GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3161915

Semester –VI
Subject Name: Computational Fluid Dynamics

Type of course: Professional core course

Prerequisite: Basic course on Fluid Mechanics, Thermodynamics and Numerical Methods

Rationale: This is an introductory course in CFD. In this course, students will be exposed to basics of CFD. Students will gain knowledge on FD/ FV strategy, formulation of the problem and solution techniques.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs	Weight age
1	**Introduction to CFD & Principles of Conservation:** What is CFD? Experimental, Theoretical and Numerical Approach, Historical Background, Applications of CFD, Fundamental principles of conservation, Reynolds transport theorem, Conservation of mass, Navier-Stokes equation, Conservation of Energy, General scalar transport equation.	**04**	**10%**
2	**Classification of Partial Differential Equations and Physical Behavior:** Introduction, Physical Classification: Equilibrium Problems & Marching Problems, Mathematical classification of Partial Differential Equation: Elliptic, Parabolic and Hyperbolic partial differential equations.	**04**	**10%**
3	**Fundamentals of Discretization & Finite Difference Method :** Basics of Discretization (FDM, FVM & FEM), Finite Difference: Introduction, Finite Difference representation of PDEs, Truncation error, Round-off error, Discretization error, Explicit and Implicit Methods, Stability analysis, TDMA (Tridiagonal matrix algorithm), ADI (Alternative Direction Implicit) method, First order Upwind scheme, Lax-Wendroff Method, Second order Upwind scheme	**10**	**20%**
4	**Finite Volume Method for steady diffusion problems and** advection **-diffusion problem**: Basic concepts of Finite Volume method (FVM), Finite Volume method for 1-D steady state diffusion type problem, Finite Volume method for 2-D steady state diffusion type problem, Types of Boundary Conditions, Different advection schemes, Generalized advection -diffusion formulation, Finite volume discretization of two-dimensional advection -diffusion problem, The concept of false diffusion	**12**	**25%**
5	**Numerical Solutions of Navier-Stokes Equations:** Discretization of the Momentum Equation, Stream Function-Vorticity approach and Primitive variable approach, Staggered grid and Collocated grid, SIMPLE Algorithm, SIMPLER Algorithm, SIMPLEC Algorithm, PISO Algorithm	**08**	**15%**

6	**Numerical Grid Generation:** Definition of Grid, need for grid, Geometric modelling and surface grid, Algebraic grid generation, Automatic generation of unstructured grid, Structured and Unstructured grid, Multi Block grid, Types of grid element, factors affecting the grid	**04**	**10%**
7	**Basics of Turbulence Modeling:** Introduction to Reynolds Averaged Navier Stokes Modeling, Zero, One and Two equation models	**03**	**10%**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30%	**30%**	**20%**	**10%**	**10%**	**0**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Anderson J.D. (1995) Computational Fluid Dynamics: The Basics with Applications, McGraw-Hill Inc.
2. Anderson, D.A., Tannehill, J.C. and Pletcher, R.H. (1997).Computational Fluid Mechanics and Heat Transfer, Taylor & Francis
3. Versteeg, H. K. and Malalasekara, W. (2008), Introduction to Computational Fluid Dynamics: The Finite Volume Method. Second Edition (Indian Reprint) Pearson Education
4. T. J. Chung, Computational Fluid Dynamics, Cambridge University Press.
5. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill

Course Outcomes:

Upon completion of this course students should be able:

Sr. No.	CO statement	Marks % weightage
CO1	To understand the underlying theoretical basics of CFD.	25%
CO2	To Illustrate various discretization techniques used to solve PDE.	25%
CO3	Apply the various discretization methods, solution procedures to solve flow problems.	20%
CO4	Categorize different numerical techniques used to solve fluid flow problems.	15%
CO5	Understand various turbulence models to solve turbulent flow problems.	15%

List of Experiments:

1. Introduction to CFD software.
2. To simulate Lid driven cavity flow.
3. To simulate flow through forward facing step (FFS).
4. To simulate flow through backward facing step (BFS).
5. To simulate flow over a Flat Plate.
6. To simulate flow over a cylinder.
7. To simulate flow through C-D Nozzle.
8. To simulate Flow over an Airfoil.

Equipment / Computational facility:
Practical aspect of the subject is based on computation work so high configuration / specification computer systems are mandatory.

Software Packages:
- Open FOAM
- Scilab

List of Open Source Software/learning website:
https://nptel.ac.in/
www.cfd-online.com