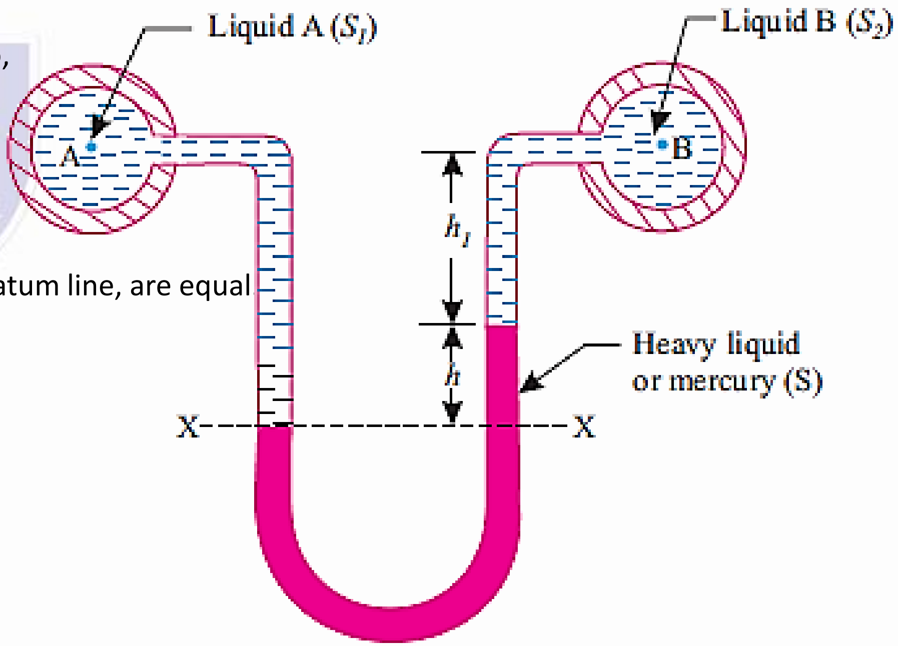
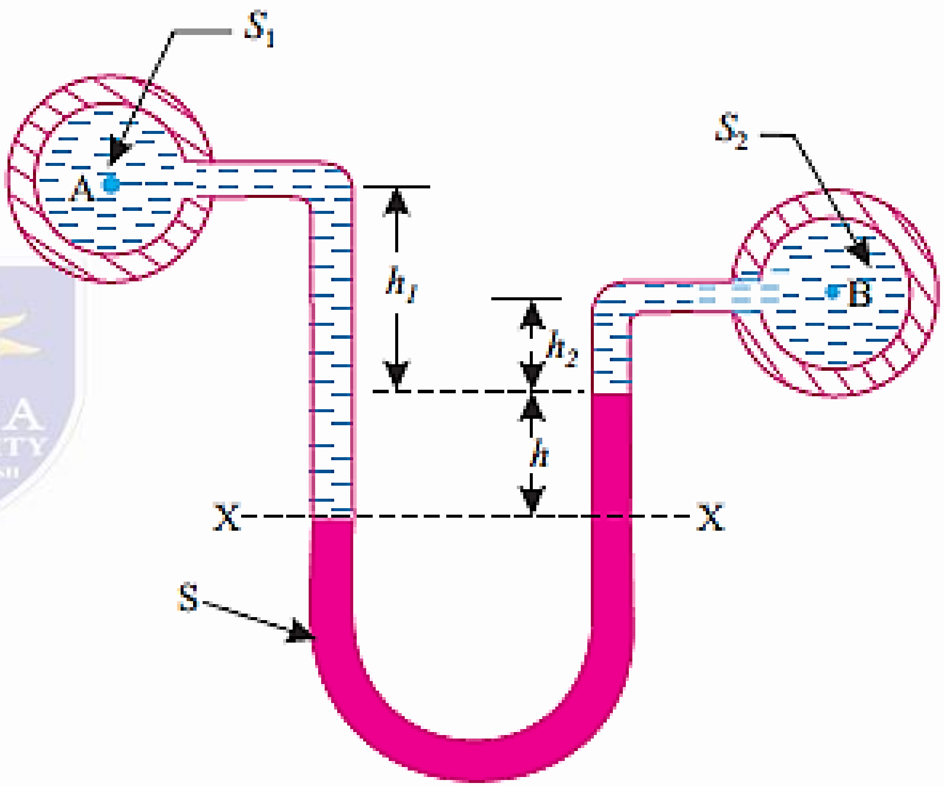
Fluid Properties

- Differential Manometers
- A differential manometer is used to measure the difference in pressures between two points in a pipe, or in two different pipes. In its simplest form a differential manometer coU-tube, containing a heavy liquid, whose two ends are connected to the points, whose difference of pressures is required to be found out. Following are the most commonly used types of differential manometers:
- 1. U-tube differential manometer.
- 2. Inverted U-tube differential manometer.
- 1. U-tube differential manometer:
- A U-tube differential manometer is shown in Fig. .
- Case I. Fig. 2.21 (a) shows a differential manometer whose two ends are connected with two
- different points A and B at the same level and containing same liquid.
- Let, h = Difference of mercury levels (heavy liquid) in the U-tube,
- h1 = Distance of the centre of A from the mercury level in the right limb,
- S1 (= S2) = Specific gravity of liquid at the two points A and B
- S = Specific gravity of heavy liquid or mercury in the U-tube,
- hA = Pressure head at A, and
- hB = Pressure head at B.
- We know that the pressures in the left limb and right limb, above the datum line, are equal
- Pressure head in the left limb
- = hA+ (h1 + h) S1
- Pressure head in the right limb
- = hB + h1 × S1 + h × S
- hA + (h1 + h)S1 = hB + h1S1 + hS
- or, hA – hB = h1S1 + hS – (h1 + h) S1
- = h1 S1 + hS – h1S1 + hS1 = h (S – S1)
- i.e., Difference of pressure head,
- hA – hB = h (S – S1)nsists of a

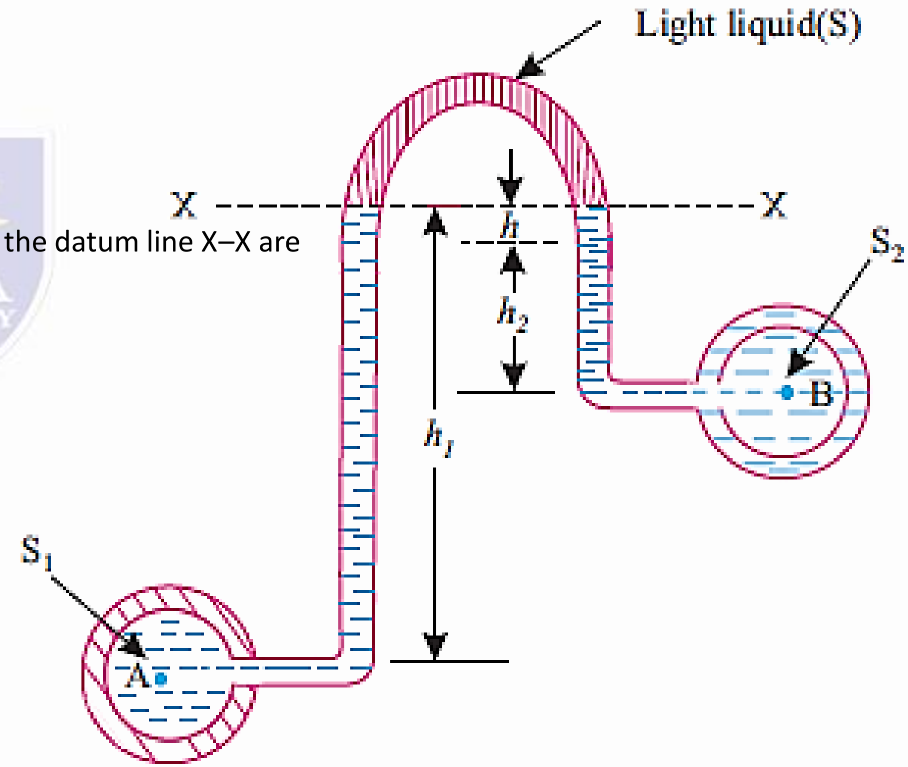


- Case II. Fig. shows a differential manometer whose two ends are connected to two different points A and B at different levels and containing different liquids.
- Let, h = Difference of mercury levels (heavy liquid) in the U-tube,
- h1 = Distance of the centre of A, from the mercury level in the left limb,
- h2 = Distance of the centre of B, from the mercury level in the right limb,
- S1 = Specific gravity of liquid in pipe A,
- S2 = Specific gravity of liquid in pipe B,
- S = Specific gravity of heavy liquid or mercury,
- hA = Pressure head at A, and
- hB = Pressure head at B.
- Considering the pressure heads above the datum line X–X, we get:
- Pressure head in the left limb = hA + (h1 + h) S1
- Pressure head in the right limb = hB + h2 × S2 + h × S
- Equating the above pressure heads, we get:
- hA + (h1 + h) S1 = hB + h2 × S2 + h × S
- (hA – hB) = h2 × S2 + h × S – (h1 + h) S1
- = h2 × S2 + h × S – h1S1 – hS1 = h (S – S1) + h2S2 – h1S1
- i.e., Difference of pressure heads at A and B,
- hA – hB = h (S – S1) + h2S2 – h1S1



Fluid Properties

- Inverted U-tube differential manometer
- This type of manometer is used for measuring difference of two pressures where accuracy is the major consideration. Refer to Fig. . It consists of an inverted U-tube, containing light liquid, whose two ends are connected to the points, (A and B) whose difference of pressures is to be found out. Let the pressure at A is more than the pressure at B.
- Let, h1 = Height of liquid in the left limb below the datum line X–X,
- h2 = Height of liquid in the right limb below the datum line,
- h = Difference of levels of the light liquid in the right and left limbs (also known as
- manometer reading),
- S1 = Specific gravity of the liquid in the left limb,
- S2 = Specific gravity of the liquid in the right limb,
- S = Specific gravity of the light liquid,
- hA = Pressure head at A, and
- hB = Pressure head at B.
- We know that pressure heads in the left limb and the right limb below the datum line X–X are
- equal.
- Pressure head in the left limb below X–X = hA – h1 × S1
- Pressure head in the right limb below X–X = hB – h2 × S2 – h × S
- Equating the above heads, we get:
- Mechanics
- hA – h1 × S1 = hB – h2 × S2 – h × S
- hA – hB = h1 × S1 – h2 × S2 – h × S
- i.e., hA – hB = h1S1 – h2S2 – hS



Fluid Properties

- Advantages and Limitations of Manometers
- Advantages:
- 1. Easy to fabricate and relatively inexpensive.
- 2. Good accuracy.
- 3. High sensitivity.
- 4. Require little maintenance.
- 5. Not affected by vibration.
- 6. Specially suitable for low pressure and low differential pressures.
- 7. It is easy to change the sensitivity by affecting a change in the quantity of manometic liquid
- in the manometer.
- Limitations:
- 1. Usually bulky and large in size.
- 2. Being fragile, get broken easily.
- 3. Readings of the manometers are affected by changes in temperature, altitude and gravity.
- 4. A capillary effect is created due to surface tension of manometric fluid.
- 5. For better accuracy meniscus has to be measured by accurate means.

- In a pipeline water is flowing. A manometer is used to measure the pressure drop for flow through the pipe. The difference in level was found to be 20 cm. If the manometric fluid is CCl4, find the pressure drop in S.I units (density of CCl4 = 1.596 g/cm3). If the manometric fluid is changed to mercury (ρ = 13.6gm/cm3) what will be the difference in level?
- Solution. Given: hCCl4 = 20 cm = 0.2 m; rCCl4 = 1.596 g/cm3

$$= 1.596 \times 10^3 \text{ kg/m}^3$$

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

$$\text{Pressure drop, } \Delta p = \rho_{CCl_4} g h_{CCl_4}$$

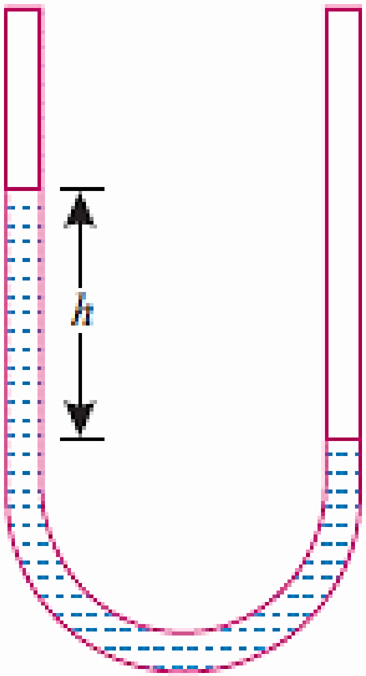
$$= 1.596 \times 10^3 \times 9.81 \times 0.2 \text{ N/m}^2$$

$$= 3131.3 \text{ N/m}^2 \text{ or Pa} = 3.131 \text{ kPa (Ans.)}$$

The difference in level with mercury,

$$h_{Hg} = h_{CCl_4} \times \frac{\rho_{CCl_4}}{\rho_{Hg}} = 0.20 \times \frac{1.596 \times 10^3}{13.6 \times 10^3}$$

$$= 0.02347 \text{ m or } 2.347 \text{ cm (Ans.)}$$



Fluid Properties

- A U-tube manometer is used to measure the pressure of oil of specific gravity 0.85 flowing in a pipe line. Its left end is connected to the pipe and the right-limb is open to the atmosphere. The centre of the pipe is 100 mm below the level of mercury (specific gravity = 13.6) in
- the right limb. If the difference of mercury level in the two limbs is 160 mm, determine the absolute pressure of the oil in the pipe.
- Specific gravity of mercury, S2 = 13.6
- Height of the oil in the left limb,
- h1 = 160 – 100 = 60 mm = 0.06 m
- Difference of mercury level,
- h2 = 160 mm = 0.16 m.
- Absolute pressure of oil:
- Let, h1 = Gauge pressure in the pipe in
- terms of head of water, and
- p = Gauge pressure in terms of
- kN/m2.
- Equating the pressure heads above the
- datum line X–X, we get:
- h + h1 S1 = h2S2
- or, h + 0.06 × 0.85 = 0.16 × 13.6 = 2.125 m
- The pressure p is given by:
- p = wh
- = 9.81 × 2.125 kN/m2
- = 20.84 kPa (Qw = 9.81 kN/m3 in S.I. units)
- Absolute pressure of oil in the tube,
- pabs. = patm. + pgauge
- = 100 + 20.84 = 120.84 kPa (Ans.)