

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination, April-May 2018

B. Tech in Chemical Engineering, Semester VI

Roll No.....

ME625 : Computational Fluid Dynamics

Time: 3 hours

Max. Marks: 100

Instructions to students:

1. Do not write anything other than your roll number on question paper.
2. Assume suitable data wherever required and mention it clearly.
3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.

Q.1A Objective type multiple choice questions (10 questions @ 1 mark)

10

- i. When an ideal fluid flows past a sphere,
 - a) highest intensity of pressure occurs around the circumference at right angles to flow
 - b) lowest pressure intensity occurs at front stagnation point
 - c) lowest pressure intensity occurs at rear stagnation point
 - d) total drag is zero
- ii. Centre of buoyancy always
 - a) coincides with the centre of gravity
 - b) coincides with the centroid of the volume of fluid displaced
 - c) remains above the centre of gravity
 - d) remains below the centre of gravity
- iii. A rectangular block 2 m long, 1 m wide and 1 m deep floats in water, the depth of immersion being 0.5 m. If water weighs 10 kN/m³, then the weight of the block is
 - a) 5kN
 - b) 10kN
 - c) 15 kN
 - d) 20 kN
- iv. When a liquid rotates at a constant angular velocity about a vertical axis as a rigid body, the pressure intensity varies
 - a) linearly with radial distance
 - b) as the square of the radial distance
 - c) inversely as the square of the radial distance
 - d) inversely as the radial distance
- v. The eddy viscosity for turbulent flow is
 - a) a function of temperature only
 - b) a physical property of the fluid.
 - c) dependent on the flow
 - d) independent of the flow
- vi. The continuity equation for steady compressible flow can be written as
 - (a) $\partial u_m / \partial x_m = 0$
 - (b) $\partial u_i / \partial x_j = 0$
 - (c) $D\rho / Dt = 0$
 - (d) none of the above

- vii. The steady-state, 2-D momentum balance in the y-direction, neglecting gravity, can be written for constant property flow as
- $u \partial u / \partial x + v \partial v / \partial y = -1/\rho \partial p / \partial x + \mu/\rho (\partial^2 u / \partial x^2 + \partial^2 v / \partial y^2)$
 - $u \partial v / \partial x + v \partial v / \partial y = -1/\rho \partial p / \partial y + \mu/\rho (\partial^2 v / \partial x^2 + \partial^2 v / \partial y^2)$
 - $u \partial v / \partial x + v \partial v / \partial y = -1/\rho \partial p / \partial y + \mu/\rho (\partial^2 u / \partial x^2 + \partial^2 v / \partial y^2)$
 - None of the above
- viii. The adiabatic heat transfer thermal boundary condition is an example of which type of boundary condition:
- Dirichlet type
 - Neumann type
 - Robin type
 - None of the above.
- xi. If we expand $f(x_0 - 3\Delta x)$ about the point x_0 in Taylor series, then the fourth term in the expansion is given by
- $-(1/6) d^3f/dx^3|_{x_0} \Delta x^3$
 - $-9/2 d^3f/dx^3|_{x_0} \Delta x^3$
 - $(9/2) d^3f/dx^3|_{x_0} \Delta x^3$
 - $(9/2) d^2f/dx^2|_{x_0} \Delta x^2$
- x. Which of the following statements is correct about solution of the linear system of algebraic equations $Ax = b$ with known coefficients:
- If Gaussian elimination works, then Gauss-Seidel method can also be used.
 - If Gauss-Seidel method works, then Gaussian elimination can also be used.
 - If Gauss-Seidel works, then TDMA can also be used.
 - If LU decomposition works, then TDMA can also be used.

Q.2 Short answer type questions (4 questions @ 2.5 marks) 10

- What is the difference between uniform grid and staggered grid?
- What is the full form of SIMPLE?
- Differentiate between implicit and explicit formulations.
- What is a staggered grid and why is it required for the solution of pressure velocity coupled problems?

Q.3A What are the difficulties in solving of Navier-stokes equations? 05

Q.3B Write a note on 05

- Turbulence modeling
- Numerical errors

Q.4A For the following equation 05

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

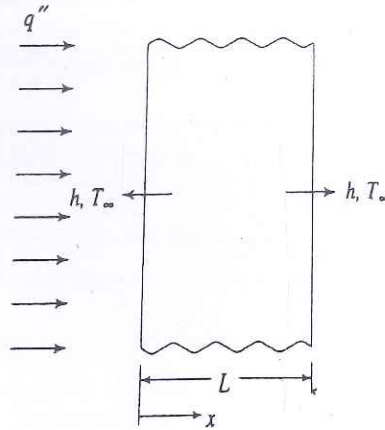
Using implicit method, write algebraic equations for 4*4 grids.

Q.4B Derive the forward and central difference, approximation to the first derivative, along with the leading error term. 05

Q.5 Write the vorticity-stream function for Navier-stokes equations. 05

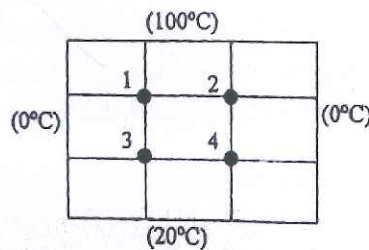
Q.6 Consider the wall of a house of thickness L. the inside and outside ambient temperature and the heat transfer coefficient are the same say T_∞ and h. the net radiation heat flux between the sun and the outer surface of the wall is q. formulate the problem by finite difference approximation so that you can calculate the steady-state heat transfer to the house take 10

$q''=1353\text{W/m}^2, K=0.69\text{W/m}^\circ\text{C}, h=8\text{W/m}^2\text{K}, T_\infty=30^\circ\text{C}$ and $L=0.5\text{m}$.



- Q.7 Consider A two dimensional problem with uniform grid spacing along x and y direction and constant density. velocity in west (u_w) and south (v_s), pressure at north and east points are given as 50, 20, 0 and 10 respectively and momentum equations are given as follows $u_e = d_e(P_P - P_E)$ and $v_n = d_n(P_P - P_N)$ here $d_e = 1$ and $d_n = 0.6$. obtain u_e , v_n and P_P by using SIMPLE Algorithm. 15

- Q.8A Consider steady state heat conduction in a square region, subjected to the boundary conditions show in figure. Use mesh size $\Delta x = \Delta y$ and determine the node temperature indicated below. 15



- Q.8B Solve the following differential equation using Galerkin and least square method in term of $u(x) = C_0 + C_1x$. Find the percentage error and compare approximate solution with exact solution. 15

$$\frac{d^2u}{dx^2} + x^2 = 0 \quad \text{for } 0 \leq x \leq 1$$

$$\text{With } u(0)=0 \text{ and } \frac{du}{dx}(1) = 1$$

OR

- Q.8B Find the solution of X using Thomas algorithm $x_1 + 2x_2 + 4x_3 = 3$, $3x_1 + 8x_2 + 14x_3 = 13$ and $2x_1 + 6x_2 + 13x_3 = 4$. 15