Lecture (4)

## Different unit

1. In S.I $N/m^2$

2. $1$ Pascal $= N/m^2$

3. $1$ bar $= 10^5$ pascal

4. $1$ atm $= 101325$ pascal

5. $\frac{1\ kgf}{cm^2} = \frac{9.81}{10^{-4}} \frac{N}{m^2} = 9.81 \times 10^4\ N/m^2 = 0.981 \times 10^5$ pascal

6. $1$ psi (Pound force per square inch)

(Pressure at sea level)

$= \frac{1\ lbf}{inch^2} = \frac{0.453}{(2.54)^2} \times \frac{kgf}{cm^2}$

$= \frac{0.453}{(2.54)^2} \times 0.981 \times 10^5$ pascal

~~1 psi~~

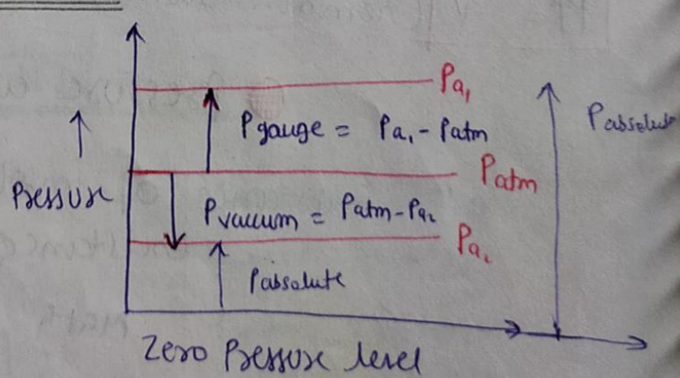
$=$ 14.09 pascal

$\frac{1\ atm}{1\ psi} = \frac{101.325 \times (2.54)^2}{0.453 \times 0.981 \times 10^5} = \boxed{14.09\ pascal}$

$\boxed{1\ atm = 14.7\ psi}$

## # Different type of pressure :-

1. atmospheric Pressure
2. Gauge Pressure
3. Absolute Pressure
4. vacuum Pressure




1. Atmospheric Pressure → It is the pressure exerted by environmental mass

2. Absolute Pressure → it is the total pressure exerted on the system measured from '0' Pressure level

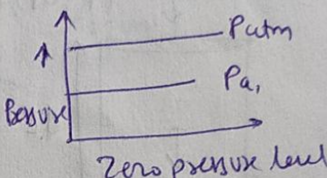
(3) Gauge Pressure → It is the value of pressure above to the atm pressure.

(4) Vaccum Pressure → It is the value of pressure below to the atm pressure

Note: −ve gauge pressure = vaccum

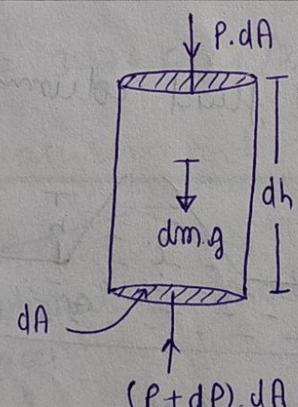
$$P_{gauge} = P_a - P_{atm}$$

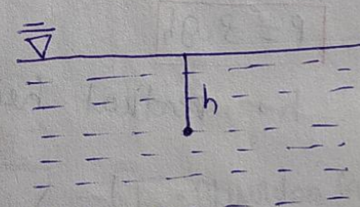
$P_{gauge} \downarrow$ (−ve), $P_a \downarrow$ less, $P_{atm} \downarrow$ more




☆ Gauge and vaccum may be (+ve) and (−ve) but atmosph absolute pressure always (+ve) (Real Pressure)

# Pressure at a point in Static fluid [In h direcⁿ] ↓




$$\vec{F} \cdot m\vec{a} = 0$$

$$P.dA - (P+dP).dA + dm.g = 0$$

$$-dP.dA = -dm.g$$

$$dP.dA = dm.g$$

$$dP.\cancel{dA} = \rho(\cancel{dA}.dh).g$$

$$dP = \rho.g.dh$$

$$\boxed{\frac{dP}{dh} = \rho g}$$

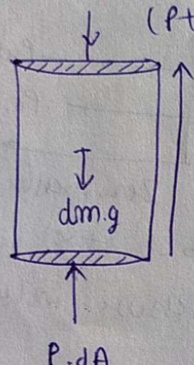
It means that pressure increase in downward dirn

Int. it

$$\int_0^P dP = \rho . g \int_0^h dh \qquad \boxed{P = \rho g H}$$

(P is gauge pressure)

In z- dirn




$$P.dA - (P + dP).dA - dmg = 0$$

$$-dP.dA = dm.g$$

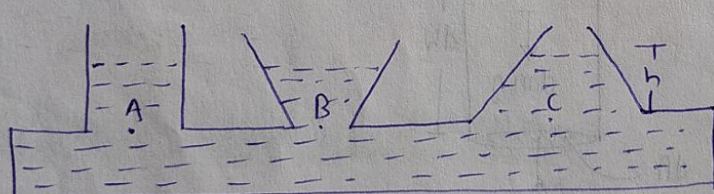
$$-dP.\cancel{dA} = (\rho.\cancel{dA}.dz).g$$

$$\boxed{\frac{dP}{dz} = -\rho g}$$

It means that Pressure decreases in upward dirn

$\boxed{P = \rho g h}$

h → vertical height of fluid column




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

take P = 1 atm = 101325 Pascal

For $H_2O$,

$$P = \rho g h = (10^3)(9.81) \times h$$

$$101325 = (10)^3 \times (9.81) \times h$$

$$\boxed{h = 10.3 \text{ m of } H_2O \text{ Column}}$$

For Hg.

$$P = \rho_{Hg} g h = (13.6 \times 10^3) \times 9.81 \times h$$

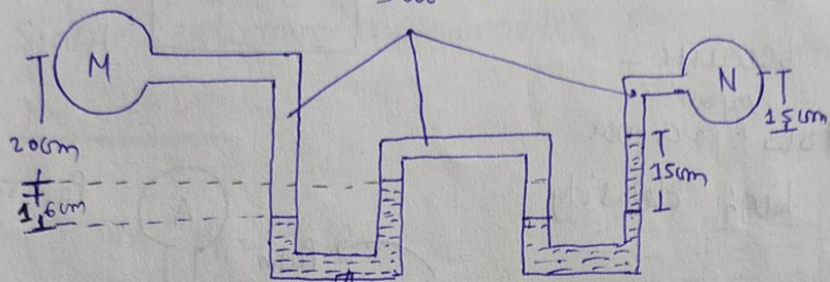
$$101325 = (13.6)(10^3) \times 9.81 \times h$$

$h = 76$ cm of Hg column

[1 atm = 10.3 m of ~~Hg~~ $H_2O$ column = 76 cm of Hg column]

(Pb) (48)

$\rho_{oil} = 800\ kg/m^3$




$\rho_{Hg} = 13.6 \times 10^3\ kg/m^3$

$P_M -$

$P_M + 800 \cdot g\,(0.36) + \rho_{Hg} \cdot g \cdot y - 13.6\,(10^3)(9.81)(0.16)$
$+ 800\,(9.81)(0.12) - (13.6\times10^3)(9.81)(0.15)$
$- 800\,(9.81)(0.15)$
$= P_N$

$P_M - P_N = 38.76$ KPa Ans

# pressure measurement Devices →

conventional devices

modern devices
- Bourdon Gauge
- Strain gauge transducers
- Piezo-electric transducers

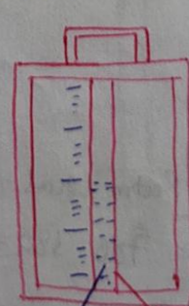
7th unit

1 Torr = 1 mm of Hg

## Conventional devices

① Barometer

- uses to measure local atmospheric pressure
- Made by torricelli

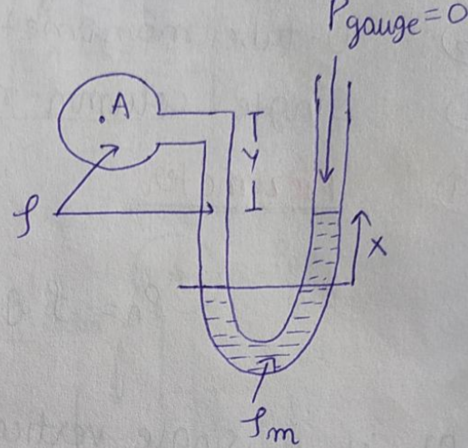


$\frac{\cancel{L}}{\cancel{\sin\theta}}$ $\boxed{L = \frac{h}{\sin\theta}}$

- to decrease sensitivity ⇒ multiply by $\sin\theta$
- to increase sensitivity ⇒ multiply by $\frac{1}{\sin\theta}$

# U tube manometer

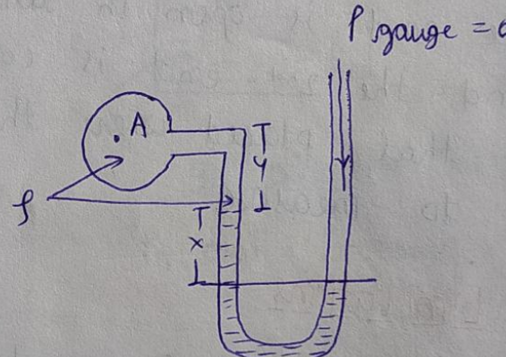
## Gauge pressure




$$P_A + \rho g(x+y) - \rho_m g x = 0$$

$$P_A = \rho_m . g . x - \rho g (x+h)$$

# Vacuum Pressure →




$$[P_A + \rho g . y + \rho_m . g . x = 0]$$

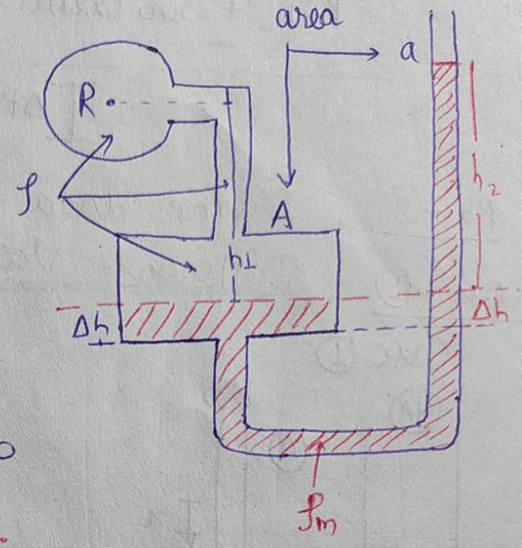
## U tube manometer →

- It consist of glass tube bent in U-shape, one end of which is connected to a point and which pressure is to be measured and the other ends remains open to atmosphere.
- In U tube manometer generally, a additional fluid is used known as manometric fluid ($\rho_m$) (mercury, water, oil)
- It is used to measure low, medium, high +ve, and (-ve) gauge pressures of liquid and gases both.

volume consumption

$\Longrightarrow$ $\Delta h . A = h_2 . a$

$$\boxed{\Delta h = \frac{a}{A} . h_2}$$




$$P_R + \rho_1 g (h_1 + \Delta h) - \rho_m g (h_2 + \Delta h) = 0$$

If $\Delta h$ = neglect

$$P_R + \rho_1 g (h_1) - \rho_m g (h_2) = 0$$

## (3) Differential manometer :-

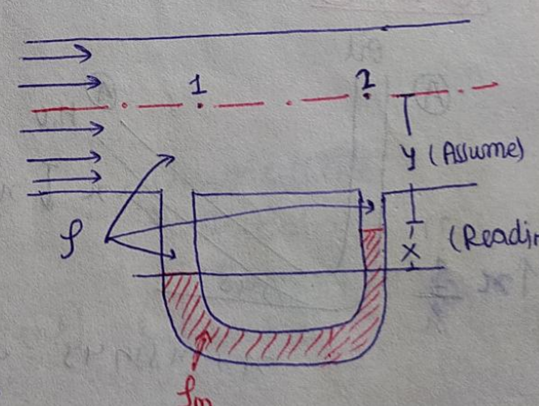
It uses for measurement of pressure difference b/w any two points.

### @ Simple differential U tube manometer $\longrightarrow$

$P_1 - P_2 = ?$

$$P_1 + \rho . g . (x + y) - \rho_M . g . x - \rho . g . y = P_2$$

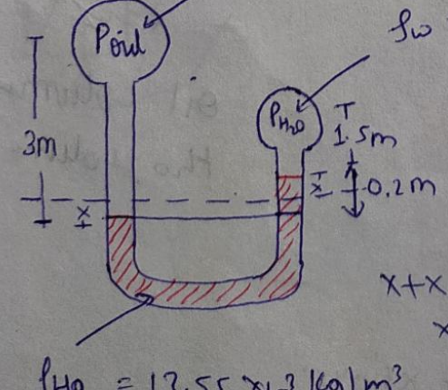
$$\boxed{P_1 - P_2} = \rho_m . g . x - \rho g . x$$




Pb - (9)

$\rho_{oil} = 900 kg/m^3$

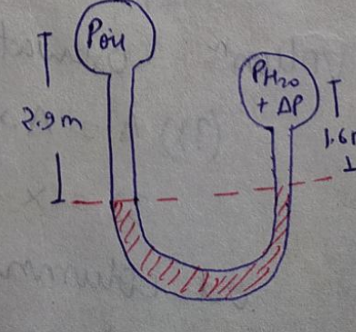
$\rho_w = 10^3 kg/m^3$




$x + x = 0.2$

$x = 0.1m$

$\rho_{Hg} = 13.55 \times 10^3 kg/m^3$



$$P_{oil} + 900(9.81)(3) = P_{H_2O} + (10)^3(9.81)(1.5) + (13.55\times10^3)(9.81)(0.2)$$

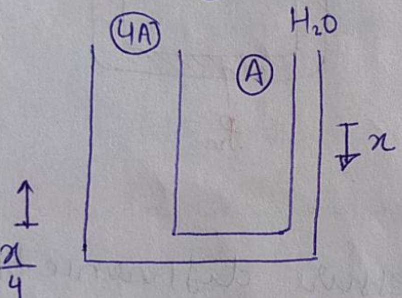
$$P_{oil} + 900(9.81)(2.9) = P_{H_2O} + \Delta P + (10^3)(9.81)(1.6)$$

$$\boxed{\Delta P = 24.7 \text{ KPascal}}$$

Pb - ②  Same data

case - ①  Different Variation

case ①




Vol^m conservation

$4(A) \cdot (??) = A \cdot X$

$?? = \frac{x}{4}$

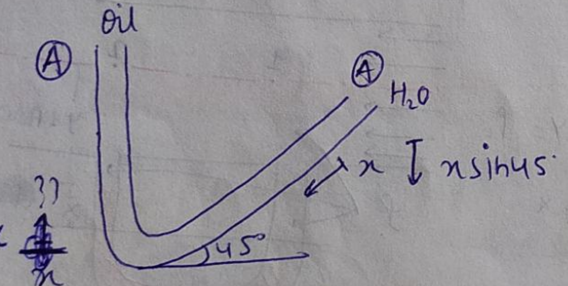
oil column $= 3 - \frac{X}{4}$

$H_2O$ column $= 1.5 + X$

$\frac{x}{1} + \frac{x}{4} = 0.2$

$x = ??$

case- ②




$x + x\sin 45 = 0.2$

$x = ✓$

volum^n cosewation

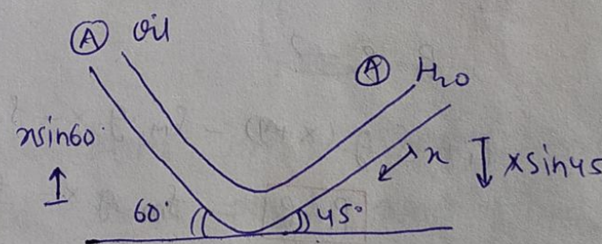
$(??) \cdot A = A \cdot X$

$?? = X$

oil column $= 3 - X$

$H_2O$ column $= 1.5 + X\sin 45$

case- ③




$X\sin 45 + x\sin 60 = 0.2$

$X = ✓$

oil column $= 3 - X\sin 60$

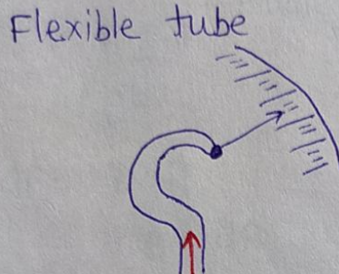
$H_2O$ column $= 1.5 + X\sin 45$

# Discussion

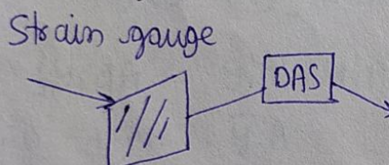
Modern devices for Pressure measurement :

① Bourdan Gauge

constructional details



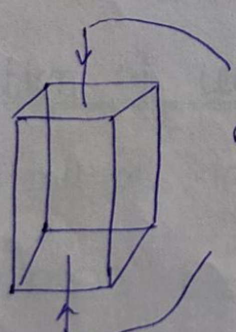

② Strain gauge transducer




strain → Pressure

calibration (in lab)

③ Piezoelectric transducers



Emf = Pressure

(Due to misalignment) of electrons

Crystalline
Quartz
Rochelle salt

calibration