20MD018 COMPUTATIONAL FLUID DYNAMICS

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Course Description and Objective:

This course offers basic understanding to solve and analyze problems involving fluid flow and heat transfer by using finite difference and finite volume methods. The objective of this course is to enable the students to formulate the interaction of fluids and gases with the surfaces for various initial and boundary conditions.

Course Outcomes:

The student will be able to:

· develop governing equations for fluid flow.
· apply appropriate boundary conditions and analyze the obtained results.
· gain skills in the actual implementation of CFD methods
· formulate finite difference and finite volume methods for various fluid flow problems
· assess stability of a given numerical scheme.

SKILLS:

- Convert partial differential equations to linear algebraic equations.
- Solve linear equations using various numerical techniques.
- Analyze the fluid flow patterns and heat transfer phenomenon using various plots.
- Compare the results with available experimental results.
- Apply finite difference methods for various fluid flow problems.
- Perform stability and grid-convergence analysis for a given numerical scheme.

UNIT – I **L-12**

GOVERNING EQUATIONS AND BOUNDARY CONDITIONS: Basics of computational fluid dynamics – Definition and overview of CFD; need; advantages; problem areas; Governing equations of fluid dynamics – Continuity; Momentum and Energy equations — Physical boundary conditions.

UNIT – II **L-12**

PARTIAL DIFFERENTIAL EQUATIONS AND DISCRETIZATION: Mathematical behavior of PDEs in CFD: Elliptic; Parabolic and Hyperbolic equations. Methods of Deriving the Discretization Equations - Taylor Series formulation – Introduction to Finite difference method – Detailed treatment of Finite Difference method; explicit and implicit methods; errors and stability analysis, convergence criteria.

UNIT - III **L-12**

FINITE DIFFERENCE METHODOLOGIES: The Lax-Wendroff Technique; MacCormack's Technique; Space marching; Direct and iterative methods; Thomas algorithm; Alternating Direction Implicit method.

UNIT - IV **L-12**

FINITE VOLUME METHOD: Finite volume formulation of steady and transient for one-dimensional and Two-dimensional conduction equation; Source term linearization incorporating boundary conditions. Finite volume formulation of steady one-dimensional convection and Diffusion problems**.**

UNIT – V **L-12**

FINITE VOLUME METHODOLOGIES: Central, upwind, hybrid and power-law schemes, Representation of the pressure gradient term and continuity equation, Staggered grid - Momentum equations - Pressure and velocity corrections - Pressure - Correction equation, SIMPLE algorithm and its variants.

TEXT BOOKS :

1. Versteeg H.K. and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", 2nd edition, Longman Publication, 2007.
2. John D. Anderson Jr, "Computational Fluid Dynamics-The Basics with Applications", 6th edition, McGraw Hill, 2009.

REFERENCE BOOKS:

1. C. Hirsch, "Numerical Computation of Internal and External Flows", Volumes I and II, 2nd edition, John Wiley and Sons, 2007.
2. Subhash V. Patankar, "Numerical heat transfer fluid flow", 2nd edition, Hemisphere Publishing Corporation, 2004.
3. Muralidhar K. and Sundararajan T., "Computational Fluid Flow and Heat Transfer", 2nd edition, Narosa Publishing House, New Delhi, 2011.