Fluid Properties

- Atmospheric pressure:
- The atmospheric air exerts a normal pressure upon all surfaces with which it is in contact, and it is known as atmospheric pressure. The atmospheric pressure is also known as 'Barometric pressure'. The atmospheric pressure at sea level (above absolute zero) is called 'Standard atmospheric pressure'.
- Gauge pressure:
- It is the pressure, measured with the help of pressure measuring instrument, in which the atmospheric pressure is taken as datum. The atmospheric pressure on the scale is marked as zero.
- Gauges record pressure above or below the local atmospheric pressure, since they measuremthe difference in pressure of the liquid to which they are connected and that of surrounding air. If the pressure of the liquid is below the local atmospheric pressure, then the gauge is designated as 'vacuum gauge' and the recorded value indicates the amount by which the pressure of the liquid is below local atmospheric pressure, i.e. negative pressure. (Vacuum pressure is defined as the pressure below the atmospheric pressure).

- Absolute pressure:
- It is necessary to establish an absolute pressure scale which is independent of the changes in atmospheric pressure. A pressure of absolute zero can exist only in complete vacuum. Any pressure measured above the absolute zero of pressure is termed as an 'absolute pressure'. A schematic diagram showing the gauge pressure, vacuum pressure and the absolute pressure
- Mathematically:
- 1. Absolute pressure = Atmospheric pressure + gauge pressure
- i.e., pabs = patm + pgauge
- 2. Vacuum pressure = Atmospheric pressure – absolute pressure
- Units for pressure:
- The fundamental S.I. unit of pressure is newton per square metre (N/m2). This is also known asPascal.

- Barometer reading = 740 mm of mercury; Specific gravity of mercury = 13.6; Intensity of pressure = 40 kPa. Express the intensity of pressure in S.I. units, both gauge and absolute.

Gauge pressure:

(i) $p = 40\text{ kPa} = 40\text{ kN/m}^2 = 0.4 \times 10^5\text{ N/m}^2 = \mathbf{0.4\text{ bar (Ans.)}}$

$(1\text{ bar} = 10^5\text{ N/m}^2)$

(ii) $h = \frac{p}{w} = \frac{0.4 \times 10^5}{9.81 \times 10^3} = \mathbf{4.077\text{ m of water (Ans.)}}$

(iii) $h = \frac{p}{w} = \frac{0.4 \times 10^5}{9.81 \times 10^3 \times 13.6} = \mathbf{0.299\text{ m of mercury (Ans.)}}$

Absolute pressure:

Barometer reading (atmospheric pressure)

$= 740\text{ mm of mercury} = 740 \times 13.6\text{ mm of water}$

$= \frac{740 \times 13.6}{1000} = 10.6\text{ m of water}$

Absolute pressure ($p_{abs.}$) = Atmospheric pressure ($p_{atm.}$) + gauge pressure (p_{gauge}).

$\therefore \quad p_{abs} = 10.06 + 4.077 = \mathbf{14.137\text{ m of water (Ans.)}}$

$= 14.137 \times (9.81 \times 10^3) = \mathbf{1.38 \times 10^5\text{ N/m}^2\text{ (Ans.)}} \quad (p = wh)$

$= \mathbf{1.38\text{ bar (Ans.)}} \quad (1\text{ bar} = 10^5\text{ N/m}^2)$

$= \frac{14.137}{13.6} = \mathbf{1.039\text{ m of mercury. (Ans.)}}$

Fluid Properties

- Calculate the pressure at a point 5 m below the free water surface in a liquid that has a variable density given by ρ = (350 + Ay) kg/m3
- where, A = 8 kg/m4 and y is the distance in metres measured from the free surface relation:

Solution. As per hydrostatic equation

$$dp = \rho . g . dy = g\,(350 + Ay)dy$$

Integrating both sides, we get:

$$\int dp = \int_0^5 g\,(350 + Ay)\,dy = g\int_0^5 (350 + 8y)\,dy$$

$$p = g\left| 350\,y + 8 \times \frac{y^2}{2} \right|_0^5$$

$$= 9.81\,(350 \times 5 + 8 \times \frac{5^2}{2}) = 18148\ \text{N/m}^2 \simeq \mathbf{18.15\ kN/m^2}$$

EX.
On the suction side of a pump a gauge shows a negative pressure of 0.35 bar.
Express this pressure in terms of:
(i) Intensity of pressure, kPa,
(ii) N/m2 absolute,
(iii) Metres of water gauge,
(iv) Metres of oil (specific gravity 0.82) absolute, and
(v) Centimetres of mercury gauge,
Take atmospheric pressure as 76 cm of Hg and relative density of mercury as 13.6.

Solution. *Given:* Reading of the *vacuum* gauge = 0.35 bar

(*i*) Intensity of pressure, kPa:

$$\text{Gauge reading} = 0.35 \text{ bar} = 0.35 \times 10^5 \text{ N/m}^2$$

$$= 0.35 \times 10^5 \text{ Pa} = \mathbf{35 \text{ kPa}} \text{ (Ans.)}$$

(*ii*) N/m^2 absolute:

$$\text{Atmospheric pressure, } p_{atm} = 76 \text{ cm of Hg}$$

$$= (13.6 \times 9810) \times \frac{76}{100} = 101396 \text{ N/m}^2$$

$$\text{Absolute pressure} = \text{Atmospheric pressure} - \textit{Vacuum} \text{ pressure}$$

$$p_{abs.} = p_{atm} - p_{vac.}$$

$$= 101396 - 35000 = \mathbf{66396 \text{ N/m}^2 \text{ absolute (Ans.)}}$$

(*iii*) Metres of water gauge:

$$p = \rho g h = wh$$

$$\therefore \quad h_{water} \text{ (gauge)} = \frac{p}{w} = \frac{0.35 \times 10^5}{9810} = \mathbf{3.567 \text{ m}} \text{ (*gauge*) (Ans.)}$$

(*iv*) Metres of oil (sp. gr. = 0.82) absolute:

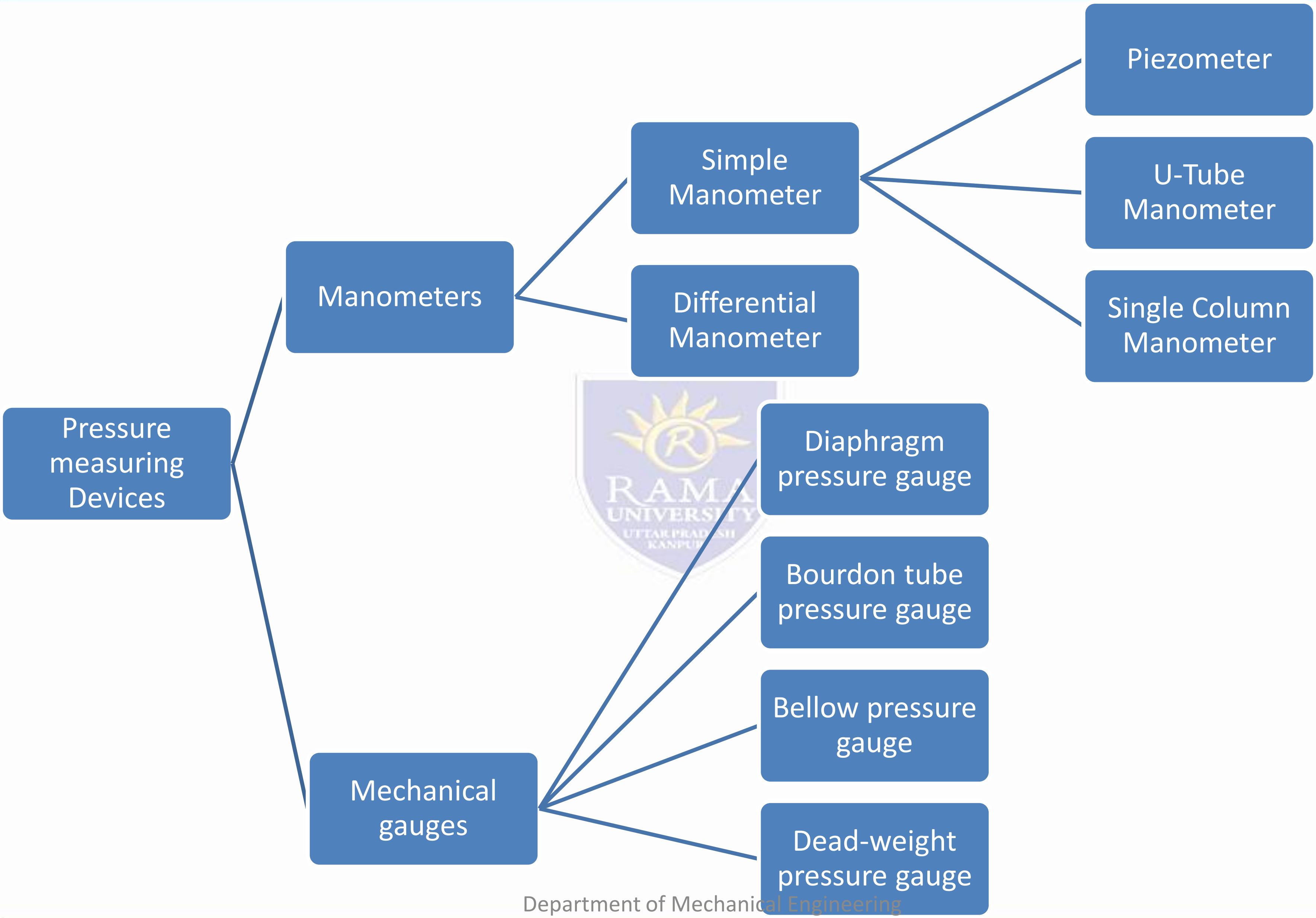
$$h_{oil} \text{ (absolute)} = \frac{66396}{0.82 \times 9810} = \mathbf{8.254 \text{ m of water}} \text{ (*absolute*) (Ans.)}$$

(*v*) Centimetres of mercury gauge:

$$h_{mercury} \text{(gauge)} = \frac{0.35 \times 10^5}{13.6 \times 9810} = 0.2623 \text{ m of mercury}$$

$$= \mathbf{26.236 \text{ cm of mercury (Ans.)}}$$

MEASUREMENT OF PRESSURE



1. 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 liquid.
2. Mechanical gauges:
These are the devices in which the pressure is measured by balancing the fluid column by spring (elastic element) or dead weight. Generally these gauges are used for measuring high pressure and where high precision is not required