SCHEME OF COURSE WORK

Course Details:

Course Title	Computational Fluid Dynamics		
Course Code	19ME2207	**L P C**	**: 3 0 3**
Program:	M.Tech. in Mechanical Engineering		
Specialization:	Thermal Engineering		
Semester	II		
Prerequisites	Fluid Mechanics and Heat Transfer		
Courses to which it is a prerequisite	Computational Fluid Dynamics lab		

Course Outcomes (COs):

At the end of the course the student will be able to

1	Explain momentum and energy balance equations, physical behavior, definitions of finite difference, finite volume methods, and turbulence modelling
2	Apply finite difference solutions to heat transfer in slab, fin, rectangular geometry and long cylinder
3	Explain ADI method and vorticity-stream function method by FDM, discretisation using finite volume method, and implementation of boundary conditions, Thomas algorithm
4	Explain ADI method and vorticity-stream function method by FDM, discretisation using finite volume method, and implementation of boundary conditions, Thomas algorithm
5	Explain upwind differencing for convection-diffusion problems, SIMPLE and SIMPLER algorithms

Program Outcomes (POs):

PO1:Exhibit in-depth knowledge in thermal engineering specialization

PO2: Think critically and analyze complex engineering problems to make creative advances in theory and practice

PO3: Solve problem, think originally and arrive at feasible and optimal solutions with due consideration to public health and safety of environment

PO4: Use research methodologies, techniques and tools, and contribute to the development of technological knowledge

PO5: Apply appropriate techniques, modern engineering and software tools to perform modeling of complex engineering problems knowing the limitations

PO6: Understand group dynamics, contribute to collaborative multidisciplinary scientific research

PO7: Demonstrate knowledge and understanding of engineering and management principles and apply the same with due consideration to economical and financial factors

PO8: Communicate complex engineering problems with the engineering community and society, write and present technical reports effectively.

PO9: Engage in life-long learning with a high level of enthusiasm and commitment to improve knowledge and competence continuously

PO10: Exhibit professional and intellectual integrity, ethics of research and scholarship and will realize his/her responsibility towards the community

PO11: Examine critically the outcomes of his/her actions and make corrective measures without depending on external feedback

Course Outcome Versus **Program Outcomes:**

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO-1	M											
CO-2	M	M			M			M				
CO-3	M	M			M							
CO-4	M	M			M			M				
CO-5	S	M			M			M				

S - Strongly correlated, *M* - *Moderately* correlated, *Blank* - *No correlation*

Assessment Methods:	Assignment / Quiz / Seminar / Case Study / Mid-Test/ End Exam

<u>Teaching-Learning and Evaluation</u>

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Week	**TOPIC / CONTENTS**	**Course Outcomes**	**Sample questions**	**TEACHING-LEARNING STRATEGY**	**Assessment Method & Schedule**
1	Governing equations: Mass, momentum and energy balance equations - Conservation form of the governing equations of fluid flow - Potential flow model, Buoyancy-driven convection and Boussinesq approximation.	CO-1	(1) Write M&E equations in non-conservation and conservation forms (2) Explain simplified flow models	Lecture Derivations	Assignment Week 4-5)
2	Physical behavior: Classification of partial differential equations according to physical behavior as elliptic,	CO-1	(1) Explain the three classifications according to physical behavior with	Lecture / Discussion	Mid-Test 1 (Week 7)

	parabolic and hyperbolic equations. Finite difference method: First and second derivatives in finite difference form using truncated Taylor series - grid generation, discretization.		examples (2) Taylor series, and derivation of first and second derivatives from truncated Taylor series	Derivations Analysis	
3	Finite volume method: concept of control volume, grid generation, discretization. Introduction to turbulence modelling: Reynolds-averaged Navier-Stokes (RANS) equations for incompressible flow – turbulence models for RANS equations – the standard k-e model – Wilcox model.	CO-1	(1) Decribe grid generation and discretization methods in FVM (2) Explain concept of turbulence, and turbulent models k-e and Wilcox	Lecture Derivations Analysis	Quiz (Week 6)
4	Finite difference method: (a) One dimensional steady heat conduction through a slab/rod with uniform heat source, (b) steady state heat transfer through a rectangular/circular fin,	CO-2	Explain grid generation and discretization by FDM (1) for ss heat conduction in a slab (2) for ss heat transfer in a fin	Lecture Derivations and analysis	
5	(c) steady state two-dimensional heat conduction in rectangular geometry with uniform heat source, (d) steady radial heat conduction in a long solid cylinder	CO-2	Explain grid generation and discretization by FDM (1) ss 2-D heat conduction in rectangular geometry (2) in radial geometry in a long cylinder	Lecture Derivations Analysis	
6	(e) Transient one-dimensional heat conduction by explicit and Crank- Nicolson's implicit methods.	CO-2	Explain solution method for 1-D transient heat conduction in a slab/rod by (1) explicit method (2) Crank-Nicolson implicit scheme	Lecture Derivations Analysis	

7	**Mid-I Examination**				
8	ADI method: Solution of transient two-dimensional heat conduction equation by Alternating Direction Implicit method.	CO-3	Solve problem of 2-D transient heat conduction by ADI method	Lecture Derivations Analysis	
9	Vorticity-Stream function method: Definitions of vorticity and stream function - problem of two- dimensional incompressible viscous flow in a lid-driven cavity by vorticity-stream function method	CO-3	Solve problem of 2-D laminar flow by vorticity - stream function method	Lecture Derivations Analysis	
10, 11	Finite volume method: Application to one-dimensional steady state heat conduction in a slab/rod with source term - Implementation of boundary conditions - solution using Thomas algorithm.	CO-3	(1) Solve problem of 1-D ss heat conduction problem by finite volume method (2) Describe method of implementation of boundary conditions (3) Explain solution by Thomas algorithm	Lecture Derivations Analysis	
12	Steady diffusion: Finite volume method for heat transfer from a fin - grid generation - discretization - solution Finite volume method for two-dimensional diffusion problem	CO-4	(1) Describe solution method for steady heat transfer from a fin by FVM (2) Solve 2-D diffusion problem by finite volume method	Lecture Derivations Analysis	Mid-Test 2 (Week 18)
13	Transient diffusion: Finite volume method for one-dimensional transient heat conduction – explicit and implicit schemes.	CO-4	Solve problem of transient 1-D heat conduction by (a) explicit method, (b) implicit scheme by finite volume discretization	Lecture Derivations Analysis	Case Study (Week 10 - 14)
14	Convection-diffusion: One-dimensional convection diffusion using central differencing scheme Properties of discretization schemes:	CO-4	(1) Explain central differencing scheme in discretization of convection-diffusion problems	Lecture Derivations Analysis	

	Conservativeness, boundedness, transportiveness.		(2) Describe properties of discretization schemes		
15	Upwind differencing scheme: One-dimensional convection diffusion using upwind differencing scheme - assessment of central and upwind differencing schemes for conservativeness, boundedness and transportiveness – hybrid differencing scheme.	CO-5	(1) Explain upwind and hybrid differencing schemes **(**2) Compare central and upwind differencing schemes w.r.t. the trasportiveness property	Lecture Derivations Analysis	
16, 17	Pressure linked momentum balance equations: u- and v-momentum balance equations with pressure gradient in internal flow - concept of staggered grid SIMPLE algorithm: Discretisation of momentum equations – pressure correction equation – under relaxation – flowchart for SIMPLE algorithm –	CO-5	(1) Explain (a) pressure linked equations, and (b) staggered grid (2) Obtain discretized momentum equation (3) Draw the flowchart and explain SIMPLE algorithm	Lecture Problem solving	
18	SIMPLER algorithm – pressure equation – flow chart for SIMPLER algorithm	CO-5	(1) How is SIMPLER algorithm different from SIMPLE algorithm (2) Draw flow chart for SIMPLER algorithm	Lecture Derivations Analysis	Seminar (Week 15)
19	**Mid-II Examination**				
20	**End Semester Examination**				

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