Department of Civil Engineering

Course Name:

Numerical Analysis in Civil Engineering

Course Number: 20-006	**Credit:** 3
Program: Undergraduate	**Course Type:** Technical required
Prerequisite: Intro Programming	**Corequisite:** -

Course Description (Objectives):
The goal of this course is to give students necessary background on numerical analysis needed to solve civil engineering problems numerically when their analytical solution is either not available or difficult to obtain. MATLAB programming environment will be introduced and used in this course.

Course Content (outline):

- Review of the Mathematical Foundation (Chapter 2)
  - Physical Meaning of Derivatives and Integrals
  - Taylor Series Expansion
  - Definition of Matrix and Vector; Matrix Algebra - Summation, Subtraction and Multiplication of Matrices; Transpose, Determinant and Rank of a Matrix

- Fundamentals of MATLAB Programming (Appendix A)

- Solving System of Linear Equations (Chapter 4)
  - Unique and Multiple Solutions, Trivial and Non-Trivial Solutions, No solution
  - Direct Methods
    - Gauss Elimination method
    - Gauss Elimination with Row Pivoting
  - Iterative Methods
    - Jacobi Method
    - Gauss-Seidel Method

- Roots of Nonlinear Equations (Chapter 3)
  - Incremental Search Method
  - Bisection Method
  - Regula Falsi and Secant Methods
  - Newton-Raphson Method

- Curve Fitting and Interpolation (Chapter 5)
  - Polynomial Interpolation – Lagrange and Newton's Polynomials
  - Cubic and Quadratic Spline Interpolation
  - Curve Fitting by Function Approximation
  - Least Squares Fit

- Numerical Differentiation (Chapter 6)
  - Finite Difference Methods – Forward, Backward and Central Difference formulae
  - Derivatives for Noisy Data
  - Finding Absolute Extrema on a Closed Interval

- Numerical Integration (Chapter 7)
  - Euler, Trapezoidal, Simpson and Gaussian Quadrature schemes.

- Solution of Ordinary Differential Equations: Initial Value Problems (Chapter 8)
  - Euler's explicit method
  - Modified Euler's method, Midpoint method
  - Runge-Kutta methods (2^{nd}, 3^{rd} and 4^{th} order methods)
  - Modified Euler's Predictor-Corrector Method

- Solution of Ordinary Differential Equations: Boundary-Value Problems (Chapter 9)
  - Shooting Method

  Finite-Difference Method
    - Chapter 1: Introduction to Statics
    - Chapter 2: Force Systems
    - Chapter 3: Equilibrium
    - Chapter 4: Structures
    - Chapter 5: Distributed Forces
    - Chapter 6: Friction (including Dry Friction and Rolling Resistance)
    - Chapter 7: Virtual Work
    - Appendix A: Area Moment of Inertia
    - Appendix B: Mass Moment of Inertia

References:

- Numerical Methods for Engineers and Scientists: An Introduction with Applications using MATLAB, Amos Gilat and Vish Subramaniam, John Wiley, 1^{st} Edition 2007/2008 [Most but not all topics are covered in the text]

- Additional recommended books and supplementary reading:
  - Applied Numerical Analysis - Using MATLAB, Laurene V. Fausett, Prentice Hall, 1999 [Good for computer codes but not so good for explanation].
  - Applied Numerical Methods with MATLAB for Engineers and Scientists, Steven C. Chapra, McGraw Hill, 2nd Edition 2007/2008 [Good for explanation but not everything is covered in this book and only a few computer codes are given].