



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: PG

Subject Code : ME02000611

Subject Name: Computational Fluid Dynamics

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

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

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
1	Develop perception of major theories, approaches and methodologies used in CFD	Apply
2	Analyze and apply CFD analysis to solve major engineering design problems involving fluid flow and heat transfer	Analyze
3	Build up the skills in the implementation of CFD methods (e.g. boundary conditions) in actual engineering using commercial CFD codes	Create

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Tutorial / Practical		
				ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Introduction: 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 behavior of partial differential equations	4	10
2.	Basic Concept of Discretization: Introduction to discretization technique, introduction to finite differences: Taylor's series expansion,	10	23



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	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		
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	17
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	12	26
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 procedure for unsteady flow calculations: SIMPLE, SIMPLEC, PISO, and MAC algorithms, Solution algorithms for pressure–velocity coupling in steady flows	11	24
Total		45	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
-	20	30	20	20	10

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. An Introduction to Computational Fluid Dynamics: The Finite Volume Method, H. K. Versteeg, W. Malalasekera, Pearson Education Ltd.



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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

(b) Open-source software and website:

1. https://onlinecourses.nptel.ac.in/noc21_me126
2. https://onlinecourses.nptel.ac.in/noc25_me10
3. OpenFOAM
4. SCILAB
5. www.cfd-online.com

Suggested Course Practical List:

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.

List of Laboratory/Learning Resources Required: High configuration work stations

Suggested Project List:

Suggested Activities for Students: Students are required to download 3-5 research papers from reputed international journals on the recent advancement in the areas of CFD. They need to go through the same and prepare a review for the research papers. The review should have three parts: Summary, Critical Evaluation and Creative synthesise

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