COMPUTATIONAL FLUID DYNAMICS

Course Code: 13ME2311 **L P C**
4 0 3

Course Outcomes:

At the end of the course, the student will be able to

CO1 : Explain basic approaches and numerical methods to solve fluid dynamics problems

CO2 : Explain finite volume method for diffusion and convection-diffusion problems using different interpolation schemes

CO3 : Solve linear algebraic equations and transient one and two dimensional heat conduction equations

CO4 : Explain stream function-vorticity method, and to solve the pressure equation

CO5 : Discuss pressure correction method to solve incompressible and compressible flows, and explain turbulent flow models

UNIT-I

Principles of conservation of mass and momentum – dimensionless form of equations – simplified mathematical models for incompressible, inviscid, potential and creeping flows, Boussinesq and boundary layer approximations – mathematical classification as hyperbolic, parabolic and elliptic flows.

Approaches to fluid dynamical problems – possibilities and limitations of numerical methods – components of numerical solution method: mathematical model, discretization method, coordinate and basis vector systems, numerical grid, finite approximations, solution method, convergence criteria, consistency, stability, convergence – discretization approaches: finite difference method, finite volume method, finite element method.

UNIT-II

Finite difference methods: approximation of first, second and mixed derivatives, uniform and non-uniform derivatives, implementation of boundary conditions, discretization errors.

Finite volume methods: approximation of surface and volume integrals – interpolation schemes: upwind differencing, central difference scheme, quadratic upwind interpolation (QUICK) scheme – implementation of boundary conditions – algebraic equation system.

UNIT III

Solution of linear algebraic equations: Gauss elimination method, Thomas algorithm for tri-diagonal system of equations.

Solution of transient one-dimensional differential equation: explicit method, Crank-Nicolson implicit scheme.

Solution of unsteady two-dimensional differential equation: Alternating Direction Implicit method.

UNIT-IV

Solution of Navier-Stokes equations-I: Discretization of derivative terms: convective and viscous terms, pressure and body force terms – conservation properties.

Variable grid: Collocated arrangement, staggered arrangement.

The pressure equation and its solution: A simple explicit time advance scheme, a simple implicit time advance scheme - stream function-vorticity method.

UNIT-V

Solution of Navier-Stokes equations-II: Implicit pressure correction methods: SIMPLE and SIMPLER algorithms.

Turbulent flows: Large eddy simulation (LES) – Reynolds averaged Navier-Stokes equations – Simple turbulence models – Reynolds stress model.

Compressible flow: Pressure correction method, pressure-velocity-density coupling, boundary conditions.

TEXT BOOK:

1. J. H, Ferziger and M. Peric, "*Computational Methods for Fluid Dynamics"*, 3rd Revised Edition, Springer, 2002.

REFERENCES:

1. C. Hirsch, "*Numerical Computation of Internal and External Flows: Volume 1, Fundamentals of Numerical Discretization"*, 2nd Edition, John Wiley & Sons, 2007.
2. C. Hirsch, "*Numerical Computation of Internal and External Flows: Volume 2, Methods of Inviscid and Viscous Flows"*, John Wiley & Sons, 2007.
3. H. K. Versteeg and W. Malalasekera, "*An Introduction to Computational Fluid Dynamics: the Finite Volume Method"*, Longman Scientific & Technical, 1996.

FUELS AND COMBUSTION

Course Code: 13ME2312

L	**P**	**C**
4	**0**	**3**

Course Outcomes:

At the end of the course, the student will be able to
CO1 : Differentiate between various fuels
CO2 : Explain different steps in refinery process of petroleum
CO3 : Analyze exhaust and flue gases
CO4 : Design burners
CO5 : Explain methods for emission control in combustion.

UNIT-I

Classification of coal, analysis and properties of coal, oxidation of coal, hydrogenation of coal, agro fuels, solid fuel handling.

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UNIT-II

Classification of petroleum products, Handling and storage of petroleum products, Refining and other conversion processes, property and testing of petroleum products, other liquid fuels.

Types of gaseous fuels, natural gases, methane from coal mines, manufactured gases, producer gas, water gas, blast furnace gas, refinery gas, LPG, cleaning and purification of gaseous fuels.

UNIT-III

Stoichiometry relations, theoretical and minimum air required for complete combustion, calculation of dry flue gases, exhaust gas analysis, flue gas analysis.

Principles of combustion, rapid methods of combustion, flame propagation, various methods of flame stabilization.

UNIT-IV

Basic features of burner, types of solid, liquid and gaseous fuel burners, design consideration of different types of burners, recuperative and regenerative burners, Pulverised fuel furnaces–fixed, entrained, and fluidized bed systems.