SPECIAL SUPPLE B.TECH/ME/7TH SEM/MECH 4144/2018

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

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

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

(iv) Isotropic means
(a) isentropic
(b) non isentropic
(c) directional dependency
(d) directional independency.

(v) Mixing–length turbulence model relates kinematic turbulent viscosity with
(a) turbulent length scale
(b) turbulent velocity scale
(c) both (a) and (b)
(d) turbulence intensity.

(vi) The turbulent kinetic energy is representative of velocity fluctuations of
(a) large eddies (b) small eddies
(c) inertial range eddies (d) all of the above.

(vii) A staggered grid system is used mainly to
- (a) overcome the stability problem
- (b) enable treatment of flow domain of irregular shape
- (c) simplify grid generation
- (d) eliminate chequerboard oscillations in pressure.

(viii) The adiabatic heat transfer thermal boundary condition is an example of which type of the following boundary conditions?
- (a) Dirichlet type
- (b) Neumann type
- (c) Robin type
- (d) None of the above.

(ix) Conduction heat transfer is a kind of
- (a) diffusion
- (b) convection
- (c) radiation
- (d) both (a) and (b).

(x) Tetrahedral computational cells have
- (a) 5 faces
- (b) 2 faces
- (c) 3 faces
- (d) 4 faces

Group – B

2. (a) What is the difference between control mass and control volume? What is Eulerian frame of reference?

(b) Derive the general mass continuity equation for fluid flow.

(3 + 3) + 6 = 12

3. Derive general momentum equation in Cartesian form for three dimensional fluid flow domain.

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Group – C

4. Heat is transferred across a large plate of thickness 0.02m with thermal conductivity 0.5W/m.K and uniform heat generation 400kW/m^3. The faces are kept at temperatures 110°C and 210°C respectively. Assuming the temperature gradients are significant along the thickness of the plate, form the set of equations for the temperature distribution along the rod using finite volume method.

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5. A property Ø per unit mass is transported by convection and diffusion through one-dimensional domain. The boundary conditions are as follows: at $x = 0$, $Ø_0 = 1$, and at $x = L$, $Ø_L = 0$. Form the linear algebraic equations for

intermediate values of Ø using central differencing scheme. Given, L = 1m, density ρ = 1kg/m^3, diffusion coefficient Γ = 0.1kg/m.s, and velocity u = 0.1m/s.

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Group – D

6. Describe the method of 'Pressure-Velocity Coupling' for steady flow condition.

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7. What is 'SIMPLE' algorithm? Describe the 'SIMPLE' algorithm in a flowchart.

(2 + 10) = 12

Group – E

8. Solve the following equation using TDMA.

$$\begin{bmatrix} 375 & -125 & 0 & 0 & 0 \\ -125 & 250 & -125 & 0 & 0 \\ 0 & -125 & 250 & -125 & 0 \\ 0 & 0 & -125 & 250 & -125 \\ 0 & 0 & 0 & -125 & 375 \end{bmatrix} \begin{bmatrix} T_1 \\ T_2 \\ T_3 \\ T_4 \\ T_5 \end{bmatrix} = \begin{bmatrix} 29000 \\ 4000 \\ 4000 \\ 4000 \\ 54000 \end{bmatrix}$$

12

9. Write short notes on:
   (i) Pre-processor
   (ii) Grid structure
   (iii) Post-processor.

(4 + 4 + 4) = 12