Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

VI SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, APRIL/MAY 2017

SUBJECT: COMPUTATIONAL FLUID DYNAMICS [AAE 4002]

REVISED CREDIT SYSTEM
(27/04/2017)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A. Differentiate between analytical, experimental and computational methods in the application of engineering. Write down the advantages and disadvantages among the methods. **(03)**

1B. Differentiate between conservative and non-conservative form of governing equations and explain their applications. Write down the Reynolds transport equation and show from this equation how we can derive continuity equation. **(03)**

1C. Derive the classification of quasi linear partial differential equations and explain its applications. **(04)**
Consider the following equations as quasi linear equations

$$a_1\frac{\partial u}{\partial x}+b_1\frac{\partial u}{\partial y}+c_1\frac{\partial v}{\partial x}+d_1\frac{\partial v}{\partial y}=f_1$$

$$a_2\frac{\partial u}{\partial x}+b_2\frac{\partial u}{\partial y}+c_2\frac{\partial v}{\partial x}+d_2\frac{\partial v}{\partial y}=f_2$$

2A. Use the explicit and implicit methods to solve for the temperature distribution of a long thin rod with a length of 15cm and with the followings values Δx=0.3cm, Δt=0.2s. At t=0, the temperature of the rod is zero and the boundary conditions are fixed for all times of T(0)=110 deg and T(15)=60 deg. **(05)**

$$\lambda=\frac{k\Delta t}{(\Delta x)^2}=0.0354$$

Do the calculation with minimum 2 iterations and for implicit method use TDMA to solve and compare the values with explicit methods.

2B. Consider the visocus flow over a flat plate with following velocity profile (Figure-1) and equation $u = 1645\left(1 - e^{-\frac{y}{3}}\right)$ **(05)**

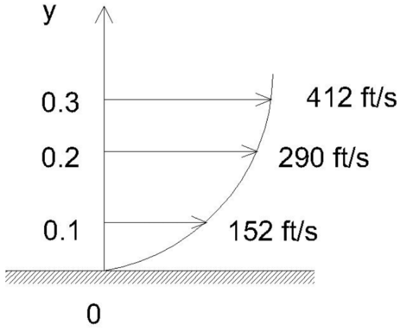


Figure-1

Given parameters are : L (characteristic length)=1 in, u= feet per second, μ= 3.756 x 10^{-7} slug/ft.s, Δy=0.1 in.

Calculate the shear stress at the wall with following conditions.

a) By using 1st order one sided difference method
b) By using 2nd order one sided differenece method
c) By using 3rd order one sided differenece method
d) Compare all the above 3 values with exact value

3A. Use Liesmann's method (Gauss-Seidel) to solve for the temperature of the heated plate which is given in the figure 2. Employ the over relaxation within the value of 1.2 for the weighing factor and go with minimum 2 iterations and write the error percentage. **(05)**

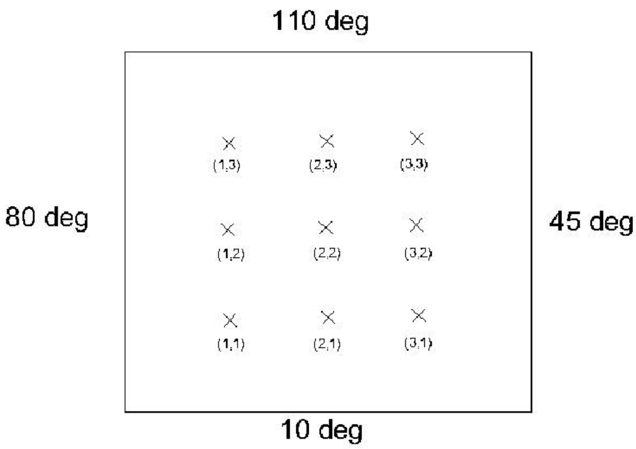


Figure-2

3B. Use forward and backward difference approximations of Order of (h) and a centered difference approximation of Order of (h^2) , **(03)**

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

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.

3C. Write down the advantages and disadvantages of high order accuracy methods. **(02)**

4A. What is body fitted coordinate system and what is the advantage of this grid generation? Explain in detail about stretched grid and how can we convert this into transformed variable grid. **(02)**

4B. Explain the basic finite volume method procedures and prove it through an example of one dimensional steady state diffusion problem. **(04)**

$$\frac{d}{dx}\left(\Gamma\frac{d\phi}{dx}\right) + s = 0$$

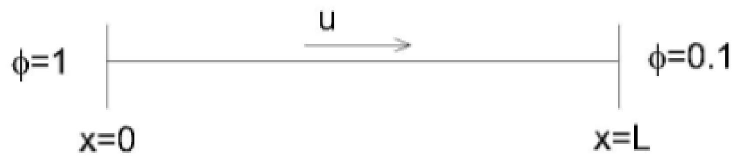
4C. Consider a thin flat plate with thickness of 2cm, constant thermal conductivity k=0.6W/m.K and uniform heat generation q=1200kW/m^3. The left and right hand side temperatures are 120 deg and 210 deg respectively. Assuming that the temperature gradient is dominant in the thickness direction. If then calculate the steady state temperature distribution by using finite volume method. **(04)**

Given parameters are: number of grids=5, A=1.2 and solve TDMA.

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

5A Explain in detail about the properties of discretization schemes. **(03)**

5B. Solve the property gradient of a thin rod by using the central differencing scheme in finite volume method. **(05)**



Given parameters are: number of grids=5, u=0.1m/s, F=ρu, D=Γ/δx, F_e=F_w=F, D_e=D_w=D, Solve the TDMA to find the solution.

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

5C. What is upwind differencing scheme? How is it different from QUICK scheme? **(02)**