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Total No. of Questions : 08

M.Tech. (ME) (2019 Onwards) (Sem.–2)

COMPUTATIONAL FLUID DYNAMICS

Subject Code : MTME-204

M.Code : 74980

Time : 3 Hrs. **Max. Marks : 100**

INSTRUCTIONS TO CANDIDATES :

1. **Attempt any FIVE questions in all.**
2. **Each question carries TWENTY marks.**

Q1. A CFD code is used to solve a two-dimensional (x and y), incompressible, laminar flow without free surfaces. The fluid is Newtonian. Appropriate boundary conditions are used. List the variables (unknowns) in the problem, and list the corresponding equations to be solved by the computer.

Q2. Summarize the eight steps involved in a typical CFD analysis of a steady, laminar flow field.

Q3. a) Briefly discuss how each of the following is used by CFD codes to speed up the iteration process :

(a) Multigridding and

(b) Artificial time

b) What is the standard method to test for adequate grid resolution when using CFD?

Q4. Derive the energy equation for a viscous flow in integral form. Show that all the three conservation equations- mass, momentum and energy can be put in a single generic integral form.

Q5. a) Consider the problem of a steady-heat conduction problem in a large brick plate with a uniform heat generation. The faces A and B as shown in Figure are maintained at constant temperatures. The governing equation is of the generic form presented as

$$\frac{d}{dx}\left(\Gamma \frac{dT}{dx}\right) + S = 0$$

The diffusion coefficient Γ governing the heat conduction problem becomes the thermal conductivity k of the material. For a given thickness L = 2 cm, with constant thermal conductivity k = 5 W/m^2 K, determine the steady- state distribution in the plate. Temperatures at T_A and T_B are 150°C and 550°C respectively, and heat generation q is 1000 kW/m^3.

b) Determine the discrete nodal temperatures across the brick plate using the finite volume method and Thomas algorithm (Taking at least 4 control volumes).

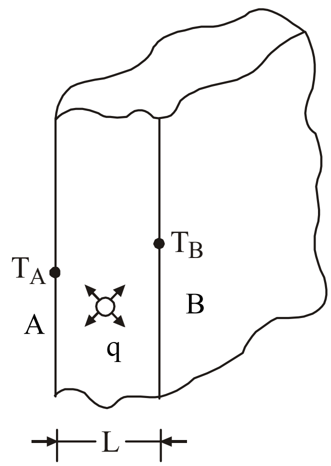

Fig. 1

Q6. Suppose that a finite-difference solution has been obtained for the temperature T, near but not at an adiabatic boundary (i.e. $\partial T/\partial y = 0$ at the boundary). In most instances, it would be necessary or desirable to evaluate the temperature at the boundary itself. For this case of an adiabatic boundary, develop expression for the temperature at the boundary, T_1, in terms of temperatures at neighboring points T_2, T_3, etc. by assuming that the temperature distribution in the neighborhood of the boundary is :

a) A straight line

b) A second degree polynomial

c) A cubic polynomial (you only need to indicate how you would derive this one)

Indicate the order of the truncation error in each of the above approximations used to evaluate T_1.

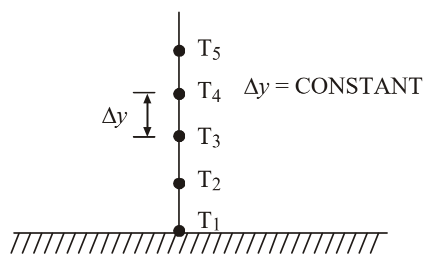

Fig. 2

ADIABATIC BOUNDARY

Q7. Describe the concept of stability. Derive the stability criteria produced by the von Neumann.

Q8. a) Think about modern high-speed, large-memory computer systems. What feature of such computers lends itself nicely to the solution of CFD problems using a multiblock grid with approximately equal numbers of cells in each individual block? Discuss.

b) What is the difference between multigridding and multiblocking? Discuss how each may be used to speed up a CFD calculation? Can these two be applied together?

NOTE : Disclosure of Identity by writing Mobile No. or Making of passing request on any page of Answer Sheet will lead to UMC against the Student.