# Applications of Linear Algebra & Differential Equations
# Math 4910-LD
Summer 2009

**Meeting time:** T & H from 7:15 p.m. to 9:55 p.m.
**Meeting dates:** May 5 through June 18
**Originating from:** USU Main Campus ENGR 401

**Instructor:** Dr. Brynja Kohler
**Office:** Lund Hall 220
**Email:** Brynja.Kohler@usu.edu
**Phone:** 797-2826

**Teaching Assistants:** Stephanie Swainston and Tamra Bunnell
**Email:** Stephanie.A.Swainston@aggiemail.usu.edu and Tamra.Bunnell@aggiemail.usu.edu

**Course Description:**

Linear algebra is the branch of mathematics concerned with the study of linear transformations and vector spaces and lies at the heart of all numerical mathematics. In recent times linear algebra research has flourished with new ideas about how to solve linear equations, carry out least squares procedures, and find eigenvalues of matrices. In this course, we will learn to solve systems of linear equations and fully characterize when solutions exist beginning with the case of $n$ equations in $n$ unknowns. We will also begin to conceptualize vector spaces through an examination of Euclidean space.

Differential equations arise in many areas of science and technology whenever a deterministic relationship involving some continuously changing quantities (modeled by functions) and their rates of change (expressed as derivatives) is known or postulated. This course is devoted to help build our familiarity with many applications and mathematical models involving *ordinary* differential equations (equations that involve derivatives of a function of a single variable – usually time). We will learn classical and computational techniques for solving differential equations and/or analyzing solution behavior.

Throughout the course we will use Matlab as our computational software. Learning to use this software for computations, simulations, and visualization is a primary course goal.

**Course topics:**

UNIT I: Complex Numbers and Matrix Algebra. (4 meetings)

1. Introduction to Complex Numbers
2. The Cartesian and Exponential Forms
3. Roots of Polynomial Equations and Numbers
4. Matrix Notation and Terminology
5. The Solution of Simultaneous Equations
6. The Algebra of Matrices
7. Matrix Multiplication
8. The Inverse of a Matrix
9. The Computation of the Inverse
10. Determinants

(a) Definitions and Fundamental Theorems
(b) Minors and Cofactors

11. Linear Independence
12. Vector Spaces

UNIT II: First Order Ordinary Differential Equations. (4 meetings)

1. The First-Order Linear Equation
   (a) Homogeneous Equations
   (b) Nonhomogeneous Equations
2. Applications
   (a) Linear Rate Equations
   (b) Fluid Flow
   (c) Radioactive Decay
   (d) Population Growth
   (e) Compound Interest
   (f) Newton's Law of Cooling
3. Nonlinear Equations of First Order
   (a) Separable Equations
   (b) Exact Equations
   (c) Euler's Method
   (d) Direction Fields

UNIT III: First Order Systems of Ordinary Differential Equations. (6 meetings)

1. Eigenvalues and Eigenvectors
2. First-Order Homogeneous Systems
   (a) Complex Eigenvalues
   (b) Repeated Eigenvalues
   (c) Phase Planes
3. Linear Differential Operators
4. Linear Independence and the Wronskian
5. Second-Order Linear Equations with Constant Coefficients
   (a) Real and Unequal Roots
   (b) Real and Equal Roots
   (c) Complex Roots
6. Spring-Mass Systems in Free Motion
   (a) Undamped Motion
   (b) Damped Motion
7. Solutions of Nonhomogeneous Systems

   (a) Undetermined Coefficients
   (b) Variation of Parameters
8. Nonhomogeneous Initial Value Problems
9. Higher Order Equations
10. Phase Plane Analysis

**Resources:**

**Course information will be posted on Blackboard Vista.**

**Notes:**
Notes for each class meeting will be posted on Blackboard the night before class. Download, print, and bring these notes with you to each meeting.

**Homework:**
Homework exercises will be assigned during each class meeting for you to complete prior to our next class. You are encouraged to post questions, results, or revelations stimulated by the homework on the discussion board of Blackboard. Nontrivial comments authored by you about the homework or lectures will be tallied for your homework participation score.

**Tests:**
There will be three take-home tests corresponding to each of the three units. The Unit I Test will be posted May 8 and due May 13, the Unit II Test will be posted May 22 and due May 27, and the Unit III Test will be posted June 5 and is due June 10. Tests must be neatly presented in a single electronic document posted to Blackboard. Almost always use complete sentences in your responses to questions and exposition of problem solutions. Your solutions will likely include mathematical computations, formulae, and plots that should be integrated into the write-up so the reader can easily follow and understand your reasoning. Edit files that contain Matlab output so that only the relevant information is included.

**Projects:**
There will be two projects. Each requires you to research a topic and write a 2-page report of your results. The first project is about population modeling with harvesting and will be due June 3. The second is about the pendulum equation and is due June 17.

**Grading:**
Each of the three tests, the two projects, and your homework participation will be equally weighted in the determination of your final grade.

**Accommodations:**
Students with physical, sensory, emotional or medical impairments may be eligible for reasonable accommodations in accordance with the Americans with Disabilities Act and Section 504 of the Rehabilitation Act of 1973. All accommodations are coordinated through the Disability Resource Center (DRC) in Room 101 of the University Inn, 797-2444 voice, 797-0740 TTY, or toll free at 1-800-259-2966. Please contact the DRC as early in the semester as possible. Alternate format materials (Braille, large print or digital) are available with advance notice. Please contact me during the first week of the semester if you will be making use of these resources and/or require accommodations for this course.