-: FLUID MECHANICS :-

Fluidstatics → Study of fluid at rest

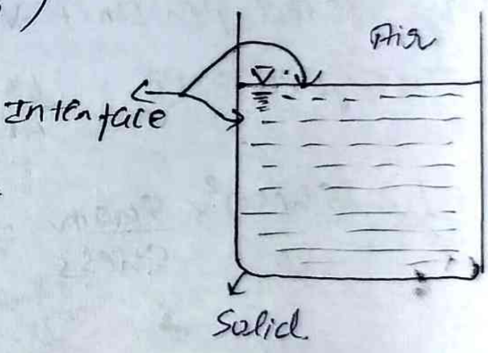
Fluid dynamics → Study of fluid in MOTION

* Fluids :- liquids and Gases are fluids → {do not have shape But definite volume}
  - Density (ρ)
  - Pressure

* Density (dm/dv)

(i) Relative density :- $\left(\frac{\text{density of Sub.}}{\text{density of Ref. Sub.}}\right)$ $RD_{x/y} = \frac{\rho_x}{\rho_y}$

(ii) Specific Gravity :- $\left(\frac{\text{density of Sub.}}{\text{density of } H_2O}\right)$ $(S.G)_x = \frac{\rho_x}{\rho_{H_2O}}$



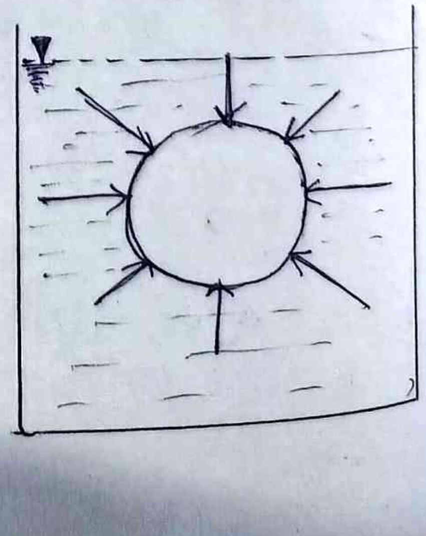
* The fluid Interface bounded by air is Called 'free surface'.

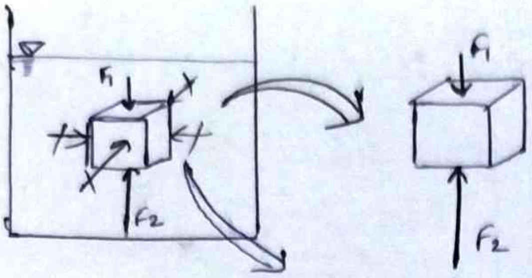
:: PRESSURE IN FLUIDS :-

When ext. force is applied on a fluid Body It develop an internally distributed Pressure At all Point. This pressure is fluid pressure

> Pressure (↑) with depth.

:: Act all Points on fluid Body





Net force due to fluid and Pressure

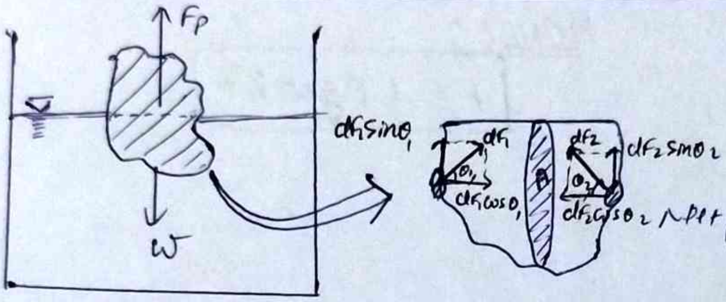
$\therefore F_{Net} = (F_2 - F_1)$

Visualization

All force due to fluid Pressure Cancel out except Net upward force

For a Body to float, Net force should be Zero

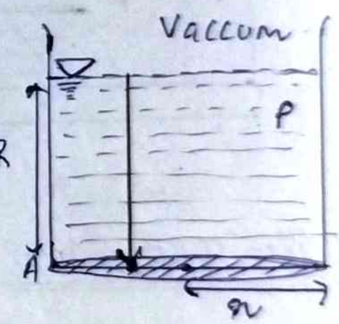
F_{Net} due to fluid Pressure = Weight of Body; $\boxed{F_B = W}$



Net(F) in $x = 0$

Net F due to fluid Pressure is only in Y direction

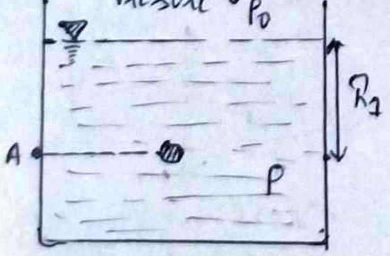
$\because$ FLUID PRESSURE DUE TO GRAVITY :-



$$(\text{Pressure})_A = \frac{W_{fluid}}{\text{Area}}$$

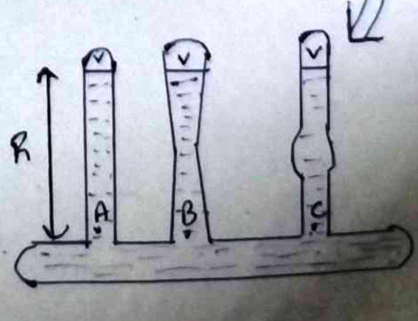
$$\Rightarrow \frac{(M_{fluid})\,g}{(\text{Area})} = \frac{(\rho \pi r^2 h) \times g}{(\pi r^2)} \Rightarrow \boxed{h\rho g}$$

ex:-

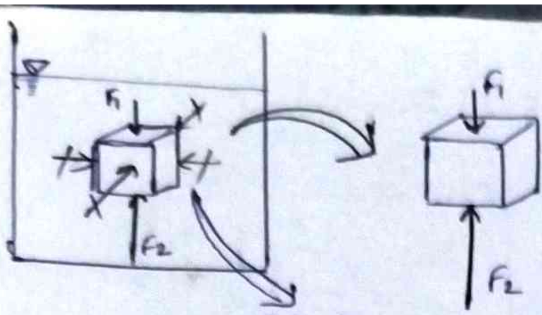


$$\boxed{P_A = P_0 + h_1 \rho g}$$

" # Pressure at a depth does not depend on shape of vessel."



$$(P_A = P_B = P_C = h\rho g) \Longleftarrow$$



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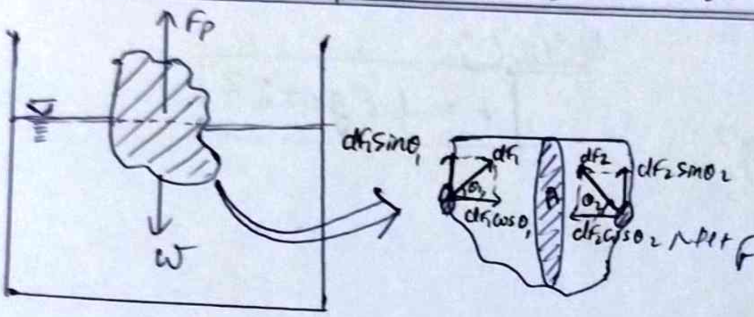

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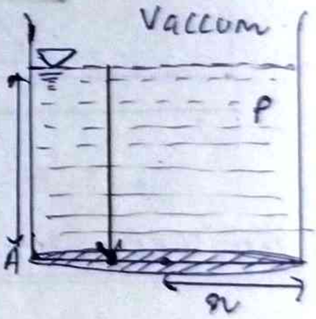
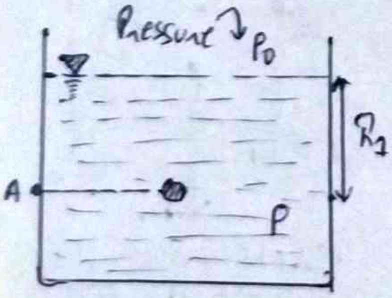


ex:-



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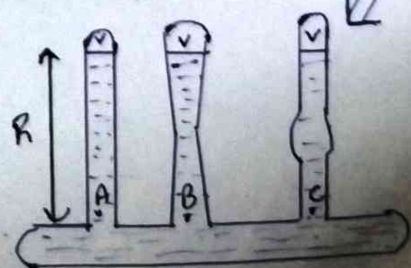

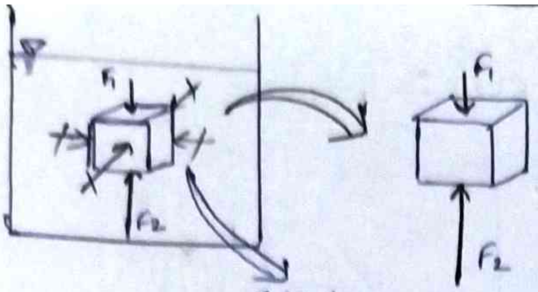

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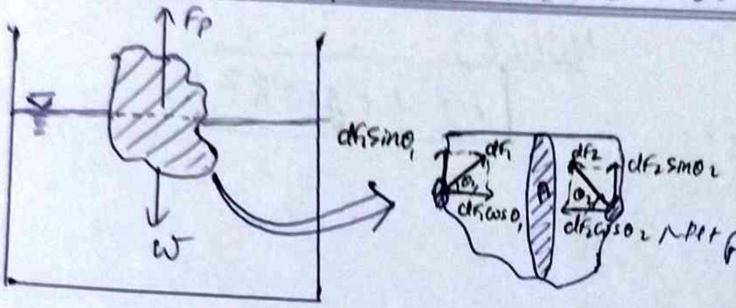

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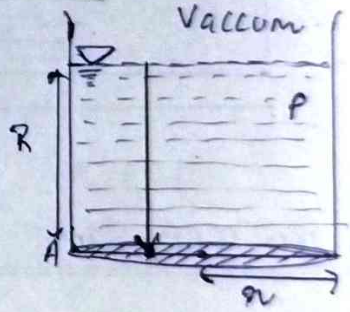
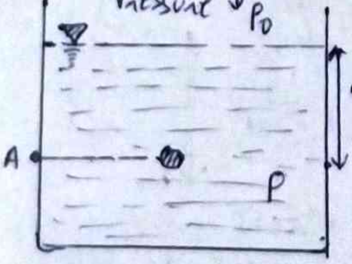


ex:-



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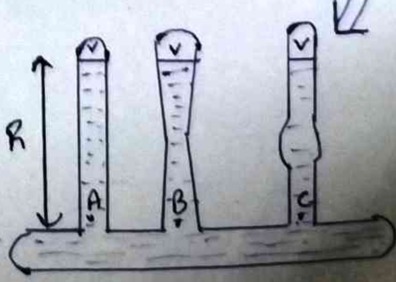

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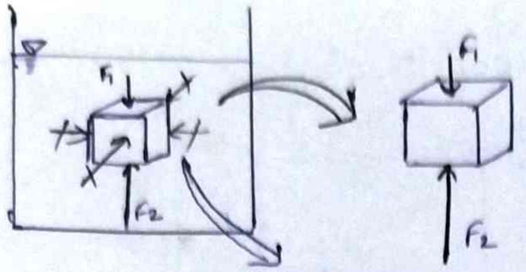

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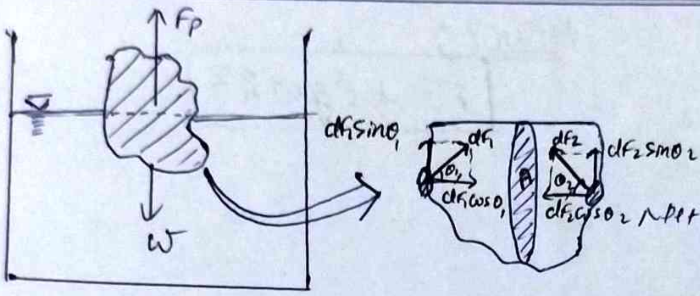

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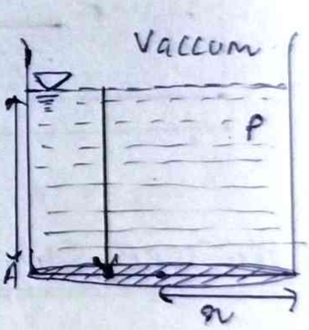

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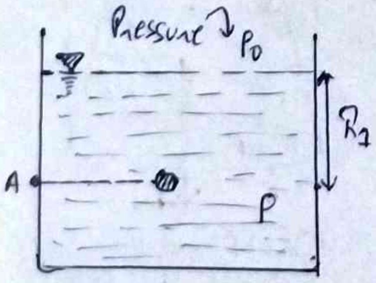

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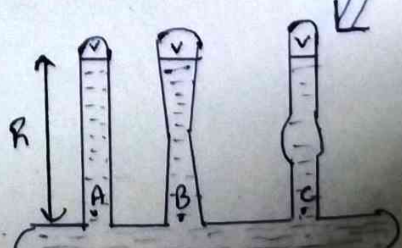
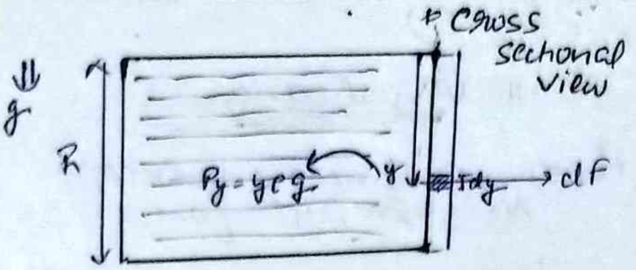
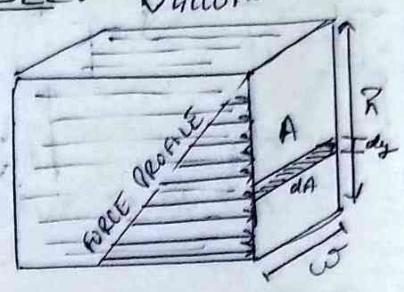


$$(P_A = P_B = P_C = R\rho g)$$

Avg. Pressure on side wall of a vessel :- Nallow





$dF = P_y dA$

$dA = w\,dy$ —①

$dF = (y\rho g)(w\,dy)$

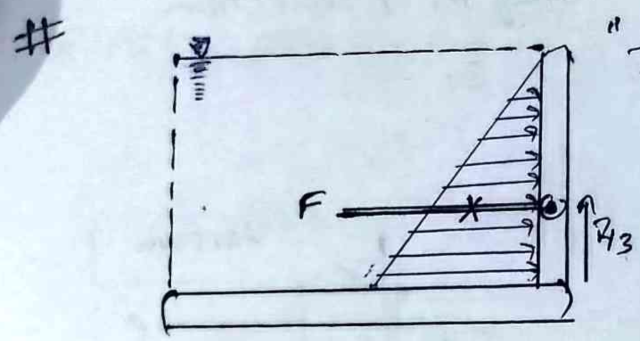
$\int dF = \rho g w \int_0^h y\,dy$

Hence;

$F = \rho g w \frac{h^2}{2} \Rightarrow \frac{1}{2}\rho g w h^2$

$$\boxed{F = \frac{1}{2}\rho g w h^2}$$

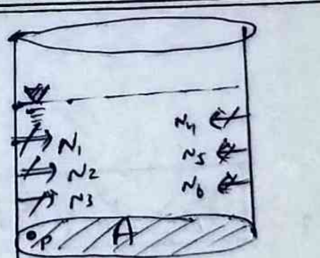
#



"The net force of all these forces should be at a h/3 height because this $\vec{F}$ should pass through com of force profile which is at a height h/3"

Why pressure same with random shaped vessels :-

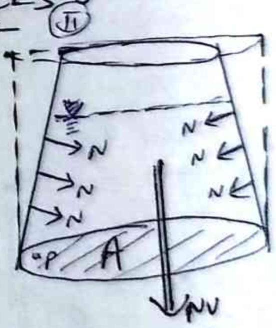
water in vessel I is much more than that in vessel (II) however;
Pressure at point P is same due to →



Net force = 0

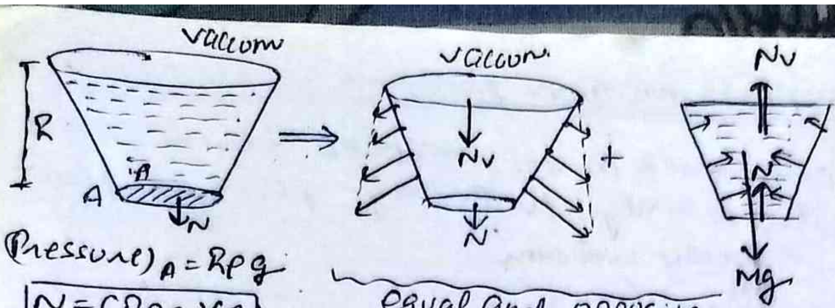
* More water
* same Pressure

Net force (Nv) = 0



* less water
* same Pressure

The force Nv Balances the Pressure



$N_v + N = Mg$ — (1)

$N_v + R\rho g A = Mg$

$\boxed{N_v = Mg - R\rho g A}$

$(\text{Pressure})_A = R\rho g$

$\boxed{N = (R\rho g)(A)}$

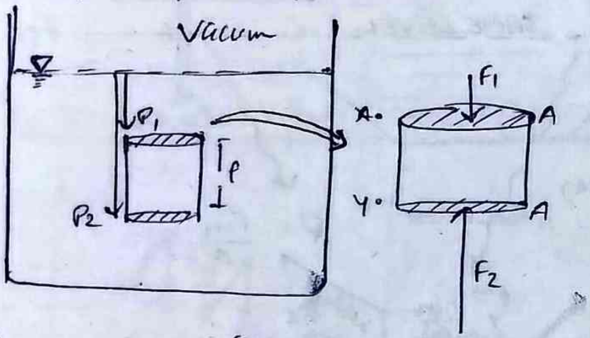
$\boxed{F = P \cdot A}$

equal and opposite Normal Rctn (N)

[N_v = Resultant of all Normal forces.
Mg = weight of water.

> ARCHIMEDES PRINCIPLE :-

A Body when submerged in a fluid is buoyant upward by a force due to fluid pressure. That is equal to weight of displaced liquid



$F_B = V \rho g$

volume submerged in fluid; density of fluid

$(\text{Pressure})_X < (\text{Pressure})_Y$

So, $\boxed{F_1 < F_2}$; net force is upward

$F_{net} = (F_2 - F_1)$

$\Rightarrow P_2 A - P_1 A$

$\Rightarrow (P_2 - P_1) A$

$[(l+R)\rho g - R\rho g] A \Rightarrow (lA)\rho g \Rightarrow \boxed{V\rho g}$

> APPARENT WEIGHT OF BODY IN A LIQUID :-

$M = \rho_s V_s$

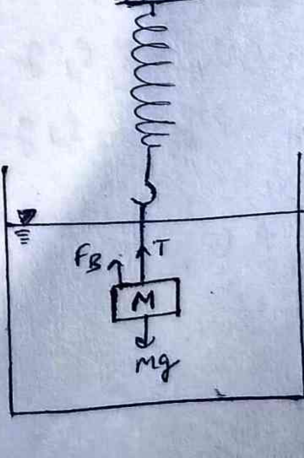
$\Rightarrow V = M/\rho_s$ — (1)

$T + F_B = Mg$

$T + (V \rho_L g) = Mg$

$T = Mg - V\rho_L g$

$\frac{T}{g} = M - M\frac{\rho_L}{\rho_s} \Rightarrow M\left(1 - \frac{\rho_L}{\rho_s}\right)$

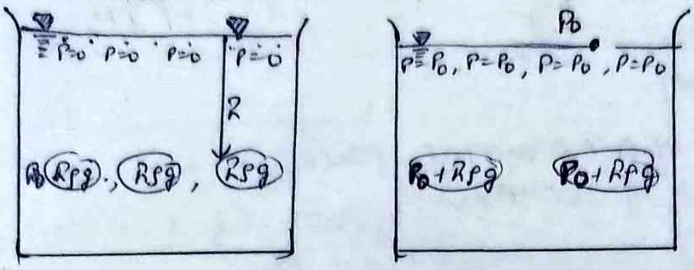


$\boxed{\text{Apparent weight} \equiv M\left(1 - \frac{\rho_L}{\rho_s}\right)}$

> PASCAL PRINCIPLE OF PRESSURE DISTRIBUTION :-

The Pressure applied at one point in an enclosed fluid Body is transmitted uniformly to every part of fluid

not in Contact with atm   in Contact with atm

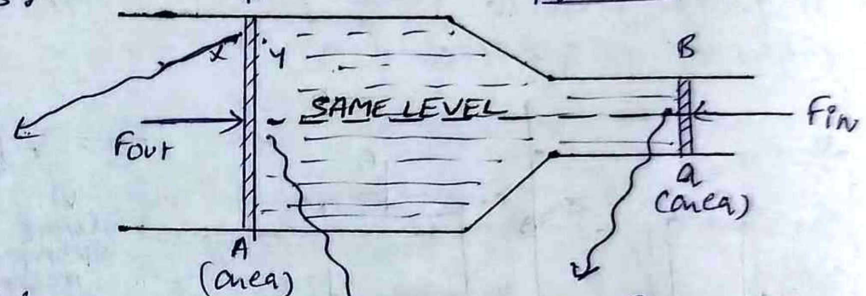


Pressure is equally (↑) by P_0 at all Points after the removal of cork.

> APPLICATION OF HYDRAULIC FORCES :-

∘ AMPLIFICATION OF FORCES :-

$\boxed{a \ll A}$



$P_x = \frac{F_{out}}{A}$

$P = \frac{F_{in}}{a}$

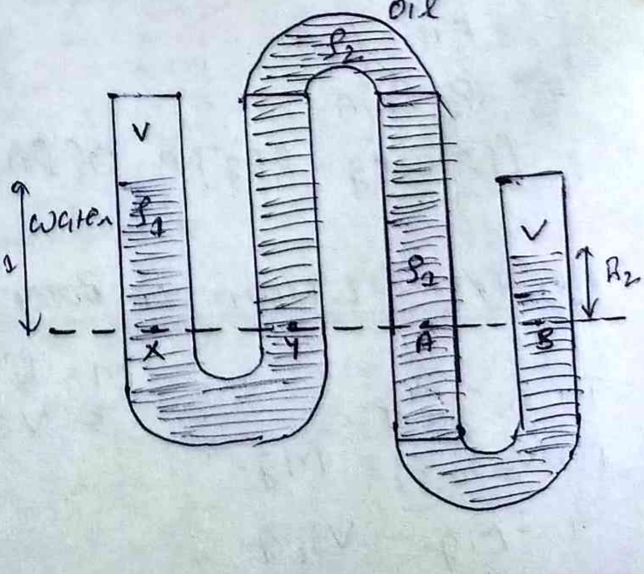
$P_y = \frac{F_{in}}{a}$ SAME

Pressure at Point x should be equal to Pressure at Point y to hold Piston.

$P_x = P_y$

$\frac{F_{out}}{A} = \frac{F_{in}}{a} \Rightarrow F_{out} = \left(\frac{A}{a}\right) F_{in}$

$\Rightarrow \boxed{F_{out} \gg F_{in}}$



we have;

$(P)_x = (P)_y = R_1 \rho_1 g$

$(P)_A = (P)_B = R_2 \rho_1 g$

But;

$(P)_y \neq (P)_A$

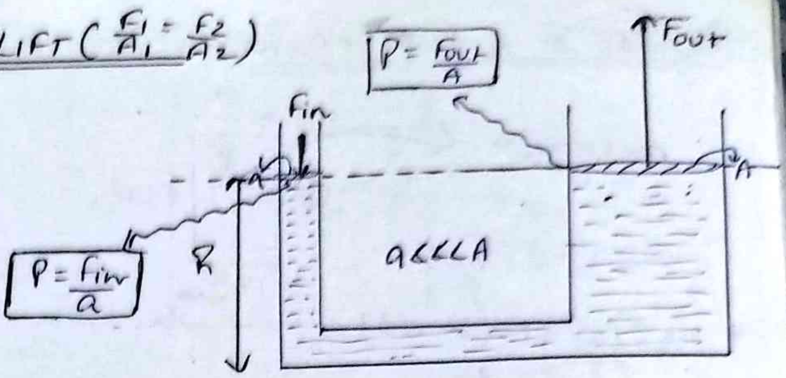
VISUALIZATION

MECHANISM OF HYDRAULIC LIFT ($\frac{F_1}{A_1} = \frac{F_2}{A_2}$)

$$\frac{F_{in}}{a} = \frac{F_{out}}{A}$$

$$F_{out} = \left(\frac{A}{a}\right) F_{in}$$

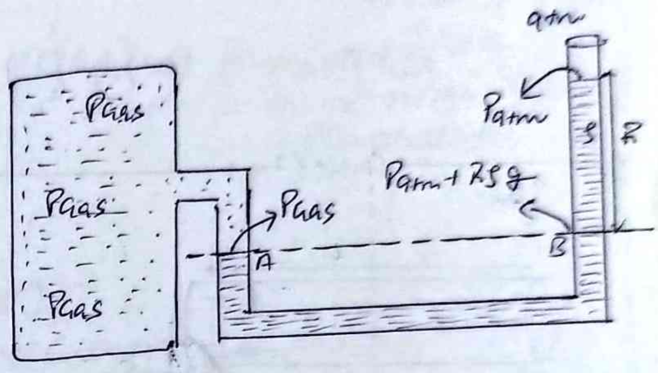
* $\boxed{F_{out} >>> F_{in}}$



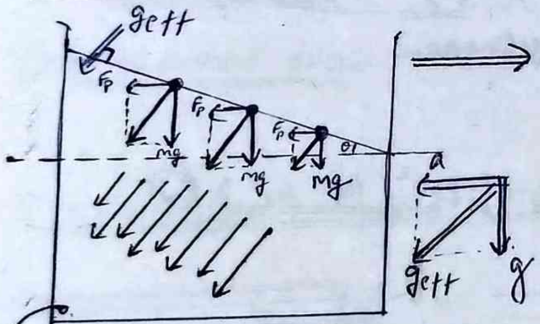
OPEN TUBE MANOMETER :-

$$(\text{Pressure})_A = (\text{Pressure})_B$$

$$\boxed{P_{gas} = P_{atm} + h\rho g}$$



PRESSURE DIST. IN ACCELERATED FRAME :-

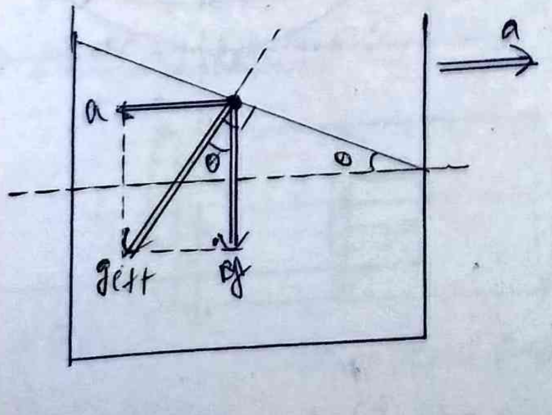


Max. Pressure Point

OBSERVATION:-

* SLANTING POSITION of H_2O
* g_{eff} is $\perp$ to free surface

$\boxed{\theta = ?}$

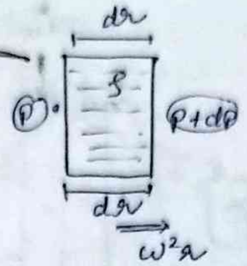


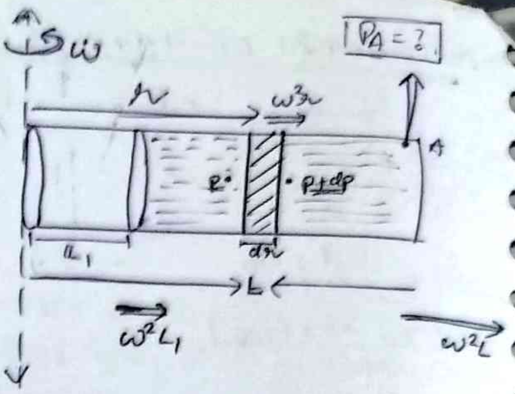
$$\tan\theta = a/g$$

$$\boxed{\theta = \tan^{-1}(a/g)}$$

> PRESSURE IN A ROTATING TUBE :-

MAGNIFIED





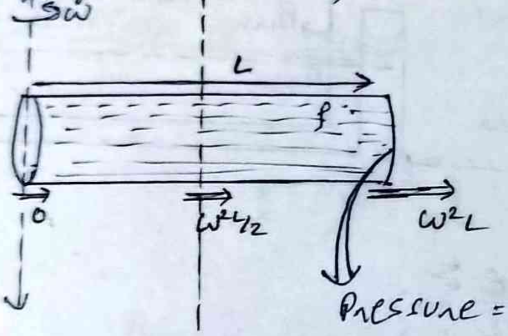
$(P) + a r \rho (\omega^2 r) = (P + dP)$

$\int dP = \int \rho \omega^2 r \, dr$

$P_A = \int dP = \rho\omega^2 \int r \, dr = \rho\omega^2 \left[\frac{r^2}{2}\right]_{L_1}^{L} = \frac{1}{2}\rho\omega^2 (L^2 - L_1^2)$

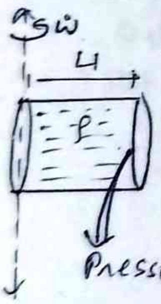
$\boxed{P_A = \frac{1}{2}\rho\omega^2 (L^2 - L_1^2)}$

Centre ($L/2$)



KILLER, PLAY WITH PRESSURE

Pressure = $(L)\rho \underbrace{\left(\omega^2 \frac{L}{2}\right)}_{\text{Avg. Acceleration}} = \boxed{\frac{1}{2}\rho\omega^2 L^2}$

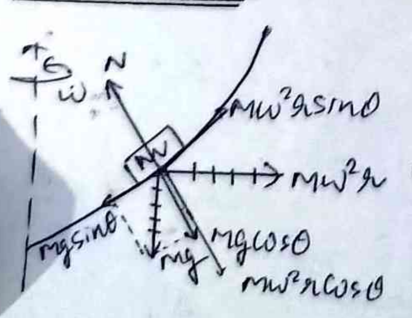


Pressure = $\frac{1}{2}\rho\omega^2 L_1^2$

$\ominus \Rightarrow$ Pressure diff = $\frac{1}{2}\rho\omega^2 (L^2 - L_1^2)$ ☺

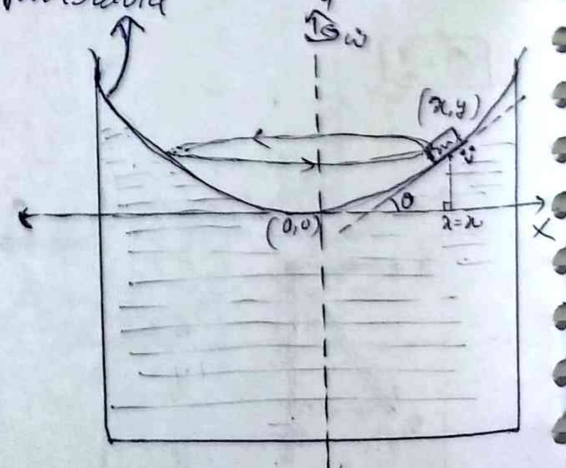
> ROTATING FLUID :-

$\tan\theta = \left.\frac{dy}{dx}\right|_{x=x}$



MAGNIFIED

Paraboloid



$mg\sin\theta = m\omega^2 x\cos\theta$

$\tan\theta = \frac{\omega^2}{g} x$

$\frac{dy}{dx} = \left(\frac{\omega^2}{g}\right) x \Rightarrow \int dy = \left(\frac{\omega^2}{g}\right)\int_0^x x \, dx$

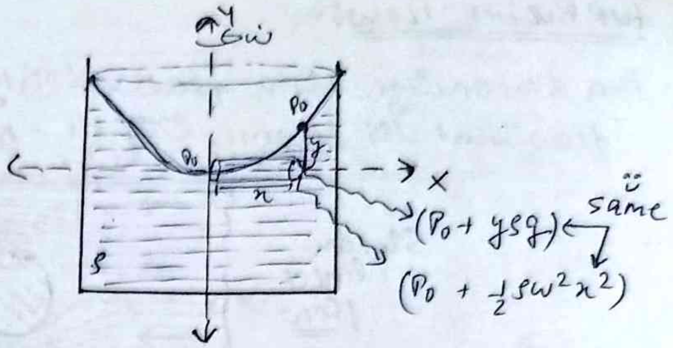
$\Rightarrow y = \left(\frac{\omega^2}{2g}\right) x^2$

ROCKSTAR METHOD

$P_0 + y\rho g = P_0 + \frac{1}{2}\rho\omega^2 x^2$

$y\rho g = \frac{1}{2}\rho\omega^2 x^2$

$$\boxed{y = \left(\frac{\omega^2}{2g}\right)x^2}$$



"Volume of Paraboloid = V of water with in Height of Paraboloid"

∴ FLUID DYNAMICS :-

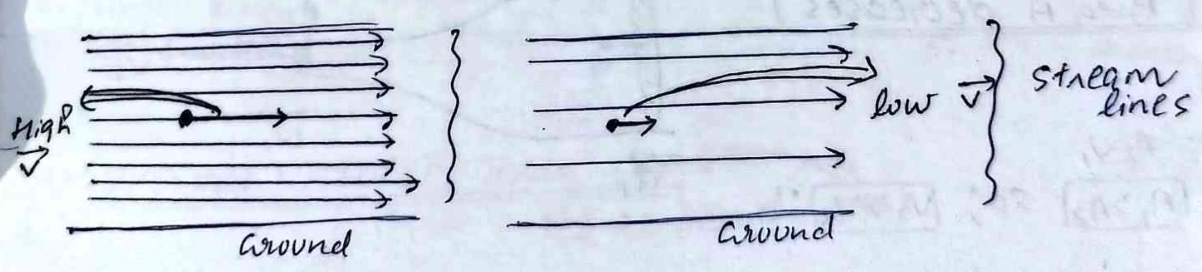
∴ Streamline flow (Laminar flow) :-
→ Velocity of fluid does not change (In mag / dirⁿ)

∴ Incompressible flow :- fluid density remains constent.

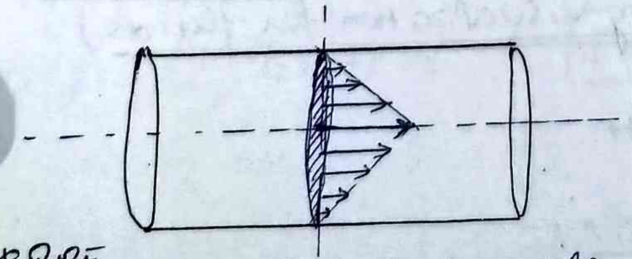
∴ Non-viscous flow :- Neglet viscous flow.

∴ Irrotational flow :- do not impart any rotational motion

> Stream lines :- (Imaginary lines) :- represent fluid flow.

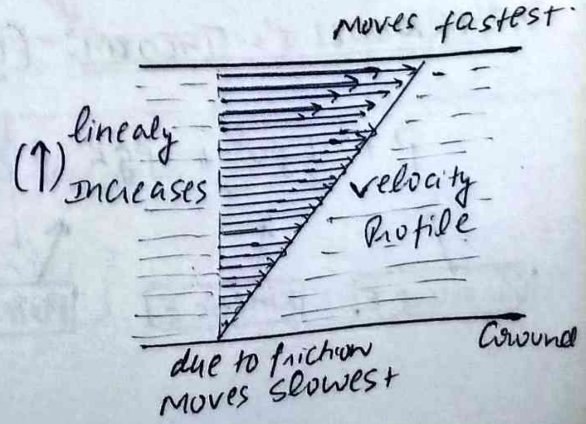


> VELOCITY PROFILE :-



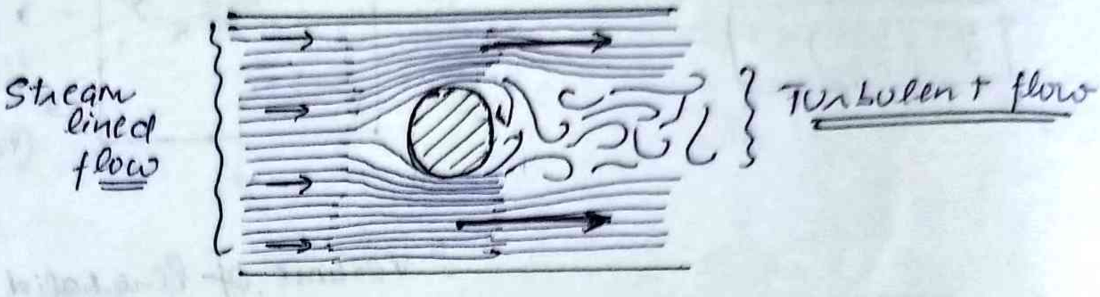
* PIPE

Paraboloid profile



TURBULENT FLOW:-

In a streamline flow, flow velocity ($\vec{v}$) at a certain point no stream line exist after this flow particles become erratic



> EQUATION OF CONTINUITY :- (Flow should be Constant)

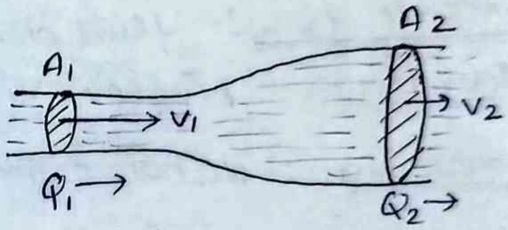
$\boxed{\text{volume / sec} = \text{Const}^{t.}}$

∵ Case(I) [Area A Constant]

$Q_1 = Q_2$

$Av_1 = Av_2 \Rightarrow \boxed{v_1 = v_2}$

∵ Case(II) [Area A Increases]

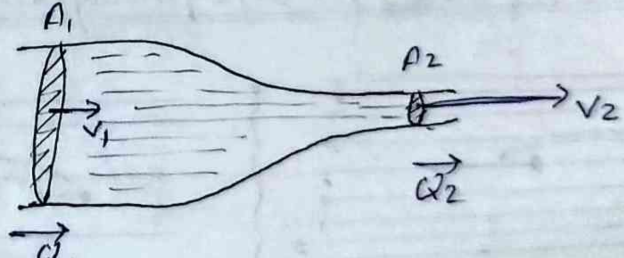


$Q_1 = Q_2$

$A_1 v_1 = A_2 v_2$

Since, $\boxed{A_1 < A_2}$ so; $\boxed{v_1 > v_2}$

∵ Case III [Area A decreases]



$Q_1 = Q_2$

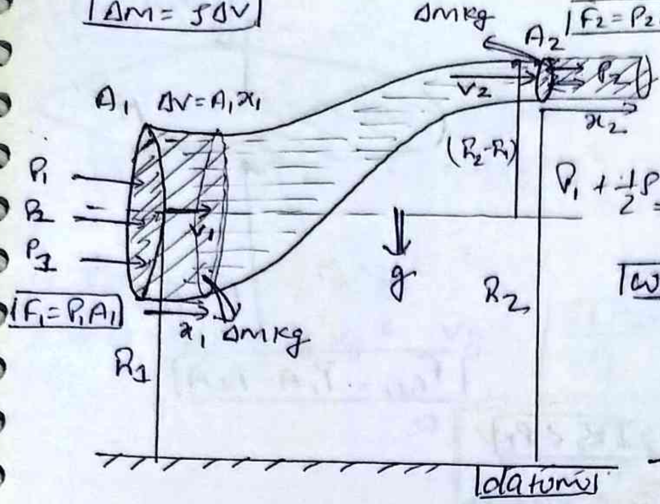
$A_1 v_1 = A_2 v_1$

Since, $\boxed{A_1 > A_2}$ so; $\boxed{v_2 > v_1}$

> BERNOULLI's THEORM:- (energy visualization for fluids)

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

Pressure E | Kinetic E | Potential E



GOLD

$(1) \to (2)$ B.T

$$\underline{P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2}$$

W-E theorem

$$W_g + W_p = \Delta KE$$

$$W_g + W_{P_1} + W_{P_2} = \Delta KE$$

$$-\Delta m g(h_2 - h_1) + F_1 x_1 - F_2 x_2 = \frac{1}{2}\Delta m(v_2^2 - v_1^2)$$

$$-\Delta m g(h_2 - h_1) + P_1 \overbrace{A_1 x_1}^{\Delta V} - P_2 \overbrace{A_2 x_2}^{\Delta V} = \frac{1}{2}\Delta m(v_2^2 - v_1)^2$$

$$-\Delta m g(h_2 - h_1) + P_1 \Delta V - P_2 \Delta V = \frac{1}{2}\Delta m(v_2^2 - v_1^2)$$

$$-\frac{\Delta m}{\Delta V} g(h_2 - h_1) + (P_1 - P_2) = \frac{1}{2}\frac{\Delta m}{\Delta V}(v_2^2 - v_1^2)$$

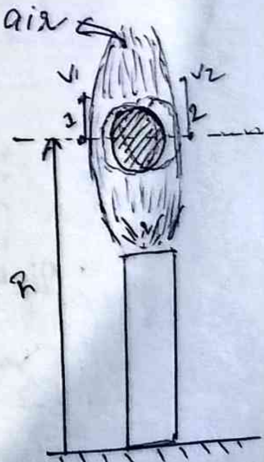
$$-\rho g(h_2 - h_1) + (P_1 - P_2) = \frac{1}{2}\rho(v_2^2 - v_1^2)$$

$$\Rightarrow \boxed{P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2}$$

So, $P + \frac{1}{2}\rho v^2 + \rho g h = \text{Const}^{t}$.

$$\underbrace{\frac{P}{\rho g}}_{\text{Pressure head}} + \underbrace{\frac{v^2}{2g}}_{\text{velocity head}} + \underbrace{h}_{\text{Potential head}} = \text{Const}^{t}$$

∴ PRESSURE VELOCITY TRADE OFF :- B.T at same height



B.T at point 1 and 2.

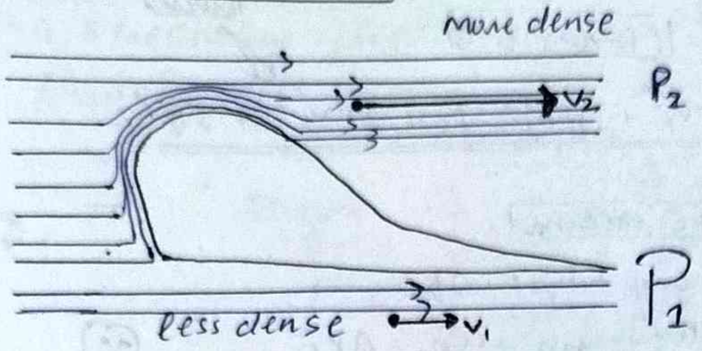
$$P_1 + \frac{1}{2}\rho v_1^2 + \cancel{\rho g h} = P_2 + \frac{1}{2}\rho v_2^2 + \cancel{\rho g h}$$

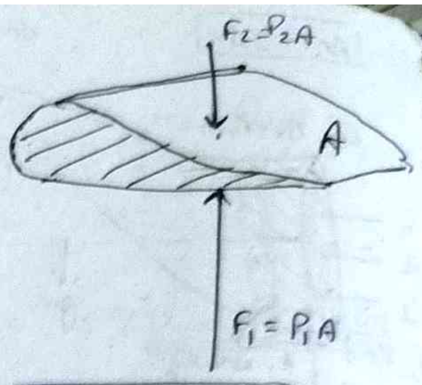
So, $P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2 \Rightarrow \boxed{P + \frac{1}{2}\rho v^2 = \text{Constant}}$

decode

$$\left\{ \begin{matrix} v(\uparrow) & v(\downarrow) \\ P(\downarrow) & P(\uparrow) \end{matrix} \right\}$$

>LIFT OF AN AEROPLANE :-





$\boxed{F_{lift} = P_1A - P_2A}$

$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$ If $v_2 > v_1$ so, $\boxed{P_2 < P_1}$

Since $P_2 < P_1$ It will lift the Aeroplane easily

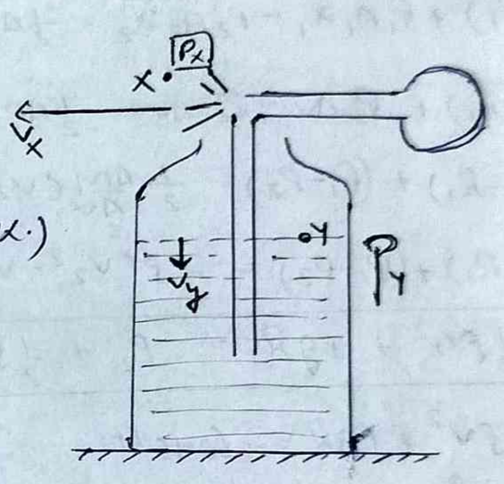
>ATOMIZER SPRAY :-

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

BT (x) - (y) at same height (approx.)

$\left(P_x + \frac{1}{2}\rho v_x^2\right) = \left(P_y + \frac{1}{2}\rho v_y^2\right)$

Since $P_y >> P_x$ so, $\boxed{v_x >> v_y}$



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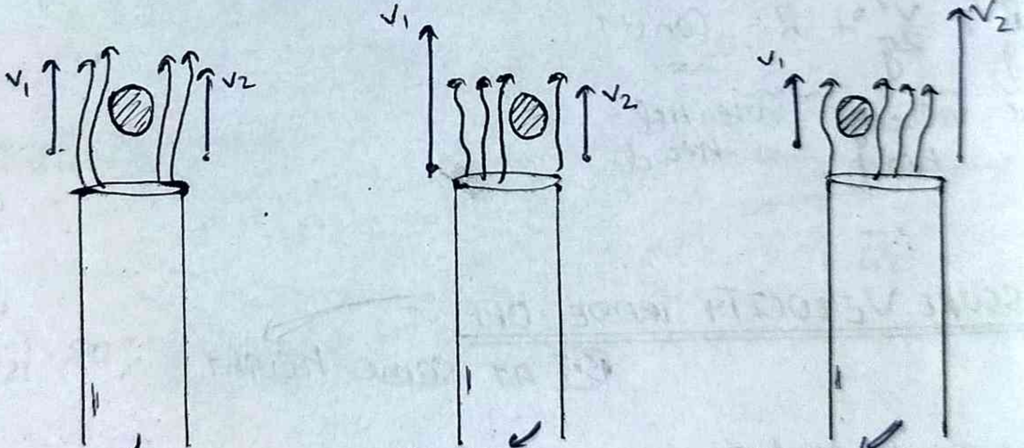
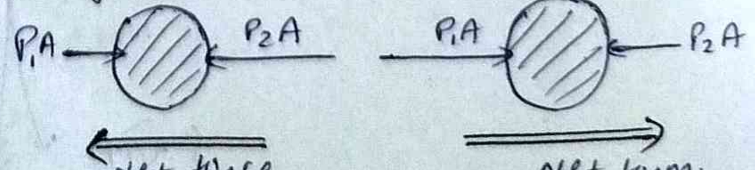


Air blow | Air blow | Air blow
$v_1 = v_2$ | $v_1 > v_2$ | $v_1 < v_2$
$P_1 = P_2$ | $P_1 < P_2$ | $P_1 > P_2$
 | (using Bernoulli Th.) | (using Bernoulli Th.)



Net force (shifts left) | Net force (shifts right)

> PITOT TUBE :-

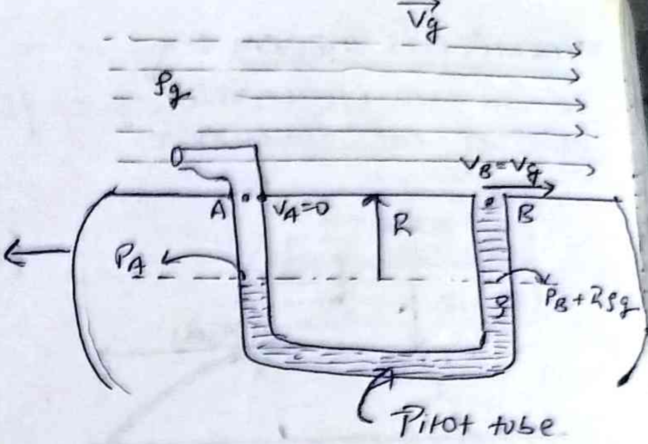
B.T for 'moving air' (A) & (B)

$$P_A + \frac{1}{2}\rho_g \underbrace{V_A^2}_{0} = P_B + \frac{1}{2}\rho_g V_B^2$$

$$P_A = P_B + \frac{1}{2}\rho_g V_g^2$$

$$(P_A - P_B) = \frac{1}{2}\rho_g V_g^2 \quad V_g = \sqrt{\frac{2(P_A - P_B)}{\rho_g}}$$

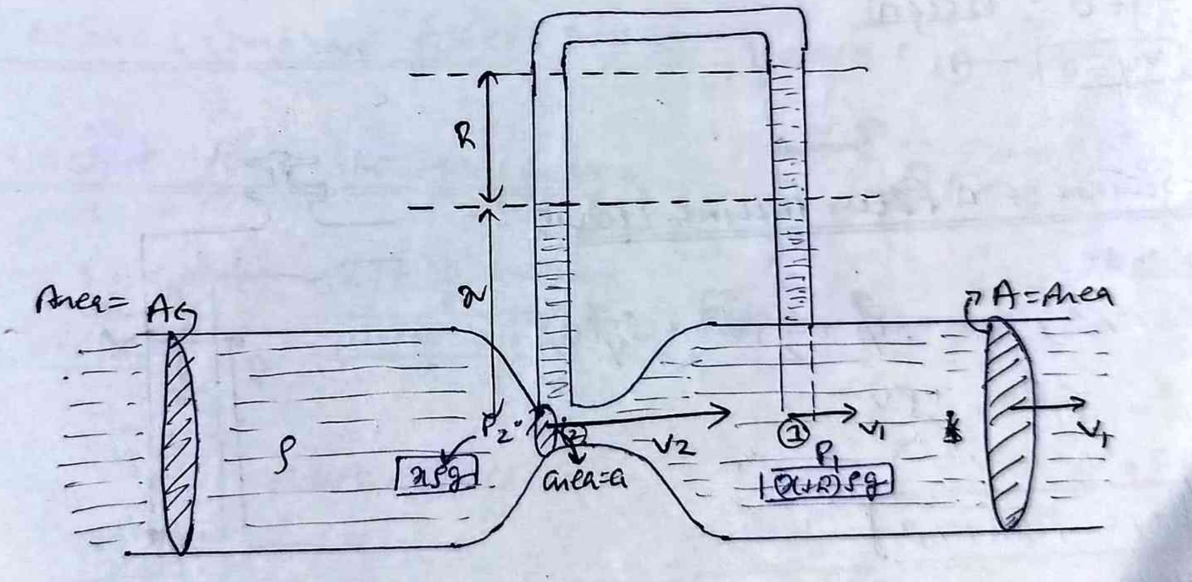
$$\Rightarrow \boxed{V_g = \sqrt{\frac{2h\rho g}{\rho_g}}}$$



$$P_A = P_B + h\rho g$$

$$\boxed{P_A - P_B = h\rho g}$$

> VENTURIMETER :- (device to measure flow velocity of liquid)



> B.T on ① and ② at same lvl

$$\left(P_1 + \frac{1}{2}\rho V_1^2\right) = \left(P_2 + \frac{1}{2}\rho V_2^2\right)$$

$$P_1 - P_2 = \frac{1}{2}\rho\left(\frac{A}{a}\right)^2 V_1^2 - \frac{1}{2}\rho V_1^2$$

$$2h\cancel{\rho} g = \frac{\cancel{\rho} V_1^2}{\cancel{2}}\left(\frac{A^2}{a^2} - 1\right)$$

$$V_1^2 = \frac{2hg}{\left(\frac{A^2}{a^2} - 1\right)} \Rightarrow V_1 = \sqrt{\frac{2gh}{(A/a)^2 - 1}}$$

> Eq. of continuity :-

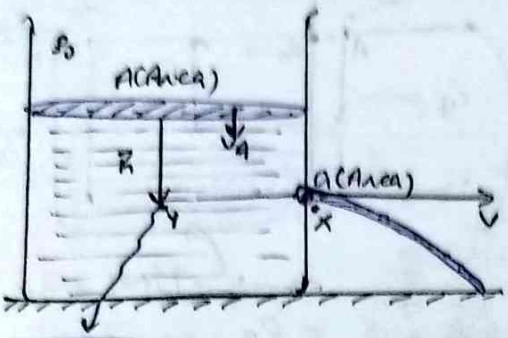
$$\boxed{a V_2 = A V_1}$$

$$P_2 = x\rho g \quad P_1 = (h + x)\rho g$$

$$(P_1 - P_2) = h\rho g$$

> TORRICELLI'S THEORM :-

∵ to Calculate efflux velocity of fluid flowing out through a hole in the Container.



$\boxed{P_0 + R\rho g}$

B.T B/w x and Y

$(P_Y + \frac{1}{2}\rho \overset{0}{v_Y^2}) = (P_X + \frac{1}{2}\rho v_A^2)$

$v_Y \simeq 0$ from eq 1 :-

$(\cancel{P_0} + R\rho g) = (\cancel{P_0} + \frac{1}{2}\rho v^2)$

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

$\boxed{V = \sqrt{2gR}}$

- Equation of Continuity :-

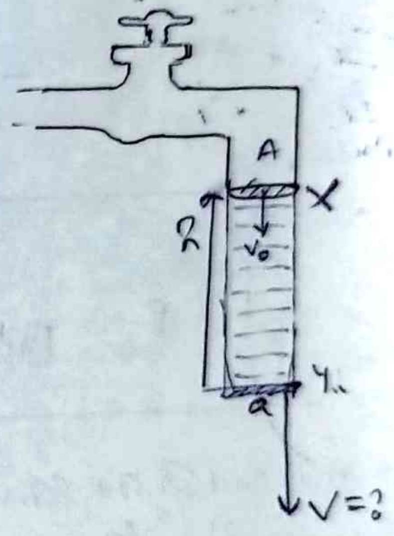
$Q = AV_Y = aV_X$

$V_Y = \left(\frac{a}{A}\right) V_X$

Since, $\left(\frac{a}{A}\right) \simeq 0$; $\boxed{a \lll A}$

so $\boxed{V_Y \simeq 0}$ — (1)

> CROSS-SECTION OF A FREELY FALLING LIQUID :-



BT x and Y

$\cancel{P_X} + \frac{1}{2}\rho v_0^2 + \rho g h = \cancel{P_Y} + \frac{1}{2}\rho v^2 + \rho \cancel{g}(0)$

$\frac{1}{2}\rho v_0^2 + \rho g h = \frac{1}{2}\rho v^2$

$2gh + v_0^2 = v^2$

$\boxed{V = \sqrt{2gh + v_0^2}}$

- eq of Continuity :- $AV_0 = aV$

$\Rightarrow \boxed{a = \frac{AV_0}{\sqrt{2gh + V_0^2}}}$

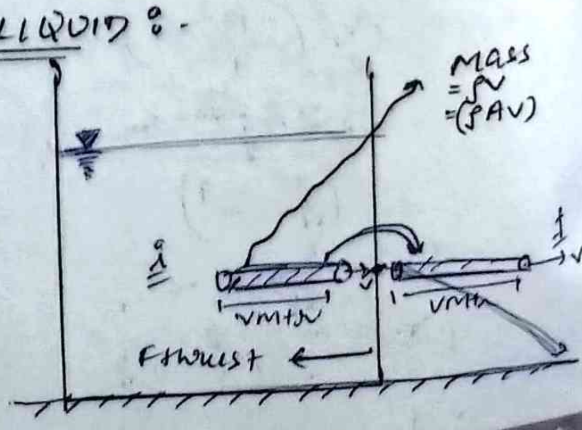
> REACTION FORCE DUE TO EJECTION OF LIQUID :-

$\vec{\Delta P}$ for 1sec

$\vec{F}_{thrust} = (\Delta P_{1sec})$

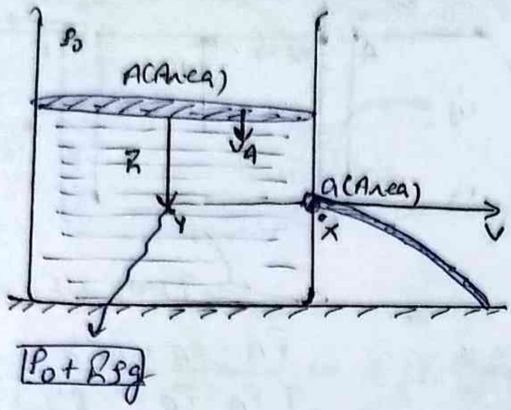
$\Rightarrow \rho AV \cdot V - 0$

$\Rightarrow \boxed{\rho AV^2}$



> TORRICELLI's THEORM :-

∵ to Calculate efflux velocity of fluid flowing out througe a Hole in the Container.



B.T B/w X and Y

$$\left(P_Y + \tfrac{1}{2}\rho v_Y^2\right) = \left(P_X + \tfrac{1}{2}\rho v_A^2\right)$$

$v_Y \simeq 0$ from eq 1 :-

$$(\cancel{P_0} + h\rho g) = (\cancel{P_0} + \tfrac{1}{2}\rho v^2)$$

$$h\rho g = \tfrac{1}{2}\rho v^2$$

$$\boxed{V = \sqrt{2gh}}$$

equationg Continuity :-

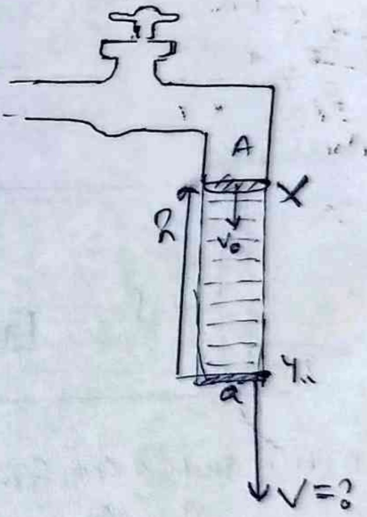
$$Q = Av_Y = a v_X$$

$$v_Y = \left(\frac{a}{A}\right) v_X$$

Since, $\left(\frac{a}{A}\right) \simeq 0$; $\boxed{a \lll A}$

so $\boxed{v_Y \simeq 0}$ — (1)

> CROSS-SECTION OF A FREELY FALLING LIQUID :-



BT. X and Y

$$\cancel{P_X} + \tfrac{1}{2}\rho v_0^2 + \rho g h = \cancel{P_Y} + \tfrac{1}{2}\rho v^2 + \rho g(0)$$

$$\tfrac{1}{2}\rho v_0^2 + \rho g h = \tfrac{1}{2}\rho v^2$$

$$2gh + v_0^2 = v^2$$

$$\boxed{V = \sqrt{2gh + v_0^2}}$$

eq of Continuity :- $Av_0 = av$

$$\Rightarrow \boxed{a = \frac{Av_0}{\sqrt{2gh + v_0^2}}}$$

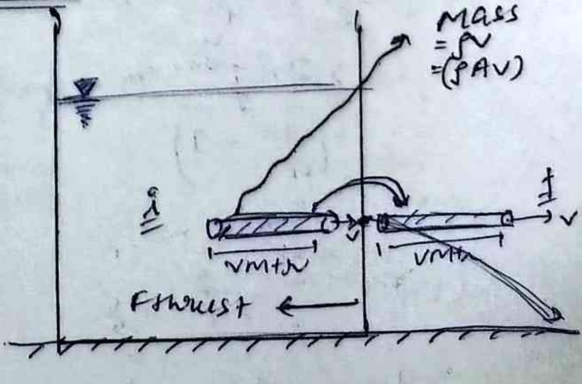
> REACTION FORCE DUE TO EJECTION OF LIQUID :-

$\Delta \vec{P}$ for 1 sec

$$\vec{F}_{thrust} = (\Delta P_{1 sec})$$

$$\Rightarrow \rho A v \cdot v - 0$$

$$\Rightarrow \boxed{\rho A v^2}$$



VISCOUS FORCE :-

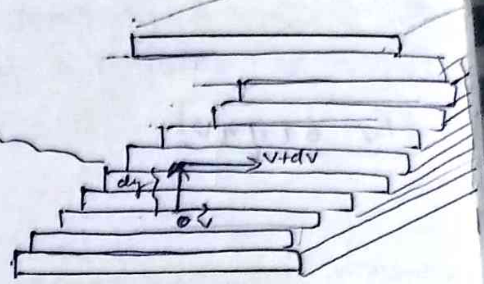
$F \propto A$

$F_v \propto \left(\frac{dv}{dy}\right)$

$F_v \propto A\left(\frac{dv}{dy}\right)$

$$\boxed{F_v = \eta A \frac{dv}{dy}}$$

∵ $\frac{dv}{dy}$ = velocity Gradient



where η = Coefficient of viscosity.

$\underbrace{1\ Pl}_{SI\ Unit} = \underbrace{10\ Poise}_{CGS\ unit}$ of Coeff. of viscosity

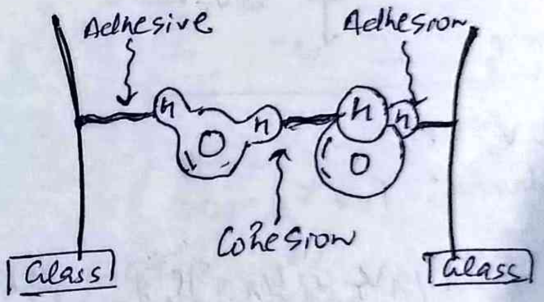
As; $\rho(\uparrow)$ $\eta(\uparrow)$
$\rho(\downarrow)$ $\eta(\downarrow)$

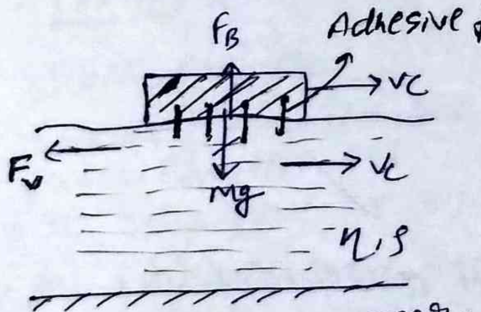
> ADHESIVE & COHESIVE FORCES :-

Attractive force b/w molecules of

Same substance → $\boxed{\text{Cohesion}}$

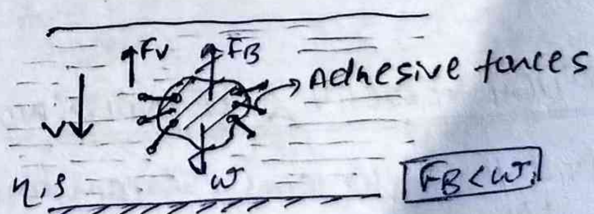
diff. substance → $\boxed{\text{adhesion}}$





Box moves with upper layer due to Adhesive forces.

∵ This Adhesive forces produces a viscous force experienced by object

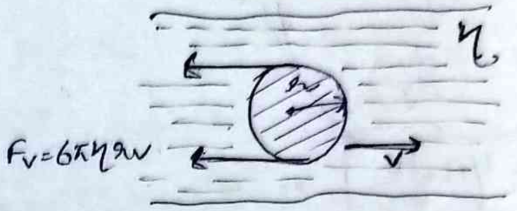


∵ This Adhesive forces produces a viscous force exp. by object.

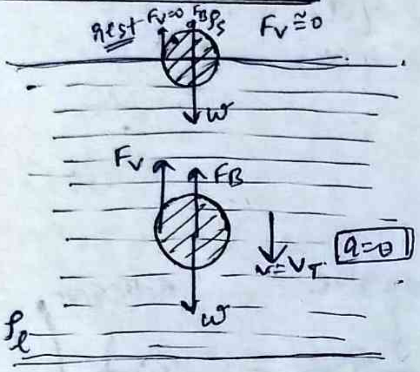
> STOKE'S LAW :-

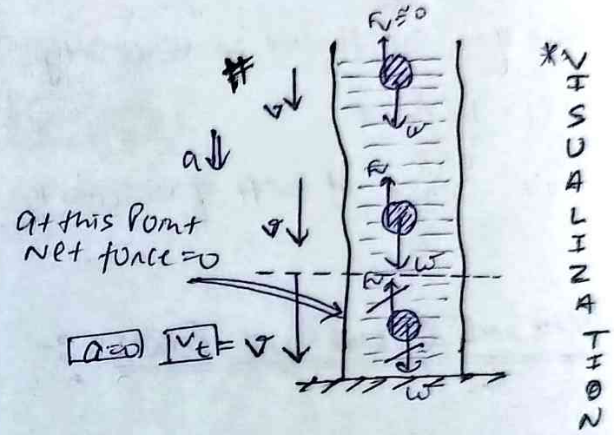
The viscous force on a sphere of ~~mass~~ radious r, with a speed v through a fluid of Coefficient of Visosity η is

$$\boxed{F_v = 6\pi\eta r v}$$



> TERMINAL VELOCITY :-





at, $v = v_t$

$F_{net} = 0$; $F_v + F_B = w$

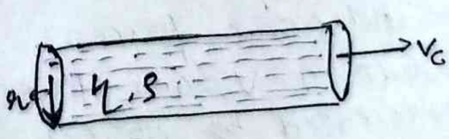
$$6\pi\eta r v_T + \left(\frac{4}{3}\pi r^3\right)\rho_l g = \left(\frac{4}{3}\pi r^3\right)\rho g$$

$$\boxed{v_T = \frac{2}{9}\frac{r^2 g(\rho_s - \rho_l)}{\eta}}$$

> CRITICAL VELOCITY & REYNOLD'S NO :-

∵ fluid flow remains streamline & beyond a critical V'it becomes turbulent.

$$\left.\begin{array}{l} v_c \propto \eta \\ v_c \propto \frac{1}{r} \\ v_c \propto \frac{1}{\rho} \end{array}\right\} \Rightarrow v_c \propto \frac{\eta}{r\rho}$$



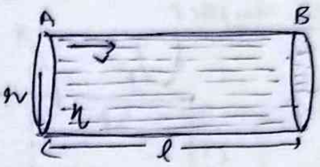
$$\boxed{v_c = \frac{N_R \eta}{r\rho}}$$ → Reynold's Number

$\frac{N_R \eta}{r\rho}$

$$\boxed{\because N_R \propto \frac{1}{\text{laminar flow}}}$$

POISEUILLE'S EQUATION:- → (Viscous flow)

$$Q = \frac{\pi r^4}{8\eta l}(P_A - P_B)$$

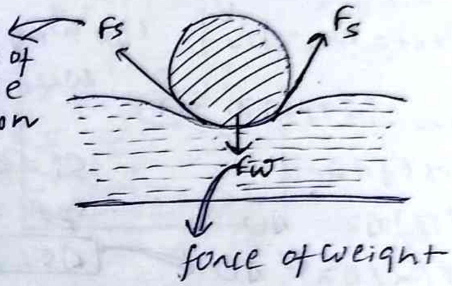


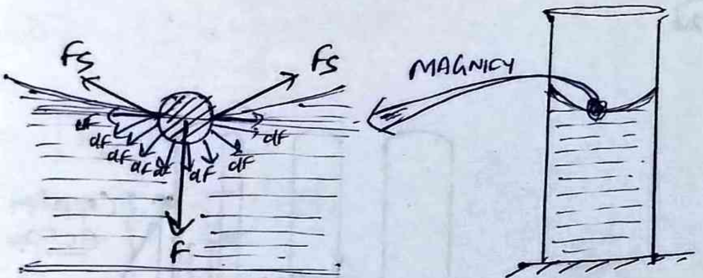
> SURFACE TENSION:-

Property of liq. due to which it free surface tries to have minimum surface area.

It is due to intermolecular attractive forces among liq. ~~forces~~ particles.

Visualizing surface tension

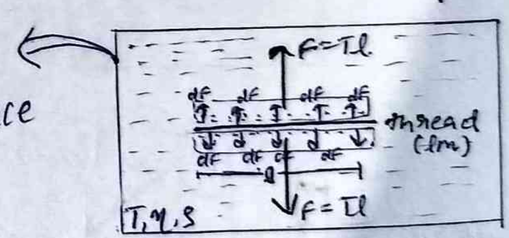




Numerically; Surface tension is the force per unit length on a hypothetical line drawn on a liquid surface normal to it

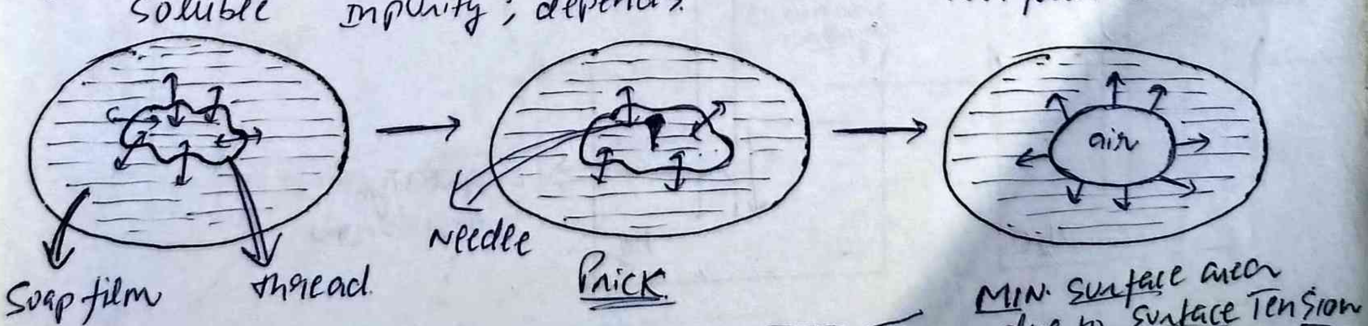
∵ $\boxed{T = F/l}$

· TOP VIEW OF WATER BODY



Net force = 0

> Scaler quantity.
> Greater Intermolecular forces Greater S·T
> as Temp· (↑) ; S·T (↓)
> for Insoluble Impurities; ST(↑)
Soluble Impurity ; depends.

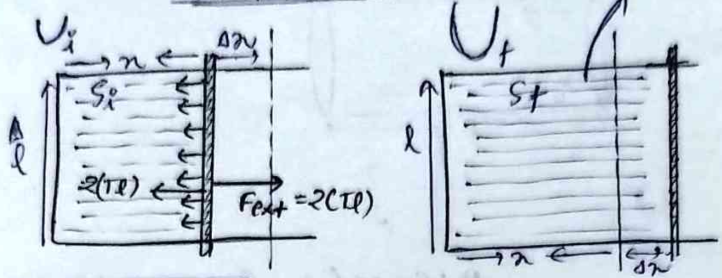


∵ for two free surfaces.

SURFACE ENERGY:-

two free surface

soap film



$\boxed{F_{ext}=2(Tl)}$

$W_{ext}=F_{ext}\cdot\Delta x$

$W_{ext}=(2Tl)\Delta x$ — ①

also

$U_i+W_{ext}=U_f$

$W_{ext}=\Delta U$ — ②

$S_i=2lx$

$S_f=2l(x+\Delta x)$

$\boxed{\Delta S=2l\Delta x}$

from eq 1 and 2

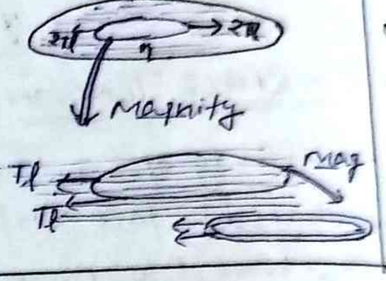
$(2Tl)\Delta x=\Delta U$

$T(2l\Delta x)=\Delta U$

$\boxed{T(\Delta S)=\Delta U}$

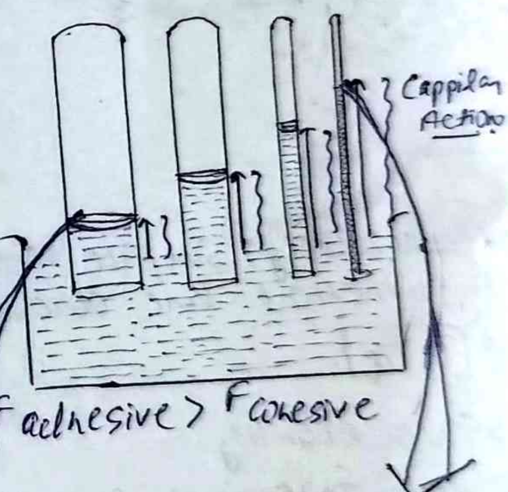
for two free surface

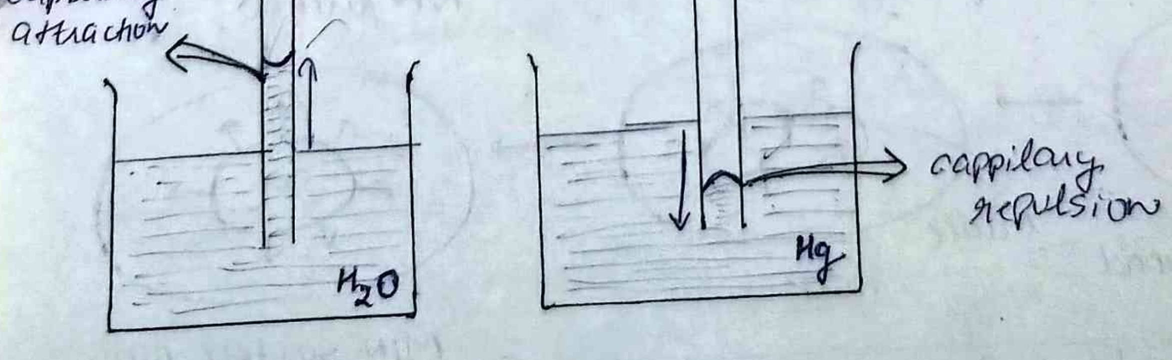
force due to surface tension is 2x force due S.T on a free surface Body.



CAPPILLARY ACTION:-

A tube of Narrow radious is called Capillary.





> HEIGHT OF CAPILLARY ACTION :-

(I)

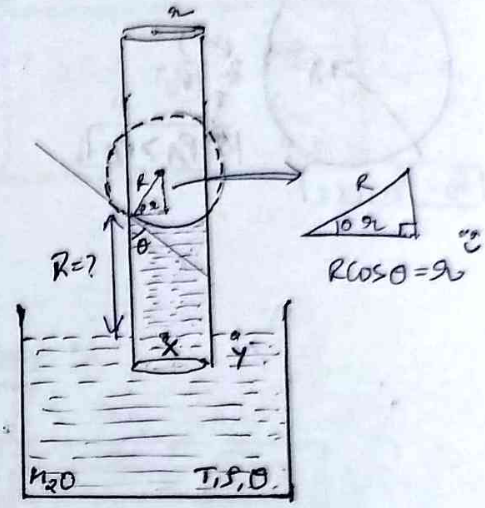
$R\cos\theta = r$

$\boxed{P_X = P_Y}$

$\cancel{P_0} - \frac{2T}{R} + h\rho g = \cancel{P_0}$

$h\rho g = \frac{2T}{R}$

$\therefore \boxed{h = \frac{2T}{R\rho g}}$ or $\boxed{h = \frac{2T\cos\theta}{r\rho g}}$



(II)

$\boxed{P_X = P_Y}$

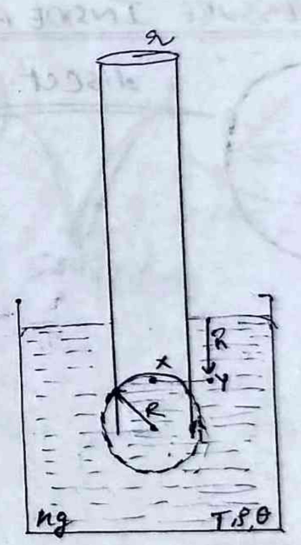
$P_X = \left(P_0 + \frac{2T}{R}\right)$ —(1)

$P_Y = P_0 + h\rho g$ —(2)

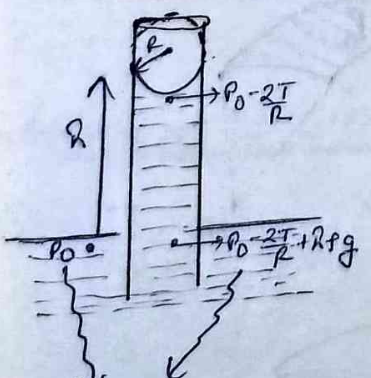
from eq 1 and 2

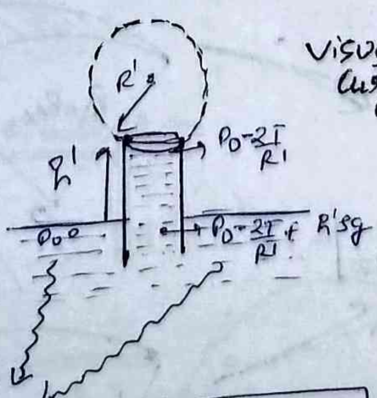
$P_0 + \frac{2T}{R} = P_0 + h\rho g$

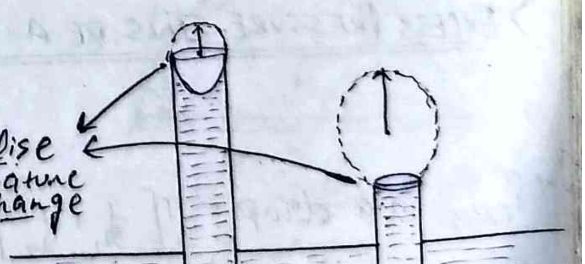
$\frac{2T}{R} = h\rho g \Rightarrow \boxed{h = \frac{2T}{R\rho g}}$



NO FREE FOUNTAINS :-



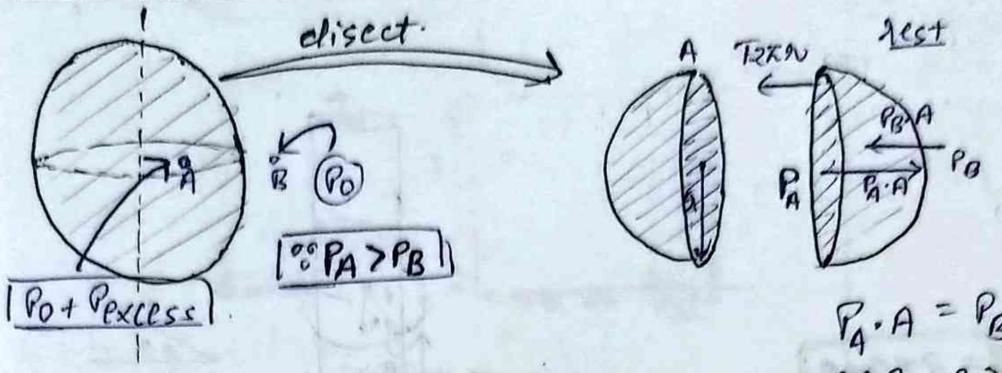




$h = \frac{2T}{R\rho g}$ $\quad h' = \frac{2T}{R'\rho g}$ $\Rightarrow \boxed{hR = h'R'}$

EXCESS PRESSURE INSIDE A LIQ. DROP :-

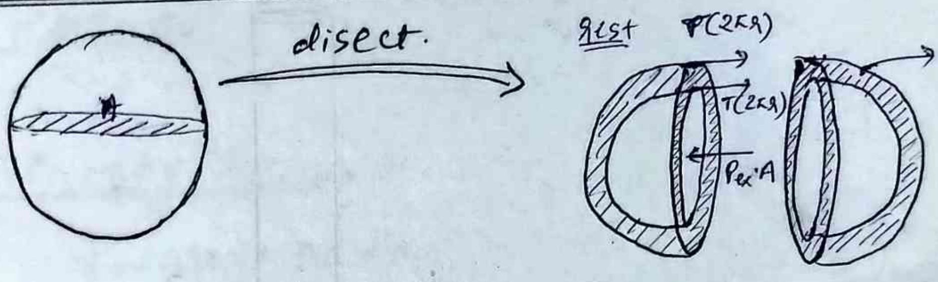
(1 free surface)



$\boxed{A = \pi r^2}$

$$P_A \cdot A = P_B \cdot A + T(2\pi r)$$
$$A(P_A - P_B) = T(2\pi r)$$
$$A P_{ex} = T(2\pi r)$$
$$P_{ex} = \frac{T(2\pi r)}{\pi r^2} = \frac{2T}{r}$$
$$\boxed{P_{ex} = \frac{2T}{r}}$$

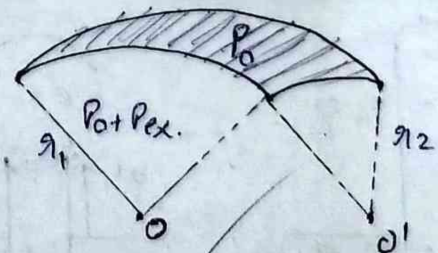
>EXCESS PRESSURE INSIDE A BUBBLE :-



→ ∞ small film of H_2O molecules (2 free surfaces)

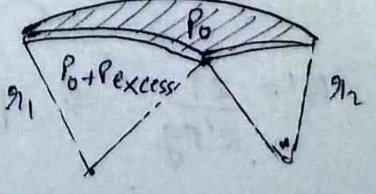
$$2[T(2\pi r)] = P_{ex}(\pi r^2)$$
$$P_{ex} = \frac{4T\pi r}{\pi r^2} \Rightarrow \frac{4T}{r} \Rightarrow \boxed{P_{ex} = \frac{4T}{r}}$$

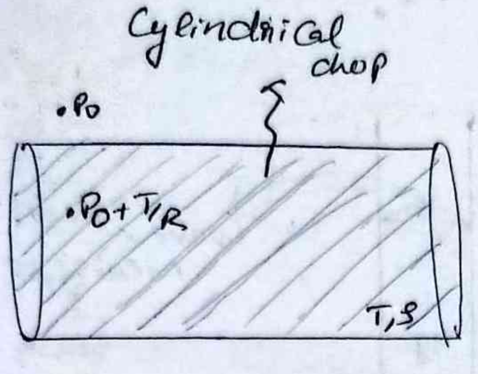
> EXCESS PRESSURE INSIDE A SURFACE OF TWO CURVATURE :-

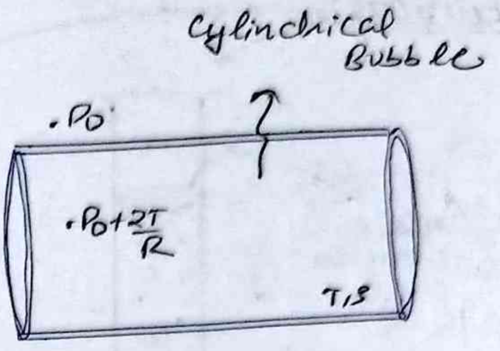


$\because P_{excess}$ in a drop $= T\left[\frac{1}{r_1} + \frac{1}{r_2}\right]$

$\because P_{ex}$ in a film $= 2T\left[\frac{1}{r_1} + \frac{1}{r_2}\right]$







> CONNECTING SOAP BUBBLE OF DIFF RADII :-

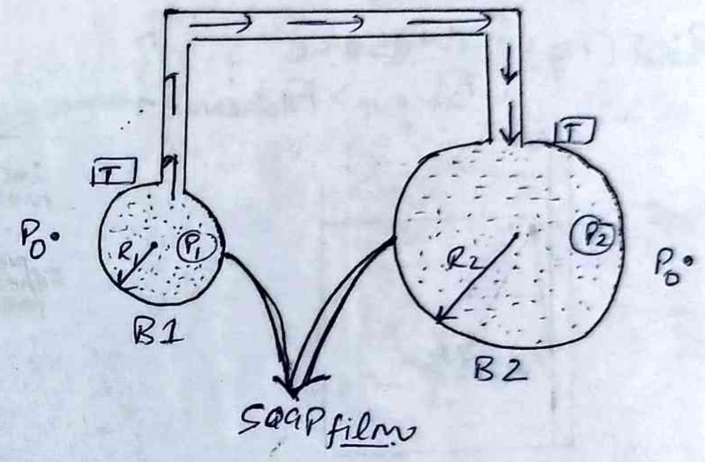
$P_1 = P_0 + \frac{4T}{R_1}$

$P_2 = P_0 + \frac{4T}{R_2}$

Since; $R_1 < R_2$

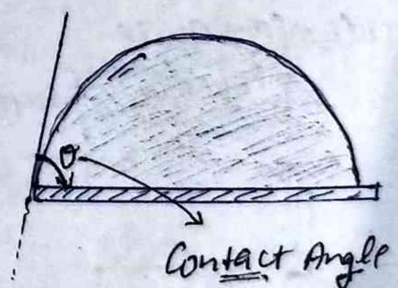
so; $\boxed{P_1 > P_2}$

Air moves from B1 to B_2



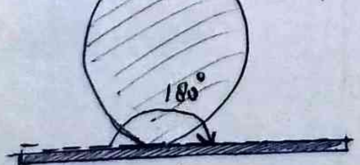
> ANGLE OF CONTACT :-

Angle b/w surface of liq. and outline of contact surface is described as contact angle 'θ'. It is also known as wetting angle.



> Measure of wettability :-

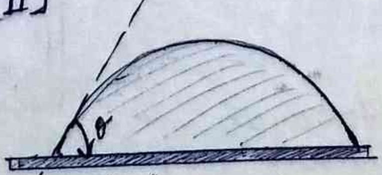
[I]



∵ θ = 180°

> Min. wetting

[II]



∴ θ = 45°

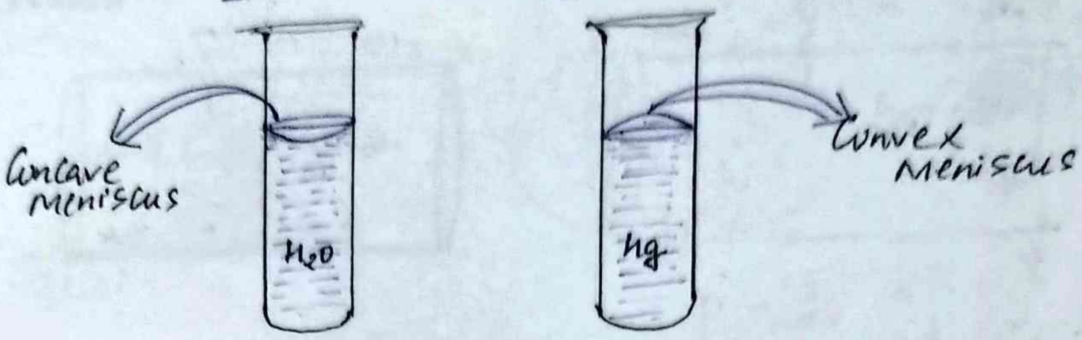
> Avg. wetting

[III]

∵ θ = 0°

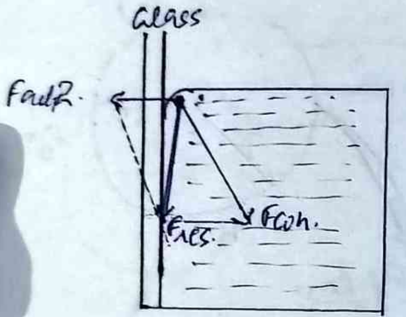
> Max. wetting

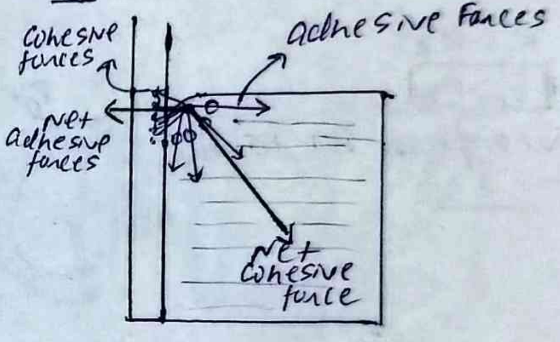
>MENISCUS:-



>ANGLE OF CONTACT:-

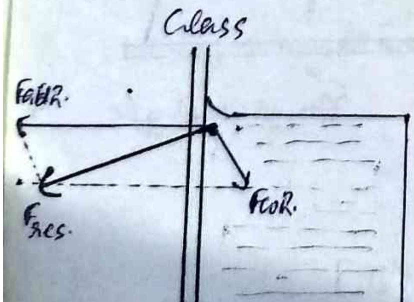
Case I (Hg) { $\theta \rightarrow$ obtuse
$F_{cohesive} > F_{adhesive}$ }

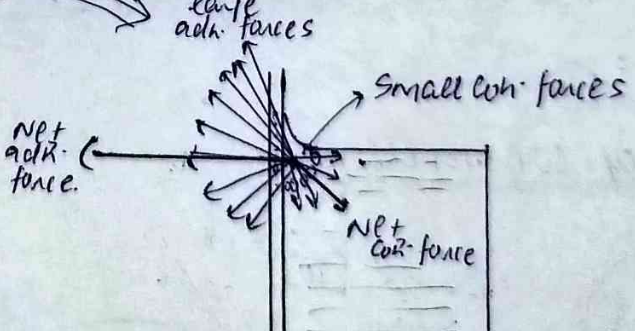




the resultant force is with in the liquid due to which. Convex meniscus is formed

Case(II)(H_2O) { $\theta \rightarrow$ acute
$F_{adhesive} > F_{cohesive}$ }





the resultant force is towards the glass due to which. Concave meniscus is formed.

> SHAPE OF LIQUID MENISCUS IN A TUBE :-

$(P_1 - P_2) = P_{excess}$ in drop $= \left(\frac{2T}{R}\right)$

let, $P_1 = P_0$

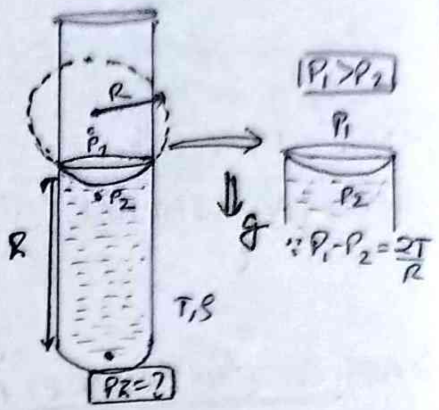
$P_0 - P_2 = \left(\frac{2T}{R}\right)$

$P_2 = \left(P_0 - \frac{2T}{R}\right)$

NOW; # PLAY WITH PRESSURE;

$P_R = P_2 + R\rho g \Rightarrow \left(P_0 - \frac{2T}{R}\right) + R\rho g$

$$\boxed{P_R = P_0 - \frac{2T}{R} + R\rho g}$$



$P_2 - P_1 = P_{excess} = \left(\frac{2T}{R}\right)$

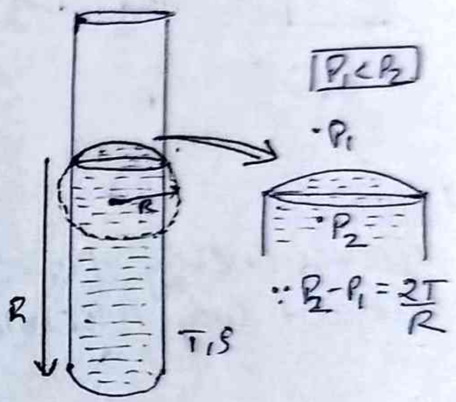
let, $P_1 = P_0$

$P_2 = \left(P_0 + \frac{2T}{R}\right)$

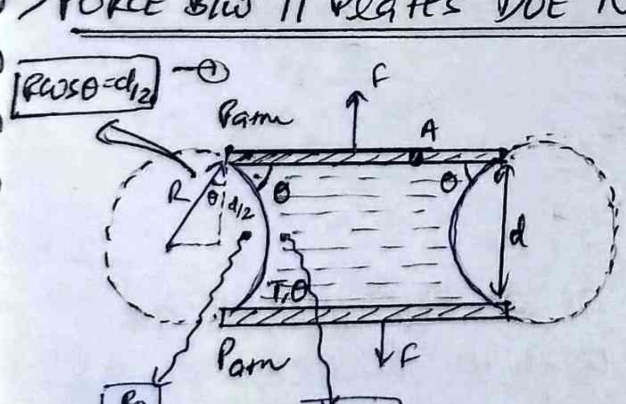
NOW; PLAY WITH PRESSURE;

$P_R = P_2 + R\rho g$

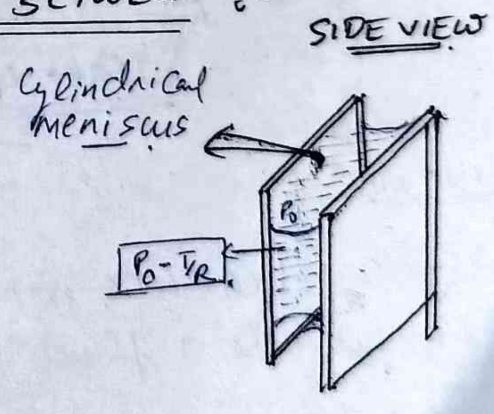
$$\boxed{P_R = P_0 + \frac{2T}{R} + R\rho g}$$



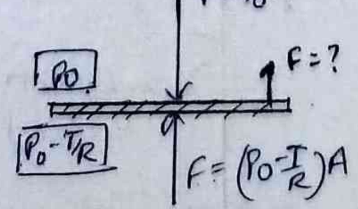
> FORCE B/W ∥ Plates DUE TO LIQ. IN BETWEEN :-



SIDE VIEW



∵ FBD of plate:-



$\left(P_0 - \frac{T}{R}\right)A + F = P_0 A$

$$\boxed{F = \frac{TA}{R}} \because = \boxed{\frac{2TA\cos\theta}{d}}$$

use eq 1.