# GOVERNMENT Polytechnic For Girls, Ahmedabad

- Civil Engineering Department

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# UNIT:1 - Introduction, Pressure and Pressure Management

- Chapter 2
- Liquid Pressure and its Measurement

# PRESSURE

- Pressure is defined as a normal force exerted by a fluid per unit area.
- Units of pressure are N/m2 , which is called a pascal (Pa).
- Since the unit Pa is too small for pressures encountered in practice, kilopascal (1 kPa = 103 Pa) and megapascal (1 MPa = 106 Pa) are commonly used.
- Other units include bar, atm, kgf/cm2 , lbf/in2=psi.

# Pressure

*Pressure* is the force per unit area, where the force is perpendicular to the area.

$$p = \frac{F}{A}$$

$F$: N

$A$: $m^2$

$p$: $Nm^{-2}$ (Pa)

$p_a = 10^5\ Nm^{-2}$

*1psi* = 6895Pa

This is the *Absolute pressure*, the pressure compared to a vacuum.

The pressure measured in your tyres is the gauge pressure, $p$-$p_a$.

# Pressure

Pressure in a fluid acts equally in all directions

Pressure in a static liquid increases linearly with depth

$$\Delta p = \rho g \Delta h$$

pressure increase

increase in depth (m)

The pressure at a given depth in a continuous, static body of liquid is constant.

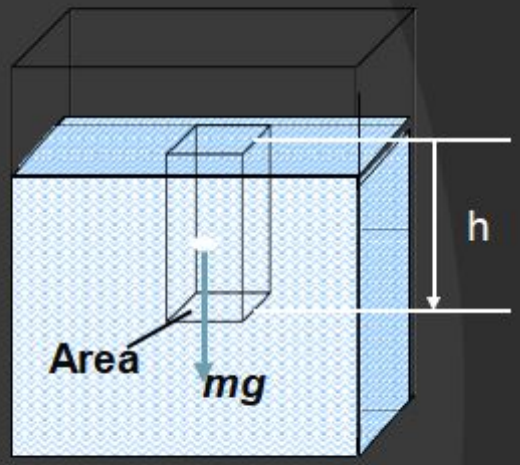

$p_1 = p_2 = p_3$

# Pressure vs. Depth in Fluid

Pressure = force/area

$$P = \frac{mg}{A}; \quad m = \rho V; \quad V = Ah$$

$$P = \frac{\rho V g}{A} = \frac{\rho A h g}{A}$$



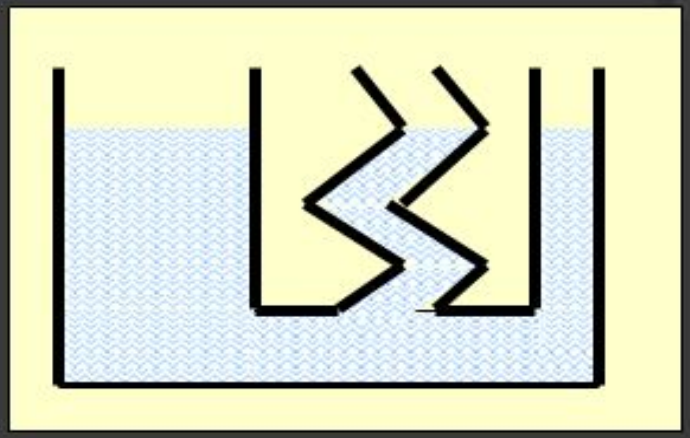

- **Pressure at any point in a fluid is directly proportional to the density of the fluid and to the depth in the fluid.**

Fluid Pressure:

$$P = \rho g$$

# Independence of Shape and Area.

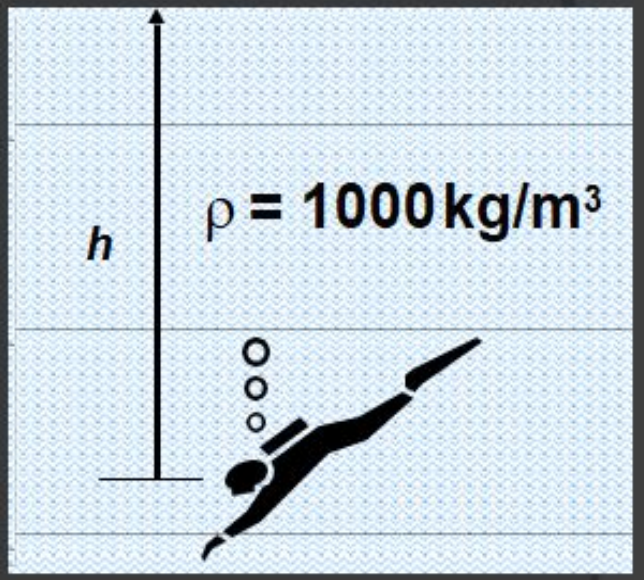
Water seeks its own level, indicating that fluid pressure is independent of area and shape of its container.



- **At any depth h below the surface of the water in any column, the pressure P is the same. The shape and area are not factors.**

Example 2. A diver is located 20 m below the surface of a lake ($\rho$ = 1000 kg/m$^3$). What is the pressure due to the water?

The difference in pressure from the top of the lake to the diver is:




$\Delta P = \rho g h$

h = 20 m; g = 9.8 m/s$^2$

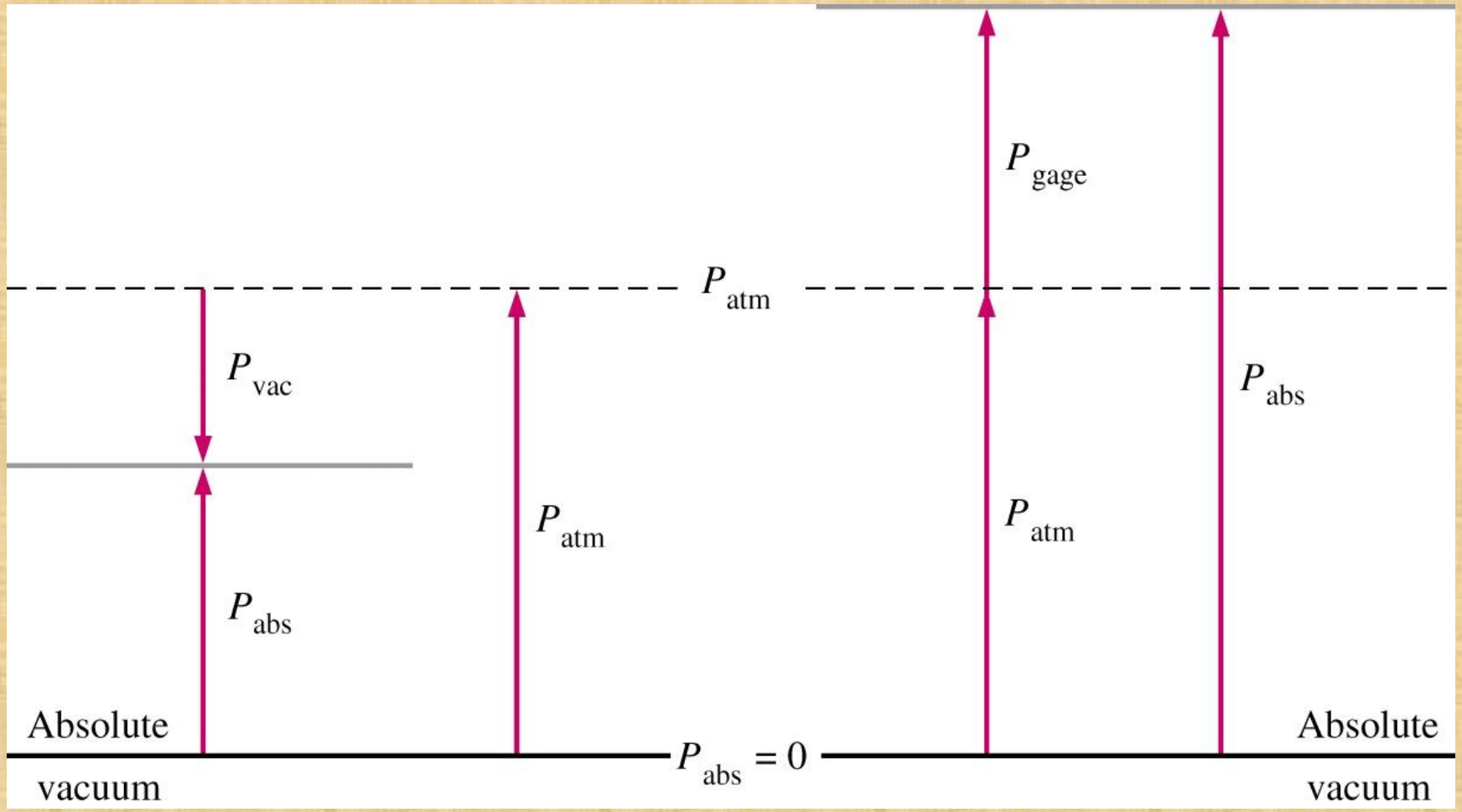
$$\Delta P = (1000\ \text{kg/m}^3\ )(9.8\ \text{m/s}^2\ )(20\ \text{m})$$

$\Delta P$ = 196 kPa

# Various types of pressure

- **Atmospheric pressure**: Pressure related to the atmosphere that surrounds the earth is atmospheric pressure. This pressure is weather-dependent.101.43 $kN/m^2$ 1.01325 bar
- **Absolute pressure**: measured w.r.t. absolute zero
- **Gauge Pressure**: measured w.r.t. atmospheric pressure.
- **Vaccume Pressure**: measured w.r.t. atmospheric pressure but it is below atmospheric pressure.
- Absolute pressure=Atmospheric pressure ± Guage pressure
- $P_{ab} = P_{atm} \pm P_g$

# Various types of pressure



- The pressure of a fluid is measured by the following devices :

Manometers. Manometers are defined as the devices used for measuring the pressure at a point in a fluid by balancing the column of fluid by the same or another column of the fluid. They are classified as: (a) Piezo meter (b)Simple Manometers (b) Differential Manometers (d) Inverted Manometer

Mechanical Gauges. Mechanical gauges are defined as the devices used for measuring, the pressure by balancing the fluid column by the spring or dead weight. The commonly used mechanical pressure gauges are : (a) Diaphragm pressure gauge, (b) Bourdon tube pressure gauge, (c) Dead-weight pressure gauge, and (d) Bellows pressure gauge.

- SIMPLE MANOMETERS
- A simple manometer consists of a glass tube having one of its ends connected to a point where pressure is to be measured and other end remains open to atmosphere.

- Classification of Manometers :

**1) Simple manometer**:

- Piezometer
- U-tube manometer
- single column manometer
- Vertical single column manometer
- Inclined single column manometer

**(2) Differential manometer :**

- U-tube differential manometer
- Inverted U-tube differential manometer

- It consists of glass tube connected to a vessel or pipe at which static pressure is to be measured. It is the simplest of all the manometers . It is used to measure very low pressures.
- The pressure in piezometer is given by the following equation.
- $p = \rho.g.h$
- Where,
- $\rho$= density of liquid
- h = height of liquid in the piezometer from the centre of the pipe.
- g = acceleration due to gravity.

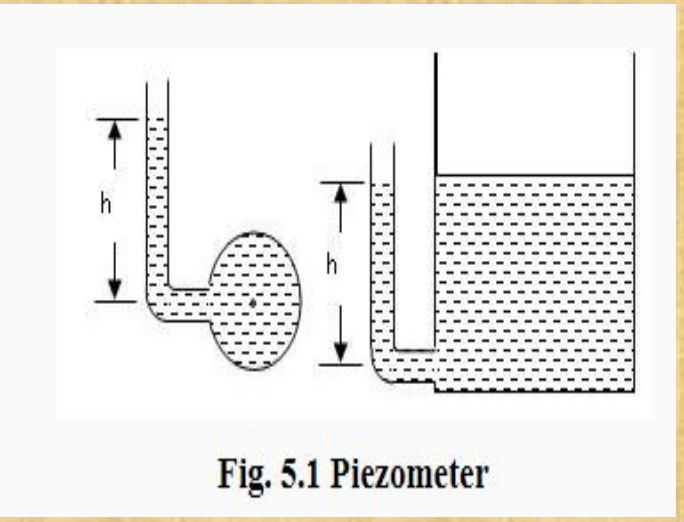
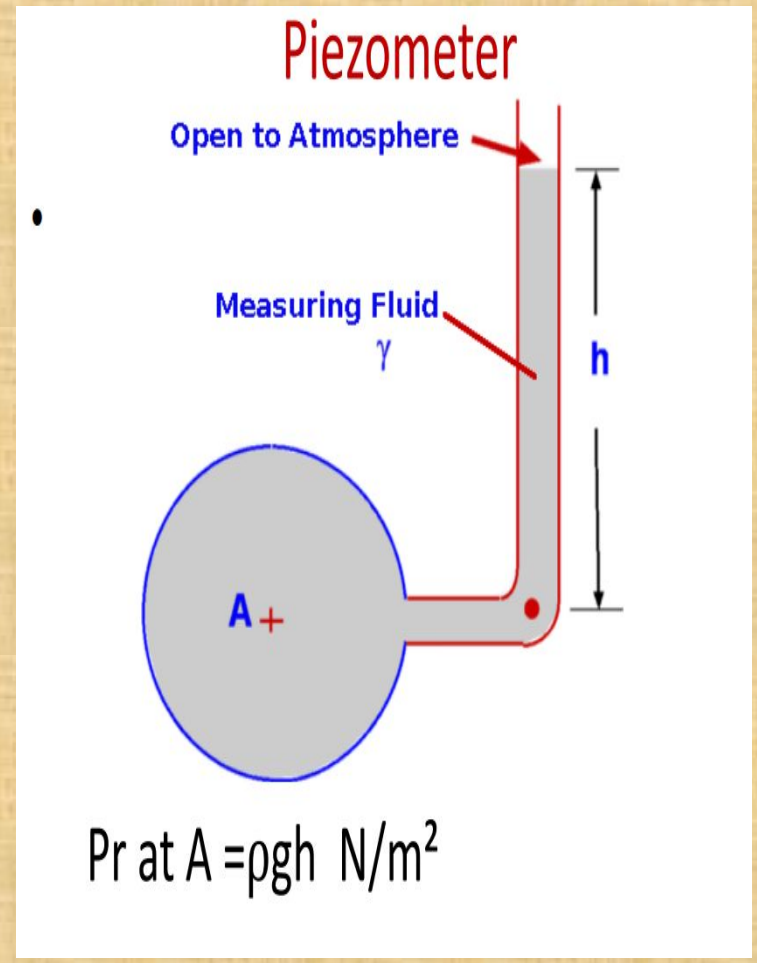
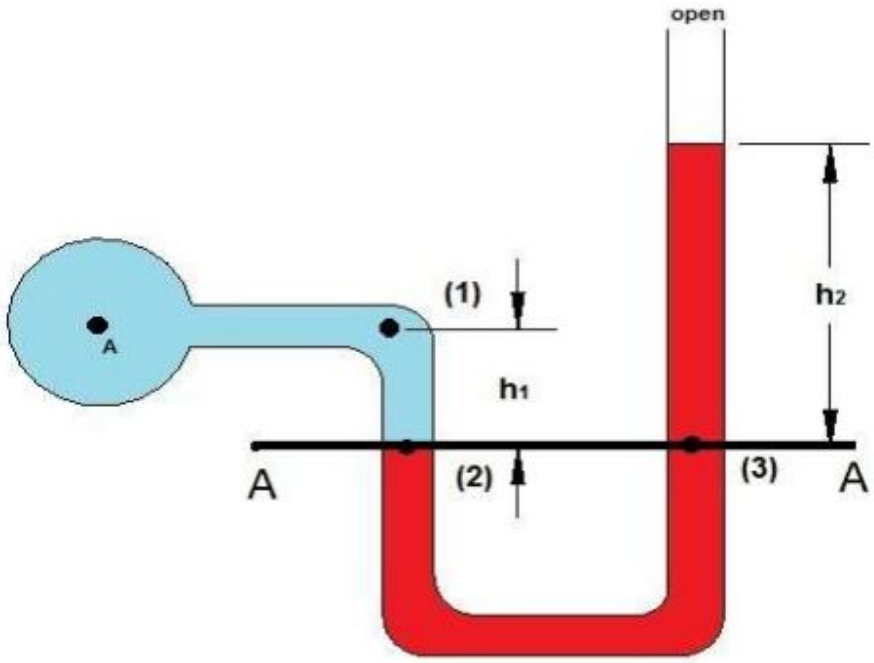


Fig. 5.1 Piezometer

# Piezometer


Piezometer
Open to Atmosphere
Measuring Fluid
γ
h
A
Pr at A =ρgh N/m²

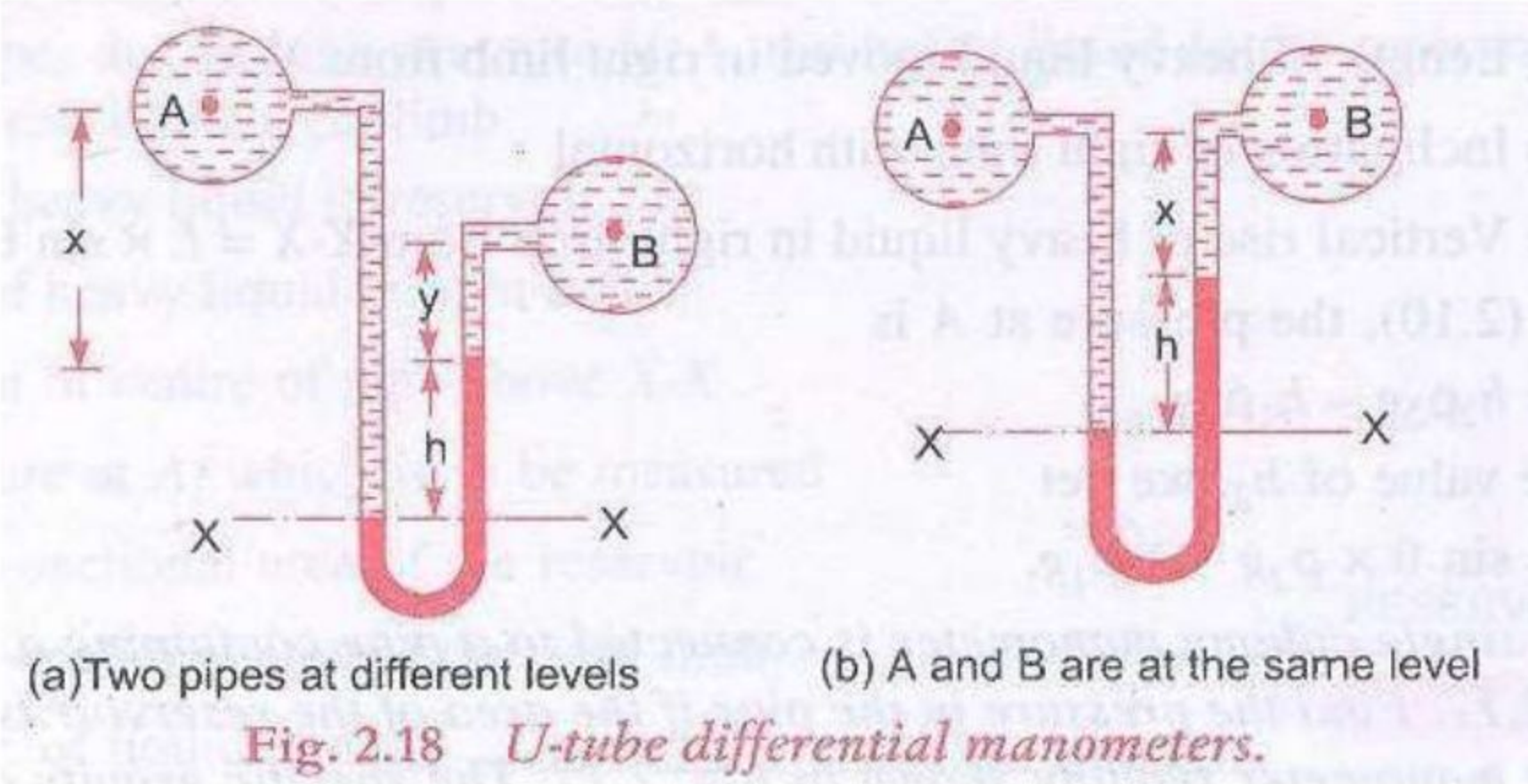
# U-tube Manometer



- • It contains two liquids
- • Let A be the point whose pressure is to be measured. h1 = Height of light liquid above the datum line
- h2 =Height of heavy liquid above the datum line
- $\rho_1$ =Density of light liquid =1000
- *$S_1$ $\rho_2$ =Density of heavy liquid =1000
- *$s_2$ As the pressure is the same for horizontal Surface. Hence Pressure above the horizontal datum line A-A should be same in both columns.
- Pressure above A-A in the left column=p+ $\rho_1$ *g* h1 Pressure above A-A in the left column= $\rho$2 *g* h2 Hence equating the two pressures p+ $\rho_1$ *g* h1 = $\rho$2 *g* h2 P=($\rho$2 *g* h2 - $\rho_1$ *g* h1 )

# DIFFERENTIAL MANOMETERS

**U-tube Differential Manometer.**




(a)Two pipes at different levels (b) A and B are at the same level

Fig. 2.18 *U-tube differential manometers.*

- • It is used for measuring the difference of pressures between two points in a pipe or in two different pipes.
- • It consists of a (i) U-tube (ii)Heavy liquid
- • Difference of pressure at A and B is given by $=h*g(\rho g - \rho_1 )+ \rho 2gy- \rho_1 gx$
- Where $\rho g$ = Density of heavy liquid or mercury y=Distance of the center of B, from the mercury level in the right limb x=distance of the centre of A, from the mercury level in the right limb

# 5. Inverted U-tube differential manometer

It is used for low pressure difference.

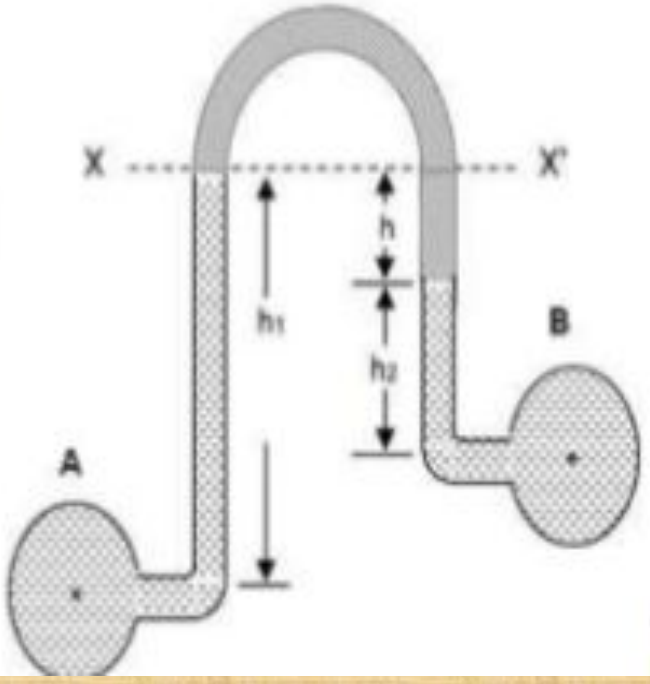
Left limb eq : $h_A - h_1 S_1$ .....(i)

Right limb eq : $h_B - h_2 S_2 - hS$ .....(ii)

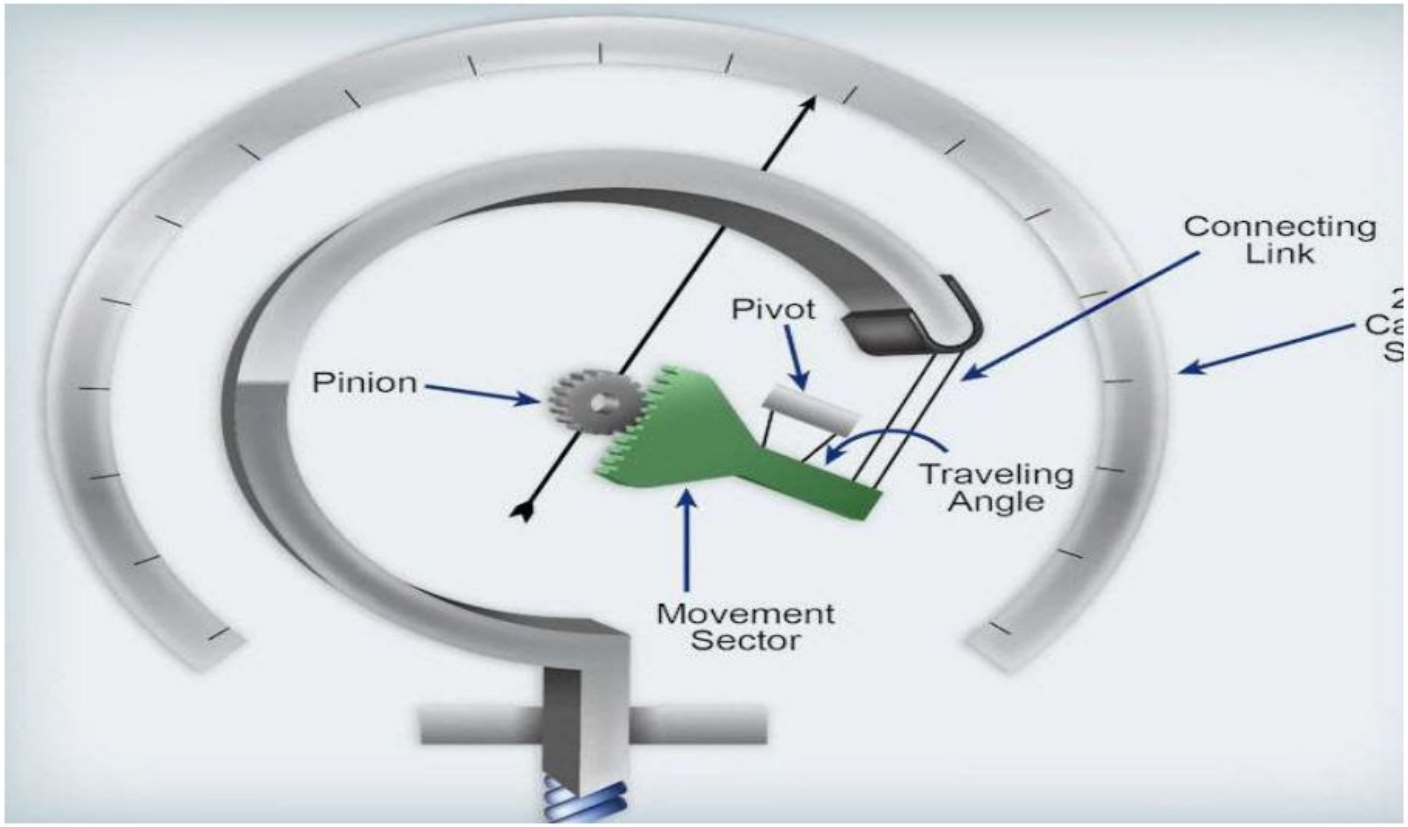
* Pressure is same at the datum line :

$h_A + h_1 S_1 = h_B - h_2 S_2 - hS$

$h_A - h_B = h_1 S_1 - h_2 S_2 - hS$



# C-type Bourdon tube



- Diaphragm are widely used for pressure (gauge pressure), particularly in very low ranges. They can detect a pressure differential even in the range of 0 to 4mm.
- The diaphragm can be in the form of Flat, Corrugated and Capsules the choice depends on the strength and amount of deflection required.