1. Department, Course Number, and Course Title:

MECHANICAL ENGINEERING

ME 419 COMPUTER-AIDED PROBLEM SOLVING IN MECHANICAL ENGINEERING

2. Designation:

Required	☐	Elective	☑
Lower Division	☐	Upper Division	☑

3. Course Description: Application of computer-aided numerical and graphical methods to the solution of problems drawn from various areas of mechanical engineering. The computer-aided methods will be implemented using a combination of one or more computer programming languages and/or existing software packages.

4. Prerequisites: CS 290 (Intro. to FORTRAN Programming, or equivalent), ME 303 (Fluid Mechanics I), ME 306 (Heat Transfer I), ME 323 (Machine Design I), ME 326A (Thermodynamics I)

5. Text and Materials: Numerical Methods for Engineers, 2^{nd} Ed., Steven C. Chapra and Raymond P. Canale, McGraw-Hill, 1988

6. Course Objectives: The student will learn and understand the characteristics and relative advantages of a number of practical numerical methods. The student will apply these methods to solve engineering problems.

Course Outcomes

- Understand the need for computer-aided numerical methods in problem solving.
- Understand the role of approximations and errors in numerical methods.
- Ability to choose and apply the best computer-aided bracketing methods and open methods for finding roots of equations.
- Ability to choose and apply the best computer-aided methods available for solving systems of linear algebraic equations.
- Ability to choose and apply the best computer-aided least-squares regression, interpolation and Fourier approximation methods for curve fitting.
- Ability to choose and apply the best computer-aided methods for numerical integration and differentiation.
- Ability to choose and apply the best computer-aided methods available for solving numerically ordinary differential equations including boundary-value problems and eigenvalue problems.
- Ability to choose and apply the best computer-aided finite difference and finite element methods for solving elliptic and parabolic partial differential equations.

7. Topics Covered: (in Order of Presentation)

- Introduction: Mathematical Modeling in Mechanical Engineering Problem Solving; Overview of Programming Languages; Overview of Numerical and Graphical Software Packages; Approximations and Errors (Ch. 1,2,3)
- Roots of Equations: Bracketing Methods: Bisection and False Position; Open Methods: One-Point Iteration, Newton-Raphson, Secant Methods; Case Studies (Ch. 4,5,6)
- Systems of Linear Algebraic Equations: Gauss Elimination; Matrix Inversion and Gauss-Seidel Method; Lower and Upper Triangular Matrix Product Decomposition Methods; Case Studies (Ch. 7,8,9,10)
- Curve Fitting: Least-Squares Regression: Linear, Polynomial, Multiple Linear, Nonlinear; Interpolation: Newton's and Lagrange Polynomials, Splines; Fourier Approximation: Fast Fourier Transform; Case Studies (Ch. 11,12,13,14)
- Numerical Integration and Differentiation: Newton-Cotes Integration Formulas: Trapezoidal and Simpson's Rules, Open Formulas; Integration of Analytical Equations: Romberg Integration, and Gauss Quadrature; Numerical Differentiation; Case Studies (Ch.15,16,17,18)
- Ordinary Differential Equations: One-Step Methods: Euler, Heun, Improved Polygon and Runge-Kutta Methods; Adaptive Step Size Control: Adaptive Runge-Kutta and Multistep Methods; Boundary-Value Problems: Shooting and Finite Difference Methods; Eigenvalue Problems: Polynomial and Power Methods; Case Studies (Ch. 19,20,21,22)
- Partial Differential Equations: Finite Differences Applied to Elliptic Equations: Laplace Equation; Finite

Differences Applied to Parabolic Equations: Heat-Conduction Equation; Finite Element Method: One Dimensional and Two Dimensional Applications; Case Studies (Ch. 23,24,25,26)

8. Class Schedule: Number of Sessions per week: 2
Duration of each session: 1 hour 40 minutes

9. Contribution of course to meeting the professional component:

This course is part of the 51 units of upper division major requirements in the mechanical engineering program.
Engineering Science 4 units

10. Relationship of course to program objectives:

This course relates to the program objectives by contributing to the following measurable outcomes at the level indicated for all engineering graduates:

Knowledge outcomes:
- an ability to apply knowledge of mathematics, science, and engineering (abet a)
- an understanding of professional and ethical responsibility (abet f)
- a knowledge of computer aided design and simulation software
- a knowledge of how mechanical engineering integrates into inter-disciplinary systems

Skill outcomes:
- an ability to communicate effectively (abet g)
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (abet k)
- an ability to think in a logical sequential process

Attitudes Outcome:
- a recognition of the need for an ability to engage in lifelong learning (abet i)
- an understanding of responsibility and accountability
- a desire to be a professional that exhibits values, dedication and a need for continual improvement

11. Prepared by: Stephen F. Felszeghy 12/1999
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