COMPUTATIONAL FLUID DYNAMICS

(MECH 4144)

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

(ii) Newton's second law is directly applicable to
(a) control volume (b) fluid particle
(c) both (a) and (b) (d) surface of control volume

(iii) Rate of linear elongating deformation component along y direction is
(a) $\frac{\partial w}{\partial z}$ (b) $\frac{\partial w}{\partial y}$ (c) $\frac{\partial v}{\partial x}$ (d) $\frac{\partial v}{\partial y}$

(iv) The turbulent intensity in laminar flow is
(a) ∞ (b) 0 (c) 1 (d) 5.

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

(vi) The time average magnitude of any fluctuating variables in a turbulent flow is_____ by definition.
(a) 0 (b) 1 (c) 2 (d) ∞.

(vii) The turbulent kinetic energy per unit mass is expressed as
(a) $\frac{1}{2}\left(\overline{u^2}+\overline{v^2}+\overline{w^2}\right)$ (b) $\frac{1}{2}\left(\overline{u'^2}+\overline{v'^2}+\overline{w'^2}\right)$
(c) $\frac{1}{2}\left(\overline{u'}+\overline{v'}+\overline{w'}\right)$ (d) $\frac{1}{2}\left(u'^2+v'^2+w'^2\right)$.

(viii) 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).

(ix) Upwind differencing scheme is suitable for
(a) steady diffusion problem (b) flow problem
(c) unsteady diffusion problem (d) both (a) and (b).

(x) 'QUAD' computational cells have
(a) 5 boundaries (b) 2 boundaries
(c) 3 boundaries (d) 4 boundaries.

Group – B

2. (a) Briefly explain the significance of (i) control mass and (ii) control volume.

(b) How the control volume concept in the differential form is applied for mass conservation in fluid flow?

(3 + 3) + 6=12

3. Describe the procedure to relate momentum and force for a differential control volume in three-dimensional general fluid flow problem.

12

Group – C

4. (a) Explain the central differencing scheme for one dimensional problem.

(b) Write the general transport equation for a scalar variable Ø per unit mass and hence construct the continuity equation by substituting Ø with suitable variable.

5 + (3 + 4) = 12

5. Explain the procedure of solving a steady state one dimensional convection-diffusion problem.

12

Group – D

6. How staggered-grid method is applied to connect pressure and velocity for steady flow condition?

12

7. Explain the guess-and-correct procedure for correcting and calculating pressure and velocity on a staggered grid arrangement with a flow chart diagram.

12

Group – E

8. Solve the matrix equation using Tri-Diagonal Matrix Algorithm (TDMA).

$$\begin{bmatrix} 300 & -100 & 0 & 0 & 0 \\ -100 & 200 & -100 & 0 & 0 \\ 0 & -100 & 200 & -100 & 0 \\ 0 & 0 & -100 & 200 & -100 \\ 0 & 0 & 0 & -100 & 300 \end{bmatrix} \begin{bmatrix} T_1 \\ T_2 \\ T_3 \\ T_4 \\ T_5 \end{bmatrix} = \begin{bmatrix} 20000 \\ 0 \\ 0 \\ 0 \\ 100000 \end{bmatrix}$$

12

9. Write short notes on:
(i) Unstructured grid
(ii) Boundary condition
(iii) Post-processor of CFD software

4+ 4 + 4 =12