ME 3255 – Computational Mechanics

Credits and Contact Hours: 3 Credits. Three 50 minute or two 75 minute lectures per week.

Instructors: Brice Cassenti, Horea Ilies, Kevin Murphy, Bi Zhang

Textbook: *Numerical Methods with MATLAB,* by G. Recktenwald, Prentice Hall, 2000

Specific Course Information:

a. Catalog Description: Topics include elementary numerical analysis, finite differences, initial value problems, ordinary and partial differential equations and finite element techniques. Applications include structural analysis, heat transfer, and fluid flow.

b. Prerequisites: CE 3110, MATH 2410Q

c. Required, Elective or Selected Elective: Required

Specific Goals:

a. Course Outcomes:

After completing ME 3255 students should be able to:

1. Use numerical techniques to find roots of an equation.
2. Use numerical approaches such as LU decomposition to solve sets of linear algebraic equations.
3. Use finite difference techniques to discretize problems.
4. Implement time marching techniques such as Euler or Runge-Kutta.
5. Apply numerical techniques to evaluate definite integrals.

b. Relationship of Course Outcomes to Criterion 3 Student Outcomes:

a) an ability to apply knowledge of mathematics, science, and engineering:
One of the central foci of this course is to have students evaluate numerical techniques in the context of physical and mathematical behavior introduced in other mechanical engineering courses. Students are required to use the fundamentals of mathematics, science and engineering to interpret the validity and usefulness of their numerical simulations.

b) an ability to design and conduct experiments, as well as analyze and interpret data:
The course covers many of the skills required to analyze and interpret data from experiments, such as temporal and spatial integration, curve-fitting and linear system solutions.

c) an ability to design a system, component, or process to meet desired needs: *not applicable*

d) an ability to function on multi-disciplinary teams: *not applicable*

e) an ability to identify, formulate, and solve engineering problems:
Numerical analysis techniques are presented in the context of common engineering problems in heat transfer, fluid and solid mechanics; students are

required to identify and/or formulate the governing equations and solve these equations using the computer-based techniques covered in lectures.

f) an understanding of professional and ethical responsibility: *not applicable*

g) an ability to communicate effectively: *not applicable*

h) the broad education necessary to understand the impact of engineering solutions in a global and societal context: *not applicable*

i) a recognition of the need for, and an ability to engage in life-long learning:
The need for life-long learning is emphasized by introducing students to emerging numerical techniques that continually evolve.

j) a knowledge of contemporary issues:
A knowledge of contemporary issues is conveyed by exposing students to common challenges and benefits of computer and networking.

k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice:
This is the central objective of this course, as outlined above in Course Objectives and Contribution to Professional Component; the course covers a wide range of techniques, skills and modern engineering tools used in engineering practice.

Topics Covered:

- Basics: finite precision issues, validation of subcodes, convergence
- Non-linear root solving: multi-dimensional Newton-Raphson
- Linear systems of equations
- The eigenvalue problem
- Finite difference techniques
- Gaussian quadrature
- Integration of ordinary differential equations
- Discretization effects and convergence of solutions
- Least squares fitting of data
- Review of basic particle and rigid body dynamics
- Review of control volume techniques in fluids and heat transfer
- Review of elementary solid mechanics