GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3722106
Semester – II
Subject Name: Computational Fluid Dynamics

Type of course: Program Elective

Prerequisite: Nil

Rationale: The course is formulated to impart detailed study of computational techniques in field of fluid flow and heat transfer.

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
1	Introduction: What is Computational fluid dynamics (CFD) and how it works? CFD as design and research tool, impact of CFD in Engineering, governing equations of fluid dynamics: Models flow, time rate of change (of moving fluid element), divergence of velocity and its physical meaning, continuity, momentum and energy equations, mathematical behaviour of partial differential equations	4
2	Basic Concept of Discretization: Introduction to discretization technique, introduction to finite differences: Taylor's series expansion, difference equations: explicit and implicit approach, errors and stability analysis, CFL condition Grid Transformation: Introduction, general transformation equations, matrices and Jacobean, transformed version of governing equation particularly suited for CFD, compressed grids, elliptic grid generation, adaptive grids	10
3	Simple CFD Technique: Lax Wandroff technique, Mac-Cormack's technique, relaxation technique and its use with low speed, alternating direction implicit technique (ADI), pressure correction technique: need for staggered grid and its formula, boundary condition for pressure correction method	8
4	Heat Conduction and Convection: Conduction: 1D conduction equation, grid layout discretization, stability and convergence, dealing with non-linearity, methods of solution, 2D conduction. Convection: 1D convection, exact solution and its discretization, upwind difference scheme, comparison of central difference scheme, upwind difference scheme and exact solution, numerical false diffusion, hybrid and power-law schemes, total variation diminishing scheme, 2D Convection: Cartesian and complex domain, Unsteady conduction and convection, Stability of the unsteady flow.	10
5	Finite Volume Method: Introduction to finite volume method (FVM), FVM for diffusion and convection–diffusion problems, discretization of equation for two-dimension, false diffusion, computation of the flow field using stream function and vorticity formulation, solution	10

	procedure for unsteady flow calculations: SIMPLE, SIMPLEC, PISO, and MAC algorithms, Solution algorithms for pressure–velocity coupling in steady flows	

Suggested Specification table with Marks (Theory):

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

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. An Introduction to Computational Fluid Dynamics: The Finite Volume Method, H. K. Versteeg, W. Malalasekera, Pearson Education Ltd.
2. Numerical Heat Transfer and Fluid Flow, Suhas V Patankar, Hemisphere Publishing Co.
3. Fundamentals of Computational Fluid Dynamics Vol. I, II, III, Hoffman and Chiang, Engineering Education System
4. Computational Heat Transfer, K. Murlidhar, G. Biswas, T. Sundarajan, V. Eshwaran, Narosa Publication
5. Computational Fluid Dynamics: A Practical Approach, Jiyuan Tu, Guan HengYeoh, Chaoqun Liu, Elsevier
6. Principles of Computational Fluid dynamics, Pieter Wesseling, Springer International Edition
7. Introduction to Fluid Mechanics, Edward J Shaughnessy, Jr., Ira M Katz, Oxford University press

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To develop perception of major theories, approaches and methodologies used in CFD	52
CO-2	To analyze and apply CFD analysis to solve major engineering design problems involving fluid flow and heat transfer	24
CO-3	To build up the skills in the implementation of CFD methods (e.g. boundary conditions) in actual engineering using commercial CFD codes	24

List of Experiments:

1. Perform Analytical and Numerical analysis on Pin-Fin to calculate temperature distribution.
2. Perform Analytical and Numerical analysis on 1-D steady state heat conduction to calculate temperature distribution along wall thickness.
3. Perform Analytical and Numerical analysis on 2-D steady state heat conduction to calculate temperature distribution along wall thickness.
4. Perform Analytical and Numerical analysis on 1-D unsteady state heat conduction along the wall thickness.
5. Perform Analytical and Numerical analysis on 2-D unsteady state heat conduction along the wall thickness.

6. Perform Analytical and Numerical analysis on steady and unsteady state heat transfer by convection.
7. Perform Numerical analysis on flow through pipe with varying Reynolds number.

Equipment / Computational facility:
To perform various Numerical Analyses, high Configuration/Specification computer systems are mandatory.

List of Open Source Software/learning website: OpenFOAM and SCILAB, www.cfd-online.com