Total No. of Questions : 12]

SEAT No. :

P1793

[Total No. of Pages : 5

[5059]-43
B.E. (Mech.)
COMPUTATIONAL FLUID DYNAMICS
(2008 Pattern) (Semester - II) (Elective - III)

Time : 3 Hours] *[Max. Marks : 100*

Instructions to the candidates:
1) *Answer any 3 questions from each section.*
2) *Answers to the two sections should be written in separate books.*
3) *Neat diagrams must be drawn wherever necessary.*
4) *Figures to the right indicate full marks.*
5) *Use of logarithmic tables slide rule, Mollier charts, electronic pocket calculator and steam tables is allowed.*
6) *Assume suitable data, if necessary.*

SECTION - I

Q1) a) Derive the continity equation in differential conservation form for a 3-D, unsteady, compressible flow. **[12]**

b) Develope 1D, steady state convective - diffusion equation from the generalised energy equation, in partial differential form. Give the justification for cancellation of different term from the energy equation. Also write Boundary conditions. **[6]**

OR

Q2) a) Explain models of flow using control volume & state what are conservation & non-conservation form of equation. **[8]**

b) What is substantial derivative? How it is different than` derivative in differential calculus? **[8]**

c) In short explain meaning of 'Divergence of velocity'? **[2]**

Q3) a) Using Taylor's series, derive the first order forward difference, backward difference and central difference approximation for the term $\partial u / \partial y$. **[6]**

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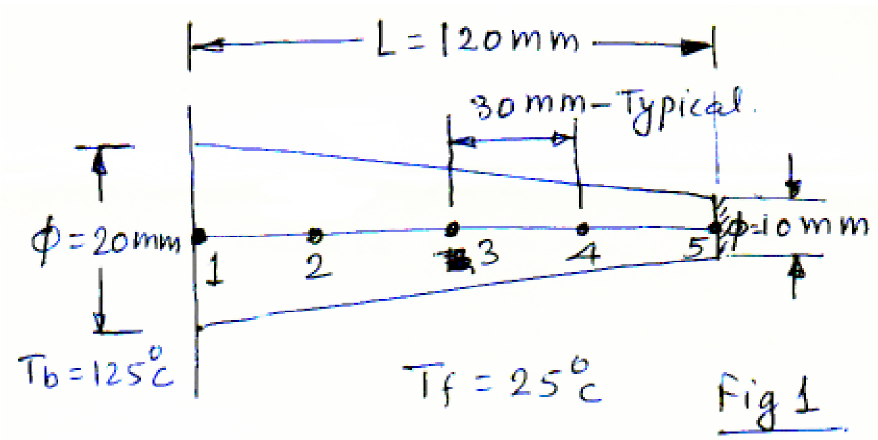
b) Flow between two plates can be expressed with relation $\mu \frac{\partial^2 u}{\partial y^2} = \frac{\partial P}{\partial x}$

Assuming constant, such that, $\frac{\partial^2 u}{\partial y^2} = 1;$ find velocity distribution in a slit having width of 10 units and upper plate moving at a velocity of 10 units with respect to stationery lower plate. Use 5 nodes for finite differencing. Use Gauss Siedel implicit method. **[10]**

OR

Q4) a) Consider steady state heat loss through circular cross-sectioned, tapered in length, fin with temperature of the fin base and the surrounding fluid as T_b = 125°C and T_f = 25°C respectively. (Ref.fig. 1) Assume the heat loss from the end face to be negligible. Obtail temperatures of nodes 2, 3, 4, 5.



Assume k = 1w/mk for fin material & h = 10w/m²k for the surrounding fluid. Derive the governing equation from the basic energy equation. Use numerical techniques. **[12]**

b) What do you understand by the word 'Descritization' in reference to finite difference approach? **[4]**

Q5) Two parallel plates extended to infinity are a distance of 40mm apart. The fluid within the plates has kinematic viscosity of $2.17 \times 10^{-4} m^2/s$ and density of 800 kg/m^3. The lower plate is stationary and the upper plate is suddenly set in motion in a constant velocity of 40m/s. Find the velocity distribution within fluid in y direction for one time step (Δt).Use 5 nodes for finite differencing and apply Crank-Nicolson's implicite method. Take $\Delta t = 0.55$. Recall that the governing equation is reduced from Navier - stokes equation and is given by

$\rho \frac{\partial u}{\partial t} = \mu \frac{\partial^2 u}{\partial y^2}$ with usual notations. **[16]**

OR

Q6) a) What are explicit and implicit approaches used in CFD analysis? State merits and demerits of these approaches. **[8]**

b) Explain Thomas Algorithm for solution of Tridiagonal matrix. Solve the following tridiagonal system with Thomas Algorithm to find T_1, T_2, T_3, T_4. **[8]**

$$\begin{bmatrix} 2.04 & -1 & 0 & 0 \\ -1 & 2.04 & -1 & 0 \\ 0 & -1 & 2.04 & -1 \\ 0 & 0 & -1 & 2.04 \end{bmatrix} \times \begin{Bmatrix} T_1 \\ T_2 \\ T_3 \\ T_4 \end{Bmatrix} = \begin{Bmatrix} 40.8 \\ 0.8 \\ 0.8 \\ 200.8 \end{Bmatrix}$$

SECTION - II

Q7) Following 2D equation is valid over the interval

$0 \le x \le 1, 0 \le y \le 1,\ t \ge 0,\ \frac{\partial T}{\partial t} = \frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}$ Initial distribution of T at $t = 0$ is given by,

$T(x, y, 0) = \sin(2\pi y) * \sin(2\pi x)$

The value of T over the boundary remains at T = 0, for $t > 0$. Find temperature variation using $h = \frac{1}{3}$ along x and y and choosing $\Delta t = \left(\frac{1}{20}\right)$S. Explain use of 'Alternate Direction Implicit Method' (ADI) for such problem. Find values at intermediate step i.e. $t = \left(\frac{1}{40}\right)$S. At fixed value in y direction (i.e.j), "sweep" in x direction to calculate T at $t = \frac{\Delta t}{2}$. **[16]**

OR

Q8) Compute the solution of the equation $\frac{\partial u}{\partial t} = -C\frac{\partial u}{\partial x}$, C = constant > 0, for the first two - steps, using

i) Lax - Wendroff scheme

ii) Mac - Cormack scheme

With initial condition

$$u(x,0) = \begin{cases} x - x^2, & 0 \le x \le 1, \\ 0 & x > 1, \end{cases}$$

and boundary condition $u(0,t) = 0$ for all t, taking $\Delta x = \frac{1}{4}$ and $r = \frac{C\Delta t}{\Delta x} = \frac{1}{2}$. **[16]**

Q9) a) Develop the solution methodology for 2D, unsteady Convection-Diffusion equation giving practicle example. Explain about the possible boundary conditions. **[12]**

b) What is the necessity of using upwind scheme over central difference scheme, in the solution of 1D, steady, Convection- Diffusion equation. **[6]**

OR

Q10 a) Consider a thin rod moving with a velocity 10^{-5} m/s as shown in fig2. The periphery of the rod is perfectly insulated,

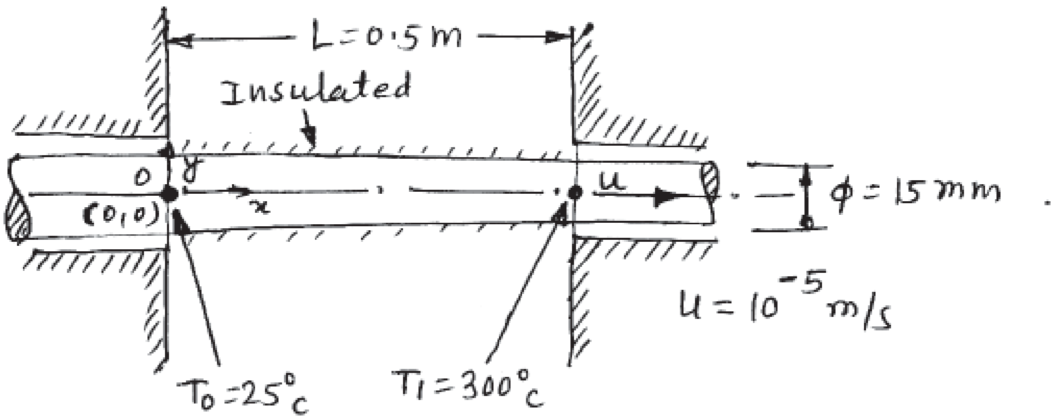


Fig 2

The rod is subjected to a specified temperature $T_0 = 25°C$ for $x \leq 0$ and $T_1 = 300°C$ for $x \geq L$.

Model the domain into 4 elements and find the temperature of rod at the node points. You may assume the governing equation as 1D, steady state, Convection-Diffusion equation. Solve using upwind difference approach. Derive the formulaes used for finding the solution. Assume $\alpha = 10^{-5}\, m^2/s$ for rod. **[12]**

b) Give advantages and disadvantages of finite volume method. **[6]**

Q11) a) Why is staggered grid adopted for incompressible flows? **[2]**

b) Show how the staggered grid is implemented for the pressure equation (SIMPLE). Draw the grid. **[4]**

c) Present the SIMPLE algorithm and show how the pressure and velocity field is determined. **[10]**

OR

Q12) a) What is difference between boundary conditions and initial conditions used in CFD. Explain about Dirichlet, Neumann and mixed boundary conditions. **[8]**

b) What are the main elements involved in a complete CFD analysis? Explain these steps in detail. **[8]**