Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL

A Constituent Institution of Manipal University

VI SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

MAKEUP EXAMINATION, JUNE 2017

SUBJECT: COMPUTATIONAL FLUID DYNAMICS [AAE 4002]

REVISED CREDIT SYSTEM
(20/06/2017)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

1A. Consider an irrotational, two dimensional, inviscid, steady flow of a compressible gas with following equations. **(05)**

$$(1 - M_\infty^2)\frac{\partial u'}{\partial x} + \frac{\partial v'}{\partial y} = C$$

$$\frac{\partial u'}{\partial y} - \frac{\partial v'}{\partial x} = 0$$

Where, $u = V_\infty + u'$, $v = v'$

Classify these equations through Cramer's rule and the Eigenvalue method.

1B. Consider the function $\phi(x,y) = e^x + e^y$. Consider the point $(x,y) = (1,1)$ **(05)**

Calculate:

a) The exact values of $\frac{\partial \phi}{\partial x}$ and $\frac{\partial \phi}{\partial y}$ at this point

b) Use first order forward and backward differences with $\Delta x = \Delta y = 0.1$, to calculate approximate values of $\frac{\partial \phi}{\partial x}$ and $\frac{\partial \phi}{\partial y}$ at point (1,1). Calculate the % of difference when compared with exact values from previous step (a).

c) Use second order forward and backward differences with $\Delta x = \Delta y = 0.1$, to calculate approximate values of $\frac{\partial \phi}{\partial x}$ and $\frac{\partial \phi}{\partial y}$ at point (1,1). Calculate the % of difference when compared with exact values from previous step (a).

2A. Use the Explicit and Implicit finite difference methods to solve for the temperature distribution of long thin rod with the length of 10cm and the following values are Δx=2cm, Δt=0.1s. At t=0 the temperature of the rod and the boundary conditions are fixed for all times at T(0)=90deg and T(10)=55deg. Represent calculated answeres through a tridiagonal matrix. $(\lambda = \frac{k\Delta t}{(\Delta x)^2} = 0.025)$ **(05)**

2B. Use Liesmann's method (Gauss-Seidel) to solve for the temperature of the heated plate which given in the below figure 1. Employ the over relaxation within the value of 1.5 for the weighing factor and go with minimum 2 iterations and write the error percentage. **(05)**

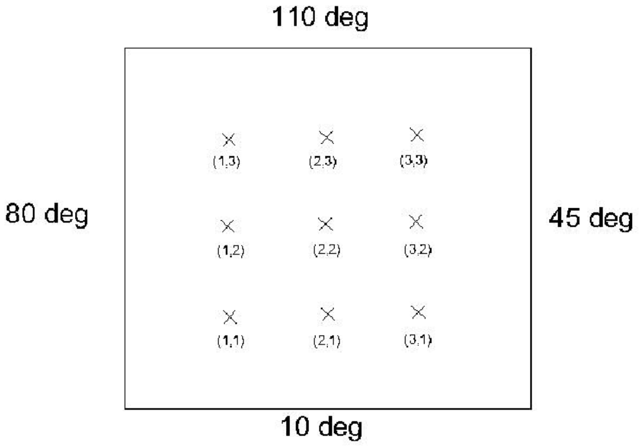


Figure-1

3A. Use forward and backward difference approximations of Order of (h) and a centered difference approximation of Order of (h^2) , **(05)**

$f(x) = -0.1x^4 - 0.15x^3 - 0.5x^2 - 0.25x + 1.2$

a) Estimate the 1st derivative of above equation at x=0.5 using step size h=0.4, where h=$(x_{i+1} - x_i)$

b) Repeat the computation by using step size h=0.2.

c) Finally conclude which step is more accurate between centered difference and forward or backward differences.

3B. Use finite volume method for a plate of thickness 3cm with constant thermal conductivity k =0.6W/m.K and uniform heat generation q=1200kW/m^3. Both left and right hand sides of the plate temperature are 110deg and 200deg respectively. Assuming that the heat generation happening only along the thickness of the plate. If then calculate the steady state temperature distribution along the plate. (Δx=0.006m) **(05)**

$$\frac{d}{dx}\left(k\frac{dT}{dx}\right) + q = 0$$

4A. Write down the advantages & disadvantages of Explicit and Implicit approaches in computational methods. **(05)**

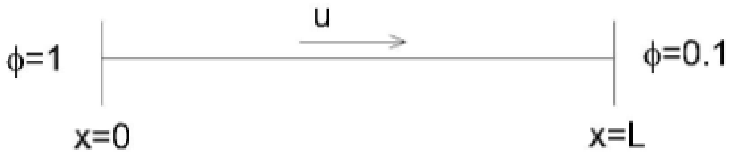
4B. Consider a thin flat plate with thickness of 2cm, constant thermal conductivity k=0.6W/m.K and uniform heat generation q=1000kW/m^3. The left and right hand side temperatures are 100 deg and 200 deg respectively. Assuming that the temperature gradient is dominant in the thickness direction. If then calculate the steady state temperature distribution by using finite volume method. **(05)**

Given parameters are: number of grids=5, A=1 and solve TDMA.

$$\frac{d}{dx}\left(k\frac{dT}{dx}\right) + q = 0$$

5A Explain the difference between Shock fitting and Shock capturing methods. **(04)**

5B. Solve the property gradient of a thin rod by using the central differencing scheme in finite volume method. **(06)**



Given parameters are: number of grids=5, u=0.2m/s, F=ρu, D=$\Gamma/\delta x$, F_e=F_w=F, D_e=D_w=D, Solve the TDMA to find the solution.

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