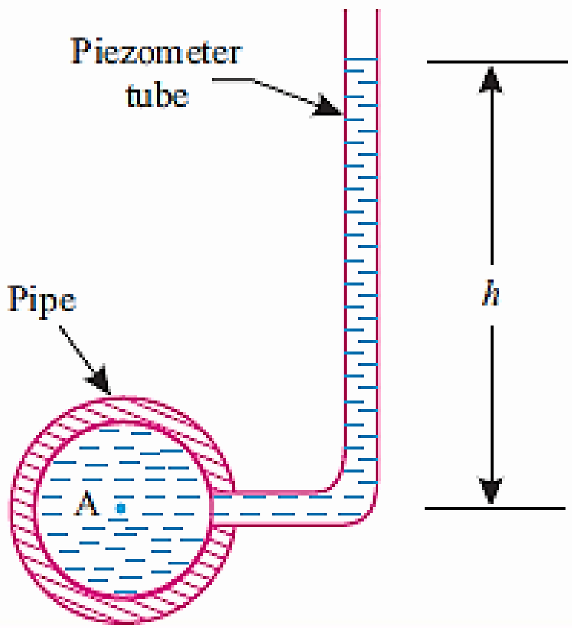
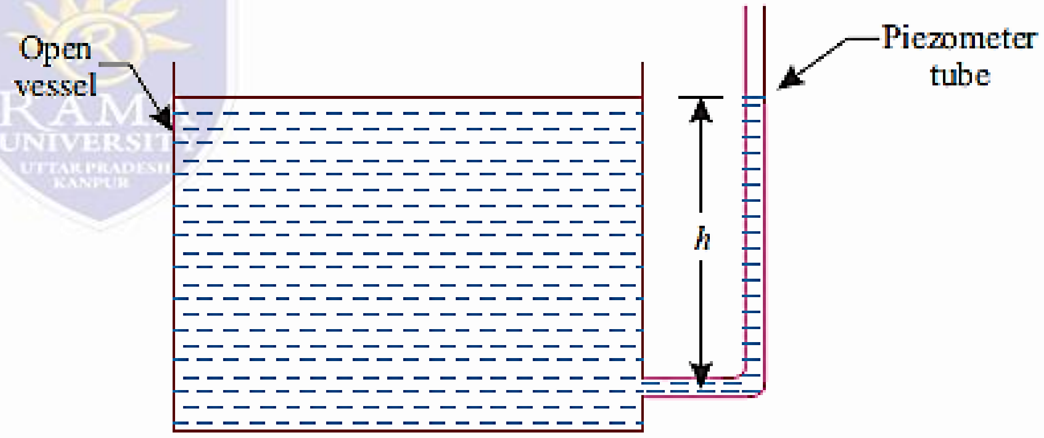
Lecture -08 Simple Manometer

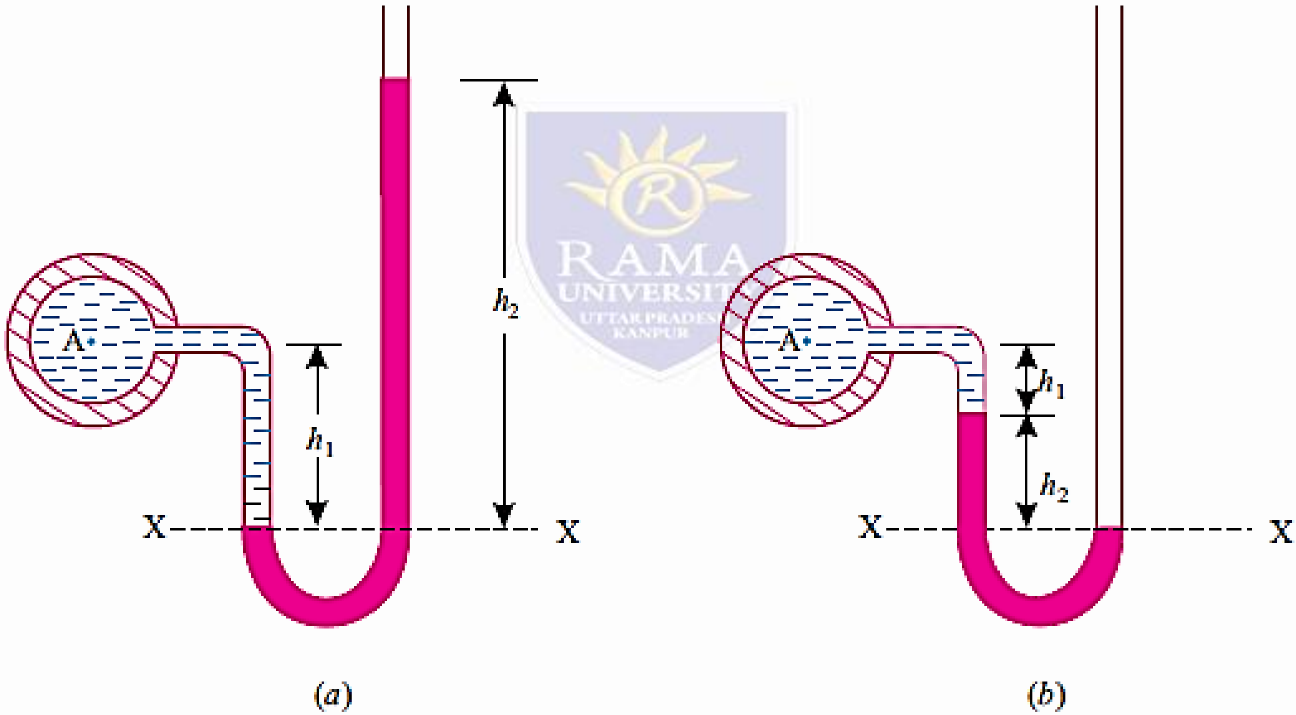
- Simple manometers
- A "simple manometer" is one which consists of a glass tube whose one end is connected to a point where pressure is to be measured and the other end remains open to atmosphere
- 1. Piezometer:
- A piezometer is the simplest form of manometer which can be used for measuring moderate pressures of liquids. It consists of a glass tube (Fig) inserted in the wall of a vessel or of a pipe, containing liquid whose pressure is to be measured. The tube extends vertically upward to such a height that liquid can freely rise in it without overflowing. The pressure at any point in the liquid is indicated by the height of the liquid in the tube above that point, which can be read on the scale attached to it. Thus if w is the specific weight of the liquid, then the pressure at point A(p) is given by:
- $p = wh$
- Piezometers measure gauge pressure only (at the surface of the liquid), since the surface of the liquid in the tube is subjected to atmospheric pressure. A piezometer tube is not suitable for measuring negative pressure; as in such a case the air will enter in pipe through the tube.





Fluid Properties

- U-tube manometer
- Piezometers cannot be employed when large pressures in the lighter liquids are to be measured, since this would require very long tubes, which cannot be handled conveniently.
- Furthermore gas pressures cannot be measured by the piezometers because a gas forms no free atmospheric surface.
- These limitations can be overcome by the use of U-tube manometers.
- A U-tube manometer consists of a glass tube bent in U-shape, one end of which is connected to a point at which pressure is to be measured and other end remains open to the atmosphere as shown in Fig.



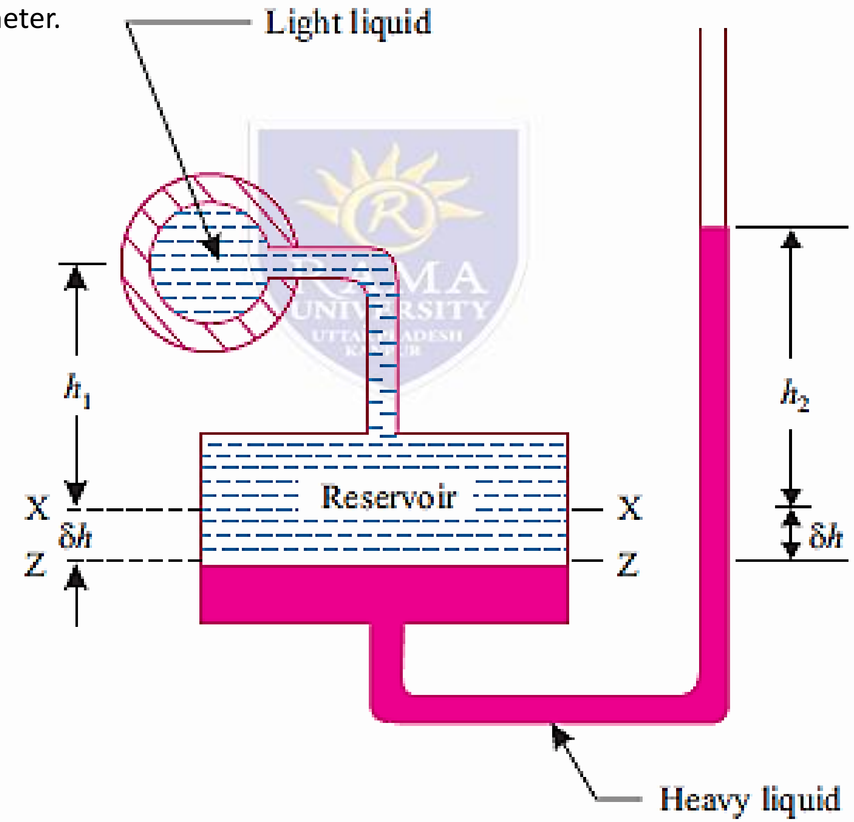
For positive pressure

For Negative pressure

- (i) For positive pressure:
- Let, A be the point at which pressure is to be measured. X–X is the datum line as shown in
- Fig. (a).
- Let, h1 = Height of the light liquid in the left limb above the datum line,
- h2 = Height of the heavy liquid in the right limb above the datum line,
- h = Pressure in pipe, expressed in terms of head,
- S1 = Specific gravity of the light liquid, and
- S2 = Specific gravity of the heavy liquid.
- The pressures in the left limb and right limb above the datum line X–X are equal (as the pressures
- at two points at the same level in a continuous homogeneous liquid are equal).
- Pressure head above X–X in the left limb = h + h1 S1
- Pressure head above X–X in the right limb = h2 S2
- Equating these two pressures, we get:
- h + h1 S1 = h2 S2 or h = h2 S2 – h1S1

- (ii) For negative pressure:
- Refer to Fig. 2.11 (b).
- Pressure head above X–X in the left limb = h + h1 S1 + h2S2
- Pressure head above X–X in the right limb = 0.
- Equating these two pressures, we get:
- h + h1S1 + h2 S2 = 0 or h = – (h1 S1 + h2S2)

- Single column manometer (micro-manometer
- The U-tube manometer described above usually requires reading of fluid levels at two or more points since a change in pressure causes a rise of liquid in one limb of the manometer and a drop in the other. This difficulty is however overcome by using single column manometers. A single column manometer is a modified form of a U-tube manometer in which a shallow reservoir having a large cross-sectional area (abo ut 100 times) as compared to the area of the tube is connected to one limb of the manometer, as shown in Fig. For any variation in pressure, the change in the liquid level in the reservoir will be so small that it may be neglected, and the pressure is indicated by the height of the liquid in the other limb. As such only one reading in the narrow limb of the manometer need be taken for all pressure measurements. The narrow limb may be vertical or inclined. Thus there are two types of single column manometer as given below:
- (a) Vertical single column manometer, and
- (b) Inclined single column manometer.



- the pipe. Now consider that the manometer is connected to a pipe containing light liquid under
- a very high pressure. The pressure in the pipe will force the light liquid to push the heavy liquid
- in the reservoir downwards. As the area of the reservoir is very large, the fall of the heavy liquid
- level will be very small. This downward movement of the heavy liquid, in the reservoir, will cause
- a considerable rise of the heavy liquid in the right limb.
- Let, h1 = Height of the centre of the pipe above X–X,
- h2 = Rise of heavy liquid (after experiment) in the right limb,
- δh = Fall of heavy liquid level in the reservoir,
- h = Pressure in the pipe, expressed in terms of head of water,
- A = Cross-sectional area of the reservoir,
- a = Cross-sectional area of the tube (right limb),
- S1 = Specific gravity of light liquid in pipe, and
- S2 = Specific gravity of the heavy liquid. We know that fall of heavy liquid in reservoir will cause a rise of heavy liquid level in the right
- limb.

Thus, $$A \times \delta h = a \times h_2 \quad \text{or} \quad \delta h = \frac{a \times h_2}{A}$$

Let us now consider pressure heads above the datum line Z–Z as shown in Fig. 2.18.

Pressure head in the left limb $= h + (h_1 + \delta h)S_1$

Pressure head in the right limb $= (h_2 + \delta h)S_2$

Equating the pressure heads, we get:

$$h + (h_1 + \delta h)S_1 = (h_2 + \delta h)S_2 \quad \text{or} \quad h = (h_2 + \delta h)\, S_2 - (h_1 + \delta h)\, S_1$$

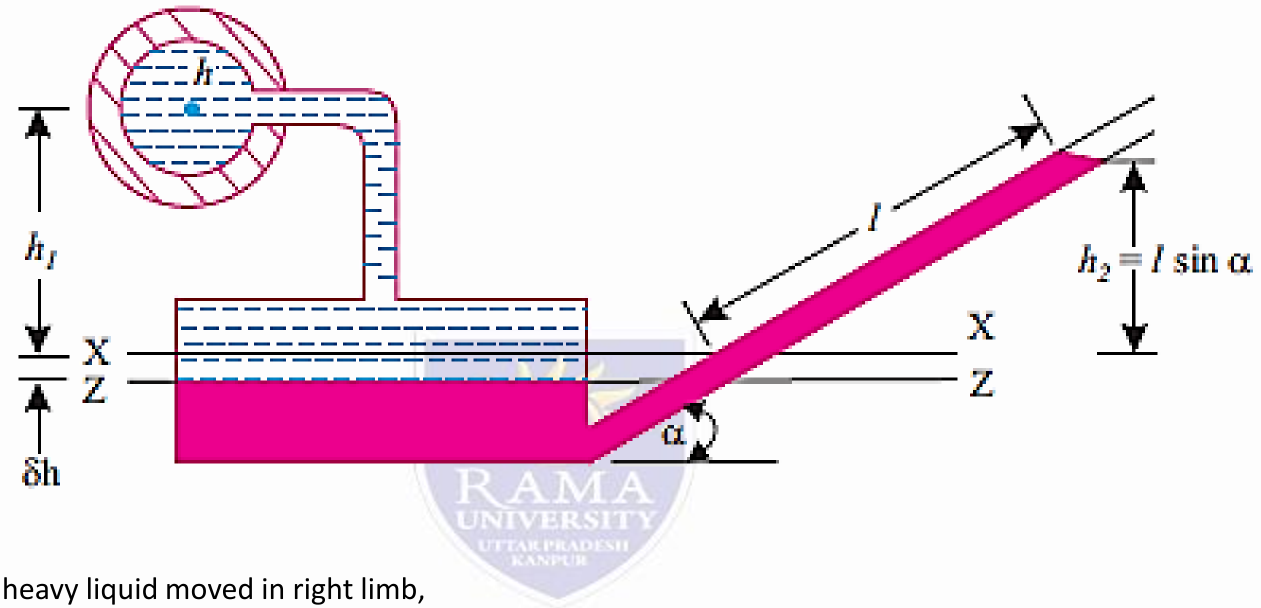
$$= \delta h\, (S_2 - S_1) + h_2 S_2 - h_1 S_1$$

But, $$\delta h = \frac{a \times h_2}{A} \qquad \ldots[$$

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

When the area A is very large as
compared to a, then the ratio a
A
becomes very small, and thus
is neglected. Then the above equation
becomes
h = h2S2 – h1S1 2.9

- (b) Inclined single column manometer:
- This type of manometer is useful for the measurement of small pressures and is more sensitive than the vertical tube type. Due to inclination the distance moved by the heavy liquid in the right limb is more.



- Let, l = Length of the heavy liquid moved in right limb,
- α = Inclination of right limb horizontal, and
- h2 = Vertical rise of liquid in right limb from X–X = $l \sin \alpha$.
- Putting the value of h2 in eqn. 2.9, we get:
- $h = l \sin \alpha \times S2 - h1\ S1$