GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170512
Semester – VII
Subject Name: Introduction to Computational Fluid Dynamics

Type of course: Professional Elective Course

Prerequisite: Fluid flow operation, Numerical methods in Chemical Engineering

Rationale: The course deals with the numerical solution of equations governing fluid flow in chemical engineering applications. In all these fields, one needs to deal extensively with fluid flow related phenomena and one needs to resolve flow-related features of the processes and equipment. Although the equations governing fluid flow have been formulated, it is only in recent years that these are being solved in the practical applications in which the flow occurs. The course deals with the basic techniques that enable the numerical solution of these equations.

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	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**Introduction:** Illustration of the CFD approach, CFD as an engineering analysis tool, Review of governing equations, Modeling in engineering, Partial differential equations- Parabolic, Hyperbolic and Elliptic equation, CFD application in Chemical Engineering, CFD software packages and tools.	5
2	**The Governing Equations of Fluid Dynamics:** Introduction, Models of the Flow, The Substantial Derivative (Time Rate of Change Following a Moving Fluid Element), The Divergence of the Velocity, The Continuity Equation, The Momentum Equation, The Energy Equation, Physical Boundary Conditions	10
3	**Mathematical Behavior of Partial Differential Equations:** Introduction, Classification of Quasi-Linear Partial Differential Equations, A General Method of Determining the Classification of Some Simple CFD Techniques: A Beginning Partial Differential Equations: The Eigenvalue Method, General Behavior of the Different Classes of Partial Differential Equations: Impact on Physical Computational Fluid Dynamics.	10

4	**Basic Aspects of Discretization:** Introduction, Introduction to Finite Differences, Difference Equations, Explicit and Implicit Approaches: Definitions and Contrasts, Errors and an Analysis of Stability	**08**
5	**Application of CFD in design:** practical applications and case study of reactor (PFR and CSTR) design, agitator design, coils and jacket design, design of insulation system, dryer design, furnace design, design of mass transfer contactors, thin-film evaporator, design and simulation of mixing, fluidized bed reactor and combustion chamber.	**12**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**20**	**25**	**20**	**15**	**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. Anderson J.D. (1995) Computational Fluid Dynamics: The Basics with Applications,McGraw-Hill, Inc.
2. .Ferziger J.H. & Peric M. (1999) Computational Methods for Fluid Dynamics, Springer, Berlin, Germany.
3. Hirsch C. (1988) Numerical Computation of Internal and External Flows, John Wiley & Sons, New York, USA.
4. Patankar S.V. (1980) Numerical Heat Transfer and Fluid Flow, Hemisphere, Washington D.C., USA.
5. Versteeg H.K. & Malalsekera W. (1995) An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Longman Scientific & Technical, Harlow, Essex, UK.

Course Outcomes:

After successful completion of the course, student will be able to

Sr. No.	CO statement	Marks % weightage
CO-1	relate importance of CFD in design	15
CO-2	to implement numerical solutions for heat, mass and momentum transport equations	35
CO-3	evaluate discretization methods and solution methodology	20

CO-4	apply CFD simulation for design of equipments and operations	30

List of Open Source Software/learning website:

- Students can refer to video lectures available on the websites including NPTEL lecture series.
- Students can refer to the CDs available with some reference books for the solution of problems using software/spreadsheets.
- Student can take MIT Open course lecture on Computational Fluid Dynamics
- Students can use OpenFOAM (open source software) or ANSYS FLUENT or other CFD software.