Fluid Mechanics

SET Self Evaluation Test -11

1. A tank 5 *m* high is half filled with water and then is filled to the top with oil of density 0.85 g/cm^3. The pressure at the bottom of the tank, due to these liquids is

(a) 1.85 g/cm^2 (b) 89.25 g/cm^2

(c) 462.5 g/cm^2 (d) 500 g/cm^2

2. Two substances of densities ρ_1 and ρ_2 are mixed in equal volume and the relative density of mixture is 4. When they are mixed in equal masses, the relative density of the mixture is 3. The values of ρ_1 and ρ_2 are

(a) $\rho_1 = 6$ and $\rho_2 = 2$ (b) $\rho_1 = 3$ and $\rho_2 = 5$

(c) $\rho_1 = 12$ and $\rho_2 = 4$ (d) None of these

3. A wooden block of volume 1000 cm^3 is suspended from a spring balance. It weighs 12 *N* in air. It is suspended in water such that half of the block is below the surface of water. The reading of the spring balance is

(a) 10 *N* (b) 9 *N*

(c) 8 *N* (d) 7 *N*

4. Two different liquids are flowing in two tubes of equal radius. The ratio of coefficients of viscosity of liquids is 52:49 and the ratio of their densities is 13:1, then the ratio of their critical velocities will be

(a) 4 : 49 (b) 49 : 4

(c) 2 : 7 (d) 7 : 2

5. Two capillary tubes of same radius *r* but of lengths l_1 and l_2 are fitted in parallel to the bottom of a vessel. The pressure head is *P*. What should be the length of a single tube that can replace the two tubes so that the rate of flow is same as before

(a) $l_1 + l_2$ (b) $\frac{1}{l_1} + \frac{1}{l_2}$

(c) $\frac{l_1 l_2}{l_1 + l_2}$ (d) $\frac{1}{l_1 + l_2}$

6. A capillary tube is attached horizontally to a constant head arrangement. If the radius of the capillary tube is increased by 10% then the rate of flow of liquid will change nearly by

(a) + 10% (b) + 46%

(c) – 10% (d) – 40%

7. Two stretched membranes of area 2 cm^2 and 3 cm^2 are placed in a liquid at the same depth. The ratio of pressures on them is

(a) 1 : 1 (b) 2 : 3

(c) 3 : 2 (d) $2^2 : 3^2$

8. Three identical vessels are filled to the same height with three different liquids *A*, *B* and $C(\rho_A > \rho_B > \rho_C)$. The pressure at the base will be

(a) Equal in all vessels (b) Maximum in vessel *A*

(c) Maximum in vessel *B* (d) Maximum in vessel *C*

9. Three identical vessels are filled with equal masses of three different liquids *A*, *B* and *C* $(\rho_A > \rho_B > \rho_C)$. The pressure at the base will be

(a) Equal in all vessels (b) Maximum in vessel *A*

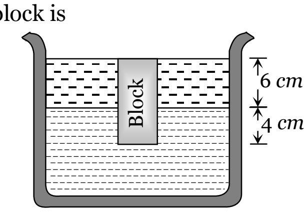
(c) Maximum in vessel *B* (d) Maximum in vessel *C*

10. A piston of cross-section area 100 cm^2 is used in a hydraulic press to exert a force of 10^7 dynes on the water. The cross-sectional area of the other piston which supports an object having a mass 2000 kg. is

(a) 100 cm^2 (b) $10^9 cm^2$

(c) $2 \times 10^4 cm^2$ (d) $2 \times 10^{10} cm^2$

11. A cubical block of wood 10 cm on a side floats at the interface between oil and water with its lower surface horizontal and 4 cm below the interface. The density of oil is $0.6 gcm^{-3}$. The mass of block is



(a) 706 *g*

(b) 607 *g*

(c) 760 *g*

(d) 670 *g*

12. A spherical ball of radius *r* and relative density 0.5 is floating in equilibrium in water with half of it immersed in water. The work done in pushing the ball down so that whole of it is just immersed in water is : (where ρ is the density of water)

(a) $\frac{5}{12}\pi r^4 \rho g$ (b) $0.5 \rho r g$

(c) $\frac{4}{3}\pi r^3 \rho g$ (d) $\frac{2}{3}\pi r^4 \rho g$

13. If *W* be the weight of a body of density ρ in vacuum then its apparent weight in air of density σ is

(a) $\frac{W\rho}{\sigma}$ (b) $W\left(\frac{\rho}{\sigma} - 1\right)$

(c) $\frac{W}{\rho}\sigma$ (d) $W\left(1 - \frac{\sigma}{\rho}\right)$

14. Which of the following is not the characteristic of turbulent flow

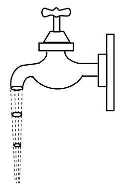
(a) Velocity more than the critical velocity

(b) Velocity less than the critical velocity

(c) Irregular flow

(d) Molecules crossing from one layer to another

15. Water coming out of the mouth of a tap and falling vertically in streamline flow forms a tapering column, *i.e.,* the area of cross-section of the liquid column decreases as it moves down. Which of the following is the most accurate explanation for this



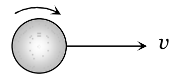
(a) As the water moves down, its speed increases and hence its pressure decreases. It is then compressed by the atmosphere

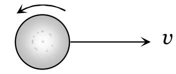
(b) Falling water tries to reach a terminal velocity and hence reduces the area of cross-section to balance upward and downward forces

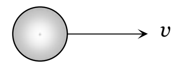
(c) The mass of water flowing past any cross-section must remain constant. Also, water is almost incompressible. Hence, the rate of volume flow must remain constant. As this is equal to velocity × area, the area decreases as velocity increases

(d) The surface tension causes the exposed surface area of the liquid to decrease continuously

16. To get the maximum flight, a ball must be thrown as

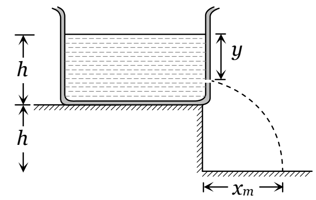
(a) 

(b) 

(c) 

(d) Any of (a), (b) and (c)

17. A tank is filled upto a height h with a liquid and is placed on a platform of height h from the ground. To get maximum range x_m a small hole is punched at a distance of y from the free surface of the liquid. Then



(a) $x_m = 2h$

(b) $x_m = 1.5h$

(c) $y = h$

(d) $y = 0.75h$

18. The relative velocity of two consecutive layers is 8 *cm/s*. If the perpendicular distance between the layers is 0.1 *cm*, then the velocity gradient will be

(a) 8sec^{-1} (b) 80 sec^{-1}

(c) 0.8 sec^{-1} (d) 0.08 sec^{-1}

19. Under a constant pressure head, the rate of flow of liquid through a capillary tube is V. If the length of the capillary is doubled and the diameter of the bore is halved, the rate of flow would become

(a) $V/4$ (b) 16 V

(c) $V/8$ (d) $V/32$

Answers and Solutions

(SET - 11)

1. (c) Pressure at the bottom $P = (h_1 d_1 + h_2 d_2)\frac{g}{cm^2}$

$= [250 \times 1 + 250 \times 0.85] = 250\ [1.85]\frac{g}{cm^2}$

$= 462.5\frac{g}{cm^2}$

2. (a) When substances are mixed in equal volume then density $= \frac{\rho_1 + \rho_2}{2} = 4 \Rightarrow \rho_1 + \rho_2 = 8$ ....(i)

When substances are mixed in equal masses then density $= \frac{2\rho_1\rho_2}{\rho_1 + \rho_2} = 3$

$\Rightarrow 2\rho_1\rho_2 = 3(\rho_1 + \rho_2)$ ....(ii)

By solving (i) and (ii) we get $\rho_1 = 6$ and $\rho_2 = 2$.

3. (d) Reading of the spring balance

= Apparent weight of the block

= Actual weight – upthrust

$= 12 - V_{in}\sigma g$

$= 12 - 500 \times 10^{-6} \times 10^3 \times 10 = 12 - 5 = 7N.$

4. (a) Critical velocity $v = N_R \frac{\eta}{\rho r}$

$\Rightarrow \frac{v_1}{v_2} = \frac{\eta_1}{\eta_2} \times \frac{\rho_2}{\rho_1} = \frac{52}{49} \times \frac{1}{13} = \frac{4}{49}$.

5. (c) For parallel combination $\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2}$

$\Rightarrow \frac{\pi r^4}{8\eta l} = \frac{\pi r^4}{8\eta l_1} + \frac{\pi r^4}{8\eta l_2} \Rightarrow \frac{1}{l} = \frac{1}{l_1} + \frac{1}{l_2} \quad \therefore l = \frac{l_1 l_2}{l_1 + l_2}$

6. (b) $V = \frac{P\pi r^4}{8\eta l} \Rightarrow \frac{V_2}{V_1} = \left(\frac{r_2}{r_1}\right)^4$

$\Rightarrow V_2 = V_1\left(\frac{110}{100}\right)^4 = V_1(1.1)^4 = 1.4641\,V$

$\frac{\Delta V}{V} = \frac{V_2 - V_1}{V} = \frac{1.4641\,V - V}{V} = 0.46$ or 46%.

7. (a) Pressure is independent of area of cross section

8. (b) $P \propto \rho$

9. (a) $P = \frac{F}{A} = \frac{mg}{A}$

10. (c) $P_1 = P_2 \Rightarrow \frac{F_1}{A_1} = \frac{F_2}{A_2} \Rightarrow \frac{10^7}{10^2} = \frac{2000 \times 10^3 \times 10^3}{A_2}$

$\therefore A_2 = 2 \times 10^4\,cm^2 \qquad (g = 980 \approx 10^3\,cm/s^2)$

11. (c) Weight of block

= Weight of displaced oil + Weight of displaced water

$\Rightarrow mg = V_1\rho_0 g + V_2\rho_W g$

$\Rightarrow m = (10 \times 10 \times 6) \times 0.6 + (10 \times 10 \times 4) \times 1 = 760\ gm.$

12. (a)

13. (d) Apparent weight in air = W – upthrust = $V\rho g - V\sigma g$

$= V\rho g\left(1 - \frac{\sigma}{\rho}\right) = W\left(1 - \frac{\sigma}{\rho}\right)$

14. (b)

15. (c)

16. (b)

17. (a,c) Velocity of liquid through orifice, $v = \sqrt{2gy}$

and time taken by liquid to reach the ground

$t = \sqrt{\frac{2(h + h - y)}{g}} = \sqrt{\frac{2(2h - y)}{g}}$

$\therefore$ Horizontal distance covered by liquid

$x = v.t. = \sqrt{2gy} \times \sqrt{\frac{2(2h - y)}{g}} = \sqrt{4y(2h - y)}$

$\Rightarrow x^2 = 4y(2h - y)$

$\Rightarrow \frac{d(x)^2}{dy} = 8h - 8y$

for x to be maximum, $\frac{d}{dy}(x^2) = 0$

$\therefore 8h - 8y = 0$ or $h = y$

So $x_m = \sqrt{4h(2h - h)} = 2h$

18. (b) $\frac{dv}{dx} = \frac{8}{0.1} = 80\,s^{-1}$

19. (d) Rate of flow under a constant pressure head,

$V = \frac{\pi p r^4}{8\eta l} \Rightarrow V \propto \frac{r^4}{l} \Rightarrow \frac{V_2}{V_1} = \left(\frac{r_2}{r_1}\right)^4 \times \frac{l_1}{l_2} = \left(\frac{1}{2}\right)^4 \times \frac{1}{2}$

$\Rightarrow V_2 = \frac{V_1}{32} = \frac{V}{32}$

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