Mathematical Methods for Mechanical Engineers
Instructor: Dr. V. Kumar (vkumar@utep.edu)

TTh 09:00-10:20AM, Office hour: by appointment, Contact: Email

Textbook: Advanced Engineering Mathematics, 8th Ed., by Erwin Kreyszig

Course description: This course is designed to introduce students to linear algebra, vector spaces, Fourier Series, orthogonal functions, partial differential equations, numerical methods and other applied mathematics concepts relevant to engineers.

Objective: After completing this course, you should be able to derive a set of partial or ordinary differential equations to model a physical phenomenon in your area, analyze such a model, and successfully compute (at least theoretically) some or all of the important quantities using techniques learned in this course.

Impact on subsequent courses in curriculum: Knowledge needed to apply mathematical methods to advanced level engineering courses and research.

Prerequisites: All students taking the course must have a basic knowledge of mathematics.

MATERIALS COVERED:
The following material will be discussed:

- ELEMENT OF VECTOR AND TENSOR ANALYSIS: Vector Algebra, Matrices and Linear Equations, Coordinate Systems and Vector Calculus
- ELEMENTS OF FUNCTIONAL ANALYSIS: Metric and Metric Spaces, Linear Vector Spaces, Normed and Inner Product Spaces, Linear Transformations (or Operators) and Functionals
- Separation of variables – heat conduction equation, wave equation, Laplace equation

GRADING: There will be several assignments at regular intervals during the semester. You are required to submit the assigned work on or before the deadline. Late submission of the assigned work will not be allowed unless medical and emergency reasons exist. The following percentages of the assignments, exams, and project will constitute the basis for the assigning of the final grade in the course:

    Assessments: Exam1: 0%, Exam2: 0%, Exam3: 0%, Homework: 0%, Project: 100%
    A (≥90%); B(<90% & ≥80%); C(<80% & ≥70%); D(<70% & ≥60%); F(<60%)

Note: Any outstanding issues related to grading of assigned work should be resolved within two weeks from the day when the graded work is returned in the class.

Academic Misconduct: Students are encouraged to work together to discuss the subject, however, all graded materials must represent the student individual work. Scholastic dishonesty is the attempt of any student to present as his or her own work of another, or any work which he/she has not honestly performed, or attempting to pass any examination by improper means. Scholastic dishonesty is a serious offense and will not be accepted. Academic misconducts will be handled according to the current university policy.

Reasonable Accommodation Policy: Any student in this course who has disability that may prevent him or her from demonstrating his or her abilities should contact me personally as soon as possible so we can discuss accommodation necessary to ensure full participation and facilitate your educational opportunities.
# COURSE PLAN


## 1. Partial Differential Equations – 4 Weeks
- Basic Concepts
- Modeling: Vibrating String,
- Wave Equation
- Separation of Variables.
- Heat Equation

## 2. Elements of Vector and Tensor Analysis - 4 Weeks

### 1. Vector Algebra
- Addition and Subtraction
- Multiplication by a Scalar, Unit Vector, Zero Vector
- Linear Dependence
- Vector & Scalar Product of Two Vectors
- Velocity of a Point of a Rotating Rigid Body
- Orthonormal Basis Systems

### 2. Matrices and Linear Equations
- Matrix Multiplication
- Inverse of a Matrix, Determinant of a Matrix
- Matrix Addition/ Transpose
- Minor, Cofactor, and Adjunct of a Matrix
- Solution of Linear Equations

### Homework

### 3. Coordinate Systems and Vector Calculus
- Cartesian/Curvilinear Coordinates
- Covariant and Contravariant Components and Bases
- Orthogonal Curvilinear Systems
- Examples of Orthogonal Curvilinear Coordinate Systems
- Derivatives of Basis Vectors
- The del Operator
- The Divergence of a Vector
- The Laplacian of a Scalar
- The Curl of a Vector
- Integral Relations

### Homework

### 4. Dyadics and Tensors
- Dyadics in Physical Applications
- General Properties of Dyadics
- Symmetric and Antisymmetric Dyadics
- Transformations of Second-Order Tensors (Dyadics)
- Invariants of a Second-Order Tensor
- The Tensor Gradient
- Double-Dot Product
- Dyadics with Orthonormal Bases
- Divergence of a Second-Order Tensor
- Integral Theorems for Dyadics

### Homework
• Eigenvectors Associated with Dyadics

Homework

3 ELEMENTS OF FUNCTIONAL ANALYSIS  - 3 Weeks

1. Metric and Metric Spaces
   • Metric Space, Subspace, and Product Spaces,
   • Continuity, Convergence, and Completeness in Metric Spaces,
   • Some Additional Concepts from Metric Spaces,

   Homework:

   Week 9:
   2. Linear Vector Spaces
      • Definition of a Linear Vector Space,
      • Linear Dependence and Independence of Vectors,
      • Span, Basis, and Dimension,

   Homework

   Week 10:
   3. Normed and Inner Product Spaces
      • Norm of a Vector,
      • Normed Linear spaces,
      • Inner Product and Inner Product Spaces,

   Homework