Fluid Mechanics

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Absolute, vacuum and gage pressure

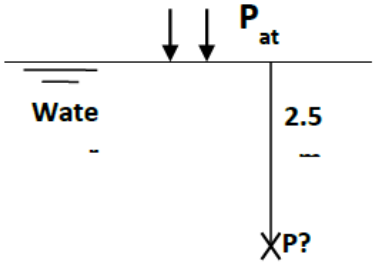
Example 9// **Determine the pressure at a point which is 2.5m below the surface of clear water. Express it as N/m2 both in absolute and gage units. Assume P_{atm}= 101.325 kpa**

Solution:-

$$P = \gamma h$$

$$P_{gage} = \frac{9810}{1000} \times 2.5 = 24.525 kpa \quad .....Ans.$$

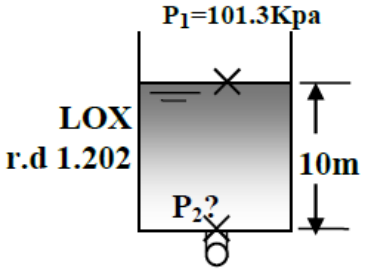
$$P_{abs} = P_{gage} + P_{atm} = 24.525 + 101.325 = 125.85 Kpa\,. \quad ....Ans.$$



Example 10// The liquid Oxygen (LOX) tank of a Saturn moon rocket is partially filled to a depth of (10m) with LOX at 196C° (r.d. 1.202). The absolute pressure in the vapor above the liquid surface is maintained at 101.3kpa. Calculate the pressure at the inlet valve at the bottom of the tank.

Solution:-

$$P_2 = P_1 + \gamma h = 101.3 + 1.202 \times 9.81 \times 10 = 219.2 Kpa$$



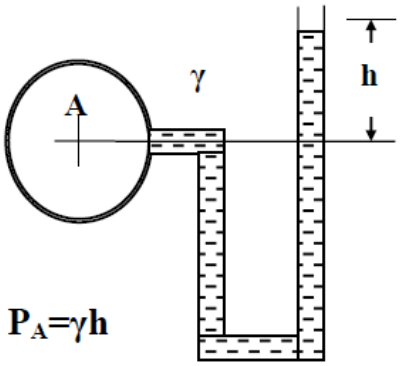
Pressure measuring instruments

A. 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.

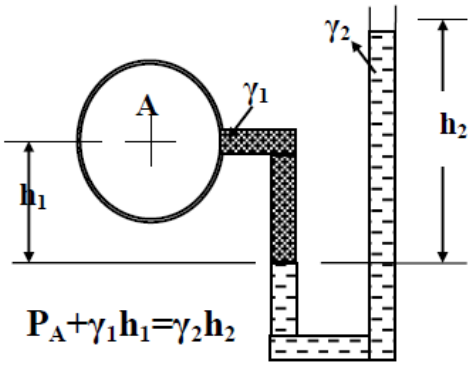
B. Manometers: these are defined as the devices used for measuring the pressure at a point in a fluid by balancing the column of fluid by the same or another column of liquid. These are classified as:

i. 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) U- tube manometer



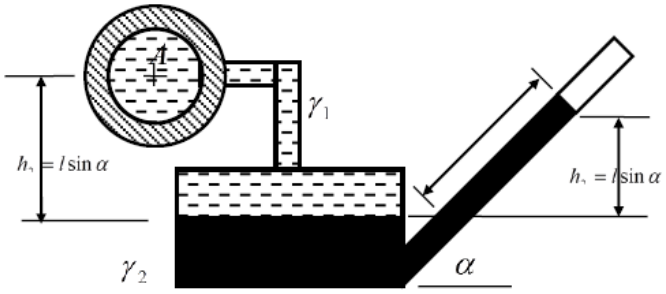
$P_A = \gamma h$



$P_A + \gamma_1 h_1 = \gamma_2 h_2$

2) Inclined manometer

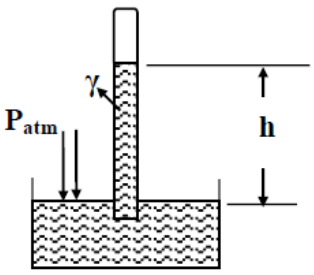
This type of manometer is useful for the measurement of small pressure and is more sensitive than the vertical tube type. Due to inclination the distance moved by the heavy liquid in the right limb is more.



$$P_A + \gamma_1 h_1 = \gamma_2 h_2 = \gamma_2 l \sin\alpha$$

3) Barometer:

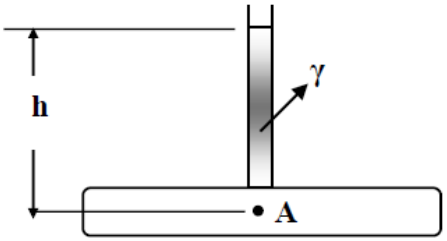
$P_{atm} = \gamma h$



4) Peizometer:

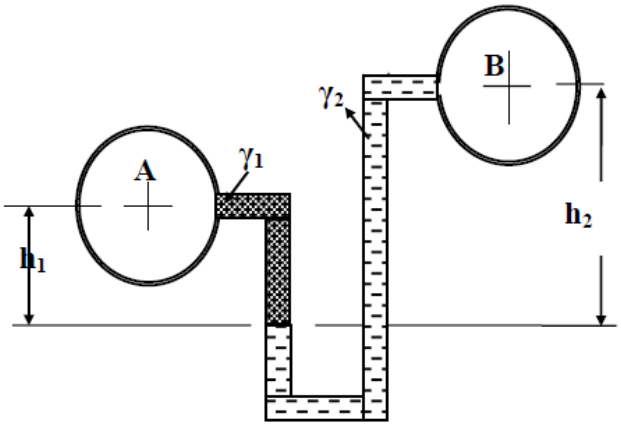
$P_A = \gamma h$

The *Piezometer* is a manometer which is used to measure the pressure in a liquid when it is above zero gage.

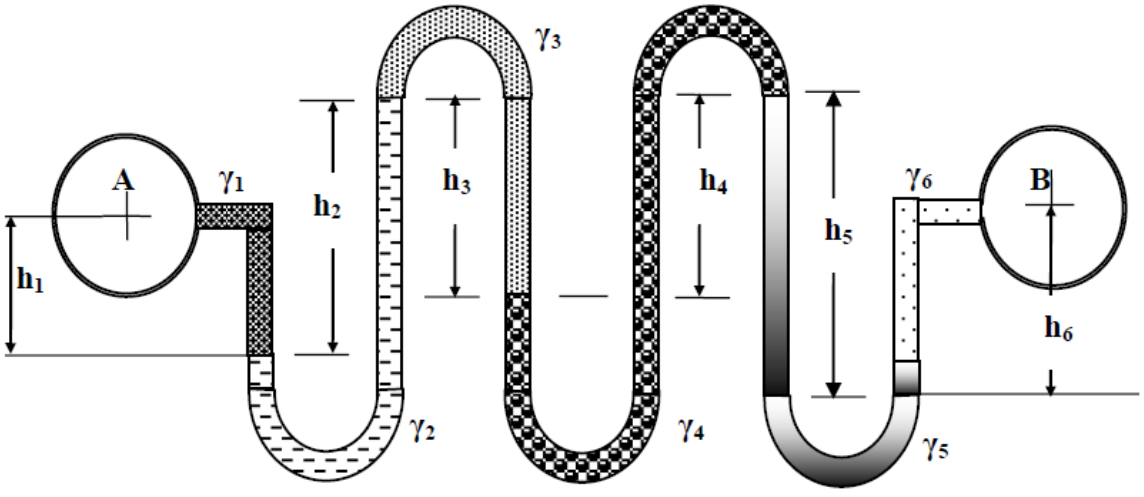


ii. **Differential manometer**

- U-tube differential manometer
- Inverted U-tube differential manometer

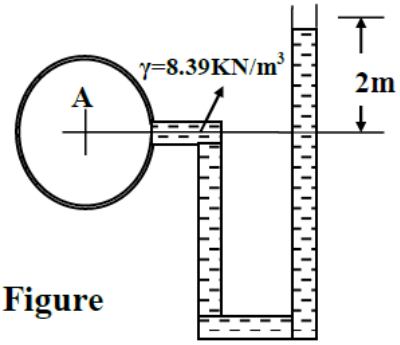


$$P_A + \gamma_1 h_1 = P_B + \gamma_2 h_2$$

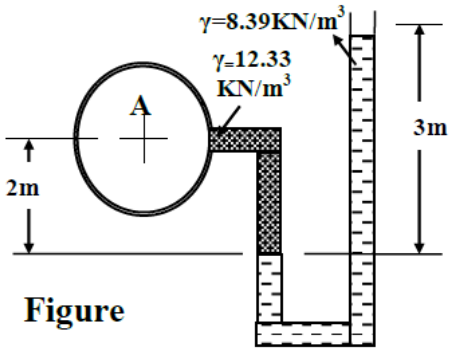


$$P_A + \gamma_1 h_1 - \gamma_2 h_2 + \gamma_3 h_3 - \gamma_4 h_4 + \gamma_5 h_5 - \gamma_6 h_6 = P_B$$

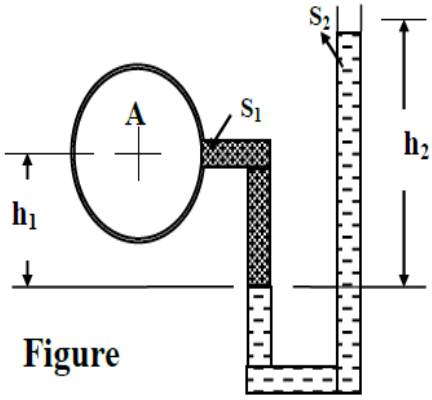
Example 11// **According to Fig.(I), find P_A , 2) According to Fig.(II), find P_A , 3) According to Fig.(III), if S_1=0.86, S_2=1, h_1=8.3cm and h_2=17cm. Find P_A**



Figure



Figure



Figure

Solution:-

1. $P_A = \gamma h = 8.39 \times 2 = 16.78 Kpa$ *Ans.*

2. $P_A + 12.33 \times 2 - 3 \times 8.39 = 0 \Rightarrow P_A = 0.15 Kpa$ *Ans.*

3. $P_A + S_1 \gamma_w h_1 - S_2 \gamma_w h_2 = 0$

$$P_A = 1 \times 9.81 \times \frac{17}{100} - 0.86 \times 9.81 \times \frac{8.3}{100} = 0.96 Kpa \quad Ans.$$

Example 12// **The container of the fig. shown holds water and air. What is the pressure at A, B, C, and D in pascals.**

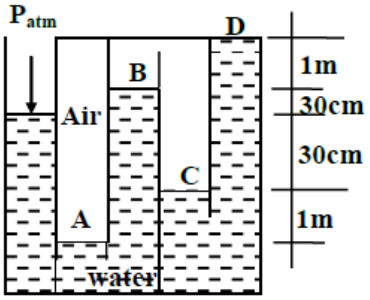
Solution:-

$$P_A = P_{atm} + \gamma h = 9810 \times 1.3 = 12753\, Pa.s$$

$$P_B = 12753 - 9810 \times 1.6 = -2943\ Pa.s$$

$$P_C \approx P_B \ \ Because\ of\ gases\ (Air)\ where\ the\ pressure\ is\ equal.$$

$$P_D = P_C - 1.6 \times 9810 = -2943 - 15696 = -18639\, Pa.s$$



Example 13// **This vertical pipe line with attached gage and manometer contains oil and mercury as shown. The manometer is open to the atmosphere, P_{atm}=760mmHg.There is no flow in the pipe. What will be the gage reading, P_{gage}?**

Solution:-

$$P_{gage} + \gamma_{oil} h_{oil} - \gamma_{mercury} h_{mercury} = P_{atm}$$

$$P_{gage} = \frac{760}{1000} \times 13.57 \times 9.81 + 13.57 \times 9.81 \times \frac{375}{1000} - 9.81 \times 0.90 \times 3$$

$$= 124.60\ Kpa$$