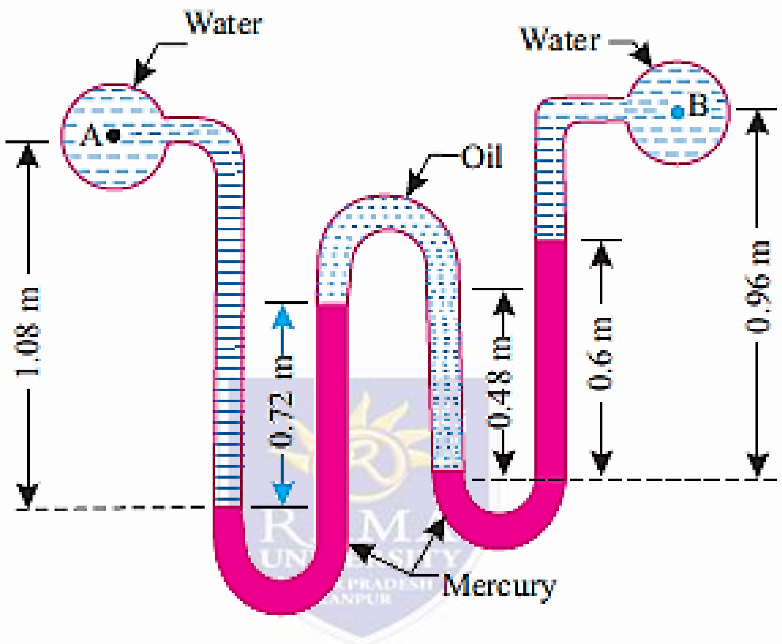
Fluid Properties

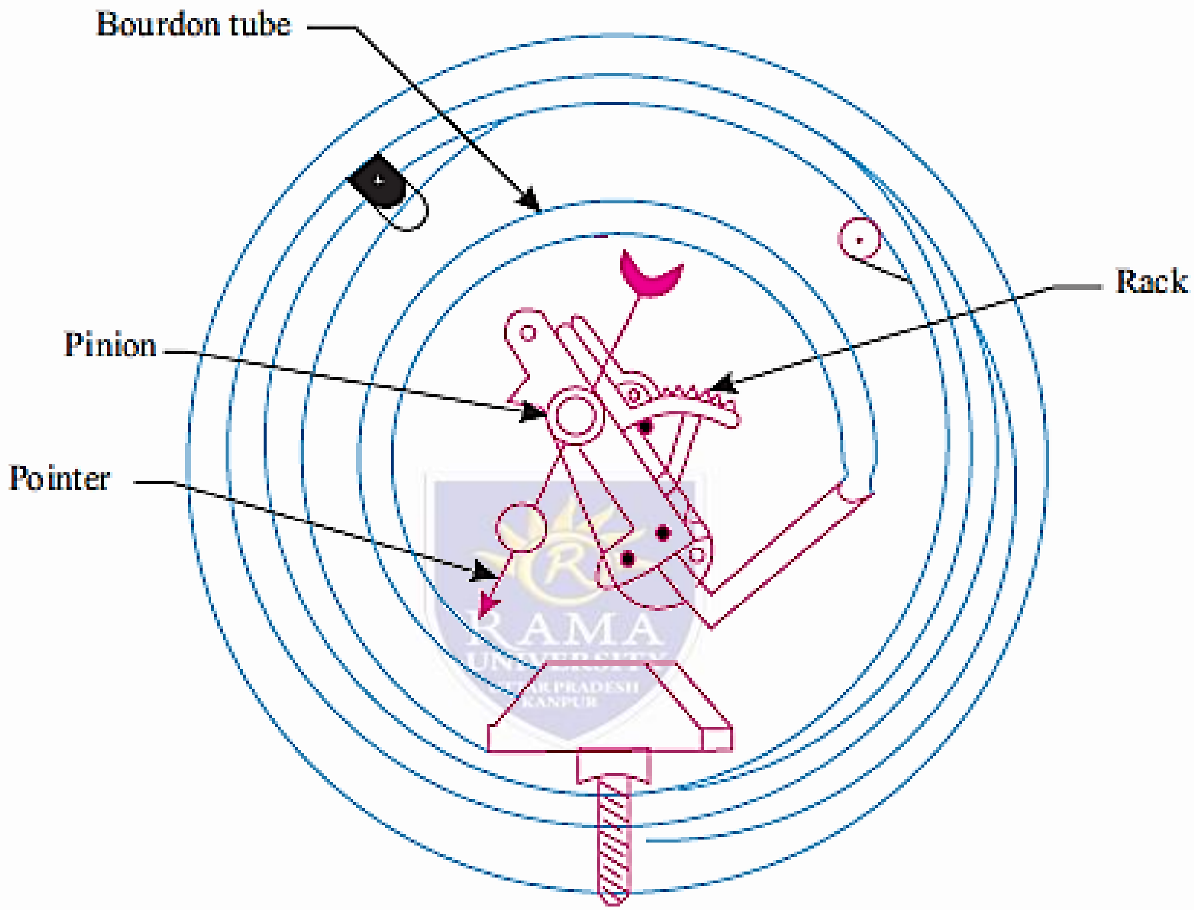
- In the Fig. is shown a compound manometer. Calculate pressure difference between the points A and B. Take ww= 10 kN/m3 for water, wm = 136 kN/m3 for mercury and w0 = 8.5 kN/m3 for oil.



- Solution. Given: ww = 10 kN/m3; wm = 136 kN/m3; w0 = 8.5 kN/m3
- pA – pB:
- Starting from point A, the governing manometric equation is:
- pA + ww × 1.08 – wm × 0.72 + w0 × 0.48 – wm × 0.6 – ww (0.96 – 0.6) = pB
- or, pA = 10 × 1.08 – 136 × 0.72 + 8.5 × 0.48 – 136 × 0.6 – 10 (0.96 – 0.6) = pB
- or, pA + 10.8 – 97.92 + 4.08 – 81.6 – 3.6 = pB
- or, pA – pB = 168.24 kN/m2 (Ans.)

- Mechanical Gauges /Transdusers
- The manometers (discussed earlier) are suitable for comparatively low pressures.
- For high pressures they become unnecessarily larger even when they are filled with heavy liquids. Therefore, for measuring medium and high pressures we make use of elastic pressure gauges.
- They employ different forms of elastic systems such as tubes, diaphragms or bellows etc. to measure the pressure.
- The elastic deformation of these elements is used to show the effect of pressure. Since these elements are deformed within the elastic limit only, therefore these gauges are sometimes called elastic gauges.
- Sometimes they are also called secondary instruments, which implies that they must be calibrated by comparison with primary instruments such as manometers etc.
- Some of the important types of these gauges are
- 1. Bourdon tube pressure gauge,
- 2. Diaphragm gauge, and
- 3. Vacuum gauge.

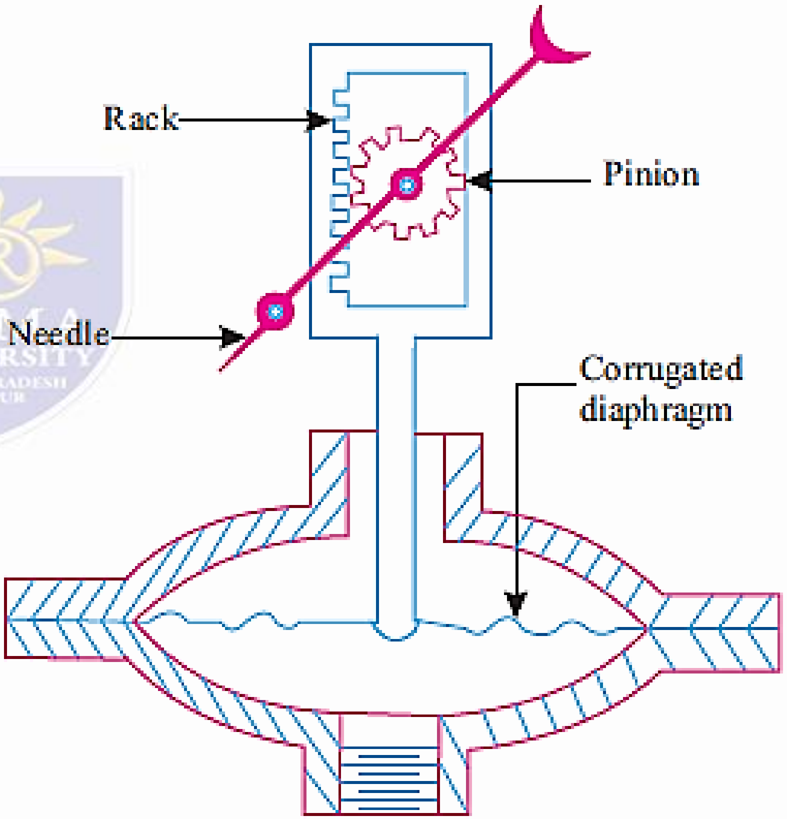
- 1. Bourdon tube pressure gauge:
- Bourdon tube pressure gauge is used for measuring high as well as low pressures.
- A simple form of this gauge is shown in Fig. . In this case, the pressure element consists of a metal tube of approximately elliptical cross-section. This tube is bent in the form of a segment of a circle and responds to pressure changes. When one end of the tube which is ttached to the gauge case, is connected to the source of pressure, the internal pressure causes the tube to expand, whereby circumferential stress i.e., hoop tension is set up.
- The free end of the tube moves and is in turn connected by suitable levers to a rack, which engages with a small pinion mounted on the same spindle as the pointer. Thus the pressure applied to the tube causes the rack and pinion to move.
- The pressure is indicated by the pointer over a dial which can be graduated in a suitable scale.
- The Bourdon tubes are generally made of bronze or nickel steel. The former is generally used for low pressures and the latter for high pressures.
- Depending upon the purpose for which they are required Bourdon tube gauges are made in different forms, some of them are:
- (i) Compound Bourdon tube–used for measuring pressures both above and below atmospheric pressure.
- (ii) Double Bourdon tube–used where vibrations are encountered.



Bourdon tube pressure gauge.

Fluid Properties

- 2. Diaphragm gauge:
- This type of gauge employs a metallic disc or diaphragm instead of a bent tube.
- This disc or diaphragm is used for actuating the indicating device.
- When pressure is applied on the lower side of the diaphragm it is deflected upward.
- This movement of the diaphragm is transmitted to a rack and pinion. The latter is attached to the spindle of needle moving on a graduated dial.
- The dial can again be graduated in a suitable scale.



Diaphragm gauge.

Fluid Properties

- Vacuum gauge:
- Bourdon gauges discussed earlier can be used to measure vacuum instead of pressure.
- Slight changes in the design are required in this purpose. Thus, in this case, the tube be bent inward instead of outward as in pressure gauges.
- Vacuum gauges are graduated in millimeters of mercury below atmospheric pressure. In such cases, therefore, absolute pressure in millimeters of mercury is the difference between barometer reading and vacuum gauge reading.
- Vacuum gauges are used to measure the vacuum in the condensers, etc. If there is leakage, the vacuum will drop.
- The pressure gauge installation requires the following considerations:
- 1. Flexible copper tubing and compression fittings are recommended for most installations.
- 2. The installation of a gauge cock and tee in the line close to the gauge is recommended because it permits the gauge to be removed for testing or replacement without having to shut down the system.
- 3. Pulsating pressures in the gauge line are not required.
- 4. The gauge and its connecting line is filled with an inert liquid and as such liquid seals are provided. Trapped air at any point of gauge lines may cause serious errors in pressure reading.

Fluid Properties

- PRESSURE AT A POINT IN COMPRESSIBLE FLUID
- The pressure at a height Z in a static compressible fluid (gas) undergoing isothermal compression

$$p = p_0 e^{(-gZ/RT)}$$

- where, p0 = Absolute pressure at sea-level or at ground level,
- Z = Height from sea or ground level,
- R = Gas constant, and
- T = Absolute temperature.
- The pressure and temperature at a height Z in a static compressible fluid (gas) undergoing adiabatic compression

$$p = p_0 \left[1 - \frac{\gamma - 1}{\gamma} gZ \frac{\rho_0}{p_0}\right]^{\frac{\gamma}{\gamma - 1}} = p_0 \left[1 - \frac{\gamma - 1}{\gamma} \frac{gZ}{RT_0}\right]^{\frac{\gamma}{\gamma - 1}}$$

- and, temperature,

$$T = T_0 \left[1 - \frac{\gamma - 1}{\gamma} \frac{gZ}{RT_0}\right]$$

- where, p0, T0 are pressure and temperature at sea-level; γ = 1.4 for air.