JEE-MAIN

SOLUTIONS

TOPIC

FLUID

FLUID

Exercise-I

1. (B)

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

a = g/3

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

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

P = 1KPa

2. (B)

Given A = 2×10^{-3}, h = 0.4 m, ρ = 900 Kg/m^3

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

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

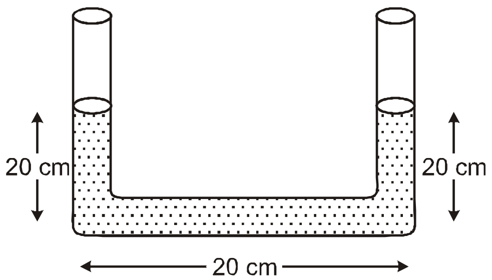
= 7.2 N

3. (A)

F = mg

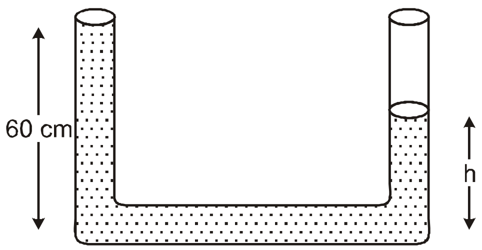
F = 10 N

4. (D)



$60\ \rho_w g = h\ \rho_\ell g$

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



So, volume = Ah

= 1 × 35 = 35 cm^3

5. (D)

O(zero) all the forces passes through O

$\therefore$ no torque.

6. (B)

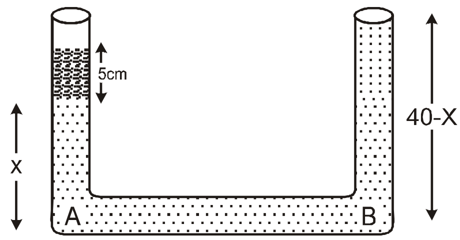
$h\rho g = 2P$

$\dfrac{4h}{5}\rho g = \dfrac{8P}{5}$ $\left\{\begin{matrix}\text{After lowering P due} \\ \text{to liquid.}\end{matrix}\right\}$

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

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

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, $h_1 = x + 5 = 15$ cm

$h_2 = 40 - x = 30$ cm

$h_2/h_1 = 2$

8. (C)

Given m = 12 kg, A = 800 cm^2, ρ = 1000 kg/m^3

P = ρgh

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

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

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

$h = \dfrac{1200}{80} = 15$ cm

9. (B)

$F_b = \rho Vg - \rho vg = 0$

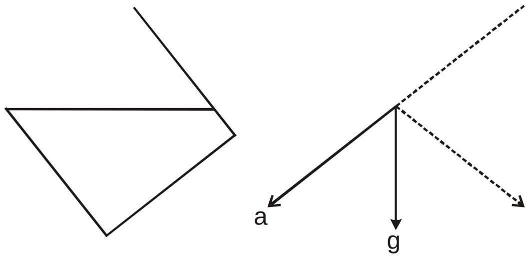
10. (A)

At same depth pressure is same

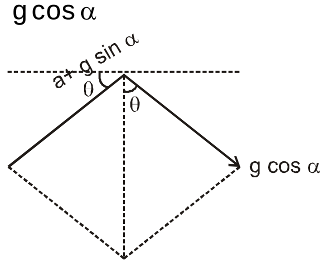
So ratio $P_1 : P_2 = 1 : 1$.

11. (B)

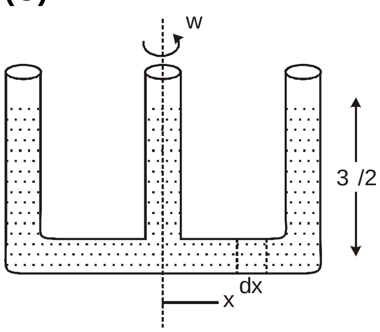
12. (B)



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



13. (C)



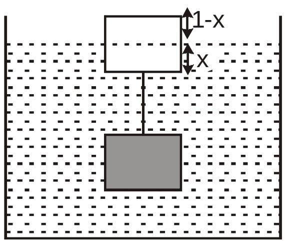
$dP \,.\, A = \rho A\, dx \,.\, \omega^2 x$

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

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

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

14. (B)



Total buoyancy

= Total Gravitation

$\Rightarrow 1^3 \times 1 \times g + 1^2 x \times 1\rho$

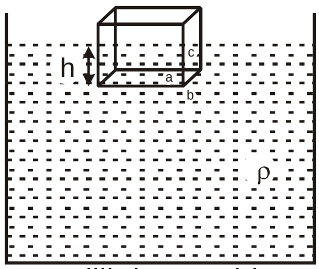
$= 1^3 \times 0.6 \times g + 1^3\, 1.15 \times g$

$1 + x = 0.6 + 1.15$

$x = 0.75$ m

$\therefore 1 - x = 25$ cm.

15. (D)



At equilibrium position

$(abc)\,(d\rho)g = (bc)\, h\rho g$

After displacing slightly x, extra buoyancy force.

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

$a = \dfrac{xbc\rho g}{abcd\rho} = \dfrac{xg}{ad}$ $\qquad \omega = \sqrt{\dfrac{g}{ad}}$

16. (B)

$\rho_1 V = \rho_2 2V$

$m_1 = m_2$

$m_1 g = 0.92\ Vg = m_2 g - xVg$

$x = 1.8\ gm/cm^3$

17. (C)

18. (B)

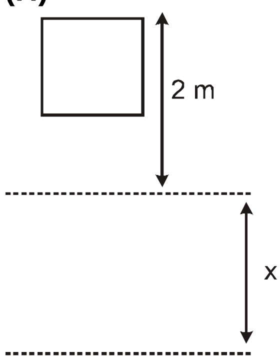
$W - v \times 1 \times g = W_1$

$W - v \times x \times g = W_2$

$\Rightarrow W - (W - W_1) \times x = W_2$

$x = \dfrac{W - W_2}{W - W_1}$

19. (A)



$mg\,(x + 2) = v \times 1 \times g \times x$

$v\ 0.8\ g\,(x + 2) = v \times 1 \times g \times x$

$0.8x + 1.6 = x$

$0.2x = 1.6$

$x = 8$

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

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

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)

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

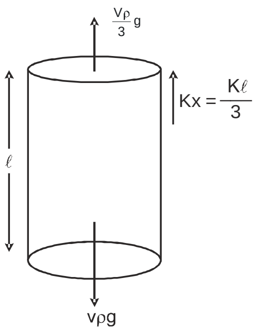
Buoyamcy = $\rho V g = 1000 \times 10^{-3} \times 10$

= 10 N

m = 1 kg

If float = 2.5 kg

24. (B)

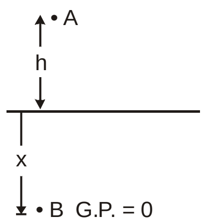


$V = A.\ell.$

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

$K = 2\rho A g$

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 = constant

A $\downarrow$ V$\uparrow$

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

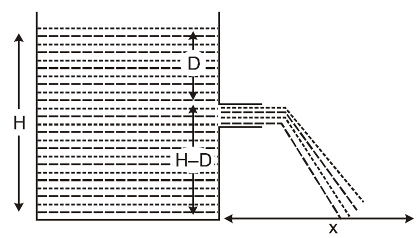
V$\uparrow$ P$\downarrow$

27. (B)

$$A_1V_1 = A_2V_2 \qquad \left(\text{Given } \frac{r_1}{r_2} = \frac{3}{2}\right)$$

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

28. (A)

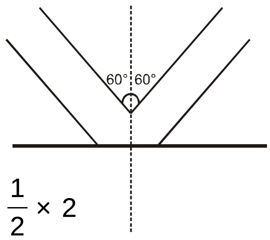


$$\Delta \rho g = \frac{1}{2}\rho v^2$$

$$v = \sqrt{2Dg}$$

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

29. (B)



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

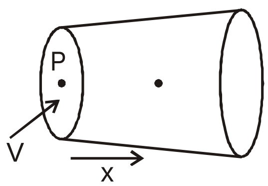
$\Delta P = F_{avg}$. 1sec.

$\Rightarrow 2\rho A v^2 \cos 60°$

$$\Rightarrow 1000 \times 6 \times 10^{-4} \times (12) \times \frac{1}{2} \times 2$$

= 86.4 Nt.

30. (A)



A = ax + b

Continuty equation $bV = (ax + b)\, V_2$

By bernaulies equation $= P_2 + \frac{1}{2}\rho v_2^2$ = constant

P_2 = Constant - $\frac{1}{2}\rho v_2^2$

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

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

Where C_1 = Constant

31. (B)

$A_1V_1 = A_2V_2$

$0.02 \times 2 = 0.01 \times V_2$

V_2 = 4 m/sec.

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

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

$= P_2 + \frac{1}{2} \times 1000 \times 4^2 \Rightarrow P_2 = 3.4 \times 10^4$ N/m²

32. (B)

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

33. (B)

34. (D)

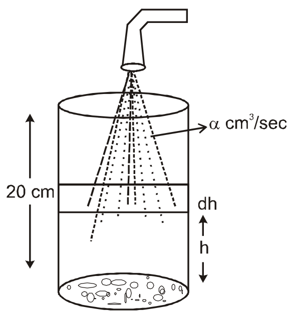
$A_1V_1 = A_2V_2$

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

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

35. (D)

Inlet = outlet



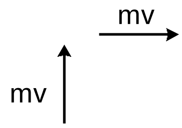
$\alpha\, dt = a\sqrt{2gh}\, dt$

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

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

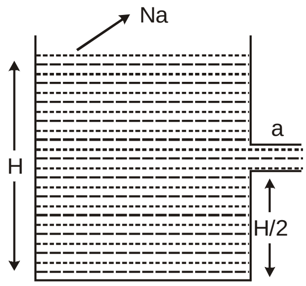
36. (D)

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



$= \sqrt{2}$ mv ; $= \sqrt{2}\rho vL$

37. (C)



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

acceleration = $\frac{\rho agh}{\rho Na.H}$ = g/N

38. (A)

From $A_PV_P = A_QV_Q$

$\frac{V_P}{V_Q} = \frac{A_Q}{A_P} = \frac{\pi(2\times10^{-2})^2}{\pi(1\times10^{-2})^2}$

$V_P = 4V_Q$

39. (B)

$\alpha dt = Av\, dt$

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

h = 0.051 m

40. (C)

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

41. (A)

42. (D)

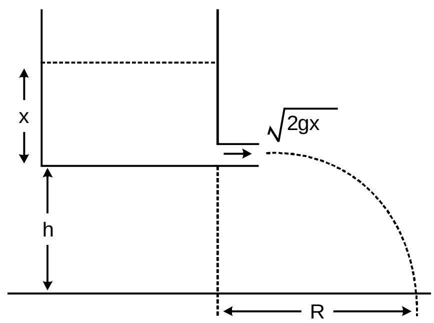
$R = \sqrt{2g(H-h_1)}\sqrt{\frac{2h_1}{g}}$; $= \sqrt{2g(H-h_2)}\sqrt{\frac{2h_2}{g}}$

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

$H = h_1 + h_2$

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

43. (B)



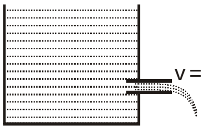
$R = \sqrt{2gx}\sqrt{\dfrac{2h}{g}}$ $\qquad$ $x = \dfrac{R^2}{4h}$

44. (B)

By bernanlies theorem

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

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



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

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

45. (A)

Change in momentum is/sec.

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

46. (B)

$\rho AV^2 = 1000 \times 2 \times 10^{-4} \times (10)^2$

= 20 N

47. (C)

Energy required in one second is the power

10^{-1} = A.V.

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

$\Rightarrow V = 10$ m/sec.

$mgh + \dfrac{1}{2} mV^2 = P$

Here m = mass in one second

$P = \rho AVgh + \dfrac{1}{2}\rho AV^3$

$P = \rho AV[10 \times 10 + 50]$

= 15 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 indendent of atmospheric pressure $p_{\text{in test tube}} = p_0 - \rho gh$

If p_0 vary then h also vary.

53. (A)

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

54. (A)

Liquid can not produce shear stress therefore it surface becomes perfendicular to g.

Exercise-II

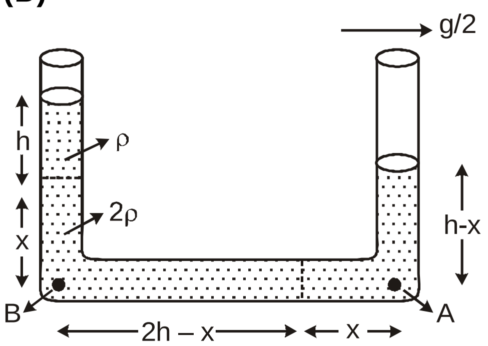
1. **(D)**
Force is same pressure is different

2. **(B)**
Take area of projection from left

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

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

3. **(B)**



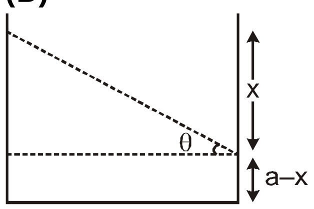
$\rho xg/2 + 2(2h\text{-}x)g/2 = P_B - P_A$
$P_A = (h - x)\rho g$
$P_B = h\rho g + 2\rho xg$
$\rho xg/2 + 2\rho(2h-x)g/2 = h\rho g + 2\rho xg - h\rho g + x\rho g$

$$\frac{4\rho hg}{2} - \frac{2\rho xg}{2} = 2\rho xg + \rho xg/2$$

$2\rho hg - \rho xg = 5Pxg/2$

$$\Rightarrow x = \frac{4h}{7}$$

4. **(B)**



$$(a\text{-}x)a^2 + \frac{1}{2}\ x\ a^2 = \frac{2}{3}a^3$$

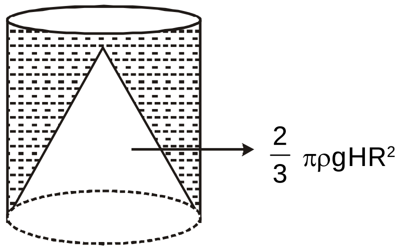
$$(a\text{-}x) + \frac{x}{2} = \frac{2}{3}a$$

$$a - \frac{x}{2} = \frac{2}{3}a$$

$$x = \frac{2a}{3}$$

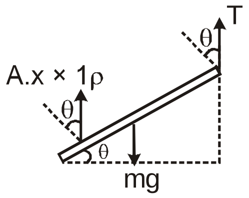
$$\therefore \tan\theta = \frac{x}{a} = \frac{acc.}{g} \qquad a = \frac{2}{3}g$$

5. **(D)**



6. **(A)**

7. **(A)**

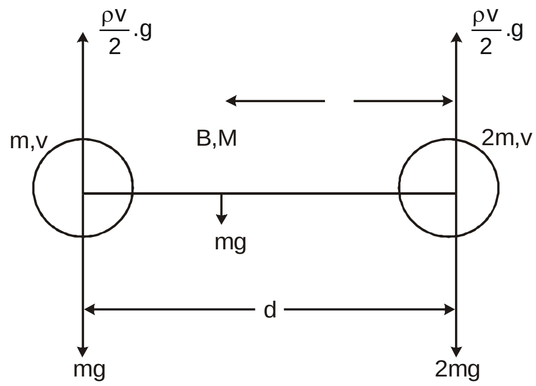


$mg = A.2L \times 0.75 \times g$
$T + Axg = A.2L \times 0.75\ g$
$T = Ag\ [1.5\ L - x]$

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

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

8. **(B)**



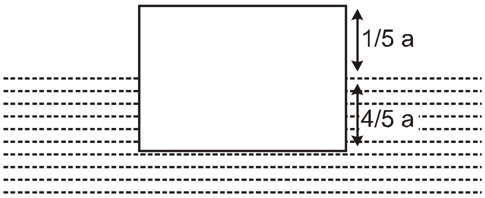
$(3M + m)g = \rho vg$
Torque balance about B

$$mg\ (d\text{-}\ell) + \rho vg\frac{\ell}{2}$$

$$= 2\ mg\ell + \frac{\rho vg}{2}(d - \ell)$$

$$\ell = \frac{d(v\rho - 2M)}{2(\rho v - 3M)}$$

9. (C)



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

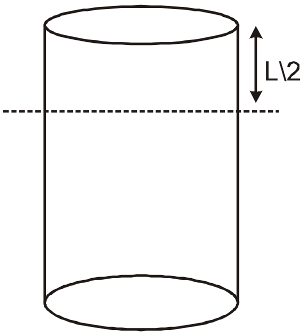
$(m + M) = \rho a^3$

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

$M = 4\,m$

10. (D)

11. (A)

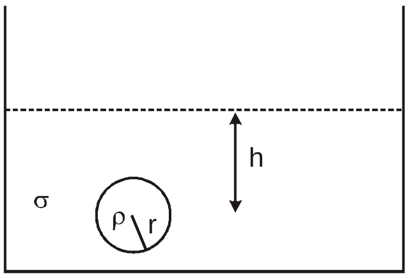


$d_1 AL + d_2 AL = \frac{3}{2} LAd$

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

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

12. (B)



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

$- mg\,(H + h) + (F_B)h = 1/2\, mv_f^2$

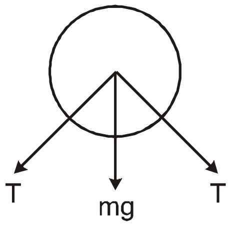
$\Rightarrow \; -\frac{4}{3}\pi r^3 \rho\,(H + h)\,g + \left(\frac{4}{3}\pi r^3\right)\sigma g h = 0$

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

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

$\boxed{H = (\frac{\sigma}{\rho} - 1)\,h}$

13. (A)



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

14. (B)

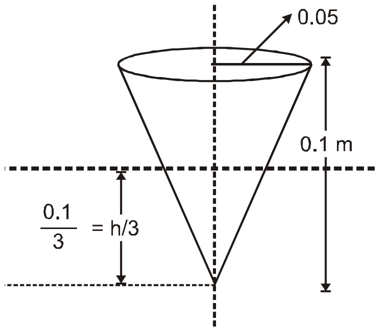
$g_{eff} = g + a$

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

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

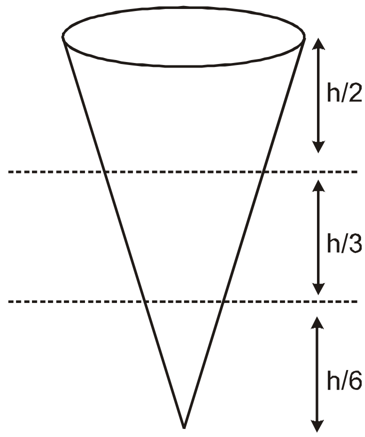
$= v[(g + a)\,(d - \rho)]$

15. (D)



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

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



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

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

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

16. (B)

Initially

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

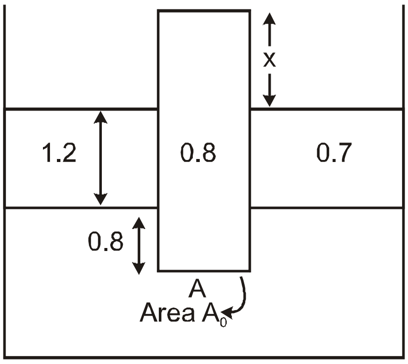
$V_{metal}\,\rho m g + V_{ice}\,\rho_{ice}\,g = V_d \rho_\ell g$

$\therefore V_d = \dfrac{V_{metal}\,\rho_m}{\rho_\ell} + \dfrac{V_{ice}\rho_{ice}}{\rho_\ell}$

finally volume displaced
$V = V_m + V_w$ (From ice)

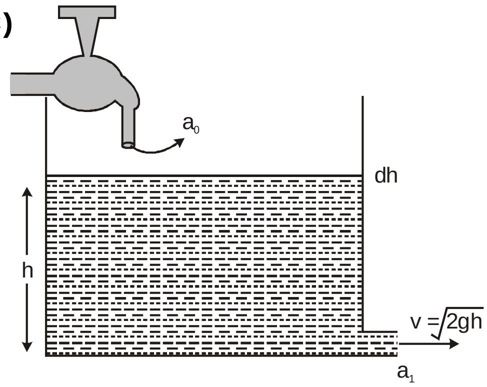
$= V_m + \dfrac{m}{\rho_w} \qquad = V_m + \dfrac{V_i\ell_i}{\rho_w}$ < previous

17. (B)



$P_A(1.2 \times 0.7 \times g + 0.8 \times 1.2\ g)$
$0.8 \times A_0\,(x + 1.2 + 0.8)\ g = \qquad P_A.P_0$
$x + 1.2 + 0.8 = 0.84 + 0.96$
$x = 0.25$ cm

18. (C)



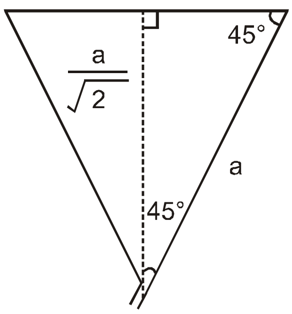
$$\frac{dm}{dt} = \rho A\frac{dh}{dt} = \rho a_0 v - \rho a_1\sqrt{2gh}$$

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

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

$\Rightarrow h = 0.8$

19. (D)



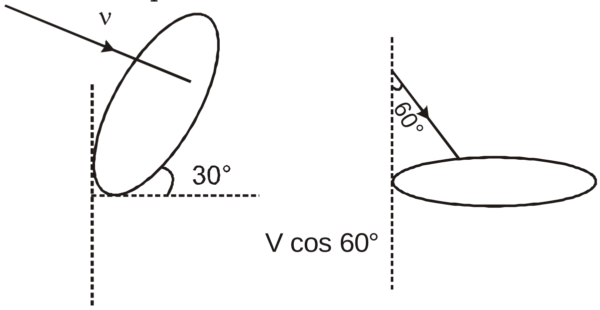
Initial

$a\rho g = \dfrac{1}{2}\ \rho V^2$

$V_0 = \sqrt{2ga}$

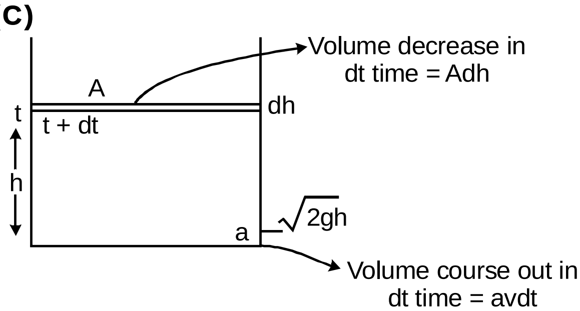
Now $V = \sqrt{2\dfrac{a}{\sqrt{2}}} = \dfrac{V_0}{\sqrt[4]{2}}$

20. C
From A_1V_1
Where $V_1 \perp$ to area



ratio $= \dfrac{V}{V\cos 60°} = 2$

21. (C)



Volume decrease = Volume outlet

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

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

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

Similarly $t_2 = \sqrt{\dfrac{H}{\eta}}$

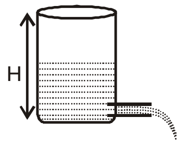
$\Rightarrow t_1 = t_2 \Rightarrow 2\sqrt{\dfrac{H}{\eta}} = \sqrt{H}$

$\eta = 4$

22. (A)

23. (D)
We know that

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



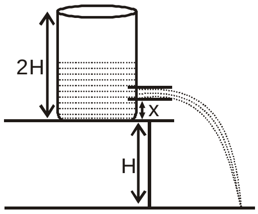
When height become 4H then time

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

$t' = 2t_0$

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

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

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

25. (D)

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

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

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

$$\Rightarrow R' = \sqrt{(2g10) + (\frac{2P_E}{\rho})}\sqrt{\frac{2H}{g}} \text{ .....(2)}$$

From (1) & (2) P_E = 3 atm.

26. (B)
From $A_1V_1 = A_2V_2$

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

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

$V_2 = 2V_1$
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
$= A_1V_1$

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

= 4.9 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)
$A_1V_1 = A_2V_2$
$10^{-2} \times 2 = 0.5 \times 10^{-2} \times V^2$
$V_2 = 4$ m/sec.

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

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

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

$P_B = 2000$ Pa

29. (A)

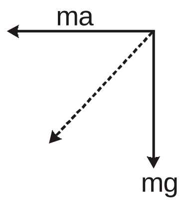
30. (A)

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

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

31. (D)
Pressure at the bottom = $2h\rho g$
force at the bottom = $2h\rho gA$
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

$\Rightarrow$ When air inside the balloon

$W = W_2$

Buoyancy eliminate the effect of air inside the balloon

$\Rightarrow W_1 = W_2$

So, $W_2 = W_1 + W$

34. (B, C)

Balance B reads = 5 Kg + Buoyancy

A reads = 2 Kg $-F_B$

35. (D)

(A) SIphon works when $h_3 > O$

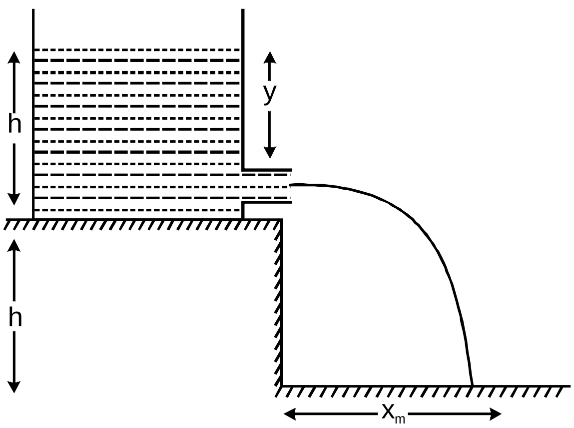
This will create a pressure difference

(B) $P_3 = P_0 = P_2 + \rho g h_3$

$P_2 = P_0 - \rho g h_3$

(C) $P_3 = P_0$

36. (A, C)



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

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

$\Rightarrow y = h$

37. (B, D)

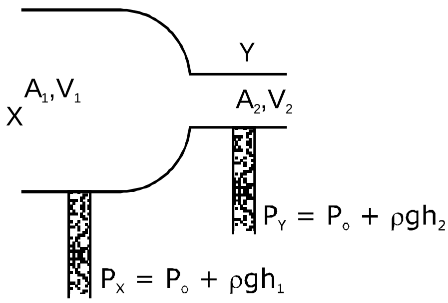
$F = \rho a v^2$

$P = Fv = \rho a v^3$

38. (B)

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

39. (D)



From $A_1 v_1 = A_2 v_2$

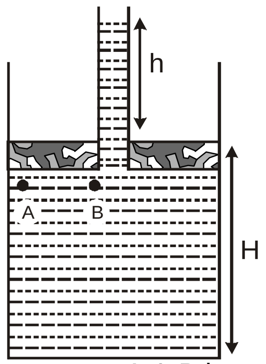
$v_2 > v_1$

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, $P_A = P_B$

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

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

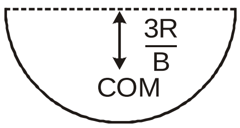
Now,

Total water is cylinder + Total water in pipe

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

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

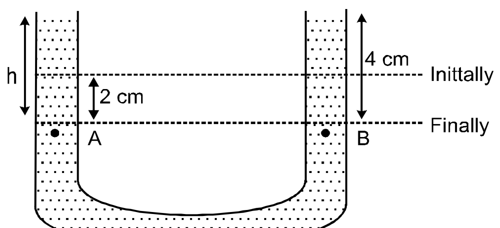
2.



W = mgh

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

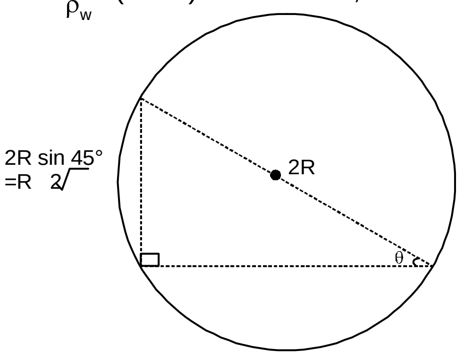
3.



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

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

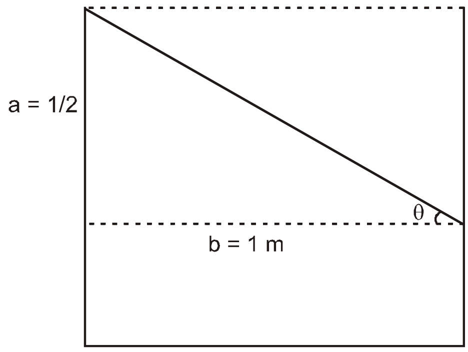
4.



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

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

5.

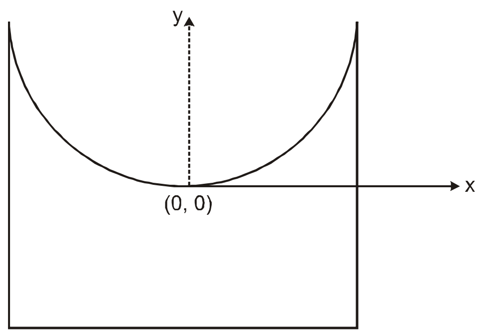


$$\tan\theta = \frac{2}{10} = \frac{1}{5}$$

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

$m = \rho V = 100$ Kg.

6.



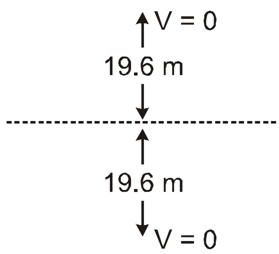
$$y = \frac{\omega^2 x^2}{2g} \qquad \frac{dy}{dx} = \frac{\omega^2 x}{g}$$

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

rad/s.

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

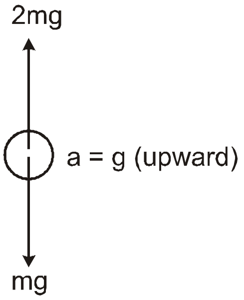
7. $W_{net} = \Delta K = 0$



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

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

$h = 19.6$ m



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

$t = 2$ sec

$T = 2t = 4$ sec.

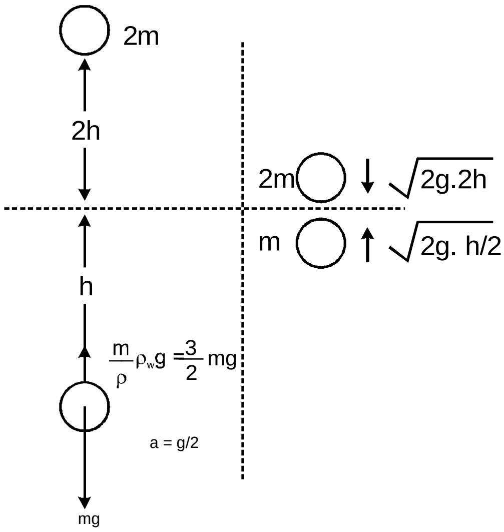
8. $m + \dfrac{V}{2}\rho_w = \left(\dfrac{m}{\rho} + V\right)\rho_w$

m = mass of beaker

V = interior volume of beaker

f = density of material of beaker

9.(a) They will meet at the surface



(b) Just before collision

2m ↓ $\sqrt{2g.2h}$

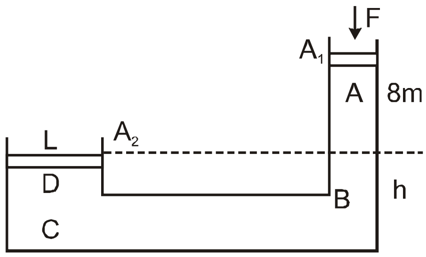
m ↑ $\sqrt{2g/2.h}$

Just After collision

3m ↓ $\sqrt{gh}$

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

10.



Pressure at point A = $\dfrac{F}{A_1}$

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

Pressure at point C = Pr. at B

Pressure at D = $P_C - \rho gh$

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

Now at equilibrium

$(600)\,g = \left[\dfrac{F}{A_1} + \rho g8\right]A/2$

$(600)\,g =$

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

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

11. $m = A\ell_0\,\rho_w$

$m + A\,\ell\,\rho = A\ell\,\rho_w$

m = mass of the test tube and lead

A = Area of Cross section

$\ell_0 = 10$ cm

$\ell = 40$ cm $\qquad \Rightarrow \dfrac{\rho}{\rho_w} = \dfrac{\ell - \ell_0}{\ell} = 0.75$

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

$3 = \dfrac{mg}{\rho/\rho_w} \qquad \dfrac{\rho}{\rho_w} = 5$

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

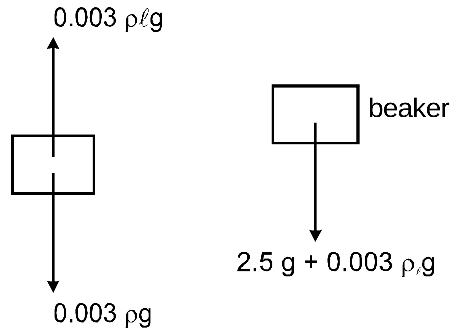
$3 = \dfrac{\rho_\ell}{\rho} = \dfrac{2}{15}, \qquad \dfrac{\rho_\ell}{5\rho_w} = \dfrac{2}{15}, \qquad \dfrac{\rho}{\rho_w} = \dfrac{2}{3}$

13. a

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

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

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



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

$\rho = \dfrac{2.5 \times 1000}{3} + \dfrac{5000}{3}$

= 2500 Kg/m^3

(b) E = 1 + 1.5 = 2.5 Kg

Δ = 2500 × 0.003 = 7.5 Kg

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

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

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

15. $A\ell d_1 = Axd_2$ $\qquad x = \dfrac{\ell d_1}{d_2}$

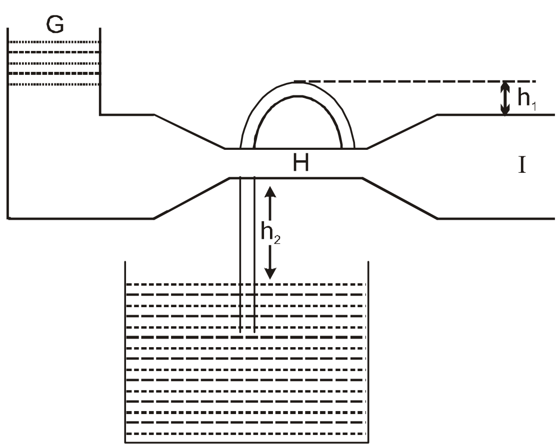
$K(\ell - x) + A\ell d_2 g = A\ell d_1 g + m$

$m = K\left[\ell - \dfrac{\ell d_1}{d_2}\right] + A\ell g d_2 - A\ell g d_1$

$= \dfrac{K\ell(d_2 - d_1)}{d_2} + A\ell g\,(d_2 - d_1)$

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

16.



Applying Bernoulli's theorem b/w

G & I we get

$P_0 + \rho g h_1 = P_0 + \dfrac{1}{2}\rho V^2$

& b/w I & H

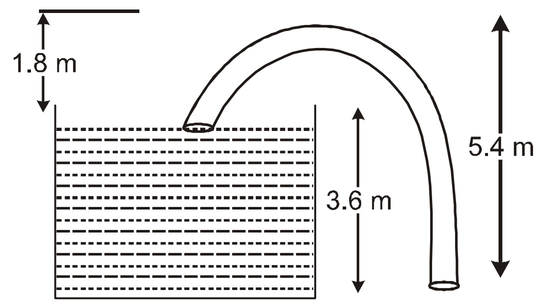
$P_H + \dfrac{1}{2}\rho\,(2V)^2 = P_0 + \dfrac{1}{2}\rho V^2$

$P_H = P_0 - \dfrac{3}{2}\rho V^2 = P_0 - 3\rho g h$

$P_H = P_0 - \rho g h_2$ $\qquad \Rightarrow 3\rho g h_1 = \rho g h_2$

$h_2 = 3h_1$

17.



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

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

(b) Discharge rate of flow = AV

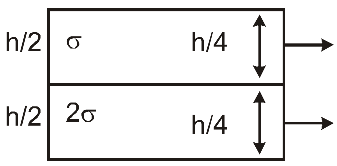
$= \pi\left(\dfrac{4}{\sqrt{\pi}}\right)^2 \times 10^{-4} \times 6\sqrt{2}$

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

(c) $P_A = P_0 - \rho g(5.4)$

$= 10^5 - 10^5\,(5.4)$, $\qquad$ = 4.6 × 10^4 N/m^2

18.



(a) for A

$\rho g \dfrac{h}{4} = \dfrac{1}{2}\rho v^2$ $\qquad v = \sqrt{g\dfrac{h}{2}}$

$R_A = vT$

$= \sqrt{g\dfrac{h}{2}} \cdot \sqrt{\dfrac{3h}{4}\cdot\dfrac{2}{g}}$ $\qquad R_A = \sqrt{3}\,\dfrac{h}{2}$

(b) for B

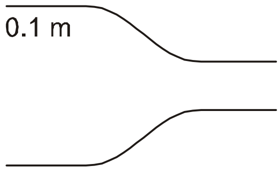
$2\sigma g\dfrac{h}{4} + \sigma g\dfrac{h}{2} = \dfrac{1}{2}.2\sigma v^2$ $\qquad gh = v^2$

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

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

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

19.

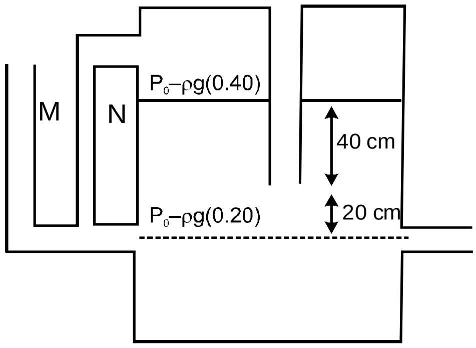


From $A_1V_1 = A_2V_2$

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

and $P_1 - P_2 = 10 N/m^2$

20.

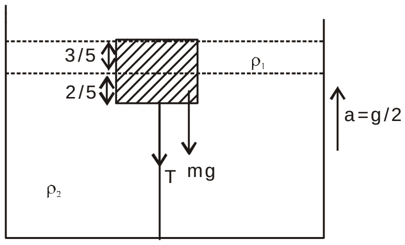


In N water level is = 60 cm.
In M = 20 cm.

—==============—

Exercise-III Level - II

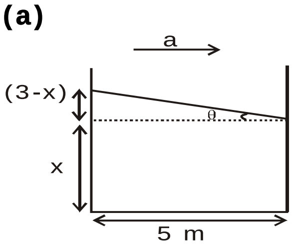
1.



$$T+mg = \left[\left(\frac{2}{5}x10^{-3}\right)x\left(1500x\frac{3g}{2}\right)\right]$$

$$+\left[\left(\frac{3}{5}x10^{-3}\right)x\left(1000x\frac{3g}{2}\right)\right] \qquad T = 6\ N$$

2. (a)

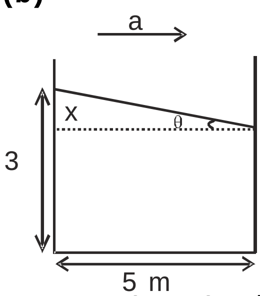


$$2\times4\times5=(5\times x\times4)+\frac{1}{2}\times5(3-x)\times4$$

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

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

(b)



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

$$\tan\theta=\frac{a}{g}=\frac{x}{5} \qquad x=2.4\,m$$

Water split out

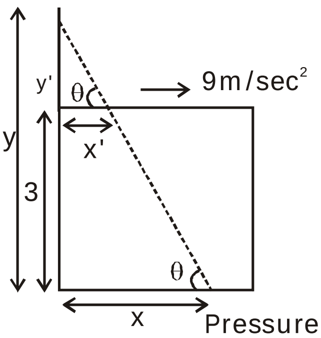
$$=(2\times4\times5)-(0.6\times5.4)-\frac{1}{2}\times2.4\times4\times5$$

$= 40 - 12 - 24 \qquad = 40 - 36 = 4m^3$

Inital $= 2 \times 4 \times 5 = 40m^3$

$$\% = \frac{4}{40}x100=10\ \%$$

(c)



Pressure = 0

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

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

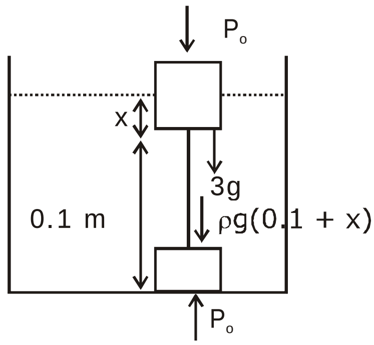
$$40 = \frac{1}{2}(y'+3)\,x\,X\,x\,4-\frac{1}{2}y'x4x\frac{y'}{0.9}$$

$x = 5$

Pressure at rear wall

$= \rho ax = 1000 \times 9 \times 5 = 45$ KPa

3.



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

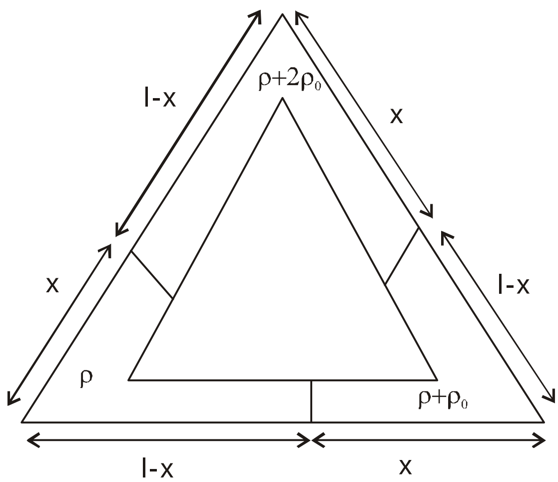
$x = 0.16$

$h = 0.1 + 0.16 = 0.26$ m

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

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

4.

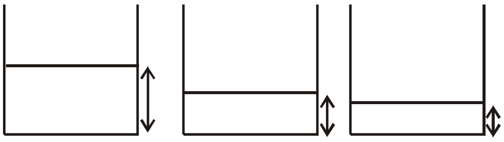


$\rho x \sin 60^0 g + (\rho+2\rho_0)(l-x)$
$\sin 60^0$
$= (\rho+2\rho_0) x \sin 60^0 g + (\rho+\rho_0)(l-x) \sin 60^0 g$

$$\rho x + (\rho + 2\rho_o)(l - x) = (\rho + 2\rho_o)x + (\rho + \rho_o)(l - x)$$

$x = l/3$

5. Initial depth in sea water = x_0



(x_0+x) (x_0+x-y) $(x-y-z)+x_0$

Water

$$W_S + W_C = x_0 A\rho_{SW} g \ldots\ldots..(1)$$

$$W_S + W_C = (x_o + x)A\rho_w g \ldots\ldots..(2)$$

$$W_S = (x_o + x - y)A\rho_w g \ldots\ldots..(3)$$

$$W_S = (x_o + x - y - z)A\rho_{sw} g \ldots\ldots..(4)$$

(1)/(2)

$$1 = \frac{\rho_{SW}}{\rho_W} \cdot \frac{x_o}{x_o + x},$$

$$x_o\left[\frac{\rho_{SW} - \rho_W}{\rho_W}\right] = x \Rightarrow x_o = \frac{\rho_W x}{\rho_{SW} + \rho_W}$$

(3)/(4) $$1 = \frac{x_o + x - y}{x_o + x - y - z}\frac{\rho_W}{\rho_{SW}}$$

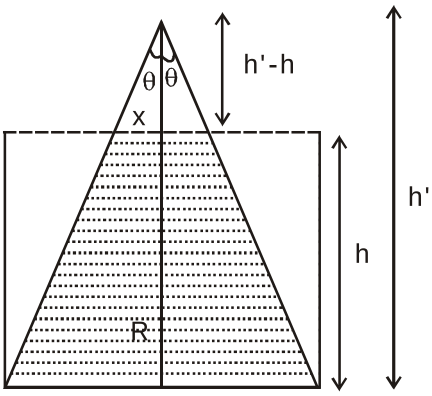
$$x_0 + x - y - z = \frac{\rho_W}{\rho_{SW}} x_o + (x - y)\frac{\rho_W}{\rho_{SW}}$$

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

$$\frac{\rho_W}{\rho_{SW}} x = (x - y)\frac{\rho_W}{\rho_{SW}} - x + y + z$$

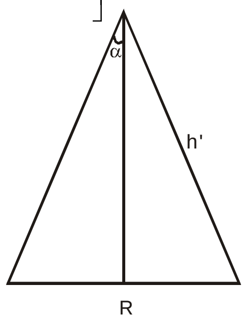
$$\frac{\rho_{SW}}{\rho_W} = \frac{y}{y - x + z}$$

6.



Upward force excuted by the liquid on the flask

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



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

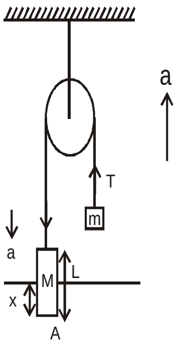
$$\frac{R}{x} = \frac{h'}{h' - h} \Rightarrow R(R\cot\alpha - h) = xR\cot\alpha$$

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

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

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

7.



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

$Mg - T - Ax\,\rho_w g = Ma$ ...(1)
$T - mg = ma$ ...(2)

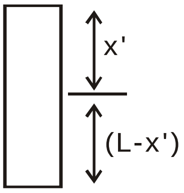
$$Mg - mg - \frac{M}{\rho L}.\rho_w xg$$

$= (M+m)\,a$

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

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

(b)
a = 0 initial x = L
M.P. is when it is just submerged.



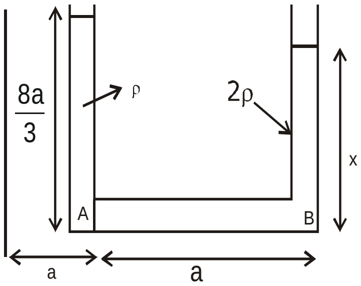
$$a=\left(\frac{M-m}{M+m}\right)g\left[1-\frac{L-x'}{L}\right]$$

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

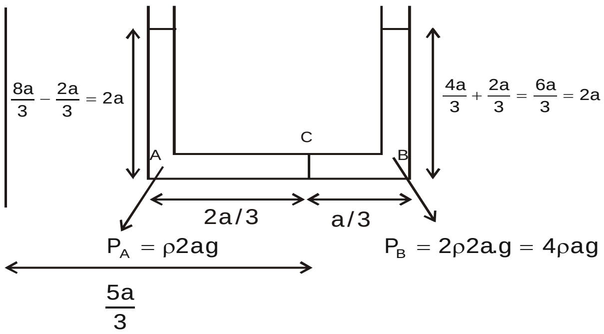
$$\omega^2=\left(\frac{M-m}{M+m}\right)\frac{g}{L} \qquad \omega=\sqrt{\left(\frac{M-m}{M+m}\right)\frac{g}{L}}$$

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

8.



$$\rho g x\frac{8a}{3}=2\rho.xg \qquad x=\frac{4a}{3}$$



$P_A=\rho 2ag$ $\qquad$ $P_B=2\rho 2a.g=4\rho ag$

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

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

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

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

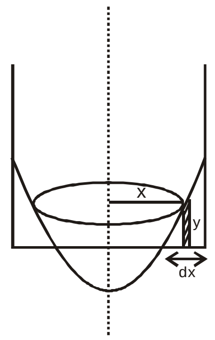
1 + 2

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

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

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

9.



$$y==\frac{\omega^2x^2}{2g}=\frac{(20)^2x^2}{2\times10}=20x^2$$

Volume = $y dx\, 2\pi x$
$1.5 = 20x^2.2\pi x dx$ $\qquad$ $1.5 = 40\pi x^3 dx$

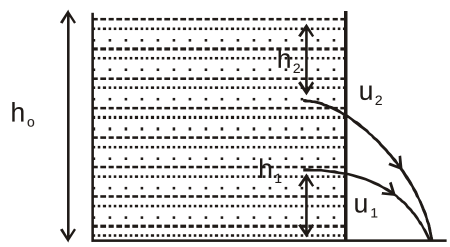
$$1.5=40\pi\int_x^{0.5}x^3dx$$

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

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

Area = πx^2 = 0.39m^2.

10.



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

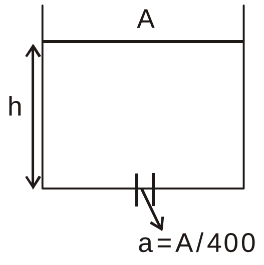
$$u_1\sqrt{\frac{2h_1}{g}}=u_2\sqrt{\frac{2(h_o-h_2)}{g}}$$

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

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

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

$$h_o=h_1+h_2 \qquad h_1-h_2=0 \qquad h_1=h_2$$

11. 

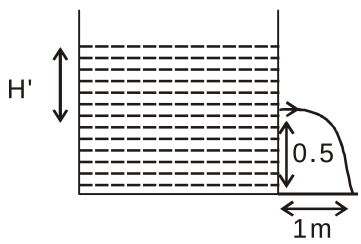
$\rho gh = \frac{1}{2}\rho x^2$ $\qquad v = \sqrt{2gh}$

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

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

(b) $v = \sqrt{2gh} = \sqrt{2x10x1} = \sqrt{20}$ m / sec

$1 x A = \sqrt{20} t x \frac{A}{400}$ $\qquad t = 40\sqrt{5}$ sec.

12. 

Range $V\sqrt{\frac{2 x 0.5}{g}} = 1$

$V = \sqrt{10} = \sqrt{2gH'}$ $\qquad H' = \frac{1}{2} = 0.5m$

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

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

t = 431 sec.

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

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

$v \approx 4m / sec.$

(ii) $\qquad F = (\rho av)v = \rho av^2$

$= 900 \times 5 \times 10^{-4} \times (4)^2 = 7.2 N$

(iii) $F_{min} = 0$

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

= 45 N

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

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

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

15. $5 = (0.8) \times 10^3 \times (0.1)^2 x$

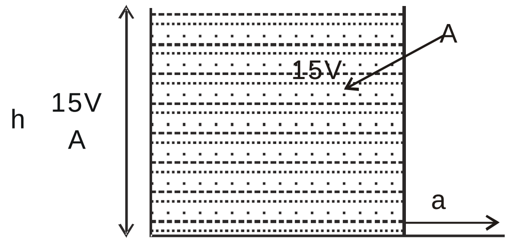
$x = 6.25 cm$

$v_i = v_f$

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

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

16. One glass of juice = Vm^3



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

14V/A

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

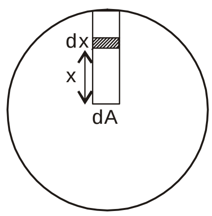
$\frac{15V}{A}$

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

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

(2)/(1)

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

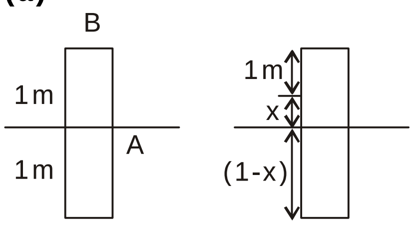
17. 

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

$$dF = \left(\rho dA.dx\right)\frac{gx}{R} \qquad F = \rho dA\frac{g}{R}\int_0^R x\,dx$$

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

18. (a)



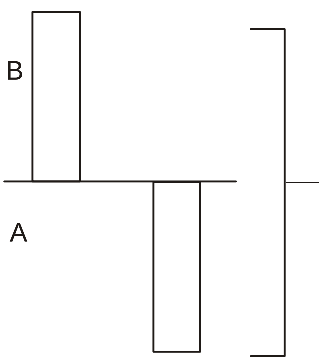
$$F_{net} = (1-x)\rho Ag - \frac{2A\rho}{2}g = -\rho Agx$$

$K_{eff} = \rho Ag$

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

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

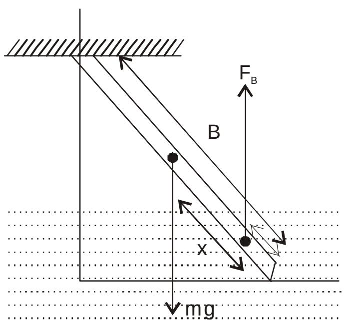
(b)



$T/2$ sec.

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

19.



$$(\rho_R Abg)\frac{b}{2}\sin\theta = \rho_W Axg.(b - \frac{x}{2})\sin\theta$$

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

x= b/3

20. (a)

cylinder floats so

mg = Buoyancy force

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

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

(ii) B

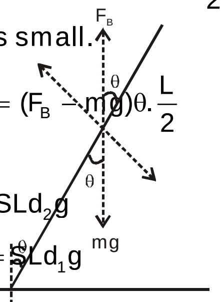
x = v (time of flight)

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

21.

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

if θ is small.



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

$F_B = SLd_2g$

$mg = SLd_1g$

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

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

$$\alpha = \frac{3g(d_2-d_1)}{d_1L^2}.\frac{\theta L}{2} \qquad \omega = \sqrt{\frac{3g(d_2-d_1)}{2d_1L}}$$

23. from $A_1V_1 = A_2V_2$

$(4x10^{-3})(1) = (8x10^{-3})V_2 \qquad V_2 = \frac{1}{2}\,m/s$

from Bernoulli's

$$P_p + \rho gh_p + \frac{1}{2}\rho V_P^2 = P_Q + \rho gh_Q + \frac{1}{2}\rho V_Q^2$$

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

= - 30000+375

$\therefore P_Q - P_P = -29625$

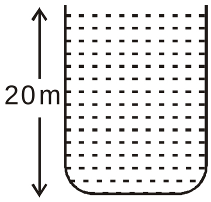
24. $M_{min} = \pi r^2\ell\left(\sqrt{\rho\sigma - \rho}\right)$

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

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_0 is the atmospheric pressure, ρ the density of liquid and v the velocity at which water is coming out.

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

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

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

2. (D)

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

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

$\rho_1 < \rho_3 < \rho_2$

3. (B)

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

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,

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

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

$$\Rightarrow \quad gh = \frac{1}{2}v_1^2\left(\left(\frac{A_2}{A_1}\right)^2 - 1\right) (\because A_1v_1 = A_2v_2)$$

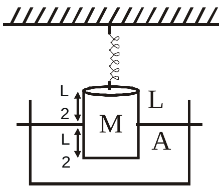
$$\Rightarrow \quad \left(\frac{A_2}{A_1}\right)^2 = 1 + \frac{2hg}{v_1^2}$$

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

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

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

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)

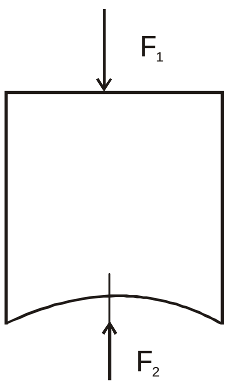
From $A_1V_1 = A_2V_2$

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

$$L^2 = \pi R^2$$

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

2. (D)



$F_2 - F_1$ = Buoyancy force

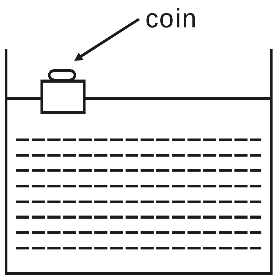
$F_2 = F_1$ + Buoyancy force

F_2 = (Pressure) (Area of Projection) + $V\rho g$

$F_2 = \rho g h(\pi R^2) + v\rho g$

$= \rho g\ (v+\pi R^2 h)$

3. (D)



Initially,

$W_{coin} + W_{block} = V_d \rho_l g$

$$V_d = \frac{W_{coin}}{\rho_l g} + \frac{W_{block}}{\rho_l g}$$

Finally

$$\frac{W_{coin}}{\rho_{coin} g} + \frac{W_{block}}{\rho_l g} = V_{d'}$$

$$\rho_{coin} > \rho_l$$

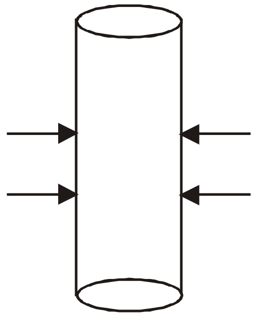
$\Rightarrow V_d' < V_d$

$\Rightarrow$ l decreases and h decreases

4.

(a)

In portion A



$F_a = 0$

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 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 $A_1V_1 = A_2V_2$

$\pi(4)^2\ (0.25) = \pi(1)^2\ V_2$

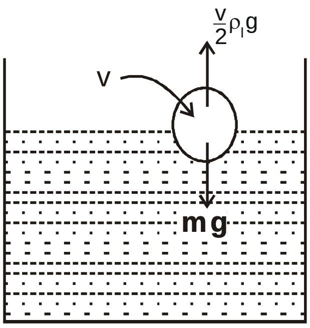
$V_2 = 4$ m/sec

Range $= V_2$ (Time of flight)

$$= 4\sqrt{\frac{2 \times 1.25}{100}}$$

$= 2$ m

6.

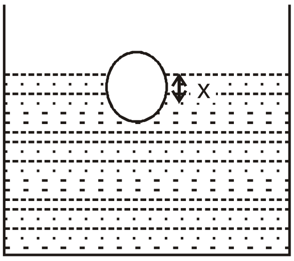


at equilibrium position

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

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

After slightly displaced from its M.P.



F_{net} = Extra Buoyancy force

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

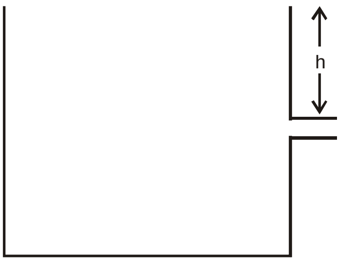
Now $f = \frac{1}{2\pi}\sqrt{\frac{K}{m}}$

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

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

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

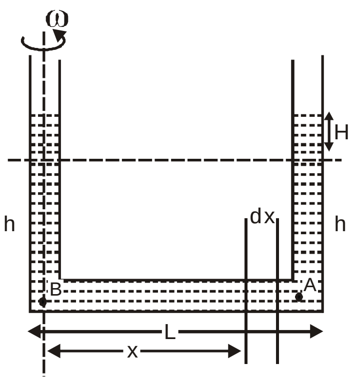
7. From $A_1V_1 = A_2V_2$ .....(1)



$$P_o + \rho g h + \frac{1}{2}\rho v_1^2 = P_o + 0 + \frac{1}{2}\rho v_2^2 \text{.......(2)}$$

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

8.



$P_B = \rho g h + P_o$

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

In small element having mass dm.

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

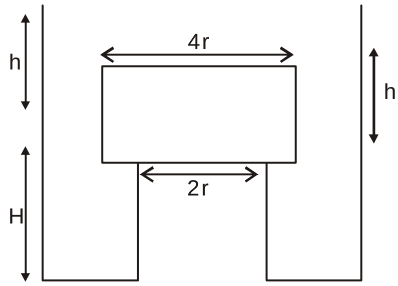
$AdP = A\rho.dx\omega^2 x$

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

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

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

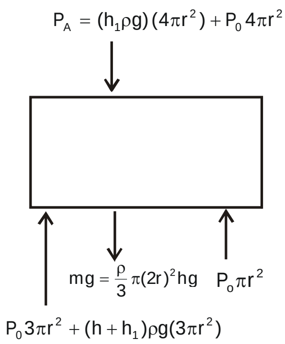
9.



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



at balancing coudition

$$P_0(4\pi r^2) + (h_1\rho g)(4\pi r^2) + \frac{\rho}{3}\pi(4r^2)hg$$

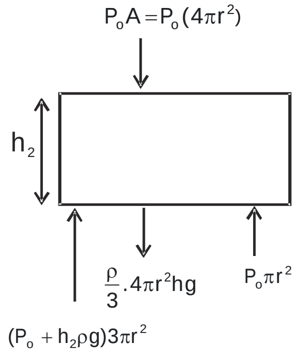
$$= P_o\pi r^2 + P_o 3\pi r^2 + (h+h_1)\rho g(3\pi r^2)$$

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

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

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

10.



At balancing condition

$$\frac{\rho}{3}.4\pi r^2 hg = h_2\rho g 3\pi r^2 \qquad h_2 = \frac{4h}{9}$$

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 $A_1V_1 = A_2V_2$

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

$P_1 = P_o + \rho_l gh \qquad T_1 = T_o$

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

16. Buoyancy force $= \rho_l Vg$

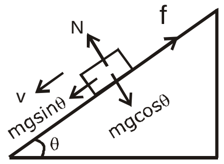
$$= \rho_l g\left[\frac{nRT_2}{P_2}\right]$$

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

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

17. 6

18.



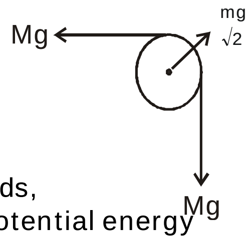
For (P)
Force exerted by x on Y.

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

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.

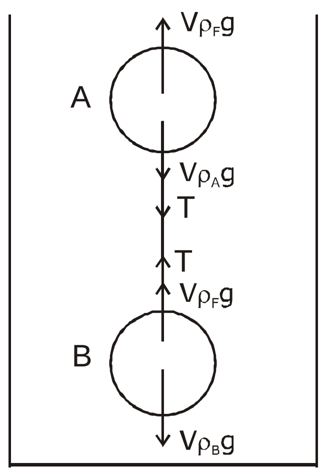
For (R)
P.E. is decreasing
Total Mechanical energy is decreasing.



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

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

$T = Vg\ (\rho_F - \rho_A)$ .... (1)

For T > 0

$\rho_F > \rho_A$

(A) is correct.

For equilibrium of B

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

$T = Vg\ (\rho_B - \rho_F)$ .... (2)

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

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

(D) is correct.