F6, F7, F8)
   b. Read pages of assigned chapter. (F1)
   c. Work problems as assigned by the instructor. (F2, F7, F8, F9, F10, F11, F12)

3. **Lesson Outline:**
   a. Section 3.1 – Introduction to Determinants
   b. Section 3.2 – Properties of Determinants
   c. Section 3.3 – Cramer’s Rule, Volume, and Linear Transformations

D. **Lesson Four:** Vector Spaces (Chapter 4)
   1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
      a. Define vector spaces and subspaces.
      b. Use null spaces, column spaces, and linear transformations.
      c. Find linearly independent sets and bases.
d. Explore the coordinate systems.
e. Find the dimensions of a vector space.
f. Define rank.
g. Use the change of basis method.
h. Explore applications to difference equations.
i. Apply Markov chains.

2. Learning Activities:
   a. Listen to classroom lecture and discuss exercises. (F5, F6, F7, F8)
   b. Read pages of assigned chapter. (F1)
   c. Work problems as assigned by the instructor. (F2, F7, F8, F9, F10, F11, F12)

3. Lesson Outline:
   a. Section 4.1 – Vector Spaces and Subspaces
   b. Section 4.2 – Null Spaces, Column Spaces, and Linear Transformations
   c. Section 4.3 – Linear Independent Sets; Bases
   d. Section 4.4 – Coordinate Systems
   e. Section 4.5 – The Dimension of a Vector Space
   f. Section 4.6 – Rank
   g. Section 4.7 – Change of Basis
   h. Section 4.8 – Applications to Difference Equations
   i. Section 4.9 – Applications to Markov Chains

E. Lesson Five: Eigenvalues and Eigenvectors (Chapter 5)
1. Learning Outcomes: Upon successful completion of this lesson, the student will be able to:
   a. Find eigenvectors and eigenvalues.
   b. Use the characteristic equation.
   c. Understand diagonalization.
   d. Use eigenvectors with linear transformations.
   e. Find complex eigenvalues.
   f. Solve discrete dynamical systems.
   g. Explore applications to differential equations.
   h. Use iterative estimates for eigenvalues.

2. Learning Activities:
   a. Listen to classroom lecture and discuss exercises. (F5, F6, F7, F8)
   b. Read pages of assigned chapter. (F1)
   c. Work problems as assigned by the instructor. (F2, F7, F8, F9, F10, F11, F12)

3. Lesson Outline:
   a. Section 5.1 – Eigenvectors and Eigenvalues
   b. Section 5.2 – The Characteristic Equation
   c. Section 5.3 – Diagonalization
   d. Section 5.4 – Eigenvectors and Linear Transformations
   e. Section 5.5 – Complex Eigenvalues
   f. Section 5.6 – Discrete Dynamical Systems
   g. Section 5.7 – Applications to Differential Equations
   h. Section 5.8 – Iterative Estimates for Eigenvalues
F. **Lesson Six:** Orthogonality and Least Squares (Chapter 6)

1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
   
   a. Define inner product, length, and orthogonality.
   b. Find orthogonal sets.
   c. Use orthogonal projections.
   d. Use the Gram-Schmidt process.
   e. Solve least-squares problems.
   f. Explore applications to linear models.
   g. Define inner product spaces.
   h. Explore applications of inner product spaces.

2. **Learning Activities:**
   
   a. Listen to classroom lecture and discuss exercises. (F5, F6, F7, F8)
   b. Read pages of assigned chapter. (F1)
   c. Work problems as assigned by the instructor. (F2, F7, F8, F9, F10, F11, F12)

3. **Lesson Outline:**
   
   a. Section 6.1 – Inner Product, Length, and Orthogonality
   b. Section 6.2 – Orthogonal Sets
   c. Section 6.3 – Orthogonal Projections
   d. Section 6.4 – The Gram-Schmidt Process
   e. Section 6.5 – Least-Squares Problems
   f. Section 6.6 – Applications to Linear Models
   g. Section 6.7 – Inner Product Spaces
   h. Section 6.8 – Applications of Inner Product Spaces