Liquid Pressure

The normal force exerted by liquid at rest on a given surface in contact is called thrust of liquid on that surface.

The normal force (or thrust) exerted by liquid at rest per unit area of the surface in contact with it, is called pressure of liquid or hydrostatic pressure.

If F be the normal force acting on a surface of area A in contact with liquid, then pressure exerted by liquid on this surface is $P = F/A$

Units : N/m^2 or Pascal (S.I.) and Dyne/cm^2 (C.G.S.)

Dimension : $[P] = \frac{[F]}{[A]} = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$

At a point pressure acts in all directions and a definite direction is not associated with it. So pressure is a tensor quantity.

Atmospheric pressure : The gaseous envelope surrounding the earth is called the earth's atmosphere and the pressure exerted by the atmosphere is called atmospheric pressure. Its value on the surface of the earth at sea level is nearly $1.013 \times 10^5 \, N/m^2$ or Pascal in S.I., other practical units of pressure are atmosphere, bar and torr (*mm* of *Hg*)

$1 atm = 1.01 \times 10^5 \, Pa = 1.01 \text{bar} = 760 \text{ torr}$

The atmospheric pressure is maximum at the surface of earth and goes on decreasing as we move up into the earth's atmosphere.

If P_0 is the atmospheric pressure then for a point at depth h below the surface of a liquid of density ρ, hydrostatic pressure P is given by $P = P_0 + h\rho g$

Guage pressure: Consider a point 'A' at a depth 'h' below the surface of a liquid open to the atmosphere. The total pressure at the point A is greater than the atmospheric pressure by an amount . where $'\rho'$ is the density of liquid.

The total pressure

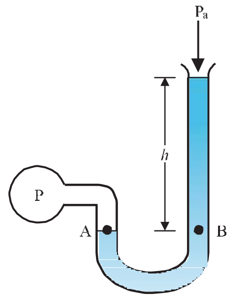
$$P = P_a + \rho g h$$

$$P - P_a = \rho g h$$ is

The excess of pressure, P-Pa., at depth h is called a guage pressure at that point.

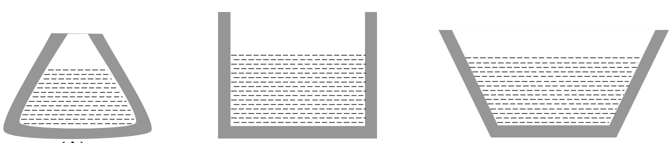
Measurement of pressure difference using manometer:

An open-tube manometer is used for measuring pressure differences. It consists of a U tube containing a suitable liquid i.e. a low density liquid (such as oil) for measuring small pressure differences or a high density liquid (such as mercury) for measuring large pressure differences.



One end of the manometer tube is open to the atmosphere and the other end is connected to the system whose pressure is to be measured. The pressure P at A is equal to pressure at B. The measurement from the manometer is guage pressure which is the pressure difference between two points A and B. which is P-Pa . This pressure difference is proportional to manometer height h.

Hydrostatic pressure depends on the depth of the point below the surface (h), nature of liquid (ρ) and acceleration due to gravity (g) while it is independent of the amount of liquid, shape of the container or cross-sectional area considered. So if a given liquid is filled in vessels of different shapes to same height, the pressure at the base in each vessel's will be the same, though the volume or weight of the liquid in different vessels will be different.



(A) (B) (C)

$P_A = P_B = P_C$ but $W_A < W_B < W_C$

In a liquid at same level, the pressure will be same at all points, if not, due to pressure difference the liquid cannot be at rest. This is why the height of liquid is the same in vessels of

different vessels of different shapes containing different amounts of the same liquid at rest when they are in communication with each other.

Density

In a fluid, at a point, density ρ is defined as: $\rho = \lim_{\Delta V \to 0} \frac{\Delta m}{\Delta V} = \frac{dm}{dV}$

In case of homogenous isotropic substance, it has no directional properties, so is a scalar.

It has dimensions $[ML^{-3}]$ and S.I. unit kg/m^3 while C.G.S. unit g/cc with $1 g/cc = 10^3 kg/m^3$

When immiscible liquids of different densities are poured in a container, the liquid of highest density will be at the bottom while that of lowest density at the top and interfaces will be plane.

Relative density or specific gravity which is defined as :

$$RD = \frac{\text{Density of body}}{\text{Density of water}}$$