FINITE DIFFERENCE METHODS IN TRANSPORT PROCESSES

Course Code: 15CH2113

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

Course outcomes: On successful completion of the course, the student should be able to

CO1: Classify partial differential equations and also able to apply FDM to solve Partial differential equations.

CO2: Discretize the partial differential equations for steady and unsteady state multidimensional diffusion and convective equations.

CO3: Analyze the velocity and temperature field in any system

CO4: Formulate and solve the phase change problems

CO5: Create and transform the irregular shaped to regular geometry

UNIT-I (10-Lectures)

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 (10-Lectures)

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 (10-Lectures)
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 (10-Lectures)
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 (10-Lectures)
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.