B E MECHANICAL ENGG. EXAMINATION
THIRD YEAR FIRST SEMESTER 2025
Subj: NUMERICAL HEAT TRANSFER

Time: Three hours **Full Marks: 100**

Answer Q. 1 (compulsory) and any four (4) questions from the rest
All parts of a question must be answered together- marks shall be deducted for scattering answers in different places.
First five answers will be evaluated – so do not attempt more than five questions.

1 (a) Explain the concept of discretization error and round off error.
(b Define Cell Pellet Number? How the value of this number can be modified?
(c) Calculate the allowable time step size for calculation of duct flow with inlet velocity of 10 m/s. The duct has been meshed with 50 cells along diameter of 30 cm.
(d) In the algebraic equation of finite difference form of a partial differential equation, the coefficients for the neighboring four points are 2,3,2,2 respectively. If the values at the four points are 10,12,12,10 respectively, find out the value of the variable at the central node.
(e) Explain the concept of staggered grid.
(f) Discuss the complexities in solving fluid dynamical problem

4+(2+1)+2+2+4+5

2 a) Derive an expression for obtaining the temperature gradient $\frac{\partial T}{\partial y}$ with second order accuracy using one sided (forward difference) scheme.
(b) Develop an expression for stability criterion for the equation: $\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2}$

8+12

3.(a) What is transportive property? Demonstrate that transportive property is violated for central difference but retained for unwinding for the equation

$$\frac{\partial \emptyset}{\partial t} + u\frac{\partial \emptyset}{\partial x} = 0$$

(b) Discretize the equation with grid spacing's of Δx and Δy, respectively in x and y –direction

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

12+8

[Turn over

4 (a)Consider the equation $\frac{\partial T}{\partial t} = \alpha(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2})$. Show the explicit and implicit form of the discretized equation considering Forward in Time Central in Space (FTCS) formulation. Compare the merits and draw-backs of these schemes.

(b) Explain the ADI scheme for the above equation.

(c) You are solving thermal field in a metal rod with thermal diffusivity of 0.01 m^2/s. The rod is 40 cm in length where 50 cells are considered. What is the maximum allowable time step size?

(10+2)+6+2

5. (a)Using central difference and unwinding , develop the finite volume ormulation for a 1-D convection-diffusion equation

$$\rho u \frac{\partial \phi}{\partial x} = \Gamma \frac{\partial^2 \phi}{\partial x^2}$$

(b) Sketch the function Q(Pe) and state the limiting values. Show the approximations for central difference, upwinding and hybrid scheme (write the expressions separately). Use Graph paper.

(8+4)+8

6. (a) Integrate the continuity equation over a two dimensional control volume with grid spacing Δx and Δy

(b) Describe the SIMPLE Scheme with necessary steps.

5+15