COURSE CODE	COURSE TITLE	L	T	P	C
1152AE213	**COMPUTATIONAL FLUID DYNAMICS**	**2**	**0**	**2**	**3**

Course Category:

Programme Elective

a. 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.

b. Prerequisite Courses:

Fluid mechanics

c. Related Courses:

Nil

d. Course Educational Objectives :

- To introduce Governing Equations of viscous fluid flows
- To introduce numerical modeling and its role in the field of fluid flow and heat transfer
- To enable the students to understand the various discretization methods, solution procedures and turbulence modeling.
- To create confidence to solve complex problems in the field of fluid flow and heat transfer by using high speed computers

e. Course Outcomes :

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Apply the physical principles to derive the governing equations which govern fluid flow and heat transfer	K3
CO2	Solve the diffusion problems using finite difference and finite volume methods	K3
CO3	Solve the typical convection diffusion problems using finite volume method	K3
CO4	Use various algorithms to analyze the flow field	K3
CO5	Select the right turbulence models for the given problem	K3

f. Correlation of COs with POs:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H			**H**			**H**	H				
CO2	H			**H**			**H**	H				
CO3	H			**H**			**H**	H				
CO4	H			**H**			**H**	H				
CO5	H			**H**			**H**	H				

H- High; M-Medium; L-Low

g. Course Content :

UNIT I GOVERNING EQUATIONS AND BOUNDARY CONDITIONS L-8

Basics of computational fluid dynamics – Governing equations of fluid dynamics – Continuity, Momentum and Energy equations – Chemical species transport – Physical boundary conditions – Time-averaged equations for Turbulent Flow – Turbulent–Kinetic Energy Equations – Mathematical behaviour of PDEs on CFD - Elliptic, Parabolic and Hyperbolic equations.

UNIT II FINITE DIFFERENCE AND FINITE VOLUME METHODS FOR DIFFUSION L-9

Derivation of finite difference equations – Simple Methods – General Methods for first and second order accuracy – Finite volume formulation for steady state One, Two and Three – dimensional diffusion problems –Parabolic equations – Explicit and Implicit schemes – Example problems on elliptic and parabolic equations – Use of Finite Difference and Finite Volume methods.

UNIT III FINITE VOLUME METHOD FOR CONVECTION DIFFUSION L-10

Steady one-dimensional convection and diffusion – Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Hybrid, Power-law, QUICK Schemes.

UNIT IV FLOW FIELD ANALYSIS L-9

Finite volume methods -Representation of the pressure gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and Velocity corrections – Pressure Correction equation, SIMPLE algorithm and its variants – PISO Algorithms.

UNIT V TURBULENCE MODELS AND MESH GENERATION L-9

Turbulence models, mixing length model, Two equation (k-Є) models – High and low Reynolds number models – Structured Grid generation – Unstructured Grid generation – Mesh refinement – Adaptive mesh – Software tools.

Total: 60 Periods

List of experiments

1. Introduction to 1D & 2D flow field equations
2. Numerical solution of fluid flow equations using FVM technique.
3. Introduction to ANSYS-Fluent.
4. Solving any flow fields over 2D bodies.
5. Solving any flow fields over 3D bodies.

h. Learning Resources

i. Text Books:

1. Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The finite volume Method", Pearson Education Ltd.Second Edition – 2007.
2. Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer", Tata McGraw Hill Publishing Company Ltd., 1998E.

ii. References:

1. Patankar, S.V. "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 2004.
2. Chung, T.J., "Computational Fluid Dynamics", Cambridge University, Press, 2002.
3. Ghoshdastidar P.S., "Heat Transfer", Oxford University Press, 2005
4. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.
5. ProdipNiyogi, Chakrabarty, S.K., Laha, M.K. "Introduction to Computational Fluid Dynamics", Pearson Education, 2005.
6. Anil W. Date, "Introduction to Computational Fluid Dynamics", Cambridge University Press, 2005.
7. Anderson, Dale A., John C. Tanhill and Richard H. Pletcher, "Computational Fluid Mechanics and Heat Transfer", McGraw Hill, New York 1984, Volumes I & II