physics

Mechanical properties of Fluids

Level-01

1. c $(\rho g h = P)$

2. $$P_1V_1 = P_2V_2$$
$$\left(P_0 + \rho g L\right) \times \frac{4}{3}\pi R^3 = P_0 \times \frac{4}{3}\pi (2R)^3$$
$$P_0 + \rho g L = 8P_0$$
$$\rho g L = 7P_0$$
$$\rho g L = 7\rho g H$$
$$L = 7H$$

3. $$P_1V_1 = P_2V_2$$
$$\left(P_0 + \rho g L\right)V = P_0 \times 3V$$
$$\left(\rho_m g \times 75 + \frac{\rho_m}{10} \times g \times L\right)V = \rho_m g \times 75 \times 3V$$
$$75 + \frac{L}{10} = 225$$
$$L = 1500 \text{ cm}$$

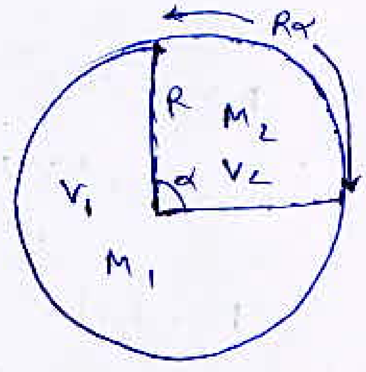
4. $$P = \rho g h$$
$$\frac{\Delta P \times 100}{P} = \frac{\Delta g}{g} \times 100 + \frac{\Delta h}{h} \times 100$$
$$0 = -2\% + \frac{\Delta h}{h} \times 100$$
$$\frac{\Delta h}{h} \times 100 = 2\% \quad \text{increases.}$$

5. $p = P_0 + \rho g h$

pressure will be same at same depth.

6. pressure will same at partition

$$p = \frac{nRT}{V}$$



$$\frac{n_1}{V_1} = \frac{n_2}{V_2}$$

$$\frac{\frac{m}{M_1}}{V_1} = \frac{\frac{m}{M_2}}{V_2}$$

$$\frac{V_2}{V_1} = \frac{M_1}{M_2} = \frac{32}{28} = \frac{8}{7}$$

$$\frac{H \times R^2 \times (\alpha)/2}{H \times R^2 \times (180-\alpha)/2} = \frac{8}{7}$$

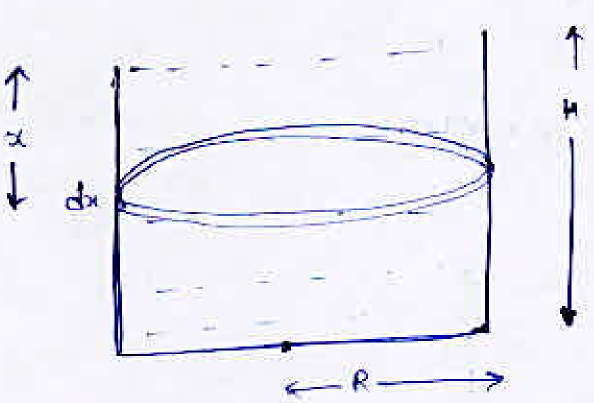
(Area of sector $= \frac{1}{2} r^2 \theta$

$$\frac{\alpha}{360-\alpha} = \frac{8}{7}$$

$$\frac{\alpha}{360} = \frac{8}{15}$$

$$\alpha = \frac{360 \times 8}{15} = 192$$

7.



Force on the side of vessell

$$dF = \rho g x \times (2\pi R dx)$$

$$F_s = 2\pi R \rho g \int_0^H x\,dx$$

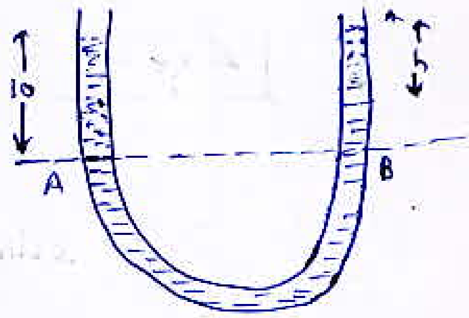
$$= 2\pi R \times \rho g \frac{H^2}{2}$$

Force on side of the vessel = Force on Bottom

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

$$H = R$$

8. At same level of mercury, pressure will be same



ρ

$$P_A = P_B$$

$$1.3 \times g \times 10 = h \times 0.8 \times g$$
$$+ (10-h) \times 13.6 \times g$$

$$13 = 0.8h + 13.6(10-h)$$

$$(13.6-0.8)h = 136 - 13$$

$$h = \frac{123}{12.8} = 9.6 \text{ cm}$$

9. —

10. $P_1 = P_2$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\frac{10^2 \text{ N}}{10^2 \text{ cm}^2} = \frac{2000 \times 10 \text{ N}}{A_2 \text{ cm}^2}$$

$$A_2 = 2 \times 10^4 \text{ cm}^2$$

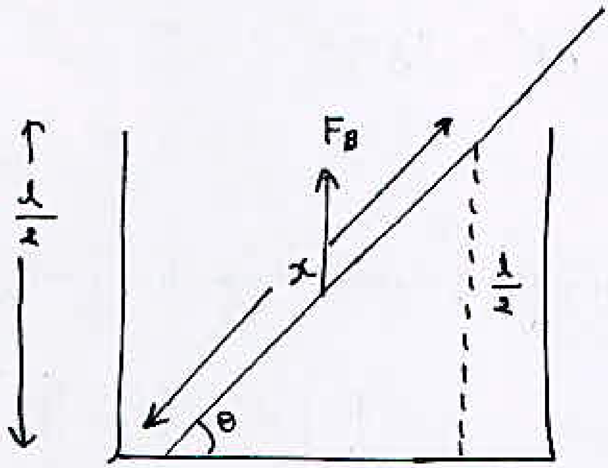
11. $$\frac{\rho_s}{\rho_w} = 7$$

$$\rho_s = 7\rho_w$$

Apparent weight = mg − Buoyancy force
$$= \rho_s V g - \rho_w V g$$
$$= Vg(\rho_s - \rho_w)$$
$$= 5 \times 5 \times 5 \times 6 \rho_w \times g$$

12. -

13.



$$x \sin\theta = \frac{l}{2}$$

$$x = \frac{l}{2\sin\theta}$$

$$F_B \times \frac{x}{2} \cos\theta = mg \times \frac{l}{2} \cos\theta$$

$$A x \rho_0 g \times \frac{l}{4\sin\theta} \times \cos\theta = A \times L \times \rho \times g \times \frac{l}{2} \cos\theta$$

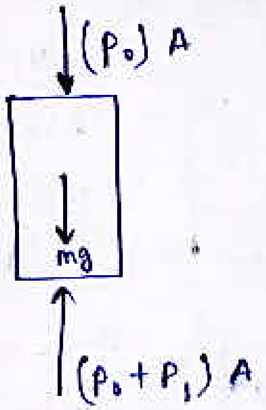
$$\frac{x \rho_0}{4\sin\theta} = \rho \frac{l}{2}$$

$$\frac{l}{2\sin\theta} \times \frac{\rho_0}{4\sin\theta} = \frac{\rho l}{2}$$

$$\sin^{\cancel{2}}\theta = \sqrt{\frac{\rho_0}{4\rho}}$$

$$\sin\theta = \frac{1}{2}\sqrt{\frac{\rho_0}{\rho}}$$

15.



$P_1 = \rho_1 g h_1 + \rho_2 g h_2$

$P_1 = (0.6 \times 6 + 1 \times 4) g$

$= (3.6 + 4) g$

$= 7.6 g$

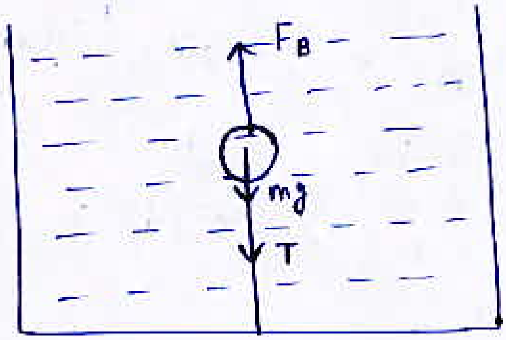
$(P_0 + P_1) A - P_0 A = mg$

$7.6 g A = mg$

$m = 7.6 \times 10 \times 10$

$= 760$ gms

16.



$T + mg =$ Buoyancy force

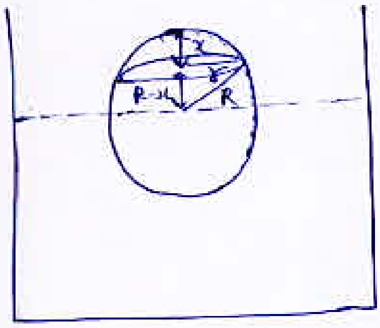
$T = \cancel{mg}\ F_B - mg$

$= (\text{volume of displaced liquid}) \times \rho_w \times g - mg$

$= \dfrac{m}{\rho_w/\eta} \times \rho_w \times g - mg$

$= mg(\eta - 1)$

17.



Take an element x at x depth from top

$$dv = \pi\left[R^2-(R-x)^2\right]dx = \pi r^2 dx$$

$$r = \sqrt{R^2-(R-x)^2}$$

$$dv = \pi\left(2Rx-x^2\right)dx$$

Buoyancy Force $= \rho\, dv \times g$

$$dF = \rho\pi(2Rx-x^2)\,dx \times g$$

Work done by this constant force dF for distance x

This is the work done By Buoyancy Force for upper part only.

$$dW = -dF \times x$$

$$dW = -\rho\pi g(2Rx^2-x^3)\,dx$$

$$W = -\int_0^R \rho\pi g\,(2Rx^2-x^3)\,dx$$

$$= -\rho\pi g\left[\frac{2}{3}R^4-\frac{R^4}{4}\right]$$

$$= -\rho\pi g\left[\frac{5}{12}\right]R^4$$

Work done by gravity $= mgR$

$$= \frac{4}{3}\pi R^3 \times \frac{\rho}{2} \times g R$$

$$= \frac{2}{3}\pi\rho g R^4$$

Work done by Buoyancy Force for half immersed part

$$= -F \times R$$

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

$$= -\frac{2}{3}\pi\rho g R^4$$

Work Energy theorem $\Rightarrow$

$$W_{gravity} + W_{External} + W_{Buoyancy\ force} = \Delta K = 0$$

$$W_{External} - \left(\frac{5}{12}\rho\pi g R^4 + \frac{2}{3}\pi\rho g R^4\right) + \frac{2}{3}\pi\rho g R^4 = 0$$

$$W_{external} = \frac{5}{12}\rho\pi g R^4$$

19.

$$V_1 = \frac{m}{\rho_1}$$

$$V_2 = \frac{m}{\rho_2}$$

$$V = V_1 + V_2$$

$$M = m + m = 2m$$

$$\rho = \frac{M}{V}$$

$$= \frac{2m}{\frac{m}{\rho_1} + \frac{m}{\rho_2}} = \frac{2\rho_1 \rho_2}{\rho_1 + \rho_2}$$

20.

$$m_1 = V \times \rho_1$$

$$m_2 = V \times \rho_2$$

$$M = m_1 + m_2 = V(\rho_1 + \rho_2)$$

$$V = 2V$$

$$\rho = \frac{M}{V} = \frac{V(\rho_1 + \rho_2)}{2V}$$

$$= \frac{\rho_1 + \rho_2}{2}$$

24.

$$A_1 V_1 = A_2 V_2$$

$$\frac{V_1}{V_2} = \frac{A_2}{A_1} = \left(\frac{r_2}{r_1}\right)^2 = \left(\frac{2}{3}\right)^2 = \frac{4}{9}$$

25.

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

$$A_1 V_1 = A_2 V_2$$

$$\cancel{A \updownarrow V} \downarrow$$

$$A \downarrow \quad V \uparrow \quad P \downarrow$$

30. $$\frac{1}{2}\rho_w v^2 = \rho_{Hg} g H$$

32. From continuity equation

$$A_1 V_1 = A_2 V_2$$

$$A_1 = A_2 \Rightarrow V_1 = V_2$$

$$V_A = V_B$$

From Bernoulli's equation

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

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

$$V_A = V_B$$

$$h_A > h_B$$

so $P_A < P_B$

33. Horizontal velocity at depth D

$$= \sqrt{2gD}$$

time taken by man from height (H-D) to ground

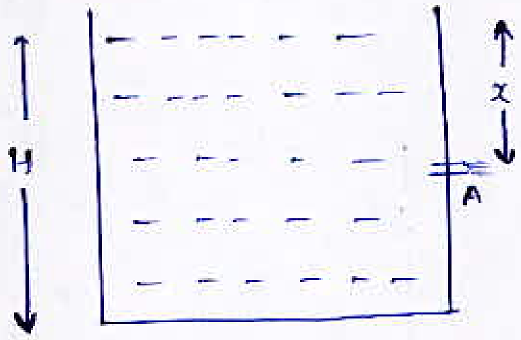
$$t = \sqrt{\frac{2(H-D)}{g}}$$

Range = Horizontal velocity (constant) × time

$$= \sqrt{2gD} \times \sqrt{\frac{2(H-D)}{g}}$$

$$= 2\sqrt{D(H-D)}$$

34.



velocity at depth $x = \sqrt{2gx}$

time from A to ground $\Rightarrow$ $H-x = ut + \frac{1}{2}at^2$

$H-x = \frac{1}{2}at^2$ (u = 0 vertical)

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

Horizontal Range = velocity (Horizontal) x time

$$= \sqrt{2gx} \times \sqrt{\frac{2(H-x)}{g}}$$

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

$$R^2 = 4x(H-x)$$

R^2 will be maximum when R is maximum

$$\frac{d(R^2)}{dx} = 4(H-x) - 4x = 0$$

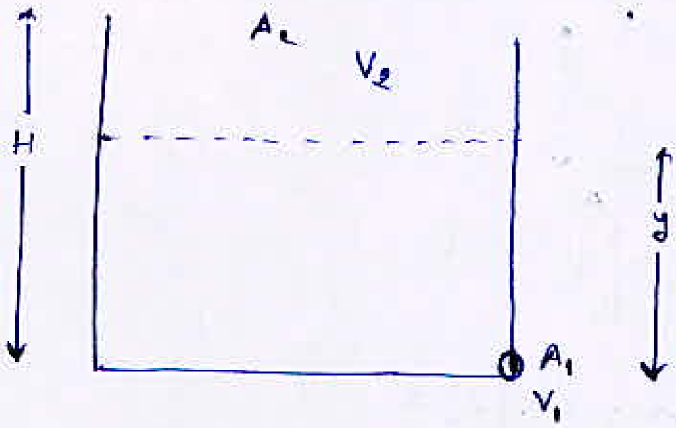
$$x = \frac{H}{2}$$

$$\frac{d^2(R^2)}{dx} = -8 \qquad \text{Maxima at } x = \frac{H}{2}$$

Horizontal distance will be maximum when hole is at half depth.

$$x = \frac{90}{2} = 45 \text{ cm}$$

35.



A_1 = Area of orifice

A_2 = cross section Area of Rectangular vessel

From equation of continuity

$$A_1 V_1 = A_2 V_2$$

At any height y

$$V_2 = -\frac{dy}{dt}$$

$$V_1 = \sqrt{2gy}$$

$$A_1 \sqrt{2gy} = -A_2 \times \frac{dy}{dt}$$

$$\int_H^0 \frac{dy}{\sqrt{y}} = \int_0^t -\frac{A_1}{A_2}\sqrt{2g}\, dt$$

$$\left(2\sqrt{y}\right)_H^0 = \frac{A_1}{A_2}\sqrt{2g} \times t$$

$$t = \frac{A_2}{A_1} \times \sqrt{\frac{2H}{g}}$$

$$t \propto \sqrt{H}$$

$$\frac{t_2}{t_1} = \sqrt{\frac{H/4}{H}}$$

$$t_2 = \frac{t_1}{\sqrt{2}} = \frac{10}{\sqrt{2}} = 7 \text{ minutes}$$

Question Asked in 2012-14

1. volume of liquid remains constant

$$n \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3 = V \quad \text{—— (1)}$$

$$R = \left(\frac{3V}{4\pi}\right)^{1/3}$$

$$r = \left(\frac{3V}{4n\pi}\right)^{1/3}$$

Released Energy $= T \times \Delta A$

$$= T \times \left[n 4\pi r^2 - 4\pi R^2\right]$$

$$= \frac{T \times}{r}\left[n 4\pi r^3 - 4\pi r R^2\right] \quad \text{From (1)}$$

$$= \frac{T}{r}\left[4\pi R^3 - 4\pi r R^2\right]$$

$$= T \times 4\pi R^3 \left[\frac{1}{r} - \frac{1}{R}\right]$$

$$= T \times 3V \left[\frac{1}{r} - \frac{1}{R}\right] \quad \text{From (1)}$$

3. $$n \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3 \quad (\text{volume remains constant})$$

$$27 \times r^3 = \left(\frac{D}{2}\right)^3$$

$$\frac{D}{2} = 3r$$

$$r = \frac{D}{6}$$

From Q.(1)

Released change in surface energy $= T \times 4\pi R^3\left(\frac{1}{r} - \frac{1}{R}\right)$

$$= T \times 4\pi \left(\frac{D}{2}\right)^3 \left(\frac{6}{D} - \frac{2}{D}\right)$$

$$= 2T\pi D^2$$

$$= 2\sigma\pi D^2$$

4. Excess pressure in bubble $= \frac{4T}{R}$

$$= \frac{4 \times 30}{\frac{8 \times 10^{-1}}{2}} = 300 \text{ dyne/cm}^2$$

5. $$h = \frac{2T\cos\theta}{r d g}$$

$$h \propto \frac{1}{r}$$

6. ~~Work done = Increase in potential Energy~~

$+$

$$\left(P_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2\right) \times V' + W_{motor}$$

$$= \left(P_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2\right) \times V$$

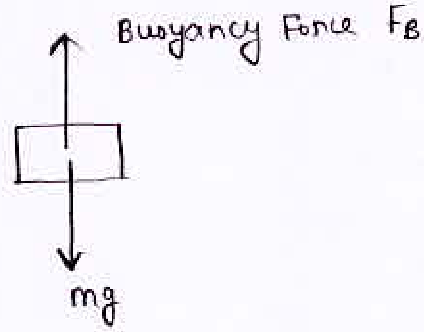
$$(10^5 + 0 + 0)4 + W_{motor} = (2 \times 10^5 + \rho g \times 20) \times 4$$

$$4 \times 10^5 + W_{motor} = 8 \times 10^5 + 10^3 \times 10 \times 20 \times 4$$

$$W_{motor} = 12 \times 10^5 \text{ J}$$

Mechanical properties of Fluids

1. $$\frac{\rho_{stone}}{\rho_w} = k$$



$$m = \rho_s V$$

$$mg - F_B = ma$$

$$\rho_s v g - v \rho_w g = \rho_s v a$$

$$\frac{\rho_s}{\rho_w} vg - \frac{v \rho_w g}{\rho_w} = \frac{\rho_s v a}{\rho_w}$$

$$kg - g = ka$$

$$a = g\left(1 - \frac{1}{k}\right)$$

2. volume of liquid $V = \frac{m}{d} = \frac{m}{d} \Rightarrow m = dv$

$$m_1 g = (dv) g - d_1 v g$$

$$m_1 = dv - d_1 v$$

$$v = \frac{m_1}{d - d_1}$$

$$m_2 g = dvg - d_2 vg$$

$$v = \frac{m_2}{d - d_2}$$

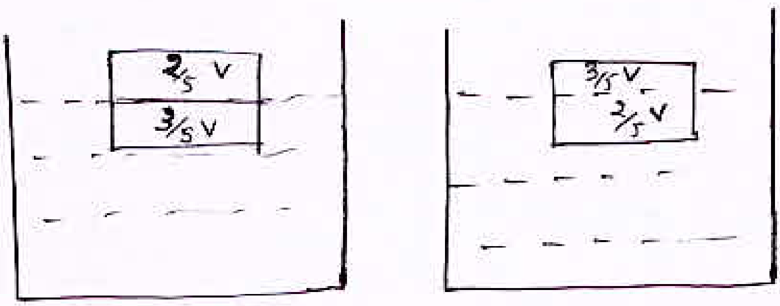
$$\frac{m_1}{d-d_1} = \frac{m_2}{d-d_2}$$

$$m_1 d - m_1 d_2 = m_2 d - m_2 d_1$$

$$d\,(m_1 - m_2) = m_1 d_2 - m_2 d_1$$

$$d = \frac{m_1 d_2 - m_2 d_1}{m_1 - m_2}$$

3.



$$v \times d \times g = \frac{3}{5} v \times \rho_w \times g$$

$$\frac{3\rho_w}{5} = d \quad \Rightarrow \quad \rho_w = \frac{5d}{3}$$

$$v \times d \times g = \frac{2}{5} v \times \rho_o \times g$$

$$\frac{2\rho_o}{5} = d \quad \Rightarrow \quad \rho_o = \frac{5d}{2}$$

$$\frac{\rho_o}{\rho_w} = \frac{5/2}{5/3} = \frac{3}{2} = 1.5$$

4. change in potential energy = Amount of work done

$$W = MgH - Mg\frac{H}{2}$$

$$= (1\times1\times1\times10^3)\, g \times 1 - (1\times1\times1\times10^3)\times10\times\frac{1}{2}$$

$$= \frac{10000}{2} = 5000 \text{ J}$$

5.

$$F = P \times A$$
$$= \rho g h \times A$$
$$= \rho g \times V$$
$$F = mg$$

$$m_A = m_B = m_C$$

8.

10 mm Hg pressure = $\rho_w g H$

$$(10 \times 10^{-1}) \times 13.6 \times g = 1 \times g \times H$$

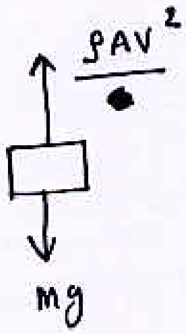
$$H = 13.6 \text{ cm}$$

9.

$$P = \rho g H$$
$$P \propto H$$

10. No Figure given

11.



$$F = \frac{dP}{dt}$$
$$= v \frac{dm}{dt}$$
$$= v \times (\rho A v)$$

$$\frac{1}{\bullet} \rho A V^2 = mg$$

$$\rho = \frac{\bullet mg}{AV^2}$$

$$= \frac{\bullet \times 1.23 \times 10}{0.1 \times 100}$$

$$= 1.23 \text{ kg/m}^3$$

pascal's Law And Archimede's principle

1. $$\rho_{wood} \times V \times g = \frac{4}{5} V \times \rho_w \times g$$

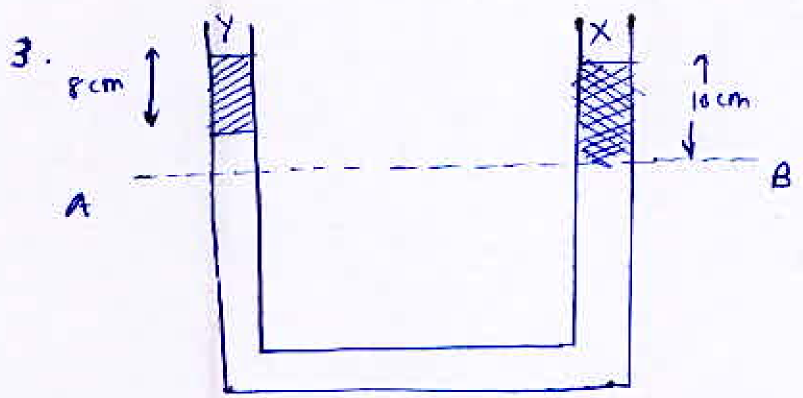
$$\rho_{wood} = \frac{4}{5} \rho_w$$

$$\rho_{wood} \times V \times g = V \times \rho_L \times g$$

$$\rho_{wood} = \rho_L = \frac{4}{5} \rho_w = \frac{4 \times 1000}{5}$$

$$= 800 \ kg/m^3$$

3.



pressure at AB line will be equal

$$\rho_y g \times 8 + \rho_{Hg} \times g \times 2 = \rho_x \times 10 \times g$$

$$\rho_y \times 8 + 13.6 \times 2 = 3.36 \times 10$$

$$\rho_y = \frac{33.6 - 27.2}{8}$$

$$= \frac{6.4}{8} = 0.8 \ gm/cm^3$$

6. volume of the body $= V$

$m = 50g$

$$40 \times g = 50 \times g - V\rho_w \times g$$

$$V = \frac{10}{\rho_w}$$

Weight in liquid $= mg - \rho_L \times v \times g$

$= 50g - 1.5\rho_w \times \frac{10}{\rho_w} \times g$

$= 35\ g$

7. density of body $= \rho$

volume $= V$

$\rho v g = \frac{2}{3} v \times \rho_w \times g$

$\rho = \frac{2}{3}\rho_w$

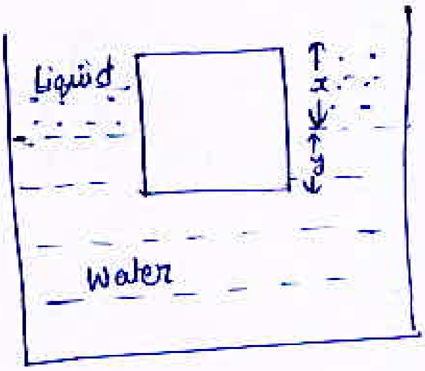
oil $\Rightarrow$ $\rho v g = \frac{1}{2} v \times \rho_o \times g$

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

$\rho = \frac{2}{3}\rho_w = \frac{\rho_o}{2}$

$\frac{\rho_o}{\rho_w} = \frac{4}{3}$

8.



Area of cross section $A = L^2$

$L^3 = V$

$x + y = L \Rightarrow$

$A x \rho_L g + A y \rho_w g = mg = A \times L \times g \times \rho$

$x\rho_L + y\rho_w = L\rho$

$x + y = L \Rightarrow x = L - y$

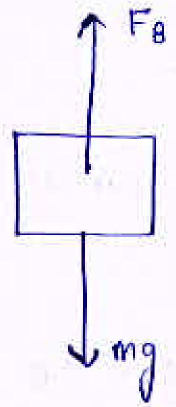
$\rho_L (L - y) + \rho_w y = L\rho$

$$y(\rho_W - \rho_L) = L(\rho - \rho_L)$$

$$\frac{y}{L} = \frac{\rho - \rho_L}{\rho_W - \rho_L} = \frac{0.9 - 0.7}{1 - 0.7} = \frac{2}{3}$$

10. same as Q. 8

14.



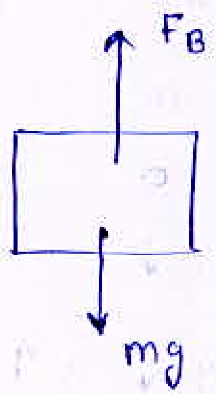
$$mg - F_B = 3\text{ N}$$

$$F_B = 4 - 3 = 1\text{ N}$$

15. velocity at the surface of water $= \sqrt{2gH}$

$$= \sqrt{2 \times 9.8 \times 0.09}$$

$$=$$



$$\text{Retardation} = \frac{F_B - mg}{m}$$

$$= \frac{V \times \rho_W \times g - V\rho g}{V \times \rho}$$

$$= \frac{\rho_W - \rho}{\rho} g = \frac{1 - 0.4}{0.4} = \frac{3}{2} g$$

$$v^2 = u^2 + 2as$$

$$0 = \left(\sqrt{2\times 9.8\times 0.09}\right)^2 - \frac{3}{2}\times 2\times 10\times s$$

$$s = \frac{2\times \cancel{10}\times 0.09\times \cancel{2}}{3\times \cancel{2}\times \cancel{10}}$$

$$= 0.06\ m = 6\ cm$$

16. For Both condition, same Amount of Buoyancy force ~~work~~ acts

In Both cases $\Rightarrow$ $mg = F_B$

$$mg = \rho_w \times V \times g$$

same Amount of volume is displaced

17. 0° to $4^\circ c \longrightarrow$ density $\uparrow$

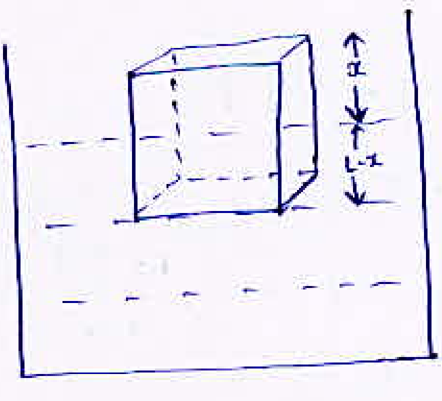
$$mg = A\times x\times d\times g$$

$$x = \frac{m}{Ad}$$

$$d \uparrow \quad x \downarrow$$

$4^\circ c - 10^\circ c \Rightarrow$ density $\downarrow$ $x \uparrow$

18.



$$mg = (L-x)\times L^2 \times \rho_w \times g$$

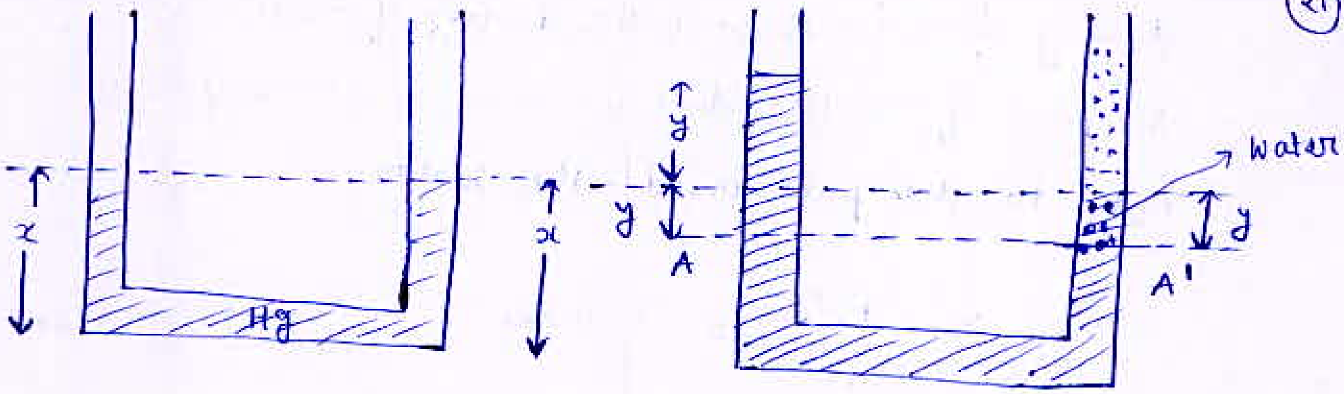
$$L^3 \times \rho = (L-x)\times L^2 \times \rho_w$$

$$\frac{L-x}{L} = \frac{\rho}{\rho_w}$$

$$1 - \frac{x}{L} = \frac{\rho}{\rho_w} \Rightarrow \frac{x}{L} = 1 - \frac{900}{1000}$$

$$= \frac{1}{10} = 10\%$$

19.



At same level in Hg pressure will be equal

$$\rho_{Hg} \times g \times 2y = 11.2 \times \rho_W \times g$$

$$y = \frac{11.2 \times \rho_W}{2\rho_{Hg}} = \frac{11.2 \times 1}{2 \times 13.6} = 0.41 \text{ cm}$$

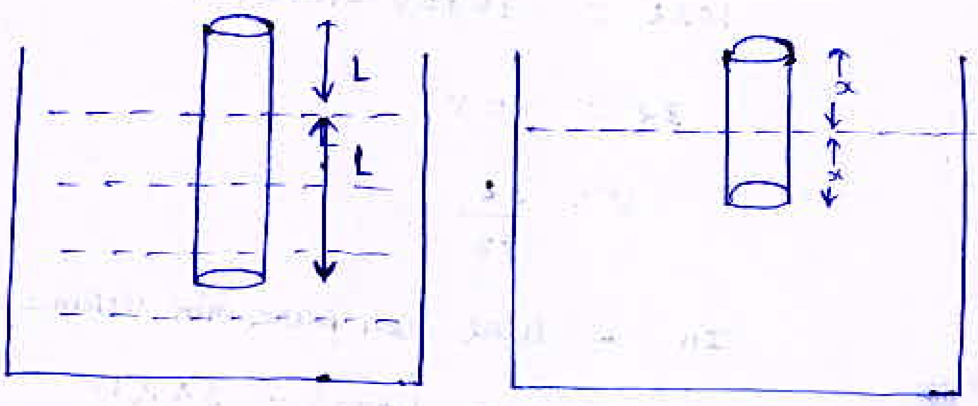
20.

$$\beta = -\frac{\Delta P}{\Delta V / V}$$

$$\frac{\Delta V}{V} = -\frac{\Delta P}{\beta}$$

$$\frac{\Delta V}{V} \propto \frac{1}{\beta}$$

21.



$\cancel{\frac{d(2L)}{dt} = 2 \text{ cm/h}}$ From Figure(1)

$$mg = \text{Buoyancy Force}$$

$$\frac{\pi d^2}{4} \times 2L \times \rho \times g = \frac{\pi d^2}{4} \times L \times \rho_W \times g$$

$$\rho_W = 2\rho$$

density of water is twice the density of candle.
so part of candle which is above water surface is equal to the part inside the water.

$$\text{As } \frac{d(2x)}{dt} = 2 \text{ cm/hr}$$

$$\frac{dx}{dt} = 1 \text{ cm/hr}$$

upper Top part will fall at the rate of $\frac{dx}{dt} = 1 \text{ cm/hr}$
And Lower part (Lowest point) will go up at the rate of $\frac{dx}{dt} = 1 \text{ cm/hr}$

22.

$$\rho_{mix} = \frac{\rho_1 V_1 + \rho_2 V_2}{V_1 + V_2}$$

$$1032 = \frac{1080 \times V + (1-V) \times 1000}{V + (1-V)}$$

$$1032 = 1080V - 1000V + 1000$$

$$32 = 80V$$

$$V = \frac{32}{80}$$

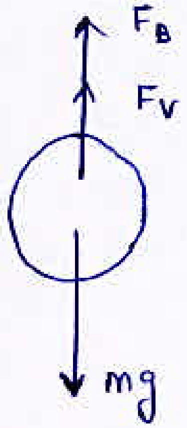
In 1 litre ~~con~~ pure mik volume $= \frac{32}{80}$

$$\text{In 10 litre} = \frac{32 \times 10}{80}$$

$$= 4 \text{ L}$$

Fluid Flow

1.



$$F_B + F_V = mg$$

Net force on sphere $= 0$

$$a = 0$$

2. Refer level 1, Q.33

3. From equation of continuity

$$A_1 V_1 = A_2 V_2$$

$$V_2 = \frac{10 \times 1}{5} = 2 \text{ m/s}$$

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

$$2000 + \rho g h + \frac{1}{2} \times 1000 \times (1)^2 = P + \frac{1}{2} \times 1000 \times 4 + \rho g h$$

$$P = 2000 + 500 - 2000$$

$$= 500 \text{ pa}$$

4. $$2 \times \frac{4}{3} \pi r^3 = \frac{4}{3} \pi R^3 \quad (\text{volume} = \text{constant})$$

$$R = 2^{1/3} r$$

After Reaching terminal velocity

Buoyancy force $= mg$

$$6 \pi \eta r V = \frac{4}{3} \pi r^3 \times \rho \times g$$

$$V \propto r^2$$

$$\frac{V_2}{V} = \left(\frac{R}{r}\right)^2 \Rightarrow V_2 = V \times \frac{R^2}{r^2}$$

5. ~~For Hana~~ From Q.4

$$V \propto r^2$$

$$M = \frac{4}{3}\pi r^3 \times \rho$$

$$8M = \frac{4}{3}\pi R^3 \times \rho$$

$$2r = R$$

$$\frac{V_2}{V} = \left(\frac{R}{r}\right)^2 = 4$$

$$V_2 = 4V$$

6. $$P + \rho gh + \frac{1}{2}\rho v^2 = \text{constant}$$

$$1 \times 13.6 \times g + \frac{1}{2} \times 1 \times 35^2 + \cancel{\rho gh}$$

$$= P + \frac{1}{2} \times 1 \times 65^2 + \cancel{\rho gh}$$

$$13.6 \times \left(1000\ cm/s^2\right) + \frac{1}{2} \times 1 \times (35-65)(35+65) = P$$

$$13600 - 1500 = P$$

$$12100 = 13.6 \times g \times h$$

$$h = \frac{12100}{13.6 \times 1000\ cm/s^2} = 0.89 \text{ cm of Hg}$$

8. Level-1 Q. 35 same question

9. For terminal velocity

Buoyancy Force = Viscous Force

$$\frac{4}{3}\pi r^3 \times \rho_L \times g = 6\pi\eta r V$$

$$\eta = \frac{2}{9} \times \frac{\rho_L r^2 g}{V}$$

$$= \frac{2}{9} \times \frac{1.5 \times 1^2 \times (1000\ gm/cm^3)}{0.25}$$

$$= \frac{1}{3} \times 4000 = 1333$$

$$= 1333 \times \left(\frac{gm.}{cm\text{-}s^2}\right)$$

$$= 1333 \times \frac{10^{-3}}{10^{-2}}\ kg/m\text{-}s^2$$

$$= 133.3\ N/m^2$$

10. sphere of volume = V', velocity = V_1, V_2

For terminal velocity ⇒

Buoyancy Force + viscous Force = weight of the body

For gold $V' \times \rho_L \times g + 6\pi\eta r V_1 = V' \times \rho_{gold} \times g$

For silver $V' \times \rho_L \times g + 6\pi\eta r V_2 = V' \times \rho_{silver} \times g$

$$6\pi\eta r V_1 = V' g\,(\rho_{gold} - \rho_L)$$

$$6\pi\eta r V_2 = V' g\,(\rho_{silver} - \rho_L)$$

$$\frac{V_2}{V_1} = \frac{(\rho_{silver} - \rho_L)}{\rho_{gold} - \rho_L}$$

$$= \frac{10.5 - 1.5}{19.5 - 1.5} = \frac{9}{18} = \frac{1}{2}$$

$$V_2 = \frac{V_1}{2} = 0.1\ m/s$$

11.

12. Pressure at the base = $\rho g H$

$= 800 \times 10 \times 0.4$

$= 3600 \ N/m^2$

Force $= P \times A$

$= 3600 \times 2 \times 10^{-3}$

$= 7.2 \ N$

13. volume of water inflow = volume of water outflow

$A_1 V_1 = A_2 V_2 + A_3 V_3$

$0.8 = 0.4 + 0.4 \times V_3$

$V_3 = 1 \ m/s$

15. sphere falls with terminal velocity,

because Net force upward = Net force downward

$mg + \text{Buoyancy Force} = \text{Viscous Force}$

But in vaccum there is no viscous force, so its velocity will keep on increasing.

16. $\frac{1}{2} \rho_W V^2 = \rho_{Hg}\, g\, H$

$\frac{1}{2} \times 10^3 \times V^2 = 13.6 \times 10^3 \times 10 \times 40 \times 10^{-2}$

$V = 10.3 \text{ m/s}$

17. $A_1V_1 = A_2V_2 = AV = \text{Constant}$

$\cancel{A \propto \frac{1}{V}}$

$V \propto \frac{1}{A}$

18. $V = \dfrac{\pi P R^4}{8 \eta L}$

$V \propto R^4$

$\dfrac{V_2}{V} = \left(\dfrac{1.1R}{R}\right)^4$

$V_2 = 1.46\, V$

$\% \text{ Increase} = \dfrac{1.46V - V}{V} \times 100$

$= 46\%$

19. $2 \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$

$R = 2^{1/3} r$

mg = ~~Buoyer~~ viscous Force

$$\frac{4}{3}\pi r^3 \times \rho \times g = 6\pi\eta r v$$

$$v = \frac{2r^2\rho g}{9\eta}$$

$$v \propto r^2$$

$$\frac{v_2}{v_1} = \left(\frac{r_2}{r_1}\right)^2 = \left(\frac{2^{1/3} r}{r}\right)^2$$

$$v_2 = v \times 2^{2/3}$$

22. Refer question 19

23. velocity head = ~~d~~ pressure difference

$$\frac{1}{2}\rho v^2 = 0.5 \times 10^5$$

$$v^2 = \frac{10^5}{10^3}$$

$$v = 10 \text{ m/s}$$

24.

$$mg = 6\pi\eta r v$$

$$\rho v g = 6\pi\eta r v$$

$$\rho \times \frac{4}{3}\pi r^3 \times g = 6\pi\eta r v$$

$$\rho \times \frac{4}{3}\pi r^2 \times g = 6\pi\eta v$$

$$v \propto r^2$$

$$\frac{v_2}{v_1} = \left(\frac{r_2}{r_1}\right)^4$$

$$v_2 = \frac{v}{4} = 5 \text{ m/s}$$

25. $A_1 V_1 = A_2 V_2$

$$10^{-4} \times 8 \times 0.15 = 40 \times 10^{-8} \times V_2$$

$$V_2 = \frac{15 \times \cancel{8}^{2}}{\cancel{4} \times 10^{-1}}$$

$$= 300\ m/min$$

$$= 300\ m/60\,sec$$

$$= 5\ m/sec.$$

26. Refer Level-1 Q. 34

27. $\rho g H = 3 \times 10^5$

$$H = \frac{3 \times 10^5}{10^3 \times 10} = 30$$

$$V = \sqrt{2gH}$$

$$= \sqrt{2 \times 10 \times 30}$$

$$= \sqrt{600}$$

~~30~~. 31. $$\text{velocity} = \frac{\text{volume Flow Rate}}{\text{Area of Cross section}}$$

$$= \frac{200 \times 10^3}{0.5 \times 10^6}$$

$$= 0.4\ mm/s$$

32. change in pressure $= \frac{1}{2}\rho v_1^2 - \frac{1}{2}\rho v_2^2$

$$\text{Force} = P \times A$$

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

35. using Bernoulli equation

$$p + \rho g H + \frac{1}{2}\rho v^2 = p_1 + \rho g H + \frac{1}{2}\rho \times (2v)^2$$

$$P_1 = P - \frac{3}{2}\rho v^2$$

38

$$A_A V_A = A_B V_B$$

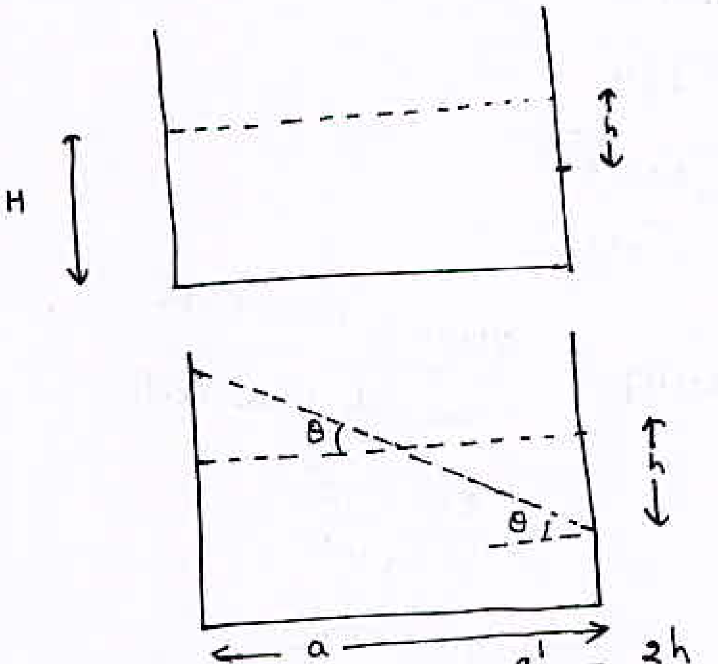
$$\pi (2r)^2 \times v = \pi r^2 \times V_B$$

$$V_B = 4V$$

39. Same as Q.38

40. viscous force Acts on the ~~bot~~ boundary

41.



$$\tan\theta = \frac{a'}{g} = \frac{2h}{a}$$

$$a = \frac{2gh}{a}$$

43.

$$A \times V = \text{volume Rate of flow}$$

$$V = \frac{200 \times 10^3}{0.5 \times 10^6} = 0.4$$

Q.44 Refer Level 1 Q-35

Q.46 First $mg >$ Buoyancy force + viscous force

velocity will increase

But As $v \uparrow$, viscous Force $= 6\pi\eta r v \uparrow$

so upward force increases.

After some time $mg =$ Buoyancy force $+ 6\pi\eta r v$

Net Force $= 0$

will Attain terminal velocity.

Surface Tension And Surface Energy

1. $\frac{4}{3}\pi R^3 = 64 \times \frac{4}{3}\pi r^3$

$R = 4r$

$r = \frac{R}{4}$

change in surface Area $= 4\pi r^2 \times 64 - 4\pi R^2$

$= 4\pi \times \frac{R^2}{16} \times 64 - 4\pi R^2$

$= 12\pi R^2$

Energy needed $= T \times \Delta A$

$= 12\pi R^2 T$

3. Initial Energy $= T \times A$

Final Energy $= T \times \frac{A}{2}$

% change $= \frac{TA - T\frac{A}{2}}{TA}$ %

$= 50\%$

4. same as Q.1

6. soap bubble ⇒ Two surface

$\Delta A = 2\left[4\pi (2R)^2 - 4\pi R^2\right]$

$= 24\pi R^2$

Required surface Energy $= T\Delta A$

$= 24\pi R^2 T$

7. $$2 \times \frac{4}{3} \pi r^3 = \frac{4}{3} \pi R^3$$

$$R = 2^{1/3} r$$

$$\frac{E_B}{E_S} = \frac{4\pi R^2 \times T}{4\pi r^2 \times T} = 2^{2/3}$$

8. surface Tension is Acting on 2l length

gravitational force = surface Tension force

$$mg = T \times 2l$$

$$\pi R^2 l \times \rho \times g = T \times 2l$$

$$R^2 = \frac{2T}{\pi \rho g}$$

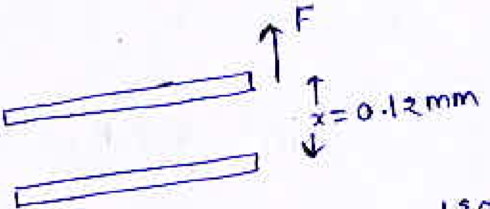
$$R = \sqrt{\frac{2T}{\pi \rho g}} = 0.75 \text{ mm}$$

9. with increase in temperature, surface Tension of water decreases

10. Increase in surface Energy $= T \times 2A$

$$= 75 \times 2 \times 8$$

$$= 1200 \text{ dyne-cm}$$



So $F \times x = 1200$ dyne-cm

$$F \times (0.12 \times 10^{-1} \text{ cm}) = 1200 \text{ dyne-cm}$$

$$F = 10^5 \text{ dyne}$$

11. When drop splits up into a number of drops, surface Area Increases.

So surface Energy Increased = $T \times \Delta A$

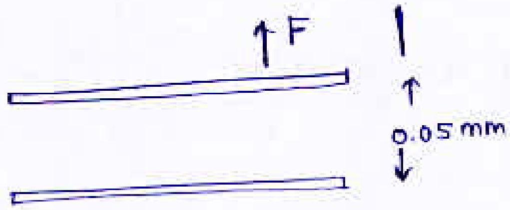
So Energy is being absorbed

12. $W_1 = T \times 4\pi R^2 = TA$

$W_2 = T \times 4\pi (3R)^2$

$$\frac{W_1}{W_2} = \frac{1}{9}$$

13.



Increase in surface Energy $= T \times 2A$

$= 70 \times 10^{-3} \times 2 \times 10^{-2}$

$= 14 \times 10^{-4}$ N-m

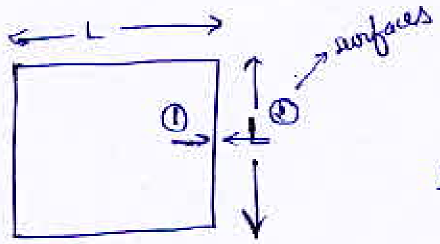
This ~~Energy is~~ work is done by External force F

Work done by Force F = Increase in surface Energy

$F \times 0.05 \times 10^{-3} = 14 \times 10^{-4}$ N-m

$$F = \frac{140}{5} = 28 \text{ N}$$

14.



As This is wire Frame, There are two surface on which surface Tension is Acting.

Force Acting $= 2T \times 4L$

$= 8TL$

15. volume will remain constan $\quad \left(\begin{array}{l} m_1 = m_2 \\ V_1 \rho = V_2 \rho \\ V_1 = V_2 \end{array} \right)$

$$\frac{4}{3}\pi R^3 = 1000 \times \frac{4}{3}\pi r^3$$

$$\frac{R}{10} = r$$

$$r = \frac{0.1 \times 10^{-1}}{10} = 10^{-3}\ m$$

Increase in surface Area $= 1000 \times 4\pi r^2 - 4\pi R^2$

$$= (1000 \times 10^{-6} - 10^{-4})\, 4\pi$$

$$= 4\pi\, [0.001 - 0.0001]$$

Increase in surface Energy $= T \times \Delta A$

$$= 7 \times 10^{-2} \times 4\pi\, [0.001 - 0.0001]$$

$$= 7.9 \times 10^{-6}\ J$$

16. $$P_{in} - P_{out} = \frac{4T}{R}$$

Electrostatic pressure $= \dfrac{\sigma^2}{2\varepsilon_0}$

17. $$V = \frac{4}{3}\pi R_1^3$$

$$2V = \frac{4}{3}\pi R_2^3$$

$$\left(\frac{R_2}{R_1}\right)^3 = 2$$

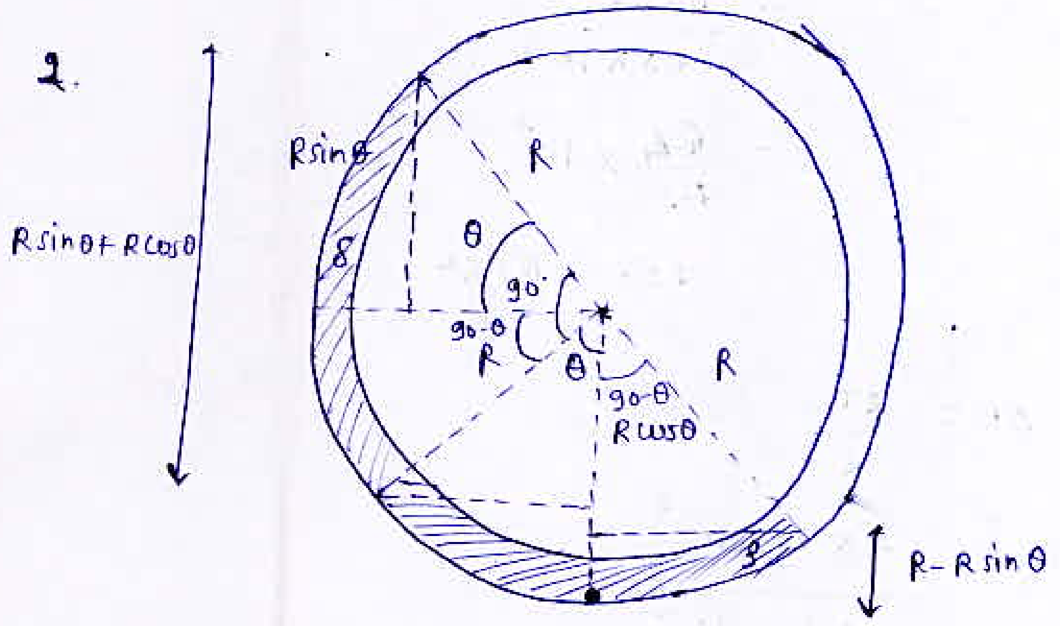
$$\left(\frac{R_2}{R_1}\right) = 2^{1/3}$$

$$\frac{W_2}{W_1} = \frac{4\pi R_2^2 \times T}{4\pi R_1^2 \times T} = \left(\frac{R_2}{R_1}\right)^2 = 2^{2/3}$$

$$W_2 = 2^{2/3}\, W = 4^{1/3}\, W$$

pressure difference

2.



$$\delta g\,(R\sin\theta + R\cos\theta) + \rho g\,(R - R\cos\theta) = \rho g\,(R - R\sin\theta)$$

$$\sin\theta\,(\delta+\rho) = \cos\theta\,(\rho-\delta)$$

$$\tan\theta = \frac{\rho-\delta}{\rho+\delta}$$

3. Excess pressure $= \frac{4T}{R}$

$$\Delta P \propto \frac{1}{R}$$

$$\frac{\Delta P_1}{\Delta P_2} = \frac{R_2}{R_1} = \frac{1}{2}$$

4. $\frac{4}{3}\pi R^3 = 8 \times \frac{4}{3}\pi r^3$

$$R = 2r$$

$$r = \frac{R}{2}$$

Excess pressure $= \frac{2T}{R}$

$$\Delta P \propto \frac{1}{R}$$

Big drop
Radius double than small
Excess pressure will
be half.

5. Excess pressure $= \dfrac{4T}{R}$

$$= \frac{4 \times 1.6}{2.5 \times 10^{-3}}$$

$$= \frac{6.4}{2.5} \times 10^{3}$$

$$= 2560 \ N/m^2$$

6. $\Delta P = \dfrac{2T}{R}$

$$= \frac{2 \times 70 \times 10^{-3}}{0.5 \times 10^{-3}}$$

$$= 280 \ N/m^2$$

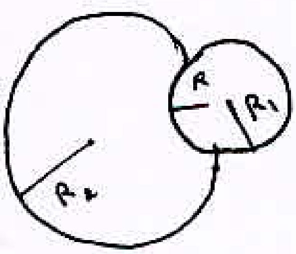
8. $\Delta P \propto \dfrac{1}{R}$

$$\frac{P_1}{P_2} = \frac{R_2}{R_1}$$

$$\frac{3P_2}{P_2} = \frac{R_2}{R_1} = 3$$

$$\frac{V_1}{V_2} = \frac{\frac{4}{3}\pi R_1^3}{\frac{4}{3}\pi R_2^3} = \left(\frac{R_1}{R_2}\right)^3 = \frac{1}{27}$$

9.



$$\frac{4T}{R_1} - \frac{4T}{R_2} = \frac{4T}{R}$$

$$\frac{1}{0.03} - \frac{1}{0.04} = \frac{1}{R}$$

$$R = 0.12 \ m$$

10. Excess pressure $\propto \frac{1}{R}$ $\left(\frac{4T}{R}\right)$

11. Excess pressure $= P_{in} - P_{out} = \frac{2T}{R}$

$$P_{in} = P_{out} + \frac{2T}{R}$$

$$= 1.013 \times 10^5 + \frac{2 \times 7.2 \times 10^{-2}}{0.1 \times 10^{-3}}$$

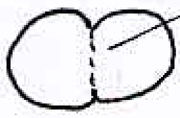
$$= 1.013 \times 10^5 + 0.014 \times 10^5$$

$$= 1.027 \times 10^5 \ N/m^2$$

12. $\frac{4T}{R_1} - \frac{4T}{R_2} = \frac{4T}{R}$

$\frac{1}{R} = 0$

$R = \infty$



Radius of curvature $= \infty$

Flat surface

13. $\Delta P = \frac{4T}{R}$

15. Excess pressure $\Delta P = \frac{4T}{R}$

$$\Delta P \propto \frac{1}{R}$$

pressure inside the soap bubble of small Radius will be more

So Air will flow from low radius bubble to higher radius bubble.

16.

$$\frac{4T}{R} = \rho g H$$

$$T = \frac{\rho g H R}{4}$$

$$= \frac{\left(0.8 \times \frac{10^{-3}}{10^{-6}}\right) \times 10 \times (2 \times 10^{-3}) \times (10^{-2})}{4}$$

$$= 4 \times 10^{-2} \ N/m^2 = 3.9 \times 10^{-2} \ N/m$$

take $g = 9.8 \ m/s^2$

17.

Excess pressure $\propto \frac{1}{R}$ $\left(\frac{4T}{R}\right)$

$$\frac{P_1}{P_2} = \frac{R_2}{R_1}$$

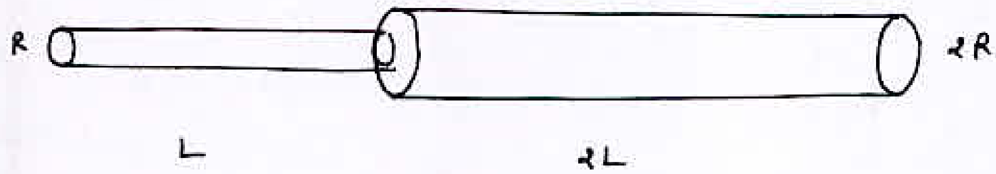
$$\frac{P_1}{P_2} = \frac{4}{1}$$

18.

$$- \quad \Delta P = \frac{4T}{R}$$

$$\Delta P \propto \frac{1}{R}$$

J.



volume of liquid flowing through both the tube is same.

For 1st tube

$$V = \frac{\pi P_1 R^4}{8\eta L}$$

$$P_1 = V\left(\frac{8\eta L}{\pi R^4}\right)$$

For 2nd tube

$$V = \frac{\pi P_2 (2R)^4}{8\eta \times 2L}$$

$$P_2 = \frac{V\times}{8}\left(\frac{8\eta L}{\pi R^4}\right)$$

$$P = P_1 + P_2$$

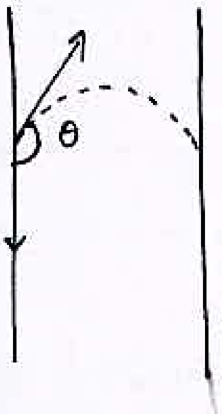
$$P = \frac{8\eta L}{\pi R^4}\left(V + \frac{V}{8}\right)$$

$$P = \frac{8\eta L}{\pi R^4} \times \frac{9V}{8}$$

$$V = \frac{8}{9} \times \frac{\pi P R^4}{8\eta L}$$

$$V = \frac{8}{9} \times$$

2.



$\theta > 90^\circ$

$F_a < \frac{F_c}{\sqrt{2}}$

convex meniscus

Liquid does not wet the solid surface

3.

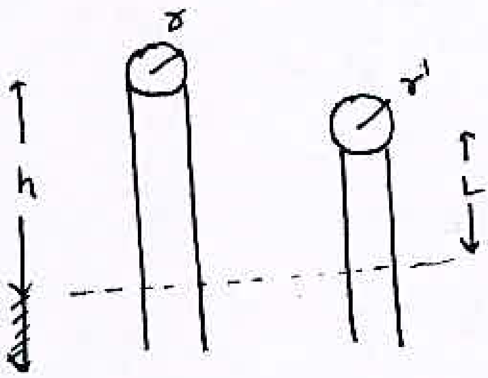
$h = \frac{2T}{Rdg}$

$h \propto \frac{1}{g}$

$\frac{h_e}{h_m} = \frac{g_m}{g_e}$

$h_m = h_e \times \frac{g_e}{g_m} = \frac{h_e}{1/6} = 6\, h_e$

4.



$hr = Lr'$ If $L < h$, $r' > r$

5. a

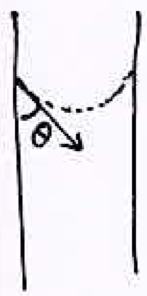
7

8. $$hdg = \frac{2T\cos\theta}{r}$$

$$h \propto \frac{1}{r}$$

Radius half, height double

9.



Acute

10. $$h \propto \frac{1}{r}$$

$$\frac{h_2}{h_1} = \frac{r_1}{r_2}$$

$$h_2 = 3 \times \left(\frac{r_1}{r_1/3}\right) = 9\ mm$$

12. $$hdg = \frac{2T\cos\theta}{r} \qquad \left(R = \frac{r}{\cos\theta}\right)$$

$$T = \frac{hdgr}{2\cos\theta}$$

$$T \propto \frac{hd}{\cos\theta}$$

$$\frac{T_w}{T_{Hg}} = \frac{h_w}{h_{Hg}} \times \frac{d_w}{d_{Hg}} \times \frac{\cos\theta_{Hg}}{\cos\theta_w}$$

$$= \frac{10}{-3.5} \times \frac{1}{13.6} \times \frac{-0.7}{1}$$

$$\frac{T_w}{T_{Hg}} = 0.15$$