

THIRD SEMESTER EXAMINATION - 2005

FLUID MECHANICS AND HYDRAULICS MACHINES

Full Marks -70

Time : 3 Hours

The figures in the right hand margin indicate full marks for the questions.

Answer Question No. 1 which is compulsory and any five from the rest.

1. Answer to the following questions must be given at one place. 2×10

- (i) On a plot of shear stress versus rate of shear strain, show a Newtonian fluid and a non-Newtonian fluid. Give one example for each of the above types of fluid.

P.T.O.

(ii) Give two ways by which the sensibility of a U-tube manometer can be increased. Illustrate by sketch.

(iii) Compute the weight of water in the container and the total force on the bottom of the tank. Is there a difference between these two values? If so, explain.

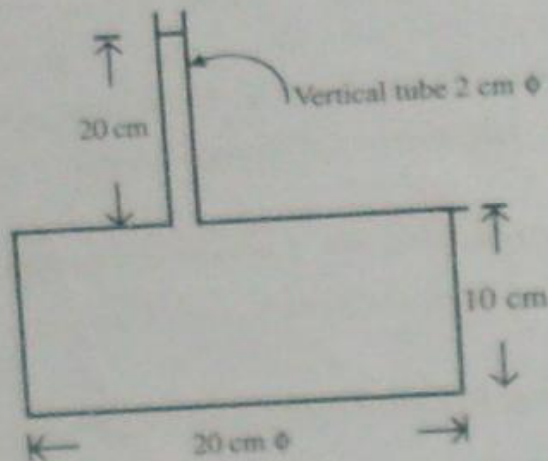


Figure - 1

(iv) Under what conditions can air be treated as incompressible fluid and water as compressible fluid?

(v) What does the following equations represent?

(a) $\bar{\nabla} \times \bar{V} = 0$

(b) $\bar{\nabla} \cdot \bar{V} = 0$

Where \bar{V} is velocity vector.

(vi) How can frictionless real fluids exist but inviscid fluids do not exist?

(vii) Write the Bernoulli's equation per unit mass of the fluid. Mention its limitation.

(viii) What is a draft tube? For which type of turbines it is used? What are its functions?

(ix) What is priming? Why is it necessary for a centrifugal pump?

(x) What is an indicator diagram for a reciprocating pump? What is its importance?

2. (a) A block of base area 20 cm^2 , weight 100 N slides down a 20° inclined plane over an oil film of 1 mm thickness, $\mu = 500$ poise. Estimate the steady state velocity of the block, assuming linear velocity profile in the oil film of Newtonian characteristic. 5

- (b) A hollow circular plate of 2 m external and 1 m internal diameter is immersed vertically in water such that the centre of the plate is 4 m deep from the water surface. Find the total pressure on one face of the plate and the depth of centre of pressure. Take specific weight of water as 10 KN/m^3 . 5

3. A vertical U-tube manometer is made up of a 5 mm ID glass tubing. Its left limb is enlarged to 20 mm ID and contains oil of R.D. 0.8 (refer figure-2). The oil free surface is in the enlarged vessel and the mercury-oil interface is in the left

limb. On application of an unknown pressure, the surface of oil is found to depress by 5 mm corresponding to both end open condition. Estimate the absolute value of the applied pressure. Given

$$P_{\text{atm}} = 1 \text{ bar and density of mercury} = 13600 \frac{\text{kg}}{\text{m}^3}.$$

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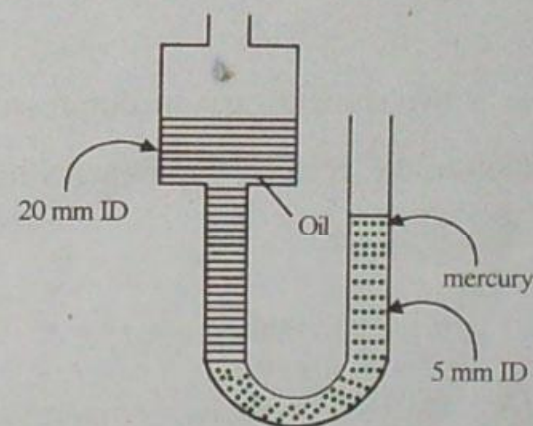


Figure - 2

4. A buoy carrying a beacon has a cylindrical upper portion of 2.5 m diameter and 1.4 m depth. The curved lower portion has an external volume of

0.5 m³. The centre of buoyancy is 1.5 m below the top of the cylinder and the centre of gravity of the buoy and the beacon is 1.2m below the cylinder top. The total weight is 2.7 tonnes. Taking the specific gravity of the sea water as 1.02, calculate the metacentric height. Mention whether the floating body is in stable equilibrium or not. 10

5. (a) In a two dimensional incompressible fluid motion the velocity components in x and y directions are

$$u = 2xy \quad \text{and} \quad v = a^2 + x^2 - y^2$$

- (i) Do these velocity components satisfy the law of conservation of mass ?
 (ii) Do these velocity components represent irrotational motion ? 5

- (b) For a hydraulic machine installed between A and B the following data are available

Flow direction : From A to B.

Diameters : At a 20 cm, at B 30 cm.

Elevations : At a 105.00 m, at B 100.00 m.

Pressure : At a 100 Kpa, at B 200 Kpa.

Discharge : 200 lps of water.

Is the machine a pump or a turbine ? 5

6. Determine the diameter of throat of a venturimeter to be introduced in a horizontal 10 cm diameter pipe so that the reading of the differential U-tube mercury manometer is 60cm when the discharge of water is 20 lps. Assume C_d as 0.95.

If the meter has been placed vertically in the same pipe with flow upwards, what would be the reading of the manometer for the same rate of flow. Assume that the inlet and throat sections are 20 cm apart. 10

7. The inner and outer diameter of an inward flow water turbine are 60cm and 120cm respectively. Water enters the blades at the outer periphery with an absolute velocity of 40 m/sec, making an angle of 20° with the tangent to the wheel at inlet tip and leaves the blades with a flow velocity of 6 m/sec. If the blade angles at inlet and outlet are 30° and 20° respectively, determine (i) the speed of the turbine runners (ii) work done per kg of water.

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8. A single acting reciprocating pump has a plunger diameter of 20cm and stroke length of 30cm. It draws water from a sump 3.5m below the centre of the pump cylinder. find the least diameter of the suction pipe if it is 6m long. The pump runs at 50rpm with SHM and separation occurs at 2.5m of water absolute pressure. Given $P_{atm} = 10.3$ m of water.

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