$$\frac{2.1\times10^{3}\times 80\times \cancel{4/2}}{3600} = K\,(\cancel{4/2})\times10^{-2}$$

$$\frac{7}{12}\times 80 = K\times10^{-2}$$

$$K = \frac{7}{12}\times 80\times10^{2}$$

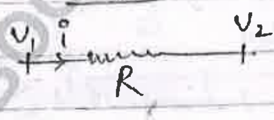
$$\therefore K = 4.67\times10^{3}\ \frac{W}{m\text{-}K} \quad \text{(Ans.)}$$

- **Thermal Resistance** (R_{th} or R)

→ Property of material to resist heat flow through it.

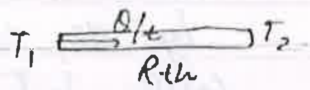
$$\boxed{R_{th} \text{ or } R = \frac{L}{KA}}$$

Wire



$$\therefore i = \frac{V_1 - V_2}{R}$$

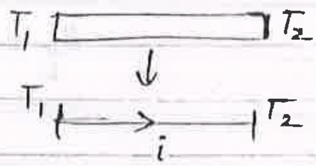
Rod



$$\therefore \frac{Q}{t} = \frac{T_1 - T_2}{R_{th}}$$

i_h = Heat current

$$i = \frac{T_1 - T_2}{R}$$



$$\because \frac{Q}{t} = \frac{KA(T_1 - T_2)}{L}$$

$$\frac{Q}{t} = \frac{T_1 - T_2}{\frac{L}{KA}}$$

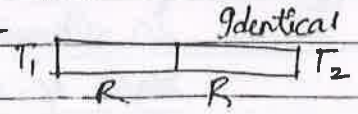
$$\left[\frac{Q}{t} = \frac{T_1 - T_2}{R}\right]$$

Note: ⇒ ① If two rods are Identical

$$\underbrace{l, A, K}_{\downarrow} \rightarrow \text{same}$$

$R \rightarrow$ same

e.g., –



$\because$ series → $R_{eq} = 2R$

(2). If two rods are Identical in dimension.

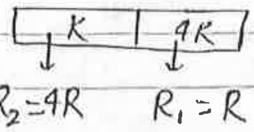
$A \ \& \ l \longrightarrow$ same.

$K \longrightarrow$ Different.

$\therefore \ R = \frac{l}{KA} \Rightarrow R \propto \frac{1}{K}$

Two rod same in dimension.

eg:-



$\therefore R \propto \frac{1}{K}$

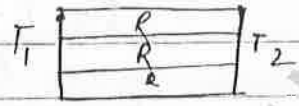
Ques:- 3 identical rods are arranged in such a way that one end of rod is connected to another end of second rod. Heat flow through the combination is 40 J in 9 minutes. If these rods would have been kept one over another then flo- time taken by the combination to flow 80 J of heat through it.

Case (I).

$\frac{Q}{t} = \frac{KA(T_1 - T_2)}{L}$

$\frac{40}{9} = \frac{T_1 - T_2}{3R}$ —(I)

Case (II).



$\therefore \frac{80}{t} = \frac{T_1 - T_2}{R/3}$ —(II)

$R_{eq} = \frac{R}{3}$

(I) ÷ (II)

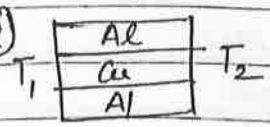
$\frac{t}{10} = \frac{R}{9R}$

$t = 2$ min (Ans):.

Ques:- $K_{Cu} = 400$ unit

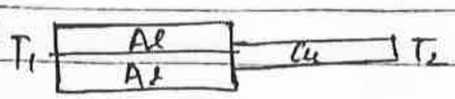
$K_{Al} = 200$ unit

(a)

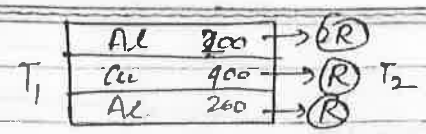


If rods are similar in dimension then ratio of heat current through (a) & (b)

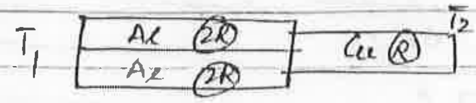
(b)



$\left\{ \begin{array}{l} l, A \longrightarrow \text{same} \\ \Rightarrow R \propto \frac{1}{K} \end{array} \right\}$

(a) 

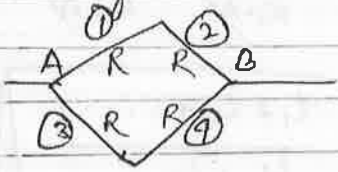
$\therefore R_{eq} = \frac{R}{2}$

(b) 

$\therefore R_{eq} = 2R$

$\therefore i \propto \frac{1}{R} \Rightarrow \frac{i_a}{i_b} = \frac{2R}{R/2} = \frac{4}{1}$

Ques:- If two identical rods are arranged in series, 40 J of heat can flow through it in 1 min. If similar 4 rods are arranged as given in diagram then f/o time taken by this combination to flow same amount of heat through it? (Temp. difference are same in both conditions)



(a). 

$\therefore R_{eq} = 2R$

$\therefore i_a = \frac{40}{60\,sec} = \frac{T_1 - T_2}{2R}$ - (1)

(b)

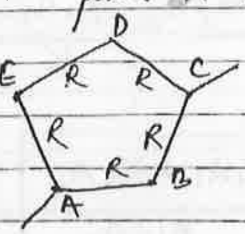
$\therefore R_{eq} = R$

$\therefore i_b = \frac{40}{t} = \frac{T_1 - T_2}{R}$ - (2)

(1) ÷ (2)

$t = 30$ sec.

Ques:- 5 identical rods are arranged in Pentagon frame and heat current through this combination is 'i' if temp. are maintained at point A & C of frame. F/o value of heat current current through combination if given temp. would have been kept at point A and B.



Case (1) $\frac{1}{R_{eq}} = \frac{1}{3R} + \frac{1}{2R}$

$R_{eq} = \frac{6R}{5}$

Case (2) $R_{eq} = \frac{4R \times R}{4R + R} = \frac{4R}{5}$

$\therefore \quad i = \dfrac{T_1 - T_2}{R}$

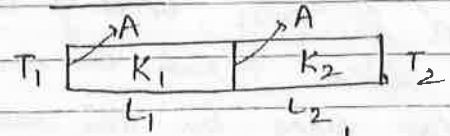
$i \propto \dfrac{1}{R} \Rightarrow \dfrac{i}{i_2} = \dfrac{4R/5}{6R/5} = \dfrac{2}{3}$

$i_2 = \dfrac{3}{2} i$

- <u>Different Combination of Rods</u>.

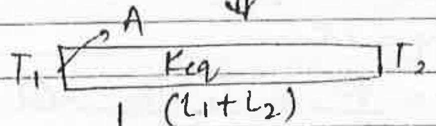
(1). <u>Series</u>

$T_1 > T_2$



$R_1 = \dfrac{L_1}{K_1 A}$ $\quad R_2 = \dfrac{L_2}{K_2 A}$

$\Downarrow$



$\therefore R_{eq} = \dfrac{L_1 + L_2}{K_{eq} \cdot A}$

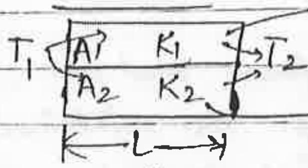
$\because$ <u>Series</u>

$\therefore R_{eq} = R_1 + R_2$

$\dfrac{L_1 + L_2}{(K_{eq}) \cdot \cancel{A}} = \dfrac{L_1}{K_1 \cdot \cancel{A}} + \dfrac{L_2}{K_2 \cdot \cancel{A}}$

$$\boxed{K_{eq} = \dfrac{L_1 + L_2 + \cdots}{\dfrac{L_1}{K_1} + \dfrac{L_2}{K_2} + \cdots}}$$

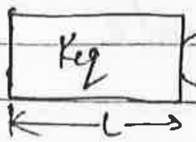
(2). <u>Parallel</u>



$R_1 = \dfrac{L}{K_1 A_1}$

$R_2 = \dfrac{L}{K_2 A_2}$

$\Downarrow$



$\rightarrow A_1 + A_2$

$R_{eq} = \dfrac{L}{K_{eq} \cdot (A_1 + A_2)}$

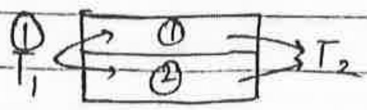
$\because$ <u>Parallel</u>

$\therefore \dfrac{1}{R_{eq}} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$

$\dfrac{K_{eq}(A_1 + A_2)}{\cancel{L}} = \dfrac{K_1 A_1}{\cancel{L}} + \dfrac{K_2 A_2}{\cancel{L}}$

$$\boxed{K_{eq} = \dfrac{K_1 A_1 + K_2 A_2}{A_1 + A_2}}$$

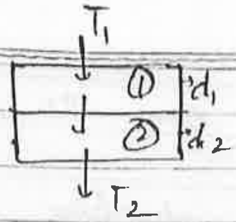
<u>Note</u>: $\Rightarrow$



<u>Parallel</u> $\quad K_{eq} = \dfrac{K_1 A_1 + K_2 A_2}{A_1 + A_2}$

02/01/2020

~~[illegible]~~

②. 

$$K_{eq} = \frac{d_1 + d_2}{\frac{d_1}{K_1} + \frac{d_2}{K_2}}$$

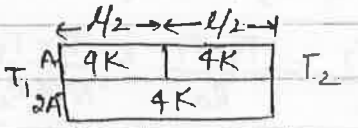
③. If temp. are not mentioned then take series as preference.

Ques:- 3 rods similar in dimension

$K_{eq} = ?$

$$\therefore K_{eq} = \frac{L+L+L}{\frac{L}{K} + \frac{L}{2K} + \frac{L}{2.5K}} = \frac{3K \times 5K}{K(5+2.5+2)}$$

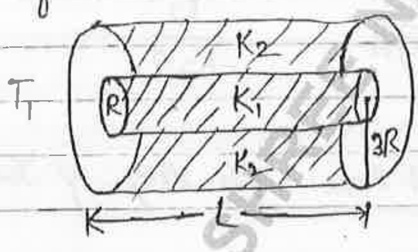
$$K_{eq} = \frac{15K}{9.5}$$

Ques:- 

$K_{eq} = ?$

$\therefore \boxed{K_{eq} = 4K} \rightarrow$ same material hai.

Ques:- 2 concentric cylinder of radius R & 3R of material K_1 & K_2 conductivity are arranged as shown. F/o equivalent conductivity of combination?



Parallel combination:-

$$\therefore K_{eq} = \frac{K_1A_1 + K_2A_2}{A_1 + A_2}$$

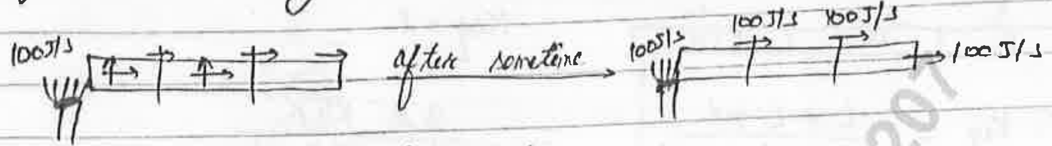
$$K_{eq} = \frac{K_1(\pi R^2) + K_2[\pi(3R)^2 - \pi R^2]}{[\pi R^2] + [\pi(3R)^2 - \pi R^2]}$$

$$K_{eq} = \frac{K_1 + 8K_2}{9}$$

- Steady state

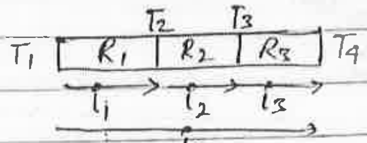
→ When a rod is heated, each & every section of rod of absorbs heat, increase it's internal energy and remaining part is transferred to next section. That's why temp. of

each and every section of rod change with time. It is k/n as Variable state.
After sometime different sections of rod stop absorbing heat and completely transfer into next section that's why temp. of each and every section remains constant (Steady) with time.



At steady state :-
Heat current [$i_{input} = i_{output}$]

eg. :-

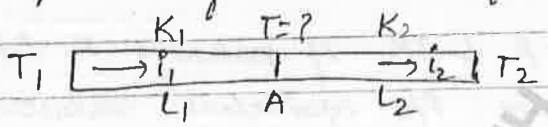


∴ steady state,

$$i_1 = i_2 = i_3 = i_4$$

$$\frac{T_1 - T_2}{R_1} = \frac{T_2 - T_3}{R_2} = \frac{T_3 - T_4}{R_3} = \frac{T_1 - T_4}{R_1 + R_2 + R_3}$$

Temperature of Junction Interface :-



Temp. of Junction = ?
Steady state at (A)

$$i_1 = i_2$$

$$\frac{T_1 - T}{\frac{L_1}{K_1 A}} = \frac{T - T_2}{\frac{L_2}{K_2 A}}$$

Ques :-

If $K_{Cu} = 4 K_{Al}$ f/o temp. of Junction.

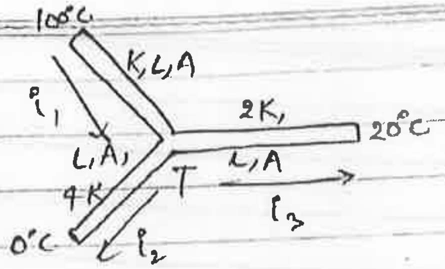
$$\therefore \frac{120 - T}{\frac{12}{\cancel{K_{Al} \cdot A}}} = \frac{T - 30}{\frac{6}{4 \cancel{K_{Al} \cdot A}}}$$

$$\frac{120 - T}{\cancel{12}\,4} = \frac{(T-30)}{\cancel{3}} \times 2$$

$$120 - T = 8T - 240$$

$$9T = 360 \Rightarrow T = 40°c$$

Ques:-



F/o temp of Junction?

$\therefore \; i_1 = i_2 + i_3$

$$\frac{100-T}{\frac{L}{\cancel{KA}}} = \frac{T-20}{\frac{L}{\cancel{2KA}}} + \frac{T-0}{\frac{L}{\cancel{4KA}}}$$

$$100-T = (T-20)\times 2 + 4T$$

$$100-T = 2T-40+4T$$

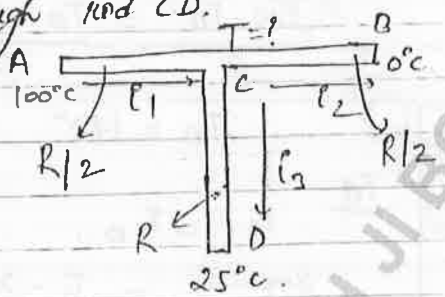
$$7T = 140$$

$$T = 20°C.$$

Imp.

Ques:- 2 rods AB & CD are similar and CD connected to mid point of AB. If resistance of CD is 4KW^{-1} then f/o heat current through rod CD.

Kelvin/watt



steady at C.

$\therefore \; i_1 = i_2 + i_3$

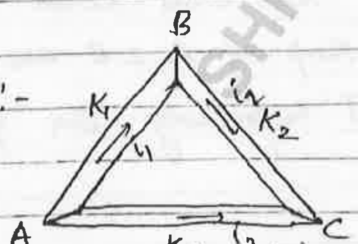
$$\frac{100-T}{\frac{R}{2}} = \frac{T-0}{\frac{R}{2}} + \frac{T-25}{R}$$

$$\Rightarrow T = 45°C.$$

Now, $i_3 = \dfrac{45-25}{4}$

$$= \frac{20}{4} = 5 \text{ Watt}.$$

Ques:-



If rods are identical in dimension arranged in equilateral triangle. If heat current through ABC is equal to that of AC then

(a) $K_3 = K_1 + K_2$

(b) $K_3 = \dfrac{K_1 K_2}{K_1 + K_2}$

(c) $K_3 = \dfrac{2K_1K_2}{K_1+K_2}$

(d) NOTA

$\therefore$ ~~$i_3 = i_1 + i_2$~~

$i_{ABC} = i_{AC}$

$\therefore$

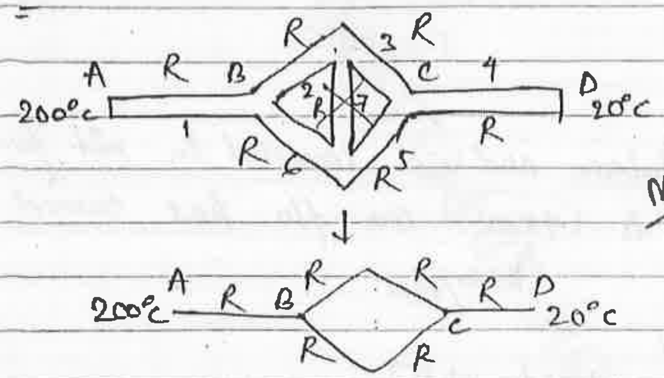
$$\frac{\cancel{T_A - T_C}}{R_{AB}+R_{BC}} = \frac{\cancel{T_A - T_C}}{R_{AC}}$$

$$\Rightarrow \quad R_{AB} + R_{BC} = R_{AC}$$

$$\frac{L}{K_1A} + \frac{L}{K_2A} = \frac{L}{K_3A}$$

$$\Rightarrow \quad K_3 = \frac{K_1K_2}{K_1+K_2}$$

Ques:- 7 Identical rods.



F/o temp. at point B & C.

M-① T_B

$$i_{AB} = i_{BD}$$

$$\frac{200 - T_B}{\cancel{R}} = \frac{T_B - 20}{2\cancel{R}}$$

$$T_B = 140^\circ$$

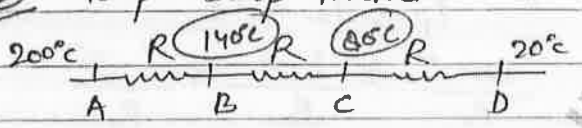
T_C

$$i_{AC} = i_{CD}$$

$$\frac{200 - T_C}{2\cancel{R}} = \frac{T_C - 20}{\cancel{R}}$$

$$T_C = 80^\circ C.$$

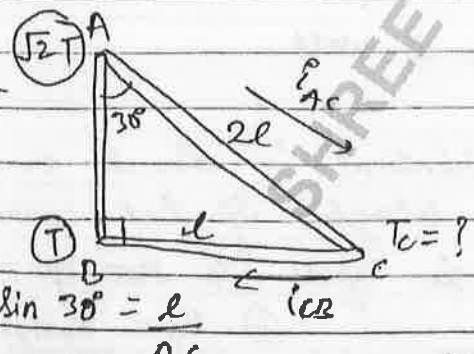
M-② Temp. Drop Method



$3R \xrightarrow{\text{temp. drop}} 180^\circ$

$R \xrightarrow{\text{"}} 60^\circ$

Ques:-



3 rods having same cross-section & material. If temp. of A & B are maintained at $\sqrt{2}T$ & T respectively then f/o temp at pt' c.

$$\sin 30^\circ = \frac{l}{AC}$$

$$AC = 2l$$

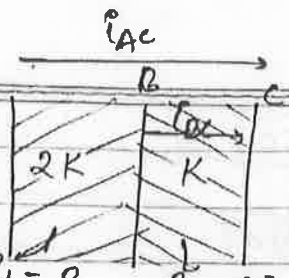
Steady state at 'c'.

$$i_{AC} = i_{CB}$$

$$\frac{\sqrt{2}T - T_c}{\frac{2l}{\cancel{KA}}} = \frac{T_c - T}{\frac{l}{\cancel{KA}}}$$

$$\Rightarrow \sqrt{2}T - T_c = 2T_c - 2T \quad \Rightarrow T_c = \frac{(2+\sqrt{2})T}{3}$$

03/01/2020



Que:- If given wall made up of layer AB & BC of same cross-section & thickness. If temp. difference across layer BC is 21°C. Then f/o

m(I) Let $R_1 = R$ $\quad R_2 = 2R$

$\because l$ & A = same so $R \propto \frac{1}{K}$.

$\therefore R_{eq} = 3R$

$\therefore \quad 2R \xrightarrow{\text{temp. drop}} 21°C$

$R \xrightarrow{\quad " \quad} 10.5°C$.

So, $3R \longrightarrow 10.5 \times 3 = 31.5°C$.

(OR)

m(II) Steady state

$$i_{BC} = i_{AC}$$

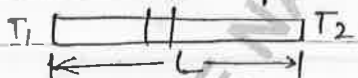
$$\frac{(\Delta T)_{BC}}{2\cancel{R}} = \frac{(\Delta T)_{AC}}{3\cancel{R}}$$

$$(\Delta T)_{AC} = \frac{3}{2} \times 21°C = 31.5°C.$$

- Temperature Gradient (dT/dx) {T.G.}

→ change in temp. of rod in per unit length.

$T_1 > T_2$



$$\therefore T.G. = \frac{dT}{dx} = \frac{T_2 - T_1}{L}$$

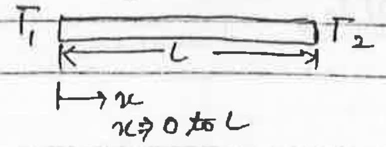
$$\therefore \frac{Q}{t} = i = \frac{KA(T_1 - T_2)}{L} = -\frac{KA(T_2 - T_1)}{L}$$

$$\Rightarrow \boxed{\frac{Q}{t} = -KA\frac{dT}{dx}}$$

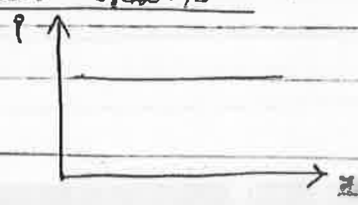
Variation of temp. across the length of Rod:-

(A). Uniform Area Rod

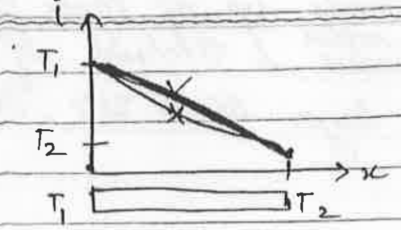
$T_1 > T_2$



(a). Heat current v/s x



(b).



Slope, $\frac{dT}{dx}$ (T.G.)

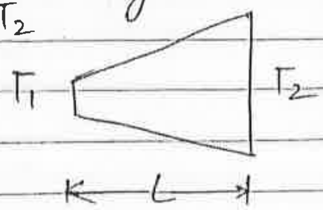
$\because \frac{Q}{t} = -KA\frac{dT}{dx}$

$\frac{dT}{dx} = -ve$
(slope)

Ⓑ Variable Area Rod

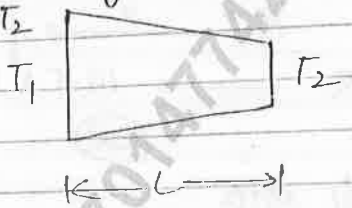
(i). Increasing area rod

$T_1 > T_2$

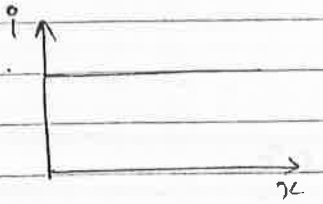


(ii). Decreasing area Rod.

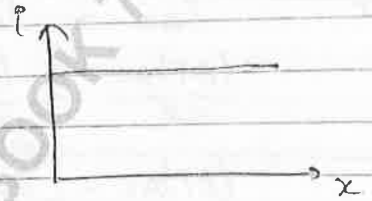
$T_1 > T_2$



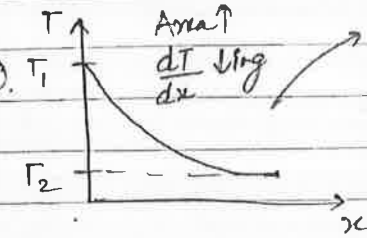
(a)



(a).



(b).

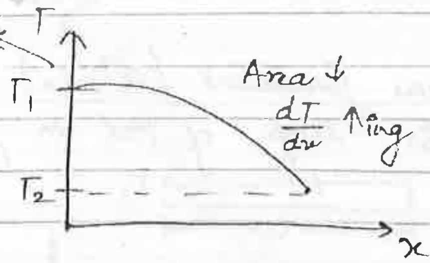


Slope$\left(\frac{dT}{dx}\right)$ = T.G.

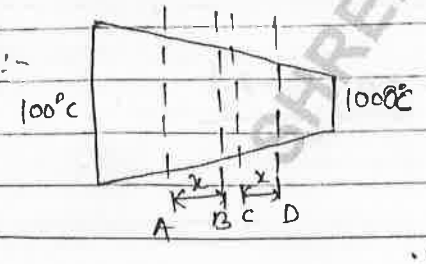
$\frac{Q}{t} = -KA\frac{dT}{dx}$

$\left[\frac{dT}{dx}_{(slope)} \propto -\frac{1}{A}\right]$

(b).



Ques:-



Here, ① $|T_A - T_B| = |T_C - T_D|$

② $|T_A - T_B| > |T_C - T_D|$

③ $|T_A - T_B| < |T_C - T_D|$

④ NOTA

$\because$ Area of CD < AB

So, $\left(\frac{dT}{dx}\right)_{CD} > \left(\frac{dT}{dx}\right)_{AB}$

$(\Delta T)_{CD} > (\Delta T)_{AB}$

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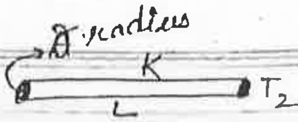
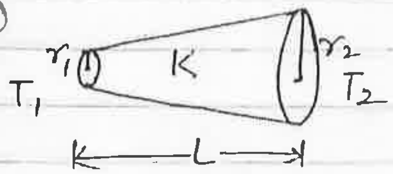
Note :⇒ ①



$T_1 > T_2$ $\quad \therefore \dfrac{Q}{t} = \dfrac{KA(T_1 - T_2)}{L}$

$$\boxed{\dfrac{Q}{t} = \dfrac{K(\pi r^2)(T_1 - T_2)}{L}}$$

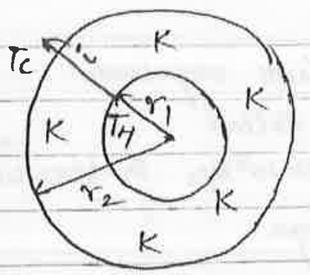
②



$$\therefore \boxed{\dfrac{Q}{t} = \dfrac{KA(T_1 - T_2)}{L} = \dfrac{K(\pi r_1 r_2)(T_1 - T_2)}{L}}$$

Illu-25

③ 2 concentric hollow sphere of radius r_1 & r_2 with a material of 'K' conductivity filled in b/w them. If temp. T_H (~~higher~~ hotter) & T_C (colder) are maintained at their surface respectively. Then $\dfrac{Q}{t} = ?$



$$\therefore \dfrac{Q}{t} = \dfrac{KA(T_1 - T_2)}{L}$$

$$\boxed{\dfrac{Q}{t} = \dfrac{K(4\pi r_1 r_2)[T_H - T_C]}{r_2 - r_1}}$$

- Formation of Ice on Water bodies

→ Anamalous Behaviour of Water :- Due to anamalous behaviour of water, it solidifies from top to bottom dirn while rest of liquids solidify (molten wax) from bottom to top dirn.

water $(0°C \to 4°C) \Rightarrow T\uparrow \Rightarrow V\downarrow \Rightarrow \rho\uparrow$

$(4°C \to 0°C) \Rightarrow T\downarrow \Rightarrow V\uparrow \Rightarrow \rho\downarrow$

→ Formation of Ice from x_1 thickness to x_2 thickness from surface of water body in time 't' is given by -

$$\boxed{t = \dfrac{\rho \cdot L}{2K\theta}[x_2^2 - x_1^2]}$$

Here, θ = temp. of Atmosphere
ρ = density
L = latent heart of fusion
K = conductivity of Ice.

$$\Rightarrow \boxed{t \propto (x_2^2 - x_1^2)}$$

Ques:- Time taken in formation of Ice upto 2cm from surface of water body is 5 hrs then f/o ~~for~~ time taken in formation

04/01/2020

of ice in furthure 1 cm.

$\therefore \quad t \propto (x_2^2 - x_1^2)$

$$\Rightarrow \frac{5}{t_2} = \frac{2^2 - 0^2}{3^2 - 2^2}$$

$$\frac{5}{t_2} = \frac{4}{5}$$

$$t_2 = \frac{25}{4} = 6.25 \text{ hrs.}$$

- Radiation

→ If $T > 0$ Kelvin ; then body emitts radiation

→ These radiations are EM waves. → No medium required; → Fastest method

$c = 3 \times 10^8$ m/s in Vacuum.

→ Wave hai toh, 'λ' or ν (frequency) bhi hoga.

→ EM wave spectrum

γ X-Ray UV V | I | M R → $\lambda\uparrow, \nu\downarrow \Rightarrow E\downarrow$

7000 Å 4×10^6 Å

→ Radiation emitted from a body comes under IR region of EM wave spectrum that's why thermal radiation are also k/n as IR radiation

→ Material :- Q (incident) → Q_r (reflected), Q_a (absorbed), Q_t (transmitted)

$$\therefore Q = Q_r + Q_a + Q_t$$

$$\frac{Q}{Q} = \frac{Q_r}{Q} + \frac{Q_a}{Q} + \frac{Q_t}{Q}$$

$$\boxed{1 = r + a + t}$$

r → Reflective Power

a → Absorptive Power / Cofficient

t → Transmittive Power

Prevost Therory of Heat Exchange

→ A/c to it each and every body emitts radiation at all possible temp. and absorbs as well.

$T \rightarrow$ temp. of body

$T_0 \rightarrow$ temp. of surrounding

① $T > T_0$ [Hum in AC room]

Radiation emitted > absorbed

By body ⇒ Net emission ⇒ I.E. ↓ ⇒ cooling

② . $T < T_0$ [Hum in Heater room]

Radiation emitted < absorbed (by body)

→ Net absorbed ⇒ I.E ↑ ⇒ heating

③ . $T = T_0$

If two bodies are at thermal eqm then they will exchange equal amount of heat by radiation but net will be zero.

Stefan's law

→ A/c to it emissive power of an Ideal black body is directly proportional to fourth power of it's absolute temp.

$$\therefore E \propto T^4$$

$$\boxed{E = \sigma T^4}$$

↳ Stefan's constant ⇒ $\sigma = 5.67 \times 10^{-8} \frac{W}{m^2\text{-}K^4}$

$$\frac{Q}{At} = \sigma T^4$$

Radiation emitted per sec OR Radiating Power $\boxed{\left(\frac{Q}{t}\right)_{IBB} = \sigma A T^4}$ ⇒ $\boxed{\left(\frac{Q}{t}\right)_{GB} = e(\sigma A T^4)}$

→ If IBB kept in T_0 (IBB) surrounding.

Stefan's for surrounding

$$E_0 = \sigma T^4$$

$$\left(\frac{Q}{t}\right)_{\text{absorbed by body}} = (\sigma T_0^4) \times A$$

$$\left(\frac{Q}{t}\right)_{\text{absorbed}} = \sigma A T_0^4$$

Ideal Black Body (IBB)

→ A hypothetical body that absorbs all the radiations incident on it, and emits as well.

For IBB ⇒ $a_{IBB} = \frac{Q_a}{Q} = \frac{Q}{Q} = 1$

$a_{IBB} = 1$; $r = 0 = t$ for IBB.

→ For Greedy bodies (GB) {Real bodies}

$\therefore a = \frac{Q_a}{Q} \Rightarrow Q_a < Q$

$a_{GB} < 1$

eg:- Sun (Assumed) ⟶ IBB

Important Definitions

(1). Absorptive Power (a)

$\left[a = \frac{Q_a}{Q}\right]$ (fraction)

$a_{IBB} = 1$
$a_{GB} < 1$

(2). Spectral Absorptive Power (a_λ)

$\left[a_\lambda = \frac{Q_{a_\lambda}}{Q_\lambda}\right]$ (fraction)

$a_{\lambda IBB} \rightarrow a_{\lambda IBB} = 1$
$a_{\lambda GB} \rightarrow a_{\lambda GB} < 1$

(3). Emissive Power (E)

→ Amount of radiation emitted from per unit area of body in per unit time at a given temp. is k/n as Emissive Power of body at that temp.

$E = \frac{Q}{At} \Rightarrow$ Unit $\rightarrow \frac{J}{m^2 \cdot sec}$ (or) $\frac{W}{m^2}$

(4). Relative Emissive Power / Emissivity (e or e_r) → (fraction)

$(e \text{ or } e_r)_{GB} = \frac{E_{GB}}{E_{IBB}} = \frac{Q_{GB}/At}{Q_{IBB}/At} = \frac{Q_{GB}}{Q_{IBB}}$

$[Q_{GB} = e\, Q_{IBB}]$

For $e_{IBB} = \frac{E_{IBB}}{E_{IBB}} \Rightarrow e_{IBB} = 1$ so $e_{GB} < 1$ ($\because Q_{GB} < Q_{IBB}$)

If $T > T_0$

$$\left(\frac{Q}{t}\right) = \underbrace{\sigma A T^4}_{\text{emitted}} - \underbrace{\sigma A T_0^4}_{\text{absorbed}}$$

$$\boxed{\frac{Q}{t} = \sigma A\left[T^4 - T_0^4\right]}$$

→ Radiation emitted per sec (Net)

$\because$ $T > T_0$ ⇒ Net emission ⇒ Heat loss.

$$\frac{Q}{t} = \frac{\text{Heat loss}}{\text{time}} \Rightarrow \text{Rate of heat loss } (R_H)$$

$$\therefore \boxed{R_H = \frac{Q}{t} = \sigma A\left[T^4 - T_0^4\right]}$$

$\because$ Heat loss ⇒ Temp. ↓ ⇒ Cooling

$$R_H = \frac{Q}{t} = \frac{ms\,dT}{dt} = \sigma A\left[T^4 - T_0^4\right]$$

$$\boxed{R_f = \frac{dT}{dt} = \frac{\sigma A\left[T^4 - T_0^4\right]}{ms} = \frac{R_H}{R_C}}$$

→ Rate of fall in temp. (or) Rate of cooling.

Note:- (1). Different shapes of same mass & material

Area:- Plate > Cube > Sphere

(2). If T & T_0 of two bodies same:-

$$R_H = \sigma A\{T^4 - T_0^4\}$$

$$R_H \propto A$$

$$\therefore R_f = \frac{\sigma A\left[T^4 - T_0^4\right]}{ms}$$

$$R_f \propto \frac{A}{ms} \propto \frac{A}{V\rho s}$$

→ Same shape (sphere)

$$\frac{r^2}{r^3 \rho s} \propto \frac{1}{r\rho s}$$

→ Different shape

$$\frac{A}{V\rho s}$$

Ques:- 2 solid spheres of same material having mass in ratio of 1/3 are heated upto same temp. and kept in same surrounding. F/o ratio of their initial rate of cooling?

$$R_f = \frac{\sigma A[T^4 - T_0^4]}{ms}$$

$$\left\{ \begin{array}{l} \therefore \frac{m_1}{m_2} = \frac{1}{3} \\ \frac{V_1 \cancel{\rho}}{V_2 \cancel{\rho}} = \frac{1}{3} \\ \frac{\cancel{\frac{4}{3}\pi} r_1^3}{\cancel{\frac{4}{3}\pi} r_2^3} = \frac{1}{3} \\ \frac{r_1}{r_2} = \left(\frac{1}{3}\right)^{1/3} \end{array} \right\}$$

$$R_f \propto \frac{A}{m\,s} \propto \frac{A}{m}$$

$$\Rightarrow \frac{R_{f_1}}{R_{f_2}} = \frac{A_1}{A_2}\left(\frac{m_2}{m_1}\right)$$

$$\frac{R_{f_1}}{R_{f_2}} = \left(\frac{r_1}{r_2}\right)^2\left(\frac{3}{1}\right) = \left(\frac{1}{3}\right)^{2/3}\left(\frac{3}{1}\right)$$

$$= \frac{(3)^{1/3}}{1}$$

Ques:- A solid sphere and a cube of same vol^m and surface finishing are heated upto same temp. and kept in a surrounding. F/o ratio of their initial rate of heat loss?

$$\left\{ \begin{array}{l} V_{sphere} = V_{cube} \\ \frac{4}{3}\pi r^3 = a^3 \\ \frac{r}{a} = \left(\frac{3}{4\pi}\right)^{1/3} \end{array} \right\}$$

$$\therefore \frac{R_{H\,sphere}}{R_{H\,cube}} = \frac{4\pi r^2}{6a^2}$$

$$= \frac{4\pi}{6}\left\{\frac{3}{4\pi}\right\}^{2/3}$$

$$= \frac{4\pi^{1/3} \cdot 2^{2/3}}{2\times 3}$$

$$= \frac{1}{2}\left(\frac{4\pi}{3}\right)^{1/3}$$

$$= \left(\frac{4\pi}{8\times 3}\right)^{1/3} = \left(\frac{\pi}{6}\right)^{1/3}$$

Ques:- A sphere, a cube and a circular plate of same mass and material heated upto same temp. and kept in a surrounding then which one will have - ① Higher rate of heat loss
② More time to cool down

① $R_H \propto A$

06/01/2020

Area ⇒ Plate > Cube > Sphere
$\downarrow$
A_{max}
So, R_H max. for Plate.

② $R_f \propto \frac{A}{mS} \propto A$.

$R_{f\,min} \longrightarrow$ Sphere
∴ Sphere will take more time to cool down.

Ques:- A solid sphere and a hollow sphere of same material and dimension heated upto 500°c temp. and kept in a surrounding then which one will have — ① Higher rate of heat loss
② Higher rate of fall in temp.

① $R_H \propto A$.
Since both the spheres (solid & hollow) have same surface area, both will have same rate of heat loss.

② $R_f \propto \frac{A}{mS} \propto \frac{1}{m}$

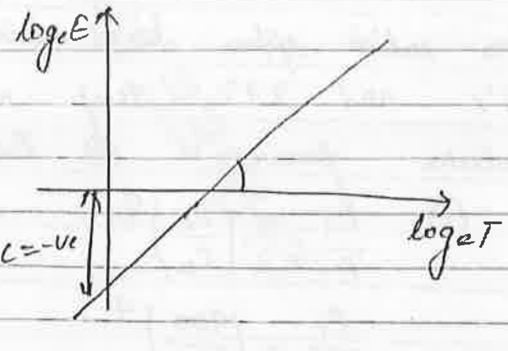
we know, $m_{solid} > m_{hollow} \Rightarrow \{R_{f\,solid} < R_{f\,hollow}\}$

Curve b/w $\log_e E$ vs $\log_e T$

$\because E = \sigma T^4$

$\underbrace{\log_e E}_{y} = \underbrace{\log_e \sigma}_{c} + \underbrace{4}_{m}\underbrace{\log_e T}_{x}$

$\therefore m = 4 (+ve)$.
$\therefore c = \log_e \sigma$
$\Rightarrow c = \log_e(5.67\times10^{-8})$
$\Rightarrow c = -ve$



Ques:- F/o %age change in emissive power of body if it's temp. is red by - ① 2% ② 20%.

① $E \propto T^4$
Change < 5% $\Rightarrow \frac{\Delta E}{E_i}\times100 = 4\left(\frac{\Delta T}{T_i}\times100\right) = 4\times2$
$= 8\%$.

② $\frac{E_1}{E_2} = \left(\frac{T}{1.2T}\right)^4 \Rightarrow \frac{E_1}{E_2} = \frac{1}{2.07}$

$\Rightarrow E_2 = 2.07 E_1$

Now, $\frac{\Delta E}{E_1} \times 100 = \frac{2.07E_1 - E_1}{E_1} \times 100$

$= 107\%$

Ques:- An ideal black body emitts radiation at 27°c temp. F/o temp at which it's emissive power becomes double.

$\therefore E \propto T^4$

$\Rightarrow \frac{E}{2E} = \left(\frac{300}{T}\right)^4$

$T = 300(2)^{1/4}$

$T = 300 \times (1.414)^{1/4}$

$T = 300 \times 1.2$

$T = 360\ K$

Ques:- Two solid sphere Ideal black body of radius R & 3R are at 627°c and 27°c temp. respectively. Then f/o ratio of their -
① emissive power ② Radiation emitted per sec.

① $\frac{E_1}{E_2} = \left(\frac{T_1}{T_2}\right)^4$

$\frac{E_1}{E_2} = \left(\frac{900}{300}\right)^4$

$\frac{E_1}{E_2} = \frac{81}{2}$

② $\frac{\left(\frac{Q}{t}\right)_1}{\left(\frac{Q}{t}\right)_2} = \frac{A_1}{A_2}\left(\frac{T_1}{T_2}\right)^4$

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$$= \frac{R^2}{9R^2}\left(\frac{81}{1}\right)$$

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

Ques:- A sphere at 527°C temp. kept in surrounding of 127°C emits 60 Watt radiation. If temp. of body is increased upto 927°C then f/o radiation emitted by it per sec.

$$\frac{Q}{t} = 60 = e\sigma A\left[800^4 - 400^4\right] \quad -①$$

$$\frac{Q}{t} = P = e\sigma A\left[1200^4 - 400^4\right] \quad -②$$

① ÷ ②

$$\frac{60}{P} = \frac{400^4\left[2^4 - 1^4\right]}{400^4\left[3^4 - 1^4\right]}$$

$$\frac{60}{P} = \frac{15}{80} \Rightarrow P = 320 \text{ Watt.}$$

Ques:- A Cu-sphere of 500°C temp kept in surrounding of room temp. of 27°C. To maintain it's temp a heater of 70 watt is required. If this sphere is now coloured black on half of it's surface area then a heater of 210 Watt is required to maintain it's temp. Then f/o emissivity of Cu-sphere.

$$\frac{Q}{t} = 70\,W = e\sigma A\left[T^4 - T_0^4\right] \quad -①$$

$$\frac{Q}{t} = 210\,W = e\sigma\left[\frac{A}{2}\right]\left[T^4 - T_0^4\right] + (1)\sigma\frac{A}{2}\left[T^4 - T_0^4\right] \quad -②$$

① ÷ ②.

$$\frac{1}{3} = \frac{e}{\frac{e}{2} + \frac{1}{2}}$$

$$\frac{e}{2} + \frac{1}{2} = 3e$$

$$\frac{1}{2} = \frac{5}{2}e \Rightarrow e = \frac{1}{5} = 0.2$$

- **Newton's law of Cooling** (NLC)

From Stephan's law,

$$R_f = \frac{dT}{dt} = \frac{e\sigma A}{ms}\left[T^4 - T_0^4\right]$$

If $T = T_0 + \Delta T$; when ΔT very-2 small $\Delta T = T - T_0$

$$\therefore\ T^4 - T_0^4 = (T_0 + \Delta T)^4 - T_0^4$$

$$= T_0^4\left[\left(1 + \frac{\Delta T}{T_0}\right)^4 - 1\right]$$

$$= T_0^4\left[\cancel{1} + 4\frac{\Delta T}{T_0} - \cancel{1}\right]$$

$$= 4T_0^3\Delta T$$

$$R_f = \frac{dT}{dt} = \left(\frac{4e\sigma A T_0^3}{ms}\right)\Delta T \Rightarrow \text{It is NLC.}$$

Acc. to NLC:-

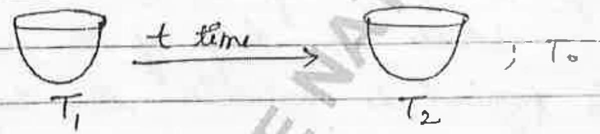
$$R_f\ (\text{Rate of cooling}) \propto (T - T_0)$$

$$\hookrightarrow \frac{dT}{dt} = -K'(T - T_0)$$

$\hookrightarrow$ -ve shows rate of cooling ↓es with time.

$$\boxed{\frac{dT}{dt} = -K'(T - T_0)}$$

eg.-

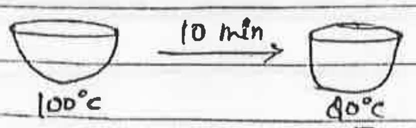


$$\frac{dT}{dt} = -K'(T - T_0)$$

$$\therefore \frac{T_2 - T_1}{t} = -K'\left[\left(\frac{T_1 + T_2}{2}\right) - T_0\right]$$

$$\boxed{\frac{T_1 - T_2}{t} = K'\left[\left(\frac{T_1 + T_2}{2}\right) - T_0\right]}$$

Ques:-



; $T_0 = 30°C$. then temp. of liquid after next 10 min.

$$\frac{100 - 80}{10} = K'\left[\left(\frac{100 + 80}{2}\right) - 30\right] \quad \text{---(1)}$$

$$2 = K'(60) \quad -①$$

$$\therefore \frac{80-T}{10} = -K'\left[\frac{80+T}{2} - 30^\circ\right]$$

$$\frac{80-T}{10} = K'\left[\frac{T+20}{2}\right] \quad - ②$$

① ÷ ②

$$\frac{20}{80-T} = \frac{60 \times 2}{T+20}$$

$$T + 20 = 480 - 6T$$

$$7T = 460$$

$$T = 65.7\,^\circ C$$

Note: ⇒ ① NLC is used to determine specific heat of liquids.

② $100^\circ C \xrightarrow{t_1} 90^\circ C \xrightarrow{t_2} 80^\circ C \xrightarrow{t_3} 70^\circ C$

$t_1 < t_2 < t_3$ [Rate of cooling ↓ with time]

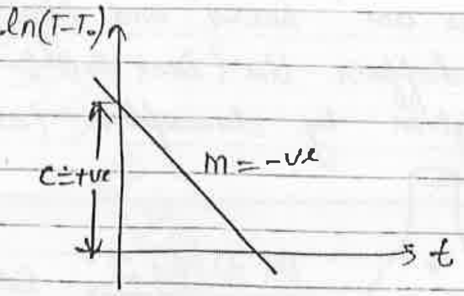
Graphs

①. $\ln(T-T_0)$ v/s time (t)

$\because$ NLC $\quad \frac{dT}{dt} = -K'(T-T_0)$

$$\int \frac{dT}{(T-T_0)} = \int -K'\,dt$$

$$\underbrace{\ln(T-T_0)}_{y} = \underbrace{-K'}_{m}\underbrace{t}_{x} + c$$



②. Variation of temp. (T) of body kept in surrounding (T_0) with time (t)

$$\ln(T-T_0) = -K't + c$$

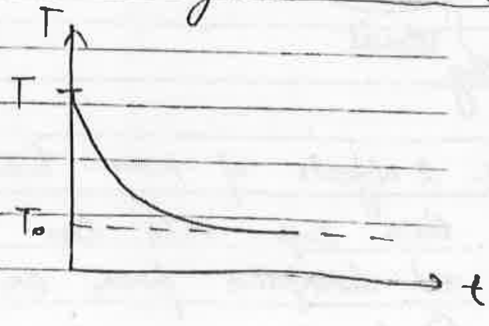
$$T - T_0 = e^{-K't} + c$$

$$T = T_0 + e^{-K't} + c \quad \text{(Exponential ↓)}$$

If $t = \infty \Rightarrow T = T_0$

OR

Slope $\rightarrow \frac{dT}{dt} \Rightarrow$ Rf(slope) $\rightarrow$ decreases with time



- Kirchhoff's law

→ A/c to it, emissive power (E) is proportional to it's absorptive power (a).

$$E \propto a$$

If $E\uparrow \Rightarrow a\uparrow$ [Good absorber is good emitter]

⇒ Good emitter is bad reflector.

$\because E\uparrow \Rightarrow a\uparrow \Rightarrow r$ & $t\downarrow$ $[\because 1 = r + a + t]$

$\Rightarrow \because E \propto a$

$\boxed{\frac{E}{a} = \text{const.}}$ → For any body at same temp.

Let have GB and IBB at same temp.

$$\left(\frac{E}{a}\right)_{IBB} = \left(\frac{E}{a}\right)_{GB}$$

$$\frac{E_{IBB}}{1} = \frac{E_{GB}}{a} \Rightarrow a = \frac{E_{GB}}{E_{IBB}}$$

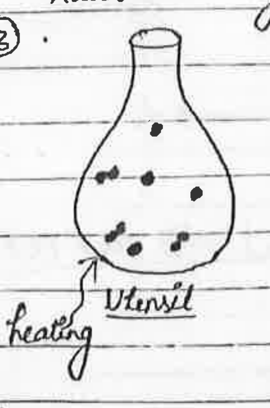
$$\boxed{a = e}$$

Application of Kirchhoff's law

① . Days are hotter and Nights are colder in deserts.

② Fraunhoffer's line (Dark line) :- Produced due to absorption of Sun radiation by chromosphere (atmosphere) of Sun.

③ .



$\xrightarrow[\text{dark room}]{\text{On taking it}}$ Black dots emits more and appear brighter.

$\because$ (Good absorber is a good emitter)

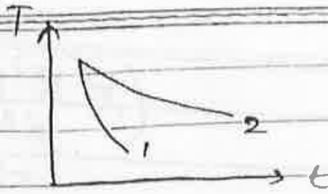
Ques:- 2 objects of same heat capacity and cross-section area change their temp with time as given in graph. If their emissivity and absorptive power are respectively e and a then -

(a) $e_1 = e_2$; $a_1 = a_2$ (b) $e_1 > e_2$; $a_1 > a_2$

07/01/2020

(c) $e_1 < e_2$; $a_1 < a_2$

(d) $e_1 < e_2$; $a_1 > a_2$



Slope $\rightarrow \frac{dT}{dt} \Rightarrow$ Rate of Cooling

Slope of $1 > 2 \Rightarrow R_f$ of $1 > 2$

$\downarrow$

More emission $1 > 2$

$e_1 > e_2 \Rightarrow a_1 > a_2$ $(e = a)$

or

$R_f = e(\sigma A)(T^4 - T_0^4)$

(MS)

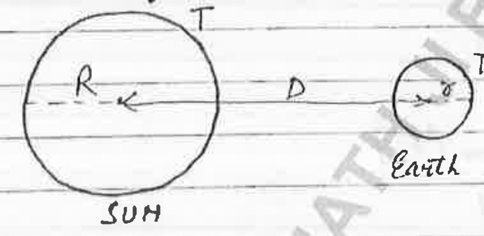
$R_{f\,1} > 2$

$e_1 > e_2$

- Solar Constant (Star constant) / 'S'

→ Amount of Radiation incident on per unit area of Earth in per unit time from Sun is k/n as Solar constant of Earth.

$\left[S \propto \frac{1}{D^2}\right]$



$$\boxed{S = \frac{\sigma R^2 T^4}{D^2}}$$ → Incident on per unit area of Planet in per sec.

For different Planets:-

R & $T \rightarrow$ same

$D \rightarrow$ Different

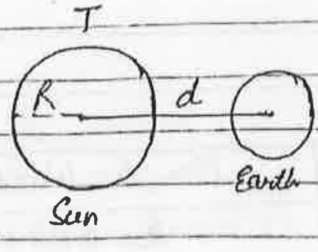
$\left[S \propto \frac{1}{D^2}\right]$

$\frac{Q}{t}$ incident on Earth at any Instant

$$\frac{Q}{t} = (S) \times [\text{Area of Projection}]$$

$$\frac{Q}{t} = \left(\frac{\sigma R^2 T^4}{D^2}\right) \times \pi r^2$$

Ques:-



F/o temp. of Earth at eq^m.

At eq^m

$$\left(\frac{Q}{t}\right)_{\text{absorbed by Earth}} = \left(\frac{Q}{t}\right)_{\text{emitted by Earth}}$$

$$\left(\frac{Q}{t}\right)_{\text{Incident}} \times \cancel{a} = \cancel{e}\,\sigma(4\pi r^2)T'^4 \quad (\because a = e)$$

$$\left(\frac{\cancel{\sigma} R^2 T^4}{d^2}\right) \times \cancel{\pi r^2} = \cancel{\sigma}(4\cancel{\pi r^2})\, T'^4$$

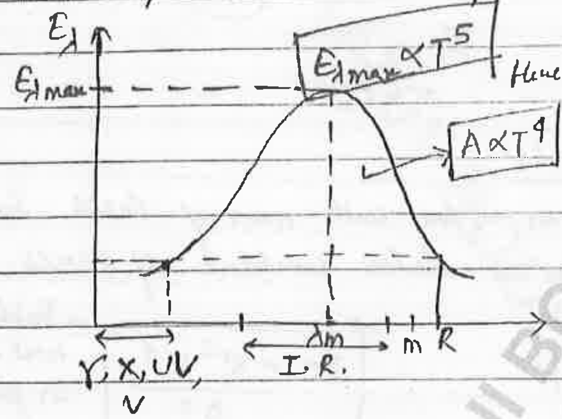
$$T'^4 = \frac{R^2 T^4}{4d^2}$$

$$T' = T\sqrt{\frac{R}{2d}}$$

- Maxwell's Energy Distribution Curve

→ A/c to it, spectrum of IBB is continuous.

Graph b/w spectral emissive power [E_λ] v/s corresponding wavelength [λ]



Here, λ_m = wavelength corresponding to max^m emission

ν_m = frequency corresponding to max^m emission

∴ Total Emissive Power [E]

$$E = \int_0^\infty \underbrace{E_\lambda\, d\lambda}$$

$$\boxed{E = \text{Area of Curve}}$$

∵ $E \propto T^4$ (Stefan)

[Area of curve $\propto T^4$]

If $T\uparrow \Rightarrow E\uparrow \Rightarrow$ Area of Curve

Wein's Displacement Law :-

A/c to it, for a IBB :-

$$\boxed{\lambda_m \propto \frac{1}{T}} \Rightarrow \boxed{\lambda_m = \frac{b}{T}}$$

Here, b = Wein's const.

$b = 2.89 \times 10^{-3}$ m-K

(or)

$b = 2.89 \times 10^{6}$ nm-K

3

$\because \lambda_m \propto \frac{1}{\nu_m} \propto \frac{1}{T} \Rightarrow \nu_m \propto T$

If temp. $\uparrow$ $\rightarrow$ $\lambda_m \downarrow \Rightarrow \nu_m \uparrow$

$\rightarrow E\uparrow \Rightarrow$ (Area of Curve $\uparrow$)

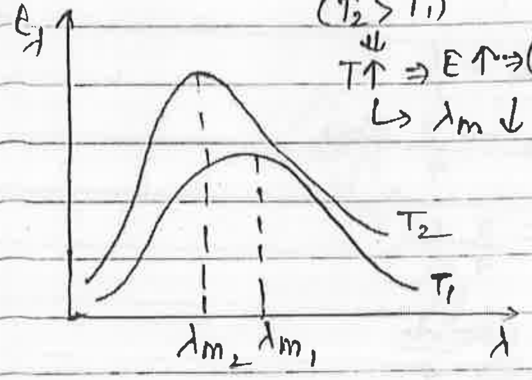
$\{E \propto T^4\}$

eg:- If IBB is heated from T_1 to T_2

($T_2 > T_1$)

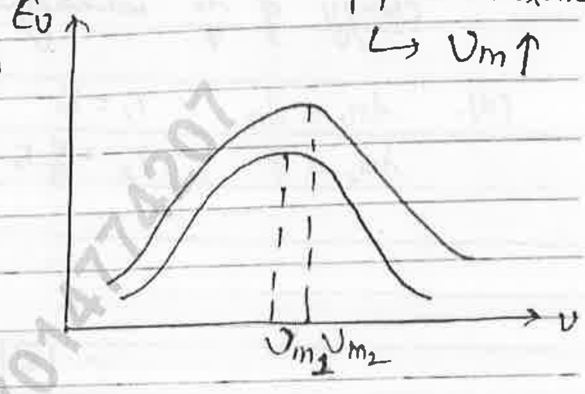
$T\uparrow \Rightarrow E\uparrow \Rightarrow$ (Area$\uparrow$)

$\hookrightarrow \lambda_m \downarrow$

① 

$T\uparrow \Rightarrow E\uparrow \Rightarrow$ (Area$\uparrow$)

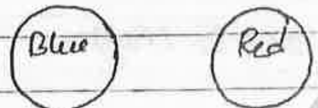
$\hookrightarrow \nu_m \uparrow$

② 

Note:- Colour of Star (hot Objects) is indication of their temp.

UV	V (VIBGYOR)	IR	Microwaves	Radiowaves $\rightarrow \lambda \uparrow$

eg:-

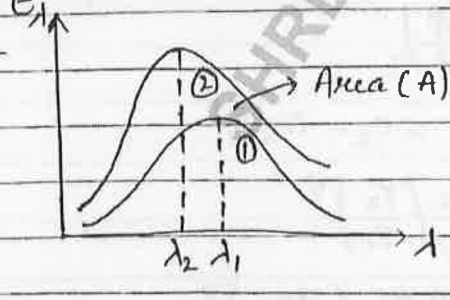


Blue Star   Red Star

$\lambda_{Blue} < \lambda_{Red}$

$T_{Blue} > T_{Red}$ $\left(\lambda_m \propto \frac{1}{T}\right)$

Que:-



If $16 A_2 = 81 A_1$ then f/o $\frac{\lambda_2}{\lambda_1} = ?$

$\because \frac{A_2}{A_1} = \frac{81}{16}$

$\because$ Area $= E \propto T^4$

$\Rightarrow \left(\frac{T_2}{T_1}\right)^4 = \frac{81}{16} \Rightarrow \frac{T_2}{T_1} = \frac{3}{2}$

$\because T \propto \frac{1}{\lambda_m}$

$\frac{\lambda_{m_1}}{\lambda_{m_2}} = \frac{3}{2} \Rightarrow \frac{\lambda_2}{\lambda_1} = \frac{2}{3}$

08/01/2020

Ques:- An IBB emits max^{m} radiation corresponding to λ_0 wavelength at T_0 temp. – (a). If temp. of IBB is ↑ed upto 4/3 times of initial then displacement of wavelength corresponding to max^{m} emission.
(b). If it is heated in such a way that IBB emits max^{m} energy of $\frac{\lambda_0}{4}$ wavelength then it's emissive Power? (If initial is E_0)

(a). $\lambda m_1 = \lambda_0$; $T_1 = T_0$
$\lambda m_2 = ?$; $T_2 = \frac{4}{3} T_0$

$\because \lambda m \propto \frac{1}{T}$

$\lambda m \rightarrow \frac{3}{4}$ times

$\lambda m_2 = \frac{3}{4}\lambda_0$

$\therefore |S| = \frac{3}{4}\lambda_0 - \lambda_0 = -\frac{\lambda_0}{4}$

(b). $\lambda m_1 = \lambda_0$; $T_1 = T_0$

$\downarrow$ $\quad$ $\downarrow \lambda m \propto \frac{1}{T}$

$\lambda m_2 = \frac{\lambda_0}{4}$ $\quad$ $T_2 = 4T_0$

$\because T \rightarrow 4$ times

$E \propto T^4$

$E \rightarrow 256$ times

$\Rightarrow E = 256\, E_0$ (Ans):-

Ques:- 2 solid spheres of emissivity 0.01 and 0.81 having wavelength corresponding to max^{m} emission in ratio of 2/3. Then f/o ratio of their radius if they emitt same amount of radiation per sec.

$\because \frac{Q}{t} = e\sigma A T^4$. $\quad \therefore \left(\frac{Q}{t}\right)_1 = \left(\frac{Q}{t}\right)_2$

$\Rightarrow \cancel{e_1 \sigma \pi r_1^2 \, t/A}$ $\Rightarrow e_1 \sigma A_1 T_1^4 = e_2 \sigma A_2 T_2^4$

$$\frac{A_1}{A_2} = \frac{e_2}{e_1}\left(\frac{T_2}{T_1}\right)^4$$

$$\left(\frac{r_1}{r_2}\right)^2 = \frac{0.81}{0.01}\left(\frac{\lambda m_1}{\lambda m_2}\right)^4$$

$$\left(\frac{r_1}{r_2}\right)^2 = \frac{81}{1} \times \frac{16}{81}$$

$$\frac{r_1}{r_2} = \frac{4}{1}$$

Ques:- Temp. of Ideal black body is 2617 °C. It emitts radiation of U_1 energy of 500 nm wavelength, radiation of U_2 energy of 1000 nm wavelength and U_3 energy of 1500 nm wavelength. If weins constant (b) = 2.09×10^6 nm-K then —

① $U_1 > U_2 > U_3$

② $U_1 < U_2 < U_3$

③ U_2 is max^m

④ $U_1 > U_3 > U_2$

$$\therefore \lambda_m = \frac{b}{T} = \frac{2.09 \times 10^6}{2090\ K} \text{ nm-K}$$

$$\Rightarrow \lambda_m = 1000 \text{ nm}$$

$\downarrow$

1000 nm emitts (max^m)

$\downarrow$

energy $\rightarrow U_2 \rightarrow$ max^m.

08/01/2020

Calorimetry

- **Heat (Q)**

→ Unit :→ Joule or Cal.
↳ S.I. unit

$1\ Cal = \underbrace{4.18}\ J \simeq 4.2\ J$
↳ Joule's const. (J).
(or) Mechanical equivalent of heat.

→ $1J = \frac{1}{4.2}\ Cal = 0.24\ Cal$

So, $100\ J = 24\ Cal$.

→ Heat(Q) ⇝ Substance
- Temp. change, Sp. heat(s) → $Q = ms\Delta T$
- Phase change (const. T & P) → $Q = mL$ Here, L = latent heat

- **Specific Heat (S)**

→ Amount of heat required to change the temp. of unit mass by 1°C (or) 1K.

$\because Q = ms\Delta T$

$\left[S = \frac{Q}{m\Delta T} \right]$ Unit :→ $\frac{J}{Kg\text{-}K}$ (S.I. unit)

→ Other units :- $\frac{J}{g\text{-}K}$ (or) $\frac{Cal}{g\text{-}K}$ (or) $\frac{Cal}{Kg\text{-}K}$

→ If S↑ ⇒ Der se garm & Der se thande hote hai.
eg :- water

→ S↓ ⇒ air

→ $S_{water} = \frac{1\ Cal}{g\text{-}K}$ (or) $\frac{4.2\ J}{g\text{-}K}$ (or) $\frac{4200\ J}{Kg\text{-}K}$ → SI unit (or) $\frac{1\ KCal}{Kg\text{-}K}$

→ $S_{Ice} = 0.5\ \frac{Cal}{g\text{-}K}$ (or) $500\ \frac{Cal}{Kg\text{-}K}$ (or) $2.1\ \frac{J}{g\text{-}K}$ (or) $2100\ \frac{J}{Kg\text{-}K}$

→ $S_{steam} = 0.47 \simeq 0.5\ \frac{Cal}{g\text{-}K}$

- **Latent Heat (L)**

$\because Q = mL$

$L = \frac{Q}{m}$ ⇒ Unit ! → $\frac{J}{Kg}$ ⇒ (S.I.)

→ Other unit :→ $\frac{Cal}{g}$

① . ice $\xrightarrow[(L_f)]{\text{melting}}$ water — Latent heat of fusion $= 80\ \frac{Cal}{g}$

$0°C$ — $0°C$

② . water $\xrightarrow[(L_v)]{\text{vapourisation}}$ steam — Latent heat of vapourisation (L_v)

$100°C$ — $100°C$ — $= 536 \simeq 540\ \frac{Cal}{g}$

Ques:- Heat required to convert 1gm ice at $-10°C$ into steam of $200°C$.

$$\underset{-10°C}{\boxed{\text{ice}}} \xrightarrow[m s_i \Delta T]{Q_1} \underset{0°C}{\boxed{\text{ice}}} \xrightarrow[m L_f]{Q_2} \underset{0°C}{\boxed{\text{water}}} \xrightarrow[m s_w \Delta T]{Q_3} \underset{100°C}{\boxed{\text{water}}} \xrightarrow[m L_v]{Q_4} \underset{100°C}{\boxed{\text{steam}}} \xrightarrow[m s_g \Delta T]{Q_5} \underset{200°C}{\boxed{\text{steam}}}$$

$\therefore\ Q = Q_1 + Q_2 + Q_3 + Q_4 + Q_5$

$Q = (1 \times 0.5 \times 10) + (1 \times 80) + (1 \times 1 \times 100) + (1 \times 540) + (1 \times 0.5 \times 100)$

$Q = 5 + 80 + 100 + 540 + 50$

$Q = 775\ Cal$

Imp.

Ques:- Some amount of ice is being heated by uniform heating source for 7 minutes. In first 2 min. of heating, it's temp increases uniformly; In next 4 min. it temp. remains const.; and during remaining time it's temp. again increases uniformly. Then f/o initial and final temp of substance.

$$\underset{T_1}{\text{ice}} \xrightarrow[①]{2\ min} \underset{0°C}{\text{ice}} \xrightarrow[②]{4\ min} \underset{0°C}{\text{water}} \xrightarrow[③]{1\ min} \underset{T_2}{\text{water}}$$

let uniform source $\Rightarrow 100\ \frac{Cal}{min}$

$\therefore\ Q_1 = 100 \times 2 = m s_i (0 - T_1)$ —①

$\therefore\ Q_2 = 100 \times 4 = m L_f$ —②

$\therefore\ Q_3 = 100 \times 1 = m s_w (T_2 - 0)$ —③

① ÷ ②

$$\frac{2}{4} = \frac{\cancel{m} s_i (0 - T_1)}{\cancel{m} L_f}$$

$$\frac{1}{2} = \frac{0.5}{80}(-T_1)$$

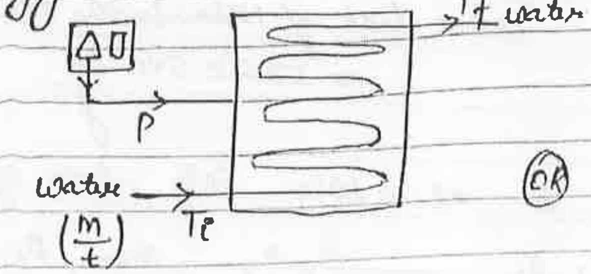
$$T_1 = -80°C.$$

② ÷ ③

$$\frac{4}{1} = \frac{80}{1 \times (T_2)}$$

$$T_2 = 20°C.$$

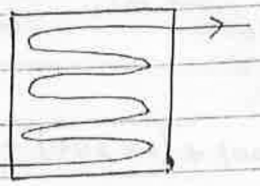
- **Gyser**



$\therefore$ P watt $\Rightarrow P \frac{Joule}{sec} = \left(\frac{m}{t}\right) \underbrace{S}_{\to Joule} \Delta T$

OR $\left(\frac{P}{4.2}\right) \frac{Cal}{sec} = \left(\frac{m}{t}\right) \underbrace{S}_{\to Cal} \Delta T$

Ques:-



F/o outlet temp. of water if Gyser is having 50% efficiency with 2.1 KW power.

10cc/sec water at 10°C
$\downarrow$
$\frac{10g}{1 sec}$ ($\because \rho = 1 g/cm^3$)

$\therefore \frac{\frac{2.1 \times 1000 \times 50}{100}}{4.2} = \left(\frac{10g}{1 sec}\right) \times \frac{1 \, Cal}{g \cdot °C} \times (T_f - 10)$

$\Rightarrow \frac{2100}{2 \times 4.2} = 10 T_f - 100$

$250 = 10 T_f - 100$

$10 T_f = 350$

$T_f = 35 °C$. (Ans):-

Ques:-

If 100 J heat is lost per sec due to leakage from bucket then f/o time taken to increase temp. of water upto 50°C.

$P = 1.15 \, KW = 1150 \frac{J}{sec}$

$\therefore$ Remaining $(1150 - 100) = 1050 \frac{J}{sec} = \frac{m S \Delta T}{t}$

$\Rightarrow 1050 \frac{J}{sec} = \frac{10 \times 10^3 g}{t} \times \frac{4.2 J}{g°C} \times (30)$

$t = 1200$ sec

$t = 20$ min.

Ex-I = 19, 24, 25, 33 to 37
Ex-II = all except 8, 26, 63, 74

09/01/2020

• **Heat Capacity (H_c)**

→ Amount of heat required to change temp of body 1°C or 1K.

Unit mass ⟶ Specific heat (s)

m mass ⟶ $\boxed{H_c = ms}$ ⟶ depends on mass & material.

$\because Q = \underbrace{ms}_{H_c}\Delta T \Rightarrow H_c = \dfrac{Q}{\Delta T}$

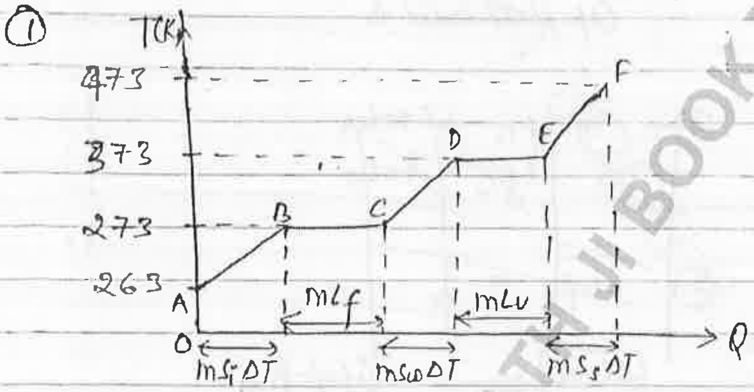
If $H_c \uparrow$ ⇒ Der se garm & Der se Thanda

• **Heating Curve**

→ Curve b/w temp. of body v/s Heat (Q) supplied to it (or time)

eg. → ice ⟶ ice ⟶ water ⟶ water ⟶ steam ⟶ steam
-10°c 0°c 0°c 100°c 100°c 200°c

(1)



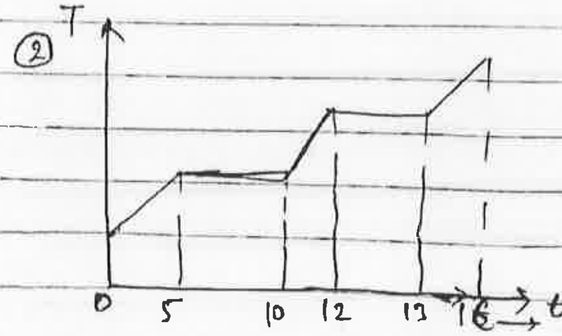
Slope ⇒ T v/s Q ⟶ $\dfrac{\Delta T}{\Delta Q}$

AB ⇒ $\text{Slope}_{AB} = \dfrac{\Delta T}{\Delta Q} = \dfrac{\cancel{\Delta T}}{ms_i\cancel{\Delta T}} = \dfrac{1}{(H_c)_{ice}}$

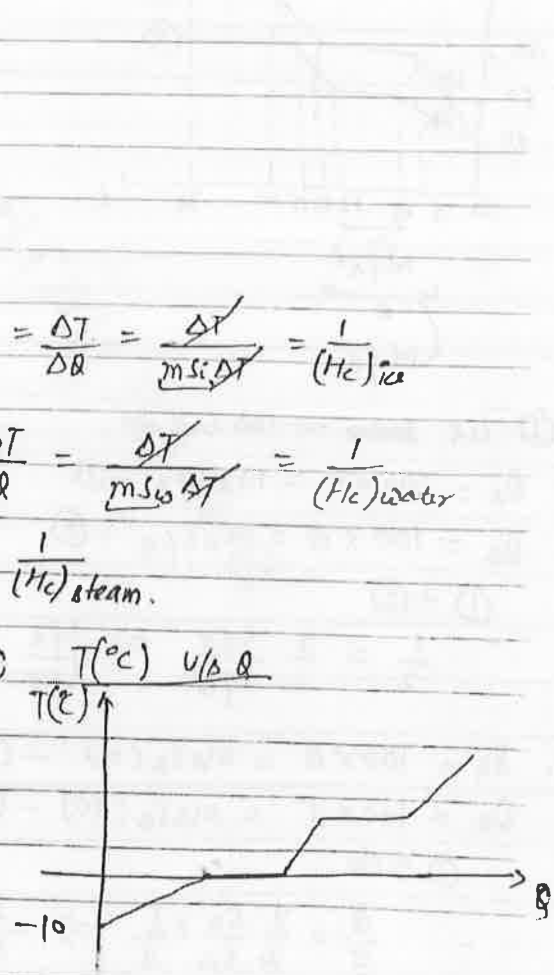
$\text{Slope}_{CD} = \dfrac{\Delta T}{\Delta Q} = \dfrac{\cancel{\Delta T}}{ms_w\cancel{\Delta T}} = \dfrac{1}{(H_c)_{water}}$

$\text{Slope}_{EF} = \dfrac{1}{(H_c)_{steam}}$.

(2)

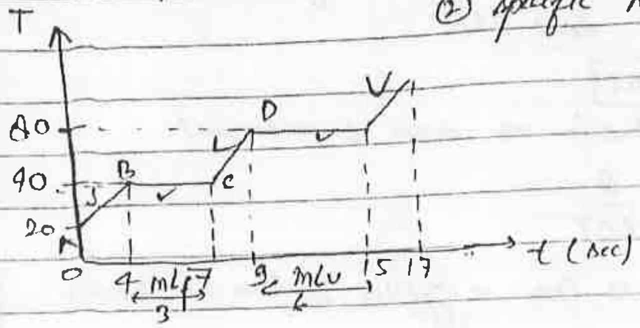


(3) T(°C) v/s Q



Scanned by CamScanner

Ques:- An unknown substance being heated by uniform heating source. Compare it's -
① Latent heat, L_v & L_f
② Specific heat in solid phase & Liquid phase.



① $mL_v > mL_f$
$\Rightarrow L_v > L_f$

② Slope $\propto \frac{1}{H_c}$

$\text{Slope}_{AB} < \text{Slope}_{CD}$

$\left(\frac{20}{4}\right) < \left(\frac{40}{2}\right)$

$(H_c)_{AB} > (H_c)_{CD}$

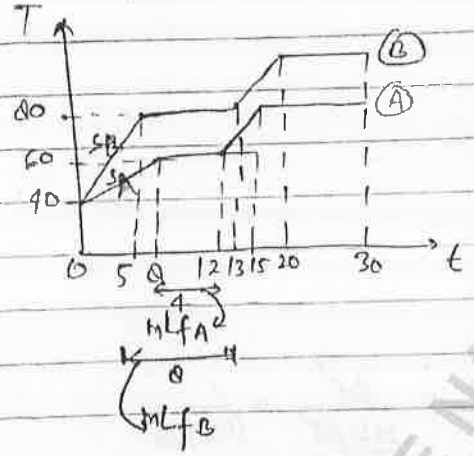
$\to$ $mS_{solid} > mS_{liq}$

$S_{solid} > S_{liq}$

Ques:- 2 substances A and B of mass in ratio of 3/2 are being heated by same uniform source as shown. Then f/o -

① $\frac{L_{fA}}{L_{fB}}$

② $\frac{(\text{Sp. heat})\ \text{solid A}}{(\text{Sp. heat})\ \text{solid B}}$



~~① $mL_{fB} > mL_A$~~
~~$\Rightarrow L_{fB} > L_A$~~

~~② Slope $\propto \frac{1}{H_c}$~~

~~$(\text{Slope})_{S_A}$ $(\text{Slope})_{S_B}$~~

~~$\frac{(80-40)}{(5-0)}$~~

Ⅰ Let source $\Rightarrow$ 100 cal/sec.

$\therefore Q_A = 100 \times 4 = m_A L_{fA}$ - ①

$\therefore Q_B = 100 \times 8 = m_B L_{fB}$ - ②

① ÷ ②

$\frac{1}{2} = \frac{3}{2} \frac{L_{fA}}{L_{fB}} \Rightarrow \frac{L_{fA}}{L_{fB}} = \frac{1}{3}$

Ⅱ. $Q_A = 100 \times 8 = m_A S_A (20)$ — Ⅰ

$Q_B = 100 \times 5 = m_B S_B (40)$ - ②

① ÷ ②

$\frac{8}{5} = \frac{3}{2} \frac{S_A}{S_B} \times \frac{1}{2} \Rightarrow \frac{S_A}{S_B} = \frac{32}{15}$

- <u>Water Equivalent (of Container) [W] in gm or Kg</u>

eg:- $\text{Ice } -10^\circ c \xrightarrow{m s_i \Delta T} \text{Ice } 0^\circ c \xrightarrow{m L_f} \text{water } 0^\circ c \xrightarrow{m s_w \Delta T} \text{water } 100^\circ c \xrightarrow{m L_v} \text{steam } 100^\circ c \xrightarrow{m s_s \Delta T} \text{steam } 200^\circ c.$

$T_{container} = -10^\circ c \xrightarrow{m_c s_c \Delta T} T_c = 0^\circ c \xrightarrow{\times} T_c = 0^\circ c \xrightarrow{m_c s_c \Delta T} T_c = 100^\circ c \xrightarrow{\times} T_c = 100^\circ c \xrightarrow{m_c s_c \Delta T} T_c = 200^\circ c$

$m_c s_c \Delta T$ or $W \Delta T$ → Cal

$m_c s_c \Delta T \rightarrow W \Delta T$

$m_c s_c \Delta T \rightarrow W \Delta T$

→ Water equivalent means ⟶ container ko bhi thanda ya garm karo

→ $W = ?$

$(Hc)_{water} = (Hc)_{container}$

$\downarrow ms \qquad \downarrow ms$

$gm \leftarrow W \times 1 = m_c s_c$

$\Rightarrow \boxed{W = m_c s_c}$

<u>Ques</u>:- 1 gm ice at $-10^\circ c$ is kept in container of 0.1 Kg water-equivalent. F/o amount of heat required to vapourise ice?

$\text{ice} \xrightarrow{m s_i \Delta T} \text{ice} \xrightarrow{m L_f} \text{water} \xrightarrow{m s_w \Delta T} \text{water} \xrightarrow{m L_v} \text{steam}$

$-10^\circ c \qquad 0^\circ c \qquad 0^\circ c \qquad 100^\circ c \qquad 100^\circ c$

container:→ $m_c s_c \Delta T \rightarrow W \Delta T = 100 \times 10 = 1000$ $\quad \times \quad$ $m_c s_c \Delta T \rightarrow W \Delta T = 100 \times 100 = 10000$ $\quad \times$

$\therefore Q = Q_{material} + Q_{container}$

$Q = [(1 \times 0.5 \times 10) + (1 \times 80) + (1 \times 1 \times 10) + (1 \times 540)] + (1000 + 10{,}000)$

$Q = 725 \text{ Cal} + 11000 \text{ Cal}$

$Q = 11725 \text{ Cal}.$

- <u>Principal of Calorimetry</u>

m_1, T_1 (A) → T_{mix} $(T) = ?$ ← (B) m_2, T_2

$T_1 > T_2$

Heat loss by A = Heat gain by B

$\boxed{T_2 \leq T_{mix} \leq T_1}$

eg:- (A) water 20°c (10g) → T ← (B) water 60° (40g)

Then f/o temp. of mixture when A & B are mixed?

Heat loss by 'B' = Heat gain by 'A'

$(ms\Delta T)$ $\qquad$ $(ms\Delta T)$

$$40 \times 1 \times (60-T) = 10 \times 1 \times (T-20)$$

$$240 - 4T = T - 20$$

$$5T = 560$$

$$T = 52°C.$$

Note :⇒ (1). (A) ← water → (B)

(A)	(B)
20°c	60°c
40 g	40 g

$(Hc)_A = (Hc)_B$

T_{mix} ⇒ Avg. [Mean of temp. (A) & (B)]

(2). If substances (A) & (B) are (T_1) (T_2) are mixed;-

$T_{mix} = \frac{T_1 + T_2}{2}$, only if they are having same heat capacity.

Que):- A bucket of water of 40 kg at 40°c has to be prepared from 2 water tank (A) & (B) of temp. 30°c & 80°c respectively. f/o respective masses taken from (A) & (B).

A	B
30°c	80°c
(m) kg	(40-m) kg

→ 40°c.

$$\therefore (40-m) \times 1 \times (80-40) = m \times 1 \times (40-30)$$

$$(40-m) \times 40 = m \times 10$$

$$160 - 4m = m$$

$$5m = 160$$

$$m = 32 \text{ kg}. \quad \text{(from A)}.$$

$$\therefore \text{From B} = 40 - 32 = 8 \text{ kg}.$$

Que):- 2 liquids

	(A)	(B)
Mass	m	3m
sp. heat	s	s/3
Temp.	T	4T

When A & B are mixed. F/o temp. of Mixture

$(Hc)_A = (Hc)_B = ms$

$$\therefore T_{mix} = \frac{T_A + T_B}{2} = \frac{T + 4T}{2} = \frac{5T}{2}$$

Que :- 170 gm water kept in Cu-container of 100 gm mass at 30°C temp. A Cu-ball of mass 100 gm and temp T is dropped into container, temp. of mixture becomes 75°C. If specific heat of Cu is 0.1 Cal/g-°c then f/o value of T = ?

Loss in temp. = Gain in temp.

$100 \times 0.1 \times (T-75) = 100 \times 0.1 \times (75-30) + 170 \times 1 \times (75-30)$

$10T - 750 = 450 + 7650$

$10T = 750 + 450 + 7650$

$T = \frac{8850}{10} = 885\ °c$

Note : ⇒ (1).

Ice		Water
2 kg		2 kg
−20°c	mixed	20°c
$2 \times 0.5 \times 20 = 20$ KCal ↓		↓ $mS\Delta T$ $2 \times 1 \times 20 = 40$ KCal
0°c Ice		0°c water

$\therefore Q = 40 - (20) = 20$ KCal

⇒ Ice + water
2 kg   2 kg

20 KCal $= mL_f$

$\Rightarrow m = \frac{20}{80} = \frac{1}{4} = 0.25$ kg (water)

$T = 0°c \begin{cases} W = 2 + 0.25 = 2.25 \text{ kg} \\ Ice = 2 - 0.25 = 1.75 \text{ kg} \end{cases}$

(2).

Ice	Water
2 kg	5 kg
−20°c	20°c
$2 \times 0.5 \times 20 = 20$ KCal ↓	↓ $5 \times 1 \times 20 = 100$ KCal
0°c Ice	0°c water

$\therefore Q = 100 - 20 = 80$ KCal

$80 = mL_f$

$\Rightarrow m = \frac{80}{80} = 1$ kg (water)

$\therefore \left. \begin{array}{l} W = 5 + 1 = 6 \text{ kg} \\ Ice = 2 - 1 = 1 \text{ kg} \end{array} \right\} T = 0°c.$

(3).

Ice	Water
2 kg	15 kg
−20°c	20°c
$2 \times 0.5 \times 20 = 20$ KCal ↓	↓ $15 \times 1 \times 20 = 300$ KCal
0°c ice	0°c water
$2 \times 80 = 160$ KCal ↓	
0°c water	

$\therefore$ water $= 2 + 15 = 17$ kg

$\therefore Q = 300 - (20 + 160)$

$Q = 120$ KCal

$mS\Delta T = 120$

$17 \times 1 \times \Delta T = 120$

$\Delta T = 7.05°c$

$T_f - 0 = 7.05°c \Rightarrow T_f = 7.05°c$

Ques:- Some steam at 100°c mixed with 200 g ice at 0°c. If temp. of mixture is 40°c then f/o amount of steam used.

Ice (200g) 0°c $\xrightarrow{200\times 80 = 16000\ cal}$ 0°c water $\xrightarrow{200\times1\times40 = 8000\ cal}$ 40°c water

Steam (m gm) 100°c $\xrightarrow{m\times540}$ water (100°c) $\xrightarrow{m\times1\times60}$ 40°c water

$\therefore$ gain = loss

$24000 = 600\,m$

$m = 40g.$

Ques:- Ice 10 kg 0°c; Steam 5 kg 100°c; T = ? Content = ?

Ice: $10\times80 = 800\ KCal$ → 0°c water → $10\times1\times100 = 1000\ KCal$ → 100°c ~~steam~~ water

Steam: $5\times540 = 2700\ KCal$ → water (100°c)

$\therefore W = 10+5 = 15\ kg\ (100°c)$

$\therefore Q = 2700-(800+1000)$

$Q = 900\ KCal.$

Now,

$Q = 900 = mL_v$

Steam → $m = \frac{900}{540} = \frac{5}{3} = 1.67\ kg$ (steam).

Water $= 15-1.67 = 13.33\ kg$ (water).

$T_{mix} = 100°c.$

Ques:- 200 g of water at 10°c temp. kept in a ~~container~~ calorimeter of 0.1 kg water equivalent. If steam of 100°c is passed into it then temp. of mix. becomes 70°c. Then f/o water content in calorimeter?

Steam (m gm) 100°c $\xrightarrow{m\times540}$ 100°c water $\xrightarrow{m\times1\times30}$ 70°c water

Water (10°c) 200g $\xrightarrow{200\times1\times60 = 12000}$ 70°c

Container (10°c) W = 100g $\xrightarrow{W\Delta T = 100\times60 = 6000}$ 70°c

$\therefore 570m = 12000 + 6000$

$m = 31.5\ gm$

$\therefore$ Water $= 200 + m$

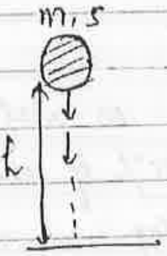
$= 200 + 31.5 = 231.5\ gm.$

Question Based on Energy Conservation

$\therefore Q = mS\Delta T$ or mL

$\underset{cal}{Q} = \underset{}{g}\ \dfrac{cal}{g\,°c}\ °c$ or $\underset{cal}{Q} = \underset{g}{m}\ \underset{cal/g}{L}$

(1)



F/o rise in temp. of ball just after strike :-

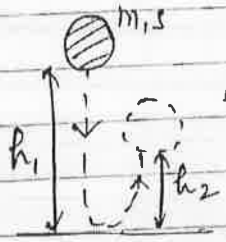
Loss in PE $= mS\Delta T$

$$\frac{\cancel{m}gh}{J} = \frac{\cancel{m}S\Delta T}{J} \quad S \rightarrow \frac{J}{Kg\,°c}$$

(OR)

$$\frac{\cancel{m}gh}{4.2} = \cancel{m}S\Delta T \quad S \rightarrow \frac{Cal}{Kg\,°c}$$

(2).



$\Delta T = ?$

$\therefore$ Loss in PE $= mS\Delta T$

$$mg(h_1 - h_2) = mS\Delta T \quad S \rightarrow J/Kg\,°c$$

(3). In Previous case-(2) if 60% of produced energy goes to surrounding

$$\frac{40}{100} \times [mg(h_1 - h_2)] = mS\Delta T$$

(4) In case-(2) 60% of energy converts into thermal energy

$$\frac{60}{100} \times mg(h_1 - h_2) = mS\Delta T$$

Ques:- If a block of (mass 'M', specific heat $C\ \frac{J}{Kg\text{-}K}$) moving with v_0 speed strikes with an obstacle and rebounds with $\frac{v_0}{2}$ speed. If energy produced equally distributed b/w obstacle & block Then f/o rise in temp. of block?

$\therefore \quad KE = \frac{1}{2}mv_0^2 \quad$ and $\quad K_f = \frac{1}{2}m\left(\frac{v_0}{2}\right)^2 = \frac{1}{2}\frac{mv_0^2}{4}$

$\therefore \quad \Delta KE = \frac{1}{2}mv_0^2\left(1-\frac{1}{4}\right) = \frac{3}{8}mv_0^2$

Since, 50% of $\frac{3}{8}\cancel{m}v_0^2 = \cancel{m}S\Delta T$

$$\frac{1}{2}\times\frac{3}{8}v_0^2 = C\Delta T$$

$$\Rightarrow \Delta T = \frac{3v_0^2}{16C}$$

Ques:- ice 0°C, h

If $1/4^{th}$ of ice gets melted on striking. Then f/o value of 'h' if 40% of energy produced lost in surrounding.

$$\frac{\frac{60}{100}\times \cancel{m}gh}{4.2} = \left(\frac{\cancel{m}}{4}\right)L_f \quad \left(L_f \to \frac{cal}{kg}\right)$$

$$\frac{\frac{\cancel{2}}{5}\times 10\times h}{\cancel{4.2}\; 1.4} = \frac{1}{4}\times 80{,}000$$

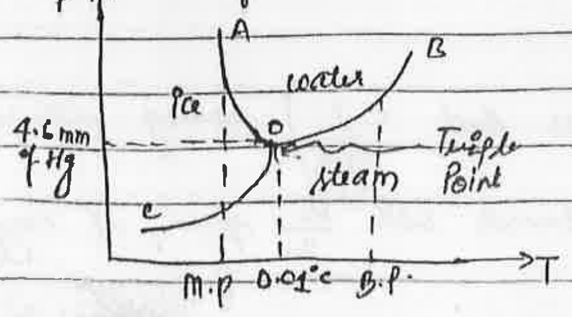
$$\Rightarrow h = 14000 \text{ m} \quad \text{or} \quad 14 \text{ km}$$

- P-T Curve (Phase Diagram)

→ It shows phase of substance at given P & T.

→ It indicates dependency of B.P. & M.P. on pressure.

(1). P-T Curve of Water



OA ⟶ M.P.

OB ⟶ B.P

OC ⟶ S.P.

11/01/2020

Slope → $\frac{\Delta P}{\Delta T}$

(OA) slope ⇒ $\frac{\Delta P}{\Delta T} = -ve$

$P\uparrow \Rightarrow T\downarrow \Rightarrow M.P\downarrow$ [Ice-skating].

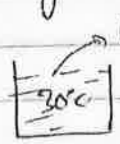
(OB) slope ⇒ $\frac{\Delta P}{\Delta T} = +ve$

$P\uparrow \Rightarrow T\uparrow \Rightarrow B.P\uparrow$

P ↑ (water) → M.P. ↓ (slope → −ve)

P ↑ (water) → B.P. ↑ (slope → +ve) [Pressure cooker]

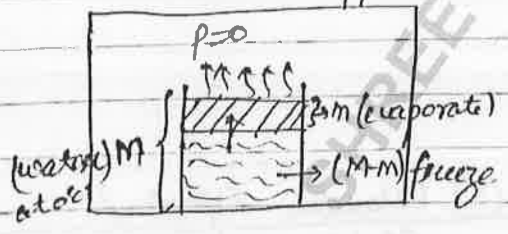
Ques:- If a glass of water at 30°c is taken to moon then what happens to water?



$P\downarrow \Rightarrow B.P.\downarrow$

so, water evaporates quickly

Ques:- If a glass of water at 0°c kept in a small vacuum chamber (P=0) then what happens to water?



$\therefore \boxed{ML_v = (M-m) \times L_f}$

$\boxed{\frac{m}{M} = 0.132 \text{ or } 13.2\%}$

↳ fraction of water evaporated

⇒ Remaining ⇒ Ice = 86.8%

In case of Pot (~~Heat~~),

$\boxed{mL_v = (M-m)\, s\, \Delta\theta}$

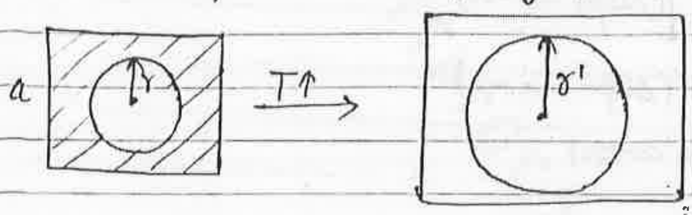
Thermal Expansion

→ If substance expans on heating or contracts on cooling then it is called Thermal Expansion.

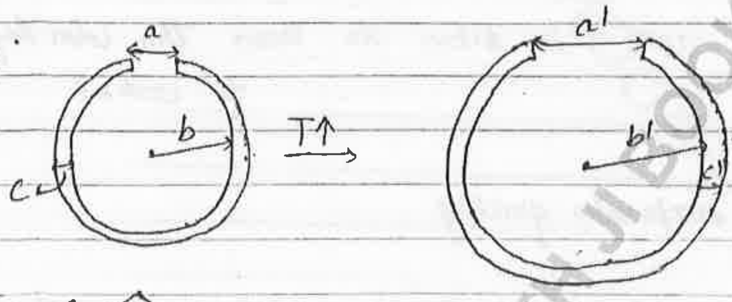
→ There are two types of vibration :-

Longitudinal	Transverse
→ If these vibration dominates on heating, substance expand.	→ If these vibration dominates on heating, substance contract.
eg: → Most of substance	eg: → Polymer (rubber).

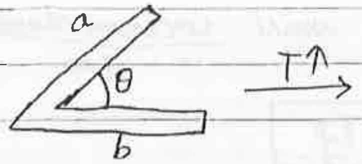
→ Thermal expansion like photographic plate enlargement.

① 

a↑
b↑
r↑

② 

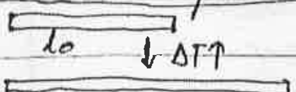
a↑
b↑
c↑

③ 

a↑
b↑
θ = const. (dimensionless)

• Termal Expansion in solids

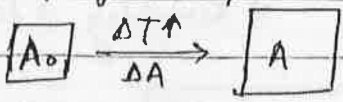
① Linear Expansion



$$\boxed{\Delta l = l_0 \alpha \Delta T}$$

↳ cofficient of linear expansion

② Areal Expansion / (Superficial expansion)



$$\boxed{\Delta A = A_0 \beta \Delta T}$$

cofficient of areal expansion

③ Volumetric Expansion / (Cubic expansion)

$$\boxed{\Delta V = V_0 \gamma \Delta T}$$

↓

cofficient of volumetric expansion

→ $\alpha = \frac{\Delta l}{l_0 \Delta T}$ ⇒ unit $= 1/°C$	→ $\beta = \frac{\Delta A}{A_0 \Delta T}$ ⇒ unit $= 1/°C$	→ $\gamma = \frac{\Delta V}{V_0 \Delta T}$ ⇒ Unit $= 1/°C$
→ % change in length $\frac{\Delta l}{l_0} \times 100 = (\alpha \Delta T) \times 100$	→ % change in area $\frac{\Delta A}{A_0} \times 100 = (\beta \Delta T) \times 100$	→ % Change in Vol^m $\frac{\Delta V}{V} \times 100 = (\gamma \Delta T) \times 100$
→ $l = l_0 + \Delta l$ $l = l_0(1 + \alpha \Delta T)$	→ $A = A_0 + \Delta A$ $A = A_0(1 + \beta \Delta T)$	→ $V = V_0 + \Delta V$ $V = V_0(1 + \gamma \Delta T)$

Note :⇒ ① If $\alpha \rightarrow$ higher

$\uparrow \alpha = \frac{\Delta l \uparrow}{l_0 \Delta T}$ then substance expans more on heating and contracts more on cooling.

②. Isotropic Material

$l \rightarrow \alpha$

$w \rightarrow \alpha$

$h \rightarrow \alpha$

∴ $\boxed{\gamma = 3\alpha}$, $\boxed{\beta = 2\alpha}$

∴ $\boxed{\alpha : \beta : \gamma = 1 : 2 : 3}$

③. Anisotropic Material

$l \rightarrow \alpha_1$

$w \rightarrow \alpha_2$

$h \rightarrow \alpha_3$

∴ $\boxed{\gamma = \alpha_1 + \alpha_2 + \alpha_3}$

④. Density → $\rho_0 = \frac{M}{V_0}$

$\rho_0 \xrightarrow{\Delta T \uparrow} \rho$

∴ $\boxed{\rho = \frac{M}{V} = \frac{M}{V_0(1 + \gamma \Delta T)} = \frac{\rho_0}{1 + \gamma \Delta T}}$

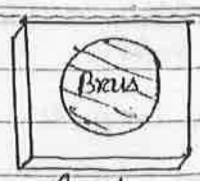
$\left(\rho = \frac{\rho_0}{1 + \gamma \Delta T}\right)$ → For solids, $\gamma \rightarrow$ very less

so

$\rho = \rho_0 (1 + \gamma \Delta T)^{-1}$

$\boxed{\rho = \rho_0 (1 - \gamma \Delta T)}$

⇒ % change in density ⇒ $\boxed{\frac{\Delta \rho}{\rho} = \gamma \Delta T \times 100}$

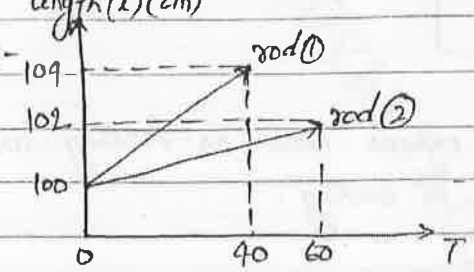
Ques:- 

Cu-Sheet

To remove Brass disc from 'Cu' sheet temp. of system should – ① T↑ ② T↓ ③ first ↑ then ↓ ④ first ↓ then ↑

Learn: $\boxed{\alpha_{Brass} > \gamma_{Cu}}$

⇒ Brass will shrink more on cooling and comes out easily → So, T↓

Imp: Ques:- 

F/o cofficient of vol^m expansion?

$$\therefore \frac{\gamma_1}{\gamma_2} = \frac{3\alpha_1}{3\alpha_2} = \frac{\alpha_1}{\alpha_2}$$

$$\frac{\gamma_1}{\gamma_2} = \frac{\frac{\Delta l_1}{l_{o_1}\Delta T_1}}{\frac{\Delta l_2}{l_{o_2}\Delta T_2}} = \frac{\frac{(104-100)}{100\times 40}}{\frac{(102-100)}{100\times 60}}$$

$$\frac{\gamma_1}{\gamma_2} = \frac{4}{40}\times\frac{60}{2} = \frac{3}{1}$$

Ques:- If %age change in length of rod of l dimension is 2% on increasing it's temp. by 100°c then f/o % change in vol^m of rod of dimension $\left(2l\times\frac{l}{3}\times 4l\right)$ of same material and same increase in temp.

$$\therefore \frac{\Delta l}{l_o}\times 100 = (\alpha\Delta T\times 100) = 2\%$$

$$\therefore \frac{\Delta V}{V_o}\times 100 = \frac{\cancel{V_o}\gamma\Delta T}{\cancel{V_o}}\times 100 = 3\{(\alpha\Delta T)\times 100\}$$

$$= 3\times 2\%$$

$$= 6\%$$

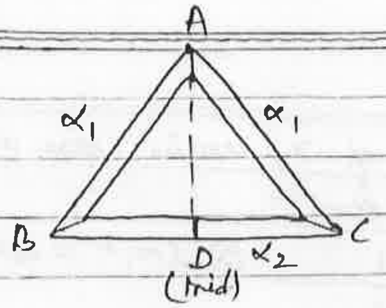
Ques:- $\underset{\text{rod ①}}{\boxed{\overset{l_1}{\alpha_1}}}$ & $\underset{\text{rod ②}}{\boxed{\overset{l_2}{\alpha_2}}}$ If rods are connected end to end then cofficient of linear expansion of new rod?

$$\therefore \Delta l_{Total} = \Delta l_1 + \Delta l_2$$

$$\alpha_{eq.}(l_1+l_2)\cancel{\Delta T} = \alpha_1 l_1\cancel{\Delta T} + \alpha_2 l_2\cancel{\Delta T}$$

$$\boxed{\alpha_{eq} = \frac{\alpha_1 l_1 + \alpha_2 l_2}{l_1+l_2}}$$

Que:-



If rod AB, BC & AC are identical in dimension and distance b/w AD remains same at all temp. then –

(a) $\alpha_1 = \alpha_2$ (b) $\alpha_1 = 4\alpha_2$

(c) $\alpha_2 = 4\alpha_1$ (d) $\alpha_2 = 2\alpha_1$

$$AD^2 = AB^2 - BD^2$$
$$= l_0^2 - \frac{l_0^2}{4} = \frac{3l_0^2}{4}$$

$$\downarrow \Delta T \uparrow$$

$$AD'^2 = AD^2 = AB'^2 - BD'^2$$
$$\frac{3l_0^2}{4} = \left[l_0(1+\alpha_1 \Delta T)\right]^2 - \left[\frac{l_0}{2}(1+\alpha_2 \Delta T)\right]^2$$
$$\frac{3}{4}\cancel{l_0^2} = \cancel{l_0^2}\left[1+\alpha_1 \Delta T\right]^2 - \frac{\cancel{l_0^2}}{4}\left[1+\alpha_2 \Delta T\right]^2$$
$$\frac{3}{4} = 1 + 2\alpha_1 \Delta T - \frac{1}{4}(1+2\alpha_2 \Delta T)$$
$$\cancel{\frac{3}{4}} = \cancel{\frac{3}{4}} + 2\alpha_1 \Delta T - \frac{1}{2}\alpha_2 \Delta T$$
$$2\alpha_1 \Delta T = \frac{\alpha_2 \Delta T}{2}$$
$$\alpha_2 = 4\alpha_1$$

Imp

Que:- M.O.I. of sphere about geometric axis is I_0. If temp of sphere incr by Δt then f/o fractional change in it's M.O.I. {take $\alpha_{sphere} = \alpha$}

m (I) $\because I_0 = \frac{2}{5}MR_0^2$

$$\downarrow \Delta t \uparrow$$

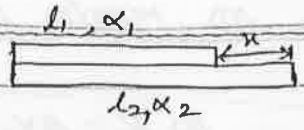
$$I = \frac{2}{5}mR^2$$
$$I = \frac{2}{5}m\{R_0(1+\alpha \Delta t)\}^2$$
$$I = \frac{2}{5}MR_0^2(1+2\alpha \Delta t)$$
$$I = I_0(1+2\alpha \Delta t)$$

$$\frac{I - I_0}{I_0} = 2\alpha \Delta t.$$

m (2) $\frac{\Delta I}{I_0} = \frac{2\Delta R}{R_0}$ $\left\{\because I = \frac{2}{5}mR^2\right\}$

$$= 2\alpha \Delta t$$

13/01/2020

Ques:- 

2 rods. F/o value of x, remains same at all condition then:—

① $\frac{l_1}{l_2} = \frac{\alpha_1}{\alpha_2}$ ② $l_1\alpha_1^2 = l_2\alpha_2^2$

③ $\frac{l_1}{l_2} = \frac{\alpha_2}{\alpha_1}$ ④ NOTA

For x = const.

$$\Delta l_1 = \Delta l_2$$

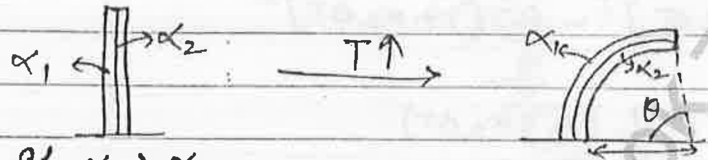
$$l_1\alpha_1\cancel{\Delta T} = l_2\alpha_2\cancel{\Delta T}$$

$$\frac{l_1}{l_2} = \frac{\alpha_2}{\alpha_1}$$

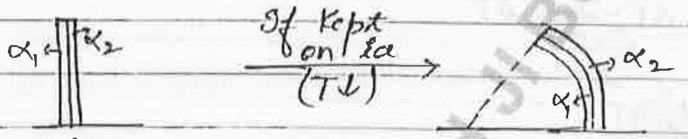
- Application of Thermal Expansion in Solids

①. Bimetallic strip

→ Used as thermostat



If $\alpha_1 > \alpha_2$



If $\alpha_1 > \alpha_2$

②. Stress and Strain

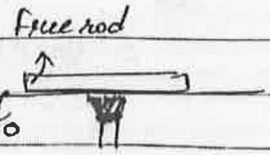
$$Y = \frac{F/A}{\Delta l / l_0}$$

compressible stress

$$\frac{F}{A} = Y\left(\frac{\Delta l}{l_0}\right) \Rightarrow \boxed{\frac{F}{A} = Y\alpha\Delta T} \qquad (\because \Delta l = l_0\alpha\Delta T)$$

$$\Rightarrow \boxed{F = YA\alpha\Delta T}$$

↳ Compressible stress force.

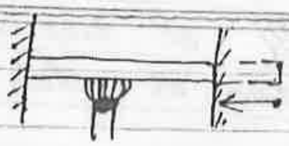
eg.:- (i). 

∵ l↑ compressible stress & strain $= 0$

(ii). 
∵ T↑ ⇒ l↑

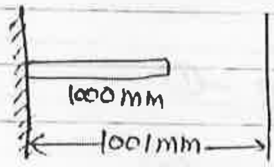
[Compressible stress & strain $= 0$]

(iii) 

(iii). 

$\because$ Agar rigid wall nhi hoti, to $l \uparrow$ but wall incompressible diya hai so compressive stress & strain.

Imp.

Ques:- 

If $\alpha_{rod} = 2 \times 10^{-4} /°C$, $Y_{rod} = 10^{11}/°C$

If temp. of rod $\uparrow$ed by $10°C$ compressive stress produced in rod?

$\therefore \Delta l = l_0 \alpha \Delta T$
$= (1000) \times 2 \times 10^{-4} \times 10$
$= 2\,mm$

$\rightarrow 1\,mm\ [0° \rightarrow 5°C] \Rightarrow$ No Compressive stress
$\rightarrow 1 \rightarrow 2\,mm\ [5°C \rightarrow 10°C] \Rightarrow$ Compressive stress Produced.

$\therefore \dfrac{F}{A} = Y \alpha \Delta T$
$= 10^{11} \times 2 \times 10^{-4} \times (5)$
$= 10^{8}\ N/m^2$

③. Time Period (t) of Clock Pendulum

$\because$ Temp. $\uparrow \Rightarrow l \uparrow$ [Thermal expansion].

$\therefore t = 2\pi\sqrt{\dfrac{l}{g}}$

In Summer:$\rightarrow$ Temp. $T\uparrow \Rightarrow l\uparrow \Rightarrow t\uparrow \Rightarrow$ Clock slow $\Rightarrow$ Time loss

In Winter:$\rightarrow$ $T\downarrow \Rightarrow l\downarrow \Rightarrow t\downarrow \Rightarrow$ Clock fast $\Rightarrow$ Time gain

$\because t = 2\pi\sqrt{\dfrac{l}{g}}$

$\therefore \dfrac{\Delta t}{t} = \dfrac{1}{2}\dfrac{\Delta l}{l}$

Time loss or gain $\leftarrow$ $\boxed{\Delta t = \frac{1}{2} \alpha \Delta T (t)}$ $\rightarrow$ Time for which loss or gain calculated.

$\rightarrow$ 'α' should be low for good Pendulum

eg.- (I). Quartz
(II). In-var (Fe-Ni alloys)

Ques:- Time loss of a clock Pendulum in a day is 18 sec, if it is used at 40°C. If it would have used at temp. of 5°C, time gain in a day is 12 sec. F/o temp. at which it will show accurate time.

$$5°C \xleftarrow[\Delta t = 12\,sec]{gain} T \xrightarrow[t = 18\,sec]{loss} 40°C$$

$\therefore$ loss $\Rightarrow$ $\Delta t = 18 = \frac{1}{2}\alpha[40 - T] \times 1$ day —①

$\therefore$ gain $\Rightarrow$ $\Delta t = 12 = \frac{1}{2}\alpha[T - 5] \times 1$ day —②

① ÷ ②,

$$T = 19°C.$$

- Application of Thermal Energy in Gases.
  → Only γ is defined.

$$\gamma = \frac{\Delta V}{V_0 \Delta T} \quad \text{or} \quad \frac{\delta V}{V_0 \delta T}$$

Ques:- If an I.G. follows PT^4 = const. then f/o cofficient of vol^m expansion of I.G. in process. [$T_0 \rightarrow$ Initial temp.]

$$\gamma = \frac{\Delta V}{V_0 \Delta T}$$

$\therefore PT^4 = \text{const.}$

$$\frac{nRT}{V} \cdot T^4 = \text{const.}$$

$$V \propto T^5$$

$$\frac{\Delta V}{V_0} = 5\frac{\Delta T}{T_0}$$

$$\gamma = \frac{\Delta V}{V_0 \Delta T} = \frac{5}{T_0}$$

Ques:- F/o cofficient of vol^m expansion of I.G. in IB process.

$\therefore \gamma = \frac{\Delta V}{V_0 \Delta T}$

IB $\rightarrow V \propto T$

$$\frac{\Delta V}{V_0} = \frac{\Delta T}{T_0}$$

$$\gamma = \frac{\Delta V}{V_0 \Delta T} = \frac{1}{T_0}$$

15/01/2020

Que:- If an I.G. follows $PV^n = \text{const}$. then f/o cofficient of vol^m expansion of I.G. in process. ($T_0 \rightarrow$ initial temp.)

$\therefore \gamma = \dfrac{\Delta V}{V_0 \Delta T}$

$\therefore PV^n = \text{const}$

$\dfrac{nRT}{V} \cdot V^n = \text{const}$

$T \propto \dfrac{V}{V^n}$

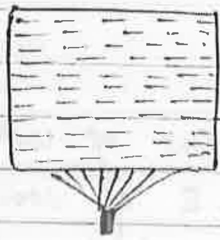
$T \propto V^{1-n}$

$\dfrac{\Delta T}{T_0} = 1-n \dfrac{\Delta V}{V_0}$

$$\boxed{\frac{\Delta V}{V_0 \Delta T} = \frac{1}{(1-n)} \times \frac{1}{T_0}}$$

- Application of Thermal Energy in Liquids

$\rightarrow$ Only γ is defined.



$\gamma = \dfrac{\Delta V}{V_0 \Delta T}$ (or) $\Delta V = V_0 \gamma \Delta T$

$V_0 \rightarrow$ Initial vol^m of container & liquid

$\rightarrow$ First container expands,

$(\Delta V)_c = V_0 \gamma_c \Delta T$ [liquid level $\downarrow$]

then liquid expands,

$(\Delta V)_L = V_0 \gamma_L \Delta T$ [liq. level $\uparrow$]

$\therefore \Delta V_{app.} = (\Delta V)_L - (\Delta V)_c$

$V_0 \gamma_{app} \Delta T = V_0 \gamma_L \Delta T - V_0 \gamma_c \Delta T$

$$\boxed{\gamma_{app} = \gamma_L - \underbrace{\gamma_c}_{3\alpha}}$$

Here, γ_c = vol^m expansion cofficient of Container

γ_L = Real / Pure / Absolute cofficient of vol^m expansion of liquid.

γ_{app} = Apperant / Relative cofficient of vol^m expansion of liquid.

→ If liquid overflows :→ $\gamma_L > \gamma_C$

$(\Delta V)_{overflow} = (\Delta V)_L - (\Delta V)_C = V_0(\gamma_L - \gamma_C)\Delta T$

→ If level remains unchanged :→ $\gamma_L = \gamma_C$

$$\gamma_L = 3\alpha$$

Ques:- If cofficient of vol^m expansion of liquid is 4/3 times of that of container then f/o value of $\frac{\gamma_{app}}{\gamma_{absolute}} = ?$

$$\gamma_L = \frac{4}{3}\gamma_C$$

$$\frac{\gamma_{app}}{\gamma_L} = \frac{\gamma_L - \gamma_C}{\gamma_L} = 1 - \frac{\gamma_C}{\gamma_L}$$

$$= 1 - \frac{3}{4} = \frac{1}{4}$$

Ques:- Apparant cofficient of vol^m expansion of a liquid filled completely in vessel A & B of same vol^m is γ_1 & γ_2. If cofficient of linear expansion of A vessel is α, then f/o that of vessel B.

$$\gamma_{app} = \gamma_L - \gamma_C$$

(A) $\gamma_1 = \gamma_L - 3\alpha_1$ —(1)

(B) $\gamma_2 = \gamma_L - 3\alpha_2$ —(2)

(1) − (2)

$$\gamma_1 - \gamma_2 = 3\alpha_2 - 3\alpha_1$$

$$\alpha_2 = \frac{\gamma_1 - \gamma_2 + 3\alpha_1}{3}$$

- Temperature Scale

→ To design a scale, it's $\boxed{\frac{\text{Reading} - M.P.}{B.P. - M.P.} = \text{const.}}$

Scale	M.P.	B.P.
°C	0	100
K	273	373
°F	32	212
°X	A	B

$$\frac{°C - 0}{100 - 0} = \frac{K - 273}{373 - 273} = \frac{°F - 32}{212 - 32} = \frac{°X - A}{B - A}$$

$$\Rightarrow \frac{°C}{100} = \frac{K - 273}{100} = \frac{°F - 32}{180}$$

$$\Rightarrow \frac{°C}{5} = \frac{K - 273}{5} = \frac{°F - 32}{9}$$

$\downarrow$ change

$$\frac{\Delta C}{5} = \frac{\Delta K}{5} = \frac{\Delta F}{9} \Rightarrow \boxed{\Delta F = \frac{9}{5}\Delta C = 1.8\Delta C}$$

Ques:- Two unknown scales °A & °B having ice point and steam point of water respectively −25°A and −5°A and −45°B & −25°B. f/o temp. of block in °A scale if it is at 10°B temp.

$$\frac{°A - (-25)}{-5 - (-25)} = \frac{°B - (-45)}{-25 - (-45)}$$

$$\Rightarrow \frac{°A + 25}{\cancel{20}} = \frac{10 + 45}{\cancel{20}}$$

$$\Rightarrow °A = 30 \qquad \text{so } A \rightarrow 30°A$$

°C/K scale Calibrated with length [Mercury Thermometer]

$$\frac{°C - 0}{100 - 0} = \frac{l_{°C} - l_{0°C}}{l_{100°C} - l_{0°C}} \quad \& \quad \frac{K - 273}{373 - 273} = \frac{l_K - l_{273}}{l_{373} - l_{273}}$$

Platinum - wire Thermometer (Resistance)

$$\frac{°C - 0}{100 - 0} = \frac{R_{°C} - R_{0°C}}{R_{100°C} - R_{0°C}}$$

Ques:- If in Hg-scale length of Hg; $l_{0°C} = 10cm$, $l_{100°C} = 60cm$, then f/o temp. at which Hg column length becomes 50cm.

$$\frac{°C - 0}{100 - 0} = \frac{50 - 10}{60 - 10}$$

$$\frac{°C}{100} = \frac{4\cancel{0}}{5\cancel{0}}$$

$$°C = \frac{400}{5} = 80\,°C$$

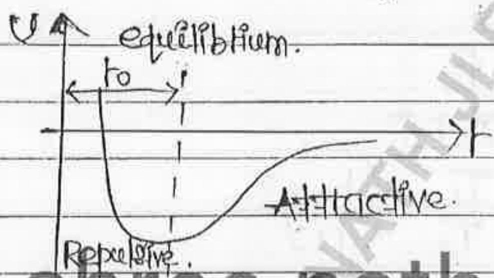
→ Elasticity.
→ Surface Tension.

→ Fluid statics
→ Fluid dynamics.
→ Viscosity.

ELASTICITY

After removal of deforming force, a body recovers or try to recover original config^n. This phenomena is elasticity.
Reason → Interatomic force of attract^n or repulsion, also c/d internal restoring force.

Perfectly Elastic - IRF large, difficult to deform.
eg. quartz, steel etc.
perfectly plastic - IRF negligible, & remains permanently deform
eg, clay, putti.



3/9/19

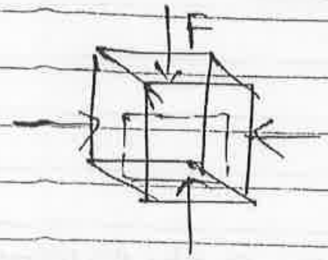
Stress = $\frac{\text{Internal Restoring force}}{\text{Area}}$ = $\frac{F_{ext}}{A}$ (in eqb^m) Nm^{-2} or Pascal.

1. Longitudinal stress -

$= \frac{F}{\pi r^2}$ cross sect^n

(a) ↓AM tensile
(b) ↓W compressional.

2. Hydraulic / volumetric



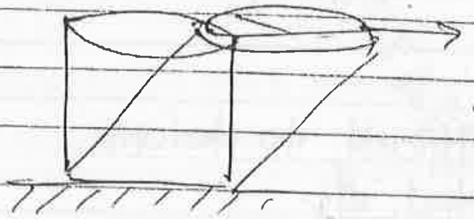
$= \Delta P$ (change in Pressure)

$= P_0 + P - P_0 = P$

$= P_0 + h\rho g - P_0$

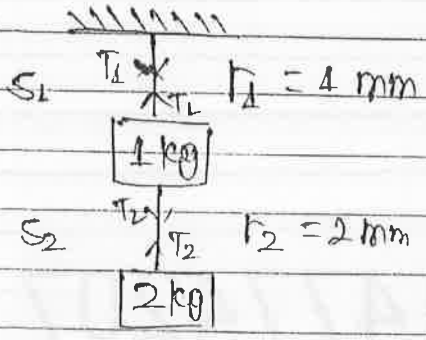
$= h\rho g$.

3. Shear or Tangential stress.



$= \frac{F}{A}$ → along which force is acting.

Q.



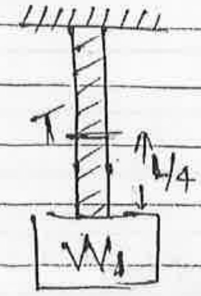
$S = \frac{F}{\pi r^2}$

$\frac{S_1}{S_2} = \frac{T_1}{T_2} \times \left(\frac{r_2}{r_1}\right)^2$

$= \frac{3g}{2g} \times \left(\frac{2}{1}\right)^2$

$= \frac{3}{2} \times \frac{4}{1} = \frac{6}{1}$

Q.



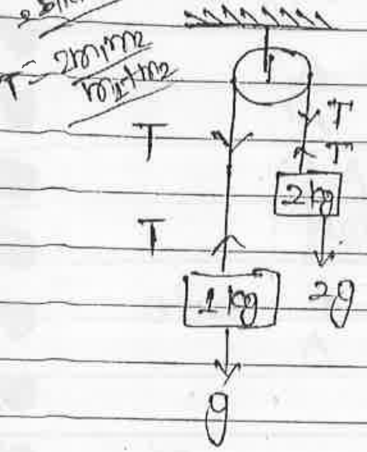
W, L, S.   Wt. of Rope is W, length is L, and area of cross-secth 'S' find stress @ dist. L/4 from lower end.

PAGE NO. icon

DATE : / /

$\rightarrow$ Stress $= \dfrac{W_L + W/4}{S}$.

Q. Find stress in the string connecting the blocks.



$T = \frac{2mm}{mtms}$

block syst.

$A = 2\ mm^2$

$$a = \frac{(m_1 g - m_2 g)}{m_1 + m_2} = \frac{2g - g}{3}$$

$$= \frac{g}{3} = \frac{10}{3}\ m/s^2.$$

$$20 - T = 2 \times \frac{10}{3}$$

$$20 - \frac{20}{3} = T \Rightarrow T = \frac{40}{3}\ N.$$

$$S = \frac{T}{A} = \frac{40/3}{2 \times 10^{-6}}$$

$$= \frac{20}{3} \times 10^{6}\ Nm^{-2}$$

$1\ mm = 10^{-3}\ m.$

$1\ mm^2 = 10^{-6}\ m^2.$

Q. A ball is taken @ a depth of 20 cm in a liqd of relative density 0.8. Find stress.

$\rightarrow$ $\Delta P = P_0 + h\rho g - P_0$

Hydraulic $= h\rho g$

$= \cancel{0.20 \times 0.8 \times 10} \cancel{\times 10} = \cancel{1.6\ N/m^2}$.) or

$= 2\cancel{0} \times 1\cancel{0}^{-2} \times 0.8 \times 10^{3} \times 1\cancel{0}$

$= 1.6 \times 10^{3}$ Pascal.

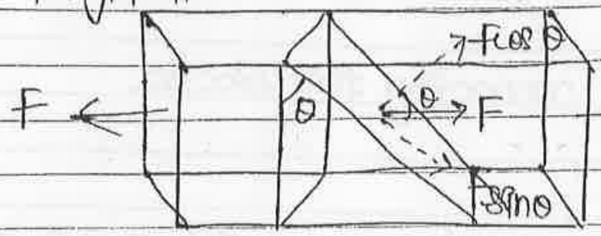
Relative density $= \dfrac{\rho}{\rho_W}$: no unit, dimensionless

Specific gravity

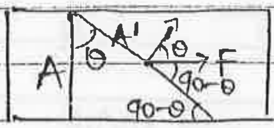
$\boxed{\rho = R.D. \times \rho_W}$

NCERT Exemplar

Q. Find longitudinal & shear stress on the inclined area on the fig.



$$\cos\theta = \frac{A}{A'}$$



$$\boxed{A' = \frac{A}{\cos\theta}}$$

$$\text{Longitudinal stress} = \frac{F\cos\theta}{A/\cos\theta} = \frac{F}{A}\cos^2\theta$$

$$\text{Shear tangential} = \frac{F\sin\theta}{A/\cos\theta} = \frac{F}{A}\sin\theta\cos\theta \times \frac{2}{2} = \frac{F}{2A}\sin 2\theta$$

Breaking stress or ultimate strength-

Max^{m} tolerated stress beyond which the body is actually broken or fractured.

$$B.S. = \frac{F\uparrow}{A\uparrow} \; Nm^{-2}$$

steel

depends only on nature of material.

independent of dimension of wire.

Breaking force

$$F = B.S. \times A$$

same metal $\boxed{F \propto A \\ F \propto r^2}$

Q. To break a wire of diameter 2 mm, req^{d} force is 20 N. To break another wire of same metal of diam. 4 mm, Req^{d} force will be-

P-222 BB-1 -- 2x All 5/6 13/6/16

$$\Rightarrow \frac{F_1}{F_2} = \left(\frac{r_1}{r_2}\right)^2$$

$$\Rightarrow \frac{20}{F_2} = \left(\frac{2}{4}\right)^2$$

$$\Rightarrow F_2 = 80\ N.$$

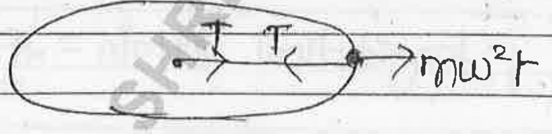
Q. A compressive force of 5×10^5 N is subjected to a bone of length 20 cm & cross sect^n 4 cm^2. If ultimate compressive strength of bone is 1.7×10^8 N/m^2, Will the bone break or not?

→ $$\text{stress} = \frac{5\times10^5}{4\times10^{-4}} = 1.25\times10^9\ N/m^2$$

stress > B.S.
Will break.

Q. A stone of mass 1 kg is tied with one end of 2m long string & cross sect^n 1 mm^2. Find max^m angular speed by which string can be revolve in the plane without breaking. (B.S. = 8×10^8 N/m^2).

→



$$T = m\omega^2 r$$

$$\text{stress} = \frac{T}{A}$$

$$B.\text{stress} = \frac{m\omega^2_{max.} r}{A}$$

$$8\times10^8 = \frac{1\ \omega^2_{max}\times 2}{10^{-6}}$$

$$\omega_{max.} = 20\ rad/s.$$

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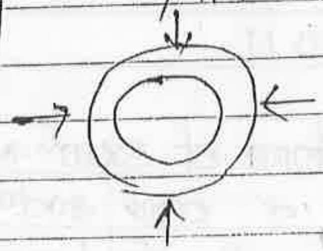
strain $= \dfrac{\text{change in configuration}}{\text{original config}^n}$ dimensionless.

1. Longitudinal strain-

$= \dfrac{\Delta l}{l}$

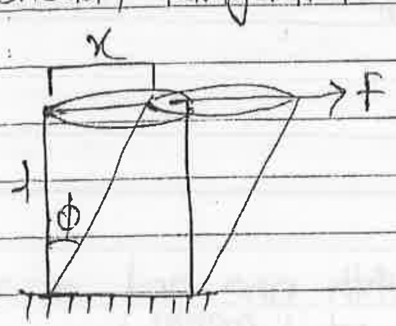
$= \dfrac{l_f - l_i}{l_i}$

2. Hydraulic / volumetric



$= \dfrac{\Delta V}{V}$

3. shear / Tangential.



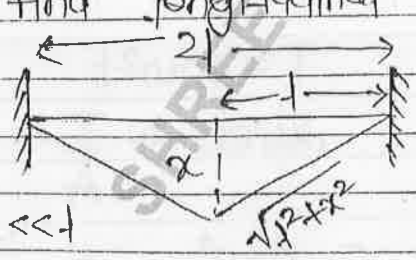
$\tan\phi = \dfrac{x}{l}$

ϕ is very small, $\tan\phi \simeq \phi$.

$$\boxed{\phi = \frac{x}{l}}$$

Q. If wire is pulled from mid point through distance 'x'. Find longitudinal strain.

Ncert



$x << l$

longitudinal strain $= \dfrac{l_f - l_i}{l_i}$

$= \dfrac{\cancel{2}\sqrt{l^2+x^2} - \cancel{2}l}{\cancel{2}l}$

$= \dfrac{l\left(1+\dfrac{x^2}{l^2}\right)^{1/2} - l}{l}$

$= \left(1+\dfrac{x^2}{l^2}\right)^{1/2} - 1$

$x << l$

$\left(\dfrac{x}{l}\right)^2 <<< 1$

$= 1 + \dfrac{1}{2}\dfrac{x^2}{l^2} - 1$

$= \dfrac{x^2}{2l^2}.$

PAGE NO.

DATE : / /

Hooke's law -

Under small deformation,

stress $\propto$ strain.

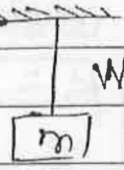
stress = E × strain.

Modulus of Elasticity, $E = \frac{\text{stress}}{\text{strain}}$ Nm^{-2} or Pascal.

→ depends only on nature of material.

1. Young's modulus -

$$Y = \frac{F/A}{\Delta l / l} \Rightarrow \boxed{Y = \frac{Fl}{A\Delta l}}$$



Wire

$\Rightarrow \boxed{Y = \frac{mgl}{\pi r^2 \Delta l}}$

Q. When tension in a wire is T_1 its length is l_1 & when tension is T_2, length l_2, find original length.

Area = const.

→ $Y = \frac{Fl}{A\Delta l}$ $\Rightarrow F \propto \Delta l$.

$$\frac{F_1}{F_2} = \frac{\Delta l_1}{\Delta l_2}$$

$$\frac{T_1}{T_2} = \frac{l_1 - l}{l_2 - l}$$

$$\Rightarrow T_1 l_2 - T_1 l = T_2 l_1 - T_2 l$$

$$\Rightarrow l(T_2 - T_1) = T_2 l_1 - T_1 l_2.$$

$$l = \frac{T_2 l_1 - T_1 l_2}{T_2 - T_1}$$

Q. When tension in wire is 4 N, its length is 'a'. When tension is 5 N, length is b. Find the length of the wire when tension is 9 N.

PAGE NO.
DATE : / /

$4N \rightarrow a$
$5N \rightarrow b$] given
$9N \rightarrow x$ tot

$\frac{F_1}{F_2} = \frac{\Delta l_1}{\Delta l_2}$

$\frac{4}{5} = \frac{a-l}{b-l}$

$4b - 4l = 5a - 5l.$

$\boxed{l = 5a - 4b}$

$\frac{5}{9} = \frac{b-l}{x-l}$

$5x - 5l = 9b - 9l.$

$5x = 9b - 4l$

$= 9b - 4(5a - 4b)$

$= 9b - 20a + 16b$

$5x = 25b - 20a$

$\boxed{x = 5b - 4a.}$

$F = \left(\frac{YA}{l}\right)\Delta l$ (elasticity)

$F = kx$ (spring)

* Spring constant of Wire :-

$$\boxed{k = \frac{Y\pi r^2}{l}}$$

Q: Find force req^d to stretch a wire by 0.2 % diameter 2 mm & $Y = 2\times10^{11}\ N/m^2$.

$\rightarrow$ $Y = \frac{Fl}{A\Delta l}$

$\Rightarrow F = \frac{YA\Delta l}{l} = Y\pi r^2 \frac{\Delta l}{l}.$

$= 2\times10^{11} \times 3.14 \times (10^{-3})^2 \times \frac{0.2}{100}$

$= 1.256 \times 10^3$

$= 1.256$ KN.

let cylinder wire

Q. From vol^m 'V' of Al, a wire of length 'l' is drawn for constant stretching force. Wof graph is st. line ?

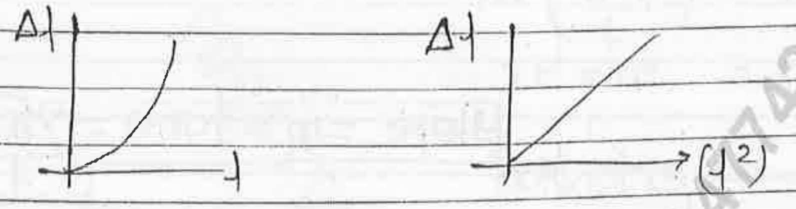
$\rightarrow$ 1) Δl vs l.
2) Δl vs $1/l$
3) Δl vs $1/l^2$
4) Δl vs l^2.

$V = A l$

$A = \frac{V}{l}$ (ans. 'l' में दिया है, so. 'A' को eliminate करेंगे). जो दिया है उसके opp. को eliminate किया करना है form. से.

$Y = \frac{F l^2}{V \Delta l}$

$\Delta l \propto l^2$



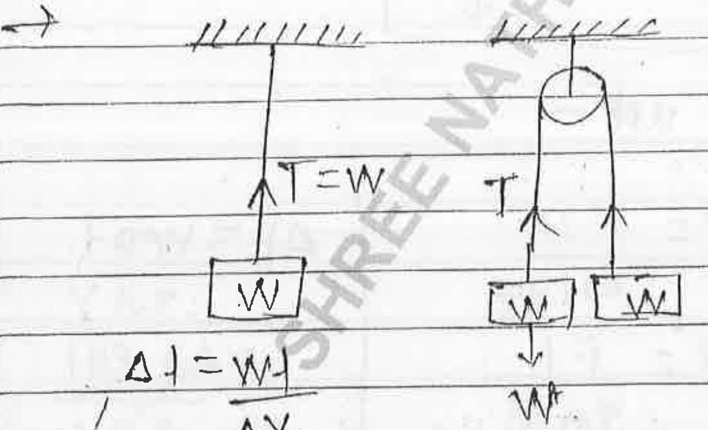
$l = \frac{V}{A}$

$Y = \frac{FV}{A^2 \Delta l}$

$\Delta l \propto 1/A^2$.

Q. A block of wt. 'W' is suspended by a wire, extension produced is 'l'. Now the same wire passes over massless & frictionless pully and blocks of each of weight "W" are suspended by the both end. Find elongation.

Only shows dirn of tension.



$\Delta l = \frac{Wl}{AY}$

$\Delta l' = \frac{Wl}{AY}$

Q. Four wires of same metal are given. for same streching force, which will have largest elongatn.

a) length of wire = 300 cm , diam. = 3 mm

b) — " — = 50 cm , — " — = 0.5 mm

c) — " — = 100 cm , — " — = 1 mm

d) — " — = 200 cm , — " — = 2 mm.

$Y = \frac{Fl}{A\Delta l}$

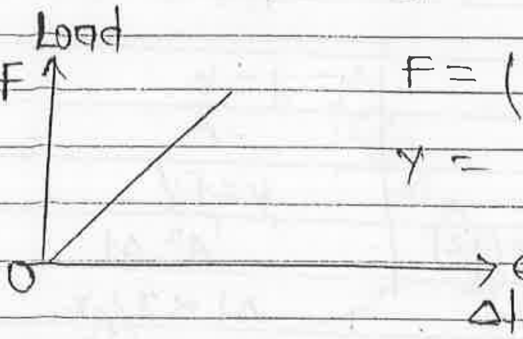
$\boxed{\Delta l \propto \frac{l}{r^2}}$ LE

1) $\frac{33}{1}$ $\frac{300}{9}$: $\frac{5000}{0.25}$ $\frac{200}{1}$: $\frac{100}{1^2}$: $\frac{200}{4}$ $\frac{50}{1}$

↓

LE

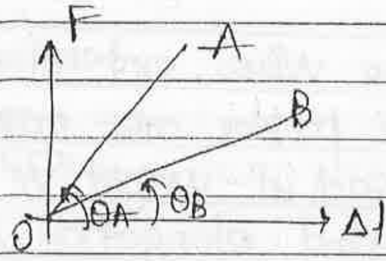
सबसे [illegible]



$F = \left(\frac{Y\pi r^2}{l}\right)\Delta l$

$y = mx + c$

$\boxed{\text{slope} = m = \tan\theta = \frac{Y\pi r^2}{l}}$

Q. 

eg. Both of same metal, same thickness.

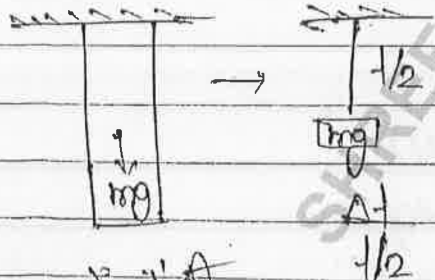
$\tan\theta = \frac{Y\pi r^2}{l}$

$\boxed{\uparrow \tan\theta \propto \frac{1}{l\downarrow}}$

$\theta_A > \theta_B$

$l_A < l_B$.

Extension due to own wt —



$Y = \frac{F/A}{\Delta l / \frac{l}{2}}$

$Y = \frac{Fl}{2A\Delta l}$

$\Delta l = \frac{mgl}{2AY}$

$\Delta l = \frac{V\rho g l}{2AY}$

$= \frac{Al\rho g l}{2A \cdot Y}$

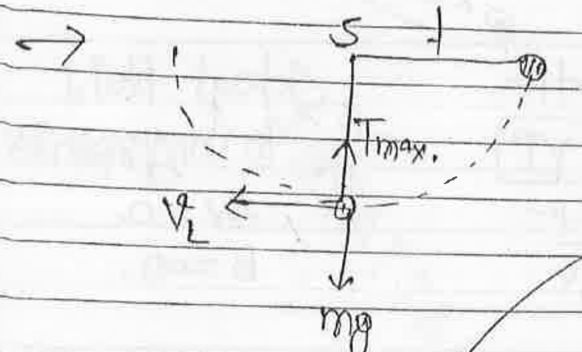
$\boxed{\Delta l = \frac{l^2 \rho g}{2Y}}$

strain में 'l' की जगह $l/2$

BB-2 → 228- 1,2,3,
Ex-I, - 1→8, 14,15,16,18, 20, 22, 24, .
Ex-II - 6, 9, 14
29, III - 1,2

icon
PAGE NO.
DATE : / /

Q. A simple pendulum is made by wire length 'l' & radius 'r'. mass of bob is 'm'. If pendulum is released from Hz positn. Find maxm extension in the wire. young's modulus 'y'.



$$T_{max} - mg = \frac{mV_L^2}{l}$$

$$T_{max} = \frac{mV_L^2}{l} + mg$$

COME,

Loss in P.E. = Gain in K.E.

$$mgl = \frac{1}{2}mV_L^2$$

$$V_L^2 = 2gl$$

$$T_{max} = \frac{m}{l} \times 2gl + mg$$

$$T_{max} = 3mg$$

$$\therefore \boxed{\Delta l = \frac{(3mg)l}{(\pi r^2)y}}$$

5/9/19

Bulk Modulus - [B or K]

$$B = \frac{\Delta P}{\frac{-\Delta V}{V}}$$ [P↑↑, V↓↓, while Bulk modulus always +ve].

$$\boxed{B = -\frac{\Delta P V}{\Delta V}}$$ ~~Pascal or N-m^-2~~

PAGE NO.
DATE : / /

compressibility [C].

$C = \frac{1}{B}$ Pascal^{-1}.

→ fluid also possess Bulk modulus.

Gas

gradually ← Isothermal: $\boxed{B_I = P}$

@ a sudden → Adiabatic: $\boxed{B_a = \gamma P}$, $\gamma = \frac{C_P}{C_V}$.

Ideal fluid: incompressible. $\Delta V = 0$. $B = \infty$.

Q. A cube of Cu of side 10 cm is subjected to a hydraulic stress of 7×10^5 Pa. If bulk modulus of Cu is ~~114~~ 140×10^9 Pa. Find vol^m compression.

→ $\Delta V = -\frac{\Delta P\, V}{B} = \frac{-7 \times \cancel{10^6}}{140 \times 10^9} \cancel{(10)}^3 \text{ cm}^3$.

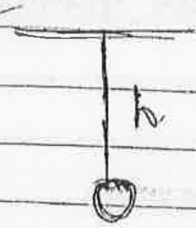
$\Delta V = -0.05 \cancel{\times} \text{ cm}^3$.

vol^m compressed by 0.05 cc.

Q. Bulk modulus of rubber ball is 9×10^8 Pa. upto what depth it should be taken in water so that its vol^m ~~dec by~~ compressed by 0.2%.

$P = h\rho g$

→



$B = \frac{-h\rho g}{\Delta V / V}$

$h = B \times \frac{\Delta V}{V} \times \frac{1}{\rho g} = 9 \times 10^8 \times \frac{0.2}{100} \times \frac{1}{10^3 \times 10}$

$= 180$ m.

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PAGE NO. icon
DATE : / /

Q. A hydraulic stress of 'P' is applied on a ball. of bulk modulus is 'B'. Find – (i) fractional change in vol^n.
(ii) " " Radius.
(iii) " " Density.

→ (1) $\frac{\Delta V}{V} = -\frac{P}{B}$. fractional compression $= \frac{P}{B}$.

(2) $V = \frac{4}{3}\pi r^3$.

$\frac{\Delta V}{V} = \frac{3\Delta r}{r}$ $\quad 3\frac{\Delta r}{r} = -\frac{P}{B}$.

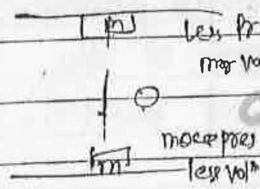
$\frac{\Delta r}{r} = -\frac{P}{3B}$. fractional compression in radius $= P/3B$.

(3) $\rho = \frac{m}{V}$

$\frac{\Delta \rho}{\rho} = -\frac{\Delta V}{V}$ ⇒ $\frac{\Delta \rho}{\rho} = \frac{P}{B}$ (fractional increment in density.)

NCERT solved example PMT-15

Q. An ocean is 3000 mt. deep ($P = h\rho g$). If compressibility of water is 45.4×10^{-11} Pa^{-1}. Find fractional compressional of water @ its waters.

→ 

water की water pressure

$\frac{\Delta V}{V} = -\frac{P}{B}$
$= -h\rho g \times C$
$= 3000 \times 10^3 \times 10 \times 45.4 \times 10^{-11}$
$= 136.2 \times 10^{-4}$
$= 0.01362$.

Q. Find density of water @ a depth in an ocean. where Pres. due to water column is 80 atm. Bulk mod. of water 2.2×10^9 Pas.

1 atm = 105 pascal.

→ P_0 ρ (m)

Porthsg ρ_2 (m) 80 atm

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

$$\frac{\Delta\rho}{\rho} = \frac{-\Delta V}{V}$$

$$B = \frac{\Delta P}{\frac{\Delta\rho}{\rho}}$$

$$\Delta\rho = \frac{\Delta P}{B}\rho$$

$$\rho_2 - \rho = \frac{\Delta P}{B}\rho$$

$$\rho_2 = \rho\left[\frac{\Delta P}{B} + 1\right]$$

$$= 10^3\left[\frac{80 \times 10^5}{2.2 \times 10^8} + 1\right]$$

$$= 10^3\left[0.0036 + 1\right].$$

$$= 1.0036 \times 10^3 \text{ kg/m}^3$$

η Modulus of

$$\eta = \frac{F/A}{\phi}$$

$$\eta = \frac{F/A}{x/l}$$

$$\boxed{\eta = \frac{Fl}{Ax}}$$

modulus of Rigidity –

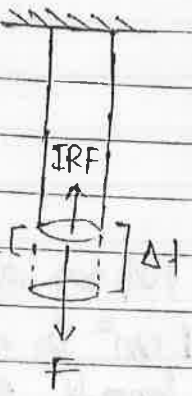
Q. A sq. slab of side 5 cm & thickness 10 ml (1 cm.) is rigidly clamp from the narrower surface. Now a force of 8 kilo N is applied along the upper surface. If $\eta = 8 \times 10^8$ N/m². Find displacement of the surface with respect to fixed surface.

→ $$x = \frac{Fl}{A\eta} = \frac{8 \times 10^3 \times 5 \times 10^{-2}}{5 \times 1 \times 10^{-4} \times 8 \times 10^8}$$

$$= 10^{-3} \text{ m}$$

$$= 1 \text{ mm.}$$

Elastic Potential Energy stored in a stretched wire :-



$F = \frac{YA}{l}x$.

$W = \int F dx$

$F_{av.} = \frac{0+F}{2}$

Work against IRF to stretch a wire,

$W = F_{av} \, x$.

$W = \frac{F}{2} \times \Delta l$.

$\boxed{U = \frac{1}{2} F \Delta l}$

$\Leftarrow U = \frac{1}{2} \times \frac{F}{A} \times \frac{\Delta l}{l} \times Al$

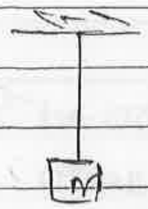
$\boxed{U = \frac{1}{2} \times \text{stress} \times \text{strain} \times \text{vol}^m \text{ of wire}}$ Joule.

Energy density on P.E. per unit vol^m.

$\boxed{u = \frac{U}{V} = \frac{1}{2} \times \text{stress} \times \text{strain}}$ Joule/m^3. or N-m^{-2}.

$Y = \frac{\text{stress}}{\text{strain}}$ & $\text{strain} = \frac{\text{stress}}{Y}$.

$\boxed{u = \frac{(\text{stress})^2}{2Y}}$



$U = \frac{1}{2} mgl$.

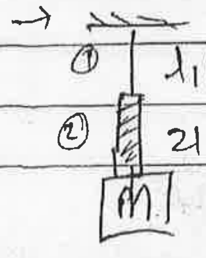
$\Delta l = l$.

store = $\frac{1}{2} mgL$ (gain in PE).

Loss in gravitational P.E. = Mgl.

$\frac{1}{2} mgL$ = Loss in Heat

Q. Find Ratio of elastic potential energy stored in the wires.



① l, r, Y.

② $2l, 2r, 2Y$

$U = \frac{1}{2} \times F \times \Delta l$

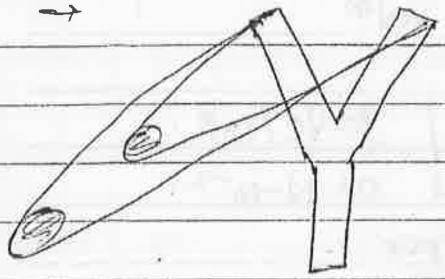
$= \frac{1}{2} \times \frac{F \times F l}{\pi r^2 Y}$

$$\frac{U_1}{U_2} = \frac{l_1}{l_2}\times\left(\frac{r_2}{r_1}\right)^2\times\left(\frac{Y_2}{Y_1}\right)$$

$$= \frac{1}{2}\times\left(\frac{2r}{r}\right)^2\times\frac{2Y}{Y}$$

$$= 4/1.$$

Q. A stone of mass 5 gm is tied with a rubber string of length 10 cm & area of cross-sec 1 cm² in a catapult. Now the string is pulled upto length 15 cm & released. Find speed of projection of stone. ($Y = 8\times10^7$.)



→

$$\frac{1}{2}F\Delta l = \frac{1}{2}mv^2$$

$$\frac{YA\Delta l}{l}\times\Delta l = mv^2$$

$$v = \sqrt{\frac{YA}{ml}}\,\Delta l$$

$$= \sqrt{\frac{8\times10^7\times10^{-4}}{5\times10^{-3}\times10\times10^{-2}}}\times5\times10^{-2}$$

$$= \sqrt{16\times10^6}\times5\times10^{-2}$$

$$= 4\times10^3\times5\times10^{-2} = 200\ ms^{-1}.$$

Q. 2 wires of same metal have diameters in ratio 1:3. Both are stretched by same force. Find ratio of elastic P.E. stored per unit volm in them.

→

$$u = \frac{1}{2}\times\frac{F}{A}\times\frac{\Delta l}{l} \qquad Y = \frac{F/A}{\Delta l/l}$$

$$= \frac{1}{2}\times\frac{F}{A}\times\frac{F}{AY} \qquad \frac{\Delta l}{l} = \frac{F}{AY}$$

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(3) EX-II - 6, 9, 14, 23, 25, III - (17, 19, 21, 23) leave BB-2 icon EX-I - 1-16, 18, 17, 28

PAGE NO.
DATE : / /

$$Y \propto \frac{1}{A^2} \quad [A = \pi r^2]$$

$$Y \propto \frac{1}{r^4} \Rightarrow \frac{Y_1}{Y_2} = \left(\frac{r_2}{r_1}\right)^4$$

$$\Rightarrow \left(\frac{3}{1}\right)^4 = \frac{81}{1}.$$

6/9/19

* Poisson's Ratio (σ) -

Lateral strain $= \frac{\Delta D}{D} = \frac{\Delta r}{r}$.

Longitudinal strain $= \frac{\Delta l}{l}$.

$$\boxed{\sigma = \frac{-\Delta D/D}{\Delta l/l} = \frac{-\Delta r/r}{\Delta l/l}}$$ dimensionless.

$$\boxed{\text{Theoritical value } -1 \le \sigma \le 0.5}$$

Practical value $= 0.2$ to 0.4.

Q. If a wire is stretched & there is no change in its vol^m. Find value of Poisson's ratio.

$\rightarrow$ $V = \pi r^2 l$.

$$\frac{\Delta V}{V} = \frac{2\Delta r}{r} + \frac{\Delta l}{l}.$$

$$\frac{-2\Delta r}{r} = \frac{\Delta l}{l} \Rightarrow \boxed{\frac{-\Delta r/r}{\Delta l/l} = \frac{1}{2}} = 0.5.$$

PAGE NO.
DATE : / /

Relation -

Y, B, η, σ.

$$\boxed{\begin{aligned} &* \; Y = 3B(1-2\sigma). \\ &* \; Y = 2\eta(1+\sigma). \\ &* \; \frac{9}{Y} = \frac{3}{\eta} + \frac{1}{B} \end{aligned}}$$

Interatomic force const. (K)

$\boxed{K = Yr_0}$ Nm^{-1}.

r_0 = interatomic separation.

Q. Y of a material is $\frac{2.4}{\cancel{3}\,4}$ times of η. Find σ.

$\Rightarrow \frac{2.4}{\cancel{4}}\eta = 2\cancel{\eta}(1+\sigma)$

$\Rightarrow 1.2 = 1+\sigma$.

$\sigma = 0.2$.

Q. B and σ of a mat. are 10^{10} Pa. & 0.2. If $r_0 = 1.2\,A^\circ$, find K.

$Y = 3\times10^{10}(1-2\times0.2)$

$Y = 1.8\times10^{10}$ Nm^{-2}.

$K = 1.8\times10^{10}\times1.2\times10^{-10}$

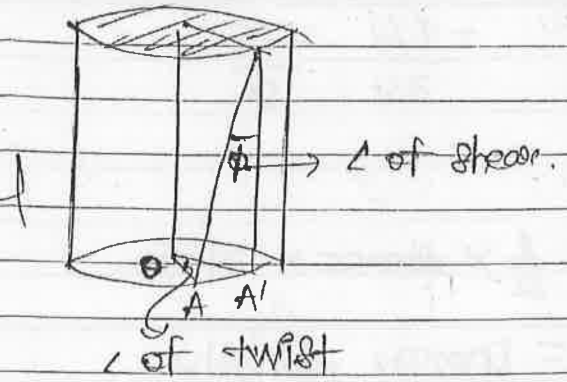
$= 2.16$ N/m.

---

all last 4 Que. on Q.

7, 19, 21, 23.

Relation b/w ∠ of Twist & ∠ of Shear



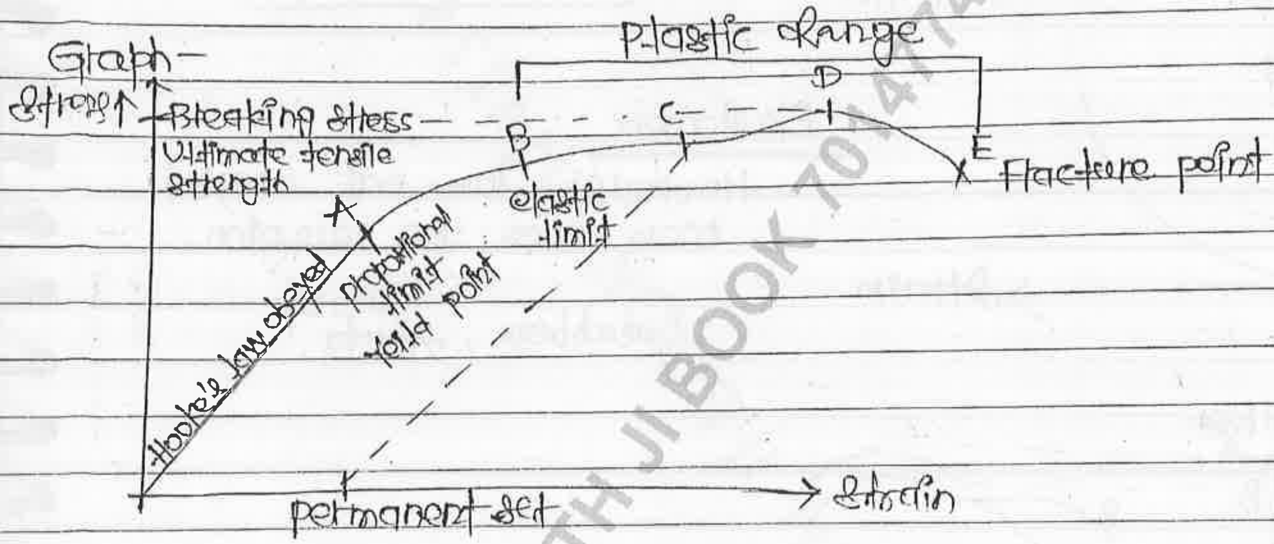
$\theta = \frac{AA'}{r}$

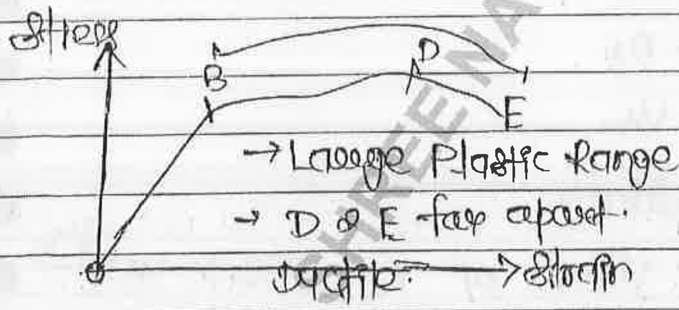
$AA' = r\theta$

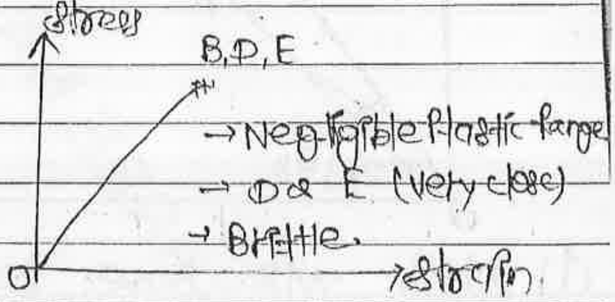
$AA' = l\phi$

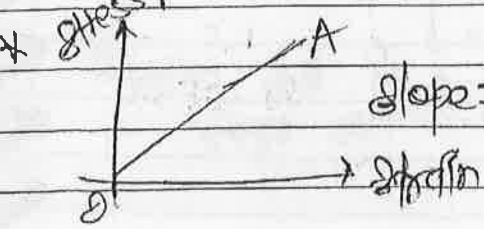
$\boxed{r\theta = \phi l}$

Graph –

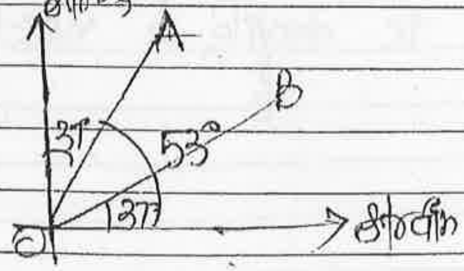






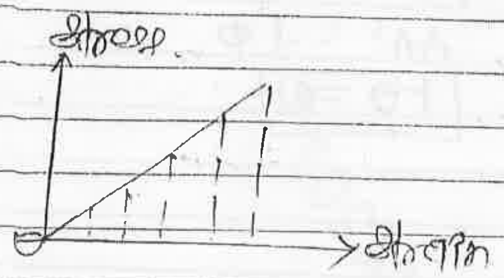


slope = tanθ = Y.



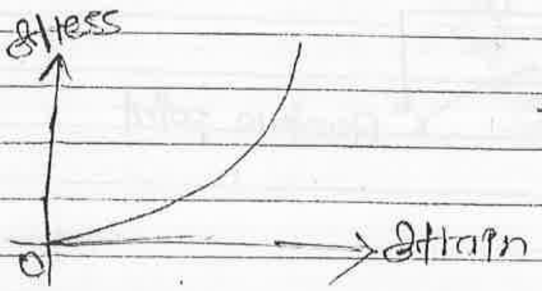
$$\Rightarrow \frac{Y_A}{Y_B} = \frac{\tan\theta_A}{\tan\theta_B} = \frac{\tan 53^\circ}{\tan 37^\circ} = \frac{4/3}{3/4} = \frac{16}{9}.$$

*



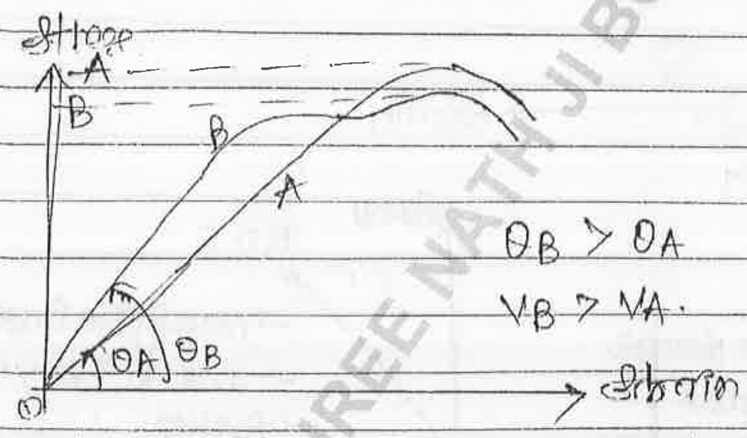
Area = $\frac{1}{2}$ × stress × strain.
= Energy density.

*



Elastomers
Hooke's law not obeyed more over the region.
→ rubber, tissue of Aorta.

Q.



$\theta_B > \theta_A$
$Y_B > Y_A$.

(i) Which wire have larger value of Y. $\theta_B > \theta_A$] $Y_B > Y_A$
(ii) " " is stronger than other. B.S.(A) > B.S.(B).
(iii) Which is ductile & which is brittle.]
B A
A का B.S. ज्यादा है तो strong.

* Thermal stress –

$$\frac{F}{A} = Y \times \frac{\Delta l}{l}$$

$$\boxed{\frac{F}{A} = Y\alpha\Delta\theta} \quad Nm^{-2}.$$

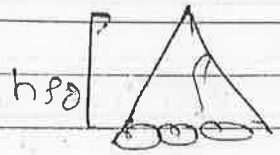
Tension. $\boxed{F = YA\alpha\Delta\theta}$ N.

$$l' = l(1+\alpha\Delta\theta).$$
$$l' = l + l\alpha\Delta\theta.$$
$$\frac{l'-l}{l} = \alpha\Delta\theta.$$
$$\frac{\Delta l}{l} = \alpha\Delta\theta$$

α = coefficient of linear expansion $^{\circ}C$.

$\Delta\theta$ = change in temp.

1.* The max^{m} ht of mountain on earth ~~to~~ can be 10 km.
bcoz, if ht exceeds this, then stress in the base rock, exceeds Breaking stress.



$$BS < h\rho g.$$
$$\frac{BS}{\rho g} < h.$$

7/9/19

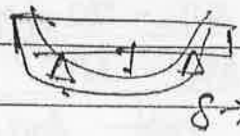
2. Thickness of cable of lift :-

$$B.S. = \frac{W}{A}$$

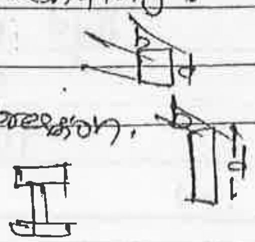
Area of cross-section of lift $\leftarrow$ $A = \dfrac{W}{B.S.}$

3. Girder – A rod having cross-sect^{n} in shape of letter I this rod can tolerate wt. without bending.

$$\delta = \frac{wl}{4bd^3Y}$$



$\delta \rightarrow$ depression.



SURFACE TENSION

PAGE NO.
DATE : 9/9/19

Surface tension is a property of free surface of liquid due to which its free surface tries to minimise its surface area.

Reason → Intermolecular force of attractⁿ or cohesive force.

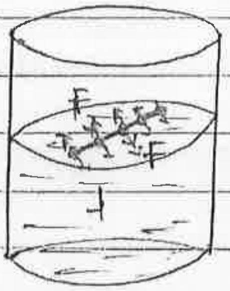
Cohesive force → Force of attractⁿ b/w the molecules of same substance.

* Solid posses definite shape due to strong cohesive force.

* Adhesive force → force of attractⁿ b/w the molecules of different substance.

 Eg. Ink sticks with paper.

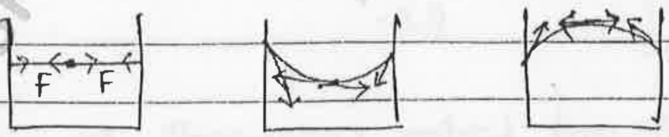
Force Acting on either side of an imaginary line drawn on the free surface of liqd, where the force is ⊥ to the line & along the surface.



$\boxed{T = \frac{F}{l}}$ N/m or dyne/cm.

Scalar $[M^1 L^0 T^{-2}]$.

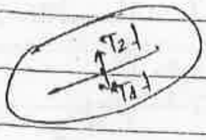
$\boxed{F = Tl}$ → Nature of liqd.



Q. A Matchstick of length 8 cm is placed on surface of a liqd of S.T. 72 dyne/cm. by some process at 1 of its side S.T. is reduced upto 60 cm/dyne. Find net force on the stick

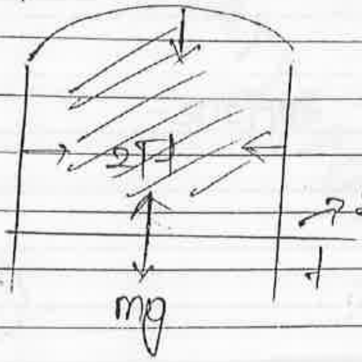
→

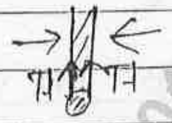
→ $F = Tl$ $\quad T_1 > T_2$.



$$F_{net} = T_1 l - T_2 l$$
$$= (T_1 - T_2) l$$
$$= (72-60) 8$$
$$= 12 \times 8 = 96 \text{ dyne}.$$

Q. A soap soluᵗⁿ film (→ 2 surface) of surface tension 5×10^{-3} N/m is made on a U-shape wire frame A/c to figure. For eqbᵐ of slider. Find its radius. Density of slider $= 5/\pi$ kg/m³

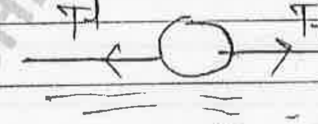


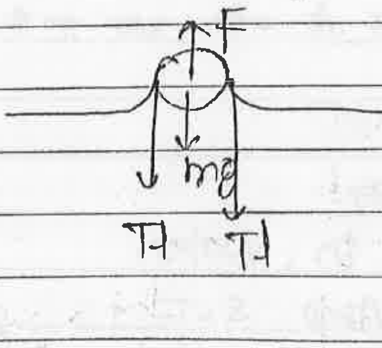


$$\boxed{2Tl = mg} \qquad \boxed{m = \frac{2Tl}{g}}$$

$$2Tl = V\rho g.$$
$$2Tl = \pi r^2 l \rho g.$$
$$r = \sqrt{\frac{2T}{\pi \rho g}} = \sqrt{\frac{2 \times 5 \times 10^{-3}}{\pi \times \frac{5}{\pi} \times 10}}$$
$$= \sqrt{2 \times 10^{-4}} = 1.414 \times 10^{-2} \text{ m}.$$
$$= 1.414 \text{ cm}.$$

Minᵐ force reqd to lift an object from liqᵈ surface -



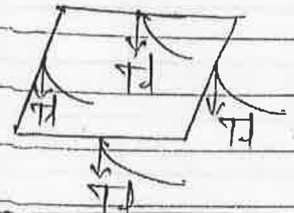


$$\boxed{F_{min} = mg + 2Tl}$$

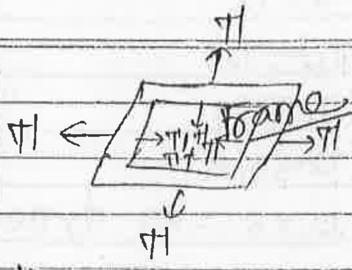
In additⁿ to weight,

$$\boxed{F_{ex} = 2Tl}$$

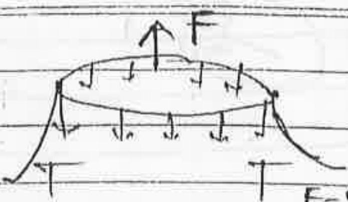
Pg. - 258 - BB 26-1,2,3,4.
269 ~~II - 69, 70, 80, 87, 108~~ II - 27, 30, 34. III - 23.



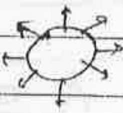
$\boxed{F_{min.} = mg + 4Tl}$



$\boxed{F_{min.} = mg + 8Tl}$



$F = T.l$



$l = 1$, $F = T$

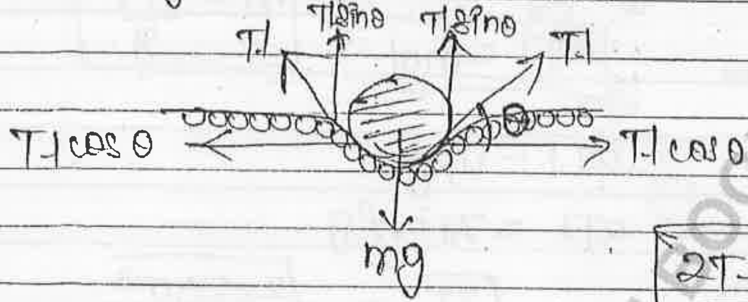
$l = 1$, $F = T$

$l = 2\pi r$, $F = 2\pi r T$

$\boxed{F_{min.} = mg + 2\pi r T}$

$\boxed{F_{min.} = mg + 2 \times 2\pi r T}$

Floating of steel Needle on water surface -



$\boxed{2T.l \sin\theta = mg}$

If not given $\theta = 90°$

$\sin 90° = 1$

$\boxed{W_{max.} = 2T.l}$

S.T. depends on -

1. Temperature -

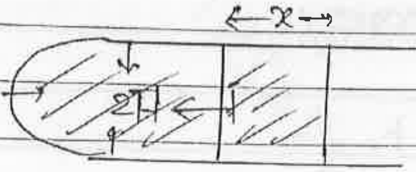
temp. ↑↑, IMFA ↓↓ , S.T. ↓

2. Boiling point - S.T. = 0
critical temp. - S.T. = 0.
↳ इसमें किसी भी कि लगा तो water इतना गुरु से ही नहीं करेगी.

2. Impurities -
(a) soluble - S.T. increases.
eg. NaCl in water.
(b) less soluble - decreases S.T.
eg. soap or detergent in water.

Surface Energy :-

To increase free surface area of a liqd, work has to be done against force of ~~wor~~ surface tension. This work is stored as a P.E. among the molecules in free surface of liqd, so molecules on free surface posses additional energy than the molecules well inside the liqd. This additional energy is c/d surface energy.



$W = Fx$

$W = 2Tl \times x$

$W = T \times 2lx$

$$\boxed{W = \Delta E = T\Delta A}$$

$\Delta A = A_f - A_i$

$\Delta A = 2(lx)$

$= 2 \times (\Delta A)_{upper}$

$$\boxed{T = \frac{\Delta E}{\Delta A} = \frac{W}{\Delta A}} \quad J/m^2$$

→ surface energy stored per unit area is c/d surface tension

→ work done ~~by~~ to ↑ surface area by unit.

Film or bubble

Numerical आएँगे नहीं होगा।

air

$W = T \times 2 (\Delta A)_{upper}$

$1 J = 10^7$ erg

1 erg $= \frac{1}{10^7}$ J

drop

air $W = T (\Delta A)_{upp.}$

Q1. Find work done to ↑ area of a soap sol^n film from 40 cm × 50 cm to 60 cm × 80 cm. ~~ΔT~~ $= T = 75$ dyne/cm

→ $W = T \times 2 (\Delta A)_{upper}$

$= 75 \times 2 (4800 - 2400) = 150 \times 2400$

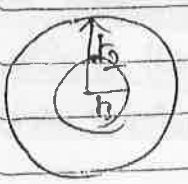
$= 360000$ erg.

$= 0.036$ J

Sp. cases :-

I. Drop :-

1. Work to increase radius of a drop from r_1 to r_2.



$$W = T\,(\Delta A)_{upper}$$
$$= T\,[4\pi r_2^2 - 4\pi r_1^2]$$
$$W = 4\pi T\,[r_2^2 - r_1^2]$$

Increase in surface energy.

2. Work to form a drop of radius r.

$$W = T\,(\Delta A)_{upper}$$
$$= T\,[4\pi r^2 - 0]$$
$$W = 4\pi r^2 T.$$

Total surface Energy.

II. Bubble.

3. Work to increase radius of a bubble from r_1 to r_2

$$W = T \times 2\,(\Delta A)_{upper}$$
$$= T \times 2\,[4\pi r_2^2 - 4\pi r_1^2]$$
$$W = 8\pi T\,[r_2^2 - r_1^2].$$

4. Work to form a bubble of radius r.

$$W = T \times 2 \times (4\pi r^2 - 0)$$
$$W = 8\pi r^2 T.$$

Q. Find work done to make radius of a bubble 3 times of init. init rad. $= r$. & S.T. $= T$.

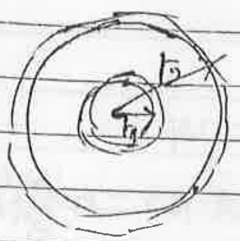
$\rightarrow$

$$W = T \times 2 \times [4\pi r_2^2 - 4\pi r_1^2] \quad \cancel{(9-1)}$$
$$W = 8\pi T[(3r)^2 - r^2] \quad \cancel{= 8\pi r^2 T\,(9-1)}$$
$$\omega = 8\pi r^2 T\,(9-1) \Rightarrow = 64\pi r^2 T.$$

Q. Find work done to ↑ vol^m of soap bubble by 700 % initial reed. 'r' & T.

(1)

→



$W = T \times 2 \times [4\pi r_2^2 - 4\pi r_1^2]$

$W = 8\pi T\,[r_2^2 - r_1^2]$.

$W = 8\pi T\,[(2r_1)^2 - r_1^2]$

$W = 24\pi r^2 T$. $4r^2 - r^2 = 3r^2$

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

$\frac{V_1}{V_2} = \left(\frac{r_1}{r_2}\right)^3$

$\frac{100}{800} = \left[\frac{r_1}{r_2}\right]^3$

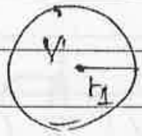
$\frac{1}{2} = \frac{r_1}{r_2}$

$r_2 = 2r_1$

Q. work done to form a water drop of vol^m 'V' is W. Find work done to form a drop of vol^m 2V.

formula

→



$W = T\,[4\pi r_1^2 - 0]$

$W = 4\pi T r_1^2$.

$W_2 = T\,[4\pi r_2^2 - 0]$

$\frac{W_2 = 4\pi T r_2^2}{W = 4\pi r_1^2} = \left(\frac{r_2}{r_1}\right)^2$

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

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

$= (2^2)^{1/3}\, W$

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

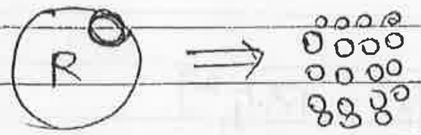
$\frac{V_1}{V_2} = \left(\frac{r_1}{r_2}\right)^3$

$\frac{V}{2V} = \left(\frac{r_1}{r_2}\right)^3$

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

PAGE NO. DATE : / /

5. बड़ी Drop छोटी drop में ~~spray~~ change हो रही —



n droplets each of radius 'r'.

$V_i = V_f$

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

$\boxed{R = n^{1/3} r}$

$r = \frac{R}{n^{1/3}}$

$W = \Delta E = T \times (\Delta A)_{upper}$
$= T[n \times 4\pi r^2 - 4\pi R^2]$

$W = \Delta E = 4\pi T[nr^2 - R^2]$
$= 4\pi T\left[\frac{n \times R^2}{n^{2/3}} - R^2\right]$

$\boxed{W = \Delta E = 4\pi R^2 T[n^{1/3} - 1]}$ change in SE

energy absorbed from surrounding.

Also

$ms\Delta\theta J = 4\pi R^2 T\left[\frac{R}{r} - 1\right] \times \frac{R}{R}$

$\Delta\theta = \frac{4\pi R^3 T}{\frac{4}{3}\pi R^3 \rho s J}\left[\frac{1}{r} - \frac{1}{R}\right]$

$\boxed{\Delta\theta = \frac{3T}{\rho s J}\left[\frac{1}{r} - \frac{1}{R}\right]}$

☆ Surface area ↑. surface energy ↑. Internal energy ↓. temperature of droplet ↓.

so, energy absorbed from surrounding, that's why we feel cool near fountain.

6. small droplet form big drop

coalesc

$\Rightarrow \boxed{W = -4\pi R^2 T[n^{1/3} - 1]}$

-ve surface area decrease.

BB → 6 completely.
I − 71, 88, 90, 92, 99, 101, 102, 106, 107, 140.
II − 10, 20.

PAGE NO.
DATE : / /

decrease in surface energy

$$\boxed{W = 4\pi R^2 T\,[n^{1/3} - 1]}$$ energy released to surrounding.

$\rightarrow [T\uparrow]$

surface area ↓es.
surface energy ↓es.
Internal energy ↑es.
~~dece~~ temp. of droplet ↑es, so energy is released to surrounding.

Q. Some amount of droplets each of radius 'r' coalesc to form a drop of radius R. then w/of is correct –

(1) $4VT\left[\frac{1}{r} - \frac{1}{R}\right]$ energy released.

(2) $3VT\left[\frac{1}{r} + \frac{1}{R}\right]$ energy released.

~~3)~~ $3VT\left[\frac{1}{r} - \frac{1}{R}\right]$. energy released.

4) Energy neither released nor absorbed.

$$W = 4\pi R^2 T\,[n^{1/3} - 1]$$ energy released to surrounding.

$$= 4\pi R^2 T\left[\frac{R}{r} - 1\right]$$

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

$3V = 4\pi R^3$ $$= 3VT\left[\frac{1}{r} - \frac{1}{R}\right].$$

Q. 125 identical droplets coalesce. Find ratio of total final surface energy to total initial surface energy.

$\frac{R}{r} = n^{1/3}$

→ $n_1\ r$ ⟶ R

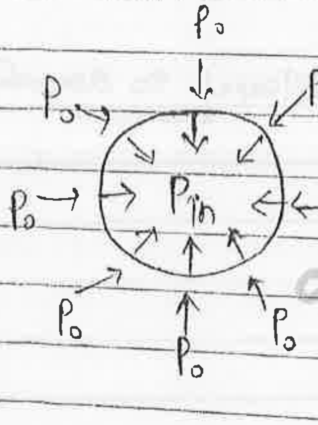
$$\frac{E_f}{E_i} = \frac{T[4\pi R^2 - 0]}{T[4\pi r^2 - 0]} = \frac{1}{n} \times \left(\frac{R}{r}\right)^2$$

$$= \frac{1}{n} \times n^{2/3}$$

$$= \frac{1}{n^{1/3}} = \frac{1}{(125)^{1/3}} = \frac{1}{5}$$

EXCESS PRESSURE :-

The free surface of liq drop tries to minimise its free surface area and compresses the matter enclosed. in eqb^m the pressure inside the drop is more than the pressure outside & the difference of pressure inside & outside is c/d excess pressure.



$P_{in} = P_0 + P_{ex}$

$$\boxed{P_{ex} = P_{in} - P_0}$$

Drop

$$\boxed{P_{ex} = \frac{2T}{r}}$$

Bubble

$$\boxed{P_{ex} = \frac{4T}{r}}$$

PAGE NO.
DATE : / /

Q. Pressure inside two soap bubbles are 1.08 atm & 1.06 atm, find ratio of their surface area.

→ $\frac{P_1}{P_2} = \frac{r_2}{r_1} \Rightarrow \frac{0.08}{0.06} = \frac{r_2}{r_1}$

$\frac{r_1}{r_2} = \frac{3}{4}$

$P_{in} = P_0 + \frac{4T}{r}$

$P_{ex} = \frac{4T}{r}$

$1.08 - 1 = \frac{4T}{r_1}$

$0.08 = \frac{4T}{r_1}$

$\frac{A_1}{A_2} = \frac{2 \times 4\pi r_1^2}{2 \times 4\pi r_2^2}$

$= \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{3}{4}\right)^2 = \frac{9}{16}$

Q. Excess pressure inside a soap bubble is 3 times that of another. Find ratio of their volm.

→ $P_1 = 3P_2 \Rightarrow \frac{P_1}{P_2} = \frac{3}{1}$ $\quad \frac{P_1}{P_2} = \frac{r_2}{r_1}$

$\frac{3\cancel{P_2}}{\cancel{P_2}} = \frac{r_2}{r_1} \Rightarrow \frac{r_1}{r_2} = \frac{1}{3}$

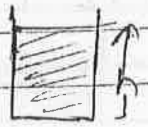
$\frac{V_1}{V_2} = \left(\frac{r_1}{r_2}\right)^3 = \left(\frac{1}{3}\right)^3 = \frac{1}{27}$

Q. Excess pressure inside a water drop is 27 pascal. If 27 such drops coalesc. Find excess pressure in the new drop.

→ $P \quad n, r \longrightarrow R$

$\frac{P_1}{P_2} = \frac{r_2}{r_1} \Rightarrow \frac{27}{P_2} = \frac{R}{r} = \frac{3r}{r} \Rightarrow P_2 = 9$ Pascal

Q. The difference of pressure inside & outside of a bubble of radius 2 millimeter is equal to 8 mm of water column. Find surface tension of soap solⁿ.



→ Rex. = 8 mm.

$P_{in} - P_o = \frac{4T}{r} = h\rho g$

$P_o + h\rho g$.
Water column $= h\rho g$.

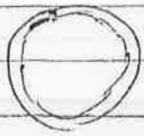
$T = \frac{hr\rho g}{4} = \frac{\overset{2}{\cancel{8}} \times 10^{-3} \times 2 \times 10^{-3} \times 10^3 \times 10}{\cancel{4}}$

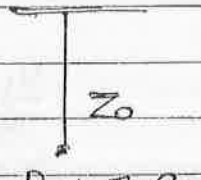
$= 4 \times 10^{-2}\ Nm^{-1}$.

Q. 21 Pressure inside a bubble of radius 1 mm which is made by detergent solⁿ of S.T. 2.5×10^{-2} N/m is equal to the pressure @ a pt. z_0 depth below free water surface. Find value of z_0.

Neet

→ $P_{in} = \cancel{P_0} + \frac{4T}{r} = \cancel{P_0} + z_0 \rho g$





$z_0 = \frac{4T}{r\rho g}$

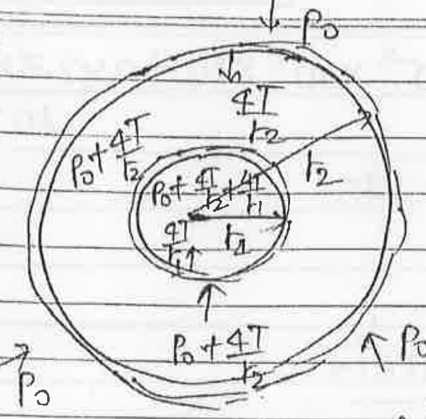
$z_0 = \frac{4 \times 2.5 \times 10^{-2}}{\cancel{10^{-3}} \times \cancel{10^3} \times 10}$

$z_0 = 10.0 \times 10^{-3}\ m.$

$= 10\ mm = 1\ cm$

Q. A soap bubble of radius 4 mm is held inside another soap bubble of rad. 3 mm. Find the rad. of a bubble which have excess pressure equal to the difference of pressure inside the smaller & outside the larger.

→



$$\frac{4T}{r} = \cancel{P_0} + \frac{4T}{r_2} + \frac{4T}{r_1} - \cancel{P_0}$$

$$\frac{1}{r} = \frac{r_1+r_2}{r_1 r_2}$$

$$r = \frac{r_1 r_2}{r_1+r_2} = \frac{1\times 3}{1+4} = \frac{3}{4}$$

$= 0.75$ mm.

but act as a drop.

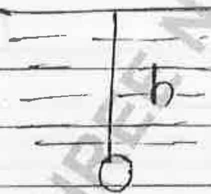
cavity

(a) Bubble just below water surface

$$P_{in} - P_0 = \frac{2T}{r}$$

$$P_{in} = P_0 + \frac{2T}{r} \Rightarrow \boxed{P_{in} - P_0 = \frac{2T}{r}}$$

(b) 'h' depth below.



$$\boxed{P_{in} = P_0 + h\rho g + \frac{2T}{r}}$$

Q. Find Pressure inside a bubble of radius 1 mm held @ a depth of 8 cm below water surface. surface Tension of water 7.3×10^{-2} N/m. ($P_0 = 1.03\times10^5$ Pa)

→ $$P_{in} = P_0 + h\rho g + \frac{2T}{r}$$

$$\cancel{= 1 + 8\times10^{-2}\times1\times10 + \frac{2\times7.3\times10^{-2}}{1\times10^{-}}}$$

$$= 1.013 \times 10^5 + 8\times10^{-2} \times 10^3 \times 10 + \frac{2\times 7.3\times10^{-2}}{10^{-3}}$$

$$= 1.013 \times 10^5 + 800 + 146$$

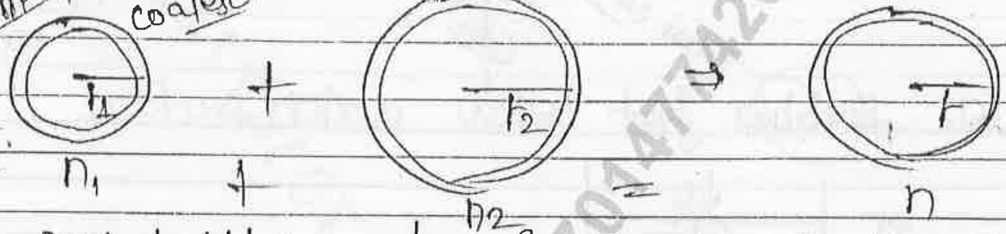
$$= 101300 + 946$$

$$= 102246$$

$$= 1.02246 \times 10^5 \text{ Pascals}$$

Vacuum Isothermally

coalesc



time

$PV = nRT$

If two soap bubbles coalesc in vacuum isothermally, then radius of new bubble -

$$\frac{P_1V_1}{\cancel{RT}} + \frac{P_2V_2}{\cancel{RT}} = \frac{PV}{\cancel{RT}}$$

$$\Rightarrow \frac{4T}{r_1} \times \frac{4}{3}\pi r_1^3 + \frac{4T}{r_2} \times \frac{4}{3}\pi r_2^3 = \frac{4T}{r} \times \frac{4}{3}\pi r^3$$

$$r_1^2 + r_2^2 = r^2$$

$$\boxed{r = \sqrt{r_1^2 + r_2^2}}$$

JEE Main (17)

Q. Two soap bubbles coalesc in air isothermally. If in the process change in vol^m ΔV & change in surface area ΔA. then prove

$\boxed{3P_0\Delta V + 4T\Delta A = 0}$ $\Delta V, \Delta A$

BB→7 → 3,4,5
EX-I → 72, 73, 79, 91, 94, 99, 100, 102, 109
II - 2,
III - 21, 22.

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PAGE NO.
DATE : / /

→ $n_1 + n_2 = n$

$$\left(P_0 + \frac{4T}{r_1}\right)\frac{4}{3}\pi r_1^3 + \left(P_0 + \frac{4T}{r_2}\right)\frac{4}{3}\pi r_2^3 = \left(P_0 + \frac{4T}{r}\right)\frac{4}{3}\pi r^3$$

$$\Rightarrow P_0 \times \frac{4}{3}\pi r_1^3 + \frac{4T}{3} \times 4\pi r_1^2 + P_0 \times \frac{4}{3}\pi r_2^3 + \frac{4T}{3} \times 4\pi r_2^2 = P_0 \times \frac{4}{3}\pi r^3 + \frac{4T}{3} \times 4\pi r^2$$

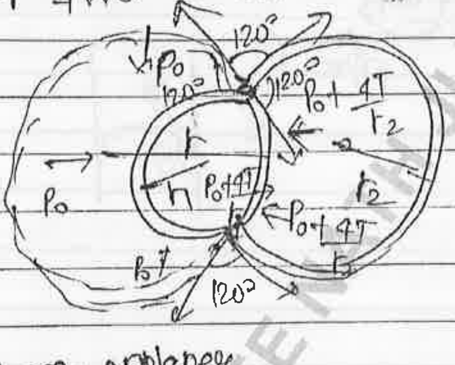
$$\Rightarrow P_0\left(\frac{4}{3}\pi r_1^3 + \frac{4}{3}\pi r_2^3 - \frac{4}{3}\pi r^3\right) + \frac{4T}{3}\left(4\pi r_1^2 + 4\pi r_2^2 - 4\pi r^2\right) = 0$$

$$\Rightarrow P_0 \Delta V + \frac{4T}{3}\Delta A = 0$$

$$\Rightarrow 3P_0 \Delta V + 4T \Delta A = 0.$$

Hence Proved

If two bubbles are kept in contact then Radius of curvature of common interface



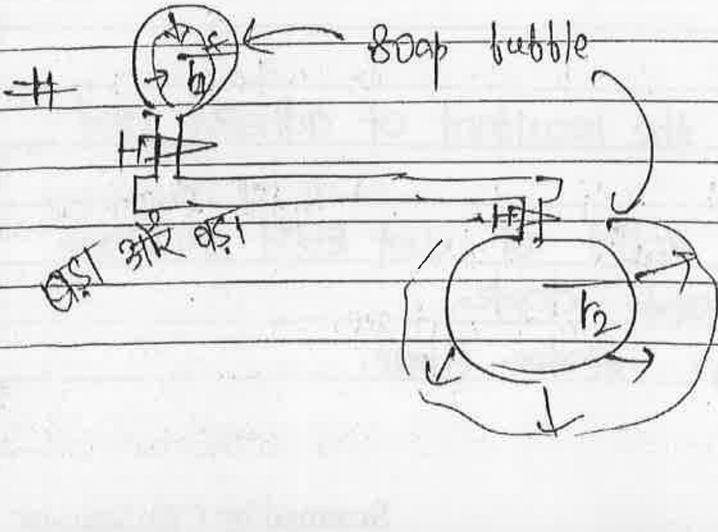
Three coplaner vector → 120° ∠

$$\frac{4T}{r} = P_0 + \frac{4T}{r_1} - \left[P_0 + \frac{4T}{r_2}\right]$$

$$\Rightarrow \frac{4T}{r} = \cancel{P_0} + \frac{4T}{r_1} - \cancel{P_0} - \frac{4T}{r_2}$$

$$\boxed{r = \frac{r_1 r_2}{r_2 - r_1}}$$

#



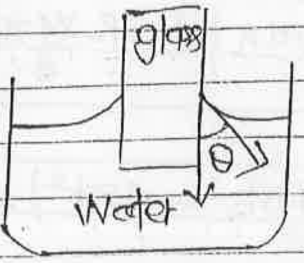
$\uparrow P \propto \frac{1}{r\downarrow}$; Larger expands while small contracts & ultimately collapse.

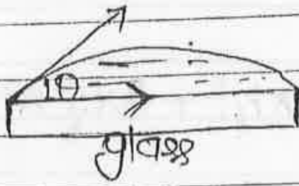
$r_1 < r_2$

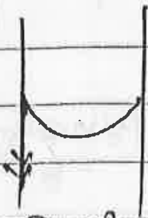
$P_1 > P_2$.

Angle of contact :-

1. water-glass

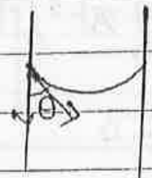






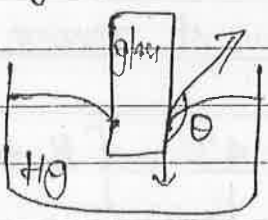
$\theta = 0°$

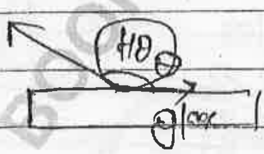
menisus → Hemispherical

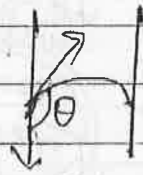


water glass ~8°.
pure-water glass - 0°.
$\theta < 90°$ acute.

2. Hg - glass.

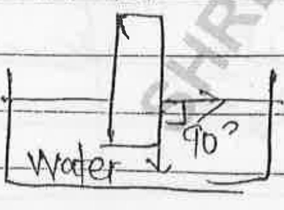






Hg - glass $\theta \sim 135°$.
$\theta > 90°$ obtuse.

3. silver - water.



* ∠ of contact depends on the resultant of adhesive and cohesive force.
* If a liquid spreads over solid or wet solid surface then ∠ of contact is ~~obt~~ acute.

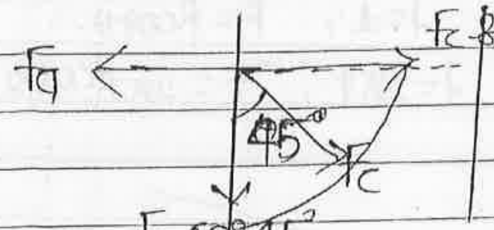
e.g. water glass.

* If liqd doesnot spread over solid ~~or doesnot wet solid~~; then ∠ of contact → obtused. eg. Hg & glass, wax - water, Lotus leaf - water etc.

* water proofing agent converts ∠ of contact from acute to obtuse.

* Angle of contact is independent of inclinatn of solid inside the liqd.

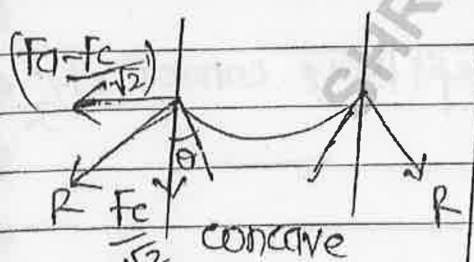
Shape of meniscus.



$F_c \sin 45^\circ = \frac{F_c}{\sqrt{2}}$

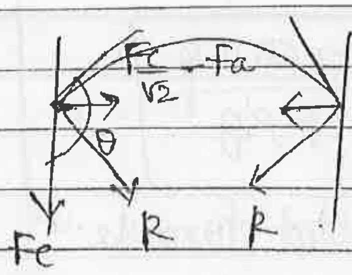
$F_c \cos 45^\circ = \frac{F_c}{\sqrt{2}}$

(a) $F_a > \frac{F_c}{\sqrt{2}}$.



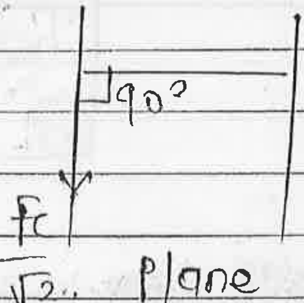
concave
θ<90°
acute

(b) $F_a < \frac{F_c}{\sqrt{2}}$.



convex
θ > 90°

(c) $F_a = \frac{F_c}{\sqrt{2}}$.



Plane
θ=90°.

PAGE NO.
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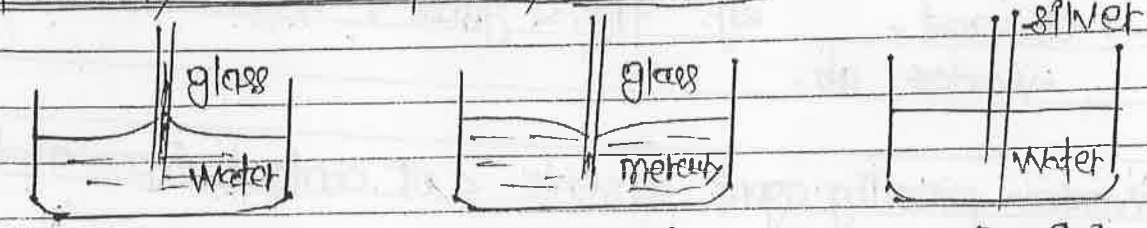
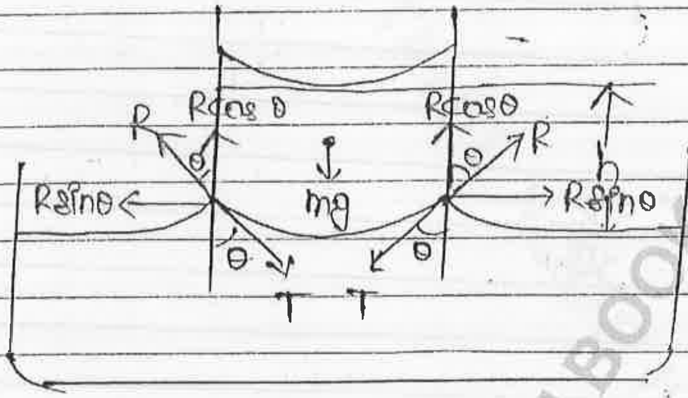
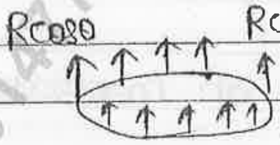
Capillarity or capillary Action :-



$\theta < 90^\circ$ | $\theta > 90^\circ$ | $\theta = 90^\circ$

Liqd wet solid (rise) | Liqd doesnot wet solid (fall) | neither rise nor fall.





$T = R$

$l = 1, \quad F = R\cos\theta.$

$l = 2\pi r, \quad F = 2\pi R\cos\theta.$

$2\pi r R\cos\theta = mg.$

$2\pi r T\cos\theta = V\rho g.$

$2\pi r T\cos\theta = \pi r^2 h\rho g$

$$\boxed{h = \frac{2T\cos\theta}{r\rho g}}$$

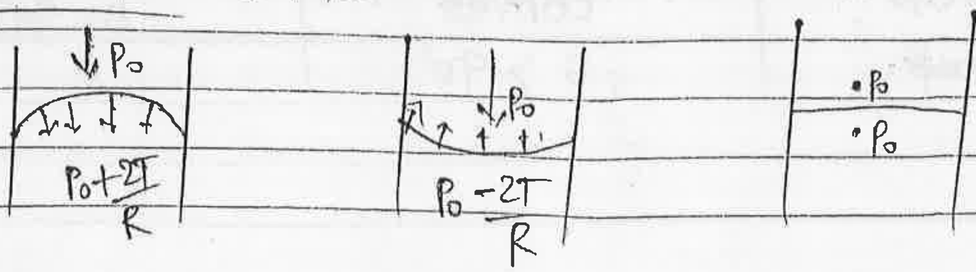
Ascent formula

For approx

$$\left(h + \frac{r}{3}\right) = \frac{2T\cos\theta}{r\rho g}.$$

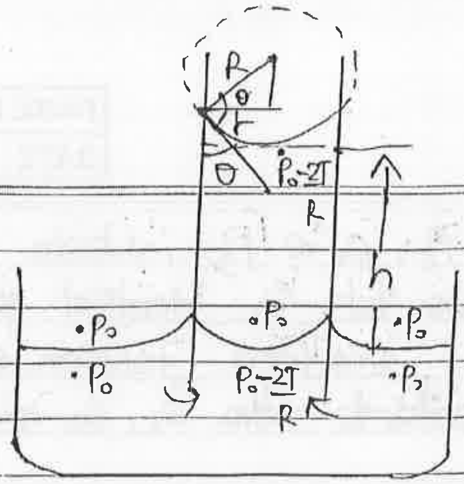
capillary correctn = 1/3.

pressure - volm Balance.



BB-7 → I से 5.
I → 74, 83, 84, 93, 104, 1
II – 7, 32,
III – 9, 10, 11, 12

PAGE NO.
DATE : / /



$h\rho g = \frac{2T}{R}$

$\cos\theta = \frac{r}{R}$, $h\rho g = \frac{2T}{r/\cos\theta}$

$R = \frac{r}{\cos\theta}$

$h\rho g = \frac{2T\cos\theta}{r}$

$$\boxed{h = \frac{2T\cos\theta}{r\rho g}}$$

* $h = \frac{2T\cos\theta}{r\rho g}$ → ht given

* $2\pi r T\cos\theta = mg$ → liqd rise or mass given.

12.09.19

Q. Wt. of water rise in a capillary is 6.28×10^{-4} N, S.T. is 2×10^{-2} N/m. If $\theta = 0°$ find –
(i) radius of the capillary.
(ii) inner circumference.

→ (i) $r = \frac{mg}{2\pi T\cos\theta} = \frac{6.28\times10^{-4}}{2\times3.14\times2\times10^{-2}\times1}$ ⇒ 0.5×10^{-2} mt.

$= 0.5$ cm $= 5$ mm.

(ii) $2\pi r = \frac{mg}{T\cos\theta} = \frac{6.28\times10^{-4}}{2\times10^{-2}\times1} = 3.14\times10^{-2}$

$= 3.14$ cm.

Q. A capillary tube of diameter 1.46×10^{-3} mt. is held vertically in water upto some length. If S.T. is 0.073 N/m. Find the ht upto which water rises.

→ $h = \frac{2T\cos\theta}{r\rho g} = \frac{2\times0.073\times1}{0.73\times10^{-3}\times10^{3}\times10}$

$= \frac{2}{100}$ m $= 2$ cm.

Q. Three liq^ds of densities ρ_1, ρ_2 & ρ_3, where $\rho_1 > \rho_2 > \rho_3$. All rises upto same ht in identical capillaries. All the three have same surface tension. If their corresponding $\angle$ of contacts are θ_1, θ_2 and θ_3. then WOF is correct ?

(i) $\frac{\pi}{2} < \theta_1 < \theta_2 < \theta_3 < \pi$.

(ii) $\pi > \theta_1 > \theta_2 > \theta_3 > \pi/2$.] obtuse

(iii) $\frac{\pi}{2} > \theta_1 > \theta_2 > \theta_3 \geq 0°$,

~~(iv)~~ $0° \leq \theta_1 < \theta_2 < \theta_3 < \pi/2$.] acute

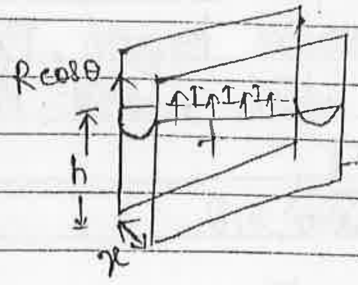
$$h = \frac{2T\cos\theta}{r\rho g} \Rightarrow \uparrow \rho \propto [\cos\theta] \uparrow$$

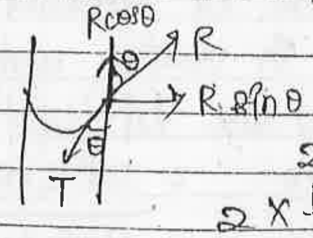
$$\theta \downarrow$$

Rises $\rightarrow \theta_1$ acute

$$0° < \theta_1 < \theta_2 < \theta_3 < \frac{\pi}{2}$$

Q. Two identical rectangular glass plates are kept $\parallel$ to each other with very small separat^th x. Their lower edges touch water. upto what ht. b/w them, water will rise ?

→ 



$l = 1$, $R\cos\theta$

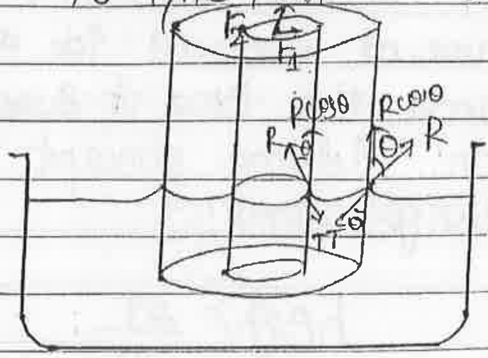
$2 \times l \times R\cos\theta = mg.$

$2 \times l\, T\cos\theta = l \times x \times h \rho g.$

$$\boxed{h = \frac{2T\cos\theta}{x\rho g}}$$

Q. A capillary tube of radius 2 mm is dept vertically in water upto some length. Now a cylindrical glass of rod of radius 1 mm is inserted inside it coaxially. Find ht of water rise.
S.T. = 70 dyne / cm. & $\theta = 0°$.

→

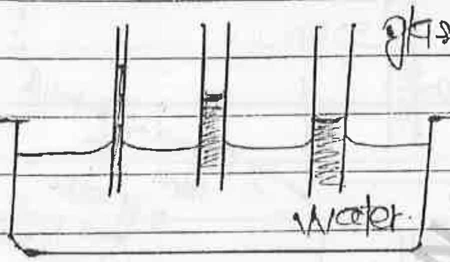


$2\pi r_2 R\cos\theta + 2\pi r_1 R\cos\theta = mg$
$= V\rho g$
$= (\pi r_2^2 - \pi r_1^2) h\rho g$

$2\pi T\cos\theta\,(r_1 + r_2) = \pi(r_2 + r_1)(r_2 - r_1)h\rho g$

$h = \dfrac{2T\cos\theta}{(r_2 - r_1)\rho g} = \dfrac{2 \times 70 \times 1}{(0.2 - 0.1) \times 1 \times 1000}$
$= 1.4$ cm.

case 01



$h = \dfrac{2T\cos\theta}{r\rho g}$

$\boxed{h \propto \dfrac{1}{r}}$

Zuerin's law, $\Rightarrow \boxed{\dfrac{h_1}{h_2} = \dfrac{r_2}{r_1}}$

Eg. If radius is doubled then ratio of P.E. of liqd rised in both case.

→ $\dfrac{U_1 = m_1 g\, h_1/2}{U_2 = m_2 g\, h_2/2}$

$= \dfrac{m_1}{m_2} \times \dfrac{h_1}{h_2}$

$= \dfrac{m}{2m} \times \dfrac{2}{1} = 1:1$

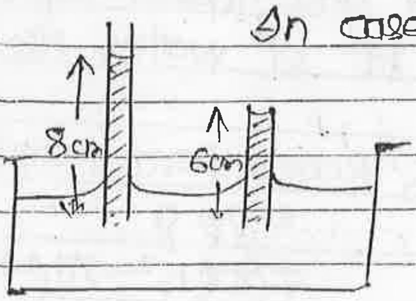
$2\pi r T\cos\theta = mg$

$\boxed{r \propto m}$

$\dfrac{h_1}{h_2} = \dfrac{2r}{r} = \dfrac{2}{1}$

PAGE NO.
DATE : / /

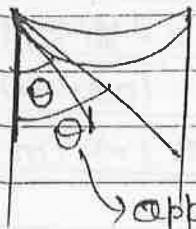
2. In case of insufficient length, liqd fills up to full length, but never spills out because the radius of curvature of meniscus ↑es & balances the force of surface Tension. (same concept in weightlessness)



$2\pi r T \cos\theta$.

$$h\rho g = \frac{2T}{R}$$

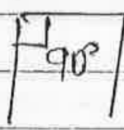
$$\downarrow h \propto \frac{1}{R\uparrow}$$



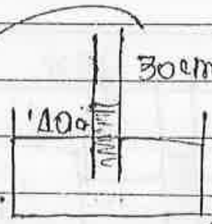
apparant angle of contact.

$2\pi r T(\cos\theta\uparrow) \downarrow$

weightlessness.



$2\pi r T\cos\theta$
$\cos 90° = 0$

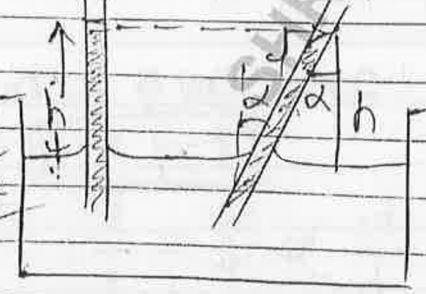


Natural satellite moon नहीं, 0 kt eske mass jyada hote hai. so gravity considerable

upto 30 cm. full length ho jayega

1) free fall
11) Artificial satellite.
111) Center of earth.
1v) Null pt on e in outer space

3.



$h\rho g = \frac{2T}{R}$

ht of meniscus will remain same.

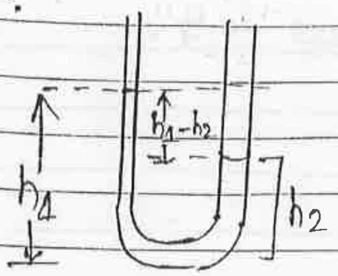
length of the liqd in the tube,

$$\cos\alpha = \frac{h}{l}$$

$$\boxed{l = \frac{h}{\cos\theta}}$$

Scanned by CamScanner

4.



Level of difference,

$$h_1-h_2 = \frac{2T\cos\theta}{r_1\rho g} - \frac{2T\cos\theta}{r_2\rho g}$$

$$\boxed{h_1-h_2 = \frac{2T\cos\theta}{\rho g}\left[\frac{1}{r_1}-\frac{1}{r_2}\right]}$$

13.9.19

Q. Two capillaries of diameter 1 mm and 2 mm are connected and some water is poured in 1 arm. Find level diff. of water in both arms. T = 70 dyne/cm. & $\theta = 0°$

→ $$h_1-h_2 = \frac{2T\cos\theta}{\rho g}\left[\frac{1}{r_1}-\frac{1}{r_2}\right]$$ radius.

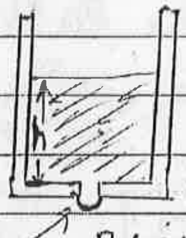
$$= \frac{2\times 7\cancel{0}\times 1\times 2}{1\times 100\cancel{0}}\left[\frac{1}{0.1}-\frac{1}{0.2}\right]$$

$$= \frac{\cancel{2}\times 7\times 2}{1\cancel{00}}\times\frac{(0.2-0.1)}{0.1\times 0.\cancel{2}} = 14\times 0.1 = 1.4\ cm.$$

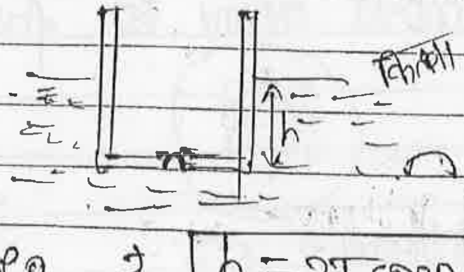
* $h = \dfrac{2T\cos\theta}{r\rho g}$ * $\downarrow h \propto \dfrac{1}{g\uparrow}$ * $g_{moon} = \dfrac{g_{earth}}{6}.$

* $h_{moon} = 6\, h_{earth}.$

* Max^m ht upto which water can be filled without leakage.



किसी पानी भरी नली में पानी का बाहर निकलना.

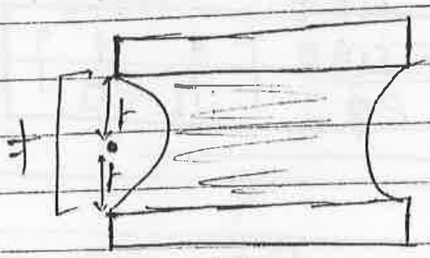


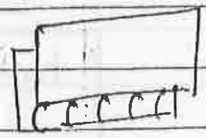
किसी dip करें पानी का Enter करें.

orifice

$$P_0 + \frac{2T}{R} = P_0 + h\rho g \Rightarrow \boxed{h = \frac{2T\cos\theta}{r\rho g}}$$

* Min^m force require to separate 2 glass plates which held a water film in b/w them of thickness → t.





$t = 2r$
$r = t/2$

glass plate

$$P_{ex} = \frac{T}{r}$$

$$\frac{F}{A} = \frac{T}{t/2} \Rightarrow \boxed{F = \frac{2TA}{t}}$$

for eg. Q. A water film of vol^m 0.05 cm^3 is held b/w 2 glass plates. of thickness 0.1 cm. Find min^m force require to separate them. $T = 70$ dyne/cm

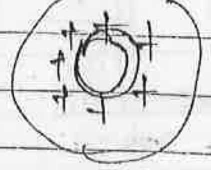
→ $V = At$

$$A = \frac{V}{t} = \frac{0.05}{0.1} = 0.5 \text{ cm}^2$$

$$F = \frac{2TA}{t} = \frac{2 \times 70 \times 0.5}{0.1}$$

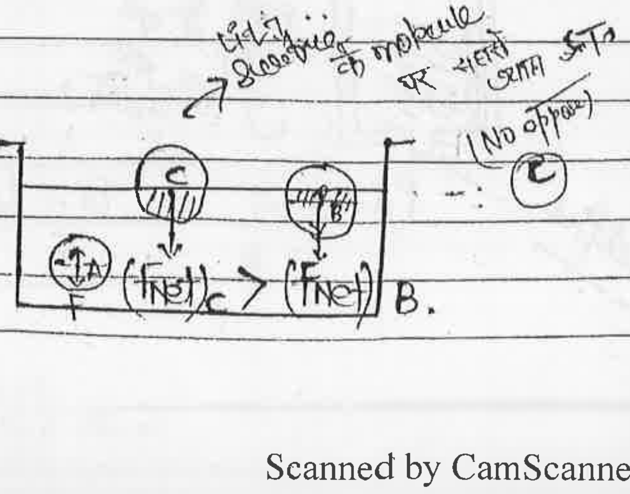
$$F = 700 \text{ dyne}$$

* If a soap bubble is charged, then due to mutual repulsion, it tries to move away @ farthest distance. so its vol^m Ies.



*sphere of influence → 10^{-9} m.

molecule



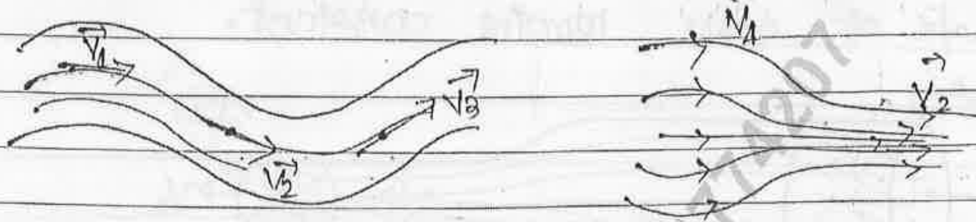
Fluid Dynamics

PAGE NO.
DATE : / /

Nature of flow -

I. Stream line flow -

During the flow of a fluid at a time, each molecule passes with same velocity both in magnitude & dirn, their paths are stream line which does not intersect.



$|\vec{V_1}| < |\vec{V_2}|$

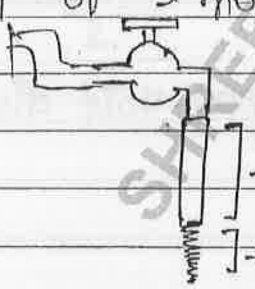
II. Laminar Flow -

At different points in the flow, magnitude of velocities may be different but their dirns are ∥.

$|\vec{V_1}| > |\vec{V_2}|$

III. Turbulent Flow -

If speed of flow exceeds critical speed, then motn of molecules becomes irregular.



* Ideal Fluid -

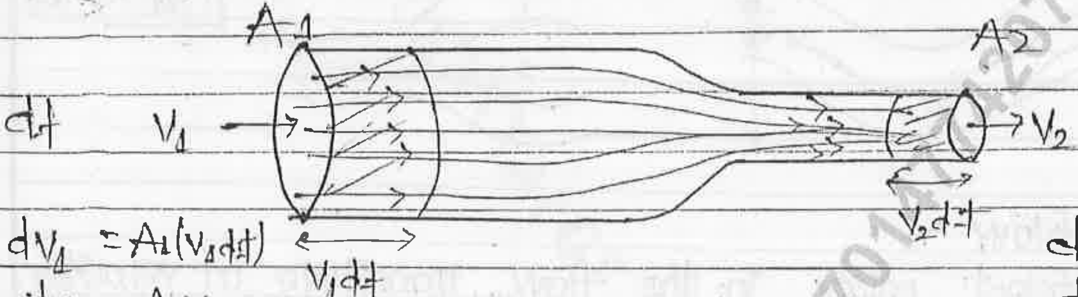
→ Incompressible. $\Delta V = 0$, $\rho =$ const.
$B = \infty$.

→ Non-viscous fluid dejtn viscosity $= 0$.

→ Streamline or steady.

Equation of continuity :-

During an ideal fluid flow at each and every point the vol^m flowing per unit time or rate of flow remains const. If area of cross-sect^n ↓es then speed of flow ↑es in a way that rate of flow remains constant.



$dV_1 = A_1(v_1 dt)$ $\qquad$ $dV_2 = A_2(v_2 dt)$

$\frac{dV_1}{dt} = A_1 V_1$ $\qquad$ $\frac{dV_2}{dt} = A_2 V_2$

$$\frac{dm_1}{dt} = \frac{dm_2}{dt}$$

$$\frac{dV_1}{dt}\rho = \frac{dV_2}{dt}\rho$$

$$\boxed{A_1 V_1 = A_2 V_2}$$

$$\boxed{\frac{dV}{dt} = AV = \text{constant}} \quad m^3/s \text{ or } \frac{\text{Litre}}{s}$$

Rate of flow or vol^m flowing per unit time.

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

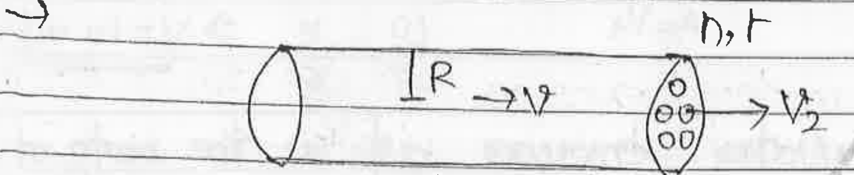
$$\boxed{\frac{V_1}{V_2} = \frac{A_2}{A_1} = \left(\frac{r_2}{r_1}\right)^2}$$

$\boxed{r_1^2 V_1 = r_2^2 V_2}$ $\qquad$ $\boxed{1 \text{ Litre} = 10^{-3} m^3}$

Q. One end of a horizontal tube of radius 8 cm is closed with a plate having 40 narrow holes each of radius 1 mm. If speed of water flow in the tube is 10 cm s^{-1}. Find the speed of water emerges out of each hole.

(No Press. → Eqn of continuity only speed, area.

→



$A_1V_1 = A_2V_2$

$V_2 = \frac{A_1V_1}{A_2}$

$= \frac{\cancel{\pi}R^2}{n \times \cancel{\pi}r^2} \times v$

$V_2 = \left(\frac{R}{r}\right)^2 \frac{v}{n}$

$V_2 = \left(\frac{8}{0.1}\right)^2 \times \frac{10}{40}$ cm/s.

$= \cancel{6400}^{1600} \times \frac{10}{\cancel{40}}$ cm/s.

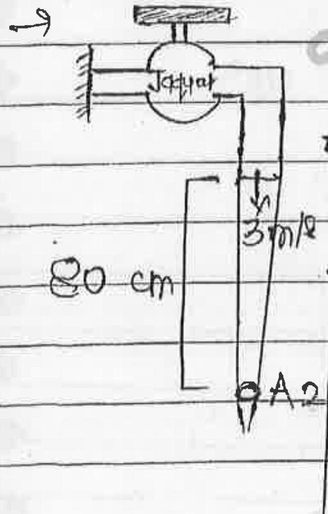
$= 1600$ cm/s.

$= 16$ cm/s.

Q. Water stream emerges out from a tap of area of cross-sectn 2 cm^2 with speed 3 m/s. Find area of cross-sectn of stream 80 cm below the tap.

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

→



$A_1V_1 = A_2V_2$

$A_1 = 2 cm^2$. $A_2 = \frac{V_1}{V_2} A_1$

So narrower to maintain Rate of flow

$V_2^2 = u^2 + 2as$

$= 9 + 2 \times 10 \times 0.8$

$= 9 + 16$

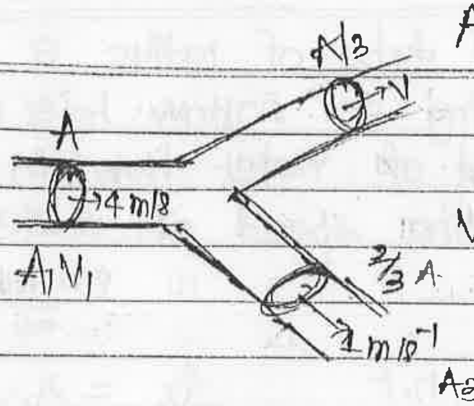
$V_2^2 = 25$

$V_2 = 5$ m/s.

$= \frac{3}{5} \times 2$ cm^2.

$= \frac{6}{5}$ cm^2 $= 1.2$ cm^2.

Q.



$A_1V_1 = A_2V_2 + A_3V_3$

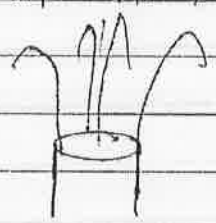
$\Rightarrow A \times 4 = \frac{A}{3} \times V + \frac{2}{3} \cancel{A} \times 1$

V?

$\Rightarrow 4 - \frac{2}{3} = \frac{V}{3}$

$\frac{10}{\cancel{3}} = \frac{V}{\cancel{3}} \Rightarrow \underline{V = 10\ m/s}$

Q. From a fountain water emerges out @ the rate of 3000 lit./min. and attains a ht. 10 mt. Find area of cross-sectⁿ. ($g = 9.8\ m/s^2$)



$\rightarrow$ $\frac{dV}{dt} = AV$

$\frac{\overset{5}{\cancel{30}}00 \times 10^{-3}}{\cancel{60}} \frac{m^3}{s} = A \times \sqrt{2gH}$

$5 \times 10^{-2} = A\sqrt{2 \times 9.8 \times 10}$

$= A\sqrt{196}$

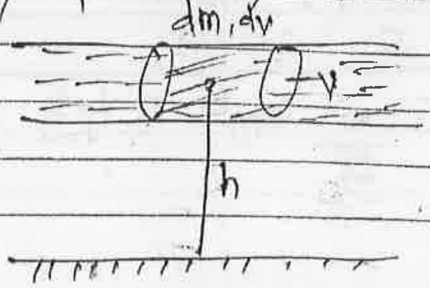
$A = \frac{5 \times 10^{-2}}{14} m^2$

$\Rightarrow A = \frac{5 \times 10^{-2} \times 10^4}{14} cm^2$

$= \frac{\cancel{500}\ \cancel{250}}{\cancel{14}\ 7} = 35.5\ cm^2$.

$\times$

* Energy possessed by flowing fluid -



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BB-4 -1
Ex I-46-48
53, 54,
57, 59.
II-3, 8, 13, 17
31.

PAGE NO.
DATE : / /

1. per unit vol^m K.E.

$$\frac{K.E.}{dV} = \frac{1}{2}\frac{dm}{dV}v^2$$

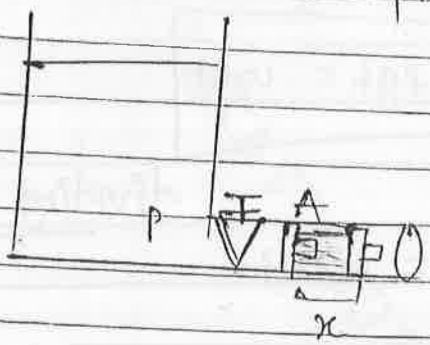
$$= \frac{1}{2}\rho v^2.$$

2. per unit vol^m P.E.

$$\frac{P.E.}{dV} = \frac{dm}{dV}gh.$$

$$= \rho g h.$$

3. per unit volume pressure energy -



$W = Fx$

$= PAx$.

$W = Pdv$

$\frac{W}{dv} = P.$

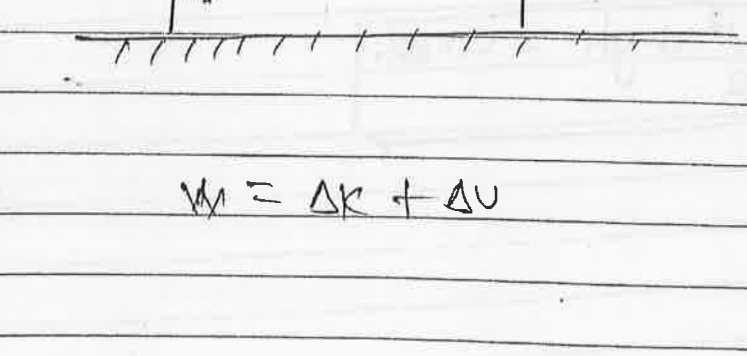
$P = \frac{F}{A}$

$F = PA$ (ma)

—— X ——

Bernaulli's Theorem :-

During an ideal fluid flow, the sum of per unit vol^m pressure energy, per unit vol^m K.E. & per unit vol^m P.E. @ each & every point remains constant.



$W = (P_1 - P_2)\, dV.$

$\Delta K = \frac{1}{2} dm (v_2^2 - v_1^2)$

$W = \Delta K + \Delta U$

$\Delta U = dmg (h_2 - h_1)$

PAGE NO.
DATE : / /

$$(P_1 - P_2)\, dV = \frac{1}{2} dm\ (V_2^2 - V_1^2) + dmg\ (h_2 - h_1).$$

$$P_1 - P_2 = \frac{1}{2} \rho\ (V_2^2 - V_1^2) + \rho g\ (h_2 - h_1)$$

$$P_1 + \frac{1}{2}\rho V_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho V_2^2 + \rho g h_2$$

$$\boxed{P + \frac{1}{2}\rho V^2 + \rho g h = \text{const}}$$

16.9.19

dividing by ρg

$$\frac{P}{\rho g} + \frac{V^2}{2g} + h = \text{const.}$$

Pressure head ↓ gravitational head.

velocity head

$\boxed{\text{per unit mass}}$, $\frac{KE}{dm} = \frac{1}{2}\frac{dm V^2}{dm} = \frac{V^2}{2}$.

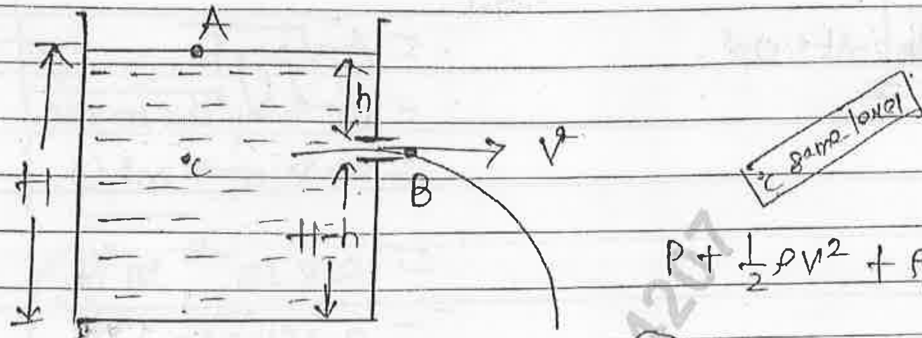
— " — , $\frac{PE}{dm} = \frac{dm\, gh}{dm} = gh.$

— " — $= \frac{P dV}{dm} = \frac{P}{\rho}.$

$$\boxed{\frac{P}{\rho} + \frac{V^2}{2} + gh = \text{const.}}$$

Applicatn →

I. Speed of Efflux :-



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

$v_1 << v_2$

A surface — B

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

$$P_0 + 0 + \rho g H = P_0 + \frac{1}{2}\rho v^2 + \rho g (H - h)$$

$$\cancel{\rho g H} = \frac{\rho}{2} v^2 + \cancel{\rho g H} - \rho g h$$

$$\frac{v^2}{2} = gh$$

$$\boxed{v = \sqrt{2gh}}$$

Torricelli's theorem →

speed of efflux = speed acquired by the particle falling freely in air from level of water to the orifice.

Q. Pressure at the bottom of a water filled open container is 3 atm. There is an orifice of area 1 cm^2 at its base. Find the vol^m of water emerges out in 1 sec. initially.

$$\frac{dV}{dt}$$

$$\frac{dV}{dt} = AV$$

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

$$= 10^{-4}\sqrt{2\times10\times20}$$

$$= 20\times10^{-4}\ m^3/s.$$

$$= 2\times10^{-3}\ m^3/s$$

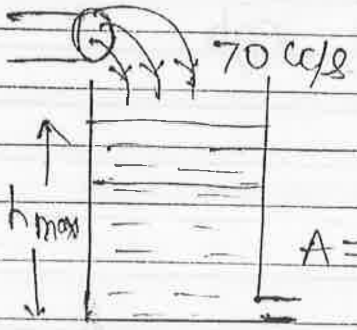
$$= 2\ \text{Liter}/s.$$

$P = P_0 + h\rho g.$

$3P_0 = P_0 + h\rho g$

$h = \frac{2\times10^5}{10^3\times10} = 20$

Q. Water is poured in an open container at the rate 70 cc/s. There is an office at its base. Find the max^m ht. upto which water can be filled in the container. (area of orifice = 1 cm²).

→ 

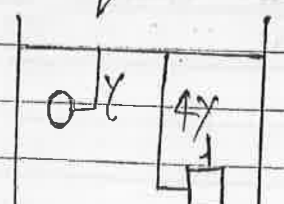
$$\frac{dV}{dt} = AV.$$

$$\left(\frac{dV}{dt}\right)_{in} = \left(A\sqrt{2g\,h_{max}}\right)_{out}$$

$$70 = 1\sqrt{2\times980\times h_{max}}$$

$$h_{max} = \frac{4900}{2\times980} = \frac{10}{4} = 2.5\ cm.$$

Q. If vol^m emerging out per sec from both holes are equal find radius of circular hole in terms of side 'l' of square hole.

→ 

$$\left(\frac{dV}{dt}\right)_1 = \left(\frac{dV}{dt}\right)_2$$

$$A_1V_1 = A_2V_2$$

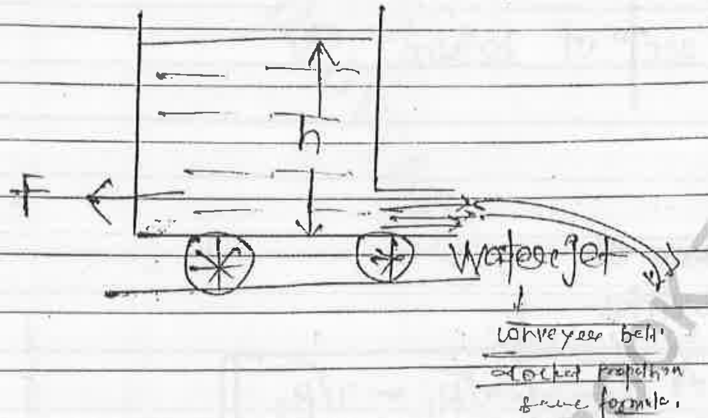
$$A_1 v_1 = A_2 v_2.$$

$$\pi R^2 (\sqrt{2gy}) = 1^2 \sqrt{2g \times 4y}$$

$$\pi R^2 = 1^2 \times 2.$$

$$\boxed{R = \sqrt{\frac{2}{\pi}}\, l}$$

Q. When water emerges out. Find the H.Z force on container



$$F = v\frac{dm}{dt}$$

$$= v\left(\frac{dV}{dt}\right)\rho$$

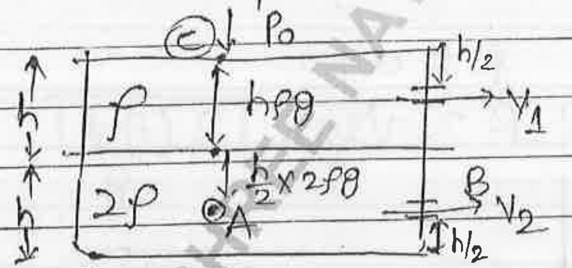
$$= v(Av)\rho.$$

$$F = Av^2\rho.$$

$$= A(2gh)\rho.$$

$$\boxed{F = 2gAh\rho}$$

Q. Find the ratio speed of fluid emerging out of fluids.



$$V_1 = \sqrt{2g\,h/2} = \sqrt{gh} \quad -① $$

A B

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

$$P_0 + h\rho g + \frac{h}{2}\times 2\rho g = P_0 + \rho V_2^2.$$

$$2gh = V_2^2.$$

$$\boxed{V_2 = \sqrt{2gh}} \quad ②$$

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

PAGE NO.

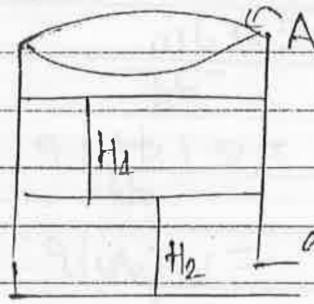
DATE: / /

(C) (B)

$$P_0 + 0 + \rho g h + 2\rho g h = P_0 + \frac{1}{\cancel{2}} \times \cancel{2}\rho V_2^2 + \frac{h}{\cancel{2}} \times \cancel{2}\rho g.$$

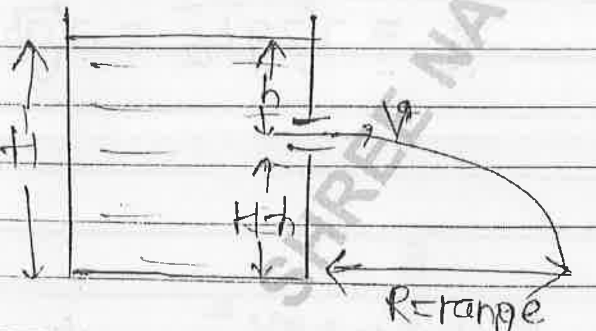
$$3h\rho g - h\rho g = \rho V_2^2$$

Time taken by the level to fall from H_1 to H_2 above orifice.



$$\boxed{t = \frac{A}{a}\sqrt{\frac{2}{g}}\left[\sqrt{H_1} - \sqrt{H_2}\right]}$$

Range of field →



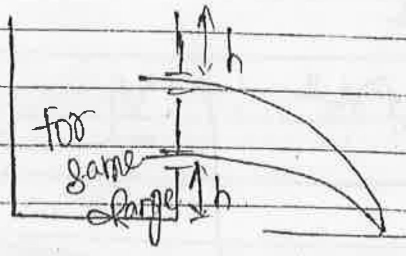
$$R = uT$$

$$R = \sqrt{2gh}\sqrt{\frac{2(H-h)}{g}}$$

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

For max^m Range, $\boxed{h = \frac{H}{2}}$

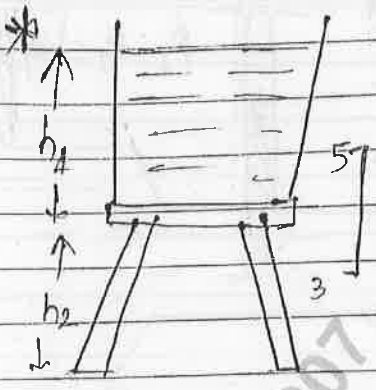
$$\boxed{R_{max} = H}$$



H.W → BB → 4 → 2
Ex-I → ~~50, 53, 54, 57,~~
II → ~~1, 3, 8, 33~~
III − 18, 19.
P-2 → 2, 3, 4, 5, 16,

PAGE NO.
DATE : / /

10 m		
9 m	1×9	9
8 m	2×8	16
7 m	3×7	21
6 m	4×6	24
5 m	5×5	25
4 m	6×4	24
3 m	7×3	21



For maxm range

$$\boxed{h = \frac{h_1 + h_2}{2}}$$

then base

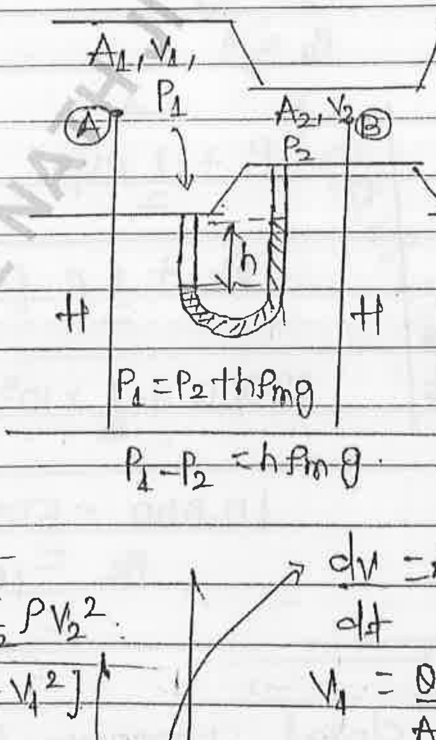
RCT ag-n start,

18.9.19.

2, Venturimeter −

Eqn of continuity
$A_1 > A_2$.
$V_1 < V_2$.

Bernoulli's
$\uparrow P + \frac{1}{2}\rho v^2 \downarrow = \text{const.}$
$V_1 < V_2$,
$P_1 > P_2$



$P_1 - P_2 = h\rho_m g$.

A B

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

$$\boxed{P_1 - P_2 = \frac{1}{2}\rho[V_2^2 - V_1^2]}$$

$h\rho_m g = \frac{1}{2}\rho[V_2^2 - V_1^2]$

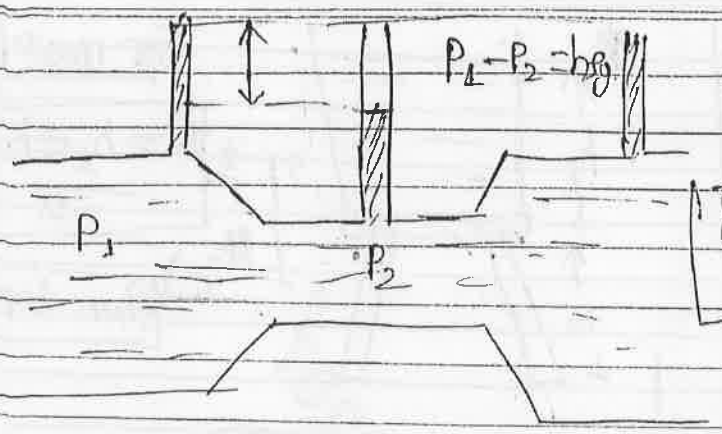
$\frac{dv}{dt} = A_1V_1 = A_2V_2 = Q$

$V_1 = \frac{Q}{A_1}$, $V_2 = \frac{Q}{A_2}$.

$h\rho_m g = \frac{1}{2}\rho\left[\frac{Q^2}{A_2^2} - \frac{Q^2}{A_1^2}\right]$

$$\boxed{h\rho_m g = \frac{1}{2}\rho Q^2\left[\frac{A_1^2 - A_2^2}{A_1^2 A_2^2}\right]}$$

Bernoulli → Pr. 4.



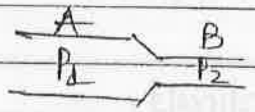
$$\boxed{h\rho g = \frac{1}{2}\rho\left[V_2^2 - V_1^2\right]}$$

Q. Water is flowing through a horizontal tube of cross-section 10 cm² with speed ~~2~~ 5 m/s. pressure is 10 k pascal. At a place where area of cross-section is 5 cm². Find pressure.

→ $A_1 = 10\,cm^2$ $\quad A_2 = 5\,cm^2$

$V_1 = 5\, m/s$ $\quad V_2 = ?$

$P_1 = 10{,}000\ Pa$ $\quad P_2 = ?$



$A_1V_1 = A_2V_2$

$V_2 = \frac{A_1V_1}{A_2}$

$= \frac{10 \times \cancel{2}}{5}$ ~~= 10 m/s~~ $= 4\ m/s$

A B

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

$P_1 + \frac{1}{2}\rho\left[V_1^2 - V_2^2\right] = P_2$

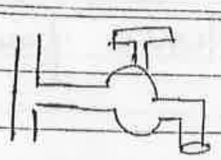
$10{,}000 + \frac{1}{2} \times 10^3 \left[4 - 16\right] = P_2$

$10{,}000 - 500 \times 12 = P_2$

$P_2 = 10000 - 6000$

$= 4000$ Pascal

Q. When tap is closed pressure in the tube is 2.5×10^5 Pascal when tap is opened, pressure in the tube is 2×10^5 Pascal. Find speed of flow of water.

→ 

$$\underset{A}{P_1 + \frac{1}{2}\rho V_1^2} = \underset{B}{P_2 + \frac{1}{2}\rho V_2^2}.$$

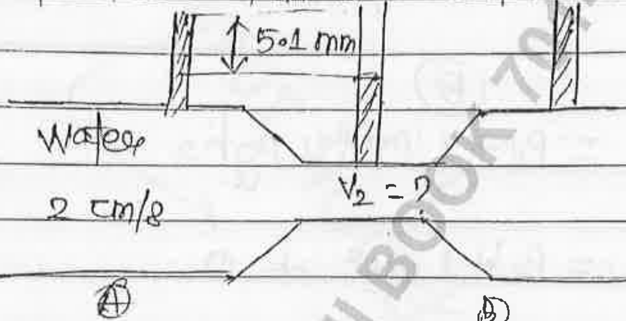
$$2.5 \times 10^5 + 0 = 2 \times 10^5 + \frac{1}{2} \times 10^3 \times V_2^2.$$

$$0.5 \times 10^5 = 500 V_2^2$$

$$V_2^2 = \frac{0.5 \times 10^5}{500} = 100.$$

$$V_2 = 10 \text{ m/s.}$$

Q. Find speed in narrower sect^n. $V_2 = ?$



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

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

$$h\rho g + \frac{1}{2}\rho V_1^2 = \frac{1}{2}\rho V_2^2$$

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

$$= 2 \times 1000 \cdot \times 0.51 + 4.$$

$$= 1020 + 4.$$

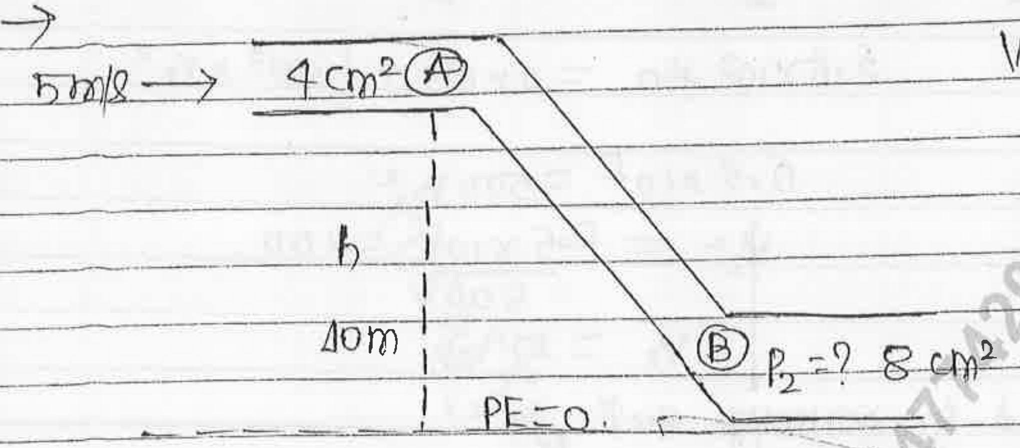
$$V_2^2 = 1024. \Rightarrow V_2 = 32 \text{ cm/s.}$$

Q. Water is flowing through a tube of cross-sect^n 4 cm^2 with speed 5 m/s. Water gradually descends by 10 m. Whereas cross-sect^n becomes 8 cm^2. If pr. in the upper

Exm

part is 1.5×10^5 Pa. Find pressure at the lower part.

→



$V_2 = \frac{A_1 V_1}{A_2}$

$= \frac{4}{8} \times 5$

$= 2.5$ m/s

A B

$P_1 + \frac{1}{2}\rho V_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho V_2^2 + \rho g h_2$

$P_1 + \frac{1}{2}\rho V_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho V_2^2 + 0.$

$P_1 + \frac{1}{2}\rho\ [V_1^2 - V_2^2] + \rho g h_1 = P_2.$

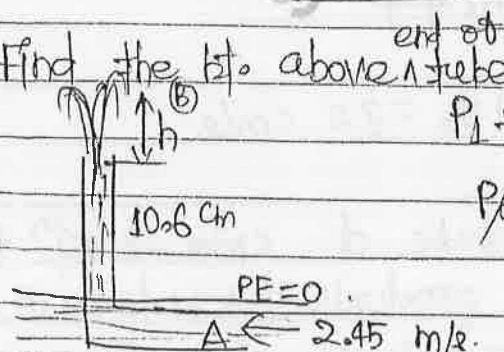
$1.5 \times 10^5 + \frac{1}{2} \times 10^3\ [25 - 6.25] + 10^3 \times 10 \times 10 = P_2.$

$1.5 \times 10^5 + 500\ [18.75] + 10^5 = P_2.$

$P_2 = 2.5 \times 10^5 + 0.09375 \times 10^5$

$P_2 = 2.59375 \times 10^5$ Pascal.

Q. Find the ht. above end of the tube where water spills out.



$P_1 + \frac{1}{2}\rho V_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho V_2^2 + \rho g h_2.$

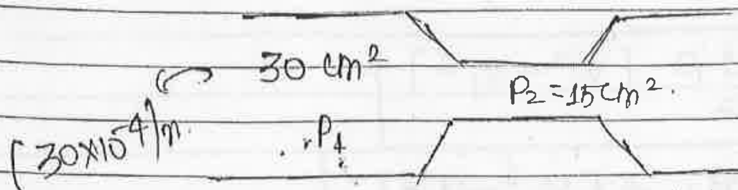
$\cancel{P_0} + \frac{1}{2}\cancel{\rho} V_1^2 + 0 = \cancel{P_0} + 0 + \cancel{\rho} g\,(10.6 \times 10^{-2} + h)$

$10.6 \times 10^{-2} + h = \frac{V_1^2}{2g}$

$h = \frac{2.45 \times 2.45}{2 \times \cancel{9.8}\ 4} - 10.6 \times 10^{-2} = 30.6 - 10.6$

$= 20$ cm.

Q. Find vol^m flowing per unit time through the tube.



$P_1 - P_2 = 600 N/m^2$.

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

$P_1 - P_2 = \frac{1}{2} \rho Q^2 \left[\frac{A_1^2 - A_2^2}{A_1^2 A_2^2} \right]$

$600 = \frac{1}{2} \times 10^3 \times Q^2 \left[\frac{900 \times 10^{-8} - 225 \times 10^{-8}}{900 \times 10^{-8} \times 225 \times 10^{-8}} \right]$.

$1.2 = Q^2 \left[\frac{\cancel{675}^{225} \times \cancel{10^{-8}}}{\cancel{900}_{300} \times \cancel{225} \times \cancel{10^{-16}} 10^{-8}} \right]$

$1.2 = \frac{Q^2}{300 \times 10^{-8}}$

$Q^2 = 360 \times 10^{-8}$
$= 36 \times 10^{-7}$

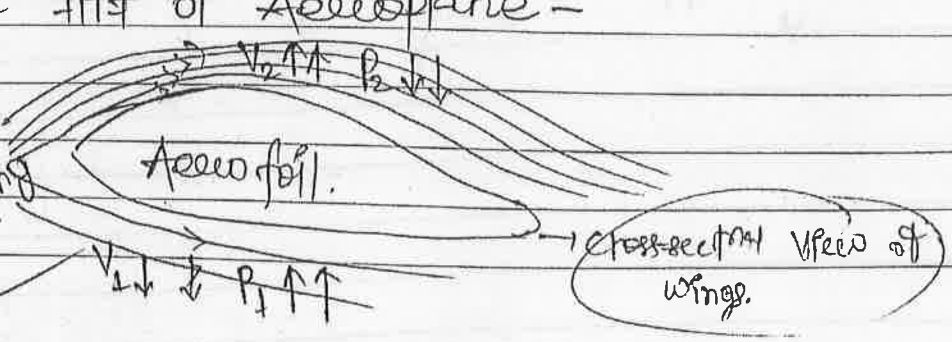
$Q^2 = \frac{36 \times 10^{-6}}{10}$.

$Q = \frac{6 \times 10^{-3}}{\sqrt{10}} m^3/s$.

III. Dynamic lift of Aeroplane -

$P_1 - P_2 = \frac{F}{A}$.

$F = (P_1 - P_2) A = mg$



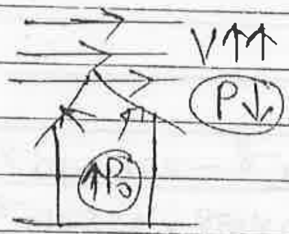
Q-2 ↓ PAGE 7 - 6, 15, 17, III - 18, 19 BB-4 compl Ex-I → 46-59 4 II - 3, 8, 12, 17, 18

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

$$\boxed{P_1 - P_2 = \frac{1}{2}\rho\,[V_2^2 - V_1^2]}$$

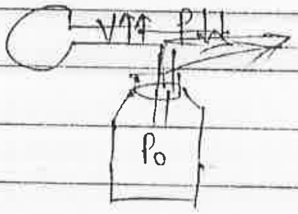
$$\boxed{F = \frac{1}{2}\rho_{air}\,A\,[V_2^2 - V_1^2]}$$

$$\boxed{\rho_{air} = 1.29\ kg/m^3}$$



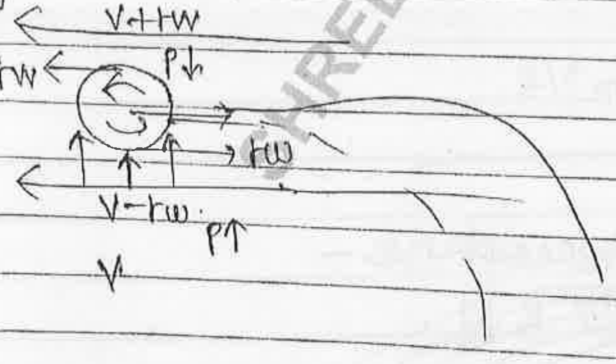
$$F = \frac{1}{2}\rho_{air}\,A\,[V_2^2 - 0]$$ → Inside room.

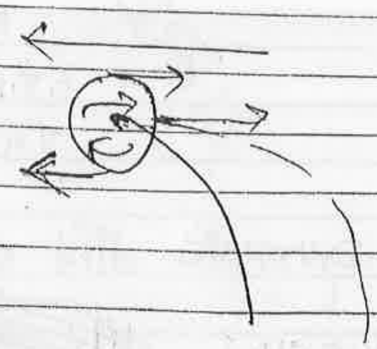
* Atomizer , Paint gun, pesticide spray



19.9.19

Magnus Effect →

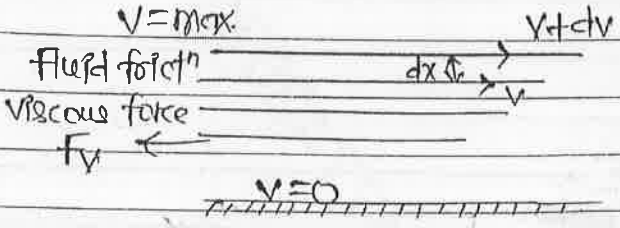




VISCOSITY

Due to relative motion b/w different layers of a fluid a force comes into play which opposes their relative motn. This force is c/d viscous force & the phenomena viscosity.

Reason - IMF of attractn or cohesive force. (electromagnetic).



$F_V \propto A$

$F_V \propto \frac{dv}{dx}$

$F_V \propto \frac{A\,dv}{dx}$

$$\boxed{F_V = \eta A \frac{dv}{dx}}$$

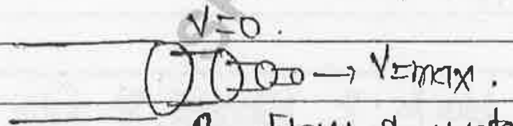
velocity gradient $= \frac{dv}{dx}$

$\eta = \frac{F_V\,dy}{A\,dx}$ $\quad \frac{N-m}{m^2-m}\,s$ $\quad \frac{M^1L^1T^{-2}}{L^2}\,T^1$

$[M^1L^{-1}T^{-1}]$

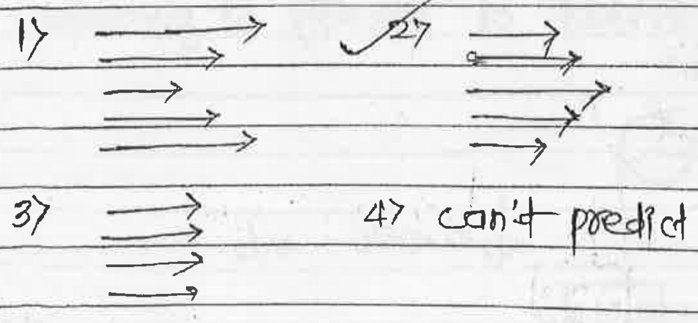
Coefficient of viscosity ⇓ Nature of fluid

	M.K.S.	C.G.S.
→	$\frac{N}{m^2}-s$ or Pascal-s	→ $\frac{dyne}{cm^2}-s$
→	Poiseulli decapoise	→ Poise



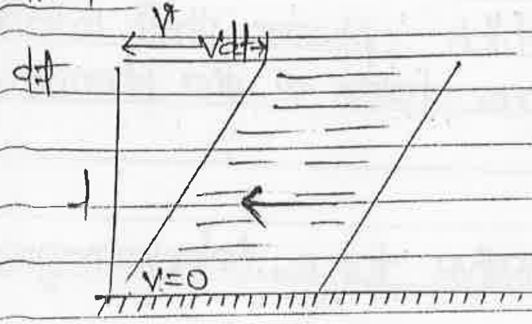
central → maxm speed.

Q. Flow of water in pipe → speed



4) can't predict

Method-2



shear stress $= \frac{F}{A}$.

shear strain $= \frac{v\,dt}{l}$

shear strain rate $= \frac{v}{l}$.

coefficient viscosity,

$$\eta = \frac{\text{shear stress}}{\text{shear strain rate}}$$

$$\eta = \frac{F_v/A}{v/l} \Rightarrow \boxed{\eta = \frac{F_v l}{A v}}$$

Q. A glass slab of length 3 mt. & breadth 2 mt is placed on a layer of honey of thickness 10 cm. Find force reqd to drag it with velocity 20 cm/s. η of honey $= 2.5 \times 10^{-4}$ Pa-s.

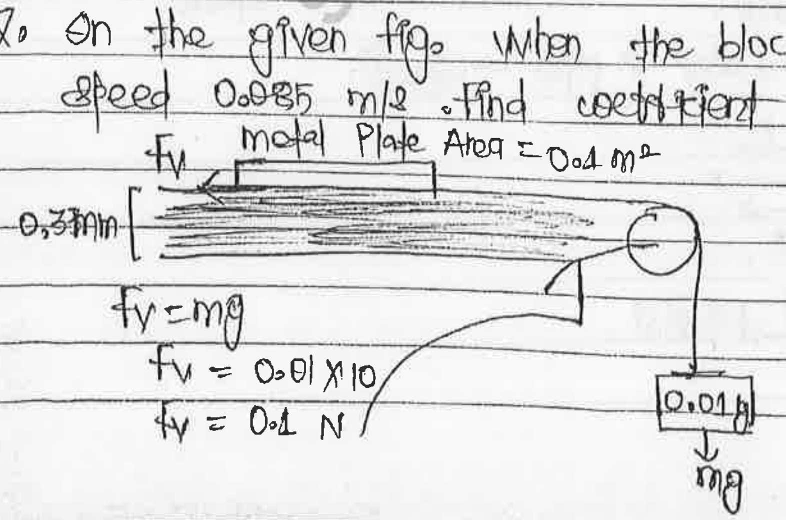
$\rightarrow$ $F_v = \frac{\eta A v}{l} = \frac{2.5 \times 10^{-4} \times 6 \times 0.2}{0.1}$

$= 30 \times 10^{-4}$.

$= 3 \times 10^{-3}$ N.

NCERT

Q. On the given fig. when the block is released, it falls with speed 0.085 m/s. Find coefficient of viscosity of glycerine.



$F_v = mg$

$F_v = 0.01 \times 10$

$F_v = 0.1$ N

$\downarrow$ 0.085 m/s.

Vol^m body का
density fluid का
× g = Buoyancy

NCERT uses practical data.

PAGE NO.

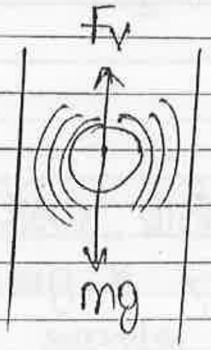
DATE : / /

$$\eta = \frac{F_v l}{AV}$$

$$= \frac{0.1}{0.1} \times \frac{0.3\times10^{-3}}{0.085} = \frac{0.3\times10^{3}\times10^{-3}}{85} = \frac{\overset{3.5}{\cancel{300}}}{\cancel{85}}\times10^{-3} \text{ Pascal-s}$$

II. STOKE's law :-

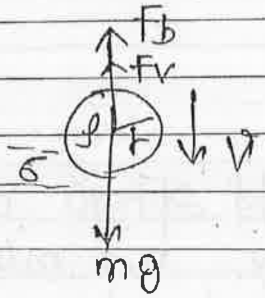
When a spherical body is released in viscous med^m, due to relative motion, viscous force acts on it which counter-balances the effective wt. ∞ body further falls with a const. velocity which is c/d terminal velocity.



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

$$\vec{F_v} = -6\pi\eta r\vec{v}$$

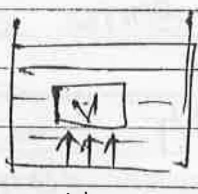
$$F_v = -kv$$



$$F_v + F_b = mg$$

$$F_v = mg - F_b$$

$$= \frac{4}{3}\pi r^3 \rho g - \frac{4}{3}\pi r^3 \sigma g$$



$V \sigma g$ = Buoyancy

Body का, fluid का

$$6\pi\eta r v_T = \frac{4}{3}\pi r^3 (\rho - \sigma) g$$

$$\boxed{v_T = \frac{2r^2(\rho-\sigma)g}{9\eta}}$$

BB-5-1 to 4 (25) | $r \Rightarrow 2$...

Ex I → 61, 40 (68)

II → 5, 4, 16,

III → 7, 8, 20

V_1 (6)

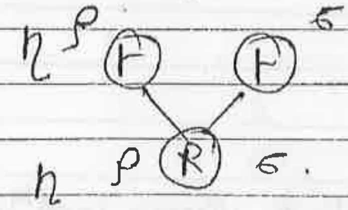
icon 7, 8, 9, 11, 12, 13, 14, 18, 20

PAGE NO.

DATE : / /

Q. Two identical rain droplets are falling in air with speed 5 m/s. Both the droplets coalesce. Find constant speed of new drop.

$$V_T = \frac{2r^2}{9\eta}(\rho - \sigma)g$$



$V \propto r^2$ $R = 2^{1/3} r$

$$\frac{V_1}{V_2} = \left(\frac{r}{R}\right)^2$$

$$= \left[\frac{r}{2^{1/3} r}\right]^2 = \frac{1}{2^{2/3}}$$

$$V_2 = 5 \times 2^{2/3}$$

$$= 5 \times 4^{1/3} \text{ cm/s.}$$

20.09.19

Q. A gold sphere of density 13 gm/cc falls with const. velocity 0.4 m/s in a liq^d of density 3 gm/cc. Find terminal vel. acq^d by Cu sphere of same size in the same liq^d. density of Cu = 8 gm/cc.

→ $$V_T = \frac{2r^2}{9\eta}(\rho - \sigma)g$$

$$\frac{V_1}{V_2} = \frac{\rho_1 - \sigma}{\rho_2 - \sigma} \Rightarrow \frac{0.4}{V_2} = \frac{13-3}{8-3} = \frac{10}{5} = 2$$

$$\Rightarrow V_2 = 0.2 \text{ m/s.}$$

Q. Two spheres of mass 'm' & '8m' of same mat. are falling in same liq^d. Find ratio of their terminal velocity.

→ $V_T \propto r^2$.

$$\frac{V_1}{V_2} = \left(\frac{r_1}{r_2}\right)^2$$

$m = V\rho$

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

$$\frac{m_1}{m_2} = \left(\frac{r_1}{r_2}\right)^3$$

$\rightarrow$ III (8) $v \propto \frac{(\rho-\sigma)}{\eta}$ $\frac{v_1}{v_2} = \frac{\eta_2}{\eta_1}\left(\frac{\rho_1-\sigma}{\rho_2-\sigma}\right)$ $\frac{10}{v_2} = \frac{13.2}{8.5\times10^{-4}}\left(\frac{7.8-1.2}{7.8-1}\right)$

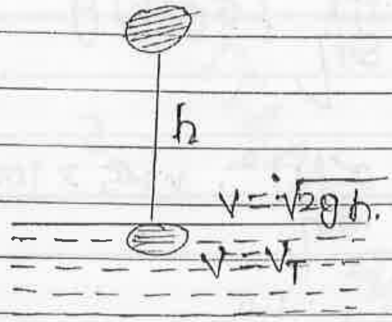
PAGE NO.

DATE : / /

$\frac{m}{8m} = \left(\frac{r_1}{r_2}\right)^3$ | $\Rightarrow \frac{v_1}{v_2} = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$, $\Rightarrow \frac{r_1}{r_2} = \frac{1}{4}$.

Q. A ball of radius 10^{-4} m & density 10^4 kg/m³. is dropped from ht. 'h' above water surface. just after entering in water it further falls with a const. vel.. find 'h'. η of water $= 10^{-5}$ Pa-s.

$\rightarrow$



$$\sqrt{2gh} = \frac{2r^2}{9\eta}(\rho-\sigma)g$$

$$= \frac{2\times(10^{-4})^2}{9\times10^{-5}}\times[10\times10^3-10^3]\times10$$

$$= \frac{2\times10^{-8}\times\cancel{9}\times10^3\times10}{\cancel{9}\times10^{-5}}$$

$$\sqrt{2gh} = 20.$$

$$h = \frac{20\times20}{20}\ m$$

Q. A sphere of radius 'r' is dropped in a viscous liqd. Heat is produced due to viscous force. when the sphere acquires constant velocity. then rate of heat productⁿ depends on radius of sphere a/c to the relation -

1) r.
2) r^2.
3) r^5.
4) r^4.

$\frac{dQ}{dt}$ = Power $= F_v v$.
$= 6\pi\eta r v v$.
Power $\propto r v^2$.
Power $\propto r\times r^4$.
Power $\propto r^5$.

$\uparrow v \propto r^2 \uparrow$
$v^2 \propto r^4$

PAGE NO.
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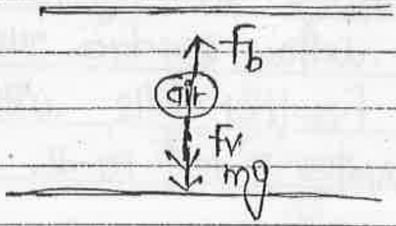
Q. An air bubble of radius 1 cm is rising in a liq^d of density 1.5 gm/cc with speed 2 mm/sec. Find 'η'. Ignore air ~~tat~~ density.

→



$$F_b = F_V + mg$$
$$F_V = F_b - mg$$

$$V_T = \frac{2r^2}{9\eta}(\sigma - \rho) g$$

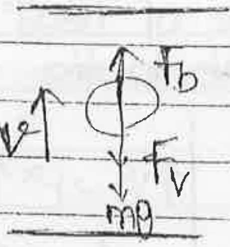
$$\frac{0.1}{0.2} = \frac{2(1)^2}{9\eta} \times 1.5 \times 1000$$

$$\eta = \frac{5}{3} \times 1000 = 1.6 \times 10^3 \text{ Poise}$$

Q. A ball is rising with constant speed in water. Density of water 6 times that of ball. Find ratio of force of frict^n to the wt of ball.

$\sigma = 6\rho$

→

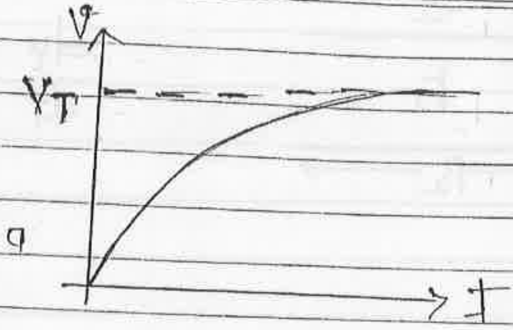


$$F_b = F_V + mg$$
$$F_V = F_b - mg$$
$$= V\sigma g \frac{\rho}{\rho} - V\rho g$$
$$= V\rho g\left(\frac{\sigma}{\rho} - 1\right)$$

$$F_V = W\left[\frac{\sigma}{\rho} - 1\right]$$
$$\frac{F_V}{W} = \left[\frac{6\rho}{\rho} - 1\right]$$
$$\frac{F_V}{W} = \frac{5}{1}$$

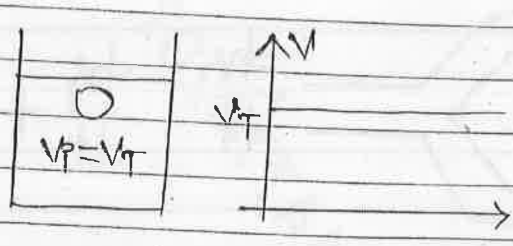
Graph →

1.)

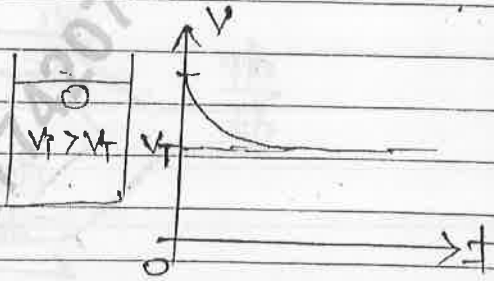


$$\frac{W_{eff.} - (6\pi\eta r v_T)}{m} = a$$

2.)



3.)



Reyonld's NO. →

Estimates nature of flow.

$v \rightarrow \eta$ ○] diameter = d

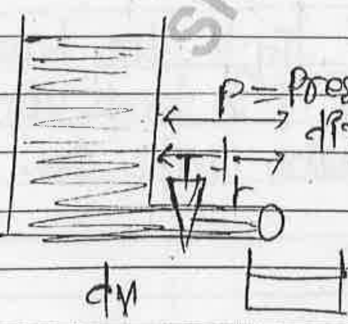
$$R_n = \frac{\rho v d}{\eta}$$

Range

* $\boxed{R_N < 1000}$ Flow is Streamline
* $\boxed{1000 < R_N < 2000}$ Stream-line converting into turbulant.
* $\boxed{R_N > 2000}$ Turbulant

$$\boxed{R_N = \frac{\rho V D}{\eta} \times \frac{AV}{AV} = \frac{AV^2\rho}{\eta A V/d} = \frac{\text{Inertial Force}}{\text{Viscous Force.}}}$$

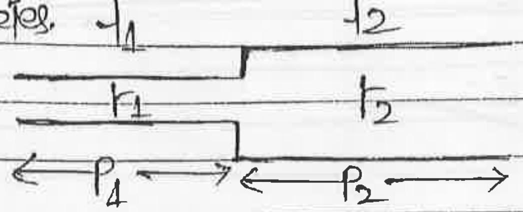
Poiseulli' Formula → estimates rate of flow or vol^m flowing per unit time.



$$\boxed{\frac{dv}{dt} = \frac{\pi}{8} \frac{Pr^4}{\eta l} \; m^3/s \text{ or } lit./sec.}$$

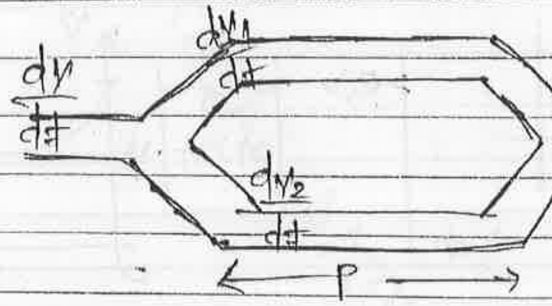
$$\frac{dv}{dt}$$

I. Series.



$\frac{dv}{dt}$ = same

II. Parallel.



$$\frac{dv}{dt} = \frac{dv_1}{dt} + \frac{dv_2}{dt}.$$

Q. Two tubes of length 'l' & '2l' are connected in series, ratio of their radii is 1 : 2. Find ratio of pressure difference across them.

→ $\frac{dv}{dt} = \frac{\pi}{8}\frac{Pr^4}{\eta l}$. $\quad P \propto \frac{l}{r^4}$.

$$\Rightarrow \frac{P_1}{P_2} = \frac{l_1}{l_2} \times \left(\frac{r_2}{r_1}\right)^4$$

$$= \frac{1}{2} \times \left(\frac{2}{1}\right)^4 = \frac{8}{1}.$$

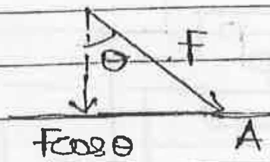
* With ↑ in temperature viscosity of liquids ↓es bcoz, cohesive force ↓es while with ↑ in temp. viscosity of gases ↑es because their diffusion rate ↑es.

——X——

Fluid statics

Pressure $= \frac{F}{A}$ N/m² or Pascal. (scalar) $[M^1L^{-1}T^{-2}]$

Here force is normal to the area.



$F = $ const.

$\downarrow\downarrow P \propto \frac{1}{A\uparrow}$

$\frac{F\cos\theta}{A}$.

Types of Pressure :-

1. Atmospheric Pressure -

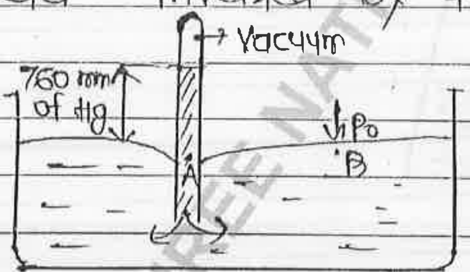
Pressure exerted by atmosphere or air column pressure.

$1 \text{ atm} = 760 \text{ mm of Hg} = 76 \text{ cm of Hg} = h\rho_m g = 1.013\times10^5$ Pascal.

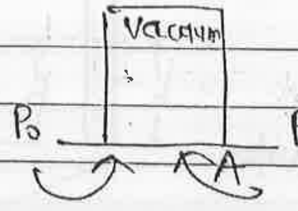
In case of water, $h\rho_w g = 1.013\times10^5$.
$h_{water} = 10.33$ mt.

$1 \text{ bar} = 10^5$ Pascal.
$1 \text{ torr} = 1 \text{ mm of Hg} = 133$ Pascal.
$1 \text{ atm} = 760$ torr.

Barometer → invented by Torricelli.



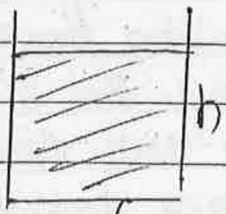
$P_A = P_B$
$h\rho_m g = P_0$.



$F = (P_0 - P)A > mg$.

2. Gauge Pressure -

Excess pressure over 1 atmospheric is gauge Pressure

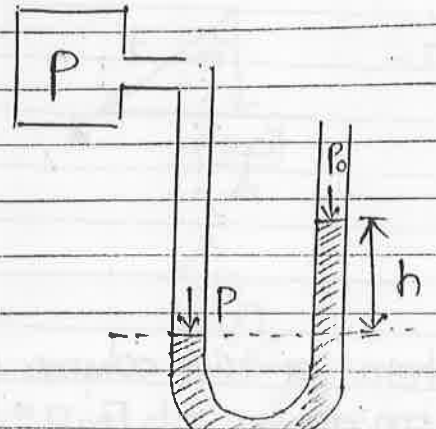


$P = P_0 + \frac{mg}{A}$

$= P_0 + \frac{V\rho g}{A} = P_0 + \frac{\cancel{A}h\rho g}{\cancel{A}}$

$P = P_0 + h\rho g$

Manometer -

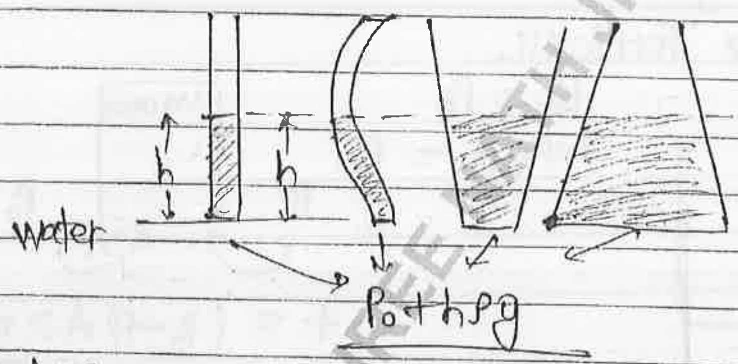


$$P = P_0 + h\rho g$$
$$P - P_0 = h\rho g.$$

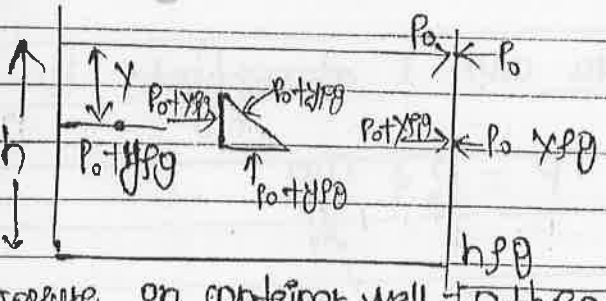
3. Absolute Pressure - / Pressure / Total Pressure -

$$P_{total} = P_0 + h\rho g.$$

* Liqd column pressure depends on height. It is independent of shape & size of container & amount of liqd.



* Avg. Pressure -

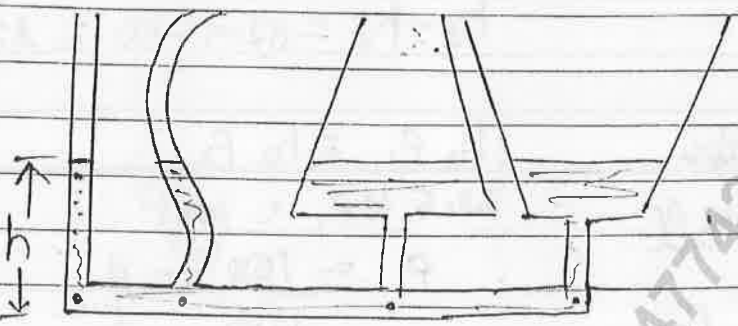


Fluid exerts equal pressure in all dirⁿ @ a given depth. Whatever be the ~~ore orientation~~ of surface. that is why container wall also experiences pressure.

Avg. Pressure on container wall $= \boxed{\dfrac{0 + h\rho g}{2}}$

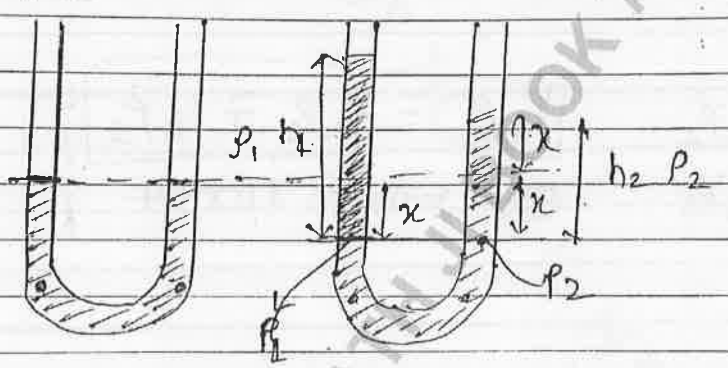
Force on container wall, $F = P_{av}A = \boxed{\dfrac{h\rho g}{2} \times A}$.

* The height of liqd in interconnected open containers is same bcoz liqd maintains equal pressure at same Hz level. It is c/d hydrostatic paradox.



Hydrostatic Paradox.

* U-Tube



$$P_1 = P_2.$$
$$P_0 + h_1\rho_1 g = P_0 + h_2\rho_2 g$$
$$\boxed{h_1\rho_1 = h_2\rho_2}$$

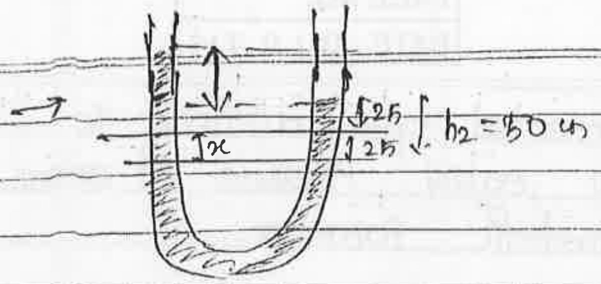
Q. Hg is partially filled in a U-shaped tube. Now some H_2O is poured in one arc upto length 27.2 cm. By what amount level of Hg is rises in other arm.

→ $h_1\rho_1 = h_2\rho_2.$ For. H^2 $2x$.

$27.2 \times 1 = \underline{2x} \times 13.6.$ But value of x asked.

$x = 1$ cm.

Q. A U-tube is partially filled with water. Now, an Immiscible oil of density 0.8 gm/cc is poured in one arm. Until level of water rises by 25 cm in other arm. How much ht. of oil level above water level.

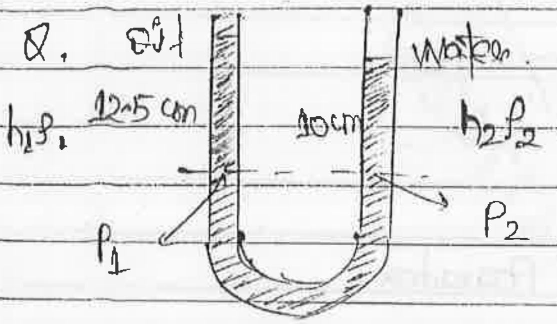


$h_1 \times 0.8 = 50 \times 1$

$h_1 = \frac{500}{0.8} = 62.5$ cm

$h_1 - h_2 = 62.5 - 50 = 12.5$ cm

Q.

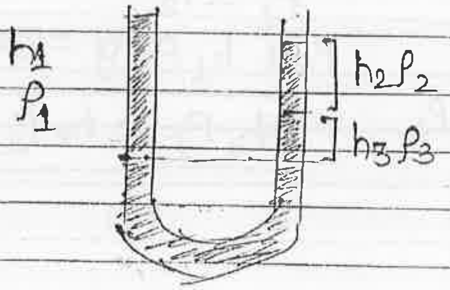


$h_1 \rho_1 = h_2 \rho_2$

$12.5 \times \rho_1 = 10 \times 1$

$\rho_1 = \frac{100}{125} = \frac{4}{5}$

$\rho_1 = 0.8$ gm/cc



$\boxed{h_1\rho_1 = h_2\rho_2 + h_3\rho_3}$

~~$62.5 \times 0.8 = 10 \times 1 +$~~

Q. A bubble rises from bottom of lake on reaching surface, its radius becomes double. Find depth of the lake. If 1 atm pr. is eq. to 'H' ht of water column.

→

IT
gradual
process

air 2r P_2V_2

air r P_1V_1

$P_1 V_1 = P_2 V_2$

$(P_0 + h\rho g)\frac{4}{3}\pi r^3 = P_0 \times \frac{4}{3}\pi 8r^3$

$h\rho g = 7P_0$ $\quad$ $1P_0 = H\rho g$

$h = \frac{7P_0}{\rho g} = \frac{7H\rho g}{\rho g}$

$\boxed{h = 7H}$

Q. If pr. at half depth of a lake is 2/3 times that of at bottom. find depth of the lake (1 atm = 10^5 Pa)

$\Longrightarrow$ h, h/2

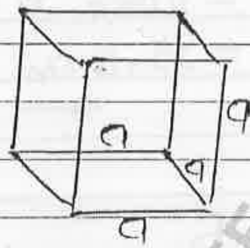
$$P_0 + \frac{h}{2}\rho g = \frac{2}{3}(P_0 + h\rho g)$$

$$\Rightarrow 3P_0 + \frac{3}{2}h\rho g = 2P_0 + 2h\rho g$$

$$\Rightarrow P_0 = \frac{1}{2}h\rho g \Rightarrow h = \frac{2\times10^5}{10^3\times10} = 20\,m.$$

Q. A cube of side 'A' is completely filled with liq^d of density 'ρ' find —
(I) Force on 1 wall due to liq^d.
(II) Force on Base due to liq^d.

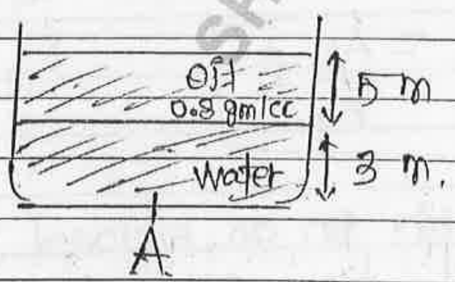
$\rightarrow$



(I) $F_{wall} = \frac{a\rho g}{2} \times a^2 = \frac{a^3\rho g}{2}$

(II) $F_{base} = a\rho g \times a^2 = a^3\rho g$.

Q. Find Pressure at Pt. 'A' due to liq^d. 1 gm/cc = 10^3 kg/m³

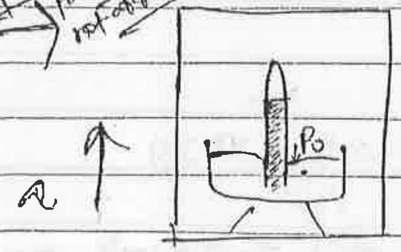


$$P_A = h_1\rho_1 g + h_2\rho_2 g$$

due to liq^d $= 5\times0.8\times10^3\times10 + 3\times10^3\times10$
$= (4+3)\,10^4$
$= 7\times10^4$ Pascal

Q. A barometer is kept inside a stationary lift & its reading is 76 cm. Now the lift starts ascending with acc^n to 9 m/s². Find reading of Barometer.

atmospheric pressure not affected.



$g_{eff} = g + a$

$P_0 = h\rho_m g$

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

$\frac{h_1}{h_2} = \frac{g_2}{g_1}$

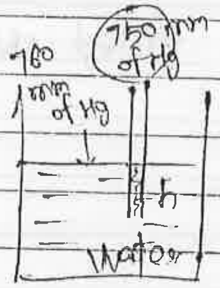
$\frac{76}{h_2} = \frac{g+a}{g}$

$h_2 = \frac{76 \times 10}{19}$

$h_2 = 40$ cm

Ex 2.

Q 1.



10 mm of Hg $\geq h\rho g$.

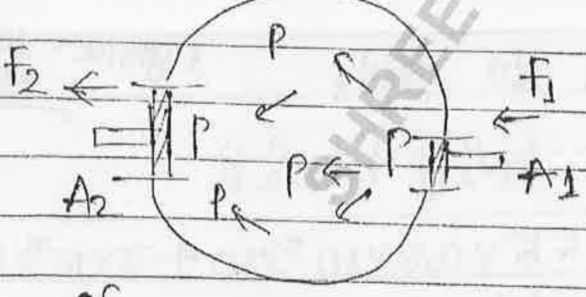
1 cm of Hg $= h_{max} \cdot \rho g$.

$h_1 \rho_1 g = h_{max} \cdot \rho_2 g$

$1 \times 13.6 = h_{max} \times 1$.

$h_{max} = 13.6$ cm

Pascal's law :-



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

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

eg.

$A_2 = 3A_1$

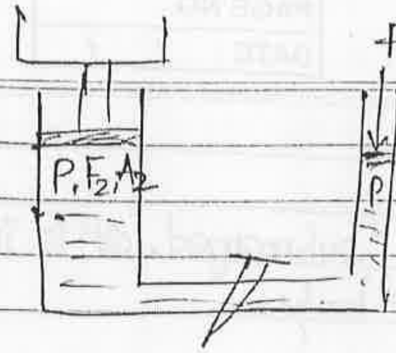
$F_2 = 3F_1$

If a pressure is applied at a pt. on an enclosed fluid, then this pressure is equally transmitted to each & every pt. undiminished.

Ex-3 1, 5, 10, 11, 15, 17.

P-238 - BB-3 Q-2, 3 A, I-29, 30, 38, 40, 42, 44 II-1, 26. III-3, 15, 16, 17, 13

PAGE NO.
DATE : / /



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

$$F_2 = \left(\frac{h_2}{h_1}\right)^2 F_1.$$

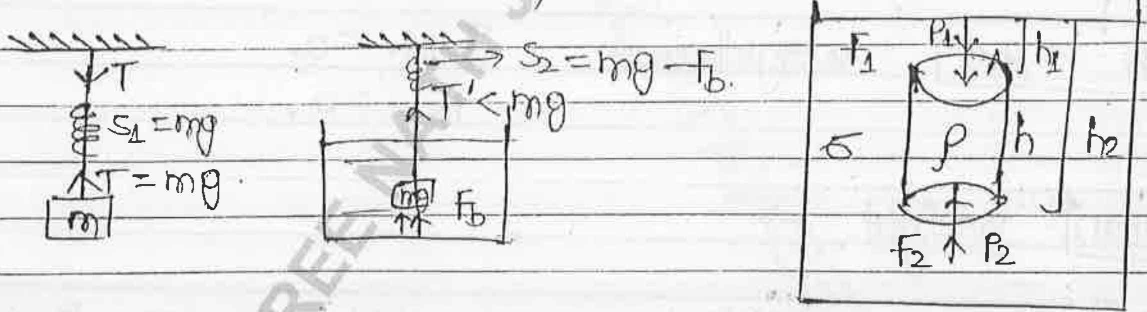
1) Hydraulic lift;
2) Hydraulic Brakes.
3) Hydraulic Press.

24.7.19

Buoyancy / Archimedes Principle -

When a body completely or partially submerged in a fluid then it experiences upward force. It is c/d buoyant force & phenomena buoyancy.

A/c to Archimedes, Buoyant force = wt. of fluid displaced



$$F_1 = (P_0 + h_1 \sigma g) A.$$
$$F_2 = (P_0 + h_2 \sigma g) A.$$

$$F_{net} = F_2 - F_1 = \cancel{P_0 A} + A h_2 \sigma g - \cancel{P_0 A} - A h_1 \sigma g$$
$$= A (h_2 - h_1) \sigma g$$
$$= A h \sigma g.$$

not depend on ht. when completely submerged.

$$\boxed{F_b = V \sigma g}$$

depends on press. diff. with ht.

$$\cancel{A} \; \cancel{h} \; \sigma \; g$$

* $F_b = V_{in} \sigma g$

1. $\boxed{F_b \propto V_{in}}$

* F_b depends only on the vol^m of body submerged. It is independent of shape, size & density of body.

$V_1 = V_2$

Wood   Iron

water $F_b = F_b$

Float   sink

$F_b > mg$ $F_b < mg$

2. $\boxed{\uparrow F_b \propto \sigma \uparrow}$ $\sigma_{sea} > \sigma_{fresh}$

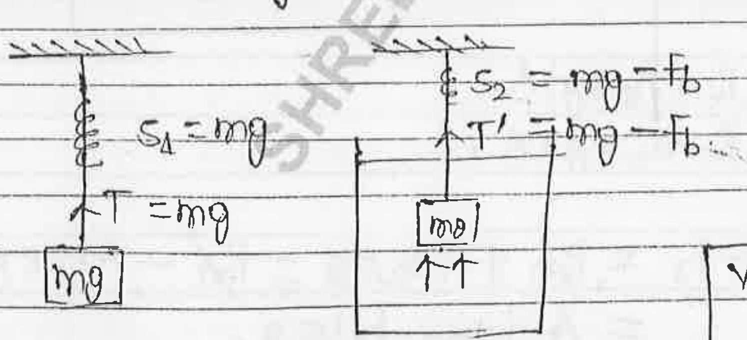
→ It is easier to swim in sea than river.

→ When ship comes from sea to river, it further slightly sinks.

3. $\boxed{\uparrow F_b \propto g \uparrow}$ Weightlessness $g_{eff.} = 0.$

$F_b = 0.$

Apparant weight →



$$W_{app.} = mg - F_b$$
$$= V\rho g - V\sigma g$$
$$= V\rho g\left[1 - \frac{\sigma}{\rho}\right]$$

$$\boxed{W_{app.}' = mg\left[1 - \frac{\sigma}{\rho}\right]}$$

$$\cancel{m}\, g_{eff} = \cancel{m}g\left[1 - \frac{\sigma}{\rho}\right]$$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$W_{app.} = W\left[1 - \frac{\sigma}{\rho}\right]$$

PAGE NO.
DATE : / /

Q. A block of mass 3 kg is suspended by thread. Now the block is submerged in a liqd of relative density 0.5. Relative density of block is 10. what will be the tension in the string..

$$R.D. = \frac{\rho}{\rho_w}$$

$$\rho = R.D. \times \rho_w$$

→ $W_{app.} = mg\left[1 - \frac{\sigma}{\rho}\right]$

$= 3\times10\left[1 - \frac{0.5\times10^3}{10\times10^3}\right]$

$= 30\,[1 - 0.05]$

$= 30 \times 0.95$

$= 28.5$ N.

$= 28.5 \times \frac{1}{10}$ kg wt $= 2.85$ kg-wt.

1 kg wt. = 10 N.
1 gm-wt. = 1000 dyne
1 kg F = 10 N.
1 gm f = 1000 dyne
1 N = $\frac{1}{10}$ kg wt

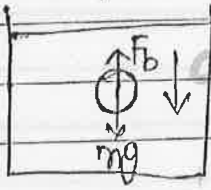
Laws of Floatation :-

1. $W > F_b$

$V\rho g > V\sigma g$

$\boxed{\rho > \sigma}$

Sink upto bottom.



$W_{app.} = mg - F_b$

2. $W = F_b$

$\rho = \sigma$.

Float completely submerged.

Neutral eqb^m
of pushed downward then sink upto bottom

W=100N
Fb=100N

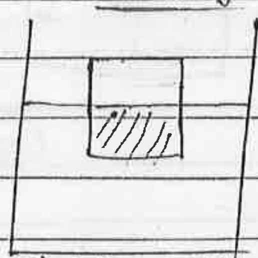
$W_{app.} = 0$

3. $W < F_b$.

90% gyan

$\rho < \sigma$

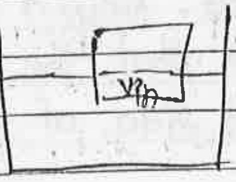
Floate partially submerged.



Stable eqb^m.

$W_{app.} = 0$.

#



$$\boxed{\begin{aligned} mg &= V_{in}\,\sigma\,g \\ V\rho &= V_{in}\,\sigma \end{aligned}}$$

PAGE NO.
DATE : / /

Q. A cube of side 10 cm and mass 700 gm is floating in water. Find its vol^m outside water.

→ $m\cancel{g} = V_{in}\,\sigma\,\cancel{g}$

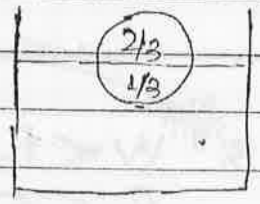
$700 = V_{in} \times 1.$

$V_{in} = 700\ cc$

$V = (10)^3 = 1000\ cc.$

$V_{out} = 300\ cc.$

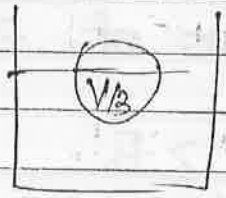
Q. A sphere floats in water by 2/3 part vol^m outside, & floats in a liq^d by 80 % vol^m outside. Find density of sphere & liq^d.

→ 

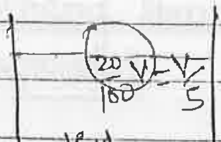
$\cancel{mg = V_{in}\,\sigma\,g}$

$V\rho = V_{in}\,\sigma$

$V\rho = \frac{V}{3}\,\sigma$



$\rho = \frac{1}{3}\ gm/cc. = \frac{1}{3} \times 10^3\ kg/m^3.$



$V\rho = V_{in}\,\sigma_1$

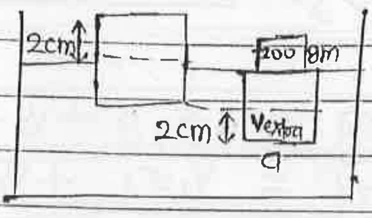
$V \times \frac{1}{3} \times 10^3 = \frac{V}{5} \times \sigma_1.$

$\sigma_1 = \frac{5}{3} \times 10^3\ kg/m^3.$

Q. A cube is floating in water such that, it's one phase is 2 cm above water surface. Now a block of mass 200 gm is placed over it. So that the cube floats just completely submerged. Find side of the cube.

BB-3 – 2,3,4,6,7,8
I → 33,34,37,41, 43,45
III → 14,15,16,17.
R → 3 → 2,3,4,7,8, 12,13,14,18, 20

PAGE NO.
DATE : / /

→ 

$(mg)_{extra} = (F_b)_{extra}$

$mg = V_{extra}\,\sigma\,g$

$200 = a \times a \times 2 \times 1$

$a^2 = 100$

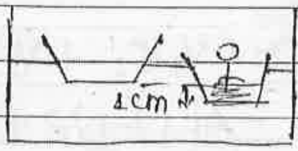
$a = 10\ cm.$

Q. A boat of length 3 mt. & breadth 2 mt. is floating on water. Now a man gets inside it & both boat further sinks by 1 cm. Find mass of the man. (60 kg)

→ $mg = V_{in}\,\rho\,g$

$m = 3 \times 2 \times 10^{-2} \times 10^{3} = 60\ kg.$

25.9.19



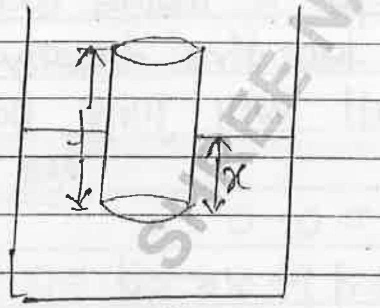
(OR)

$(mg)_{extra} = F_{b\,extra}$

$mg = V_{extra}\,\sigma\,g$

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

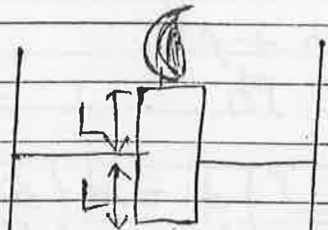
$m = 60\ kg.$

\# 

$V\rho = V_{in}\,\sigma$

$\cancel{A}\,l\,\rho = \cancel{A}\,x\,\sigma$

$\boxed{\dfrac{l}{x} = \dfrac{\sigma}{\rho} = const.}$



Candle burns @ 2cm/hr.

after 1 hr.

$\dfrac{l_1}{x_1} = \dfrac{l_2}{x_2}.$

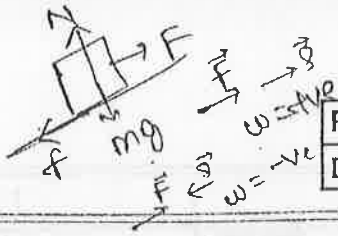
$\dfrac{2L}{L} = \dfrac{2L-2}{x_2}$

$x_2 = L-1$

① Length outside falls @ 1 cm/hr.

② Length inside also falls @ 1 cm/hr.

WE Theory



PAGE NO.
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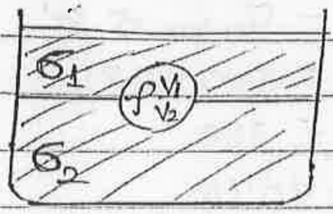


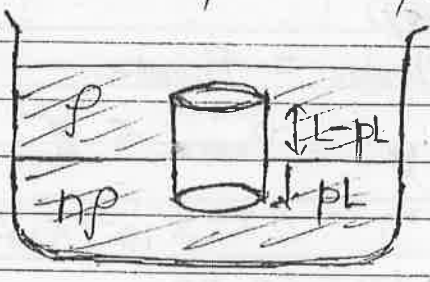
$$mg = V_1\sigma_1 g + V_2\sigma_2 g.$$

$$\boxed{V\rho = V_1\sigma_1 + V_2\sigma_2}$$

$\sigma_2 > \sigma_1 \qquad \sigma_2 > \rho > \sigma_1.$

Q. Two immisible liq^{ds} of density 'ρ' and '$n\rho$' ($n>1$), are placed in a container. Both have same ht. 'h'. A cylinder of length 'L' & density 'd' floats in them with axis excess veoticle. If pL length is in denser med^m ($p<1$). Find density of cylinder.

→



$$V\rho = V_1\sigma_1 + V_2\sigma_2.$$
$$ALd = AL(1-p)\rho + ApL\, n\rho.$$
$$d = (1-p+np)\rho.$$
$$d = [1+p(n-1)]\rho.$$

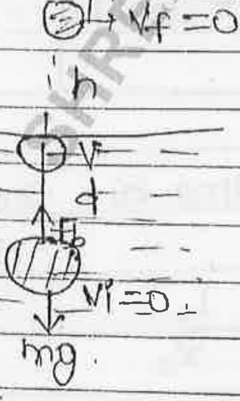
Q. A wooden ball is taken to a depth 'd' inside water & released. If density of ball 'ρ' is less than density of water 'σ'. upto what ht. ball will jump out.

→

$g_{eff} = g\left(\frac{\sigma}{\rho}-1\right)$

$\rho < \sigma.$

$v = \sqrt{2gd\left(\frac{\sigma}{\rho}-1\right)}$



$$W_{all} = k_f - k_i$$
$$W_g + W_b = 0 - 0.$$
$$-V\rho g(h+d) + V\sigma g d = 0.$$
$$\sigma d = \rho h + \rho d.$$
$$(\sigma-\rho)d = \rho h.$$
$$h = \left(\frac{\sigma-\rho}{\rho}\right)d. = d\left(\frac{\sigma}{\rho}-1\right).$$

Mod → P → 2 Hm
NoHo → all Q. पूछे
NCERT – solved
exemp

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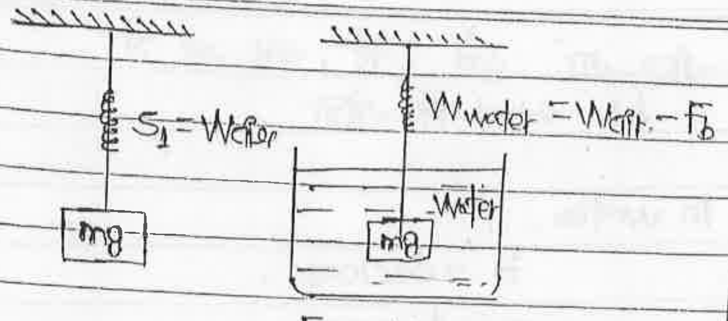
PAGE NO.
DATE: / /

Density -



$F_b = W_{air} - W_{water}$

$R.D. = \dfrac{V\rho g}{V\rho_w g}$

$R.D. = \dfrac{W_{air}}{F_b \text{ in water}}$ (solid)

$$\boxed{R.D. = \frac{W_{air}}{W_{air} - W_{water}}}$$

$\rho = R.D. \times \rho_W = R.D.\ gm/cc$
$= R.D. \times 10^3\ kg/m^3.$

(liqd) $R.D. = \dfrac{V\rho_l g}{V\rho_w g} = \dfrac{F_b \text{ in liqd}}{F_b \text{ in water}}$

$$\boxed{R.D. = \frac{W_{air} - W_{liqd}}{W_{air} - W_{water}}}$$

Q. Wt. of body in air = 10 N & in water = 8 N & in liqd = 4 N. Find density of body & liqd.

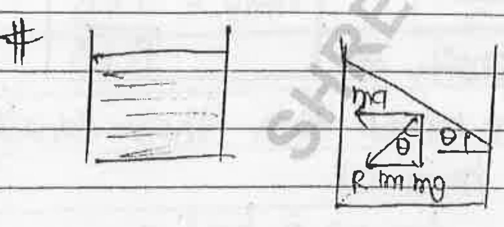
→ (solid) $\rho_{body} = R.D. = \dfrac{10}{10-8} = \dfrac{10}{2} = 5.$

$\rho = 5\ gm/cc = 5 \times 10^3\ kg/m^3$

(Liqd) $R.D._{liqd} = \dfrac{10-4}{10-8} = \dfrac{6}{2} = 3.$

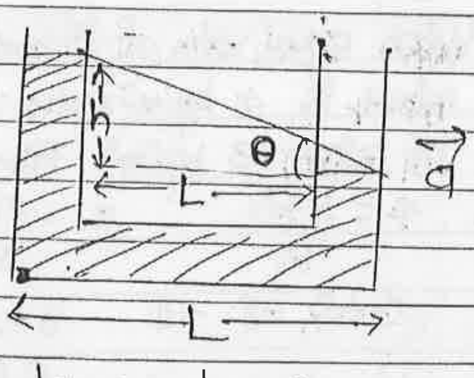
$\rho_{liqd} = 3\ gm/cc = 3 \times 10^3\ kg/m^3.$

#



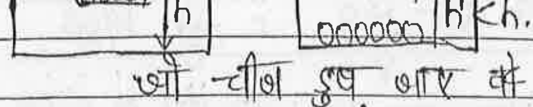
$\tan\theta = \dfrac{ma}{mg}$

$\tan\theta = \dfrac{a}{g}$

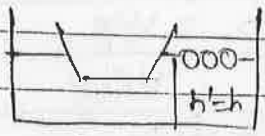


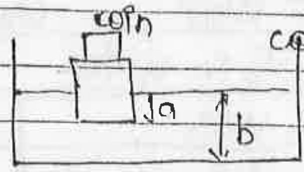
$\tan\theta = \dfrac{h}{L} = \dfrac{a}{g}$

$$\boxed{h = \frac{aL}{g}}$$



यो टील हुए जार के
उनमें level कम हो जाता है।

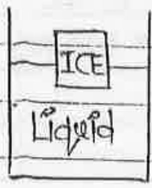
*  जो नीचा था डूबे ; तैरे, इस case में
h+ equal ही रहेगा

*  coin slips in water.

b → decrease.

a → decrease.

26.9.19

* 

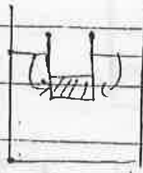
$mg = V_i \sigma_l g$.

$V_i = \frac{m}{\sigma_l}$ —(1)

melt water,

$V_f = \frac{m}{\sigma_W}$ —(2)

$\frac{V_i}{V_f} = \frac{\sigma_W}{\sigma_l}$.



(1) $\sigma_W > \sigma_l$.

$\frac{\sigma_W}{\sigma_l} > 1$

$\frac{V_i}{V_f} > 1$.

$V_i > V_f$

Level fall.

(2) $\sigma_W < \sigma_l$

$\frac{\sigma_W}{\sigma_l} < 1$.

$V_i < V_f$

Level rise.

(3) $\sigma_W = \sigma_l$.

$V_i = V_f$.

Level remain same.

* Density – $\rho = \frac{m}{V}$ kg/m³.

gm/cc. (1 gm/cc $= 10^3$ kg/m³).

* Density of mixture –

m_1	m_2
V_1	V_2
ρ_1	ρ_2

$$\boxed{\rho_{mix} = \frac{m_1+m_2}{V_1+V_2}}$$

(1) Equal volᵐ mixed

$V_1 = V_2 = V$.

$\rho_{mix.} = \frac{V\rho_1 + V\rho_2}{V+V}$

$$\boxed{\rho_{mix} = \frac{\rho_1+\rho_2}{2}}$$

(2) Equal masses

$m_1 = m_2 = m$

$\rho_{mix.} = \frac{m+m}{\frac{m}{\rho_1}+\frac{m}{\rho_2}}$

$$\boxed{\rho_{mix.} = \frac{2\rho_1\rho_2}{\rho_1+\rho_2}}$$

Q. When equal volm of 2 mat. are mixed density of mixer is 4 kg/m³. when their eq. masses are mixed then their density of mixer 3 kg/m³. Find densities of material.

→ $4 = \frac{\rho_1+\rho_2}{2}$

$\rho_1+\rho_2 = 8$ —①

$3 = \frac{2\rho_1\rho_2}{\rho_1+\rho_2}$

$3 \times 8 = 2\rho_1\rho_2$

$\rho_1\rho_2 = 12$ —②

sum = 8 & prod. = 12

⇓

$\boxed{6 \text{ kg/m}^3, \ 2 \text{ kg/m}^3}$

* Relative density –

R.D. $= \frac{\rho_{sub.}}{\rho_W \text{ at } 4°c}$ unitless, dimensionless.

Specific wt. $= \frac{mg}{V} = \rho g$ N/m³.

Specific gravity $= \frac{\text{sp. wt. of subst.}}{\text{sp. wt. of water @ } 4°c}$

$$\boxed{S.G. = \frac{\rho g}{\rho_W g}}$$

contd.