4/4 B.Tech. SEVENTH SEMESTER

ME7T5D COMPUTATIONAL FLUID DYNAMICS Credits: 4

Lecture:- 4 periods/week - Internal assessment: 30marks
Tutorial : 1 periods/week Semester end examination: 70 marks

Objectives:

1. Propose an overview of numerical techniques applied to fluid flow and heat transfer and introducing the student to the fundamental principles of discretization techniques.
2. Specify need for implementation aspects to finite difference equations, consistency, explicit and implicit methods.
3. Acquire knowledge of first order wave equation, stability of hyperbolic and elliptic equations.
4. Recognize finite volume method, linear interpolation and quadratic interpolation. Common matrix methods such as direct methods for matrix inversion and direct methods for banded matrices.

Learning outcomes:

At the end of course the students will be able:

1. Classify various Numerical techniques and matrix methods for banded matrices
2. Apply the heat transfer and fluid flow transfer techniques to form different types of equations.
3. Identify finite difference equations and wave equations to real fluid flow modeling problems.
4. Summarize the concepts of interpolation to all three dimensional surfaces and analyze the problems.

Prerequisite

Engineering Mechanics, Mathematics –II, Numerical Methods, Fluid Mechanics, Thermal engineering and Heat Transfer

UNIT-I

GOVERNING EQUATIONS OF FLUID DYNAMICS:

Definition of Computational fluid dynamics (CFD) Applications in Engineering, Models of Fluid flow, Substantial derivative the divergence of the velocity

UNIT-II

FORMATION OF EQUATIONS:

Continuity equation, the momentum equation, energy equation, physical boundary conditions Forms of governing equations particularly suited to CFD

UNIT-III

MATHEMATICAL BEHAVIOR OF PARTIAL DIFFERENTIAL EQUATIONS : Introduction Classification of Quasi linear partial differential equations General method of determining the classification of partial differential equations, General behavior of different classes of partial differential equations, Hyperbolic parabolic and elliptic equations

UNIT-IV

ELEMENTARY DETAILS IN NUMERICAL TECHNIQUES:

Number system and errors, Representation of integers, Fractions, Floating point Arithmetic, loss of significance and error propagation, condition and instability, Computational methods for error estimation, Convergence of Sequences.

UNIT - V

FINITE DIFFERENCE APPLICATIONS IN HEAT CONDUCTION AND CONVENTION – Heat conduction, steady heat conduction in a rectangular geometry, transient heat conduction, finite difference application in convective heat transfer, closure.

UNIT - VI

FINITE DIFFERENCES:

Discretization, consistency, stability, and Fundamentals of fluid flow modeling: Introduction, elementary finite difference quotients, implementation aspects of finite-difference equations, consistency, explicit and implicit methods.

UNIT - VII

REVIEW OF EQUATIONS GOVERNING FLUID FLOW AND HEAT TRANSFER: Introduction, conservation of mass, Newton's second law of motion, expanded forms of Navier-stokes equations, conservation of energy principle, special forms of the Navier-stokes equations.

UNIT - VIII

STEADY FLOW, DIMENSIONLESS FORM OF MOMENTUM AND ENERGY EQUATIONS,:Stokes equation, conservative body force fields, stream function - Vorticity formulation.

Learning resources

Text book :

1. Computational fluid dynamics - Basics with applications, by John. D. Anderson, Mc Graw Hill, Singapur, International Edition, 1995.
2. Numerical heat transfer and fluid flow, by Suhas V. Patankar, Butter-worth Publishers, Washington, 1980.

References books :

1. Computational Fluid Flow and Heat Transfer, (1st Edition) by by Pradip Niyogi, Tata McGraw-Hill Education,.
2. Fundamentals of Computational Fluid Dynamics, by Tapan K. Sengupta, Universities Press, Hyderabad, 2004.