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
<u>any 5 (five)</u> from Group B to E, taking <u>at least one</u> 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)   Derivative in the Eulerian framework is
            (a) substantial   (b) temporal   (c) total   (d) convective.

    (ii)   Unsteady fluid flow means the fluid properties and flow parameters are
            (a) time independent   (b) time dependent
            (c) uniform in space   (d) space dependent only.

    (iii)   Rate of linear deformation of a fluid element along z axis is
            (a) $\dfrac{\partial u}{\partial z}$ (b) $\dfrac{\partial v}{\partial z}$ (c) $\dfrac{\partial w}{\partial z}$ (d) $\dfrac{\partial v}{\partial x}$

    (iv)   Out of the following which is known as 'body force'?
            (a) shear force   (b) weight due to gravity
            (c) force due to pressure   (d) normal reaction force.

    (v)   A general variable φ in the general transport equation means
            (a) any scalar   (b) any vector
            (c) both (a) and (b)   (d) only density.

    (vi)   Central differencing scheme is mostly suitable for accuracy on
            (a) convection problems   (b) diffusion problems
            (c) convection-diffusion problems   (d) radiation problems.

    (vii)   A 'node' is situated at the _____ of a cell
            (a) east boundary   (b) west boundary
            (c) centre   (d) both (a) and (b).

    (viii) A hybrid mesh structure in 3-dimensional domain is composed of
            (a) triangular and quadrilateral cells   (b) tetrahedral and hexahedral cells
            (c) quadrilateral and hexahedral cells   (d) triangular and hexahedral cells.

(ix)   Which one out of the following is not CFD software?
    (a) FLUENT   (b) OpenFOAM
    (c) CFX   (d) STAAD

(x)   Hexahedral cells have
    (a) 4 faces   (b) 5 faces   (c) 6 faces   (d) 8 faces.

Group – B

2. (a)   Relate the Eulerian and Lagrangian frame of reference in fluid flow systems.

   (b)   Interpret the mass conservation principle on infinitesimal control volume in a fluid flow system.

6 + 6 = 12

3. (a)   Summarize the Navier-Stokes equations for Newtonian fluids and explain the significance of various terms.

   (b)   Show the different forces acting on an infinitesimally small control volume in a laminar fluid flow domain with standard notations.

6 + 6 = 12

Group – C

4.   Construct a one-dimensional grid arrangement with all important features and build the algebric expressions considering steady state, source free convection-diffusion problem.

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5.   Consider one-dimensional source free convection-diffusion problem where a property φ is being transported in the domain. The domain length L=2m, density ρ=2 kg/m³, and diffusion coefficient μ=0.2 Pa-s. The boundary conditions are φ_0 =2 at x=0 and φ_L =0 at x=2m. Express simplified algebric equations for φ on one intermediate node and one boundary node using five equal cells in the domain and central differencing scheme. Assume fluid velocity u=0.2m/s all through.

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Group – D

6.   Examine the necessity of pressure-velocity coupling in steady flows leading to the requirement of staggered-grid configuration.

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7.   Briefly explain any pressure-velocity coupling algorithm using a flow-chart diagram for calculating pressure and velocities in iterative method.

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Group – E

8. Consider the following matrix expression and solve for θ using Tri Diagonal Matrix Algorithm (TDMA).

$$\begin{bmatrix} 300 & -100 & 0 & 0 & 0 \\ -100 & 200 & -100 & 0 & 0 \\ 0 & -100 & 200 & -100 & 0 \\ 0 & 0 & -100 & 200 & -100 \\ 0 & 0 & 0 & -100 & 300 \end{bmatrix} \begin{bmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \\ \theta_4 \\ \theta_5 \end{bmatrix} = \begin{bmatrix} 2000 \\ 0 \\ 0 \\ 0 \\ 10000 \end{bmatrix}$$

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9. Write short notes on:
    (i) Structured mesh generation.
    (ii) Pre-Processing in CFD software.
    (iii) Processing in CFD software.

4 + 4 + 4 = 12

Department & Section	Submission link:
ME	https://classroom.google.com/c/MTIyNDgzODAxODA3?cjc=t4nm3dq