

<b>JEE-MAIN</b>	<h1>SOLUTIONS</h1>
<h2>TOPIC</h2>	<h1>FLUID</h1>
<h2>FLUID</h2>	

**Exercise-I**

1. (B)

Pressure =  $h \rho g_{\text{eff}}$

$a = g/3$

$g_{\text{eff}} = g - g/3 = 2g/3$

$\Rightarrow P = \frac{0.15 \times 1000 \times 2 \times 10}{3}$

$P = 1 \text{ KPa}$

2. (B)

Given  $A = 2 \times 10^{-3} \text{ m}^2$ ,  $h = 0.4 \text{ m}$ ,  $\rho = 900 \text{ kg/m}^3$

$F = mg = V\rho g = (\pi r^2 h)\rho g$

$= 2 \times 10^{-3} \times 0.4 \times 900 \times 10$

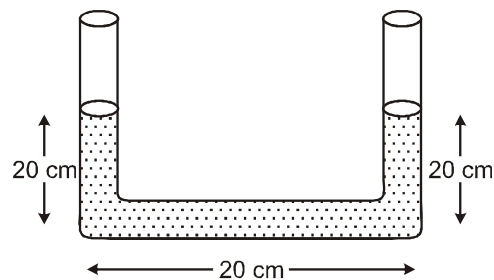
$= 7.2 \text{ N}$

3. (A)

$F = mg$

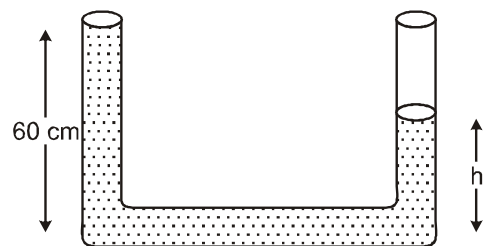
$F = 10 \text{ N}$

4. (D)



$60 \rho_w g = h \rho_l g$

$\Rightarrow 60 \times 1 \times g = h \times 4 \Rightarrow h = 15 \text{ cm}$



So, volume =  $Ah$   
 $= 1 \times 35 = 35 \text{ cm}^3$

5. (D)

O(zero) all the forces passes through O  
 $\therefore$  no torque.

6. (B)

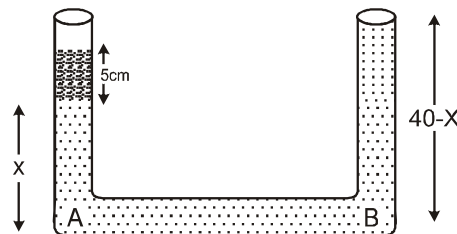
$h \rho g = 2P$

$\frac{4h}{5} \rho g = \frac{8P}{5}$  (After lowering P due to liquid.)

$\therefore P_T = \frac{8P}{5} + P$  (Atmospheric pressure)

$= \frac{13P}{5}$

7. (C)



$P_A = P_B$

$\Rightarrow 5 \times 4 \times g + x \times 1 \times g$

$= (40 - x) \times 1 \times g$

$\Rightarrow x = 10$

Now,  $h_1 = x + 5 = 15 \text{ cm}$

$h_2 = 40 - x = 30 \text{ cm}$

$h_2/h_1 = 2$

8. (C)

Given  $m = 12 \text{ kg}$ ,  $A = 800 \text{ cm}^2$ ,  $\rho = 1000 \text{ kg/m}^3$

$P = \rho gh$

$\frac{mg}{A} = \rho gh$

$\frac{12 \times 10}{800 \times 10^{-4}} = 1000 \times 10 \times h$

$\frac{12}{80} = h$

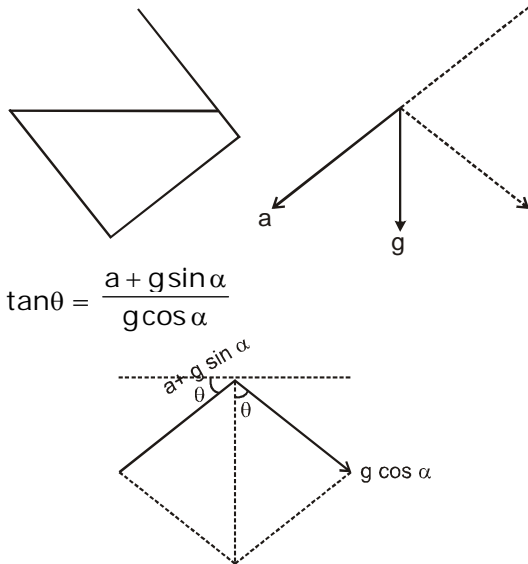
$h = \frac{1200}{80} = 15 \text{ cm}$

9. (B)  
 $F_b = \rho Vg - \rho vg = 0$

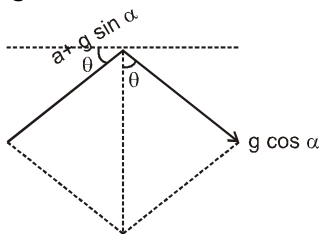
10. (A)  
 At same depth pressure is same  
 So ratio  $P_1 : P_2 = 1 : 1$ .

11. (B)

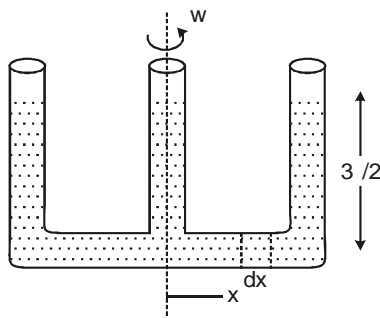
12. (B)



$$\tan \theta = \frac{a + g \sin \alpha}{g \cos \alpha}$$



13. (C)



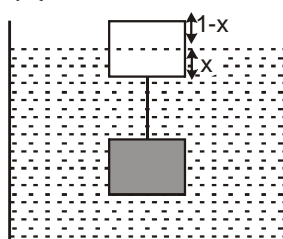
$$dP \cdot A = \rho A dx \cdot \omega^2 x$$

$$\int dp = \int \rho \omega^2 x dx$$

$$\Delta P = \frac{\rho \omega^2 \ell^2}{2} = \frac{3 \ell \rho g}{2}$$

$$\omega = \sqrt{\frac{3g}{\ell}}$$

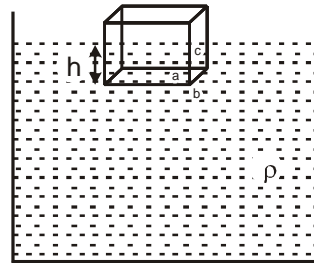
14. (B)



Total buoyancy  
 = Total Gravitation

$$\begin{aligned} &\Rightarrow 1^3 \times 1 \times g + 1^2 x \times 1 \rho \\ &= 1^3 \times 0.6 \times g + 1^3 1.15 \times g \\ &1 + x = 0.6 + 1.15 \\ &x = 0.75 \text{ m} \\ &\therefore 1 - x = 25 \text{ cm.} \end{aligned}$$

15. (D)



At equilibrium position  
 $(abc) (\rho) g = (bc) h \rho g$   
 After displacing slightly x,  
 extra buoyancy force.

$$\rho_{\text{net}} = ((bc)x) \rho g$$

$$a = \frac{xbcp g}{abcd \rho} = \frac{xg}{ad} \quad \omega = \sqrt{\frac{g}{ad}}$$

16. (B)

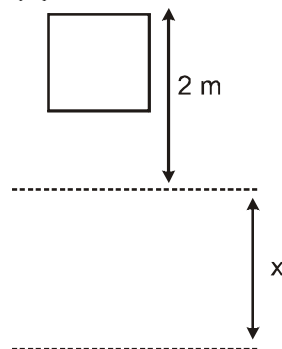
$$\begin{aligned} \rho_1 V &= \rho_2 2V \\ m_1 &= m_2 \\ m_1 g &= 0.92 Vg = m_2 g - xVg \\ x &= 1.8 \text{ gm/cm}^3 \end{aligned}$$

17. (C)

18. (B)

$$\begin{aligned} W - v \times 1 \times g &= W_1 \\ W - v \times x \times g &= W_2 \\ \Rightarrow W - (W - W_1) \times x &= W_2 \\ x &= \frac{W - W_2}{W - W_1} \end{aligned}$$

19. (A)



$$\begin{aligned} mg(x + 2) &= v \times 1 \times g \times x \\ v 0.8 g(x + 2) &= v \times 1 \times g \times x \\ 0.8x + 1.6 &= x \\ 0.2x &= 1.6 \\ x &= 8 \end{aligned}$$

20. (D)

Equilibrium Position  $W = F_B$

$$W = L^2 h \rho_M g$$

$$h = \frac{W}{L^2 \rho_M g}$$

21. (C)

$\therefore$  Volume where metal is present

$$= \frac{9.8}{7800} = 1.256 \times 10^{-3}$$

$$\text{Buoyancy} = v \rho g = 1.5 g$$

$$\Rightarrow v \times 1000 = 1.5$$

$$v = 1.5 \times 10^{-3}$$

fraction of volume =

$$\frac{1.5 \times 10^{-3} - 1.256 \times 10^{-3}}{1.5 \times 10^{-3}} \times 100 = 16\%$$

22. (A)

$$\sigma \times \frac{4}{3} \pi (R^3 - r^3) g = 1 \times \frac{4}{3} \pi R^3 g$$

$$\frac{R}{r} = \left( \frac{\sigma}{\sigma - 1} \right)^{1/3}$$

23. (B)

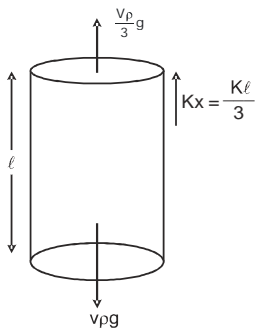
$$\text{Volume} = \frac{0.5}{500} = 10^{-3} \text{ m}^3$$

$$\text{Buoyancy} = \rho V g = 1000 \times 10^{-3} \times 10 = 10 \text{ N}$$

$$m = 1 \text{ kg}$$

$$\text{If float} = 2.5 \text{ kg}$$

24. (B)

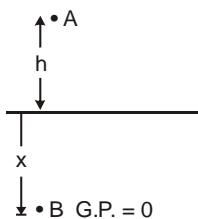


$$V = A \cdot l$$

$$\text{Now } \frac{A l \rho g}{3} + \frac{K l}{3} = A l \rho$$

$$K = 2 \rho A g$$

25. (C)



$$W_{FB} = \{K_B + U_B\} - \{K_A + U_A\}$$

$$- V \rho x = 0 + 0 - 0 - V \rho' g (x + h)$$

$$\rho g x = \rho' g x + \rho' g h$$

$$x = \frac{\rho' h}{\rho - \rho'}$$

26. (A)

$$AV = \text{constant}$$

$$A \downarrow V \uparrow$$

$$P + \rho g h + \frac{1}{2} \rho v^2 = \text{constant}$$

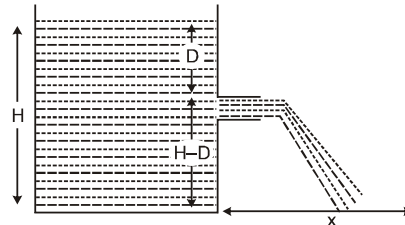
$$V \uparrow P \downarrow$$

27. (B)

$$A_1 V_1 = A_2 V_2 \quad (\text{Given } \frac{r_1}{r_2} = \frac{3}{2})$$

$$\frac{v_1}{v_2} = \frac{A_2}{A_1} = \frac{\pi r_2^2}{\pi r_1^2} = \left( \frac{2}{3} \right)^2 = \frac{4}{9}$$

28. (A)



$$\Delta p g = \frac{1}{2} \rho v^2$$

$$v = \sqrt{2 D g}$$

$$x = V \sqrt{\frac{2(H-D)}{g}} = 2 \sqrt{D(H-D)}$$

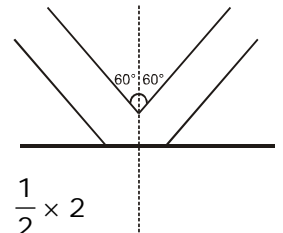
29. (B)

$$\frac{dm}{dt} = \rho A v$$

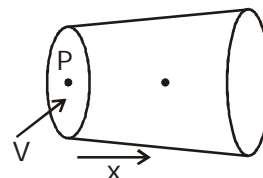
$$\Delta P = F_{\text{avg}} \cdot 1 \text{ sec.}$$

$$\Rightarrow 2 \rho A v^2 \cos 60^\circ$$

$$\Rightarrow 1000 \times 6 \times 10^{-4} \times (12) \times \frac{1}{2} \times 2 = 86.4 \text{ Nt.}$$



30. (A)



$$A = ax + b$$

$$\text{Continuity equation } bV = (ax + b) V_2$$

$$\text{By Bernoulli's equation } = P_2 + \frac{1}{2} \rho v_2^2 = \text{constant}$$

$$P_2 = \text{Constant} - \frac{1}{2} \rho V_2^2$$

$$P_2 = \text{Constant} - \frac{1}{2} \rho \frac{b^2 V^2}{(ax + b)^2}$$

$$P_2 = \text{Constant} - \frac{C_1}{(ax + b)^2}$$

Where  $C_1 = \text{Constant}$

31. (B)

$$A_1 V_1 = A_2 V_2$$

$$0.02 \times 2 = 0.01 \times V_2$$

$$V_2 = 4 \text{ m/sec.}$$

$$P_1 + \frac{1}{2} \rho V_1^2 = P_2 + \frac{1}{2} \rho V_2^2$$

$$4 \times 10^4 + \frac{1}{2} \times 1000 \times 2^2$$

$$= P_2 + \frac{1}{2} \times 1000 \times 4^2 \Rightarrow P_2 = 3.4 \times 10^4 \text{ N/m}^2$$

32. (B)

$$\sqrt{2 \times 20 \times 10^{-2} \times 10} = 2 \text{ m/sec.}$$

33. (B)

34. (D)

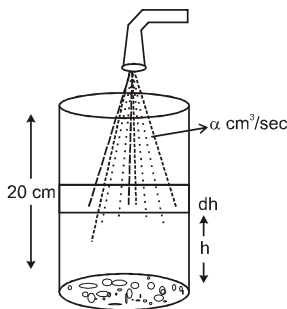
$$A_1 V_1 = A_2 V_2$$

$$\pi (1 \times 10^{-2})^2 \times 3$$

$$= 100 \times \pi \frac{(0.05 \times 10^{-2})^2}{4} \times V_2 \Rightarrow V_2 = 48 \text{ m/sec.}$$

35. (D)

Inlet = outlet



$$\alpha dt = a \sqrt{2gh} dt$$

$$h = \frac{\alpha^2}{2ga^2}$$

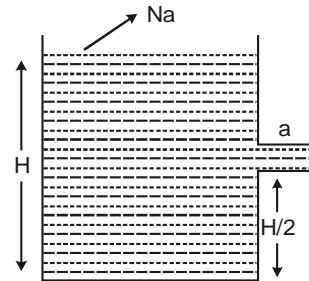
$$h = \frac{(100)^2}{2 \times (1000)(1)}$$

36. (D)

Force exerted by the water on the corner = change in momentum in 1 sec

$$= \sqrt{2} mv ; = \sqrt{2} \rho v L$$

37. (C)



$$\text{Force} = \rho a (\sqrt{2gh/2})^2$$

$$\text{acceleration} = \frac{\rho a g h}{\rho N a H} = g/N$$

38. (A)

$$\text{From } A_p V_p = A_o V_o$$

$$\frac{V_p}{V_o} = \frac{A_o}{A_p} = \frac{\pi(2 \times 10^{-2})^2}{\pi(1 \times 10^{-2})^2}$$

$$V_p = 4V_o$$

39. (B)

$$\alpha dt = Av dt$$

$$\Rightarrow 10^{-4} = 10^{-4} \sqrt{2gh} \Rightarrow h = \frac{1}{2g}$$

$$h = 0.051 \text{ m}$$

40. (C)

$$\frac{dV}{dt} = A \sqrt{2gh}$$

41. (A)

42. (D)

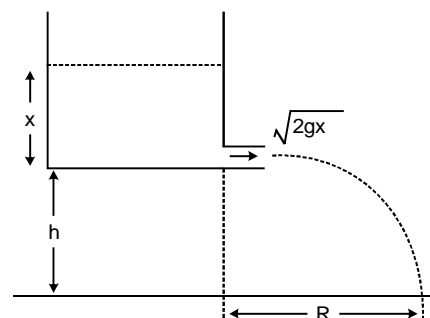
$$R = \sqrt{2g(H-h_1)} \sqrt{\frac{2h_1}{g}} ; = \sqrt{2g(H-h_2)} \sqrt{\frac{2h_2}{g}}$$

$$(H-h_1) h_1 = (H-h_2) h_2$$

$$H = h_1 + h_2$$

$$\text{For max. range} = \frac{H}{2}$$

43. (B)



$$R = \sqrt{2gx} \sqrt{\frac{2h}{g}} \quad x = \frac{R^2}{4h}$$

44. (B)

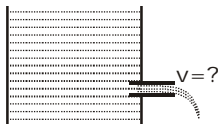
By Bernoulli's theorem

$$P_0 + \frac{10 \times 10}{1000 \times 10^{-4}} + 1000 \times 10 \times \frac{50}{100}$$

$$= P_0 + \frac{1}{2} \times 1000 \times v^2$$

$$6000 = \frac{1}{2} \times 1000 \times v^2$$

$$v = \sqrt{12} = 3.4 \text{ m/s}$$



45. (A)

Change in momentum is/sec.

$$\sqrt{2} \rho A v^2 = 565.7 \text{ N.}$$

46. (B)

$$\rho A v^2 = 1000 \times 2 \times 10^{-4} \times (10)^2 = 20 \text{ N}$$

47. (C)

Energy required in one second is the power

$$10^{-1} = A \cdot V$$

$$\Rightarrow 10^{-1} = 10^{-2} \times V$$

$$\Rightarrow V = 10 \text{ m/sec.}$$

$$mgh + \frac{1}{2} m v^2 = P$$

Here m = mass in one second

$$P = \rho A V g h + \frac{1}{2} \rho A V^3$$

$$P = \rho A V [10 \times 10 + 50] = 15 \text{ Kwatt}$$

48. (C)

49. (B)

With height density decreases.

50. (D)

$\rho_1 V_1 g$  is not the force applied by liquid 01 on body it is although net force (buoyant) come out to be  $\rho_1 V_1 g + \rho_2 V_2 g$ .

51. (D)

52. (D)

By the definition of buoyant force it is independent of atmospheric pressure  $p_{\text{in test tube}} = p_0 - \rho g h$   
If  $p_0$  vary then h also vary.

53. (A)

At rest they may touch the floor. In this case no force exerted by water from bottom hence net force due to water may be downwards.

54. (A)

Liquid can not produce shear stress therefore its surface becomes perpendicular to g.

Exercise-II

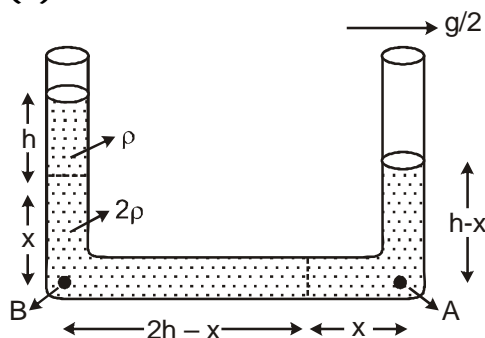
1. (D)  
Force is same pressure is different

2. (B)  
Take area of projection from left

$$\frac{2\rho g \ell h^2}{2} = \frac{3\rho g \ell R^2}{2}$$

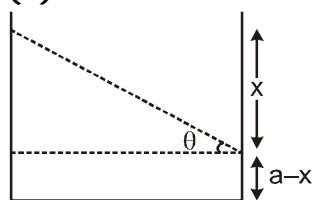
$$h = \sqrt{\frac{3}{2}} \cdot R$$

3. (B)



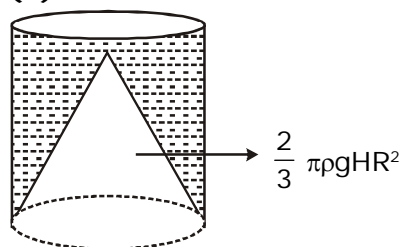
$$\begin{aligned} \rho xg/2 + 2(2h-x)g/2 &= P_B - P_A \\ P_A &= (h-x)\rho g \\ P_B &= h\rho g + 2\rho xg \\ \rho xg/2 + 2\rho(2h-x)g/2 &= h\rho g + 2\rho xg - h\rho g + x\rho g \\ \frac{4\rho hg}{2} - \frac{2\rho xg}{2} &= 2\rho xg + \rho xg/2 \\ 2\rho hg - \rho xg &= 5\rho xg/2 \\ \Rightarrow x &= \frac{4h}{7} \end{aligned}$$

4. (B)



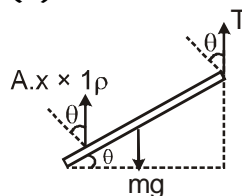
$$\begin{aligned} (a-x)a^2 + \frac{1}{2} x a^2 &= \frac{2}{3} a^3 \\ (a-x) + \frac{x}{2} &= \frac{2}{3} a \\ a - \frac{x}{2} &= \frac{2}{3} a \\ x &= \frac{2a}{3} \\ \therefore \tan \theta &= \frac{x}{a} = \frac{\text{acc.}}{g} \quad a = \frac{2}{3}g \end{aligned}$$

5. (D)



6. (A)

7. (A)

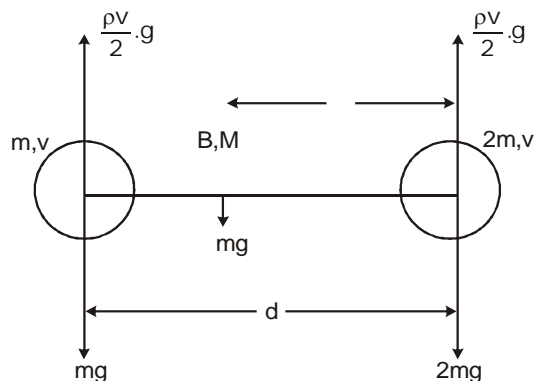


$$\begin{aligned} mg &= A \cdot 2L \times 0.75 \times g \\ T + Axg &= A \cdot 2L \times 0.75 \times g \\ T &= Ag [1.5 L - x] \end{aligned}$$

$$A xg \cos \theta \left( \ell - \frac{x}{2} \right) = T \cos \theta \ell$$

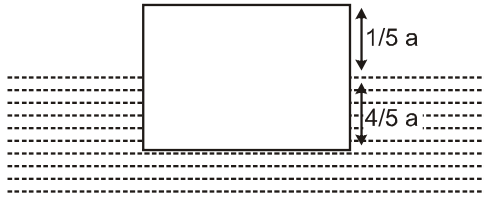
$$x \left( \ell - \frac{x}{2} \right) = \ell [1.5 L - x] \quad x = \ell$$

8. (B)



$$\begin{aligned} (3M + m)g &= \rho v g \\ \text{Torque balance about B} \\ mg(d-l) + \rho v g \frac{l}{2} &= 2mg\ell + \frac{\rho v g}{2}(d-l) \\ \ell &= \frac{d(v\rho - 2M)}{2(\rho v - 3M)} \end{aligned}$$

9. (C)



$$\rho \cdot \frac{4}{5} a^3 = M$$

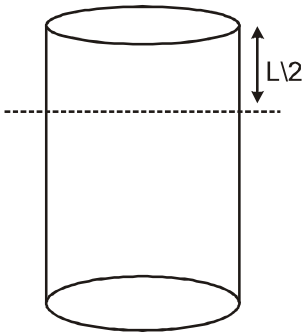
$$(m + M) = \rho a^3$$

$$m = \frac{5}{4} M$$

$$M = 4 m$$

$$m = \frac{M}{4}$$

10. (D)



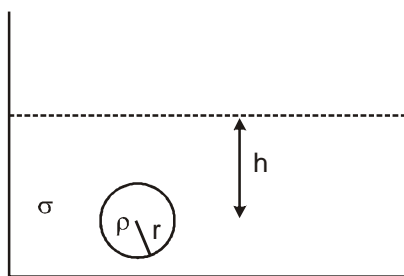
11. (A)

$$d_1 AL + d_2 AL = \frac{3}{2} LAd$$

$$d_1 + d_2 = \frac{3d}{2}$$

$$\therefore d_1 > \frac{3d}{4}$$

12. (B)



$$(W.D.)_{mg} + (W.D.)_{FB} = \Delta K$$

$$-mg(H + h) + (F_B)h = \frac{1}{2} mv^2$$

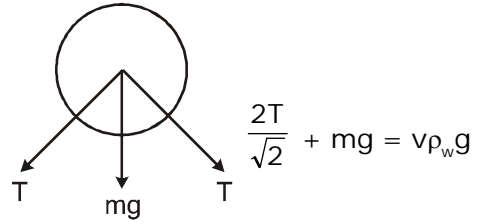
$$\Rightarrow -\frac{4}{3} \pi r^3 \rho (H + h) g + \left(\frac{4}{3} \pi r^3\right) \sigma gh = 0$$

$$-\rho g H - \rho g h + \sigma g h = 0$$

$$gh(\sigma - \rho) = \rho g H$$

$$H = \left(\frac{\sigma}{\rho} - 1\right) h$$

13. (A)



$$\frac{2T}{\sqrt{2}} + mg = v \rho_w g$$

14. (B)

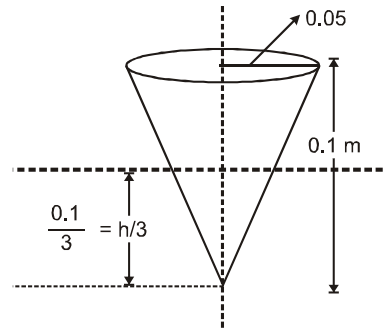
$$g_{eff} = g + a$$

$$\Rightarrow t + mg_{eff} = F_B$$

$$T = Vd(g + a) - v\rho(g + a)$$

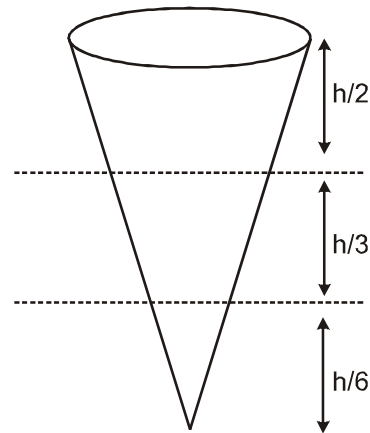
$$= v[(g + a)(d - \rho)]$$

15. (D)



$$\frac{1}{3} \pi r^2 h \rho_c g = \frac{1}{3} \pi (r/3)^2 \frac{h}{3} (0.8)g$$

$$\rho_c = \frac{0.8}{27}$$



$$\frac{1}{3} \pi r^2 h \rho_c g = \frac{1}{3} \pi \left(\frac{r}{6}\right)^2 \frac{h}{6} \times 0.8 \times g +$$

$$\frac{1}{3} \pi \left[ \left(\frac{r}{2}\right)^2 \frac{h}{2} - \left(\frac{r}{6}\right)^2 \frac{h}{6} \right] \rho g$$

$$\Rightarrow \frac{0.8}{27} = \frac{0.8}{36 \times 6} + \left[ \frac{1}{8} - \frac{1}{36 \times 6} \right] \rho \quad \rho = 1.9$$

16. (B)

Initially

$$W_{metal} = W_{ice} = \text{Buoyancy}$$

$$V_{metal} \rho_m g + V_{ice} \rho_{ice} g = V_d \rho_l g$$

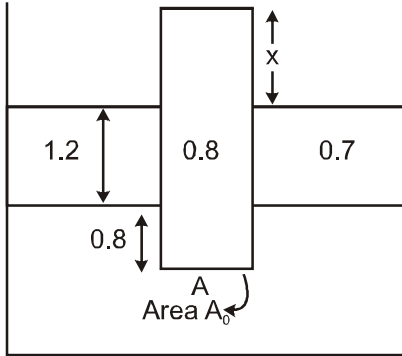
$$\therefore V_d = \frac{V_{\text{metal}} \rho_m}{\rho_l} + \frac{V_{\text{ice}} \rho_{\text{ice}}}{\rho_l}$$

finally volume displaced

$$V = V_m + V_w \text{ (From ice)}$$

$$= V_m + \frac{m}{\rho_w} = V_m + \frac{V_i \rho_i}{\rho_w} < \text{previous}$$

17. (B)



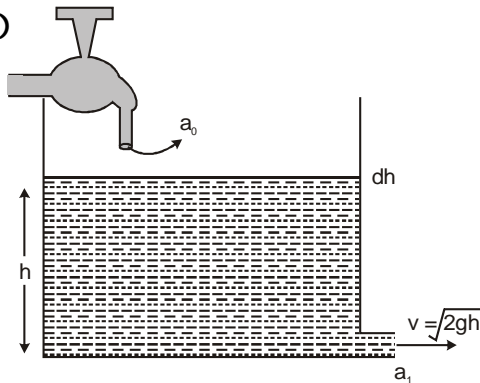
$$P_A(1.2 \times 0.7 \times g + 0.8 \times 1.2 \text{ g}) = P_A \cdot P_0$$

$$0.8 \times A_0(x + 1.2 + 0.8) g = P_A \cdot P_0$$

$$x + 1.2 + 0.8 = 0.84 + 0.96$$

$$x = 0.25 \text{ cm}$$

18. (C)



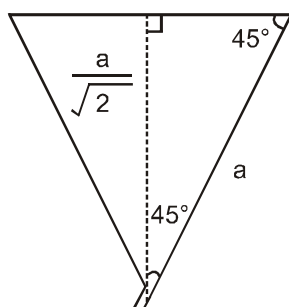
$$\frac{dm}{dt} = \rho A \frac{dh}{dt} = \rho a_0 v - \rho a_1 \sqrt{2gh}$$

$$\Rightarrow 4000 \frac{dh}{dt} = 1 \times 2 - 0.5 \sqrt{2gh}$$

$$\text{for } t = \infty \frac{dh}{dt} = 0; \Rightarrow 2 = 0.5 \sqrt{2gh}$$

$$\Rightarrow h = 0.8$$

19. (D)



Initial

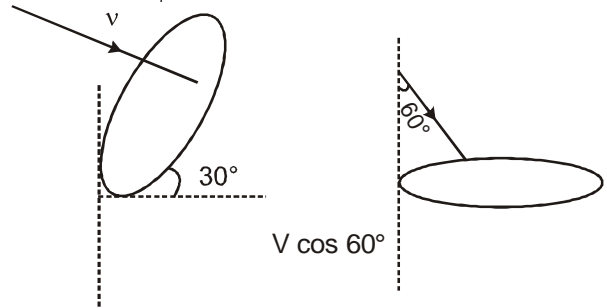
$$apg = \frac{1}{2} \rho v^2$$

$$V_0 = \sqrt{2ga}$$

$$\text{Now } V = \sqrt{2 \frac{a}{\sqrt{2}}} = \frac{V_0}{\sqrt[4]{2}}$$

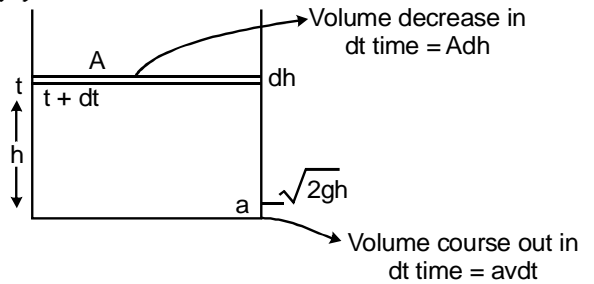
20. C

From  $A_1 V_1$   
Where  $V_1 \perp$  to area



$$\text{ratio} = \frac{V}{V \cos 60^\circ} = 2$$

21. (C)



Volume decrease = Volume outlet

$$Adh = a \sqrt{2gh} dt$$

$$\frac{-dh}{dt} = \frac{a \sqrt{2gh}}{A} \Rightarrow \int_H^{H/\eta} \frac{dh}{\sqrt{2gh}} = - \int_0^t \frac{a}{A} dt$$

$$t_1 = \left[ -\sqrt{\frac{H}{\eta}} + \sqrt{H} \right]$$

$$\text{Similarly } t_2 = \sqrt{\frac{H}{\eta}}$$

$$\Rightarrow t_1 = t_2 \Rightarrow 2 \sqrt{\frac{H}{\eta}} = \sqrt{H}$$

$$\eta = 4$$

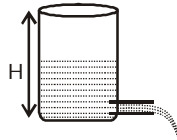
22. (A)

23. (D)

We know that

$$t_0 = \sqrt{\frac{2H}{g}}$$





When height become 4H then time

$$t' = \sqrt{2 \frac{(4H)}{g}}$$

$$t' = 2t_0$$

24. (C)

$$R = vt$$

$$v = \sqrt{2(2H - x)g}$$

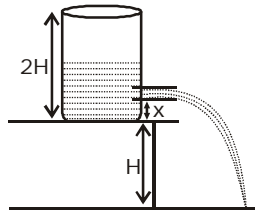
$$t = \sqrt{\frac{2(H + x)}{g}}$$

$$R_{\max} = \frac{dR}{dx} = 0$$

& we get

$$x = \frac{H}{2}$$

$$\text{Total height from ground} = H + \frac{H}{2} = 1.5 H$$



25. (D)

$$R = \sqrt{2g \times 10} \sqrt{\frac{2H}{g}} \dots\dots\dots (1)$$

$$\text{Now } \rho gh + P_o + P_E = P_o + \frac{1}{2} \rho V^2$$

$$\Rightarrow V^2 = 2gh + \frac{2P_E}{\rho}$$

$$\Rightarrow R' = \sqrt{(2g10) + \left(\frac{2P_E}{\rho}\right)} \sqrt{\frac{2H}{g}} \dots\dots(2)$$

From (1) & (2)  $P_E = 3 \text{ atm}$ .

26. (B)

$$\text{From } A_1 V_1 = A_2 V_2$$

$$(1) (V_1) \left(\frac{1}{2}\right) V_2$$

$$\Rightarrow \frac{V_1}{V_2} = \frac{1}{2}$$

$$V_2 = 2V_1$$

Now,

$$V_2^2 = V_1^2 + 2gh$$

$$4V_1^2 = V_1^2 + 2(10) \left(\frac{10}{100}\right)$$

$$V_1 = \sqrt{\frac{2}{3}}$$

Now volumetric rate of flow

$$= A_1 V_1$$

$$= \frac{1 \times 10^{-4}}{10^{-3}} \times \frac{60\sqrt{2}}{\sqrt{3}}$$

$$= 4.9 \text{ lit/min.}$$

27. (D)

$$v_1 = \sqrt{2gh/2} = \sqrt{gh}$$

for  $v_2$

$$\rho gh + 2\rho g \frac{h}{2} = \frac{1}{2} 2\rho v_2^2$$

$$2gh = v_2^2$$

$$v_2 = \sqrt{2gh}$$

28. (C)

$$A_1 V_1 = A_2 V_2$$

$$10^{-2} \times 2 = 0.5 \times 10^{-2} \times V^2$$

$$V_2 = 4 \text{ m/sec.}$$

$$P_A + \frac{1}{2} \rho V_A^2 = P_B + \frac{1}{2} \rho V_B^2$$

$$8000 + \frac{1}{2} 1000 \times 2^2$$

$$= P_B + \frac{1}{2} 1000 \times 4^2$$

$$P_B = 2000 \text{ Pa}$$

29. (A)

30. (A)

$$\mu mg = \frac{2}{2} \rho \pi \left(\frac{d}{2}\right)^2 .2gH.$$

$$d = \sqrt{\frac{2\mu M}{\pi \rho H}}$$

31. (D)

Pressure at the bottom = 2hpg

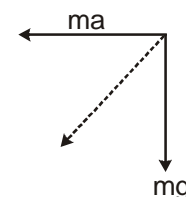
force at the bottom = 2hpgA

At balancing condition

Downward force by vessel wall + W = F

$$\Rightarrow F.W. = F_D$$

32. (A, C)



$$\tan \theta = \frac{a}{g} \text{ (backward)}$$

33. (A, C)

$$W_B = W_1$$

$$W_a = W$$

Buoyancy due to air = W

⇒ When air inside the balloon

$$W = W_2$$

Buoyancy eliminate the effect of air inside the balloon

$$\Rightarrow W_1 = W_2$$

$$\text{So, } W_2 = W_1 + W$$

34. (B, C)

Balance B reads = 5 Kg + Buoyancy

A reads = 2 Kg - F<sub>B</sub>

35. (D)

(A) Sphon works when h<sub>3</sub> > 0

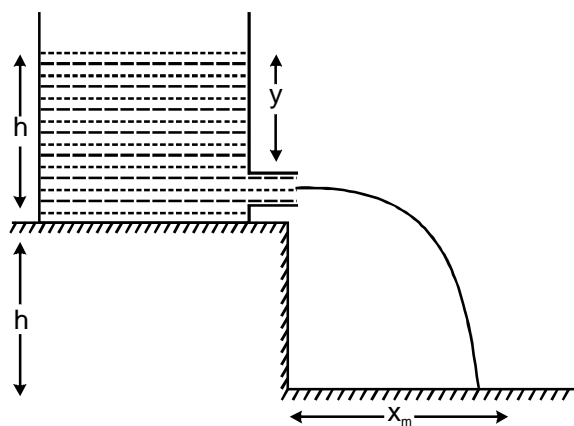
This will create a pressure difference

$$(B) P_3 = P_0 = P_2 + \rho gh_3$$

$$P_2 = P_0 - \rho gh_3$$

$$(C) P_3 = P_0$$

36. (A, C)



$$x = \sqrt{2gy} \sqrt{\frac{2(2n - y)}{g}}$$

$$\text{for } x_m \Rightarrow \frac{dx}{dy} = 0$$

$$\Rightarrow y = h$$

37. (B, D)

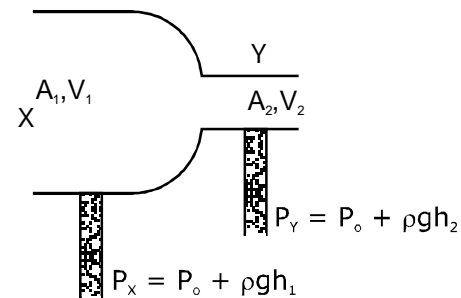
$$F = \rho av^2$$

$$P = Fv = \rho av^3$$

38. (B)

$$x = \sqrt{2gy} \sqrt{\frac{2(H - y)}{g}}$$

39. (D)



$$\text{From } A_1 v_1 = A_2 v_2$$

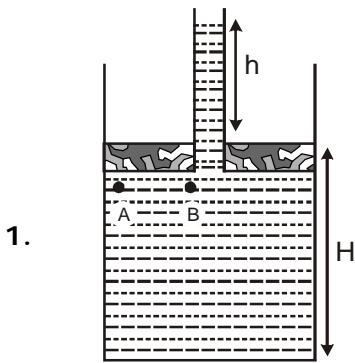
$$v_2 > v_1$$

From Bernoulli's

$$P_x + \frac{1}{2} \rho v_1^2 = P_y + \frac{1}{2} \rho v_2^2$$

Exercise-III

Level - I



1.

Pressure at A & B is same  
So,  $P_A = P_B$

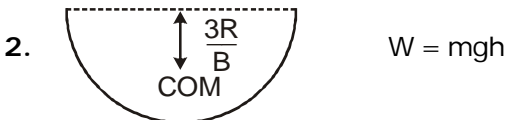
$$\Rightarrow P_0 + \frac{Mg}{\pi(R^2 - r^2)} = P_0 + \rho gh$$

$$\Rightarrow h = \frac{M}{\pi(R^2 - r^2)\rho_w}$$

Now,  
Total water is cylinder + Total water in pipe

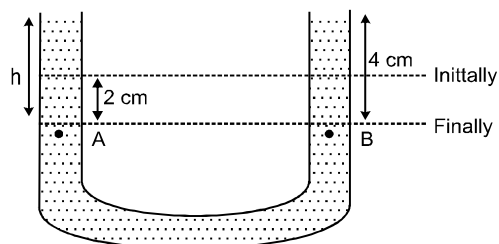
$$= \frac{750}{1000} \text{ Kg} \quad \Rightarrow \pi R^2 H \rho + \pi r^2 h \rho = \frac{750}{1000}$$

$$H = \left( \frac{3}{4} - \pi r^2 h \rho \right) \frac{1}{\pi R^2 \rho}$$



2.

$$= \frac{2}{3} \pi R^3 \rho \times g \times h$$

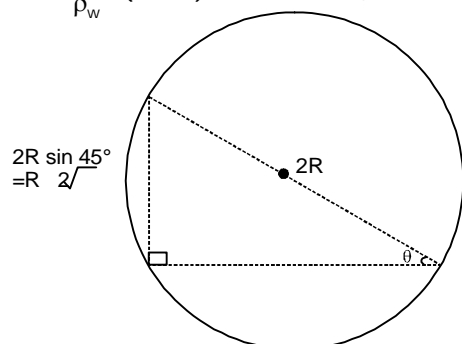


3.

$$P_A = P_B \quad \Rightarrow \rho_w gh = \rho_{Hg} g (0.04)$$

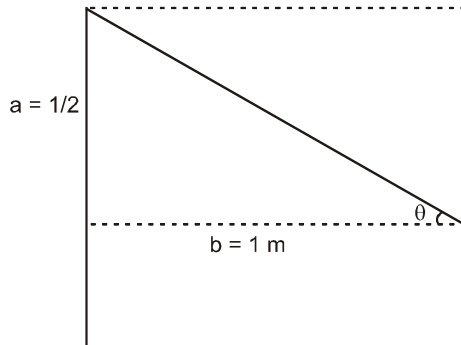
$$h = \frac{\rho_{Hg}}{\rho_w} (0.04) = 13.5 \times 4, \quad h = 54 \text{ cm}$$

4.



$$\theta = \tan^{-1} \frac{a}{g} = 45^\circ$$

$$\therefore P_{\max} = \rho g R \sqrt{2}$$

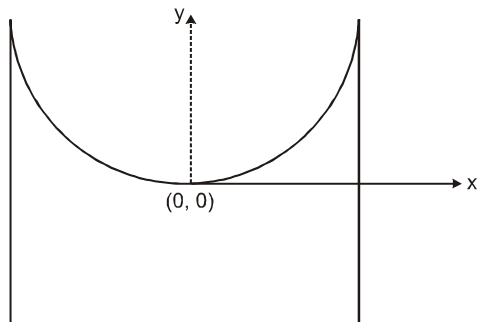


5.

$$\tan \theta = \frac{2}{10} = \frac{1}{5}$$

$$V = \frac{(b)^2 a}{2} = \frac{1 \times 1 \times 1/5}{2} = \frac{1}{10} \text{ m}^3$$

$$m = \rho V = 100 \text{ Kg.}$$



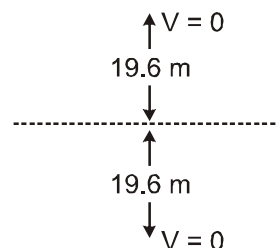
6.

$$y = \frac{\omega^2 x^2}{2g} \quad \frac{dy}{dx} = \frac{\omega^2 x}{g}$$

$$\frac{dy}{dx} = 1 \text{ at } x=0.3 \text{ m} \Rightarrow \omega = \sqrt{\frac{10}{0.3}} = \frac{10}{\sqrt{3}} \text{ rad/s.}$$

$$\frac{dy}{dx} \Big|_{x=\frac{1}{2} \text{ m}} = \frac{\left(\frac{10}{\sqrt{3}}\right)^2 \times \frac{1}{2}}{10} = \frac{5}{3} = \text{Tan} \alpha$$

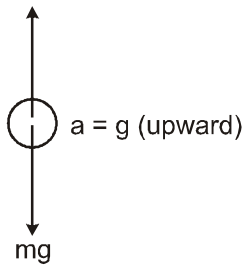
7.  $W_{\text{net}} = \Delta K = 0$



$$\Rightarrow W_{mg} = W_B = 0$$

$$mg(19.6 + h) = 2 mgh$$

$$h = \frac{19.6 m}{2mg}$$



$$\therefore \frac{1}{2}gt^2 = h$$

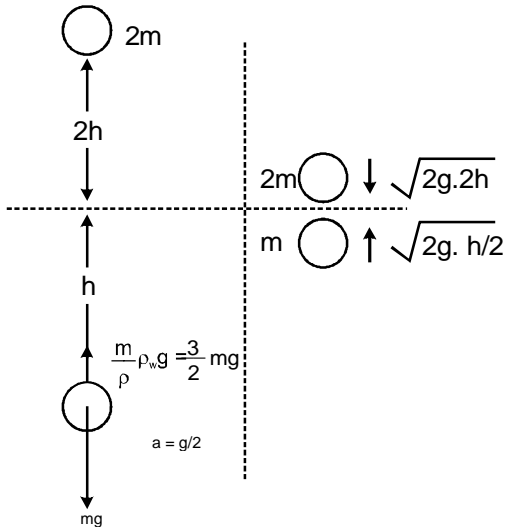
$$t = 2 \text{ sec}$$

$$T = 2t = 4 \text{ sec.}$$

8.  $m + \frac{V}{2} \rho_w = \left(\frac{m}{\rho} + V\right) \rho_w$

$m$  = mass of beaker  
 $V$  = interior volume of beaker  
 $\rho$  = density of material of beaker

9.(a) They will meet at the surface



(b) Just before collision

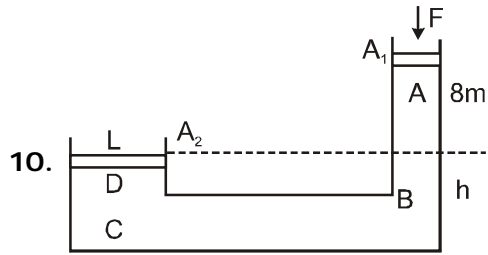
$$2m \text{ } \downarrow \sqrt{2g \cdot 2h}$$

$$m \text{ } \uparrow \sqrt{2g/2 \cdot h}$$

Just After collision

$$(3m) \text{ } \downarrow \sqrt{gh}$$

$$\therefore H_{\max} = \frac{(\sqrt{gh})^2}{2g} = \frac{h}{2}$$



10.

$$\text{Pressure at point A} = \frac{F}{A_1}$$

$$\text{Pressure at point B} = \frac{F}{A_1} + \rho g(8+h)$$

$$\text{Pressure at point C} = P_r \text{ at B}$$

$$\text{Pressure at D} = P_C - \rho gh$$

$$= \left[ \frac{F}{A_1} + \rho gh \right]$$

Now at equilibrium

$$(600) g = \left[ \frac{F}{A_1} + \rho g 8 \right] A/2$$

$$(600) g =$$

$$\left[ \frac{F}{25 \times 10^{-4}} + 750 \times 10 \times 8 \right] 800 \times 10^{-4}$$

$$\frac{60}{8} = \frac{F}{25} + 6 \Rightarrow \boxed{F = 37.5N}$$

11.  $m = A l_o \rho_w$   
 $m + A l \rho = A l \rho_w$   
 $m$  = mass of the test tube and lead  
 $A$  = Area of Cross section  
 $l_o = 10 \text{ cm}$

$$l = 40 \text{ cm} \Rightarrow \frac{\rho}{\rho_w} = \frac{l - l_o}{l} = 0.75$$

12.(a)  $15 - 12 = \frac{m}{\rho} \cdot \rho_w \cdot g$

$$3 = \frac{mg}{\rho / \rho_w} \quad \frac{\rho}{\rho_w} = 5$$

(b)  $15 - 13 = \frac{m}{\rho} \cdot \rho_\ell \cdot g$

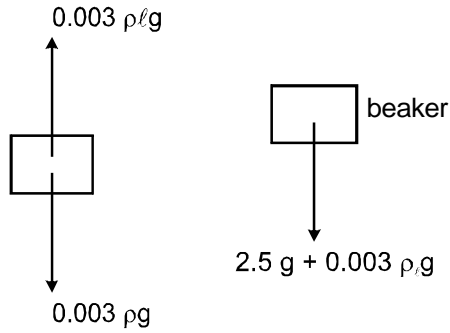
$$3 = \frac{\rho_\ell}{\rho} = \frac{2}{15}, \quad \frac{\rho_\ell}{5\rho_w} = \frac{2}{15}, \quad \frac{\rho}{\rho_w} = \frac{2}{3}$$

13. a

$$0.003 \rho g - 0.003 \rho_\ell g = 2.5 g$$

$$\rho - \rho_\ell = \frac{2.5}{3} \times 1000 \dots\dots\dots (1)$$

$$2.5 g + 0.003 \rho_\ell g = 7.5$$



$$\rho_\ell = \frac{7.5 - 2.5}{0.003} = \frac{5000}{3} \text{ Kg/m}^3$$

$$\rho = \frac{2.5 \times 1000}{3} + \frac{5000}{3} = 2500 \text{ Kg/m}^3$$

(b)  $E = 1 + 1.5 = 2.5 \text{ Kg}$   
 $\Delta = 2500 \times 0.003 = 7.5 \text{ Kg}$

14.  $\frac{2}{3} V \rho_\ell = V \rho$

$$nV\rho_\ell + (1 - n)V\rho_w = V\rho = \frac{2}{3} V\rho_\ell$$

$$n = \frac{2\rho - 3\rho_w}{3(\rho_\ell - \rho_w)} = \frac{3}{5}$$

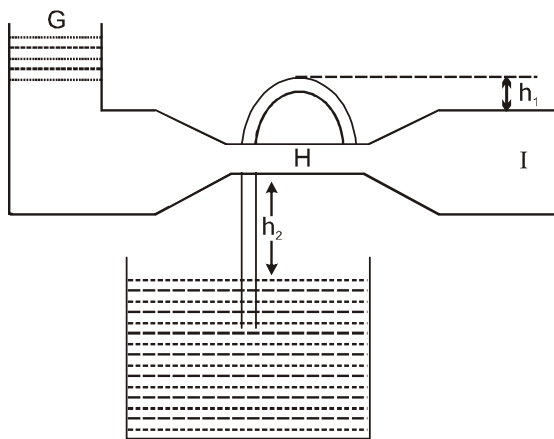
15.  $Ald_1 = Axd_2$        $x = \frac{\ell d_1}{d_2}$

$$K(\ell - x) + Ald_2g = Ald_1g + m$$

$$m = K\left[\ell - \frac{\ell d_1}{d_2}\right] + Alg d_2 - Alg d_1$$

$$= \frac{K\ell(d_2 - d_1)}{d_2} + Alg(d_2 - d_1)$$

$$= \ell(d_2 - d_1) \left[ \frac{K}{d_2} + Ag \right]$$



16.

Applying Bernoulli's theorem b/w

G & I we get

$$P_0 + \rho gh_1 = P_0 + \frac{1}{2} \rho V^2$$

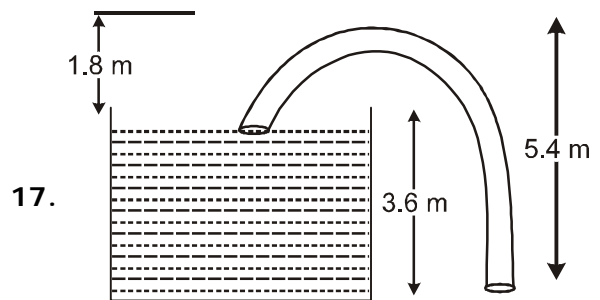
& b/w I & H

$$P_H + \frac{1}{2} \rho (2V)^2 = P_0 + \frac{1}{2} \rho V^2$$

$$P_H = P_0 - \frac{3}{2} \rho V^2 = P_0 - 3\rho gh$$

$$P_H = P_0 - \rho gh_2 \Rightarrow 3\rho gh_1 = \rho gh_2$$

$$h_2 = 3h_1$$



17.

(a)  $\rho g(3.6) = \frac{1}{2} \rho V^2$

$$V = 6\sqrt{2} \text{ m/s}$$

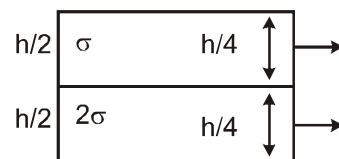
(b) Discharge rate of flow = AV

$$= \pi \left( \frac{4}{\sqrt{\pi}} \right)^2 \times 10^{-4} \times 6\sqrt{2}$$

$$9.6\sqrt{2} \times 10^{-3} \text{ m}^3 / \text{s}$$

(c)  $P_A = P_0 - \rho g(5.4)$   
 $= 10^5 - 10^5 (5.4), \quad = 4.6 \times 10^4 \text{ N/m}^2$

18.



(a) for A

$$\rho g \frac{h}{4} = \frac{1}{2} \rho v^2 \quad v = \sqrt{g \frac{h}{2}}$$

$$R_A = vT$$

$$= \sqrt{g \frac{h}{2}} \cdot \sqrt{\frac{3h}{4} \cdot \frac{2}{g}} \quad R_A = \sqrt{3} \frac{h}{2}$$

(b) for B

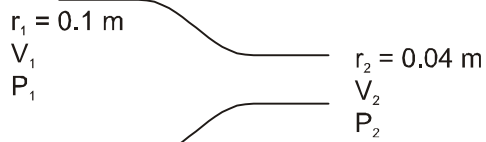
$$2\sigma g \frac{h}{4} + \sigma g \frac{h}{2} = \frac{1}{2} \cdot 2\sigma v^2 \quad gh = v^2$$

$$v = \sqrt{gh} \quad R_B = \sqrt{gh}$$

$$\sqrt{\frac{2h}{4g}} = \frac{h}{\sqrt{2}}$$

$$\frac{R_A}{R_B} = \frac{\sqrt{3h}}{2h} \sqrt{2} = \frac{\sqrt{3}}{\sqrt{2}}$$

19.

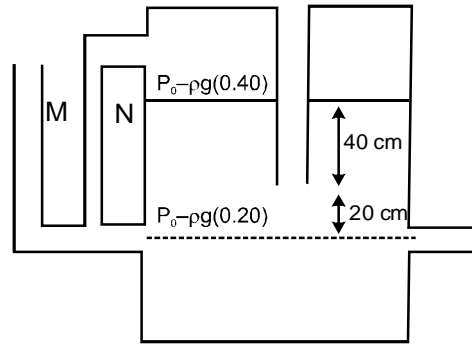


From  $A_1 V_1 = A_2 V_2$

and  $P_1 + \frac{1}{2} \rho V_1^2 = P_2 + \frac{1}{2} \rho V_2^2$

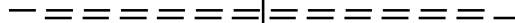
and  $P_1 - P_2 = 10 \text{ N/m}^2$

20.



In N water level is = 60 cm.

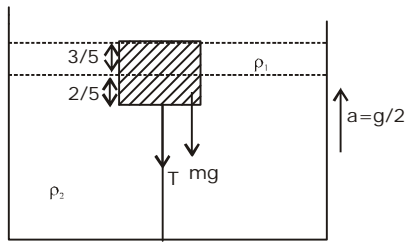
In M = 20 cm.



Exercise-III

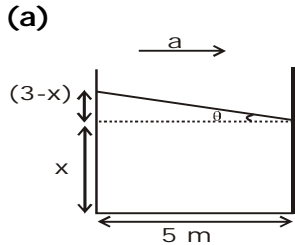
Level - II

1.



$$T + mg = \left[ \left( \frac{2}{5} \times 10^{-3} \right) \times \left( 1500 \times \frac{3g}{2} \right) \right] + \left[ \left( \frac{3}{5} \times 10^{-3} \right) \times \left( 1000 \times \frac{3g}{2} \right) \right] \quad T = 6 \text{ N}$$

2.

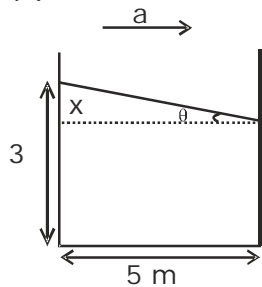


$$2 \times 4 \times 5 = (5 \times x \times 4) + \frac{1}{2} \times 5(3-x) \times 4$$

$$\Rightarrow x = 1 \text{ m} \quad \tan \theta = \frac{a}{g} = \frac{3-x}{5}$$

$$\frac{a}{10} = \frac{2}{5} \Rightarrow a = 4 \text{ m/sec}^2$$

(b)



$$a = 4 \times 1.2 = 4.8 \text{ m/sec}^2$$

$$\tan \theta = \frac{a}{g} = \frac{x}{5} \quad x = 2.4 \text{ m}$$

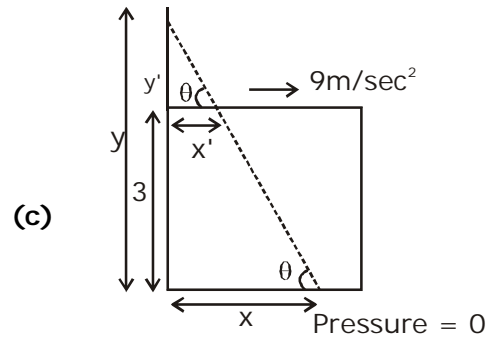
Water split out

$$= (2 \times 4 \times 5) - (0.6 \times 5 \times 4) - \frac{1}{2} \times 2.4 \times 4 \times 5$$

$$= 40 - 12 - 24 = 40 - 36 = 4 \text{ m}^3$$

$$\text{Initial} = 2 \times 4 \times 5 = 40 \text{ m}^3$$

$$\% = \frac{4}{40} \times 100 = 10\%$$



$$\tan \theta = \frac{9}{10} = \frac{y'}{x} = 0.9 = y' / x$$

$$\tan \theta = \frac{9}{10} = \frac{y}{x} = \frac{y'+3}{x} \quad y' = 0.9x - 3$$

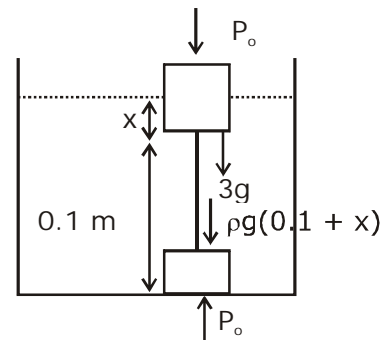
$$40 = \frac{1}{2} (y'+3) \times x \times 4 - \frac{1}{2} y' \times 4 \times \frac{y'}{0.9}$$

$$x = 5$$

Pressure at rear wall

$$= \rho a x = 1000 \times 9 \times 5 = 45 \text{ KPa}$$

3.



$$\rho g / (0.1 + X) \pi (0.05)^2 + 3g = \rho g \pi (0.1)^2 x$$

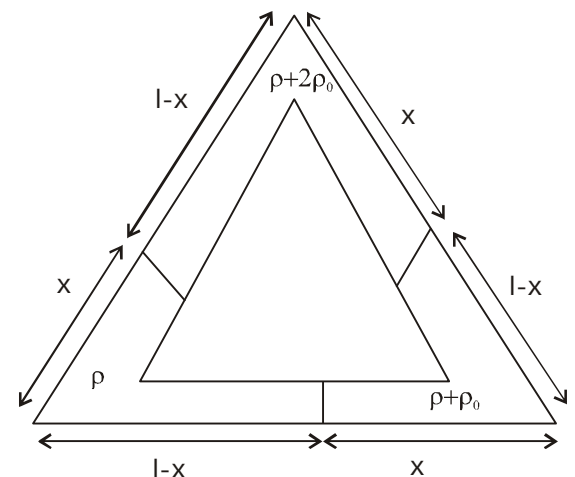
$$x = 0.16$$

$$h = 0.1 + 0.16 = 0.26 \text{ m}$$

$$(b) 30 = \pi (0.1)^2 \times x \times 1000 \times 10$$

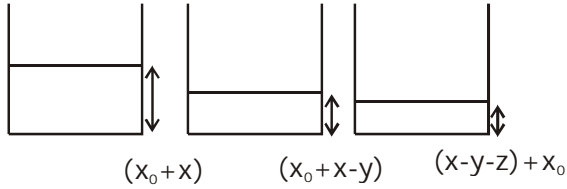
$$x = \frac{30}{100 \times \pi} = 0.096 \text{ m} \quad \text{Total} = 0.196 \text{ m.}$$

4.



$$\begin{aligned} & \rho x \sin 60^\circ g + (\rho + 2\rho_0) (l-x) \sin 60^\circ \\ & = (\rho + 2\rho_0) x \sin 60^\circ g + (\rho + \rho_0) (l-x) \sin 60^\circ g \\ & \rho x + (\rho + 2\rho_0)(l-x) = (\rho + 2\rho_0)x + (\rho + \rho_0)(l-x) \\ & x = l/3 \end{aligned}$$

5. Initial depth in sea water =  $x_0$



Water

$$\begin{aligned} W_s + W_c &= x_0 A \rho_{sw} g \dots (1) \\ W_s + W_c &= (x_0 + x) A \rho_w g \dots (2) \\ W_s &= (x_0 + x - y) A \rho_w g \dots (3) \\ W_s &= (x_0 + x - y - z) A \rho_{sw} g \dots (4) \end{aligned}$$

(1)/(2)

$$1 = \frac{\rho_{sw}}{\rho_w} \cdot \frac{x_0}{x_0 + x}$$

$$x_0 \left[ \frac{\rho_{sw} - \rho_w}{\rho_w} \right] = x \Rightarrow x_0 = \frac{\rho_w x}{\rho_{sw} + \rho_w}$$

(3)/(4)  $1 = \frac{x_0 + x - y}{x_0 + x - y - z} \frac{\rho_w}{\rho_{sw}}$

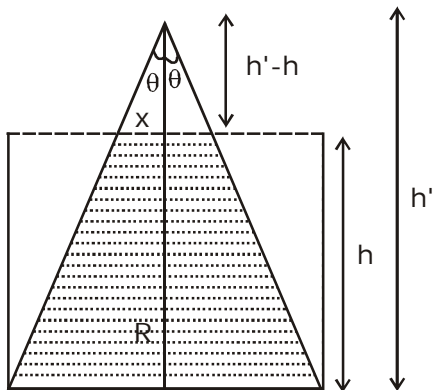
$$x_0 + x - y - z = \frac{\rho_w}{\rho_{sw}} x_0 + (x - y) \frac{\rho_w}{\rho_{sw}}$$

$$x_0 \left[ \frac{\rho_{sw} - \rho_w}{\rho_{sw}} \right] = (x - y) \frac{\rho_w}{\rho_{sw}} - x + y + z$$

$$\frac{\rho_w}{\rho_{sw}} x = (x - y) \frac{\rho_w}{\rho_{sw}} - x + y + z$$

$$\frac{\rho_{sw}}{\rho_w} = \frac{y}{y - x + z}$$

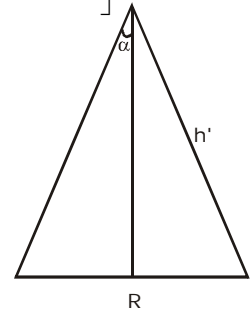
6.



Upward force exerted by the liquid on the flask

$$\rho g \left[ \pi R^2 h - \left\{ \frac{1}{3} \pi R^2 h' - \frac{1}{3} \pi x^2 (h' - h) \right\} \right] = W$$

$$\tan \alpha = \frac{R}{h'} \Rightarrow h' = R \cot \alpha$$



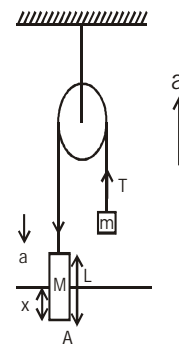
$$\frac{R}{x} = \frac{h'}{h' - h} \Rightarrow R(R \cot \alpha - h) = x R \cot \alpha$$

$$x = \frac{R \cot \alpha - h}{\cot \alpha}$$

$$W = \rho g \left[ \pi R^2 h - \left\{ \frac{1}{3} \pi R^2 R \cot \alpha - \frac{1}{3} \pi \left( \frac{R \cot \alpha - h}{\cot \alpha} \right)^2 (R \cot \alpha - h) \right\} \right]$$

$$\rho = \frac{W}{\pi g h^2 \tan \alpha \left( R - \frac{1}{3} h \tan \alpha \right)}$$

7.



$$\rho = \frac{M}{LA} \Rightarrow A = \frac{M}{\rho L}$$

$$Mg - T - Ax \rho_w g = Ma \dots (1)$$

$$T - mg = ma \dots (2)$$

$$Mg - mg - \frac{M}{\rho L} \cdot \rho_w x g = (M+m) a$$

$$(M - m) - \frac{M}{L} \frac{\rho_w}{\rho} x g = (M + m) a$$

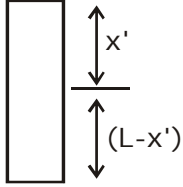


$$a = \left(\frac{M-m}{M+m}\right)g - \left(\frac{M-m}{M+m}\right)\frac{gx}{L}$$

(b)

a = 0 initial x = L

M.P. is when it is just submerged.



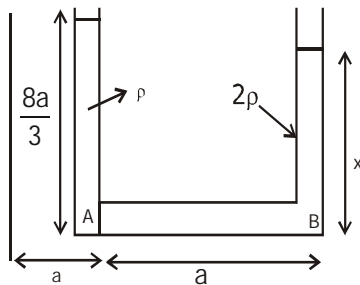
$$a = \left(\frac{M-m}{M+m}\right)g \left[1 - \frac{L-x'}{L}\right]$$

$$= \left(\frac{M-m}{M+m}\right)\frac{gx'}{L}$$

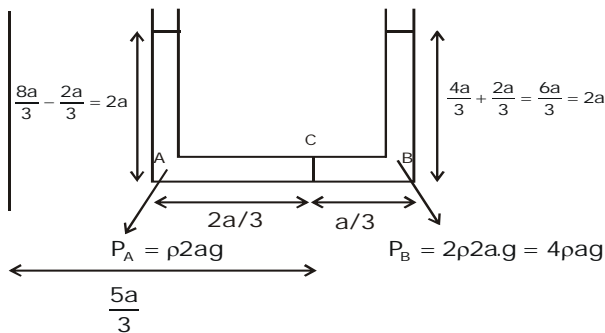
$$\omega^2 = \left(\frac{M-m}{M+m}\right)\frac{g}{L} \quad \omega = \sqrt{\left(\frac{M-m}{M+m}\right)\frac{g}{L}}$$

$$T = 2\pi\sqrt{\left(\frac{M+m}{M-m}\right)\frac{L}{g}} \quad \frac{T}{4} = \frac{\pi}{2}\sqrt{\left(\frac{M+m}{M-m}\right)\frac{L}{g}}$$

8.



$$\rho g x \frac{8a}{3} = 2\rho \cdot x \cdot g \quad x = \frac{4a}{3}$$



$$(P_C - P_A)S = \rho s \omega^2 \int_a^{5a/3} x dx = \frac{\rho \omega^2}{2} \left[ \frac{25a^2}{9} - a^2 \right]$$

$$= \frac{8}{9} \rho s \omega^2 a^2 \dots \dots \dots (1)$$

$$(P_B - P_C)s = 2\rho s \omega^2 \int_{5a/3}^{2a} x dx$$

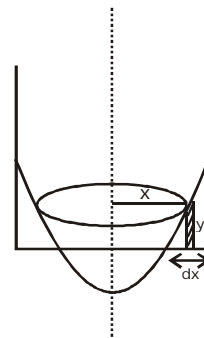
$$= \frac{2\rho s \omega^2}{2} \left[ 4a^2 - \frac{25a^2}{9} \right] = \rho s \omega^2 a^2 x \frac{11}{9} \dots (2)$$

1 + 2

$$(P_B - P_A)S = \rho s \omega^2 a^2 \left[ \frac{8}{9} + \frac{11}{9} \right]$$

$$4\rho a g - 2\rho a g = \rho \omega^2 a^2 x \frac{19}{9}$$

$$2g = \omega^2 a \frac{19}{9} \Rightarrow \omega = \sqrt{\frac{18g}{19a}}$$



9.

$$y = \frac{\omega^2 x^2}{2g} = \frac{(20)^2 x^2}{2 \times 10} = 20x^2$$

$$\text{Volume} = y dx \cdot 2\pi x$$

$$1.5 = 20x^2 \cdot 2\pi x dx \quad 1.5 = 40\pi x^3 dx$$

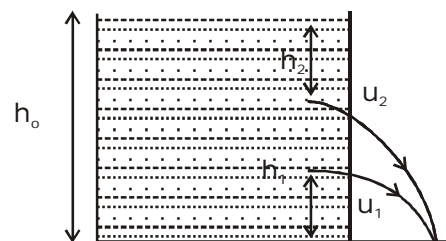
$$1.5 = 40\pi \int_x^{0.5} x^3 dx$$

$$1.5 = \frac{40\pi}{4} [(0.5)^4 - x^4]$$

$$x = (0.0155)^{\frac{1}{4}}$$

$$\text{Area} = \pi x^2 = 0.39 \text{m}^2.$$

10.



$$u_1 = \sqrt{2g(h_0 - h_1)} \quad u_2 = \sqrt{2gh_2}$$

$$u_1 \sqrt{\frac{2h_1}{g}} = u_2 \sqrt{\frac{2(h_0 - h_2)}{g}}$$

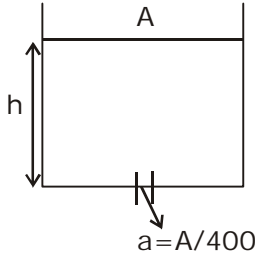
$$u_1^2 h_1 = u_2^2 (h_0 - h_2)$$

$$2g(h_0 - h_1)h_1 = 2gh_2(h_0 - h_2)$$

$$h_0(h_1 - h_2) = h_1^2 - h_2^2$$

$$h_0 = h_1 + h_2 \quad h_1 - h_2 = 0 \quad h_1 = h_2$$

11.



$$\rho gh = \frac{1}{2} \rho x^2 \quad v = \sqrt{2gh}$$

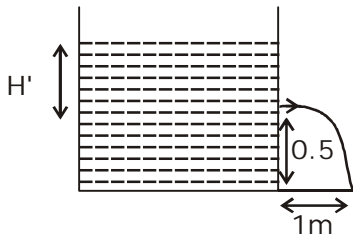
(a)  $-Adh = \frac{A}{400} v dt \quad \int_1^0 \frac{-dh}{\sqrt{2gh}} = \int_0^t \frac{dt}{400}$

$$t = 80\sqrt{5} \text{ sec.}$$

(b)  $v = \sqrt{2gh} = \sqrt{2 \times 10 \times 1} = \sqrt{20} \text{ m/sec}$

$$1 \times A = \sqrt{20} t \times \frac{A}{400} \quad t = 40\sqrt{5} \text{ sec.}$$

12.



$$\text{Range } v \sqrt{\frac{2 \times 0.5}{g}} = 1$$

$$v = \sqrt{10} = \sqrt{2gH'} \quad H' = \frac{1}{2} = 0.5 \text{ m}$$

$$-Adh = av dt \quad \int_{0.81}^{0.5} \frac{-dh}{\sqrt{2gh}} = \int_0^t \frac{a}{A} dt$$

$$\frac{2}{\sqrt{20}} [\sqrt{0.81} - \sqrt{0.5}] = \frac{1 \times 10^{-4}}{0.5} t$$

$$t = 431 \text{ sec.}$$

13. (i)  $\frac{1}{2} \rho v^2 = (600 \times 10 \times 0.6) + (900 \times 10 \times 0.4)$

$$\frac{1}{2} 900 v^2 = 3600 + 3600 = 7200$$

$$v \approx 4 \text{ m/sec.}$$

(ii)  $F = (\rho av)v = \rho av^2$   
 $= 900 \times 5 \times 10^{-4} \times (4)^2 = 7.2 \text{ N}$

(iii)  $F_{\text{min}} = 0$

$$\mu mg = 0.01 [900 \times 0.6 \times 0.5 + 600 \times 0.6 \times 0.5] \times 10$$

$$= 45 \text{ N}$$

$$F_{\text{max}} = 45 + 7.2 = 52.2 \text{ N.}$$

(iv)  $A_1 v_1 = A_2 v_2 \quad 0.5 v_1 = 5 \times 10^{-4} \times 4$

$$v_1 = 4 \times 10^{-3} \text{ m/sec for both}$$

15.

$$5 = (0.8) \times 10^3 \times (0.1)^2 x$$

$$x = 6.25 \text{ cm}$$

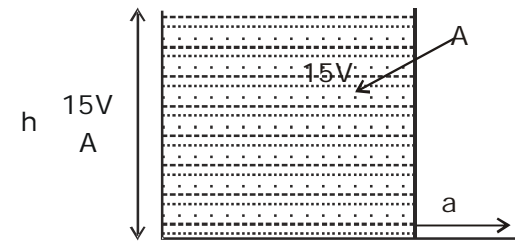
$$v_i = v_f$$

$$15 \times 15 \times 8 = 15 \times 15 \times H - 10 \times 10 \times 6.25$$

$$H = 10.7 \text{ cm} = \frac{388}{36} \text{ cm}$$

16.

$$\text{One glass of juice} = Vm^3$$



$$-adh = a\sqrt{2gh} dt$$

$$14V/A$$

$$-\int \frac{dh}{\sqrt{2gh}} = \int \frac{a}{A} dt \text{ cm}$$

$$\frac{15V}{A}$$

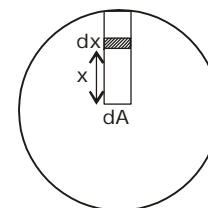
$$\frac{2}{\sqrt{2g}} \left[ \sqrt{\frac{15V}{A}} - \sqrt{\frac{14V}{A}} \right] = \frac{a}{A} \times 12 \dots (1)$$

$$\frac{2}{\sqrt{2g}} \left[ \sqrt{\frac{14V}{A}} - 0 \right] = \frac{a}{A} t \dots (2)$$

$$(2)/(1)$$

$$\frac{t}{12} = \frac{\sqrt{14}}{\sqrt{15} - \sqrt{14}} \Rightarrow \frac{12\sqrt{14}}{\sqrt{15} - \sqrt{14}}$$

17.

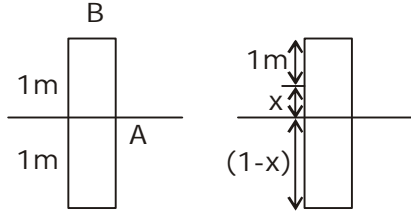


$$g_{\text{eff}} = \frac{GMr}{R^3} \quad r = x$$

$$dF = (\rho dA \cdot dx) \frac{gx}{R} \quad F = \rho dA \frac{g}{R} \int_0^R x dx$$

$$F = \frac{\rho g}{R} \cdot \frac{R^2}{2} dA = \frac{\rho g R}{2} dA \quad \text{Pressure} = \frac{\rho g R}{2}$$

18. (a)



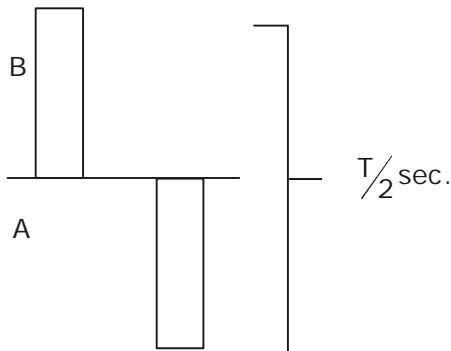
$$F_{\text{net}} = (1-x)\rho Ag - \frac{2A\rho}{2} g = -\rho Agx$$

$$K_{\text{eff}} = \rho Ag$$

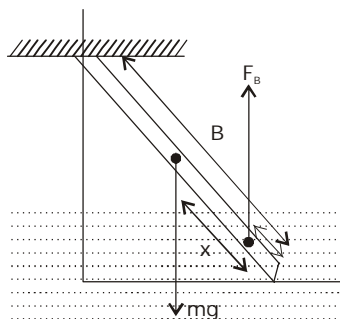
$$T = 2\pi\sqrt{\frac{m}{K}} = 2\pi\sqrt{\frac{2 \times A \times \rho / 2}{A\rho g}} = 2\pi\sqrt{\frac{1}{g}}$$

$$= T = 2\pi\sqrt{\frac{1}{\pi^2}} \approx 2 \text{ sec.}$$

(b)



$$\Rightarrow 1 \text{ sec.}$$



19.

$$(\rho_R Abg) \frac{b}{2} \sin\theta = \rho_W A x g \cdot (b - \frac{x}{2}) \sin\theta$$

$$\frac{5}{9} \cdot \frac{b^2}{2} = x \left( b - \frac{x}{2} \right) \Rightarrow \frac{5b^2}{18} = bx - \frac{x^2}{2}$$

$$x = b/3$$

20. (a)

cylinder floats so  
mg = Buoyancy force

$$\left( \frac{A}{5} L \rho_c \right) g = \left( \frac{3L}{4} \cdot \frac{A}{5} \right) dg + \left( \frac{L}{4} \cdot \frac{A}{5} \right) 2dg$$

$$\rho_c = \frac{3d}{4} + \frac{d}{2} = \frac{5}{4} d$$

(ii) B

x = v (time of flight)

$$= \sqrt{(3H - 4h) \frac{g}{2}} \sqrt{\frac{2h}{g}} = \sqrt{h(3H - 4h)}$$

21.

$$\tau_{\text{net}} = (F_B - mg) \sin\theta \cdot \frac{L}{2}$$

if  $\theta$  is small.

$$\tau_{\text{net}} = (F_B - mg) \theta \cdot \frac{L}{2}$$

$$F_B = SLd_2g$$

$$mg = SLd_1g$$

$$\Rightarrow \tau_{\text{net}} = (d_2 - d_1)SLg\theta \cdot \frac{1}{2}$$

$$\alpha = \frac{(d_2 - d_1)SLg(3)}{mL^2} \cdot \frac{\theta L}{2}$$

$$\alpha = \frac{3g(d_2 - d_1)}{d_1 L^2} \cdot \frac{\theta L}{2} \quad \omega = \sqrt{\frac{3g(d_2 - d_1)}{2d_1 L}}$$

23. from  $A_1 V_1 = A_2 V_2$

$$(4 \times 10^{-3})(1) = (8 \times 10^{-3})V_2 \quad V_2 = \frac{1}{2} \text{ m/s}$$

from Bernoulli's

$$P_p + \rho gh_p + \frac{1}{2} \rho V_p^2 = P_o + \rho gh_o + \frac{1}{2} \rho V_o^2$$

$$= 10^3 \times 10(2 - 5) + \frac{1}{2} \times 10^3(1 - \frac{1}{4})$$

$$= -30000 + 375$$

$$\therefore P_o - P_p = -29625$$

24.  $M_{\text{min}} = \pi r^2 \ell (\sqrt{\rho\sigma} - \rho)$

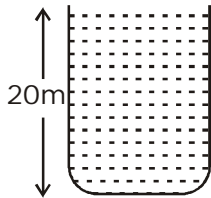
If tilted then its axis should become vertical  
Centre of Mass should be lower than Centre of buoyancy.

Exercise-IV

Level - I

1. (B)

Applying the Bernoulli's theorem just inside and outside the hole. Take reference line for gravitational potential energy at the bottom of the vessel.



Let  $P_o$  is the atmospheric pressure,  $\rho$  the density of liquid and  $v$  the velocity at which water is coming out.

$$P_{\text{inside}} + \rho gh + 0 = P_{\text{outside}} + \frac{\rho v^2}{2}$$

$$\Rightarrow P_o + \rho gh = P_o + \frac{\rho v^2}{2}$$

$$\text{or } v = \sqrt{2gh} = \sqrt{2 \times 10 \times 20} = 20 \text{ms}^{-1}$$

2. (D)

$\rho_1 < \rho_2$  as denser liquid acquires lowest position of vessel.

$\rho_3 > \rho_1$  as ball sinks in liquid 1 and  $\rho_3 < \rho_2$  as ball doesn't sink in liquid 2, so

$$\rho_1 < \rho_3 < \rho_2$$

3. (B)

$$\rho_{\text{oil}} < \rho < \rho_{\text{water}}$$

Oil is the least dense of them so it should settle at the top with water at the base. Now the ball is denser than oil but less denser than water. So, it will sink through oil but will not sink in water. So it will stay at the oil-water interface.

4. (C)

From Bernoulli's theorem,

$$\rho gh = \frac{1}{2} \rho (v_2^2 - v_1^2)$$

$$\Rightarrow gh = \frac{1}{2} v_1^2 \left( \left( \frac{v_2}{v_1} \right)^2 - 1 \right)$$

$$\Rightarrow gh = \frac{1}{2} v_1^2 \left( \left( \frac{A_2}{A_1} \right)^2 - 1 \right) (\because A_1 v_1 = A_2 v_2)$$

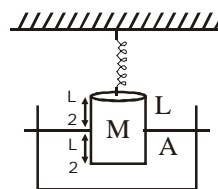
$$\Rightarrow \left( \frac{A_2}{A_1} \right)^2 = 1 + \frac{2hg}{v_1^2}$$

$$\Rightarrow \left( \frac{D_1}{D_2} \right)^4 = 1 + \frac{2hg}{v_1^2}$$

$$\Rightarrow D_2 = \frac{D_1}{\left( 1 + \frac{2hg}{v_1^2} \right)^{1/4}} = \frac{8 \times 10^{-3}}{\left( 1 + \frac{2 \times 10 \times 0.2}{(0.4)^2} \right)^{1/4}}$$

$$= 3.6 \times 10^{-3} \text{m.}$$

5. (A)



$$Mg = Kx + B$$

$$Mg = Kx + \sigma \frac{AL}{2} g$$

$$x = \frac{Mg}{K} - \frac{ALg}{2K} \sigma$$

$$= \frac{Mg}{K} \left( 1 - \frac{\sigma AL}{2M} \right)$$

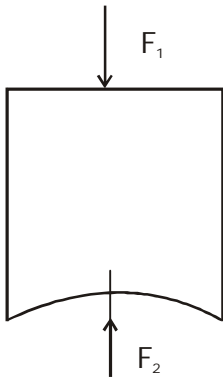
Exercise-IV

Level - II

1. (A)

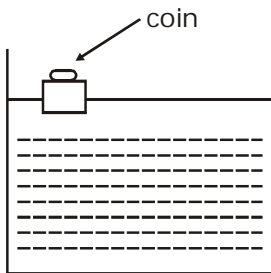
From  $A_1 V_1 = A_2 V_2$   
 $L^2 \sqrt{2gy} = \pi R^2 \sqrt{2g(4y)}$   
 $L^2 = \pi R^2$   
 $R = \frac{L}{\sqrt{2\pi}}$

2. (D)



$F_2 - F_1 = \text{Buoyancy force}$   
 $F_2 = F_1 + \text{Buoyancy force}$   
 $F_2 = (\text{Pressure}) (\text{Area of Projection}) + V\rho g$   
 $F_2 = \rho gh(\pi R^2) + v\rho g$   
 $= \rho g (v + \pi R^2 h)$

3. (D)

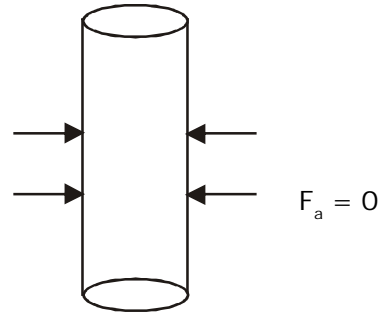


Initially,  
 $W_{\text{coin}} + W_{\text{block}} = V_d \rho_l g$   
 $V_d = \frac{W_{\text{coin}}}{\rho_l g} + \frac{W_{\text{block}}}{\rho_l g}$   
 Finally  
 $\frac{W_{\text{coin}}}{\rho_{\text{coin}} g} + \frac{W_{\text{block}}}{\rho_l g} = V_d$   
 $\rho_{\text{coin}} > \rho_l$

$\Rightarrow V_d' < V_d$   
 $\Rightarrow l \text{ decreases and } h \text{ decreases}$

4.

(a)  
 In portion A



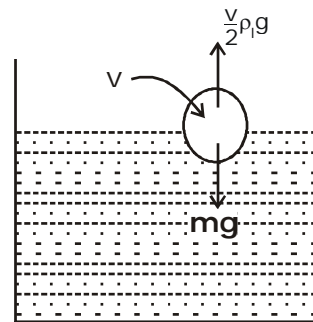
If radius of cylinder is  $r$ .  
 Then  
 Net Buoyancy = Weight of cylinder  
 $\pi r^2 h_A \rho_A g + \pi r^2 h_B \rho_B g = \pi r^2 (h + h_A + h_B) \rho_C g$   
 $h = 0.25 \text{ cm}$   
 Net upward force = extra Buoyancy force.  
 $= \pi r^2 h \rho_B g$

$a = \frac{F}{m} = \frac{\pi r^2 h \rho_B g}{\pi r^2 (h + h_A + h_B) \rho_C}$   
 $\therefore a = \frac{g}{6}$

5.

From  $A_1 V_1 = A_2 V_2$   
 $\pi(4)^2 (0.25) = \pi(1)^2 V_2$   
 $V_2 = 4 \text{ m/sec}$   
 Range =  $V_2 (\text{Time of flight})$   
 $= 4 \sqrt{\frac{2 \times 1.25}{100}}$   
 $= 2 \text{ m}$

6.

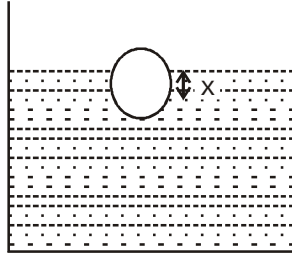


at equilibrium position

$$\Rightarrow \frac{4}{3} \pi R^3 \rho_s g = \frac{1}{2} \left( \frac{4}{3} \pi R^3 \right) \rho g$$

$$\rho_s = \frac{\rho}{2}$$

After slightly displaced from its M.P.



$F_{net}$  = Extra Buoyancy force

$$F_{net} = \pi R^2 x \rho g$$

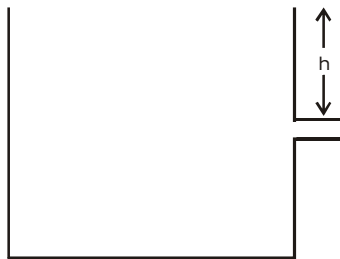
Now  $f = \frac{1}{2\pi} \sqrt{\frac{K}{m}}$

$$K = \pi R^2 \rho g$$

$$m = \frac{4}{3} \pi R^3 \rho_s g = \left( \frac{4}{3} \pi R^3 \right) \left( \frac{\rho}{2} g \right)$$

$$f = \frac{1}{2\pi} \sqrt{\frac{3g}{2R}}$$

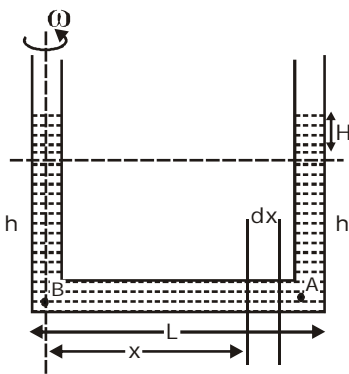
7. From  $A_1 V_1 = A_2 V_2$  .....(1)



$$P_o + \rho gh + \frac{1}{2} \rho v_1^2 = P_o + 0 + \frac{1}{2} \rho v_2^2 \dots\dots (2)$$

After solving eqn (1) & (2) you will get the answer.

8.



$$P_B = \rho gh + P_o$$

$$P_A = P_o + (H + h)\rho g \dots (1)$$

In small element having mass dm.

$$AdP = (dm)\omega^2 x$$

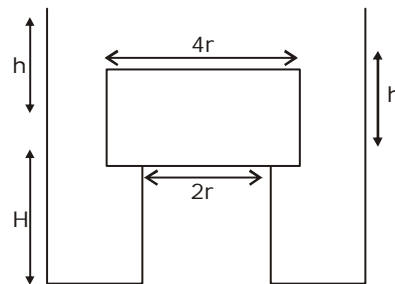
$$AdP = A\rho \cdot dx\omega^2 x$$

$$\int_{P_B}^{P_A} dP = \rho\omega^2 \int_0^L x dx$$

$$(P_A - P_B) = \frac{\rho\omega^2 L^2}{2}$$

$$H\rho g = \frac{\rho\omega^2 L^2}{2} \Rightarrow H = \frac{\omega^2 L^2}{2g}$$

9.

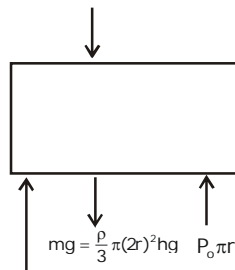


Area of Base of the cylinder =  $\pi(2r)^2 = 4\pi r^2$

Area of Hole =  $\pi(r)^2$

Net force is just balanced when height is  $h_1$  then

$$P_A = (h_1 \rho g)(4\pi r^2) + P_o 4\pi r^2$$



$$P_o 3\pi r^2 + (h + h_1)\rho g(3\pi r^2)$$

at balancing condition

$$P_o(4\pi r^2) + (h_1 \rho g)(4\pi r^2) + \frac{\rho}{3} \pi(4r^2)hg$$

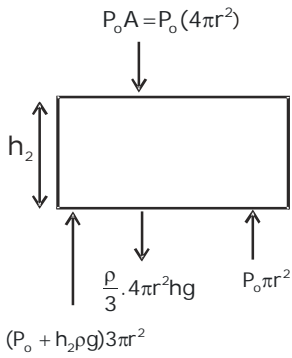
$$= P_o \pi r^2 + P_o 3\pi r^2 + (h + h_1)\rho g(3\pi r^2)$$

$$4h_1 \rho g + \frac{4}{3} \rho hg = 3hg + 3h_1 \rho g$$

$$h_1 \rho g = \frac{5}{3} hg$$

$$h_1 = \frac{5h}{3}$$

10.



At balancing condition

$$\frac{\rho}{3} \cdot 4\pi r^2 h g = h_2 \rho g 3\pi r^2 \quad h_2 = \frac{4h}{9}$$

11. Cylinder will not move up and remains at its original position

Because at  $h_2 > \frac{4h}{9}$ , cylinder bend to move

upward and  $h_2 < \frac{4h}{9}$  it remains at rest.

12. From  $A_1 V_1 = A_2 V_2$

13. (B)

air from end 1 flows towards end 2. Volume of the soap bubble at end 1 decreases

14. Buoyant force is resultant of pressure force of liquid.

$$15. P_1^{1-\gamma} T_1^\gamma = P_2^{1-\gamma} T_2^\gamma$$

$$P_1 = P_o + \rho_l g h \quad T_1 = T_o$$

$$P_2 = P_o + \rho_l g (H - y)$$

16. Buoyancy force =  $\rho_l V g$

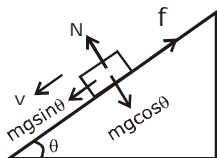
$$= \rho_l g \left[ \frac{nRT_2}{P_2} \right]$$

$$T_2 = T_o \left[ \frac{P_o + \rho_l g (H - Y)}{P + \rho_l g H} \right]^{2/5}$$

$$P_2 = P_o + \rho_l g (H - Y)$$

17. 6

18.



For (P)

Force exerted by x on Y.

$$= R = \sqrt{N^2 + f^2} = mg$$

W.D. by friction is +ve so mechanical energy of the system is decreasing

For (Q)

x is balancing weight of Y and Z.

P.E. is increasing because height is increasing.

For (R)

P.E. is decreasing

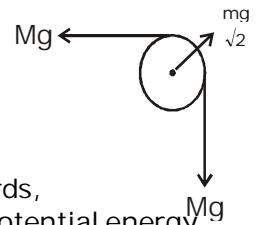
Total Mechanical energy is decreasing.

For (S)

As mass move downwards,

Fluid move upward so potential energy of x is increase.

Mechanical energy is constant because Fluid is non-viscous.



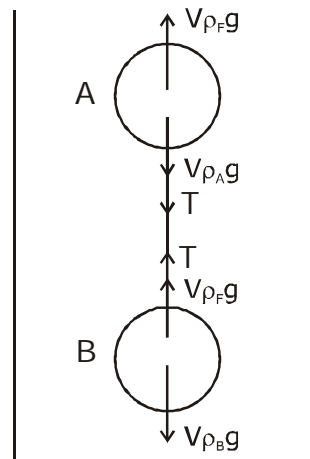
For (T)

V = constant so  $F_x = Mg$

In this due to viscous force

Mechanical energy is not conserved.

19. (A, B, D)



Let V be the volume of the sphere for equilibrium of A

$$T + V\rho_A g = V\rho_F g$$

$$T = Vg (\rho_F - \rho_A) \quad \dots (1)$$

For  $T > 0$

$$\rho_F > \rho_A$$

(A) is correct.

For equilibrium of B

$$T + V\rho_F g = V\rho_B g$$

$$T = Vg (\rho_B - \rho_F) \quad \dots (2)$$

For  $T > 0$ ,  $\rho_B > \rho_F$ ; (B) is correct.

From (1) & (2);  $2\rho_F = \rho_A + \rho_B$

(D) is correct.