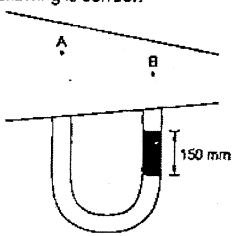
2 CHAPTER Fluid Pressure and its Measurement

Q.1 A U-tube manometer with a small quantity of mercury is used to measure the static pressure difference between two locations *A* and *B* in a conical section through which an incompressible fluid flows. At a particular flow rate, the mercury column appears as shown in the figure. (ρ_{Hg} = 13600 kg/m^3, g = 9.81 m/s^2). Which of the following is correct?



(a) Flow direction is from *A* to *B* and $p_A - p_B$ = 20 kPa

(b) Flow direction is from *B* to *A* and $p_A - p_B$ = 1.4 kPa

(c) Flow direction is from *A* to *B* and $p_B - p_A$ = 20 kPa

(d) Flow direction is from *B* to *A* and $p_B - p_A$ = 1.4 kPa

Q.2 The lower portion of a U-tube of uniform bore having both limbs vertical and open to atmosphere, is initially filled with a liquid of specific gravity 3*S*. A lighter liquid of specific gravity *S* is then poured into one of the limbs such that the length of column of lighter liquid is X. What is the resulting movement of the meniscus of the heavier liquid in the other limb?

(a) X (b) X/2

(c) X/3 (d) X/6

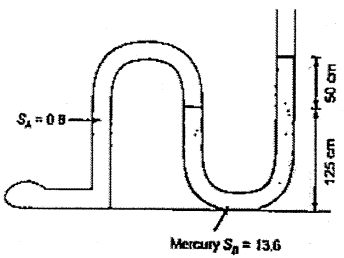
Q.3 How is the difference of pressure head '*h*' measured by a mercury oil differential manometer expressed?

(a) $h = X\left(1 - \frac{s_g}{s_o}\right)$ (b) $h = X(s_g - s_o)$

(c) $h = X(s_o - s_g)$ (d) $h = X\left(\frac{s_g}{s_o} - 1\right)$

While X = manometer reading; s_g and s_o are the specific gravities of mercury and oil, respectively.

Q.4 What is the absolute pressure at *A* measured by an open tube manometer as in the figure below? (Assume atmospheric pressure as 103 kN/m^2; s_A and s_B are the specific gravities of the two fluid)



(a) 78.5 kN/m^2 (b) 180 kN/m^2

(c) 1030 kN/m^2 (d) 103 kN/m^2

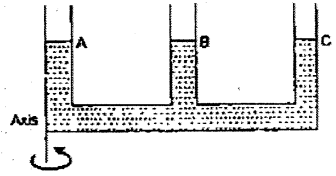
Q.5 In a quiescent sea, density of water at free surface is ρ_o and at a point much below the surface density is ρ. Neglecting variation in gravitational acceleration g and assuming a constant value of bulk modulus k, the depth '*h*' of the point from free surface is

(a) $\frac{k}{g}\left(\frac{1}{\rho_o}+\frac{1}{\rho}\right)$ (b) $\frac{k(\rho-\rho_o)}{g(\rho+\rho_o)^2}$

(c) $\frac{k}{g}\left(\frac{1}{\rho_o}-\frac{1}{\rho}\right)$ (d) $\frac{k}{g}\left(\frac{\rho\rho_o}{\rho+\rho_o}\right)$

Q.6 **Assertion (A):** The important property for a liquid to use it as manometric fluid is its colour for visibility.
Reason (R): Inclined manometers are used to measure low pressures.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.7 A multi-tube manometer filled with water up to level *A*, *B* and *C* as shown in figure is rotated about the vertical axis at *A*.

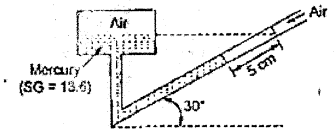


The water levels at *A*, *B* and *C* will all be on
(a) a circle (b) an ellipse
(c) a hyperbola (d) a parabola

Q.8 A U-tube open at both ends made of 8 mm diameter glass tube has mercury in the bottom to a height of 10 cm above the horizontal limb. If 19 cc of water is added to one of the limbs, the difference in mercury levels at equilibrium is
(a) 3.0 cm (b) 2.8 cm
(c) 1.0 cm (d) zero

Q.9 A vertical U-tube with two legs 2 m apart is filled with water and rotated about a vertical axis 0.5 m from one leg. The difference in elevation of water levels in the two legs, open to atmosphere, when the speed of rotation is 45 rpm is, nearly.
(a) 0.263 m (b) 2.263 m
(c) 2.546 m (d) 2.83 m

Q.10 The gauge pressure at point '*A*' in the inclined manometer shown in the given figure is:



(a) 6630 N/m²
(b) –6630 N/m²
(c) 3340 N/m²
(d) –3340 N/m²

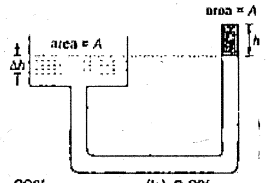
Q.11 The pressure intensity is same in all directions at a point
(a) only when fluid is frictionless and incompressible
(b) only when fluid is frictionless and is at rest
(c) only when fluid is frictionless
(d) when there is no relative motion of one fluid layer relative to other

Q.12 Consider the following statements:
1. In a fluid under motion, the pressure at a point is always perpendicular to the surface.
2. Pascal's law states that the pressure at a point is same in all directions.
3. Magnitude of pressure of a fluid at a point is obtained from hydrostatic law.
4. Pascal's law is applicable in the operation of a hydraulic press.

Which of these statements are correct?
(a) 1, 2 and 3 (b) 1, 3 and 4
(c) 1, 2 and 4 (d) 2, 3 and 4

Q.13 Which of the following is correct regarding piezometer
(a) High pressure can not be measured
(b) Negative pressure can not be measured
(c) Gas pressure can not be measured
(d) All of the above

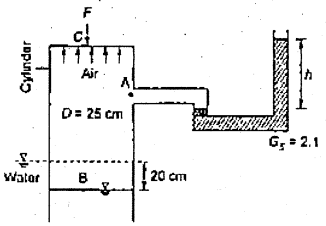
Q.14 The pressure difference between two limbs can be measured by taking measurement on one limb only, i.e., *h*. What is the error introduced in its measurement.



(a) 20% (b) 0.2%
(c) 0.5% (d) 0.32%

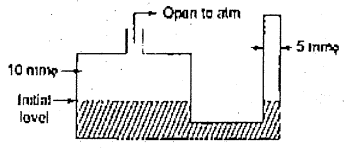
$\left[\text{Given: } \frac{a}{A}=\frac{1}{500}\right]$

Q.15 The cylindrical container having weight of 65 N is inverted and pressed into water as shown in figure. Determine the differential height h of the manometer and the force F needed to hold the container in position shown



(a) h = 9.5 cm, F = 31.31 N
(b) h = 9.5 cm, F = 62.62 N
(c) h = 4.5 cm, F = 31.31 N
(d) h = 4.5 cm, F = 62.62 N

Q.16 Initial level of apparatus is shown. When the pressure p is applied, the liquid rises in the limb by 100 mm from initial level. The other limb is open to atmosphere (P_A pressure). Find $(P-P_A)$



(a) –1225 N/m² (b) –980 N/m²
(c) 1250 N/m² (d) 100 N/m²

Q.17 In a mercury differential manometer used for measuring pressure differences across a venturimeter in a water pipeline, if an error of 2 mm has been made in observing a differential head of 10 mm, the percentage error in pressure difference is
(a) 12.6 (b) 25.2
(c) 20 (d) 2

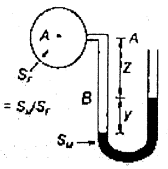
Q.18 The Piezometric head in a static liquid
(a) varies in the horizontal direction, provided the liquid is continuous
(b) varies only in the vertical direction
(c) remains constant throughout the fluid
(d) does not vary in the vertical direction

Q.19 Match List-I (Features) with List-II (Type of manometers) and select the correct answer using the codes given below the lists:

List-I
A. Open ended manometer for positive pressure
B. Negative pressure manometer
C. For measuring pressure in liquids or gases
D. For measuring pressure in liquids only

List-II

1. $S = S_u/S_f$



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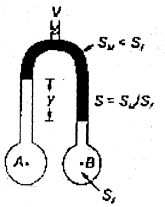

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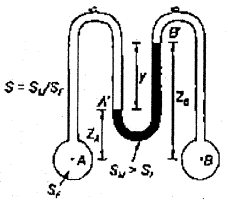

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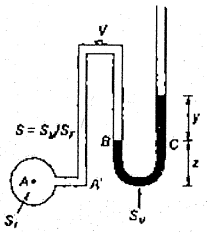

Codes:

	A	B	C	D
(a)	3	4	1	2
(b)	1	2	3	4
(c)	3	2	1	4
(d)	1	4	3	2

Q.20 A pressure gauge reads 57.4 kPa and 80 kPa respectively at heights of 8 m and 5 m fitted on the side of a tank filled with liquid. What is the approx. density of the liquid in kg/m³?

(a) 393
(b) 768
(c) 1179
(d) 7530

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Answers Fluid Pressure and Its Measurement

1. (a)	2. (d)	3. (d)	4. (b)	5. (c)	6. (d)	7. (d)	8. (b)	9. (b)	10. (d)
11. (d)	12. (d)	13. (d)	14. (b)	15. (a)	16. (a)	17. (c)	18. (c)	19. (b)	20. (b)

Explanations Fluid Pressure and its Measurement

1. (a)

$$p_A - p_B = \rho_g \Delta h$$

$$= 13.6 \times 1000 \times 9.81 \times \left(\frac{150}{1000}\right) = 20 \text{ kPa}$$

2. (d)

$(S) \times (x) = (3S) \times (y)$

$y = x/3$

∴ Resulting movement of meniscus = $x/6$

4. (b)

$P_A - (\rho_A g h_{A'}) - (\rho_m g h_m) + \rho_a = 0$

$P_A - (0.8 \times 10^3 + 9.812 \times 1.25)$

$- (13.6 \times 10^3 \times 9.812 \times 0.5) - 103 \times 10^3 = 0$

$\Rightarrow P_A = 179.53$ kPa

6. (d)

The important property for a liquid to use it as manometric fluids is its high density and low vapour pressure.

Inclined manometers are more sensitive than vertical manometers, hence they are used for low pressures

8. (b)

$$\frac{19}{\frac{\pi}{4} \times (0.8)^2} \times \gamma_w + \left(10 - \frac{h}{2}\right) \times 13.6 \gamma_w$$

$$= \left(10 + \frac{h}{2}\right) 13.60\, \gamma_w$$

$\Rightarrow h = 2.8$ cm

9. (b)

$$\omega = \frac{2\pi N}{60} = \frac{2 \times 3.14 \times 45}{60}$$

$= 4.71$ rad/sec

At limb-1,

$$h = \frac{P_1}{\gamma_w} = \frac{w^2 r^2}{2g}$$

$$= \frac{(4.71 \times 0.5)^2}{2 \times 9.81} = 0.283 \text{ m}$$

At limb-2,

$$h = \frac{P_2}{\gamma_w} = \frac{(4.71 \times 1.5)^2}{2 \times 9.81} = 2.544 \text{ m}$$

∴ Difference in heads

$= 2.544 - 0.283 = 2.26$ m

10. (d)

Gauge pressure at point A will be negative due to drop in mercury level.

$p = -\rho_m g\, S \sin 30°$

$$= -13.6 \times 9810 \times 0.05 \times \frac{1}{2}$$

$= -3335.4$ N/m²

14. (b)

Instead of measuring $h + \Delta h$, we are measuring h

Hence error $= (h + \Delta h) - h = \Delta h$

$$\text{Percent error} = \frac{\Delta h}{h + \Delta h} \times 100$$

$$\frac{\Delta h}{h} = \frac{a}{A} = \frac{1}{500}$$

∴ Percent error

$$= \frac{\Delta h/h}{1 + \Delta h/h} \times 100$$

$$= \left(\frac{1/500}{1 + \frac{1}{500}}\right) \times 100\% \approx 0.2\%$$

15. (a)

$P_D = \gamma_w \times 20$ cm

$P_B = P_A$

$P_A - G_S \gamma_w h = 0$

$\Rightarrow P_A = G_S \gamma_w h$

$20 \gamma_w = G_S \gamma_w h$

$$\Rightarrow h = \frac{20}{2.1} = 9.5 \text{ cm}$$

Now, $P_C = P_B$

$\Rightarrow F + W = P_C \times A$

$\Rightarrow F = P_C A - w$

$$= \frac{20 \gamma_w}{100} \times \frac{\pi}{4} \times 0.25^2 - 65$$

$= 31.31$ N

16. (a)

$x \times 10^2 = 100 \times 5^2$

[x = decrease in level in limb open to atm.]

$\Rightarrow x = 25$ mm

∴ Total $h = 125$ mm

$$\therefore P + \frac{125}{1000} \times \gamma_w = P_{atm}$$

$\Rightarrow P - P_a = -0.125\, \gamma_w$

$= -0.125 \times 9810$

$= -1226$ N/m²

17. (c)

$$\text{Percent error} = \frac{\Delta p}{h} \times 100 = \frac{2}{10} \times 100 = 20\%$$

20. (b)

Pressure difference

$= P_1 - P_2 = \rho g (h_2 - h_1)$

$\Rightarrow 80 \times 10^3 - 57.4 \times 10^3$

$= \rho \times 9.81 \times (8 - 5)$

$\Rightarrow \rho = 768$ kg/m³

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