Ref. No. : Ex/ME(M2)/ES/B/T/124/2024

B. E. MECHANICAL ENGINEERING FIRST YEAR SECOND SEMESTER EXAM. 2024

FLUID MECHANICS I

Time : 3 Hours **Full Marks: 100**

Answer any five questions

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

1. a) What is Newton's law of viscosity? What are Newtonian fluids and non-Newtonian Fluids? Give two examples of each. Draw the Shear stress vs. velocity gradient for Newtonian fluids and non-Newtonian fluids. (2+2+1+3=08)

b) If the velocity profile of a fluid over a flat plate is parabolic with the vertex 20.75 cm from the plate, where the velocity is 120.75 cm/s. Calculate the velocity gradients and shear stresses at a distance of 0, 10.5 and 20.75 cm from the plate respectively, if the viscosity of the fluid is 8.75 poise. Draw the velocity profile and shear stress distribution along the normal direction. (12)

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

(b) In Figure 1, a differential manometer is connected at two points of A and B respectively. At B the air pressure is 9.81N/cm^2 (Absolute), find the absolute pressure at A.

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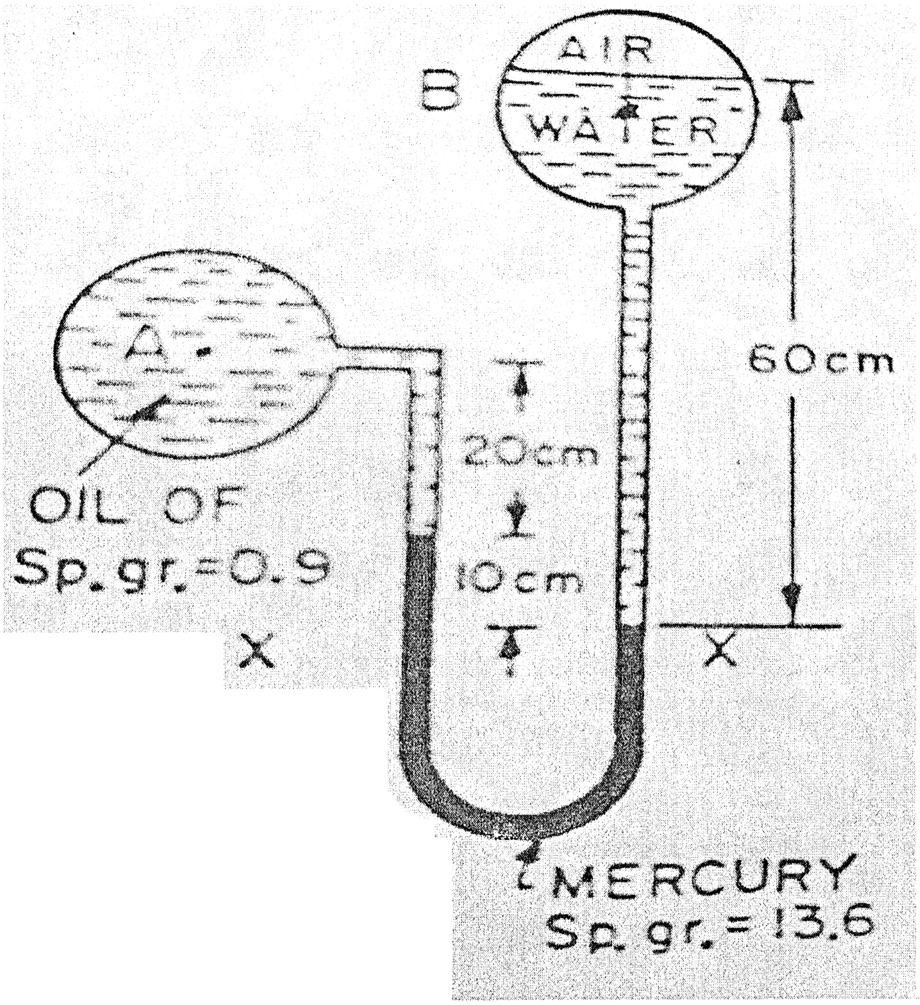

Figure 1, question 2 (b)

(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 circular plate 1.5 m diameter is submerged in water, with its least and greatest depths are below the surface as 0.75 m and 2 m respectively. Determine,

1. The total hydrostatic force on one face of the plate
2. The position of the centre of pressure. (10)

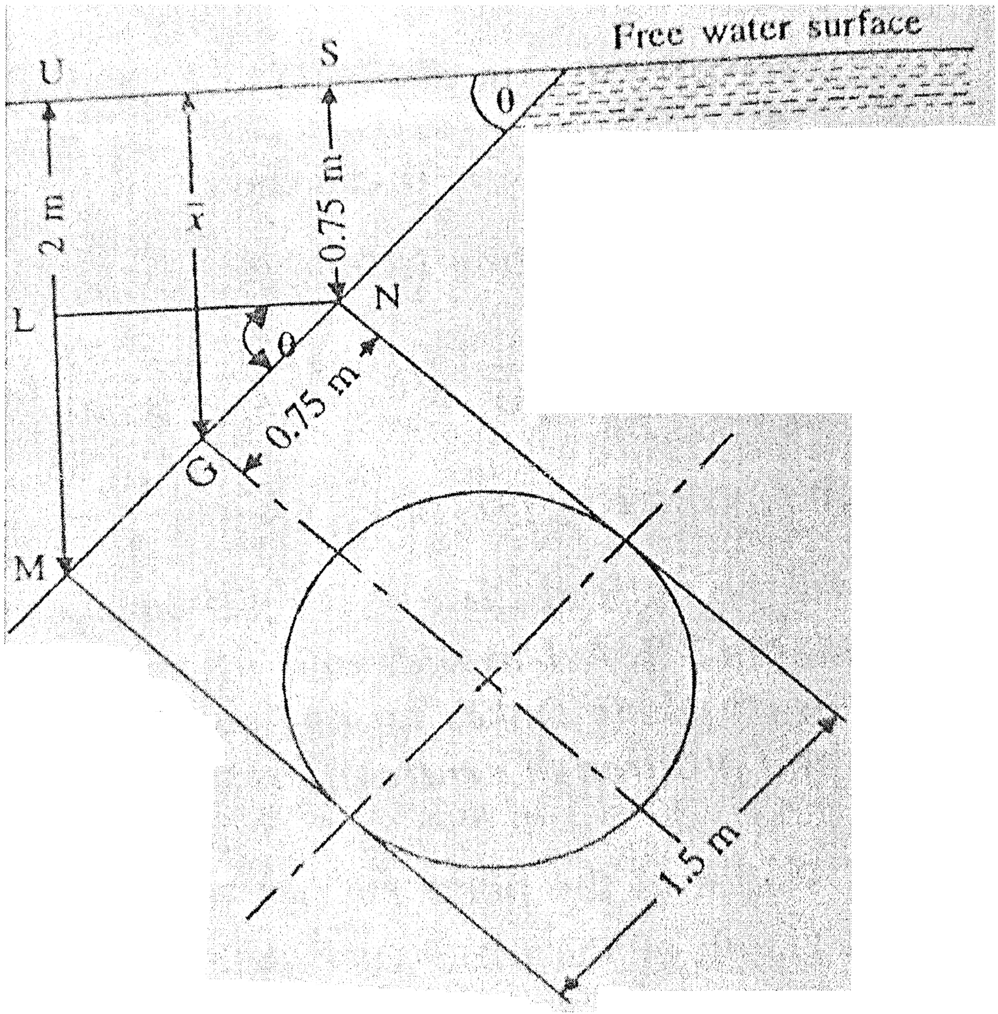

Figure 2, question 3 (b)

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

b) Find the velocity and acceleration at a point (2, 3, 4) after 1.5 second for a three dimensional and unsteady fluid flow system given by:
$u = (yz+t)$ m/s, $v = (xz-t)$ m/s and $w = xy$ m/s. (10)

5. a) Write down clearly the assumptions and derive Euler equation of motion for the flow through a stream line also from this equation, derive Bernoulli equation and explain the terms. (10)

b) A 6 m long pipe is inclined at an angle of 20° with the horizontal. The smaller section of the pipe which is at lower level is of 100 mm diameter and the larger section of the pipe is of 300 mm diameter as shown in the figure 3. If the pipe is uniformly tapering and the velocity of water at the smaller section is 1.8 m/s, determine the difference of the pressures between the two sections, considering (1) no loss of head and (2) a loss of 0.5 m of head. (10)

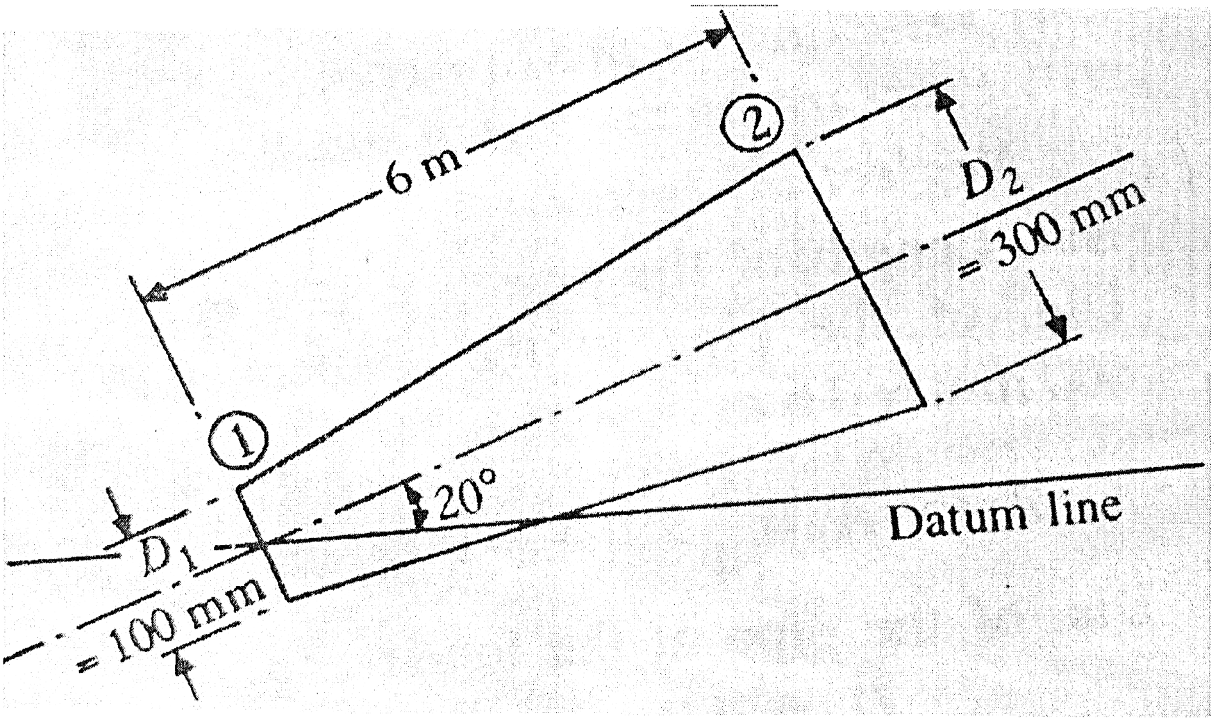

Fig. 3, question no 5(b)

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

b) In Figure 4, a reducing bend of angle 55° in a pipeline has been shown. The diameter of the bend initially i.e. at section 1-1 is 310 mm and the final diameter i.e. at section 2-2 is 160 mm respectively. The pipeline carrying water with a discharge rate, Q = 370 litres/s. The pressure at the commencement of the bend i.e. at section 1-1 is P_1 = 2.953 bar. The frictional loss in the pipe bend may be assumed to be as 10.5% 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)

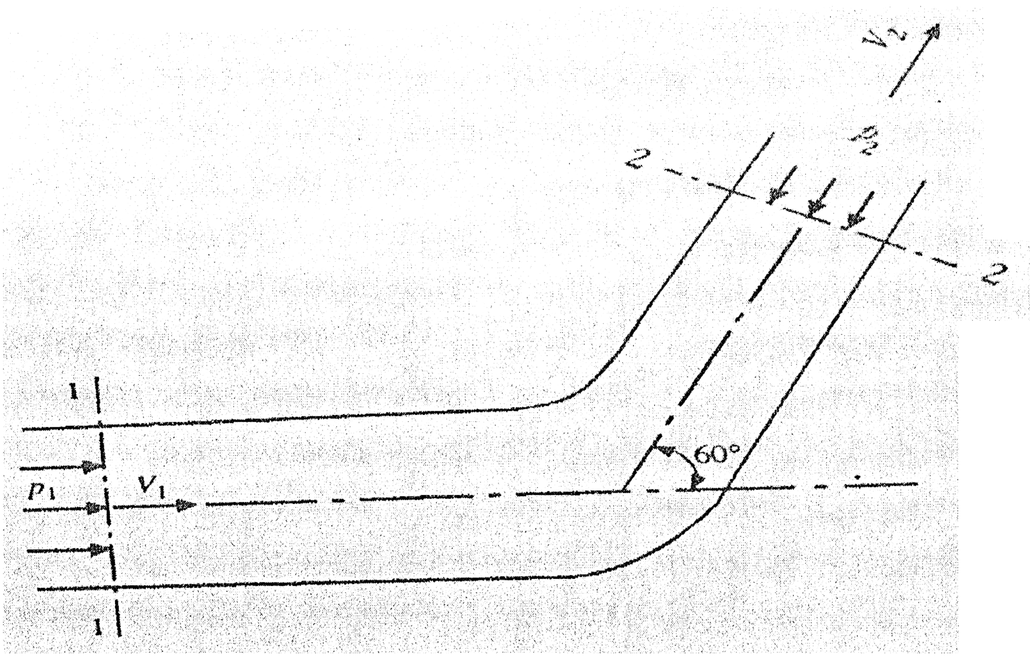

Figure 4, question 6 (b)

7. a) With a neat diagram explain the fully developed flow. Deduce Hagen-Poiseuille equation for a laminar fully developed flow through a circular pipe. (03+07=10)

b) What is friction factor and write Blasius expression for friction factor for turbulent flow. Show that for a laminar fully developed flow friction factor $f = \frac{64}{\text{Re}}$ (05)

c) A fluid of viscosity 8.5 poise and specific gravity 1.25 is flowing through a circular pipe of diameter 120 mm. The maximum shear stress at the pipe wall is 220 N/m^2. Find

i) the pressure gradient

ii) the average velocity

iii) Reynolds number. (05)

8. Write short notes on any of the four: (4 X 5 =20)

i) Meta centre and Metacentric height

ii) Stream line and stream tube

iii) Circulation and irrotational flow

iv) Transition and Turbulent Flow

v) Rectangular weir

vi) Hydraulic Jump

vii) Pitot tube