COMPUTATIONAL FLUID DYNAMICS

PE -II: ME								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AMEB35	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		

COURSE OBJECTIVES:

The student will try to learn:

I The evolution of the major theories, approaches, methodologies and programming techniques in Computational fluid dynamics.

II The development of various fluid flow governing equations from the conservation laws of motion and Fluid mechanics.

III The rigorous and comprehensive treatment of numerical methods in fluid flow and heat transfer problems in engineering applications.

IV The environment and usage of commercial Computational Fluid Dynamics packages and carry out research in interdisciplinary applications.

COURSE OUTCOMES:

At the end of the course students are able to:

CO 1 **Summarize** the basics of computational fluid dynamics and its applications in various industries as a tool for fluid analysis.

CO 2 **Select** an appropriate finite difference approach for numerical formulations based on fluid mechanics and/or heat transfer concepts to get the approximate solutions.

CO 3 **Develop** the governing equations for computational fluid dynamics CFD analysis by setting appropriate boundary conditions.

CO 4 **Select** the type of flow from the finite control volume and infinitesimal small fluid element for the fluid flow analysis.

CO 5 **Identify** different CFD techniques available for relevant partial differential equations to get analytical solutions for fluid flow .

CO 6 **Analyze** the numerical solution of fluid flow problems using discretization methods addressing accuracy, stability and convergence aspects to minimise the errors.

CO 7 **Distinguish** various grid generation and transformation techniques in the implementation of finite difference and finite volume methods useful in solving complex thermal problems.

CO 8 **Outline** the concepts of finite volume method and its difference from finite difference method to solve basic fluid flow model in the real world applications.

CO 9 **Demonstrate** the computational methods, algorithms and applied boundary conditions that will affect the approximate solution.

CO 10 **Solve** the parameters of thermo-fluid systems using computational methods to validate numerical and experimental results

CO 11 **Build** up the skills in the actual implementation of CFD methods and codes to investigate the results.

MODULE –I	INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS	Classes : 09
Introduction: History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Numerical Methods Programming fundamentals, simple coding techniques for numerical problems.		
MODULE –II	**GOVERNING EQUATIONS OF FLUID FLOW AND HEAT TRANSFER**	**Classes: 09**
Governing Equations of Fluid Dynamics: Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, NavierStokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions.		
MODULE-III	**PARTIAL DIFFERENTIAL EQUATIONS AND ITS NUMERICAL BEHAVIOUR**	**Classes: 09**
The Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching problems. Mathematical Behavior of Partial Differential Equations: Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations		
MODULE-IV	**DISCRETIZATION AND NUMERICAL METHODS OF PDEs**	**Classes: 09**
Basic aspects of Discretization: Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, uniform and unequally spaced grid points. Grids With Appropriate Transformation: General transformation of the equations, Metrics and Jacobians. Stability Analysis: Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, Artificial dissipation and dispersion; Grid Generation: Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, and Parabolic Grid Generation.		
MODULE-V	**SOLUTION METHODS AND APPLICATIONS OF NUMERICS TO SIMPLE PROBLEMS**	**Classes: 09**
Parabolic Partial Differential Equations: Finite difference formulations, Explicit methods – FTCS, Richardson. Implicit methods – Lasonen and Crank-Nicolson; Finite Volume Method For Structured and Unstructured Grids: Advantages, Cell Centered and Nodal point Approaches, Numerical Solution of Quasi 1D Flow equation and 2D heat conduction equation.		

Text Books:

1. Anderson, J.D. (Jr), “Computational Fluid Dynamics”, McGraw-Hill Book Company, 1st Edition, 1995.
2. Hoffman, K.A., and Chiang, S.T., “Computational Fluid Dynamics”, Vol. I, II and III, Engineering Education System, Kansas, USA, 2000.
3. Anderson, D.A., Tannehill, J.C., and Pletcher, R.H., “Computational Fluid Mechanics and Heat Transfer”, McGraw Hill Book Company, 2002.

Reference Books:

1. Chung, T.J., “Computational Fluid Dynamics”, Cambridge University Press, 2003
2. Muralidhar K and Sundararajan., “Computational Fluid Flow & Heat Transfer”, 2009.

Web References:

1. https://nptel.ac.in/courses/112105045/