COMPUTATIONAL FLUID DYNAMICS
(MECH 3221)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Unsteady state means
(a) uniform in space (b) time independent
(c) time dependent (d) both (a) and (b).

(ii) A source term for generation is considered
(a) positive (b) negative
(c) always zero (d) may have any value.

(iii) Most of the kinetic energy of turbulence is contained
(a) in the smallest eddies (b) in the largest eddies
(c) both (a) and (b) (d) not within eddies.

(iv) Substantial derivative is
(a) partial derivative (b) total derivative
(c) temporal derivative (d) convective derivative.

(v) The modified form of quadratic interpolation scheme is known as
(a) QUIKE (b) QUITE
(c) QUICK (d) QUIET.

(vi) Shear force in fluid flow is a type of
(a) body force (b) surface fore
(c) both (a) and (b) (d) pressure force.

(vii) 'SIMPLE' algorithm stands for
(a) Semi Implicit Method for Patankar Linked Equations
(b) Semi Implicit Method for Path Linked Equations
(c) Semi Implicit Method for Pressure Linked Equations
(d) Semi Indirect Method for Pressure Linked Equations.

(viii) Hexahedral cells have
(a) 36 faces (b) 16 faces (c) 12 faces (d) 6 faces.

(ix) In one dimensional central differencing scheme
(a) east cell boundary is considered for interpolation
(b) west cell boundary is considered for interpolation
(c) surrounding nodal values are considered for interpolation
(d) both (a) and (b).

(x) In k-ε model, k stands for
(a) turbulent dissipation rate (b) turbulent kinetic energy
(c) laminar dissipation rate (d) laminar kinetic energy.

Group- B

2. (a) What do you understand by Eulerian method of describing fluid motion. [(CO1)(Understand/LOCQ)]

(b) Relate the total derivative of a scalar variable with temporal and convective derivatives and also explain the significance of different terms. [(CO1)(Analyze/IOCQ)]

6 + 6 = 12

3. (a) Draw a free body diagram of a differential fluid element in fluid flow showing all the force components acting on the element along z axis. [(CO1)(Analyze/IOCQ)]

(b) Briefly explain the concept of turbulence modelling for general fluid flow problems. [(CO2)(Understand/LOCQ)]

6 + 6 = 12

Group - C

4. (a) Briefly describe the "initial value problem" with suitable example in the context of fluid flow and heat transfer. [(CO2)(Understand/LOCQ)]

(b) Suggest a suitable differencing scheme for diffusion dominant problem and evaluate the validity of such scheme. [(CO3)(Evaluate/HOCQ)]

6 + 6 = 12

5. (a) Illustrate the methodology of meshing and discretisation for steady state convection problem in one-dimensional domain using finite volume method. [(CO3)(Analyze/IOCQ)]

(b) What do you understand by "marching problem"? [(CO3)(Understand/LOCQ)]

9 + 3 = 12

Group - D

6. (a) What do you understand by (i) cell centre (ii) cell boundary? [(CO4)(Understand/LOCQ)]

(b) Briefly explain any pressure-velocity coupling algorithm in flowchart form.

[(CO4) (Analyze/IOCQ)]

(3 + 3) + 6 = 12

7. Solve the following matrix using Tri-Diagonal Matrix Algorithm (TDMA).

$$\begin{bmatrix} 400 & -100 & 0 & 0 & 0 \\ -100 & 300 & -100 & 0 & 0 \\ 0 & -100 & 300 & -100 & 0 \\ 0 & 0 & -100 & 300 & -100 \\ 0 & 0 & 0 & -100 & 400 \end{bmatrix} \begin{bmatrix} T_1 \\ T_2 \\ T_3 \\ T_4 \\ T_5 \end{bmatrix} = \begin{bmatrix} 30000 \\ 0 \\ 0 \\ 0 \\ 90000 \end{bmatrix}$$

[(CO5) (Evaluate/HOCQ)]

12

Group - E

8. (a) Illustrate the scope of multi-block structured grid generation for fluid flow domain around a 2-D aerofoil. [(CO6)(Analyze/IOCQ)]

(b) What are the possible boundary condition inputs for fluid flow in a 2-D convergent-divergent nozzle? [(CO6)(Evaluate/HOCQ)]

9 + 3 = 12

9. (a) What do you understand by (i) 'no-slip' boundary condition, (ii) 'pressure inlet' boundary condition. [(CO6)(Understand/LOCQ)]

(b) How to create custom field functions in CFD software? [(CO6)(Create/HOCQ)]

(3 + 3) + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	34.37	37.5	28.13

Course Outcome (CO):

After the completion of the course students will be able to

1. Describe the fundamental conservation laws of fluid mechanics.
2. Express the transport equations in general form.
3. Construct the methodologies for converting Partial Differential Equations (PDE) to discretised algebraic forms using Finite Volume Method (FVM).
4. Analyze various CFD solution algorithms for steady and unsteady flows.
5. Compare the results obtained from direct analytical solution and FVM using Tri-Diagonal Matrix Algorithm (TDMA).
6. Formulate CFD problems using CFD software and examine the validity of such schemes.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question