Total No. of Questions :12]

SEAT No. :

P1703

[Total No. of Pages :4

[4859]-44
B.E (Mechanical)
a : COMPUTATIONAL FLUID DYNAMICS
(2008 Course) (Elective - III) (Semester - II)

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

Instructions to the candidates:

1) *Answer three questions from each section.*
2) *Answers to the two sections should be written in separate answer books.*
3) *Neat diagrams must be drawn wherever necessary.*
4) *Figures to the right indicate full marks.*
5) *Use scientific calculator is allowed.*
6) *Assume suitable data, if necessary and mention it clearly.*

SECTION - I

Q1) a) State different models of flow using control volume and explain the conservation and non-conservation form of equations. **[8]**

b) What is substantial derivative? Explain the local and convective derivatives with suitable physical example. **[8]**

OR

Q2) Consider an appropriate control volume model and derive an expression for 3-D conservative form of momentum equation in partial differential form.**[16]**

a) Justify the selection of the control volume model used to derive momentum equation in conservation form.

b) Explain the force components in brief.

Q3) a) Derive expressions for first order accurate forward difference, backward difference and central difference equations in y-direction. Explain order of accuracy for each expression. **[10]**

b) Explain underrelaxation and overrelaxation with its merits and demerits.**[6]**

OR

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Q4) a) Discretize the following equations with suitable approximations. **[6]**

i) The two dimensional steady state and transient heat conduction equation.

ii) The one dimensional transient convection diffusion equation.

b) Consider a steady state heat transfer through circular cross-section tapered fin, governed by the equation given below $\frac{\partial^2 T}{dx^2} = \frac{hp}{kA}(T - T_f)$. The temperature at the one end of the fin, as shown in figure, $T_b = 125°C$ and the temperature of the surrounding fluid is given as $T_f = 25°C$. Assume the tapered end is insulated. Obtain the temperature at interior nodes placed equidistance using suitable numerical technique**[10]**

Assume k = 1 W/mK and h = 10 W/m^{2}K

D_1 = 20 mm, D_5 = 10 mm L = 120 mm, Taper angle, Θ= 2.39°

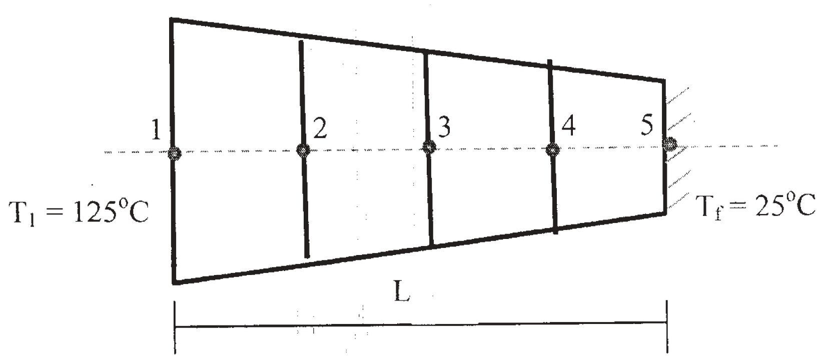

Figure 1

Q5) a) Explain in detail different types of boundary conditions. Give suitable example for each boundary condition. **[8]**

b) Explain Thomas algorithm in detail for the solution of tri-diagonal matrix system. Give one example of a physical system where you get a tridiagonal system. **[10]**

OR

Q6) Two parallel plates with an infinite length are separated by distance 40mm. The lower plate is stationary while the upper plate is started moving with velocity 40 m/s. The flow is governed by following equation.

$$\rho \frac{\partial u}{\partial t} = \mu \frac{\partial^2 u}{dy^2}$$

Find the velocity distribution in y-direction for single time step with $\Delta t = 0.5$s. Apply Crank-Nocolson's implicit method and use 5 nodes for finite difference approximation. Assume density of the fluid 800 kg/m3 and the kinematic viscosity of the fluid is 2.17 X 10^{-4} m^2/s. **[18]**

SECTION - II

Q7) a) Explain MacCormack's technique with predictor and corrector step.**[8]**

b) What is implicit method? Explain in detail about Alternating Direction Implicit method. **[10]**

OR

Q8) Compute the solution of the first order wave equation wiht wave speed given as below **[18]**

$$\frac{\partial u}{\partial t} + C\frac{\partial u}{\partial x} = 0, \qquad c = \text{constant} > 0$$

For the first two steps using

a) Lax-Wendroff scheme and

b) Mac-cormack scheme.

c) Comment on which of the above two scheme is more accurate?

The initial condition and boundary conditions are given below.

Initial condition: $u(x,0) = \begin{cases} (1-x)x, & 0 \le x \le 1 \\ 0, & x > 1 \end{cases}$

Boundary condition: $u(0, t) = 0$, for all t.

Take $\Delta x = 0.25,\ C\frac{\Delta t}{\Delta x} = 0.25$

Q9) a) Derive a finite volume formulation for 2D convection diffusion equation. **[8]**

b) What is upwind method? Derive an upwind formulation for 1D wave linear equation. **[8]**

OR

Q10) a) Explain in detail the merits of finite volume method over finite difference mehtod. Justify your comments. **[8]**

b) Develop the solution methodology for 2D, unsteady convection-diffusion equation. **[8]**

Q11) a) What is staggered grid? Explain its significance using incompressible flows. **[8]**

b) Write in detail the SIMPLE algorithm to compute the flow field quantities. **[8]**

OR

Q12) Write short note on (Any three): **[16]**

a) Structured Grid Generation.

b) CFD Simulation process.

c) Stability criteria.

d) Finite volume method.