ME 570 - Numerical Methods for Engineers

Credit Hours: 3

Course Description: This graduate level course focuses on the solution of problems arising in Mechanical and Aerospace Engineering using numerical methods. Topics include nonlinear algebraic equations, sets of linear equations, eigenvalue problems, numerical differentiation and integration, ordinary differential equations (ODE), partial differential equations (PDE). Applications include fluid mechanics and heat transfer.

Objectives: Introduce the students to numerical methods available for engineering problem solving; improve programming skills; emphasize fundamental understanding of numerical techniques.

Textbook: Joe D. Hoffman (2001), *Numerical Methods for Engineers and Scientists, 2nd Edition*, Boca Raton, FL: CRC Press.

Instructor: Dr. Kivanc Ekici, ekici@utk.edu, 415 Dougherty Eng. Bldg.

Office hours: I have an open-door policy.

Lecture hours: TR 9:50-11:05, DO-406

Topics covered:

1. Introduction and review of basic numerical tools
   - Nonlinear equations
   - Numerical differentiation and integration
   - Solution of systems of linear and nonlinear equations
2. Numerical solution of ordinary differential equations (ODE)
   - Initial value problems
     - Explicit and implicit solution techniques
     - Accuracy, stability, convergence and consistency
   - Boundary value problems
     - Shooting method
     - Equilibrium method
     - Treatment of Dirichlet, Neumann and Mixed Boundary conditions
3. Numerical solution of partial differential equations (PDEs)
   - Classification of PDEs
   - Characteristics and their mathematical and physical meaning
   - Boundary and initial conditions
   - von Neumann stability analysis

- Elliptic PDEs
  - Accuracy, stability, convergence and consistency
  - Linear and nonlinear problems
  - Relaxation methods
  - Direct solution methods
- Parabolic PDEs
  - Forward-time Central-space (FTCS) method
  - Accuracy, stability, convergence and consistency
  - Leapfrog and DuFort-Frankel method
  - Backward-time Central-space (BTCS) method
  - Crank-Nicholson method
- Hyperbolic PDEs
  - The FTCS method applied to hyperbolic problems
  - The Lax method
  - One-step and two-step Lax-Wendroff techniques
  - The Mac-Cormack method
  - The upwind technique
  - BTCS method
  - Method of Lines (MOL)

4. Introduction to structured mesh generation techniques

Evaluation: Mid-term 1 (25%), Mid-term 2 (25%), Final (25%), and HW+Project (25%).

The assigned homeworks and project will require code development using a programming language of your choice. Academic integrity and honesty is of utmost importance and any violation of academic honesty will not be tolerated. All work must be performed on an individual basis.