ME 3255 – Computational Mechanics

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

Instructors: Brice Cassenti, Julian Norato Escobar, Ryan Cooper, Ying Li, and Reza Sheikhi

Textbook: *Applied Numerical Methods with MATLAB,* by S.C. Chapra, 4th Edition, McGraw-Hill, 2012.

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:

1. An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics.
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.

2. An ability to apply both analysis and synthesis in the engineering design process, resulting in designs that meet desired needs.
The course covers a wide range of techniques, skills and modern engineering tools used in engineering practice.
3. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
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.
4. An ability to communicate effectively with a range of audiences.
Not Applicable

5. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
   A knowledge of contemporary issues is conveyed by exposing students to common challenges and benefits of computer and networking.
6. An ability to recognize the ongoing need for additional knowledge and locate, evaluate, integrate, and apply this knowledge appropriately.
   The need for life-long learning is emphasized by introducing students to emerging numerical techniques that continually evolve.
7. An ability to function effectively on teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty.
   Not Applicable

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