BACHELOR OF ENGINEERING (MECHANICAL ENGG) 3rd YR 2nd SEMESTER EXAM 2024

NUMERICAL HEAT TRANSFER

Time: 3 Hours **Full Marks: 100**

Answer any Five Questions. *All the parts of a question must be answered together.*
Symbols *carry their usual meanings. Assume any missing data if required.*

1. (i) Write down Taylor Series Expansion and formulate the basic expressions for Forward, Backward, and Central differencing terms along their order of truncation errors

   (ii) Using the Finite Difference Method (FDM), discretize the following one-dimensional fin and unsteady equations: (a) $\frac{\partial^2 T}{\partial x^2} + m^2(T - T_\infty) = 0$ and (b) $\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2}$. **[20]**

2. With a neat sketch and a simple illustrating problem, explain all key steps involved in the Finite Volume Method (FVM) for one-dimensional steady-state diffusion. **[20]**

3. Apply numerical techniques in heat transfer to solve a heat conduction problem with no external sources. Consider an insulated rod with a length of 0.5 meters and a uniform cross-sectional area of 10 square millimeters. The rod's ends are maintained at constant temperatures of 100°C and 500°C, respectively. Determine the steady-state temperature distribution within the rod assuming a thermal conductivity of 1000 W/m.K. Present your computed results graphically, showing both numerical and exact solutions. **[20]**

4. For two-dimensional velocity-pressure coupled Navier-Stokes Equations, mathematically formulate the discretized Navier-Stokes and pressure-correction equations. Neatly draw mesh diagrams for velocities and pressure. **[20]**

5. Explain the properties of discretization schemes used for problems involving both convection and diffusion. Identify and discuss various sources of inaccuracy associated with numerical solutions. **[20]**

6. Formulate Central and Upwind difference schemes for a one-dimensional flow problem with a velocity field u governed by the equation:

$$\frac{d}{dx}(\rho u \phi) = \frac{d}{dx}(\Gamma \frac{d\phi}{dx}).$$

   This flow is described by the continuity equation given as $\frac{d}{dx}(\rho u) = 0$. Provide clear explanations accompanied by neat diagrams. **[20]**

7. Discuss SIMPLE and SIMPLER algorithms and explain their relative merits and demerits. Present these algorithms graphically. **[20]**

8. Write short notes on the following. Answer **ANY FOUR** **[4×5 = 20]**

   i) Continuity Equation
   ii) Tri-Diagonal-Matrix Algorithm
   iii) Navier-Stokes Equations
   iv) Phase change problems
   v) Staggered grid
   vi) Scalar Transport Equation.