USN | | | | | | | | | |

10MTP322

Third Semester M.Tech. Degree Examination, June/July 2013
Computational Methods in Heat Transfer and Fluid Flow

Time: 3 hrs. Max. Marks: 100

Note: ***Answer any FIVE full questions.***

1 a. Derive the momentum equations in usual notation and explain the physical meaning of each term. **(08 Marks)**

b. Distinguish between three types of second order partial differential equations. **(06 Marks)**

c. Determine the transient temperature distribution in a 1-D solid with a thermal diffusivity 'α' if the initial temperature in the solid is 0° and if at all subsequent times, the temperature of the left side is held at 0° while the right side is held at T_0. **(06 Marks)**

2 a. Establish steady heat loss through a long straight fin of the following:

$$\left.\frac{dT}{dx}\right|_{x=L} = \frac{3T_{N+1} - 4T_N + T_{N-1}}{2\Delta x} = 0$$ **(10 Marks)**

b. A square plate with edge of length 1 m has temperature 500°C on the top and 100°C on the left face. It is subjected to convection environment of h = 10 W/m^2 °C and T_∞ = 100°C on the right face and bottom face. If the thermal conductivity of the plate is 10 W/m °C. Set up equations with temperature distribution on the plate using finite difference scheme with $\Delta x = \Delta y = 1/3$. **(10 Marks)**

3 a. Derive discretise two-dimensional steady state diffusion equation using finite volume method. **(10 Marks)**

b. Consider source free heat conduction in an insulated rod whose ends are maintained at constant temperature of 100°C and 500°C respectively. The one dimensional problem is given by $\frac{d}{dx}\left(k\frac{dT}{dx}\right) = 0$. Calculate the steady state temperature distribution in the rod using five volume elements. Thermal conductivity K = 1000 W/m K, Cross sectional area A is $10 \times 10^{-3}\ m^2$, Length of rod = 0.5 m. **(10 Marks)**

4 a. State the relative merits of implicit, explicit and Crank Nicolson methods for discretisation of 1-D unsteady heat diffusion equations. **(09 Marks)**

b. Derive one dimensional unsteady heat conduction equation using finite volume method given by, $\rho c\frac{\partial T}{\partial t} = \frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right) + S$, where ρc is a constant. **(11 Marks)**

5 a. Show that the analytical solution for the one-dimensional convection diffusion problem for a scalar variable ϕ may be written as

$$\frac{\phi - \phi_0}{\phi_c - \phi_0} = \frac{\exp(\rho u x/\Gamma) - 1}{\exp(\rho u L/\Gamma) - 1},$$ where $\phi(0) = 1$, and $\phi(L) = 0$. **(10 Marks)**

b. Calculate the distribution of ϕ as a 1 – D of x for constant flow velocity u = 0.1 m/s, diffusion coefficient Γ = 0.1 kg/m/s, the fluid density ρ = 1 kg/m^3 and the length of flow domain L = 1.0 m. Use five equally spaced grids. **(10 Marks)**

6 a. Write sequence of operation in a CFD procedure in the calculation of pressure and velocity in SIMPLE algorithm. **(10 Marks)**

b. Explain clearly the Thomas algorithm for solution of a linear equation system with tridiagonal coefficient matrix. **(10 Marks)**

7 a. Develop expressions for upwinding purely in terms of stream function ψ at the node (i, j) as well as its neighbours. **(10 Marks)**

b. What are four basic rules formulating the problems to be solved by the SIMPLE algorithm? Explain. **(10 Marks)**

8 a. Describe unsteady transonic potential flow. **(10 Marks)**

b. Explain Riemann solver for one dimensional Euler equation. **(10 Marks)**

* * * * *