9 Mechanical Properties of Fluids

Diagram Based Questions :

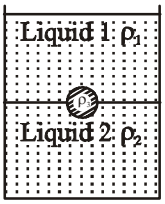
1. A jar is filled with two non-mixing liquids 1 and 2 having densities ρ_1 and, ρ_2 respectively. A solid ball, made of a material of density ρ_3, is dropped in the jar. It comes to equilibrium in the position shown in the figure. Which of the following is true for ρ_1, ρ_1 and ρ_3?

(a) $\rho_3 < \rho_1 < \rho_2$

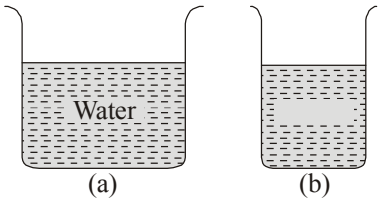
(b) $\rho_1 > \rho_3 > \rho_2$

(c) $\rho_1 < \rho_2 < \rho_3$

(d) $\rho_1 < \rho_3 < \rho_2$



2. From the figure, the correct observation is



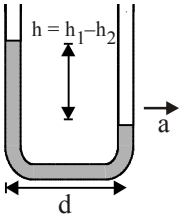
(a) the pressure on the bottom of tank (a) is greater than at the bottom of (b)

(b) the pressure on the botttom of the tank (a) is smaller than at the bottom (b)

(c) the pressure depend on the shape of the container

(d) the pressure on the bottom of (a) and (b) is the same.

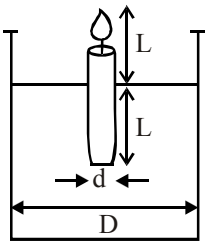
3. Figure shows a U-tube of uniform cross-sectional area A, accelerated with acceleration a as shown. If d is the separation between the limbs, then what is the difference in the levels of the liquid in the U-tube is



(a) $\frac{ad}{g}$ (b) $\frac{ag}{d}$

(c) $\frac{a}{d}$ (d) $\frac{dg}{a}$

4. A candle of diameter d is floating on a liquid in a cylindrical container of diameter D (D >> d) as shown in figure. If it is burning at the rate of 2 cm/hour then the top of the candle will



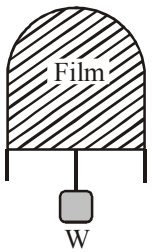
(a) remain at the same height

(b) fall at the rate of 1 cm/hour

(c) fall at the rate of 2 cm/hour

(d) go up at the rate of 1 cm/hour

5. A thin liquid film formed between a U-shaped wire and a light slider supports a weight of 1.5×10^{-2} N (see figure). The length of the slider is 30 cm and its weight negligible. The surface tension of the liquid film is



(a) $0.0125\ Nm^{-1}$ (b) $0.1\ Nm^{-1}$

(c) $0.05\ Nm^{-1}$ (d) $0.025\ Nm^{-1}$

Solution

1. **(d)** From the figure it is clear that liquid 1 floats on liquid 2. The lighter liquid floats over heavier liquid. Therefore we can conclude that

$\rho_1 < \rho_2$

Also $\rho_3 < \rho_2$ otherwise the ball would have sink to the bottom of the jar.

Also $\rho_3 > \rho_1$ otherwise the ball would have floated in liquid 1. From the above discussion we conclude that

$\rho_1 < \rho_3 < \rho_2$.

2. **(d)** Pressure = $h\rho g$ i.e. pressure at the bottom is independent of the area of the bottom of the tank. It depends onthe height of water upto which the tank is filled with water. As is both the tanks, the levels of water are the same, pressure at the bottom is also the same.

3. **(a)** Mass of liquid in horizontal portion of U-tube = $Ad\rho$

Pseudo force on this mass = $Ad\rho a$

Force due to pressure difference in the two limbs

$= (h_1\rho g - h_2\rho g)\, A$

Equating both the forces

$(h_1 - h_2)\, \rho g A = Ad\rho a$

$$\Rightarrow \quad (h_1 - h_2) = \frac{Ad\rho a}{\rho g A} = \frac{ad}{g}$$

4. **(b)** The candle floats on the water with half its length above and below water level. Let its length be 10 cm. with 5 cm. below the surface and 5 cm. above it. If its length is reduced to 8 cm, it will have 4 cm. above water surface. So we see tip going down by 1 cm. So rate of fall of tip = 1 cm/hour.

5. **(d)** At equilibrium, weight of the given block is balanced by force due to surface tension, i.e.,

$2L.\ S = W$

$$\text{or} \quad S = \frac{W}{2L} = \frac{1.5 \times 10^{-2}\, N}{2 \times 0.3\, m} = 0.025 Nm^{\ 1}$$