- A simple U-tube manometer is installed across an orificemeter. The manometer is filled with mercury (sp. gravity = 13.6) and the liquid above the mercury is carbon tetrachloride (sp. gravity = 1.6). The manometer reads 200 mm. What is the pressure difference over the manometer in newtons per square metre.

Solution. Specific gravity of heavier liquid, $S_{hl} = 13.6$

Specific gravity of lighter liquid, $S_{ll} = 1.6$

Reading of the manometer, $y = 200$ mm

Pressure difference over the manometer : p

Differential head,

$$h = y\left[\frac{S_{hl}}{S_{ll}} - 1\right]$$

$$200\left[\frac{13.6}{1.6} - 1\right] = 1500 \text{ mm of carbon tetrachloride}$$

Pressure difference over manometer,

$$p = wh = (1.6 \times 9810) \times \left(\frac{1500}{1000}\right)$$

or $$p = 23544 \text{ N/m}^2 \quad \text{(Ans.)}$$

- Fig. 2shows a single column manometer connected to a pipe containing liquid of specific gravity 0.8. The ratio of area of the reservoir to that of the limb is 100. Find the pressure in the pipe. Take specific gravity of mercury as 13.6.
- Solution. Specific gravity of liquid in the pipe, S1 = 0.8.
- Specific gravity of mercury, S2 = 13.6

$$\frac{\text{Area of reservoir}}{\text{Area of right limb}} = \frac{A}{a} = 100$$

- Height of the liquid in the left limb, h1 = 300 mm
- Height of mercury in the right limb, h2 = 500 mm
- Let, h = Pressure head in the pipe.
- Using the relation:

$$h = \frac{a}{A} h_2 (S_2 - S_1) + h_2 S_2 - h_1 S_1$$

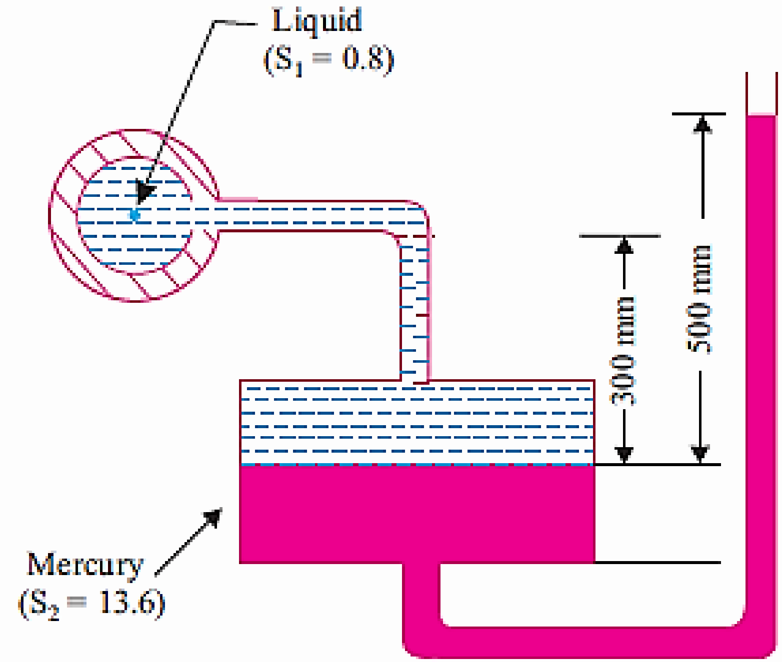
$$h = \frac{1}{100} \times 500 (13.6 - 0.8) + 500 \times 13.6 - 300 \times 0.8 \text{ mm of water}$$

$$= 6624 \text{ mm of water} \quad \text{or} \quad 6.624 \text{ m of water}$$

$$p = wh = 9.81 \times 6.624$$

$$= 64.98 \text{ kN/m}^2 \text{ or } 64.98 \text{ kPa}$$

$$p = 64.98 \text{ kPa (Ans.)}$$



Fluid Properties

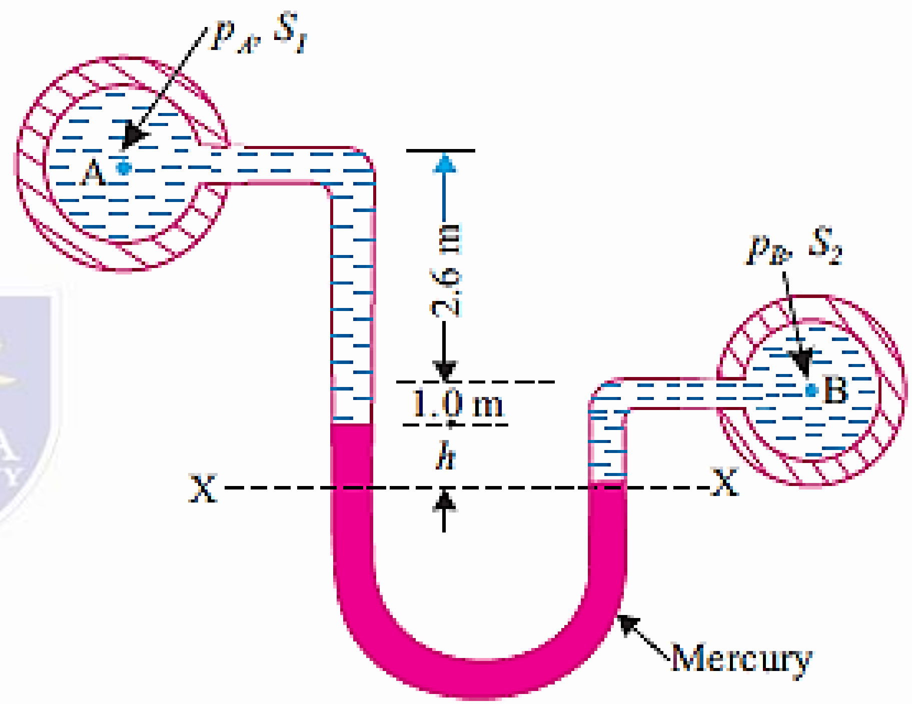
- Fig shows a U-tube differential manometer connecting two pressure pipes at A and B. The pipe A contains a liquid of specific gravity 1.6 under a pressure of 110 kN/m2. The pipe B contains oil of specific gravity 0.8 under a pressure of 200 kN/m2. Find the difference of pressure measured by mercury as fluid filling U-tube.
- Solution. Specific gravity of liquid at A, S1 = 1.6
- Specific gravity of liquid at B, S2 = 0.8 Pressure at A, pA = 110 kN/m2
- Pressure head at A,

$$h_A = \frac{p_A}{w} = \frac{110}{9.81} = 11.21 \text{ m of water}$$

Pressure at B, $p_B = 200 \text{ kN/m}^2$

Pressure head at B,

$$h_B = \frac{p_B}{w} = \frac{200}{9.81} = 20.38 \text{ m of water}$$



- Taking X – X as the datum line:
- Pressure head above X–X in the left limb
- = hA + (2.6 + 1.0) S1 + h × 13.6 m of water
- Pressure head above X–X in the right limb
- = hB + (1.0 + h) × S2 m of water
- Equating the above pressure heads, we get:
- hA + (2.6 + 1.0) S1 + h × 13.6 = hB + (1.0 + h) S2
- 11.21 + 5.76 + 13.6 h = 20.38 + (1.0 + h) × 0.8
- or, 16.97 + 13.6 h = 20.38 + 0.8 + 0.8 h or 12.8h = 4.21
- or, h = 0.329 m or 329 mm (Ans.)

- Fig. 2. shows a differential manometer connected at two points A and B. At A air pressure is 100 kN/m2. Find the absolute pressure at B.

Solution. Pressure of air at A,

$$p_A = 100 \text{ kN/m}^2$$

Pressure head at A,

$$h_A = \frac{100}{9.81} = 10.2 \text{ m}$$

Let the pressure at B is p_B.

Then, pressure head at $B = \frac{p_B}{w}$

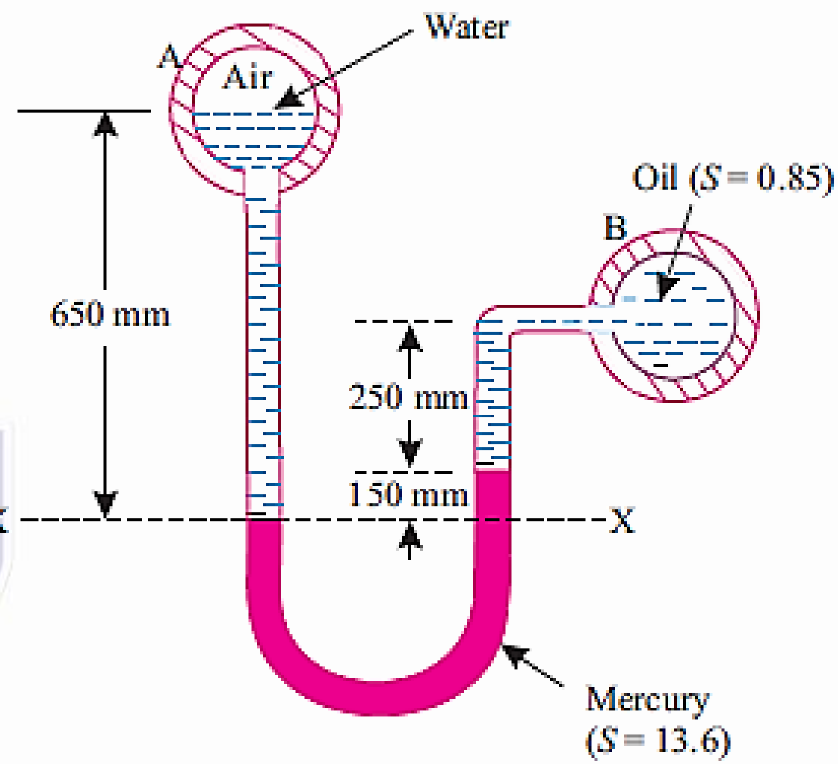
Considering pressure heads above the atum line X–X, we have:

Pressure head in the *left limb*

$$= \frac{650}{1000} + h_A = 0.65 + 10.2 = 10.85 \text{ m}$$

Pressure head in the *right limb*

$$= h_B + \frac{250}{1000} \times 0.85 + \frac{150}{1000} \times 13.6$$



$$= h_B + 0.212 + 2.04 = h_B + 2.25$$

Equating the above pressure heads, we get:

$$10.85 = h_B + 2.25 \quad \text{or} \quad h_B = 8.6 \text{ m}$$

But,

$$h_B = \frac{p_B}{w}$$

$$p_B = wh_B = 9.81 \times 8.6 = 84.36 \text{ kN/m}^2$$

or,

$$p_B = \mathbf{84.36 \text{ kPa (Ans.)}}$$

Lecture- Fluid Pressure

- An inverted differential manometer is connected to two pipes A and B carrying water under pressure as shown in Fig. The fluid in the manometer is oil of specific gravity 0.75. Determine the pressure difference between A and B.
- Solution. Specific gravity of oil, S = 0.75
- Specific gravity of water, S1, S2 = 1
- Difference of oil in the two limbs = (450 + 200) – 450 = 200 mm
- We know that pressure heads on the left and right limbs below the datum line X–X are equal.
- Pressure head in the left limb below X–X

$$= h_A - \frac{450}{1000} \times 1 = h_A - 0.45$$

Pressure head in the right limb below X–X

$$= h_B - \frac{450}{1000} \times 1 - \frac{200}{1000} \times 0.75$$

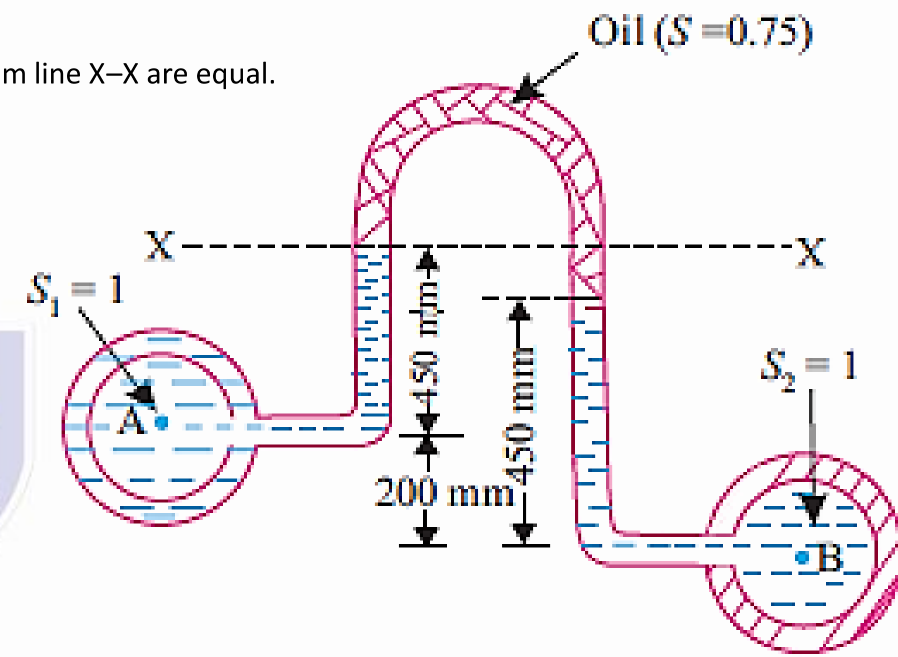
$$= h_B - 0.45 - 0.15 = h_B - 0.6$$

Equating the two pressure heads, we get:

$$h_A - 0.45 = h_B - 0.6$$

$$h_B - h_A = \mathbf{0.15\ m\ (Ans.)}$$

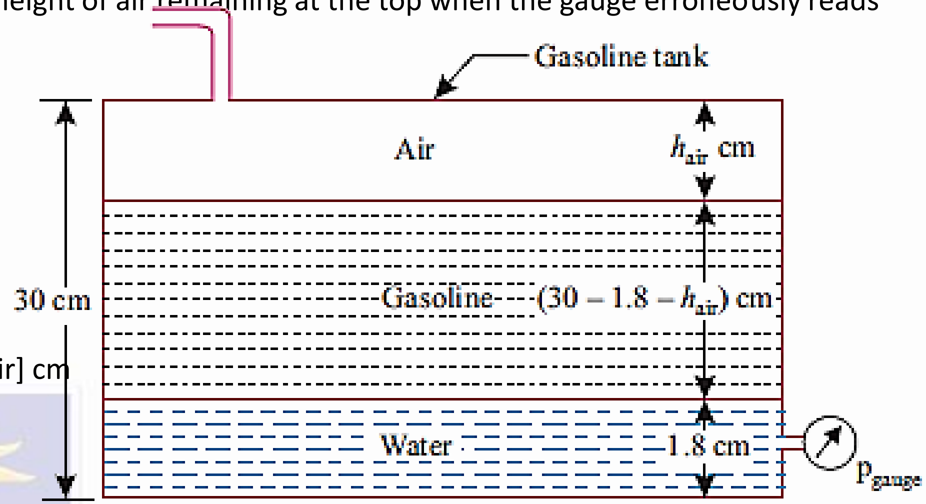
$$\text{or, } \frac{p_B}{w} - \frac{p_A}{w} = 0.15 \quad \text{or } p_B - p_A$$



- = w × 0.15 = 9.81 × 0.15 = 1.47 kN/m2 = 1.47 kPa (Ans.)

- Fig. . shows a fuel gauge, for a gasoline tank in car, which reads proportional to the bottom gauge. The tank is 30 cm deep and accidently contains 1.8 cm of water in addition to the gasoline. Determine the height of air remaining at the top when the gauge erroneously reads
- full. Take: wgasoline = 6.65 kN/m3, and wair = 0.0118 kN/m3.
- Solution. When the tank is full of gasoline,

$$p_{gauge} = wh = 6.65 \times \frac{30}{100} = 1.995 \text{ kN/m}^2$$



- The gauge would erroneously read 1.995 kN/m2 even
- when h cm of air remains at the top;
- evidently when water is also accidently present.
- ∴ Pressure due to h cm height of air + pressure due to [30 – 1.8 – hair] cm
- height of gasoline + pressure due to 1.8 cm of water = 1.995

or, $$0.0118 \times \frac{h_{air}}{100} + 6.65 \times \frac{(30 - 1.8 - h_{air})}{100} + 9.81 \times \frac{1.8}{100} = 1.995$$

or, $$0.0118\, h + 187.53 - 6.65\, h_{air} + 17.658 = 199.5$$

or, $$h_{air} = \frac{187.53 + 17.658 - 199.5}{6.638} = \mathbf{0.857 \text{ cm (Ans.)}}$$