**IV B.TECH - I SEMESTER**

**COMPUTATIONAL FLUID DYNAMICS**

**Course Code: ME7T5D** **Credits: 3**
**Lecture: 3 periods/week** **Internal assessment: 30 marks**
**Tutorial: 1 period/week** **Semester end examination: 70 marks**

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**COURSE OBJECTIVES:**

- Propose an overview of numerical techniques applied to fluid flow and heat transfer and introducing the student to the fundamental principles of discretization techniques.
- Specify need for implementation aspects to finite difference equations, consistency, explicit and implicit methods.
- Acquire knowledge of first order wave equation, stability of hyperbolic and elliptic equations.
- 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.

**COURSE OUTCOMES:**

Upon completion of this course the student will be able to:

1. Form the governing equations for fluid dynamics problems
2. solve partial differential equations and analyze the behavior of them
3. Apply Numerical techniques and matrix methods to solve banded matrices
4. Apply finite difference techniques to solve the heat transfer and fluid flow equations
5. Apply energy equations to solve fluid flow and heat transfer problems

**Prerequisite:** Engineering Mechanics, Numerical Methods, Fluid Mechanics, Heat Transfer

**UNIT I**
**FORMATION OF 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
Continuity equation, the momentum equation, energy equation, physical boundary conditions Forms of governing equations particularly suited to CFD

**UNIT II**
**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 III**

**ELEMENTARY DETAILS IN NUMERICAL TECHNIQUES AND ENERGY EQUATIONS:**

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. Stokes equation, conservative body force fields, stream function – Vorticity formulation.

**UNIT IV**

**FINITE DIFFERENCE AND ITS APPLICATIONS IN HEAT CONDUCTION AND CONVECTION**

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.

Heat conduction, steady heat conduction in a rectangular geometry, transient heat conduction, finite difference application in convective heat transfer.

**UNIT V**

**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

## 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.