MASTER OF MECHANICAL ENGG. 1st Yr 1st SEM EXAMINATION 2018

Subj: COMPUTATIONAL HEAT TRANSFER

Time: 3hrs **Total Marks:100**

Use separate answer script for each part

Part I : Full Marks 50

Answer any two questions

Q: 1. Consider the equation $\frac{\partial u}{\partial t} + c\frac{\partial u}{\partial x} = 0$. If $\frac{\partial u}{\partial t}$ is discretized as $\frac{\partial u}{\partial t} = \frac{u_i^{n+1} - \frac{1}{2}(u_{i+1}^n + u_{i-1}^n)}{\Delta t}$ and $\frac{\partial u}{\partial x}$ is discretized using central difference scheme, show that the discretization scheme is conditionally stable. Find the condition of stability. 25

Q:2(a) Consider the equation $\frac{d^2T}{dx^2} - m^2T = 0$. Discretize the equation considering finite difference or finite volume scheme. How is convective boundary condition discretized? 15

(b) Using Taylor series approach, develop a second order accurate backward differencing scheme for discretization of dy/dx 10

Q: 3(a) Derive the expressions for dy/dx and d^2y/dx^2 using Pade-2 scheme. 12

(b) Classify the following equations as hyperbolic, parabolic or elliptic: 8

$$\frac{\partial^2 c}{\partial t^2} = a^2 \frac{\partial^2 c}{\partial x^2}$$

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

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

(c) Discuss the implication of hyperbolic, parabolic and elliptic equations for CFD analysis. 5

PART: II Full Marks 50

Answer question No. 1 and any two (2) from the remaining questions.

NB: Assume any data, if not furnished, consistent with the problem

1a) Write down the energy equation in 3-d Cartesian coordinate and mark the convective and diffusive terms? 2

b) Define Cell Pellet Number? How the value of this number can be modified? 4

c) Sketch the function Q(Pe) and state the limiting values. Show the approximations for central difference, upwinding and hybrid scheme (write the expressions separately). 8

Use Graph paper.

d) A variable was initially 100 and after computation assumes a value of 99. If the variable is undereralxed by a factor of 0.8, what should be the current value of the variable 1

e) Explain staggered grid and its advantages. 3

2 a) Using central difference, derive the finite volume coefficients for a 1-D problem, for the equation 10

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

b) Show that use of upwinding scheme do not produce unrealistic result taking positive sign of velocity ($u > 0$) and nodal values of ϕ bounded at 1 and 0. 6

3. Discuss the complexities in solving convection equation and hence briefly outline the SIMPLE scheme.. 16

4a) Explain the concept of artificial viscosity using an appropriate equation. 8

b) Derive the finite difference coefficients A_P A_E ... A_s (five points) for steady conduction equation in a 2-D rectangular domain assuming uniform mesh. 8