B E MECHANICAL ENGG. EXAMINATION
THIRD YEAR FIRST SEMESTER 2024
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) Write down the governing equations for solving flow and temperature field considering three dimensional incompressible flow. Discuss the complexities of solving the equations of fluid flow.
(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) What do you mean by under-relaxation – explain with example.
(e) In the algebraic equation from, the coefficients for the neighboring four points are 2,4,2,2 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.
(f) Explain the concept of grid independence.

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

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

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

(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) Derive an expression for obtaining first derivative with second order accuracy using one sided (forward difference) scheme. Hence calculate the gradient if nodal values are 10, 20 and 40 with a distance of 1 unit between successive points.

(2+12)+6

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 implicit form of the discretized equation considering Forward in Time Central Space (FTCS) formulation and hence formulate the matrix required for solution of the problem. What are the advantages and draw-backs of implicit scheme over explicit scheme.

(b) 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?

(6+8)+4+2

5. (a)Using central difference, develop the finite volume formulation 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.

12+8

6. Explain the concept of staggered grid and its role in solving fluid mechanical problem. Describe the SIMPLE Scheme with necessary steps.

5+15