## PHYSICS SOLUTIONS

**1.** **[A]**

**Sol.** $Av = A_1v_1 + A_2v_2 + A_3v_3 + A_4v_4$

$Av = 4(A_1v_1)$

$12 \times 0.75 = 4 [4 \times v]$

$v = \frac{3}{4} \times 0.75$

$= 0.75 \times 0.75$

$v = 0.56$ m/s

**2.** **[D]**

**Sol.** $Q = Av \quad v = \frac{Q}{A} = \frac{100 \times 10^{-6}}{0.25}$

$v = 400 \times 10^{-3}$ mm/s $= 0.4$ mm/s

**3.** **[C]**

**Sol.** Let a be the size of each side of the cube. Then,

$200 \times g = (2) \times (a^2) \times 1 \times g$

$\therefore \quad a = 10$ cm

**4.** **[C]**

**Sol.** For equilibrium, the total upward pull will be equal to the gravitational force

$$\frac{V}{2} \times 13.6 \times g + \frac{V}{2} \times (0.8)g = V\rho g$$

$\rho = 7.2$ g/cc

**5.** **[A]**

**Sol.** Velocity of efflux at a depth h is given by $v = \sqrt{2gh}$ . Volume of water flowing out per second from both the holes are qual.

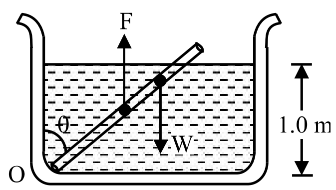
$\therefore \ a_1v_1 = a_2v_2$

or $(L^2)\sqrt{2g(y)} = \pi R^2 \sqrt{2g(4y)}$

or $R = \frac{L}{\sqrt{2\pi}}$

**6.** **[C]**

**Sol.** Length of rod inside the water $= 1.0 \sec\theta = \sec\theta$




Upthrust $F = \left(\frac{2}{2}\right) (\sec\theta) \left(\frac{1}{500}\right) (1000)\ (10)$

or $F = 20 \sec\theta$

Weight of rod $W = 2 \times 10 = 20$ N

For rotational equilibrium of rod net torque about O should be zero.

$\therefore F \left(\frac{\sec\theta}{2}\right) (\sin\theta) = W = (1.0 \sin\theta)$

or $\frac{20}{2} \sec^2\theta = 20$

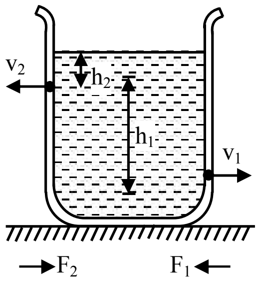
or $\theta = 45º$

$\therefore F = 20 \sec 45º$

$= 20\sqrt{2}$ N

**7.** **[C]**

**Sol.** Thrust force




$F = F_1 - F_2 = \rho a v_1^2 - \rho a v_2^2$

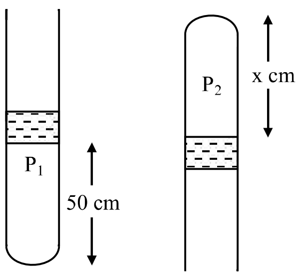
$= \rho a\,(2gh_1) - \rho a\,(2gh_2)$

$= 2\rho a g\,(h_1 - h_2)$

$= 2\,\rho a g h$

**8.** **[B]**

**Sol.**




$P_1 \times 50 = P_2 \times x$

$\Rightarrow x = \frac{50P_1}{P_2}$

$P_1 = 80$ cm of Hg

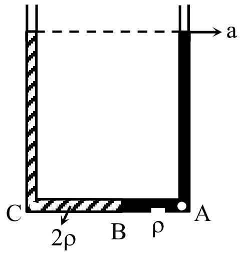
$P_2$ = 70 cm of Hg

$\therefore$ x = $\frac{50 \times 80}{70}$

= 57.12 cm $\approx$ 57 cm

**9.** **[B]**

**Sol.** For the given situation, liquid of density 2ρ should be behind that of ρ from right limb :




$P_A = P_{atm} + \rho gh$

$P_a = P_A + \rho a\frac{\ell}{2} = P_{atm} + \rho gh + \rho a\frac{\ell}{2}$

$P_C = P_a + (2\rho)\, a\frac{\ell}{2} = P_{atm} + \rho gh + \frac{3}{2}\,\rho a\ell$ ...(1)

But from left limb :

$P_C = P_{atm} + (2\rho)\, gh$ ...(2)

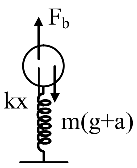
from (1) and (2)

$P_{atm} + \rho gh + \frac{3}{2}\,\rho a\ell = P_{atm} + 2\rho gh$

$\Rightarrow h = \frac{3a}{2g}\ell$

**10.** **[C]**

**Sol.**




$\rho_\ell V(g + a) - m\,(g + a) = kx$

(1.1)V (g + a) – 1 × V (g + a) = 200 x

x = 6 cm

**11.** **[B]**

**Sol.** $P_A + \frac{1}{2}\rho v_A^2 = P_B + \frac{1}{2}\rho v_B^2$

$$P_A - P_B = \frac{1}{2}\rho(v_B^2 - v_A^2)$$

$0.02 \times 12000 \times 10 = \frac{1}{2} \times 1000\ (v_B^2 - 20.2)$

$4.8 = v_B^2 - 20.2 \Rightarrow v_B = 5 m/s$

$\Rightarrow A_3.v_B = A_1v_1 + A_2v_2$

$\Rightarrow 30 = 4v_1 + 8$

$\Rightarrow 4v_1 = 22 \Rightarrow v_1 = \frac{22}{4} = 5.5$ m/s

**12.** **[C]**

**Sol.** $h = \frac{2T\cos\theta}{rdg} \Rightarrow r_1 h_1 = r_2 h_2$

and $A = 2\pi r^2 \Rightarrow r\ \alpha\sqrt{A}$

$\therefore \sqrt{A_1}\ h_1 = \sqrt{A_2}\ h_2$

$\Rightarrow \sqrt{A} \times 4 = \sqrt{\frac{A}{4}} \times h_2$

$\Rightarrow h_2 = 8$ cm

**13.** **[A]**

**Sol.** $2T\ell \cos\theta = mg = \pi r^2 \ell \rho g$

$\therefore r = \sqrt{\frac{2T}{\pi\rho g}}$

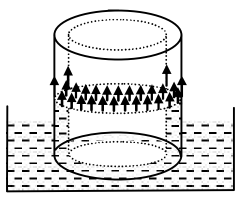
**14.** **[C]**

**Sol.** Because mercury meniscus is convex. The pressure just inside the hole will be less than the outside pressure by $\frac{2T}{r}$

$\therefore h\rho g = \frac{2T}{r}$ or $h = \frac{2T}{r\rho g}$

**15.** **[D]**

**Sol.**



Net upward force

$= 2\pi R_2 S + 2\pi R_1 S$ contact angle = 0°

$\therefore$ Capillary rise is given by

$h = \dfrac{2\pi S(R_1 + R_2)}{\pi(R_2^2 - R_1^2)\rho g}$

$= \dfrac{2S}{(R_2 - R_1)\rho g}$

**16.** **[C]**

**Sol.** $\frac{4}{3}\pi R^3 = n \times \frac{4}{3}\pi r^3$ or $r = \frac{R}{n^{1/3}}$

Now work done = increase in area × surface tension

$= (4\pi r^2 n - 4\pi R^2) \times T = 4\pi\left(\frac{R^2}{n^{2/3}} n - R^2\right) \times T$

$\propto (n^{1/3} - 1)$

**17.** **[B]**

**Sol.** $v \propto r^2$ ; $\frac{r_1}{r_2} = \sqrt{\frac{v_1}{v_2}}$

**18.** **[C]**

**Sol.** $VP^n = (V + \Delta V)(P + \Delta P)^n$

$VP^n = VP^n \left(1 + \frac{\Delta V}{V}\right)\left(1 + n\frac{\Delta P}{P}\right)$

$\therefore \frac{\Delta V}{V} = -n \frac{\Delta P}{P}$

$K = -\frac{\Delta P}{\Delta V / V} = \frac{P}{n}$

**19.** **[A]**

**Sol.** $\Delta \ell = \left(\frac{\ell}{YA}\right).W$

i.e., graph is a straight line passing through origin

(as shown in question also), the slope of which is $\frac{\ell}{YA}$.

$\therefore$ Slope $= \left(\frac{\ell}{YA}\right)$

$\therefore Y = \left(\frac{\ell}{A}\right)\left(\frac{1}{\text{slope}}\right)$

$= \left(\frac{1.0}{10^{-6}}\right) \frac{(80 - 20)}{(4 - 1) \times 10^{-4}} = 2.0 \times 10^{11}$ N/m$^2$.

**20.** **[D]**

**Sol.** $\because$ $\Delta x = \frac{F.L}{A.Y}$

$\therefore \quad F = \frac{Y.A.\Delta x}{L}$ ...........(1)

Volume = A.L. = A'L' = constant

$\Rightarrow$ AL = 3AL'

$\Rightarrow$ L' = L/3 ......... (2)

From equation (1)

$$\frac{F'}{F} = \frac{A'}{A}.\frac{L}{L'}$$

$$= 3 \times 3$$

$\Rightarrow$ F' = 9F

**21. [C]**

**Sol.** The density would increase by 0.1% if the volume decrease by 0.1%,

$$K = \frac{\Delta P}{\frac{\Delta V}{V}}$$

$$\Rightarrow \Delta P = K\frac{\Delta V}{V} = 2 \times 10^9 \times \frac{0.1}{100} = 2 \times 10^6 \text{ Nm}^{-2}$$

**22. [A]**

**Sol.** $\frac{\text{Energy}}{\text{volume}} = \frac{1}{2} \times \text{stress} \times \text{strain}$

$$= \frac{1}{2} \times (Y\alpha\Delta T) \times \left(\frac{\Delta\ell}{\ell}\right) = \frac{1}{2} Y\alpha\Delta T \times \left(\frac{\ell \propto \Delta T}{\ell}\right)$$

$$= \frac{1}{2} Y \alpha^2(\Delta T)^2 = 2880 \text{ J/m}^3$$

**23. [C]**

**Sol.** P = 4T/R ; R is less for smaller bubble, P is more for larger bubble, R is more, P is less. Since air flows from higher pressure to lower pressure therefore the air shall flow from smaller bubble to larger bubble.

**24. [B]**

**Sol.** When break into eight drop radius of small drop is $r = \frac{R}{n^{1/3}} \Rightarrow r = \frac{R}{8^{1/3}} = \frac{R}{2}$

For large drop $\Delta P_1 = \frac{2T}{R}$

for small drop $\Delta P_2 = \frac{2T}{r} = \frac{2T}{(R/2)} = 2\left(\frac{2T}{R}\right)$

**25. (B)**

**26. (A)**

**Sol.** Let y be the height of liquid at some instant.

Then $-\frac{dy}{dt}$ = constant (given)

From equation of continuity,

$(\pi x^2)\left(-\frac{dy}{dt}\right) = a\sqrt{2gy}$ (a = area of hole)

Here, $\pi\left(\frac{-dy}{dt}\right)$, a and g are constants

Hence, squaring the equation, we get $y = kx^4$.

**27.** **(C)**

**Sol.** From conservation of energy

$v_2^2 = v_1^2 + 2gh$ ... (1)

[can also be found by applying Bernouilli's theorem between 1 and 2]

From continuity equation

$A_1 v_1 = A_2 v_2$

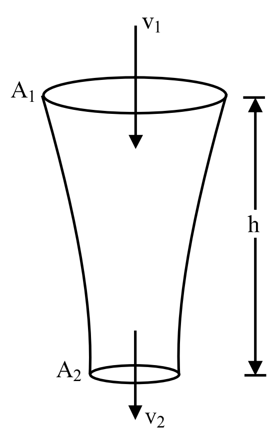
$v_2 = \left(\frac{A_1}{A_2}\right) v_1$ ... (2)

Substituting value of $v_2$ from Eq. (2) in Eq. (1)

$\frac{A_1^2}{A_2^2} \cdot v_1^2 = v_1^2 + 2gh$

or $A_2^2 = \frac{A_1^2 v_1^2}{v_1^2 + 2gh}$

$\therefore A_2 = \frac{A_1 v_1}{\sqrt{v_1^2 + 2gh}}$



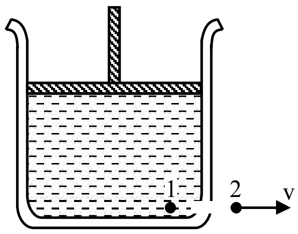
Substituting the given values

$$A_2 = \frac{(10^{-4} m^2)(1.0 m/s)}{\sqrt{(1.0 m/s)^2 + 2(10)(0.15)}}$$

$A_2 = 5.0 \times 10^{-5}\ m^2$

**28.** **(B)**

**Sol.** Applying Bernoulli's theorem at 1 and 2 : difference in pressure energy between 1 and 2 = difference in kinetic energy between 1 and 2




or $\rho gh + \frac{mg}{A} = \frac{1}{2} \rho v^2$

or $v = \sqrt{2gh + \frac{2mg}{\rho A}} = \sqrt{2\left(gh + \frac{mg}{\rho A}\right)}$

**29.** **(A)**

**Sol.** $\Delta U = mg \left(\frac{h}{2} - \frac{h}{6}\right) = mg\ \frac{h}{3}$

$= Adhg.\ \frac{h}{3} \quad = \frac{Adh^2 g}{3}$

**30.** **(A)**

**Sol .** Fraction of volume immersed is independent of effective g