Ex/ME(M2)/ES/B/T/124/2023

BACHELOR OF MECHANICAL ENGINEERING EXAMINATION, 2023

(1st Year, 2nd Semester)

FLUID MECHANICS I

Time : Three hours — Full Marks : 100

Answer any five questions

Assume any data related to the questions if not given, with proper reasoning

1. a) Define the dynamic and kinematic viscosity of a fluid and provide the units in S. I. system. Also explain how it changes with temperature for liquids and gases respectively. (2+2+1+5=10)

   b) Two large fixed parallel planes are 12 mm apart. The space between the surfaces is filled with oil of viscosity 0.972 N-s/m^2. A flat thin plate of 0.25 m^2 area moves through the oil at a velocity of 0.3 m/s. Draw the velocity distributions and calculate the drag force:

   (i) When the plate is equidistance from both the planes, and

   (ii) When plate is at a distance of 4 mm from one of the plane surfaces.

   (10)

2. (a) With a neat sketch explain the working principal of a U-tube differential Manometer. (10)

   (b) In Figure 1, a U-tube differential manometer connecting two pressure pipes at A and B respectively.

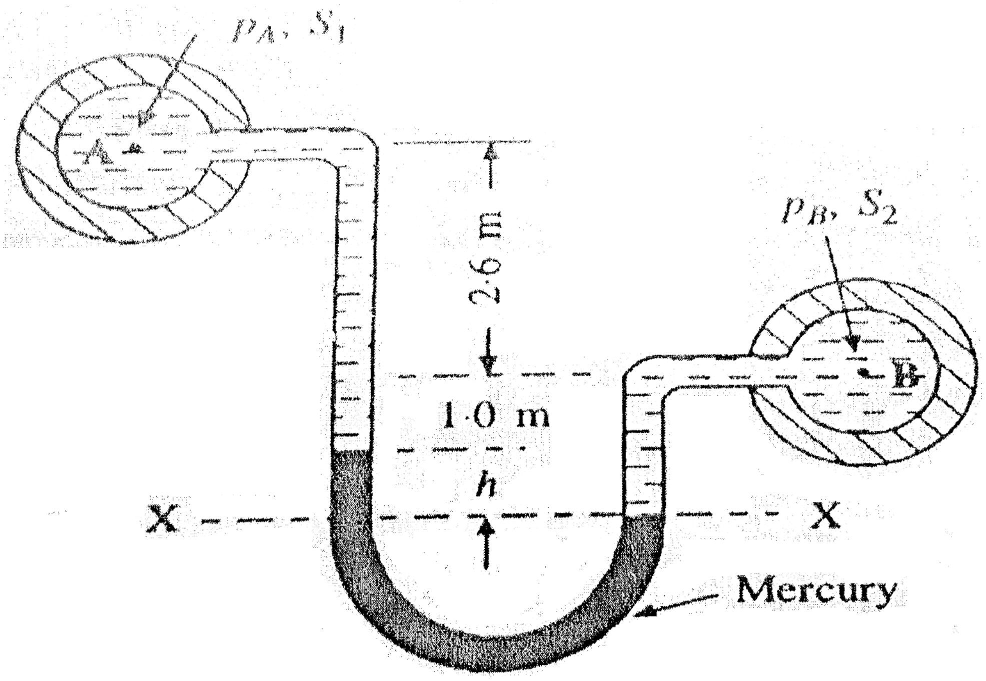

Figure 1, question 2 (b)

The pipe A contains a liquid of specific gravity 1.6 under a pressure of 110 KN/m^2. The pipe B contains oil of specific gravity 0.8 under a pressure of 200 KN/m^2. Find the difference of pressure measured by mercury as fluid filling the U-tube. (10)

3. (a) Find the total thrust on an inclined plane surface submerged in a fluid with an angle of inclination θ with the horizontal with a neat sketch. Also locate the centre of pressure. (10)

(b) In Figure 2, a curved surface LM has been shown, which is in the form of a quadrant of a circle of radius 3 m, immersed in the water. If the width of the gate is unity, calculate the horizontal and vertical components of the total force acting on the curved surface. Also calculate the total force and its direction w.r.t. horizontal.

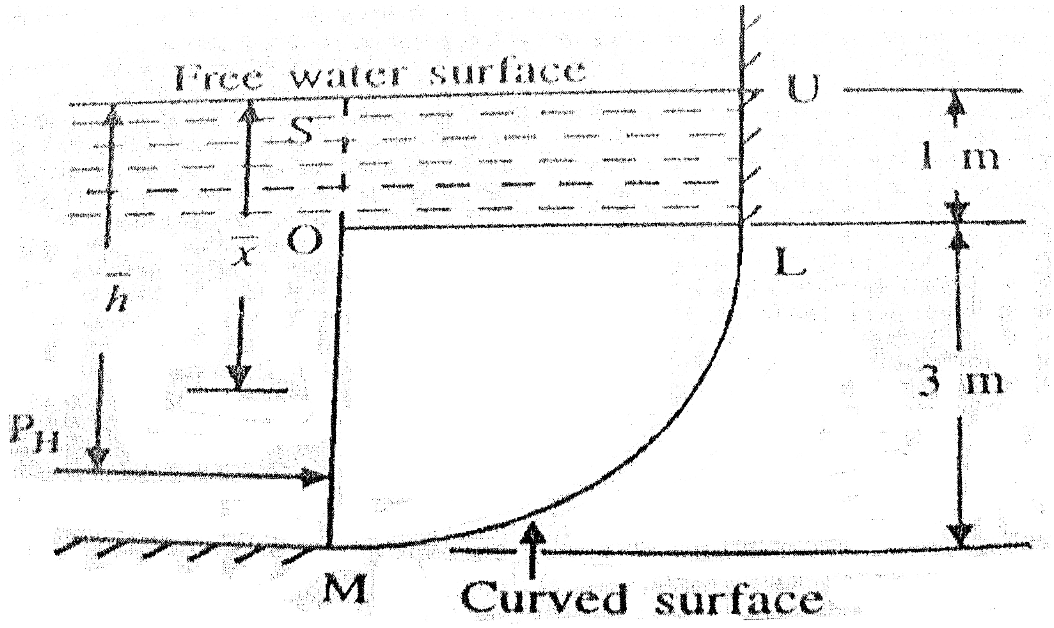

Figure 2, question 3 (b)

4. a) Derive the 3-D continuity equation for an unsteady fluid flow system. (10)

   b) In a two dimensional fluid flow system the x-component of velocity, u and y-component of velocity, v are given by the following relations: $u = 4ax(x^2 - 3y^2)$ and $v = 4ay(3x^2 - y^2)$ respectively. Calculate the x and y component of the acceleration at steady state condition. Examine whether these velocity components represent a physically possible two-dimensional flow. If so, determine whether the flow is rotational or irrotational. (10)

5. a) Derive Euler equation of motion for the flow through a stream line along with the assumptions you follow to do so. From this equation, derive Bernoulli equation and explain the terms. (10)

b) A tapering pipe line carrying oil of specific gravity 0.8 changes in diameter from 300 mm at position 1 to 600 mm diameter at position 2 which is 5 m at a higher level than the position 1. If the pressures at positions 1 and 2 are 100 k-N/m^2 and 60 k-N/m^2 respectively and the discharge is 300 litres/s, determine the following:

i) the head loss and ii) the direction of the flow. (10)

6. a) With a neat diagram explain the working principle of a venturimeter. What is co-efficient of discharge? (10)

b) In Figure 3, a reducing bend of angle 60° in a pipeline has been shown. The diameter of the bend initially i.e. at section 1-1 is 300 mm and the final diameter i.e. at section 2-2 is 150 mm respectively. The pipeline carrying water with a discharge rate, Q = 360 litres/s. The pressure at the commencement of the bend i.e. at section 1-1 is P_1 = 2.943 bar. The frictional loss in the pipe bend may be assumed to be as 10% of the kinetic energy at the exit of the bend i.e. at section 2-2. Determine the force exerted by the reducing bend and its direction of action. (10)

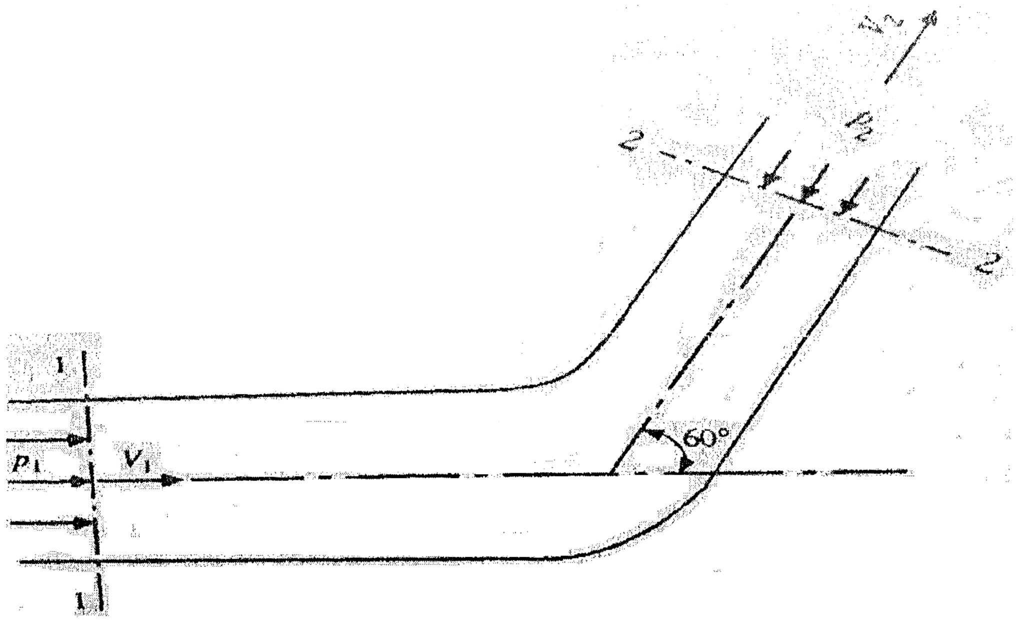

Figure 3, question 6 (b)

7. a) What is a fully developed flow? Deduce Hagen-Poiseuille equation for a laminar fully developed flow through a circular pipe. (08)

   b) What is friction factor? Show that for a laminar fully developed flow friction factor $f = \frac{64}{\text{Re}}$ (06)

   c) A fluid of viscosity 8 poise and specific gravity 1.2 is flowing through a circular pipe of diameter 100 mm. The maximum shear stress at the pipe wall is 210 N/m^2. Find

   i) the pressure gradient

   ii) the average velocity

   iii) Reynolds number. (06)

8. Write short notes on any of the four:

   i) Meta centre and Metacentric height

   ii) Stream function and Velocity potential

   iii) Circulation and irrotational flow

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iv) Laminar and Turbulent Flow

v) V-notch weir

vi) Specific energy curve of open channel flow

vii) Pitot tube