

B.TECH / ME /7TH SEM/ MECH 4144/2017
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) Unsteady state means

(a) uniform in space	(b) time independent
(c) time dependent	(d) both (a) and (b).
 - (ii) 'SIMPLE' algorithm stands for

(a) Semi Implicit Method for Patankar Linked Equations	(b) Semi Implicit Method for Path Linked Equations
(c) Semi Indirect Method for Pressure Linked Equations	(d) Semi Implicit Method for Pressure Linked Equations.
 - (iii) Pressure force is a type of

(a) Body force	(b) Viscous force
(c) Surface force	(d) coriolis force.
 - (iv) Rate of shearing deformation in x-y plane is

(a) $\frac{1}{2} \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} \right)$	(b) $\left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} \right)$
(c) $\frac{1}{2} \left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} \right)$	(d) $\left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} \right)$
 - (v) Shear stresses on fluid element are

(a) asymmetric	(b) skew symmetric
(c) symmetric	(d) both (b) and (c).
 - (vi) A source term for generation is considered

(a) positive	(b) negative	(c) always zero	(d) may have any value.
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- (vii) 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.
- (viii) The solution of discretized equations contain distribution of variables at the

(a) control volume boundaries	(b) nodal points
(c) boundaries	(d) both (a) and (c).
- (ix) Convection is related to

(a) bulk fluid movement	(b) fluid movement at molecular level
(c) no fluid movement	(d) both (a) and (b).
- (x) In Power Law Differencing scheme diffusion is set to zero, when

(a) $Pe = 0$	(b) $0 < Pe < 10$
(c) $Pe > 10$	(d) $Pe < 0$.

Group - B

2. (a) What is the difference between a fluid particle and a fluid element?
 - (b) Briefly discuss on:
 - (i) Lagrangian frame
 - (ii) Temporal derivative
 - (iii) Substantial derivative
- 3 + (3 + 3 + 3) = 12**
3. (a) Write Navier-Stokes equations for Newtonian fluid in Cartesian form and mention significance of each term.
 - (b) Write general transport equation for a general scalar variable ϕ per unit mass and hence deduce momentum equation by substituting ϕ with suitable variable.

6 + (2 + 4) = 12

Group - C

4. Consider one dimensional steady state source free heat conduction in an insulated metallic rod of 0.8m length, whose ends are maintained at constant temperature of 200°C and 600°C respectively. The thermal conductivity and cross sectional area of the rod are $k=1000W/m.K$ and $A=0.01m^2$ respectively. Find out the set of algebraic equations for the temperature distribution along the rod using finite volume method. Hence, represent the algebraic equations in the matrix form.
5. Describe the finite volume method for one dimensional, steady state convection-diffusion problem without source term.

10 + 2 = 12

Group - D

6 . Explain the 'staggered grid' concept for two-dimensional situation.

12

7. What is 'SIMPLER' algorithm? Describe the 'SIMPLER' algorithm in flowchart form.

12

Group - E

8 . Solve the following matrix equation using TDMA.

$$\begin{bmatrix} 20 & -5 & 0 & 0 & 0 \\ -5 & 15 & -5 & 0 & 0 \\ 0 & -5 & 15 & -5 & 0 \\ 0 & 0 & -5 & 15 & -5 \\ 0 & 0 & 0 & -5 & 10 \end{bmatrix} \begin{bmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \\ \theta_4 \\ \theta_5 \end{bmatrix} = \begin{bmatrix} 1100 \\ 100 \\ 100 \\ 100 \\ 100 \end{bmatrix}$$

12

9. Write short notes on:

- i. Grid topology
- ii. Boundary conditions
- iii. CFD softwares

4 + 4 + 4 = 12