GUJARAT TECHNOLOGICAL UNIVERSITY

AERONAUTICAL ENGINEERING (01)

COMPUTATIONAL FLUID DYNAMICS I

SUBJECT CODE: 2140107

B.E. 4th SEMESTER

Type of Course: Engineering Science

Prerequisite: Basic principles of fluid, Fluid Properties and types of fluids

Rationale: CFD is advanced technique to solve problems involving fluid flow and having applications in various field of engineering

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)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	Introduction: Introduction to Computational Fluid Dynamics, Need for problem solving with CFD, Applications of CFD, Models of fluid flow, concept of substantial derivative, Governing equations of fluid flow: Continuity, Momentum & Energy equation, Conservation and Non-conservation forms of governing equation, Navier-Stokes's model and Euler's model	**07**	**25%**
2	Mathematical behavior of Partial Differential equations: Classification methods for simple PDEs: Cramer's rule & Eigen value method, Role of characteristic lines in hyperbolic equations	**04**	
3	Basic descretization techniques: Descretization, Need to descretize the domain, Classification: FDM, FVM, FEM, Finite difference method, Finite volume method, FVM for 1-D diffusion problem, Types of solution (Explicit & Implicit)	**10**	**25%**
4	Grid Generation: Introduction, Types of grid, Factors affecting the grid, Grid transformation, Prandtl-Mayer expansion waves, Streched grids	**08**	**30%**
5	Introduction to Boundary Conditions: Introduction, Physical boundary conditions for inviscid fliud, viscid fluid, compressible flows and unsteady flows	**04**	
6	Basic Numerical Techniques: Mac-cormack technique, Lax-wendroff technique, ADI Scheme, Relaxation technique	**06**	**20%**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks				
R Level	U Level	A Level	N Level	E Level
10%	30%	15%	25%	20%

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate 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 Methd by H K Versteeg & W Malalasekera
2. Computational Fluid Dynamics by John D. Anderson.
3. Computational Methods for Fluid Dynamics by Joel H. Ferziger, et al
4. Computational Fluid Mechanics and Heat Transfer Anderson, D. A., Tannehill, J. C., Pletcher, R. H., Hemisphere
5. Numerical Heat Transfer and Fluid Flow by S.V. Patankar

Course Outcomes:
After successful completion of course students should be able to

1. To know about the fundamentals of CFD and steps involved in solving CFD problems
2. To understand the physical significance of governing flow equations
3. To understand the mathematical behavior of Partial differential equations
4. To understand the need of descretization and basic descretization techniques
5. To understand the need and importance of grid generation
6. To understand the basics of Boundary conditions
7. To understand the basic numerical techniques

List of practicals:

1. An Introduction to MATLAB.
2. Study of mathematical operations.
3. Study of matrix operations.
4. Program to find maximum and minimum from the set of an array.
5. Evaluate the sum of geometrics series.
6. Write a program to implement the method of least square.
7. Find the integral by the trapezoidal rule and simpson's 1/3rd rule.
8. Find the roots of an equation by Newton Raphson method.
9. Write a program to implement Runge kutta 4th order method to solving $dy/dx = x+y$; $y(0) = 1$
10. Write a program to solve Laplace equation over a region R.
11. Program to solve PDE using inbuilt function and implementing various plots.

Open Ended Problems: Apart from above experiments a group of students has to undertake one open ended problem. Few examples of the same are given below.

1. Flow over a flat plate.
2. Flow through Nozzle/ Diffuser.
3. Flow over an Airfoil.

Major equipments: MATLAB R2014b software package

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.