COURSE CONTENT

APPLIED COMPUTATIONAL FLUID DYNAMICS								
I Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
BAEE05	**Elective**	3	-	-	3	40	60	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: Aircraft structures								

I. COURSE OVERVIEW:

This course deals with the theory behind the commercially available computational fluid dynamic softwares and numerical methods for theory of the fluid flows. The primary focus of this course is on most used, progressive numerical techniques and time dependent methods used to solve the partial differential equations. The students will learn about the boundary layer equations and its transformations. Generation of the grids and its types, various boundary conditions in a fluid flow at different conditions discussed. Philosophy of methods of characteristics for solving the supersonic flow is appreciated. Quintessential method for solving flow around an airfoil that is Panel Methods is addressed.

II. COURSE OBJECTIVES:

The students will try to learn:

I. Advanced techniques in the numerical solution of aerodynamic problems, issues that arise in the solution of such equations in CFD.
II. The formation of boundary layer equations and the boundary conditions to solve the aerodynamics problems.
III. Different methods evolved in analyzing numerical stability of solutions and evaluate the parameters over which the stability depends and their range of values.
IV. Basic formulation of panel methods and consideration to establish the numerical solutions.

III. COURSE OUTCOMES:

After successful completion of the course, students will be able to:

CO 1 Apply the flux approach, flux vector splitting, upwind reconstruction- evolution methods for solving the compressible flow problems using Euler's equations.
CO 2 Make use of the explicit, implicit, time split methods and approximate factorization schemes for obtaining the stabilized numerical solution of subsonic and supersonic nozzle flows.
CO 3 Develop the boundary layer transformation equations for steady external flows on airfoil, wings and aircraft using finite difference method.
CO 4 Analyze the structured, unstructured grids and dummy cells using physical boundary conditions for attaining the accurate results of fluid flow problems.
CO 5 Identify the characteristic lines and compatibility equations for designing the supersonic nozzle having shock free and isentropic flow.
CO 6 Utilize the effects of compressibility and viscosity on thin airfoil for establishing the numerical solution in aerodynamic problems.

IV. COURSE CONTENT:

MODULE-I: NUMERICAL SOLUTIONS OF SOME FLUID DYNAMICAL PROBLEMS (09)
Basic fluid dynamics equations, Equations in general orthogonal coordinate system, Body fitted coordinate systems, mathematical properties of fluid dynamic equations and classification of partial differential equations - Finding solution of a simple gas dynamic problem, Local similar solutions of boundary layer equations, Numerical integration and shooting technique. Numerical solution for CD nozzle isentropic flows and local similar solutions of boundary layer equations Panel methods

MODULE-II: GRID GENERATION (09)
Need for grid generation - Various grid generation techniques - Algebraic, conformal and numerical grid generation - importance of grid control functions - boundary point control - orthogonality of grid lines at boundaries. Elliptic grid generation using Laplace's equations for geometries like aero foil and CD nozzle. Unstructured grids, Cartesian grids, hybrid grids, grid around typical 2D and 3D geometries - Overlapping grids - Grids around multi bodies.

MODULE-III: TIME DEPENDENT METHODS (09)
Stability of solution, explicit methods, FTFS, FTCS, FTBS, Leapfrog method, Lax method. Implicit methods: Euler's FTCS, Crank Nicolson method.

Description of Lax-Wendorff scheme, McCormack two step predictor corrector method, description of time split methods, approximate factorization schemes.

MODULE-IV: BOUNDARY CONDITIONS (09)
Boundary Layer Equations: Setting up the boundary layer equations, flat plate boundary layer solution, boundary layer transformations, explicit and implicit discretization, solution of the implicit difference equations, integration of the continuity equation, boundary layer edge and wall shear stress, Keller-box scheme. Concept of dummy cells, solid wall inviscid flow, viscous flow, far field concept to characteristic variables, modifications for lifting bodies inlet outlet boundary, injection boundary, symmetry plane, coordinate cut, periodic boundaries, interface between grid blocks, flow gradients at boundaries of unstructured grids.

MODULE-V: FLOW WITH HEAT TRANSFER (09)
Introduction to Heat Transfer Prediction, Heat Conduction in Solids, Natural Convection in Cavities- Laminar Flow-Turbulent Flow, Effects of Fluid Properties on Natural Convection, Simulation of Forced Convection Heat Transfer, Periodic Heat Transfer, Conjugate Heat Transfer.

V. TEXT BOOKS:

1. Bose. TK, "Numerical Fluid Dynamics", Narosa Publishing House, 2001.
2. Tannehill John C, Anderson Dale A, Pletcher Richard H, "Computational Fluid Mechanics and Heat Transfer", Taylor & Francis, 2nd Edition,1997.
3. ChungT G, "Computational Fluid Dynamics", Cambridge University Press, 2nd Edition, 2010.
4. Katz Joseph and Plotkin Allen, "Low-Speed Aerodynamics", Cambridge University Press, 2nd Edition, 2006.

VI. REFERENCE BOOKS:

1. Sedat Biringen & Chuen -Yen Chow, "Introduction to Computational Fluid Dynamics by Example", Wiley publishers, 2nd edition, 2011.
2. Anderson J D, "Computational Fluid Dynamics", Mc Graw Hill, 1995.

VIII. MATERIALS ONLINE

1. Course template
2. Assignments
3. Tutorial question bank
4. Model question paper – I
5. Model question paper – II
6. Lecture notes
7. Power point presentations