**MASTER OF MECHANICAL ENGG. 1ST SEM EXAMINATION 2017**

**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

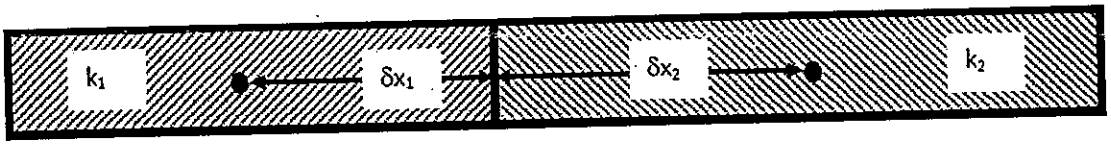
Q:1. Consider the equation $\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2}$. Show that the Forward Time Central Space (FTCS) scheme of discretisation of the above equation is conditionally stable. Find the condition for stability. 25

Q: 2 (a). Consider the following equation $\frac{\partial^2 T}{\partial x^2} + (p - qT^2)$ where p and q are positive constants. Using Finite Volume method, discretize the equation and express the discretized equation in the form

$a_p T_p = a_E T_E + a_W T_W + b$

where the symbols have standard meaning. 9

(b) Consider two dissimilar materials having thermal conductivities $k_1$ and $k_2$. Derive an expression for effective thermal conductivity at the interface of the two materials as shown below in the figure for calculation of interfacial flux in a finite volume formulation. 8




(c) Explain Pade scheme of discretization. 8

Q:3 (a) Consider a second order equation for the variable $u(x,y)$ of the form

$$A\frac{\partial^2 u}{\partial x^2} + B\frac{\partial^2 u}{\partial x \partial y} + C\frac{\partial^2 u}{\partial y^2} + D\frac{\partial u}{\partial x} + E\frac{\partial u}{\partial y} + Fu + G = 0$$

where A, B, C, D, E, F, G are constants. Determine the conditions under which the above equation becomes parabolic, elliptic or hyperbolic. 15

Consider the one-dimensional wave equation given by $\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2}$. Find out the region influencing the solution of any point in t-x plane. 5

(b) Classify the following equations as parabolic, hyperbolic or elliptic: 5

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

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

Q:4 (a) Derive the equation for conservation of mass for finite-sized and infinitesimal fixed control volumes. Show that they are equivalent. 15

b) Derive second order accurate forward difference expression for $\frac{dy}{dx}$ on a uniform grid. 5

c) What is the difference between discretization error and truncation error? 5

**Part: II** **Full Marks 50**

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

1a) Name the basic steps for analyzing a problem using CFD 2

b) A variable P has a initial value of 100 and after computation assumes a value of 101. If the variable is undereralxed by a factor of 0.8, what should be the final value of P. 2

c) In the algebraic equation from, the coefficient of the concerned point is 8 and the coefficients for the neighboring four points are 2,3,2,3 respectively. If the values at the four points are 10,12,12,10 respectively, find out the value of the variable. 3

d) 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 7

2 a) Define Cell Pellet Number and what does it signify? How the value of this number can be modified? 5

b) Explain the upwinding scheme and why it is needed? What is the accuracy of Quick scheme. 5

c) Sketch the function Q(Pe) and clearly show the approximations for central difference, upwinding and hybrid scheme (write the expressions separately). Use Graph paper 8

3 .a) What are the reasons for the difficulty of solving the momentum equation? In this connection, discuss how SIMPLE scheme works.. 15

b) What do you mean by staggered grid explain with sketch. 3

4 a) Develop the procedure for finite volume formulation for one dimensional convection. 10

B) Derive the expression for the eastern node at e (between P and E) using QUCIK formulation 8