



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering (Part Time)

Subject Code: 2951911

COMPUTATIONAL FLUID DYNAMICS

Semester V

Type of course: Engineering Science

Prerequisite: Calculus, Vector Calculus and linear Algebra, Advanced Engineering Mathematics, Complex Variables and Numerical Methods and Fluid Mechanics.

Rationale: The course aims to impart basic skills of computational aspects and models of fluid dynamics.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		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	Fluid Mechanics Review: Vector calculus, Vector algebra, Ordinary differential equations and Partial differential equations with engineering applications.	03
2	Numerical Methods & High Performance Computing: Introduction to numerical analysis, Discretisation approaches: finite difference, finite volume, finite element and spectral methods, Numerical methods for algebraic equations/systems of equations, Numerical schemes for hyperbolic, parabolic and elliptic systems and for fluid dynamics, Desktop versus distributed computing facilities, Hardware and software aspects of HPC, Parallel computing challenges and main issues.	12
3	Numerical Modeling for Incompressible & Compressible flow: Overview of various formulations of the governing equations and numerical methods for incompressible flows, Solution approaches: pressure Poisson, projection (approximate and exact), Mathematical properties of hyperbolic systems, Conservation Laws, Explicit and implicit time-stepping schemes.	12
4	Turbulence Modeling: Introduction to Reynolds Averaged Navier Stokes Modeling, Zero, One and Two equation models, Reynolds Stress Transport Schemes, Low-Re Modeling, Transition Modeling Extensions, Classical Large Eddy Simulation (LES) and sub-grid scale models, Implicit LES (numerical and physical principles), Numerical and physical properties of Direct Numerical Simulation (DNS), Applications and challenges for LES and DNS	12
5	Grid Generation: Computer aided design interface with grid generation, Geometry Modeling and Surface Grids, Algebraic Mesh Generation, Structured Meshes from Partial Differential Equations, Automatic generation of Unstructured Meshes, Multiblock Mesh Generation, Mesh Adaptation on Unstructured Grids, Unstructured Grids for Viscous Flows, Grid generation tutorials with available software.	10



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Reference Books:

1. RH Pletcher, JC Tannehill, DA Anderson (2012) ” Computational fluid mechanics and heat transfer”, Third edition, CRC Press.
2. Computational Fluid Dynamics: The Basics with Applications by John D Anderson, Mc Graw Hill Book Company.
3. An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Versteeg, H. K. & W. Malalasekera, Pearson Education, Ltd.
4. Numerical Heat Transfer and Fluid Flow, Suhas V Patankar, Hemisphere Publishing.

Distribution of marks weightage for cognitive level

Bloom's Taxonomy for Cognitive Domain	Marks % weightage
Recall	10
Comprehension	10
Application	30
Analysis	40
Evaluate	0
Create	10

Course Outcome:

After learning the course the students will be able to:

- Understand the basic concepts of Finite Difference and Finite Volume Methods.
- Comprehend the methodology and algorithms of CFD analysis.
- Apply concepts of CFD for problem solving

Sr. No.	CO statement	Marks % weightage
CO-1	To review basics and fundamentals of fluid mechanics and mathematics.	10
CO-2	To introduce the basics of numerical analysis and numerical methods for partial differential and algebraic equations, relevant to Computational Fluid Dynamics,	30
CO-3	To understand the state-of-the-art CFD methods used for computing incompressible and compressible flows in science and engineering.	20
CO-4	To introduce the advanced turbulence modeling approaches used in Computational Fluid Dynamics	20
CO-5	To introduce the concepts of grid generation, including structured and unstructured approaches. To provide hands-on experience using commercial CAD and grid generation packages.	20

List of Experiments:

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1. Perform numerical analysis on flow through pipe with varying Reynolds Number.
2. To calculate hydrodynamic length and boundary layer thickness for pipe flow numerically.
3. To calculate lift and drag co-efficient for a cylinder by using numerical analysis.
4. To calculate variation of lift and drag co-efficient for an airfoil with varying angle.
5. To understand the behavior of creeping flow by numerical simulation.

Open Ended Problem:

1. Numerical study of lid driven cavity.
2. Numerical study of mixing of two fluids.

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

Website:

- www.cfd-online.com