		L	T	P	C
1152AU107	**COMPUTATIONAL FLUID DYNAMICS**	**3**	**0**	**0**	**3**

1. **Preamble**
   This Course provides an in-depth introduction to Computational Fluid Dynamics, Principles of governing equations and their derivations, classification of partial differential equations (PDEs), boundary conditions, and analysis techniques used in computational solutions of fluid mechanics problems. It also emphasis on introductory concepts in finite difference as applied to PDEs in fluid mechanics; fundamentals of spatial discretization and error and stability analyses; Basics for grid generation techniques.

2. **Pre-Requisites**
   1151AU213 Fluid Mechanics & Machinery

3. **Links To Other Courses**
   - Finite element analysis

4. **Course Educational Objectives**
   Students undergoing this course are expected:
   - To understand the governing equations of fluid flow, incompressible inviscid flow.
   - To understand the behavior of airflow over streamlined and bluff bodies with particular emphasis on 2D circular cylinder, airfoil and wing sections in the incompressible flow regime.

5. **Course Outcomes :**

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Familiar with the differential equations for flow phenomena and numerical methods for their solution	K3
CO2	Familiar with the basic procedures and able to select suitable grid generation techniques for fluid flow	K4
CO3	Discretize governing equations using Finite difference methods and carry out numerical error and stability analyses.	K3
CO4	Identify the suitable techniques to analyse the Strong and Weak Formulations of a Boundary Value Problem	K3
CO5	Apply finite volume techniques to solve 1-D, 2-D and Non linear system problems	K3

6. Correlation of COs with Programme Outcomes :

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H	M	H	H			M		L		H	H
CO2	H	H	H	M	H	H			L		L		H	H
CO3	H	H	H	M	H	H			H		L		H	H
CO4	H	H	H	M	H	H			M		L		H	H
CO5	H	H	H	M	H	H			M		L		H	H

H- High; M-Medium; L-Low

7. Course Content

UNIT I FUNDAMENTAL CONCEPTS **L-9**

Introduction - Basic Equations of Fluid Dynamics - Incompressible In Viscid Flows - Source, Vortex and Doublet Panel, Methods - Lifting Flows Over Arbitrary Bodies - Mathematical Properties of Fluid Dynamics Equations - Elliptic, Parabolic and Hyperbolic Equations - Well Posed Problems - Discretization of Partial Differential Equations. Explicit Finite Difference Methods of Subsonic, Supersonic and Viscous Flows

UNIT II GRID GENERATION **L-9**

Structured Grids - Types and Transformations - Generation of Structured Grids - Unstructured Grids - Delany Triangulation.

UNIT III DISCRETIZATION **L-9**

Boundary Layer Equations and Methods of Solution - Implicit Time Dependent Methods For Inviscid and Viscous Compressible Flows - Concept of Numerical Dissipation – Stability Properties of Explicit and Implicit Methods - Conservative Upwind Discretization For Hyperbolic Systems - Further Advantages of Upwind Differencing.

UNIT IV FINITE ELEMENT TECHNIQUES **L-9**

Overview of Finite Element Techniques in Computational Fluid Dynamics. Strong and Weak Formulations of a Boundary Value Problem.

UNIT V FINITE VOLUME TECHNIQUES **L-9**

Finite Volume Techniques - Cell Centered Formulation - Lax - Vendoroff Time Stepping - Runge - Kutta Time Stepping - Multi - Stage Time Stepping - Accuracy -. Cell Vertex Formulation - Multistage Time Stepping - FDM -Like Finite Volume Techniques – Central and Up-Wind Type Discretization - Treatment of Derivatives. Flux – Splitting Schemes.Pressure Correction Solvers – SIMPLE, PESO. Vorticity Transport Formulation. Implicit/Semi-Implicit Schemes.

TOTAL: 45 periods

8. Text Books

1. Fletcher, C.A.J., "Computational Techniques for Fluid Dynamics", Vols. I and II,Springer - Verlag, Berlin, 1988.
2. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer",Narosa Publishing House, New Delhi, 1995.

3. Ghoshdasdidar, P.S., “Computer Simulation of flow and heat transfer” Tata McGraw-Hill Publishing Company Ltd., 1998.
4. Subas, V.Patankar “Numerical heat transfer fluid flow”, Hemisphere Publishing Corporation, 1980.

9. References

1. John F. Wendt (Editor), “Computational Fluid Dynamics - An Introduction”, Springer –
   Verlag, Berlin, 1992
2. Charles Hirsch, “Numerical Computation of Internal and External Flows”, Vols. I and II.
   John Wiley & Sons, New York, 1988
3. Klaus A Hoffmann and Steve T. Chiang. “Computational Fluid Dynamics for Engineers”, Vols. I & II Engineering Education System, P.O. Box 20078, W. WichitaK.S., 67208 - 1078 USA, 1993
4. Anderson, Jr.D., “Fundamentals of Aerodynamics”, McGraw-Hill, 2000