GUJARAT TECHNOLOGICAL UNIVERSITY

MECHANICAL (THERMAL ENGINEERING) (21)

COMPUTATIONAL FLUID DYNAMICS
SUBJECT CODE: 2722106
SEMESTER: II

Type of Course: Engineering Science

Prerequisite: Zeal to learn the subject

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
				Theory Marks		Practical Marks				
L	T	P	C	ESE (E)	PA (M)	ESE (V)		PA (I)		
						ESE	OEP	PA	RP	
3	0	4#	5	70	30	20	10	10	10	150

Content:

Sr. No	Topic	Hours	% Weightage
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	9
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	5	12
3	**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.	5	12
4	**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	19
5	**Heat Conduction and Convection** Conduction: 1D conduction equation, grid layout discretisation, stability and convergence, dealing with non-linearity, methods of solution, 2D conduction. Convection: 1D convection, exact solution and its discretisation, 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	24
6	**Finite Volume Method** Introduction to finite volume method (FVM), FVM for diffusion and	10	24

	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		

References:

1. Computational Fluid Dynamics the Basics with Applications, John D Anderson, Jr., McGraw Hill Book Company.
2. An Introduction to Computational Fluid Dynamics: The Finite Volume Method, H K Versteeg, W Malalasekera, Pearson Education Ltd.
3. Introduction to Computational Fluid Dynamics, Anil W Date, Cambridge University Press.
4. Numerical Heat Transfer and Fluid Flow, Suhas V Patankar, Hemisphere Publishing Co.
5. Computational Fluid Dynamics: A Practical Approach, JiyuanTu, Guan HengYeoh, Chaoqun Liu, Elsevier.
6. Principles of Computational Fluid dynamics, Pieter Wesseling, Springer International Edition
7. Fundamentals of Computational Fluid Dynamics, Tapan K. Sengupta, Universities Press.
8. Introduction to Fluid Mechanics, Edward J Shaughnessy,Jr., Ira M Katz, Oxford University press

Course Learning Outcome:

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

- Develop perception of major theories, approaches and methodologies used in CFD.
- Analyse and apply CFD analysis to solve major engineering design problems involving fluid flow and heat transfer.
- Build up the skills in the implementation of CFD methods (e.g. boundary conditions.) in actual engineering using commercial CFD codes.

List of Experiments:

1. Perform Analytical and Numerical analysis on Pin-Fin to calculate temperature distribution. [8 Hours]
2. Perform Analytical and Numerical analysis on 1-D steady state heat conduction to calculate temperature distribution along wall thickness. [8 Hours]
3. Perform Analytical and Numerical analysis on 2-D steady state heat conduction to calculate temperature distribution along wall thickness. [8 Hours]
4. Perform Analytical and Numerical analysis on 1-D unsteady state heat conduction along the wall thickness. [8 Hours]
5. Perform Analytical and Numerical analysis on 2-D unsteady state heat conduction along the wall thickness. [8 Hours]
6. Perform Analytical and Numerical analysis on unsteady state heat transfer by convection. [8 Hours]
7. Perform Numerical analysis on flow through pipe with varying Reynold’s number. [8 Hours]

Open Ended Problem:

1. Numerical study of lid driven cavity.
2. Numerical study of flow over an object.
3. Numerical study of mixing of two fluids.

Equipment / Computational facility:

To perform various Numerical Analyses, high Configuration/Specification computer systems are mandatory.

Software Packages:

- OpenFOAM

- SCILAB

Website:

http://www.cfd-online.com

Review Presentation (RP): The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website.