FINITE DIFFERENCE METHODS IN HEAT AND FLUID FLOW

Course Code: 13CH2111 **L P C**
4 0 3

PREREQUISITES: The student should have knowledge of differential equations related to heat and momentum transfer.

Course Educational Objectives:

1. To give introduction on finite difference, FEM and FVM
2. To understand the numerical problems on fluid flow and heat transfer related problems.
3. To Learn steady and unsteady state diffusive, and Diffusive - convective systems using FD method

Course Outcomes: After completion of the course the student would be able to

1. Understand what is Finite Difference, Finite element, Finite volume methods.
2. Solve the numerical problems on fluid flow and heat transfer related problems.

UNIT-I

Basic Relations: Classification of Second – order Partial differential Equations, Parabolic systems, Elliptic systems, Hyperbolic systems, Systems of equations, Boundary conditions, Uniqueness of the solution.

Discrete Approximation of Derivatives:

Taylor Series formulation, Finite difference operators, Control- Volume Approach, Application of control –Volume Approach, Errors involved in numerical solution.

UNIT-II

One- Dimensional Parabolic systems:

Simple Explicit Method, Simple Implicit Method, Crank- Nicolson Method, Combined Method, Three- Time-Level Method, Cylindrical and Spherical Symmetry, A summary of Finite –Difference Schemes.

Multidimensional Parabolic Systems:

Simple Explicit Method (i) Two Dimensional diffusion (ii) Two-dimensional steady laminar boundary layer flow (iii) One- Dimensional Transient convection- diffusion (iv) Two- Dimensional transient convection- diffusion, Combined Method (i) Three-dimensional diffusion (ii) One-dimensional transient convection and diffusion,

Alternating Direction Implicit (ADI) method, Alternating Direction Explicit (ADE) Method (i) One Dimensional diffusion (ii) Two dimensional diffusion, Modified Upwind Method : Transient Forced convection inside ducts for step change in fluid inlet temperature, Upwind method for free convection over a vertical plate.

UNIT-III

Elliptic systems: Steady –State diffusion, Velocity field for incompressible, Constant property, Two dimensional Flow, Temperature field in incompressible, constant property Two –dimensional Flow.

Hyperbolic System: Hyperbolic convection (Wave) equation, Hyperbolic Heat conduction equation, System of Vector equations.

UNIT-IV

Phase Change Problems: Mathematical formulation of phase change problems, Variable Time step approach for single–phase solidification, Variable Time step approach for two – phase solidification, Enthalpy Methods.

UNIT-V

Numerical Grid Generation: Coordinate Transformation relation, Basic ideas in simple transformations, Basic ideas in numerical grid generation and mapping, Boundary value problem of numerical grid generation, Finite difference representation of Boundary value problem of numerical grid generation, Steady state Heat conduction in irregular geometry, Laminar free –convection in irregular enclosures.

TEXTBOOK:

1. Ozisik M.N, *"Finite Difference Method in Heat Transfer",* CRC Press, 1994.

REFERENCE:

1. Anderson D.A, Tannehill JC, Pletcher RH, *"Computational Fluid Mechanics and Heat Transfer"* McGrawHill, 1984.

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