Numerical Methods in Thermal Engineering - ME5107

Approved Details

Description

To learn methods for obtaining numerical solutions for linear, non-linear algebraic, ordinary and partial differential equations.

Course Content

1. Solution of Linear Algebraic Equations
    - 1.1. Gaussian elimination
    - 1.2. LU decomposition
    - 1.3. Pivoting strategies
    - 1.4. Operation Count
    - 1.5. Matrix inversion
    - 1.6. Special cases
        - 1.6.1. Tridiagonal and block tridiagonal systems
    - 1.7. Well-conditioned and Ill conditioned system
    - 1.8. Matrix and Vector norms
    - 1.9. Condition Number and its implications
2. Solution of Non-linear Algebraic Equations
    - 2.1. Bisection, Newton-Raphson and Secant method
    - 2.2. System of non-linear equations
3. Basics of finite difference method
    - 3.1. Discretization of spatial and time derivatives using Taylor's series
    - 3.2. Truncation error and order of discretization
    - 3.3. Fourier (von Neumann) stability analysis
4. Solution of Ordinary Differential Equations
    - 4.1. Initial Value problems
        - 4.1.1. Euler explicit and implicit methods
        - 4.1.2. Runge-Kutta method
        - 4.1.3. Predictor-Corrector methods
    - 4.2. Boundary value problem
        - 4.2.1. Shooting method
    - 4.3. Stiff problems
        - 4.3.1. Meaning of stiffness
        - 4.3.2. Further insights into stiffness by the application of Euler explicit and implicit method to a stiff problem
        - 4.3.3. Solution to stiff problem
5. Solution of Partial Differential Equations
    - 5.1 Classification of PDEs and characteristics of a PDE
    - 5.2 Solution of Elliptic Partial Differential Equations
        - 5.2.1 Physical problems governed by elliptic PDE's
        - 5.2.2 Five-point and nine-point discretizations of Poisson's equation
        - 5.2.3 Iterative methods
            - 5.2.3.1. Point Iterative methods - Jacobi, Gauss-Seidel, and SOR
            - 5.2.3.2. Detailed theory of the convergence of iterative methods
            - 5.2.3.3. Global Iterative methods - Steepest Descent and Conjugate Gradient
    - 5.3 Solution of Parabolic Partial Differential Equations
        - 5.3.1 Physical problems governed by parabolic PDE's
        - 5.3.2 Operator splitting and ADI methods

Textbooks

1. Numerical Mathematics and Computing, by Ward Cheney and David Kincaid, International Thomson Publishing Company
2. Applied Numerical Analysis, by Curtis Gerald and Patrick Wheatley, Addison-Wesley
3. Analysis of Numerical Methods, by E. Isaacson & H. B. Keller, John Wiley & Sons
4. Numerical Solution of Partial Differential Equations: Finite Difference Methods, by G. D. Smith, Oxford University Press, 1985
5. Matrix Computations, by G. H. Golub, Johns Hopkins University Press
6. Numerical Recipes, by W. H. Press et al