U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

September / October 2023 Supplementary Examinations

Programme: B.E. **Semester: VI**
Branch: Mechanical Engineering **Duration: 3 hrs.**
Course Code: 20ME6DECFD **Max Marks: 100**
Course: Computational Fluid Dynamics

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

UNIT - I

1 a) List the different physical boundary conditions used in fluid flow and heat transfer problems. Explain one such boundary condition where both fluid flow and heat transfer is involved. **05**

b) List the advantages and disadvantages of experimental, theoretical, and computational approaches on a fluid flow problem. **05**

c) Derive an integral and conservative form of continuity equation for a finite control volume, fixed in space with fluid flowing through it. **10**

OR

2 a) What is substantial derivative?. Explain with respect to temperature field in a cartesian space. **05**

b) What are the different flow models employed in CFD? Explain any two flow models with the help of neat sketch. **05**

c) Derive the momentum equation for an infinitesimally small fluid element moving with the viscous flow in a cartesian space. **10**

UNIT - II

3 a) Show that the second-order wave equation $\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$ is a hyperbolic equation. **05**

b) What is discretization? List and briefly describe different discretization method generally used. **05**

c) With the help of suitable grids explain the forward, backward and central finite difference methods. **10**

UNIT - III

4 a) Consider the problem of source-free heat conduction in an insulated rod of 0.5 meter long whose left and right ends are maintained at constant temperatures of 100 °C and 500 °C respectively. The one- dimensional **10**

problem is governed by diffusion equation $\frac{d}{dx}\left(k\frac{dT}{dx}\right) = 0$ Thermal conductivity k equals 1000 W/m K, cross-sectional area A of rod is 10×10^{-3} m^2. Divided the computational domain into five control volumes and derive the discretised equations for inner and boundary nodes. Calculate their coefficients and express the system of equations in matrix form.

b) A large plate of thickness L = 2 cm with constant thermal conductivity k = 0.5 W/m K and uniform heat generation q = 1000 kW/m^3. The left face A and right face B are at temperatures of 100 °C and 200 °C respectively. Assuming that the dimensions in the y and z directions are so large that temperature gradients are significant in the x direction only. The 1-D heat transfer along thickness of the plate is governed by $\frac{\mathrm{d}}{\mathrm{dx}}\left(\mathrm{k}\frac{\mathrm{dT}}{\mathrm{dx}}\right) + \mathrm{q} = 0$. Divided the computational domain into five control volumes and derive the discretised equations for inner and boundary nodes. Calculate their coefficients and express the system of equations in matrix form. **10**

OR

5 a) The cooling of a circular fin is to be carried by means of convective heat transfer along its length of 1 m. Convection gives rise to a temperature-dependent heat loss or sink term in the governing equation. The cylindrical fin has uniform cross sectional area A. The base is at a temperature of 100 °C and fin tip is insulated. The fin is exposed to an ambient temperature of 20 °C. One dimensional heat transfer in this situation is governed by $\frac{d}{dx}\left(kA\frac{dT}{dx}\right) - hP(T - T_\infty) = 0$. Where h is the convective heat transfer coefficient, P the perimeter, k the thermal conductivity of the material and T_∞ the ambient temperature. Take, $n^2 = hP/(kA) = 25/m^2$ and $k\,A$ is constant. Divided the computational domain into five control volume and derive the discretised equations for inner and boundary nodes. Calculate the coefficients and express the system of equations in matrix form. **10**

b) A property ϕ is transported by means of convection and diffusion in one-dimensional domain governed by $\frac{d}{dx}(\rho u \emptyset) = \frac{d}{dx}\left(\Gamma\frac{d\emptyset}{dx}\right)$. The length of the domain (L) is 1m. The boundary conditions are, $\phi_0 = 1$ at $x = 0$ (at left face) and $\phi_L = 0$ at $x = L$ (at right face). Take $\rho = 1.0$ kg/m^3, $\Gamma = 0.1$ kg/m s, and $u = 0.1$ m/s. Using five equally spaced cells derive the discretised equations for inner and boundary nodes. Calculate their coefficients and express the system of equations in matrix form. **10**

UNIT - IV

6 a) Find the solution for the following system of linear equations using L-U decomposition method **10**

$$x_1+5x_2+x_3 = 14$$

$$2x_1+x_2+3x_3 = 13$$

$$3x_1+x_2+4x_3 = 17$$

b) Find the solution for the following system of linear equations using Gauss Seidel method approximating up to four decimal places and residual of 1×10^{-4}. Use $x_1 = 1$, $x_2 = 0$, $x_3 = 1$ as initial guess values (At least three sample calculation need to be shown or demonstrated) **10**

$$x_1+5x_2+3x_3 = 28$$

$$3x_1+7x_2+13x_3 = 76$$

$$12x_1+3x_2-5x_3 = 1$$

UNIT - V

7 a) What are the advantages and disadvantages of Stream function-Vorticity approach? **05**

b) What are the advantages and disadvantages of Primitive Variable approach? **05**

c) Explain the different types of grids used in FVM. With an example discuss how staggered grids can overcome unrealistic pressure gradient of collocated grids. **10**

******