**EAS342 : COMPUTATIONAL FLUID DYNAMICS**

**(Elective)**

**L T P C**

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**Module I 7 hours**

**Introduction:** Applications of CFD in various branches of Engineering, models of fluid flow: finite control volume and infinitesimal fluid element.

**Governing Equations and Physical Boundary Conditions:** Derivation of continuity, momentum and energy equations, physical boundary conditions, significance of conservation and non-conservation forms and their implication on CFD applications - strong and weak conservation forms - shock capturing and shock fitting approaches.

**Module II 7 hours**

**Mathematical Behavior of Partial Differential Equations and Their Impact on Computational Fluid Dynamics:** Classification of quasi-linear partial differential equations by Cramer’s rule and Eigen value method;

General behavior of different classes of partial differential equations and their importance in understanding physical and CFD aspects of aerodynamic problems at different Mach numbers involving hyperbolic, parabolic and elliptic equations; Domain of dependence and range of influence for hyperbolic equations - wellposed problems.

**Module III 12 hours**

**Basic Aspects of Discretization:** Introduction to finite differences, finite difference approximation for first order, second order and mixed derivatives. Difference equations: explicit and implicit approaches, truncation and round-off errors, consistency, stability, accuracy, convergence, efficiency of numerical solutions; Von-Neumann stability analysis and physical significance of CFL stability condition.

**Finite Volume Methods:** Basis of finite volume method, conditions on the finite volume selections, cell-centered and cell-vertex approaches, definition of finite volume discretization, general formulation of a numerical scheme, two dimensional finite volume methods with example.

**Module IV 10 hours**

**CFD Technique’s:** Lax-Fredrich’s technique, Lax-Wendroff technique, Mac Cormack’s technique, Crank Nicholson technique, Relaxation technique, ADI technique, aspects of numerical dissipation and dispersion. Pressure correction technique: application to incompressible viscous flow; Need for staggered grid. Numerical procedures: SIMPLE, SIMPLER algorithms, boundary conditions for pressure correction method.

**Module V 7 hours**

**Grid Types and Characteristics:** Need for grid generation, structured grids, cartesian grids, stretched (compressed) grids, body fitted structured grids, H-mesh, C-mesh, O-mesh, I-mesh, multi block grids, C-H mesh,

H-O-H mesh, overset grids, adaptive grids. Unstructured grids, triangular cells, tetrahedral cells, hybrid grids, quadrilateral cells and hexahedra cells.

**Text Book(s)**

1. J. D. Anderson, Computational Fluid Dynamics: The Basics with Applications, 1/e, McGraw Hill, 2012.

2. R. H. Pletcher , J. C. Tannehill , D. A. Anderson, Computational Fluid Mechanics and Heat Transfer, 3/e, Taylor and Francis, 2011.

**References**

1. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, 1/e, ANE Books, 1980.

2. C. Hirsch, Numerical Computation of Internal and External Flows: Fundamentals of Computational Fluid Dynamics, 2/e, Elsevier, 2007.

3. H. K. Versteeg, and W. Malalasekra, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2/e, Pearson Education, 2010.

4. K. Muralidhar, and T. Sundararajan, Computational Fluid Flow and Heat Transfer, Narosa Publishing House, 1995.

5. T. K. Bose, Computation Fluid Dynamics, Wiley Eastern Limited, 1988.