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10MTP322

Third Semester M.Tech. Degree Examination, December 2012
Computational Method in Heat Transfer and Fluid Flow

Time: 3 hrs. Max. Marks:100

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

1 a. What are the different types of partial differential equation? Describe how do you find their types. **(06 Marks)**

b. Write momentum and energy equations for fluid flow and explain each term in these two equations. **(08 Marks)**

c. Explain the physical meaning of divergence of velocity. Show an example of heat transfer equation with divergence of velocity. **(06 Marks)**

2 a. What are the four rules of discretization? Explain each rule with an example. **(06 Marks)**

b. Develop a finite difference method scheme to solve the following equation:

$\rho C\frac{\partial T}{\partial t}=\frac{\partial}{\partial x}\left(K\frac{\partial T}{\partial x}\right)$ where symbols have their usual meaning. Assume ρ, C and K as constants in the above equation. **(04 Marks)**

c. What do you mean by consistency truncation error and round off error. Explain these terms in the solution of a discretized equation developed using finite difference method. **(04 Marks)**

d. Develop a finite difference scheme to solve $\frac{\partial^2\phi}{\partial x^2}+\frac{\partial^2\phi}{\partial y^2}=0$. By assuming grid spacing in x and y direction as the same write the final equation. **(06 Marks)**

3 a. Derive the expression for interface thermal conductivity and mention its significance. **(06 Marks)**

b. Discretise the following unsteady conduction equation using finite volume method.

$\rho C\frac{\partial T}{\partial t}=\frac{\partial}{\partial x}\left(K\frac{\partial T}{\partial x}\right)+S$ **(08 Marks)**

c. Derive the difference equation for $\frac{\partial T}{\partial t}=\alpha\frac{\partial^2 T}{\partial x^2}$ and develop the solution scheme using implicit and explicit approach. **(06 Marks)**

4 a. What is successive over relaxation (SOR) and under relaxation process? **(03 Marks)**

b. What is scar borough criterion? Why and where is this criterion used? **(03 Marks)**

c. Take $\Delta t = 0.02s$, $\Delta x = \Delta y = (\delta x)_c = (\delta x)_w = 1$, u = 1 and boundary conditions for temperature as 100°C at x = 0 and 50°C at x = 1. Compute temperature at point P in a 1-D convection and diffusion heat transfer situation for as mentioned below. Thermal conductivity (K) and density (ρ) could be assumed as constant for the situation mention. ρ = 1, K = 400. All are in MKS units. Source term is zero. Use finite volume method (FVM) to solve this problem. **(14 Marks)**

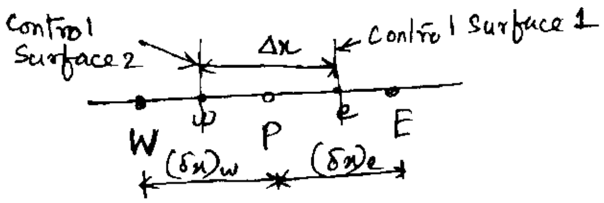

Fig. Q4 (c)

5 a. What is tridiagonal matrix algorithm? Demonstrate its use for the equation $a_i x_{i-1} + b_i x_i + c_i x_{i+1} = d_i$ where $a_1 = 0$ and $c_n = 0$; i varies from 0 to n. **(07 Marks)**

b. Discretize 1-D convection and diffusion heat transfer equation using finite volume method. Get an expression of the final discretised equation in terms of peclet number. **(10 Marks)**

c. What is tank-and-tube model? Explain it with a neat diagram. **(03 Marks)**

6 a. What is a viscous incompressible flow? Write its momentum equation in 2-D form. **(06 Marks)**

b. Describe mathematically the main difficulty in computing the flow field. **(04 Marks)**

c. What is a staggered grid? Show it with neat sketch for 2D flow field. Why is it called so? **(04 Marks)**

d. Explain different steps involved in SIMPLE algorithm to get the solution of a momentum equation. **(06 Marks)**

7 a. Develop a vorticity transport equation for a 2D incompressible flow with viscosity. **(08 Marks)**

b. Explain stream function-vorticity approach to solve N-S equation for incompressible flow. **(08 Marks)**

c. What is MAC method to compute incompressible flow? **(04 Marks)**

8 a. Write the governing flow equations for a 2D compressible flow neglecting body forces and volumetric heating. **(10 Marks)**

b. Develop the vector for of the above said governing equation Q8 (a) and then, using finite-difference equations for the vector form of governing equation, write the steps to compute flow field variables. **(10 Marks)**

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