Roll No. | | | | | | | | | | | | **Total No. of Pages : 2**

Total No. of Questions : 08

M.Tech (ME) (2017 Batch) (Sem.–2)

COMPUTATIONAL FLUID DYNAMICS

Subject Code : MTME-204

Paper ID : [74980]

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

INSTRUCTIONS TO CANDIDATES :

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

Q1. Traditionally, CFD has been used to solve aerospace and automotive engineering applications such as drag and lift for airplanes and cars. What examples can you think of where CFD is being used within nontraditional fluid engineering applications? What is the future of CFD?

Q2. Derive the Momentum equation in integral form. Show that all the three conservation equations continuity, momentum and energy can be put in a single generic integral form.

Q3. a) Consider the one dimensional Unsteady Thermal conduction equation.

$$\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2}$$

Prove that this equation is a parabolic equation.

b) Consider the Laplace's equation, given by :

$$\frac{\partial^2 \varphi}{\partial x^2} + \frac{\partial^2 \varphi}{\partial x^2} = 0$$

Prove that this equation is an elliptic equation.

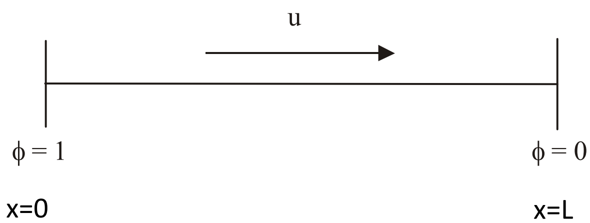
Q4. A solution of following two dimensional heat equation is desired using the simple explicit scheme. What is the stability requirement for the method?

$$\frac{\partial u}{\partial t} = \alpha \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \right)$$

Q5. Explain the donor-cell concept. Donor-cell concept is also said to be "*A cure with a cost*" elaborate on this statement. Provide a definition on the concept of convergence.

Q6. A property φ is transported by means of convection and diffusion through the one-dimensional domain sketched in figure. The governing equation is :

$$\frac{d}{dx}(\rho u \varphi) = \frac{d}{dx}\left(\Gamma \frac{d\varphi}{dx} \right)$$



The flow must also satisfy continuity equation.

Boundary conditions are φ_o =1 at x=0 and (φ_L =0 at x=L. Using five equally spaced cells and the central differencing scheme for convection and diffusion. For the following data :

u=0.1 m/s, length L=1.0 m, ρ=1.0 kg/m^3 ,Γ=0.1kg/m/s.

The analytical solution is :

$$\frac{\varphi - \varphi_0}{\varphi_L - \varphi_0} = \frac{\exp\left(\frac{\rho u x}{\Gamma}\right) - 1}{\exp\left(\frac{\rho u L}{\Gamma}\right) - 1}$$

a) Formulate the equations for each cell.

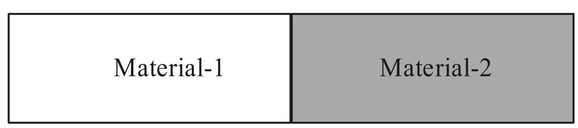
b) Find out the coefficient matrix/table

c) Solve the system of equations using TDMA

d) Plot the distribution of φ as a function of x for numerical and analytical solution on same plot.

e) Compare the results by calculation of percentage error and comment on the results.

Q7. Derive the expression to calculate diffusion coefficient (Γ) at the interfaces of the control volumes (shown in figure) using continuity of the diffusive flux at interface.



Q8. A system of algebraic equations is equivalent to its partial differential equation as the grid spacing tends to zero. Does this also mean the solution of the system of algebraic equations will approach the exact solution of the partial differential equation? Why?