Computational Fluid Dynamics **QP CODE : 26204**

Time : 3 hrs **Marks : 80 marks**

N.B: 1) Question No.1 is compulsory

2) Attempt any three questions of the remaining five questions

3) Assume suitable data wherever necessary

4) Figures to the right indicate maximum marks

Q.1 Answer any four **20**

a) Write the general scalar transport equation for any property **Φ** and explain the various terms and their significance

b) Draw the free body diagram of a fluid element and mark all the stresses acting on it.

c) Explain conservativeness, boundedness and transportiveness of finite volume schemes

d) What do you mean by grid independence. Why is it necessary to carry out grid independence studies

e) Explain the explicit and the implicit schemes for discretization of unsteady flows

Q. No.2

a) A property ϕ is transported by means of convection and diffusion through a one dimensional domain. The governing equation to be used is $\frac{d}{dx}(\rho u \phi) = \frac{d}{dx}\left(\Gamma \frac{d\phi}{dx}\right)$. The boundary conditions to be used are at **x = 0, ϕ_0 = 1 and at x = L, ϕ_L = 0.** Assume that the property is transported from x = 0 to x = L. Using five equally spaced nodes and an Central Differencing scheme, calculate the distribution of ϕ as a function of x for u = 0.40 m/s, L = 2 m, ρ = 1.2 kg/m^3, Γ = 0.20 kg/ms

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b) What is QUICK? Give the distribution of flux ϕ at the face values of a control volume

5

Q.No.3

Consider a large plate of thickness t = 2.5 cm with an internal heat generation of 1000 kW/m^3 and a constant thermal conductivity of 1 W/mK. The faces of the plate are maintained at 100 ^{0}C and 350^0 C. Assume that the dimensions in the directions perpendicular to the thickness are so large that the temperature gradients due to conduction are significant in the direction of thickness only

- Write the one dimensional governing equation for the above phenomena
- Obtain the discretized equation for each node

  Arrange the equations in the matrix form and solve it to find the steady state temperature at five equally spaced nodes using TDMA

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Q.No.4

a) The steady state convection-diffusion of a property φ in a one-dimensional flow field is governed by the equation
$d/dx\ (\rho u\varphi) = d/dx(\Gamma\ d\varphi/dx)$

Discretize the equation using an upwinding scheme for the convection term and central differencing scheme for the diffusion term to determine the variables at any point P.

14

b) Why is a staggered grid used to determine the flow field? How are the variables stored in a staggered grid? **6**

Q.No.5

a) A thin plate is infinitely long. It is 25mm thick and its thermal conductivity, k, is 10W/mK and its $\rho c = 120 \times 10^2\ kJ/m^3K$. The plate is initially at 500K. At a certain time t=0 its east side temperature is suddenly reduced to 273K and the other surface is insulated. Using an explicit scheme and a time step of 2 seconds calculate the transient temperature distribution in the plate at the end of 2, 4, and 6 seconds. Consider 5 nodes. The governing equation is as given below.

$$\rho c \frac{\partial T}{\partial t} = \frac{\partial}{\partial x}\left(k \frac{\partial T}{\partial x}\right)$$

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b) Write the Navier-Stokes equations for a compressible fluid and explain the various parameters in the equation.

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Q.No.6

Write short notes : **20**

1. Types of grids used in CFD
2. Methodology adopted by commercial CFD packages tin carrying out a CFD analysis
3. SIMPLE algorithm
4. K- ω turbulence model.
