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ME 181403

5/7/23

Roll No. of candidate

2023

B.Tech. 4th Semester End-Term Examination

FLUID MECHANICS – I

New Regulation (w.e.f. 2017-18) & New Syllabus (w.e.f. 2018-19)

Full Marks – 70   Time – Three hours

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

Answer Question No. 1 and any *four* from the rest.

1. Answer the following questions : $(10 \times 1 = 10)$

    (i)   Free surface of a liquid tends to contract to the smallest possible area due to force of

        (a)   Surface tension   (b)   Viscosity

        (c)   Friction   (d)   Cohesion

    (ii) Which of the following is not a pressure measuring device?

        (a)   Manometer   (b)   Orifice plate

        (c)   Bourdon tube   (d)   Bellows

    (iii) A body floats in stable equilibrium

        (a)   When its metacentric height is zero

        (b)   When the metacentre is above C.G

        (c)   When its C.G is below its centre of buoyancy

        (d)   Metacentre has nothing to do with position of C.G for determining stability

    (iv) An open tank contains 1 m deep water with 50 cm depth of oil of specific gravity 0.8 above it. The intensity of pressure at bottom of tank will be

        (a)   4 kN/m²   (b)   10 kN/m²

        (c)   12 kN/m²   (d)   14 kN/m²

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(v) The printer's ink is an example of

    (a)   Newtonian fluid   (b)   Non-Newtonian fluid

    (c)   Thixotropic substance   (d)   Elastic solid

(vi) The actual path followed by a fluid particle as it moves during a period of time, is called as

    (a)   path line   (b)   streak line

    (c)   filament line   (d)   stream line

(vii) What are the reasons for minor head loses in a pipe?

    (a)   Friction   (b)   Heat

    (c)   Valves and bends   (d)   Temperature

(viii) When is orifice called "large orifice"?

    (a)   If the head of liquid is less than 5 times the depth of orifice

    (b)   If the head of liquid is less than 2.5 times the depth of orifice

    (c)   If the head of liquid is less than 4 times the depth of orifice

    (d)   If the head of liquid is less than 1.5 times the depth of orifice

(ix) Energy gradient line takes into consideration

    (a)   potential and kinetic heads only

    (b)   potential and pressure heads only

    (c)   kinetic and pressure heads only

    (d)   potential, kinetic and pressure heads

(x) A phenomenon is modelled using 'n' dimensional variables with 'k' primary dimensions. The number of non-dimensional variables is

    (a) k (b) n

    (c) $n+k$ (d) $n-k$

2.   (a)   State Newton's law of viscosity. What is the effect of temperature on viscosity of water and that of air?   (2+5=7)

    (b)   A cylindrical tank of cross-sectional area 600 mm² and 2.6 m height is filled with water up to a height of 1.5 m and remaining with oil of specific gravity 0.78. The vessel is open to atmospheric pressure. Calculate:

        (i)   Intensity of pressure at the interface

        (ii)   Absolute and gauge pressures on the base of the tank in terms of water head, oil head and N/m²

        (iii)   The net force experienced by the base of the tank.   (8)

3. (a) Derive an expression for the force exerted by static fluid on a submerged vertical plane surface and locate the position of centre of pressure. (7)

(b) A circular opening, 3 m diameter, in a vertical side of a tank is closed by a disc of 3 m diameter which can rotate about a horizontal diameter. Calculate : (8)

(i) The force on the disc, and

(ii) The torque required to maintain the disc in equilibrium in the vertical position when the head of water above the horizontal diameter is 4 m.

4. (a) Show that the actual discharge (Q_{act}) for a venturimeter under ideal condition is given by the expression below

$$Q_{act} = C_d \times \frac{A_1 \times A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$$

Where C_d = coefficient of discharge, A_1 = inlet area, A_2 = throat area, h = difference in pressure head. (5)

(b) A venturimeter having inlet diameter of 300 mm and throat diameter of 150 mm is provided in a vertical pipeline carrying oil of specific gravity 0.9, flow being upward. The difference in elevation of the throat section and entrance section of the venturimeter is 300 mm. The differential U-tube mercury manometer shows a gauge deflection of 250 mm. Calculate

(i) The discharge of oil

(ii) The pressure difference between the entrance section and the throat section. Take the coefficient of discharge as 0.98 and specific gravity of mercury as 13.6. (10)

(5)

5. (a) Differentiate between

(i) Stream function and velocity potential function

(ii) Rotational and irrotational flow.

(b) In a two-dimensional incompressible flow, the fluid velocity components are given by : $u = x - 4y$ and $v = -y - 4x$.

Show that the velocity potential function exists and determine its form. Find also the stream function. (10)

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6. (a) Name the different forces present in a fluid flow. For the Euler's equation of motion, which forces are taken into consideration. (5)

   (b) A 45° reducing bend is connected in a pipe line, the diameters at the inlet and outlet of the bend being 600 mm and 300 mm respectively. Find the forces exerted by water on the bend if the intensity of pressure at inlet to bend is 8.829 N/cm² and rate of flow of water is 600 litres/s. (10)

7. (a) What is meant by geometric, kinematic and dynamic similarities? (3)

   (b) The pressure difference Δp in a pipe of diameter D and length l due to viscous flow. depends on the velocity V, viscosity μ and density ρ. Using Buckingham's π-theorem, obtain an expression for Δp. (12)