



**ARIZONA
CHRISTIAN**
UNIVERSITY

Arizona Christian University

2625 East Cactus Road
Phoenix, AZ 85032

Linear Algebra

Course Name – Linear Algebra
Course Number – MAT233
Semester Offered – Spring 2012

Instructor Information:

Name - Dr. Warren Pettitt
Office location - SCI101
Office phone – 602
Email address – warren.pettitt@arizonachristian.edu
Office hours – Tu and Th 8:30 to 11:30

Course meeting Day - Tuesday
Course meeting Time – 6:00 to 9:30
Course meeting Place – SAC210

Course Description:

Prerequisites: *College algebra*

Course Student Learning Outcomes:

- Prove elementary statements concerning the theory of systems of linear equations.
- Understand some applications of systems of linear equations.
- Perform the operations of addition, scalar multiplication, and multiplication, and find the transpose and inverse of a matrix.
- Apply matrix multiplication to rotation of matrices.
- Calculate determinants using row operations, column operations, and expansion down any column and across any row.
- Prove elementary statements concerning the theory of matrices and determinants.
- Prove algebraic statements about vector addition, scalar multiplication, inner products, projections, norms, orthogonal vectors, linear independence, spanning sets, subspaces, bases, and dimension for \mathbb{R}^n and abstract vector spaces.
- Write the relationships between A being invertible, $\det A$, $AX = 0$ having a solution, the rank of A , and the rows of A being linearly independent.
- Use the Gram-Schmidt process to orthogonalize matrices.

- Find the matrix associated with a linear transformation with respect to given bases, and understand the relationship between the operations on linear transformations and their corresponding matrices.
- Find the change-of-basis matrix.
- Prove statements of an algebraic nature concerning linear transformations.
- Calculate eigenvalues and their corresponding eigenspaces.
- Determine if a matrix is diagonalizable, and if it is, diagonalize it.
- Prove elementary facts concerning eigenvalues and eigenvectors.
- Prove certain specified theorems given in the course.

Texts and Resources:

Textbook is found online at

http://www.math.utoledo.edu/~melbially/classes/Linear%20Algebra-2890/LinAlg_Dawkins.pdf. *It is a free resource.*

Course Schedule:

Lecture 1 - Introduction

linear equations, a solution, solving, solution set, parametric solution, system of linear equations, linear systems, inconsistent systems, consistent systems, graphical solution, a linear system may have 0 or 1 or infinitely many solutions.

Lecture 2, Introduction

Motivation for studying linear algebra, Gaussian elimination, triangular form, echelon form, back-substitution, coefficient matrix, augmented matrix, right hand side column, elementary operations on a linear system, elementary row operations on a matrix.

Lecture 3, Gaussian Elimination

parametric equations and deciding 0, 1, or infinitely many solutions, echelon form, leading zeros, pivot elements, leading/dependent variables, free/independent variables, how to solve an equation given in echelon matrix form.

Lecture 4, Gaussian Elimination

Elementary row operations used to reduce an equation to its echelon form; so that it can be solved by back-substitution.

Lecture 5, Matrix Algebra

Matrix entry or element, matrix size or dimension, double subscript, matrix addition and subtraction, scalars and matrices, multiplication of a scalar and a matrix, dot product or inner product, matrix product as a collection of dot products.

Lecture 6, Matrix multiplication

more on matrix product as a collection of dot products, general formula using summation notation

Lecture 7, Interpretations of Matrix multiplication

multiplication by a diagonal matrix, a linear system written as matrix product, substitution as matrix multiplication, matrix multiplication as a sum of products of columns with rows.

Lecture 8, Different styles for Matrix multiplication

Interpretations of $A \cdot B$ in terms of dot products of rows of A with columns of B , A with columns of B , rows of A with B , row matrices of A with column matrices of B , sum of outer products of columns of A with corresponding rows of B . AX , X a vector, is the linear combination of columns of A with weights same as entries of vector X .

Lecture 9, Inverses and elementary matrices

Elementary matrix associated with multiplication of a row and exchange of two rows.

Lecture 10, Inverses and elementary matrices

Elementary COLUMN operations. Different styles (row expansion, column expansion, outer product expansion) for multiplication of matrices, related to lecture 8.

Elementary matrix associated with adding multiple of a row to another row.

General procedure for finding the inverse.

Lecture 11, Finding Inverses using elementary matrices

An example of 3×3 matrix being inverted. Short discussion of non-invertible matrices.

Lecture 12, LU factorization

LU factorization for a simple case (without permutation), description of algorithm and justification of procedure.

Lecture 13, Solving $AX=B$ via LU factorization

Advantages of LU factorization, solving systems with factorization, general permutation matrices, $PA=LU$.

Lecture 14, Solving $AX=B$ via $PA=LU$ factorization,

an example, symmetric, skew-symmetric, determinants of 2×2 and 3×3 matrices, vectors in physics

Lecture 15, Determinants

Introduction to determinants, short cuts, expansion/recursive formula

Lecture 16, Determinants

Examples, three theorems.

Lecture 17, Determinants

Properties of determinants

Lecture 18, Determinants

Method of Cofactors

Lecture 19, Determinants

Using row reduction to compute determinants and Cramer's rule

Lecture 20, Vectors

scalars, vectors, matrices, graphical addition, subtraction, and scalar multiplication of vectors

Lecture 21, length and dot product of vectors

span, distance, norm (length, magnitude, size) of a vector, angle between vectors, dot product through angle, length interim of dot product, dot product in terms of components, example: find the angle between two vectors.

Lecture 22, Dot Product theorem, Projections

Proof of Law of Cosines, Proof of $U \cdot V = u_1 v_1 + u_2 v_2 + u_3 v_3 = |U| |V| \cos$ of angle. Formula for projections

Lecture 23, Gram-Schmidt Process

Example 21. Producing a set of mutually perpendicular vectors P_i out an arbitrary given Vectors V_i using projections.

Lecture 24, Euclidean n-space, general vector spaces

Closure. Review

Lecture 25, Review of Inverse, LU, PA=LU

A brief review.

Lecture 26, Subspaces

Closure with respect to vector addition and scalar multiplication.

Lecture 27, Subspaces

Null spaces, $NS(A)$, linear combinations

linear combinations, interpretation of $AX=B$, linear dependence and independence

Lecture 28, Linear Independence

linear dependence and independence

Lecture 29, Basis

Given a set of vectors how do we detect if they are a basis for a given space?

Lecture 30, Introduction to Eigenvalues and Eigenvectors

Examples, Definitions.

Lecture 31, real, complex, double eigenvalues, characteristic polynomial of a matrix several examples.

Lecture 32, Finding eigenvectors of a matrix, matrix factorization into eigenvector matrix *eigenvalue matrix* inverse of eigenvector matrix

Lecture 33, Finding eigenvectors of a 3*3 matrix,
One example.

Lecture 34, Finding eigenvectors of a 3*3 matrix, diagonalization: matrix factorization into eigenvector matrix *eigenvalue matrix* inverse of eigenvector matrix $f(A) = V f(\lambda) V^{-1}$, several examples.

Lecture 35, Repeated eigenvalues Finding eigenvectors and basis of eigenspaces for repeated roots of characteristic polynomial, several examples.

Lecture 36, trace, determinants, and eigenvalues, diagonalizability sum of eigenvalues=trace, product of eigenvalues=determinant, $f(A) = V f(\lambda) V^{-1}$

Lecture 37, Diagonalization
Examples, non-diagonalizable matrices.

Lecture 38, Symmetric Matrices
Properties, Orthogonal (Orthonormal) matrices, Theorem: Eigenvalues of a real symmetric 2*2 matrix are real.

Lecture 39, Review of Symmetric Matrices
Solution of problem 1

Lecture 40, Partial Review of eigenvalues, eigenvectors, diagonalization.

Lecture 41, Markov Processes, an example

Assignments and Activities:

1. *Homework will be given out each week and will be due on the day of each exam that is over the given material*
2. *Quizzes will be given at the beginning of class each week over the work from the previous week.*
3. *3 exams will be given –*
 - a. *Exams 1 and 2 worth 150 points*
 - b. *Exam 3 is worth 250 points*

Assessment and Grading:

Letter Grades:

- A – 90% to 100%
- B – 80% to 89.5%
- C – 70% to 79.5%
- D – 60% to 69.5%

F - < 60%

Homework – 25% of grade

Quizzes – 25% of grade

Exams – 50% of grade

Expectations for Students:

1. Attend all lectures except in the case of illness or unforeseen emergencies. It is the student's responsibility to contact the instructor about any missed worked.
2. Be punctual.
3. Read over and take notes on the indicated chapters before they are presented in class. This activity mentally prepares one for the learning experience. It also is important because it raises questions that one needs to have answered in order to fully understand the concepts presented.
4. Homework should be a daily event, leaving it go to work on until just before a test is self-defeating. The homework is due when each exam is given.
5. Study about 2 hours for every hour in lecture.
6. Take exams on the scheduled dates. An automatic grade of zero is recorded for any exam missed.
7. Master the homework problems and turn them in on time. Most of the problems will NOT be accepted if there is only an answer given, you need to show the work.
8. Calculators may NOT be shared during exams.
9. An A on any test automatically gives you an A for the homework for those sections.
10. All phones should be turned off during class
11. Do not schedule any plane trips before finals are over, exams will not be altered for reasons of convenience.

Study Time: Most University courses require that students spend a significant amount of time outside of class in individual study time. A guideline is to spend 2 – 3 hours per week for every credit hour. This means that in a 3 credit course 6 – 9 hours of outside study per week would be expected at a minimum. The actual in-class meeting time is short in University courses because it is expected that students work independently outside of class in order to meet the course requirements.

Accommodation and Special Needs: Your instructor is willing to make any reasonable adaptations for limitations due to any disability, including learning disability, in keeping with ACU policies and the Student Handbook. Any student with documented certifiable special needs should contact the office of the Academic Advisor on campus and they will inform me of the proper accommodations you require. If you have a special need, even on a temporary basis, it is your responsibility to contact this office as soon as possible to disclose your disability information and discuss your accommodation needs. Students are required to make their requests in writing using the *Accommodation Request and Documentation Form* and document their disability in accordance with ACU policies and procedures. Documentation of the disability must be current (not older than 1 year) and provided by a qualified health care professional such as a diagnosing or current physician, psychiatrist or psychologist. It must comply with the requirements for documentation outlined on the *Accommodation Request and*

Documentation Form. Accommodations are not retroactive. ACU reserves the right to verify all professional documentation and determine reasonable accommodation for any disability, including learning disability. Please see the Student Handbook for current detailed information regarding accommodation and special needs.

Retention of Examinations and Assignments: Instructors will retain copies of student examinations and assignments not returned to students for one semester in case of dispute between a faculty member and a student in assigning or recording a grade. After that time, instructors may discard course materials in a manner that preserves student confidentiality.

E-mail Policy: Students are issued an official Arizona Christian University student email address when they are admitted to the University. These addresses all have the same form: firstname.lastname@arizonachristian.edu. This is the only electronic mailing address recognized by the University. Students are responsible for all official University communications, including attachments, transmitted to this address. ACU faculty and staff are not responsible for forwarding email to personal email accounts that are not assigned by the University. Students are required to check their ACU email on a daily basis.

Withdrawal:

Last day for withdrawal without instructor signature – February 3rd, 2012

Last day for withdrawal with instructor signature – March 23rd, 2012

References and Supplemental information: *none*

Disclaimer note: This syllabus is subject to modification. The instructor will communicate with students any changes.