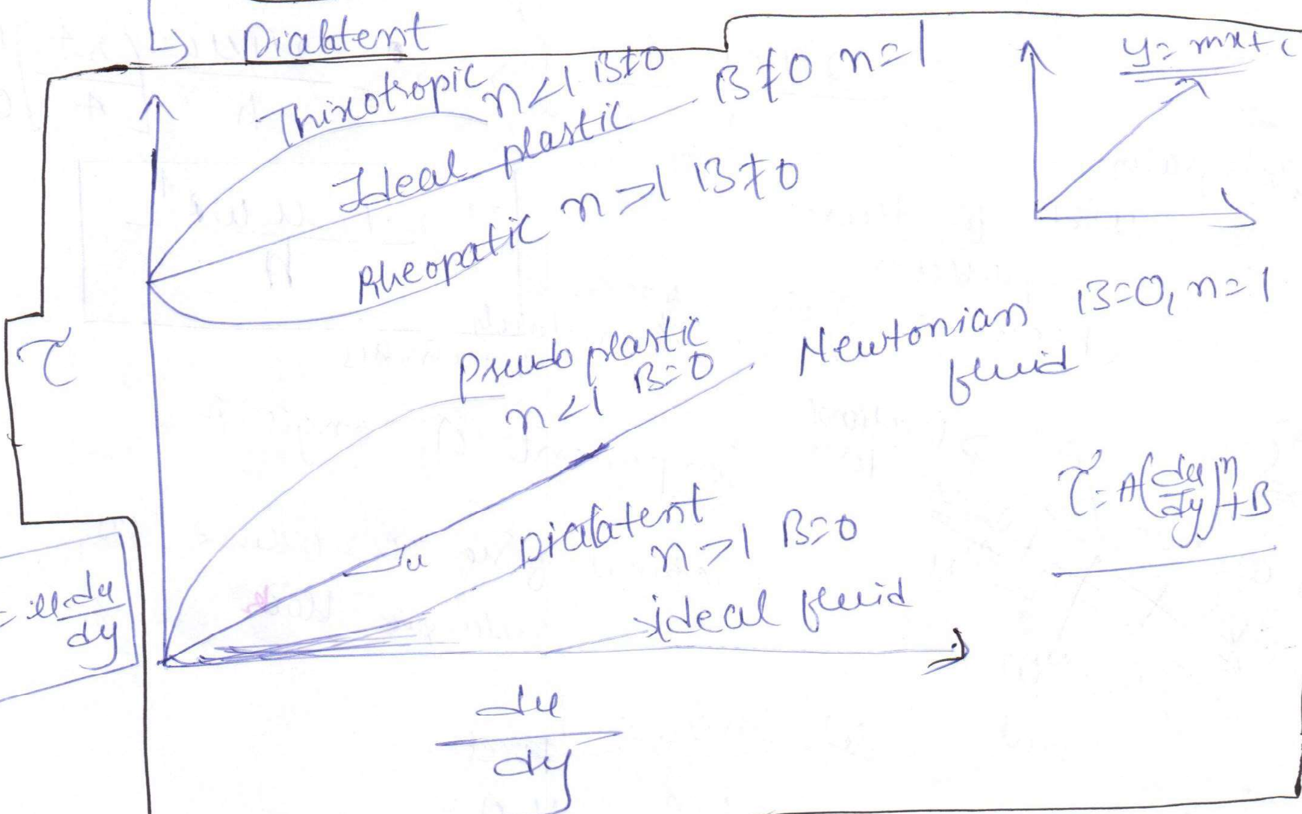
→ * Classification of fluids *

- Ideal
- Real
  - F.M → Newtonian: $\boxed{\tau = \mu \frac{du}{dy}}$
  - Rheology → Non newtonian: $\tau = A\left(\frac{du}{dy}\right)^n + B$
    - Time dependent
      - Thixotropic
      - Rheopatic
    - Time independent
      - Pseudo plastic
      - Ideal plastic (or) Bingum plastic
      - Dialatent

→ Time independent
- → pseudo plasti
- → Ideal plastic (or) Bingum plastic
- → Dialatent

$B = 0$, $\neq 0$ $\quad n = 1, < 1$, ≥ 1

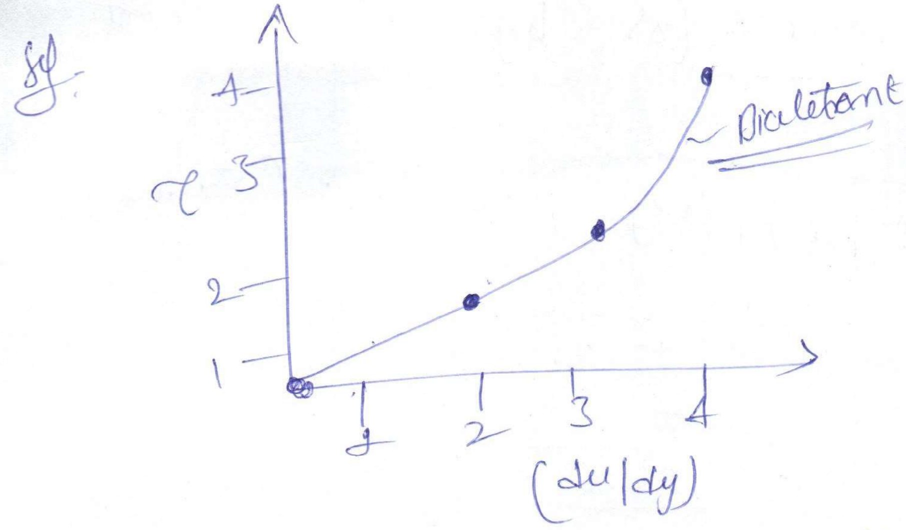


$\tau = \mu \frac{du}{dy}$

Ex: The following data refers to a fluid of

τ	0	1.2	2.3	4
du/dy	0	2	3	4

Sf.



pseudo plastic :- milk, blood, pulp paper solution
liquid content

Ideal (or) Bingum plastic :- Drilling mud, sewage sludge
fly ash, Tooth paste

NOTE: For shear thickening fluids viscosity increases with lapse(↑) of time

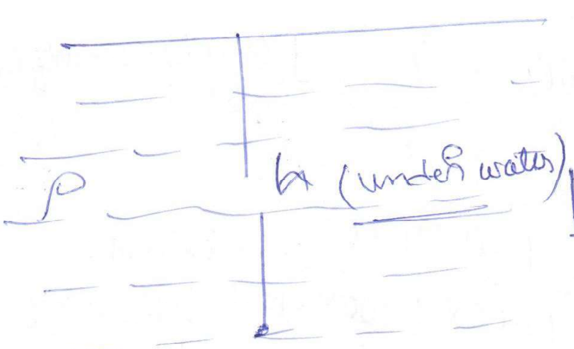
$\mu \uparrow$ (lapse of time) $\uparrow$

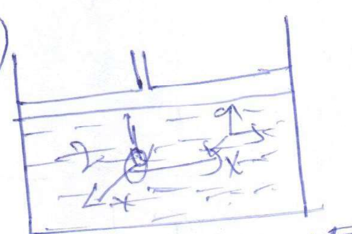
* Statics :-

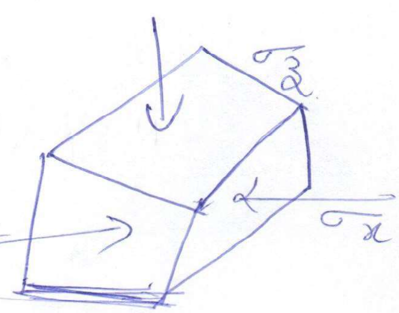
Hydrostatic law

$$P = \rho g h = \gamma h$$
$$= S \rho_w g h = S \gamma_w h$$

According to pascal law







The forces are equal in x, y, z directn

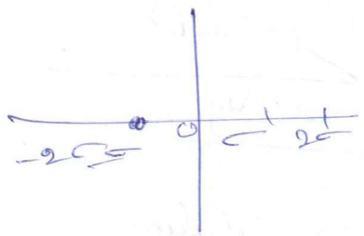
σ_y

$$\sigma_x = \sigma_y = \sigma_z$$
$$= -\sigma \text{ (comp)} = -\sigma$$

$$\boxed{\tau_{xy} = 0}$$

Mohr's circle for hydrostatic Element

Radius $= \sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2+\tau_{xy}^2}$, centre $= \left[\frac{\sigma_x+\sigma_y}{2}, \tau_{xy}\right]$



$= \sqrt{\left(\frac{(-\sigma)-(-\sigma)}{2}\right)^2+0^2} = 0$

$= \left[\left(\frac{(-\sigma)+(-\sigma)}{2}\right), 0\right] = (-\sigma, 0)$

A point on -ve axis x-axis

pressure :-

Atmospheric pressure (std) $P_{(atm)}$

$P_{atm\,std} = 1.\ \text{Atm}$
$= 1.01323\ \text{Bar}$

$P_{atm} = 1.013 \times 10^5\ N/m^2$

$P_{atm} = 760\ \text{mm of Hg}$
$= 10.3\ \text{m of water}$

1 Torr = 1 mm of Hg

Specific gravity $S = 0.8$

$P = \rho g h \Rightarrow h = \frac{P}{\rho g}$

(1) $P = \rho g h \Rightarrow h = P/\rho g$

(2) $S_1 h_1 = S_2 h_2$

$\rho h_1 = \rho_2 h_2$

Eg. $P_{atm} = 1.013 \times 10^5\ N/m^2$

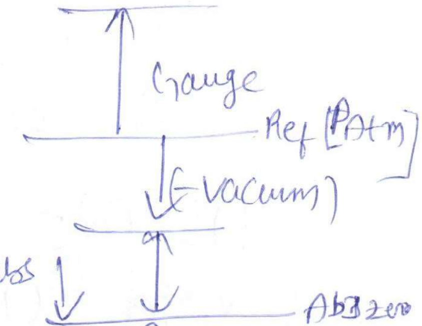
$\text{m of water} = \frac{P}{\rho_w \times g} = \frac{1.013\times10^5}{1000\times9.81} = 10.3\ \text{m of water}$

$\text{m of Hg} = \frac{P}{\rho_{Hg}\cdot g} = \frac{1.013\times10^5}{13.6\times1000\times9.81} = 0.76\ \text{m}$, $760\ \text{mm of Hg}$

$\text{m of liq}_{S=0.8} = \frac{P}{\rho_{liq}\cdot g} = \frac{1.013\times10^5}{0.8\times1000\times9.81} = 12.9\ \text{m of liq}$, $S=0.8$

Gauge pressure (P_G) :-

$$P_G > P_{atm}$$



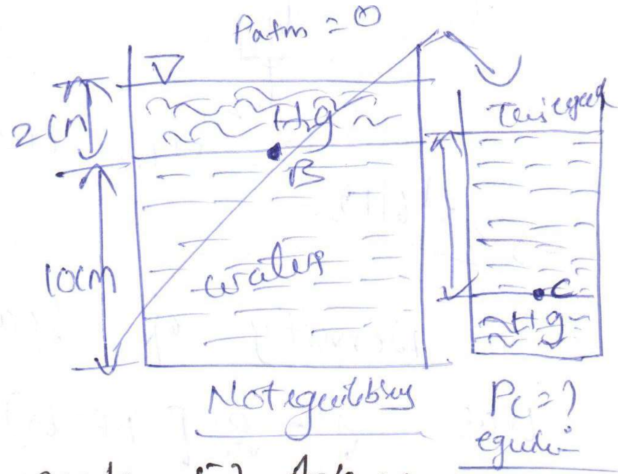
Vacuum pressure (P_V) $P_V < P_{atm}$

Absolute pressure (P_{Abs}) :- $(P_{abs}) = P_{atm} + P_G - P_V$

$$P_{Ab} = P_{atm} + (P_G / P_V)$$

NOTE:- P_{atm} = The pressure of atmosphere in which the gauge is located P_{atm} = (local Atm. pressure)

Ex: 1 A cylindrical container was filled with water to a height of 10 cm on top of that mercury is added to a height of 2 cm. when the pressure interface at equilibrium?



Sol

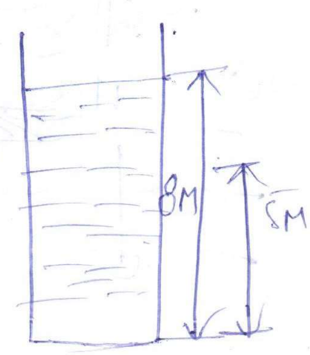
$$\boxed{P_C = \rho_{Hg}\, g\, h_w}$$

$$= 1000 \times 9.81 \times 0.1$$

$$P_C = 981\ N/m^2$$

water = 10 cm
Hg = 2 cm

Ex: 2 A pressure gauge reads 57.4 kpa and 80.0 kpa respectively at heights 8M & 5M when fixed on side of the tank container filled with liquid - the approximate density of the liquid will be?



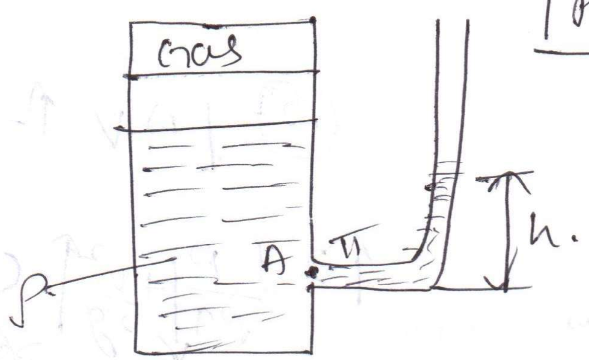
Sol Reads 57.4 kpa 80.0 kpa

~~P = ρgh~~

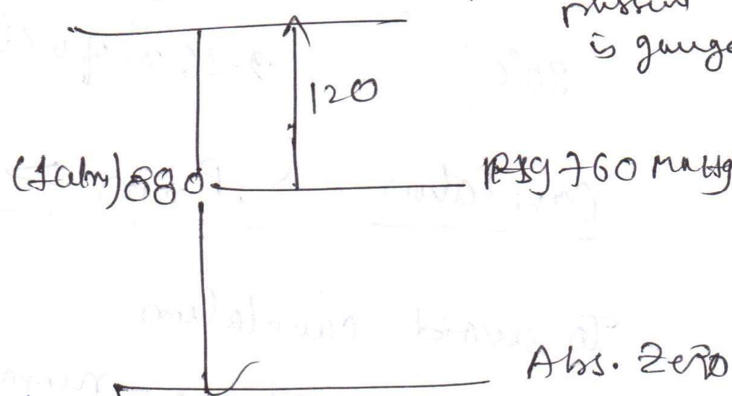
$P = \rho \times 9.81 (80.0 - 57.4)$

Piezometer :- It measuring only gauge pressure

$$\boxed{P_A = \rho \cdot g h}$$



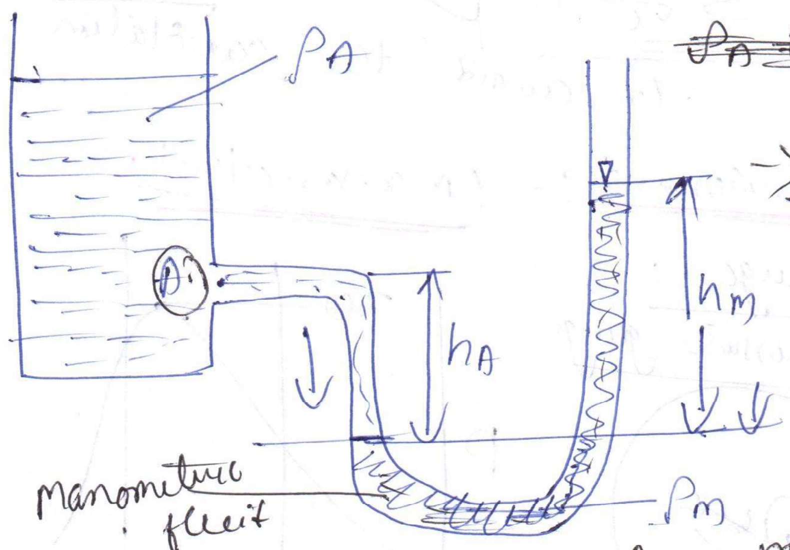
120 to 80 humans Blood pressure
120 gauge pressure
so that blood pressure is gauge



Simple U-tube manometer :-

Ist method low level refrence

~~$P_A + P_A$~~



$\rightarrow \underline{P_A + \rho_A g h_A}$

$= P_{atm} + \rho_m \cdot g h_m$

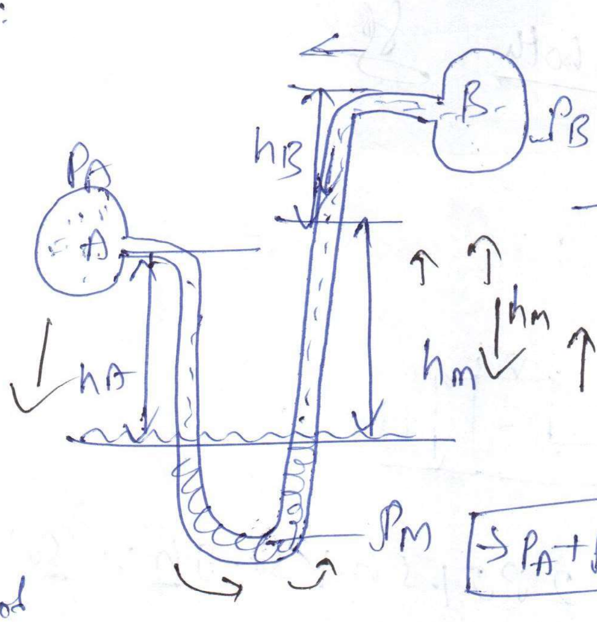
P_A = pressure at point A

$\rightarrow \; P_A + \rho_A \cdot g h_A = P_{atm} + \rho_m \cdot g h_m$

Note: $P_{atm} = 0 \longrightarrow P_A \; (P_G / P_V)$

$P_{atm} \neq 0 \longrightarrow P_A \Rightarrow (P_{Abs})$

problem:



$\rightarrow P_A + \rho_A \cdot g h_A = P_B + \rho_B g h_B + \rho_m \cdot g h_m$

$$\boxed{\rightarrow P_A + \rho_A \cdot g h_A = P_B + \rho_B g h_B + \rho_m \cdot g h_m}$$

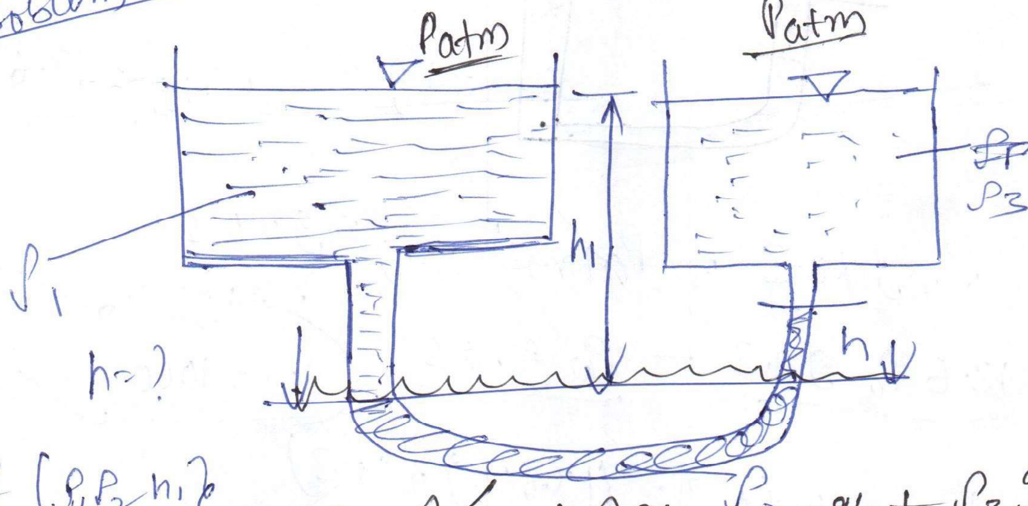
IInd method

$$\boxed{P_A + \rho_A \cdot g h_A - \rho_m g h_m - \rho_B \cdot g h_B - P_B = 0}$$

properties :-

① mercury is used as fluid in manometer
② $\rho, S, \gamma \rightarrow$ high (fluid is together properties) as possible as low in manometers
③ vapour pressure

problem :-



$f(\rho_1, \rho_2, h_1)$

Sol.
$$\cancel{P_{atm}} + \rho_1 g h_1 = \rho_2 g h + \rho_3 g (h_1 - h) + \cancel{P_{atm}}$$

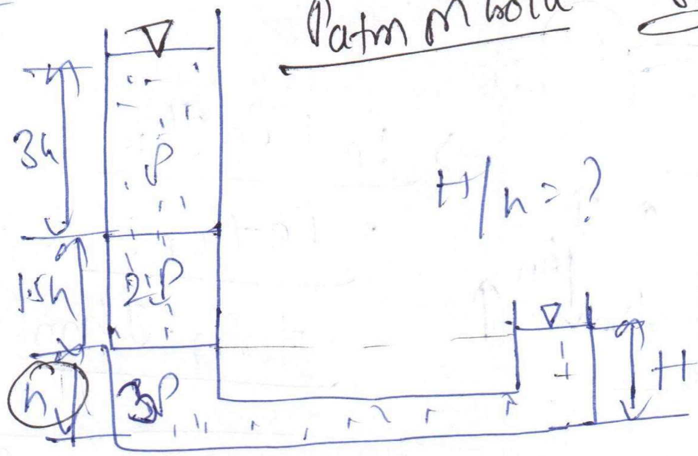
$$\rho_1 \cancel{g} h_1 = \rho_2 \cancel{g} h + \rho_3 \cancel{g} (h_1 - h)$$

$$\rho_1 h_1 - \rho_3 h_1 = \rho_2 h - \rho_3 h$$

$$h = \frac{(\rho_1 - \rho_3)}{(\rho_2 - \rho_3)} \cdot h_1$$

Sol

Patm in both



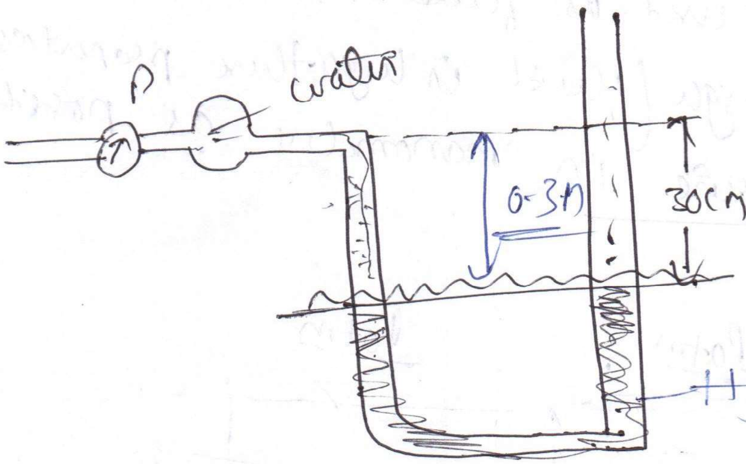
$H/h = ?$

$$P_{atm} + \rho g 3h + 2\rho g 1.5h + 3\rho . g . h = 3\rho g H + \cancel{p_{atm}}$$

$$3 . [3 \cancel{\rho . g} . h] = 3 \cancel{\rho . g} H \Rightarrow \cancel{H/h = 1/3}$$ ✓

$$\boxed{H/h = 3}$$

Eg:-



Pressure P in kPa?

$\rho_{Hg} = 13.6$

Sol:

$$P + \rho_w g \times 0.3 = P_{atm} + \rho_{Hg} \times g \times 0.3$$

$\cancel{\rho_{Hg} = 13.6}$

$$P = 13.6 \rho_w g 0.3 - \rho_w g . 0.3$$

$\rho_w = 1000$

$$\rightarrow P + \rho_w g (0.3) = (13.600) g (0.3)$$

$$P = 37.1 \text{ kPa}$$

$$P + (1000) \times \cancel{0.3} = \rho_{Hg} \times g \times 0.3$$

$$P + \cancel{1000 \times 0.3 = 13.6 \times 0.3}$$

$$P = \cancel{\frac{13.6 \times 0.3}{1000 \times 0.3}} = 300$$

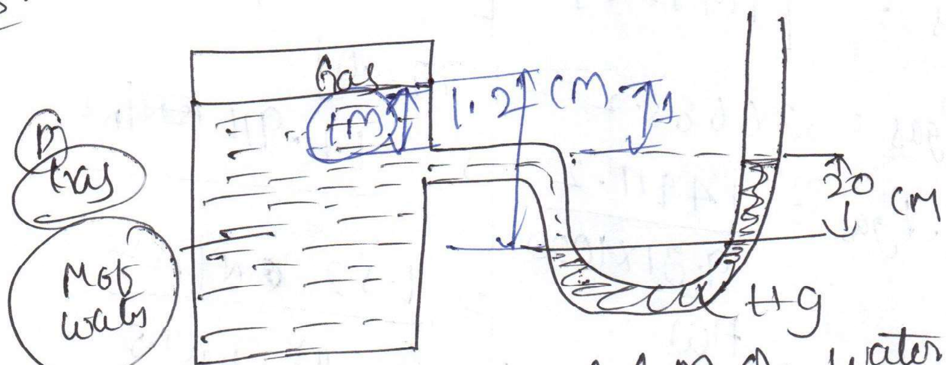
$$P_A = 0.3g\,(\overset{\rho_{Hg}}{13600} - \overset{\rho_w}{1000})$$

$$P_A = 0.3\times 9.81\,(13600 - 100)$$

$$P_A = 37081.8\ Pa \rightarrow \underline{37.1\times 10^{3}\ kPa}$$

$$\underline{37.1\times 10^{3}\ N/m^2}$$

Eg:



calculate M of water

Sol

$$\cancel{P_{gas} + \rho_w\, g\, h_w = P_{atm}\,\rho_{Hg}\, g\, h}$$

$$\cancel{\rho_w\, g\, h = \rho_{Hg}\, g\, h}$$

$$P_{gas} + \rho_w\, g\, h_w = \rho_{Hg}\, g\, h + P_{atm} \rightarrow 0$$

$$P_{gas} + 10^3 \times 9 \times 1.2 = 13.6 \times 9 \times 0.20$$

$$\rho_{gas} = 10^3 \times 9.81 \times 1.2 = 13.6 \times 9.81 \times 0.20$$

$$\rho_{gas} = \underline{1.52\ M\ of\ water}$$

$$P_G + \rho_w \times 9 \times 1.2 = P_{atm} + \rho_{Hg} \times 9 \times 0.2$$

$$P_G = [13.6\,\rho_w\, 9\, 0.2 - \rho_w\, 9\, 1.2]\ N/m^2$$

$$\frac{P_G}{\rho_w g} = 13.6 \times 0.2 - 1.2$$

$$2.72 - 1.2 = 1.52\ N/m^2$$

Sol

$P_{gas} + \rho_{water} \times g \times h = \cancel{P_{atm}}^{\,0} + \rho_{Hg} \times g \times h$

$P_{gas} + [1000 \times 9.81 \times 1.2] = 13.6\,\rho_w \times g \cdot 81 \times 0.2$

$P_{gas} + [1000 \times 9.81 \times 1.2] = [13.6 \times 1000 \times 9.81 \times 0.2]$

$P_{gas} = [11772.0] = [26683.22]$

$P_{gas} = 26683.2 - 11772.0]$

$P_{gas} = \dfrac{14911.2}{9.81 \times 1000} \Rightarrow \underline{14.911\ \cancel{kN/m^2}}$

$\underline{= 1.52\ \cancel{kN/m^2}}$

H_w

$\underline{H_w = 1.52 \text{ m of water}}$

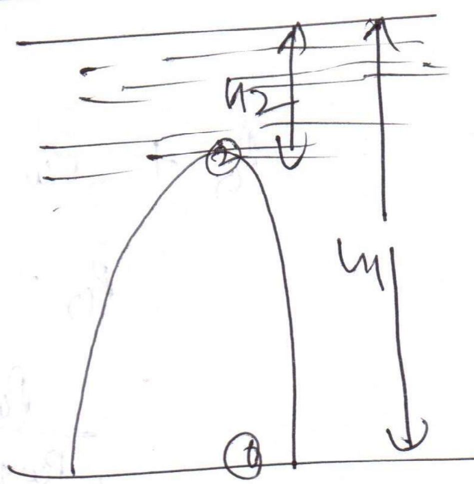
Eg: The pressure at the bottom base of mountain is 700mm of Hg at Top is 600mm of Hg Considering const. density of Air is 1.2 kg/m3. App. height of mountain will be ?

760mmHg at $1.013 \times 10^5\ N/m^2$

Sol

$P_{Base} = 700\text{mm of Hg}$ $\quad \rho_{Air} = 1.2\ kg/m^3$

$P_{Top} = 600\text{mm of Hg}$ $\quad h = ?$



$P_1 = \rho \cdot g \cdot h_1 \qquad P_2 = \rho \cdot g \cdot h_2$

$P_1 - P_2 = \rho g [h_1 - h_2]$

$h = h_1 - h_2 = \dfrac{(P_1 - P_2)}{\rho \cdot g}$

$h = \dfrac{(700 - 600)}{1.2 \times 9.81} \times \dfrac{1.013 \times 10^5}{760} = 1138\text{M}$

$= \underline{1.13\text{ KM}}$

$h = \dfrac{(700 - 600)}{1.2 \times 9.81} \times \dfrac{1.013 \times 10^5}{760} = 1138\text{M}$

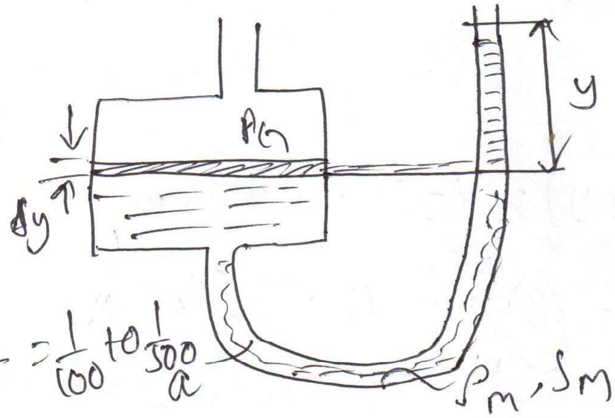
$= \underline{1.13\text{ KM}}$

$P = \rho_{Hg} \cdot g \cdot h_{Hg}$

$= 13{,}600 \times 9.8 \times (0.7 - 0.6)$

$= \underline{1.13\,\text{KN}}$ ✓

Micro meter :- Single column U-tube manometer vertical/Inclined



$\boxed{A\,\Delta y = a \cdot y}$

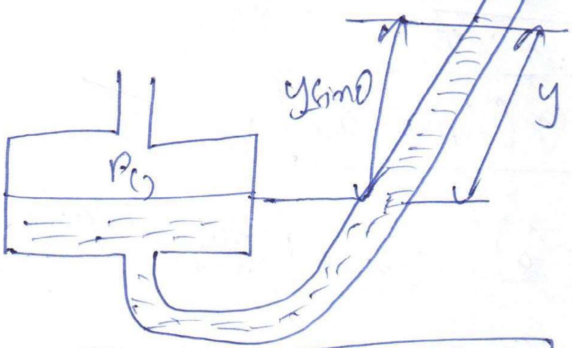
$P_G = \rho_m \cdot g \cdot y$

$= S_m \cdot \rho_w \cdot g \cdot y$

$\boxed{P_G = S_m\, \gamma_w \cdot y}$

$\frac{a}{A} = \frac{1}{100}$ to $\frac{1}{500}$

Inclined :-



$\boxed{P_G = S_M\, \gamma_w \cdot y \cdot \sin\theta}$

if $\theta \uparrow$ sensitivity $\downarrow$

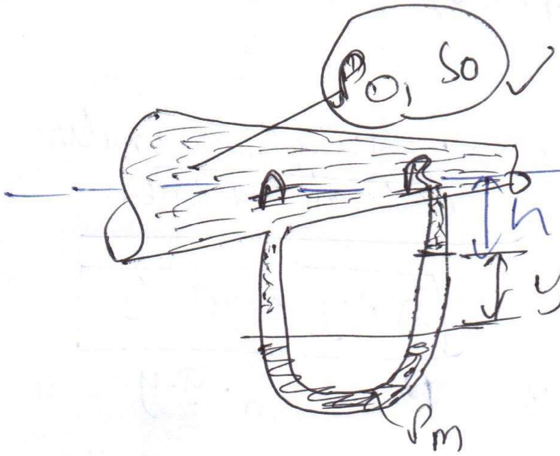
$\sin\theta \downarrow = \frac{1}{\sin\theta \uparrow}$

$\theta = 0°$ to $90°$

$\uparrow \sin\theta = 0$ to 1

Imp ✓ Differential U-tube manometer :-

Differential U-tube manometer ($P_A > P_B$)



$P_A + \rho_o g (h+y)$

$= P_B + \rho_o \cdot gh + \rho_m \cdot g \cdot y$

$\rightarrow \quad P_A + \rho_o g (h+y) = P_B + \rho_o g h + \rho_m \cdot g y$

$(P_A - P_B) = \underbrace{\rho_m}_{S_m \rho_w} g y - \overbrace{\rho_o}^{S_o \rho_w} g y = \rho_w \cdot g y [S_m - S_o]$

$= \gamma_w \, y \cdot [S_m - S_o] \; N/m^2$

$\dfrac{P_A - P_B}{\rho_w \times g} = \dfrac{\gamma_w \cdot y (S_m - S_o)}{\gamma_w \times g}$ ⟸ M of water

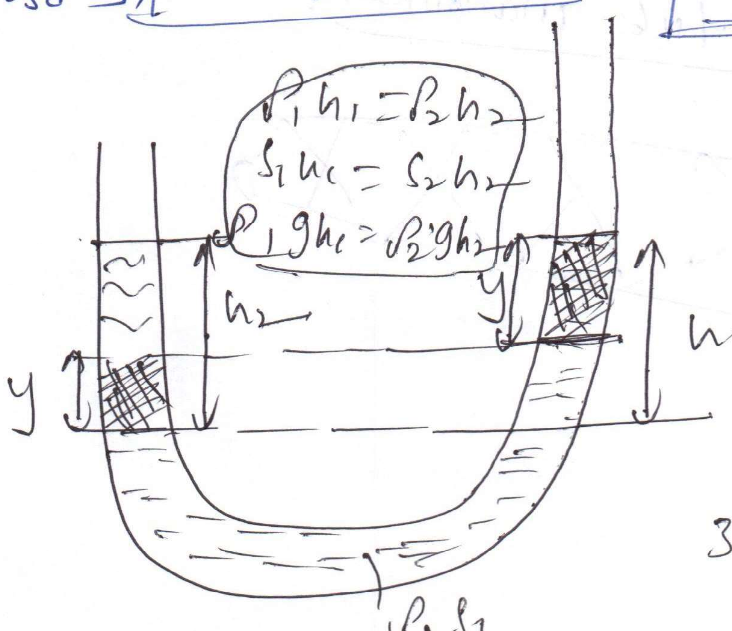
pressure head difference ⟶ $\boxed{= y (S_m - S_o)}$ ✓

$\dfrac{P_A - P_B}{\rho_o \cdot g} = \dfrac{\gamma_w \cdot y [S_m - S_o]}{S_o \rho_w \cdot g}$ ⟸ M. of liquid [flowing fluid] S_o

$\dfrac{y[S_m - S_o]}{S_o \cdot y}$ ~~$y[S_m - S_o]$~~

$\Rightarrow y \left[\dfrac{S_m}{S_o} - 1\right] \Rightarrow \boxed{= y \left[S_m - 1 / S_o\right]} \rightarrow \boxed{y \left[\dfrac{S_m}{S_o} - 1\right]}$ flowing

Ex:



$\rho_1 \; S_1$

$P_2 \; S_2$

$h_1 \; h_2$

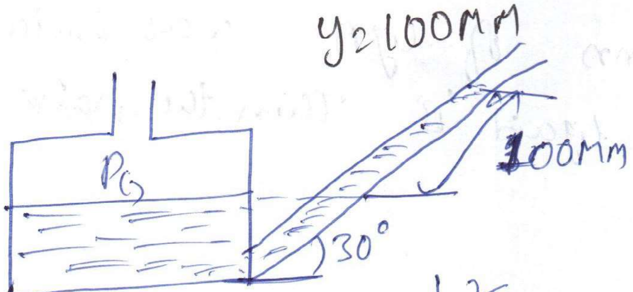
1) h_1

2) $h_2 - h_1$

3) Reuse of menisces

$y + y = h_1 \Rightarrow y = h_1/2$

Gate



$S = 0.86$

$P_G = 0$

(a) 43 MM of water (vacuum)

(b) 43 MM of water

(c) 43 " " "

(d) 199 " "

Sol. $P_{GAS} = S_m \gamma_w \cdot y \sin\theta$ N/m^2

$\rightarrow \frac{P_G}{\gamma_w} = S_M \cdot y \cdot \sin\theta$

$\rightarrow \frac{P_G}{\gamma_w} = 0.86 \times 100 \times 1/2$

$= 43$ MM of water

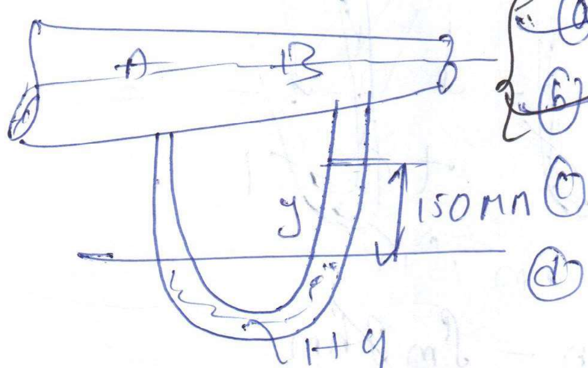
do not change because Answer MM of water

$P_{liquid} = S \times P_{water}$

$S = \frac{P_{liquid}}{P_{water}}$

$\frac{P_G}{\gamma_w} = S_m \cdot y \sin\theta$

Gate-05 :-



~~(a) Flow direction A → B, $P_A - P_B = 1.4$ kpa~~

~~(b)~~ " " " $\overrightarrow{AB}$ " $= 20$ kpa

(c) B → A $P_B - P_A$ " "

(d) --- " " 1.4 kpa

$P_A - P_B = \gamma_w \cdot y [S_M - S_O]$ N/m^2

$= 9810 \times 150 \times 10^{-3} [13.6 - 1.0]$

$= 18.4$ kN $= 20$

3) A differential mercury manometer used to measure water flow reads 20CM Then the pressure head difference in M of water

Sol $\frac{P_A - P_B}{\gamma_w \cdot g} = y [S_M - S_O]$

$= 0.2 [13.6 - 1.0]$

$= 2.52$ M of water)

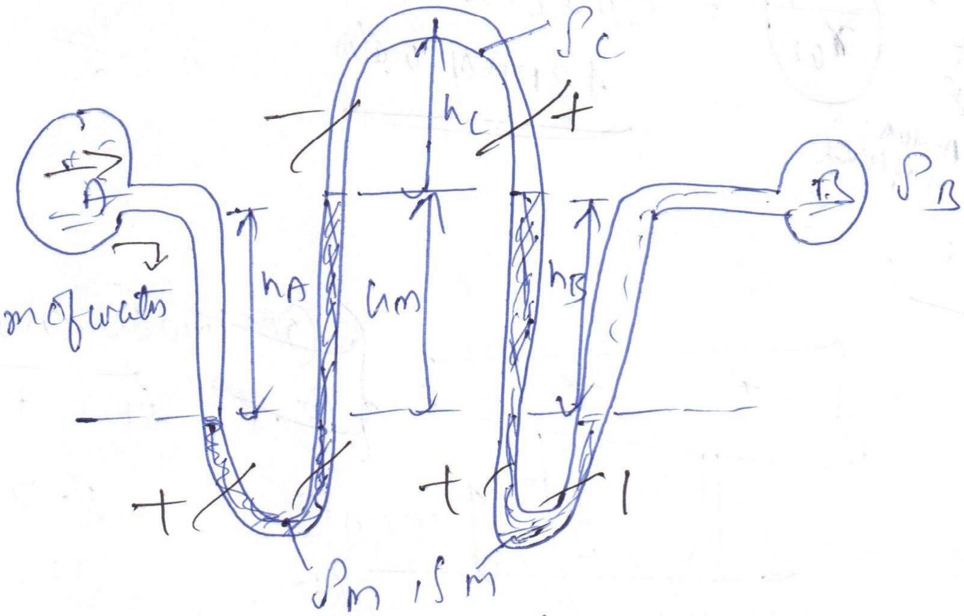
ES-15 A 6cm column of liq A was balancing 3cm column of liquid 'B' Then the ratio specific gravity $\frac{S_A}{S_B} = ?$

Sol.

$$S_A \cdot h_A = S_B \cdot h_B$$

$$\frac{S_A}{S_B} = \frac{h_A}{h_B} = 3/6 = \underline{\underline{1/2}}$$

Gate-16



$(P_A - P_B) =$ m of water

Sol.

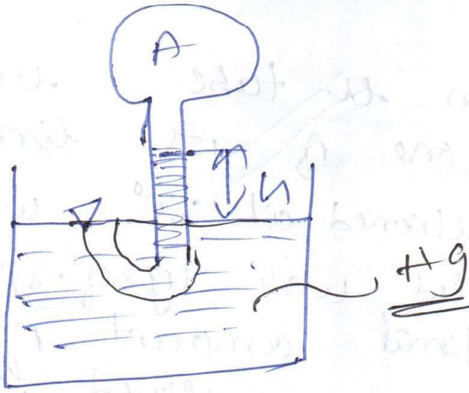
$$P_A + \rho_A g h_A - \rho_m g h_m + \rho_m g h_m - \rho_B g h_B - P_B = 0$$

$$P_A - P_B = \rho_B g h_B - \rho_A g . h_A \ N/m^2$$

$$\frac{P_A - P_B}{\rho_w \times g} = \frac{\rho_B g h_B - \rho_A g . h_A}{\rho_w \times g}$$ m of water

$$\boxed{\frac{P_A - P_B}{\rho_w \times g} = S_B \times h_B - S_A \times h_A}$$ m of water

Gate-2000



(2) The pressure of gas in bulb 'A' is 50 cm Hg vacuum and atm. pressure 76 cm Hg. Then h = ?

Note: $P_{atm} = 0 \Rightarrow P_A = P_G / P_V$
$P_{atm} \neq 0 \Rightarrow P_A = (P_{Abs})$

Sol = $P_A = 50\text{ cm Hg}$ value

$(P_{A\,Abs}) = P_{atm} - P_V$
$= 76 - 50 = 26\text{ cm}$

$P_{atm} = 76\text{ cm Hg}$ $h = ?$

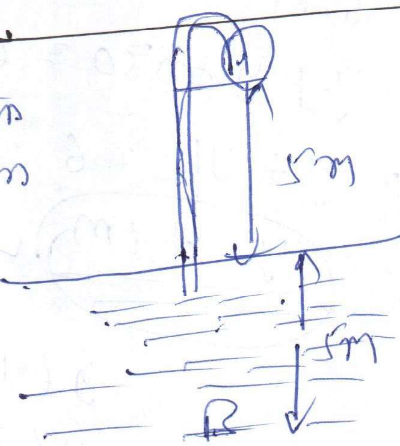
$\cancel{P_A = \rho g h}$. $\boxed{P_{atm} = P_A + \rho_{Hg} g \cdot h}$

$$\frac{P_{atm}}{\rho_{Hg} \cdot g} = \frac{P_A}{\rho_{Hg} \cdot g} + h$$

$\frac{\cancel{76}}{\cancel{73}} \rightarrow 76 = 26 + h \Rightarrow \boxed{h = 50\text{ cm}}$

* If the vaccum pressure $P_A = 50\text{ cm Hg}$ vacuum then the answer is same 50 cm, even that has 30 cm of Hg vacum answer is 30 cm

* $P_C = 5\text{ m}$ of water vaccum



$P_{atm} = P_C + \rho_w \times g \cdot 5$

$P_B = P_{atm} + \rho_w g \cdot 5$

$P_C = \cancel{P_{atm}}^{0} - \rho_w \cdot g \cdot 5$

$P_{B\,gaug} = \rho_w \times g \cdot 5$

$\frac{P_C}{\rho_w \times g} = 5\text{ m}$ of water (vacuum)

$\frac{P_B}{\rho_w \times g} = [5\text{ m of water gauge}]$

(3) IES Gate civil

An open U-tube uniform bore of 0.5 cm^2 with one of its limb vertical at the other inclined at 30° with horizonta was initially filled with liq. of specific gravity 1.25 then additional amount of 7.5 cc of water was added in inclined limb then the raise of minesus in to vertical limb will be ___?

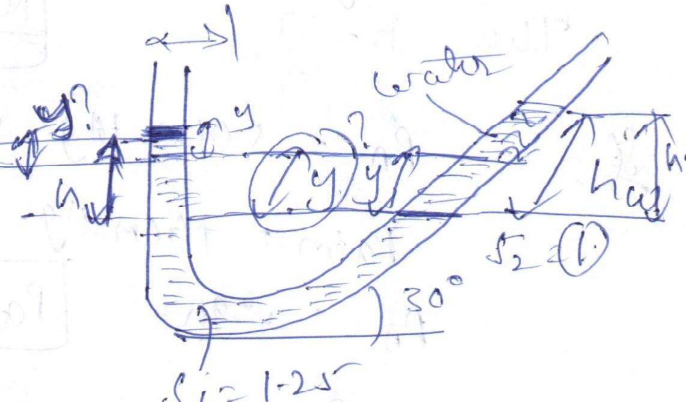
Sol: Given data

Bore = 0.5 cm^2

$S = 1.25$

7.5 cc of water

$\theta = 30°$



$\rightarrow$ $\boxed{S_1 h_1 = S_2 h_2}$

$h_w = \frac{Vol}{Area}$

Specific gravity of water = 1

$\rightarrow$ $\boxed{h_2 = h_w \times \sin\theta}$

$h_w = \frac{7.5}{0.5} = 15\,cm$

h_2 = height of water column

$h_2 = 15 \times \sin 30°$

$h_2 = 7.5\,cm$

$h_2 = h_w \sin\theta$

$h_2 = h_w \sin\theta$

$\rightarrow$ $S_1 h_1 = S_2 h_2$

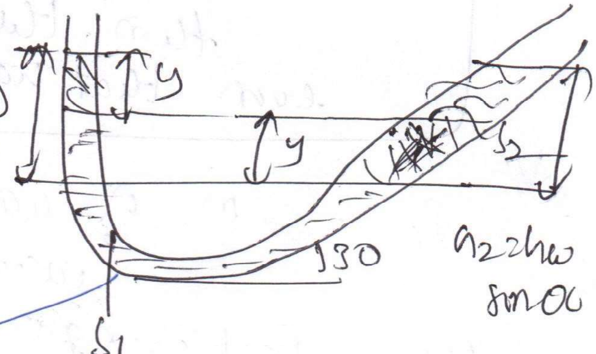
$1.25 \times h_1 = 1.0 \times 7.5$

$h_1 = 6\,cm$

$h_1 = y + y \sin 30 = 6$

$= y + y/2 = 6$

$y = 4\,cm$



$h_2 = h_w \sin\theta$

~~$h_1 = (y + y(1/2))$~~

~~$h_1 = y(1 + 1/2) = 6$~~

~~$h_1 = y\left(\frac{2+1}{2}\right)$~~

~~$6 = y3/2$~~

$y(1 + 1/2) = 6$

$y\left(\frac{2+1}{2}\right) = 6$

$3y = 12$

$y = 4$