Physics Notes Class 11 CHAPTER MECHANICAL PROPERTIES OF FLUIDS

Fluids

Fluids are those substances which can flow when an external force is applied on it.

Liquids and gases are fluids.

Fluids do not have finite shape but takes the shape of the containing vessel,

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

The SI unit of thrust is newton.

In fluid mechanics the following properties of fluid would be considered

(i) When the fluid is at rest **- hydrostatics**

(ii) When the fluid is in motion **- hydrodynamics**

Pressure Exerted by the Liquid

The normal force exerted by a liquid per unit area of the surface in contact is called **pressure of liquid** or**hydrostatic pressure**.

Pressure exerted by a liquid column

$p = h\rho g$

Where, h = height of liquid column, ρ = density of liquid

and g = acceleration due to gravity

Mean pressure on the walls of a vessel containing liquid upto height h is ($h\rho g$ / 2).

Pascal's Law

The increase in pressure at a point in the enclosed liquid in equilibrium is transmitted equally in all directions in liquid and to the Walls of the container.

The working of hydraulic lift, hydraulic press and hydraulic brakes are based on Pascal's law.

Atmospheric Pressure

The pressure exerted by the atmosphere on earth is **atmospheric pressure**.

It is about 100000 N/m^2.

It is equivalent to a weight of 10 tones on 1 m^2.

At sea level, atmospheric pressure is equal to 76 cm of mercury column. Then, atmospheric pressure

= hdg = 76 x 13.6 x 980 $dyne/cm^2$

[The atmospheric pressure does not crush our body because the pressure of the blood flowing through our circulatory system] balanced this pressure.]

Atmospheric pressure is also measured in torr and bar.

1 torr = 1 mm of mercury column

1 bar = $l0^5$ Pa

Aneroid barometer is used to measure atmospheric pressure.

Buoyancy

When a body is partially or fully immersed in a fluid an upward force acts on it, which is called buoyant force or simply buoyancy.

The buoyant force acts at the centre of gravity of the liquid displaced] by the immersed part of the body and this point is called the centre buoyancy.

Archimedes' Principle

When a body is partially or fully immersed in a liquid, it loses some of its weight. and it is equal to the weight of the liquid displaced by the immersed part of the body.

If T is the observed weight of a body of density σ when it is fully immersed in a liquid of density p, then real weight of the body

$w = T / (1 – p / \sigma)$

Laws of Floatation

A body will float in a liquid, if the weight of the body is equal to the weight of the liquid displaced by the immersed part of the body.

If W is the weight of the body and w is the buoyant force, then

(a) If W > w, then body will sink to the bottom of the liquid.

(b) IfW < w, then body will float partially submerged in the liquid.
(c) If W = w, then body will float in liquid if its whole volume is just immersed in the liquid,

The floating body will be in stable equilibrium if meta-centre (centre of buoyancy) lies vertically above the centre of gravity of the body.

The floating body will be in unstable equilibrium if meta-centre (centre of buoyancy) lies vertically below the centre of gravity of the body.

The floating body will be in neutral equilibrium if meta-centre (centre of buoyancy) coincides with the centre of gravity of the body.

Density and Relative Density

Density of a substance is defined as the ratio of its mass to its volume.

Density of a liquid = Mass / Volume

Density of water = 1 g/cm^3 or $l0^3$ kg/m^3

It is scalar quantity and its dimensional formula is $[ML^{-3}]$.

Relative density of a substance is defined as the ratio of its density to the density of water at 4°C,

Relative density = Density of substance / Density of water at 4°C

= Weight of substance in air / Loss of weight in water

Relative density also known as specific gravity has no unit, no dimensions.

For a solid body, density of body = density of substance

While for a hollow body, density of body is lesser than that of Substance.

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.

Density of a Mixture of Substances

When two liquids of mass m_1 and m_2 having density p_1 and p_2 are mixed together then density of mixture is

$p = m_1 + m_2 / (m_1 / p_1) + (m_2 + p_2)$

$= p_1 p_2 (m_1 + m_2) / (m_1 p_2 + m_2 p_1)$

When two liquids of same mass m but of different densities p_1 and p_2 are mixed together then density of mixture is

$p = 2p_1 p_2 / p_1 + p_2$

When two liquids of same volume V but of different densities p_1 and p_2 are mixed together then density of mixture is

$p = p_1 + p_2 / 2$

Density of a liquid varies with pressure

$p = p_o [1 + \Delta p / K]$

where, p_o = initial density of the liquid, K = bulk modulus of elasticity of the liquid and Δp = change in pressure