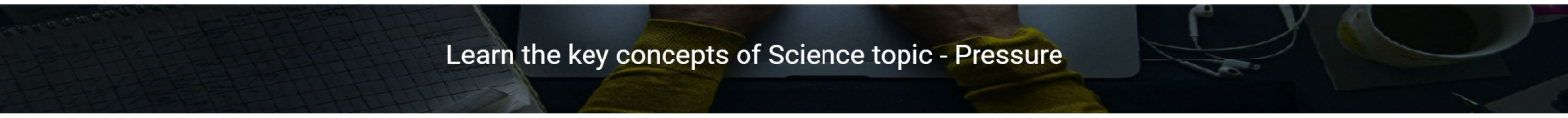

Hi dear learners, in our today's blog we will be learning about Stress, Strain, Hooke's Law, Pressure, Viscosity. So, let's start now.

Stress

The internal restoring force acting per unit area of a deformed body is called stress.

- Stress = Restoring force / Area
- Its unit is N/m^2 or Pascal and the dimensional formula is $[ML^{-1}T^{-2}]$.
- Stress is a tensor quantity. (Tensor is a mathematical quantity which is neither scalar nor vector.)

Stress is of Two Types:

1. **Normal Stress:** If deforming force is applied normal to the area, then the stress is called normal stress. If there is an increase in length due to stress, then stress is called tensile stress. If there is a decrease in length due to stress, then stress is called compression stress.
2. **Tangential Stress:** If deforming force is applied tangentially, then the stress is called tangential stress.

Strain

The fractional change in configuration is called strain.

- Strain = Change in the configuration / Original configuration
- It has no unit and it is a dimensionless quantity.

According to the change in configuration, the strain is of three types:

1. Longitudinal strain = Change in length / Original length
2. Volumetric strain = Change in volume / Original volume
3. Shearing strain = Angular displacement of the plane perpendicular to the fixed surface

Hooke's Law

Within the limit of elasticity, the stress is proportional to the strain. Stress $\propto$ Strain or, Stress = E × Strain where, E is the modulus of elasticity of the material of the body.

Pressure

The thrust experienced per unit area of the surface of a liquid at rest is called pressure.

- P = F/A
- Its SI unit is N/m^2
- When a liquid is in equilibrium, the force acting on its surface is perpendicular everywhere. The pressure is the same at the same horizontal level.
- The pressure at any point in the liquid depends on the depth (h) below the surface, density of the liquid and acceleration due to gravity.

Pascal's Law

According to Pascal's Law, the pressure applied to an enclosed liquid is transmitted undiminished to every portion of the liquid and the walls of the containing vessel.

- Hydraulic system works on Pascal's law. Force exerted to area ratio will be the same at all cross sections. **Note:** A large force is experienced in a larger cross-section if a smaller force is applied in a smaller relation section.
- A column of height h of a liquid of density p exerts a pressure P given.
- Absolute pressure (P) = Gauge pressure (P_g) + Atmospheric pressure (P_a)$\Rightarrow$**$P_g = P - P_a$**

Archimedes principle

When a body is partially or completely immersed in a liquid, it loses some of its weight. The loss in weight of the body in the liquid is equal to the weight of the liquid displaced by the immersed part of the body. The upward force exerted by the liquid displaced when a body is immersed is called buoyancy. Due to this, there is apparent loss in the weight experienced by the body.

Law of Floatation:

"A body floats in a liquid if the weight of the liquid displaced by the immersed portion of the body is equal to the weight of the body."

Equation of continuity

According to the equation of continuity, if there is no fluid source or sink along the length of a pipe, then mass of the fluid crossing any section of the pipe per unit time remains constant. i.e. $\mathbf{a_1 v_1 p_1 = a_2 v_2 p_2}$

For incompressible liquids (i.e. fluids) $p_1 = p_2$ and hence the equation is given as: $\mathbf{a_1 v_1 = a_2 v_2}$

It means that the speed of flow of liquid is more where the pipe is narrower, and speed of flow is less where the cross-section of the pipe is more.

Bernoulli's equation

For an incompressible, non-viscous, irrotational liquid having streamlined flow, the sum of the pressure energy, kinetic energy and potential energy per unit mass is constant.

$$\frac{P}{\rho}+\frac{v^2}{2}+gh = \text{Constant or } \frac{p}{\rho g}+\frac{v^2}{2g}+h = \text{Constant}$$

For steady flow of a non-viscous fluid along a horizontal pipe, Bernoulli's equation is simplified as .....

$$P_1+\frac{1}{2}pv_1^2 = P_2+\frac{1}{2}pv_2^2$$

Viscosity

Viscosity is the property of the fluid (liquid or gas) by virtue of which an internal frictional force comes into play when the fluid is in motion in the form of layers having relative motion. It opposes the relative motion of the different layers. Viscosity is also called fluid friction. The viscous force directly depends on the area of the layer and the velocity gradient.

Coefficient of viscosity

Coefficient of viscosity of a liquid is equal to the tangential force required to maintain a unit velocity gradient between two parallel layers of liquid each of area unity.

η= F/A (dv/dx)

- The SI unit of coefficient of viscosity is poiseuille (Pl) or Pa-s or Nm^{-2} s or kg m^{-1} s^{-1} .
- Dimensional formula of q is $[ML^{-1}T^{-1}]$.

Stokes' law

According to Stokes' law the backward dragging force acting on a small spherical body of radius r moving with a velocity v through a viscous medius of coefficient of viscosity u is given by, **F = 6παηv.**

Terminal velocity

It is the maximum constant velocity acquired by the body while falling freely in a viscous medium. This is attained when the apparent weight is compensated by the viscous force. It is given by:

$$V_t = \sqrt{\frac{2mg}{\rho AC_d}}$$

where p be the density of the material of the body of radius r and o be the density of the medium.

Critical velocity

The critical velocity is that velocity of liquid flow, upto which its flow is streamline and above which its flow becomes turbulent. It is given by: $V_c = k\eta/ dr$ where k is a dimensionless constant, η is coefficient of viscosity of liquid, d is density of liquid and r is the radius of tube.

Surface tension

It is the property of the liquid by virtue of which the free surface of liquid at rest tends to have minimum area and as such it behaves as a stretched elastic membrane. The force acting per unit length of line drawn on the liquid surface and normal to it parallel to the surface is called the force of surface tension.

S = Force/Length = F/L = (Work done)/(Change in area)

- The SI unit of surface tension is Nm^{-1}.
- Its dimensional formula is $[MT^{-2}]$.

Torricelli's Theorem: According to this theorem, velocity of efflux i.e. the velocity with which the liquid flows out of on orifice (a narrow hole) is equal to that which a freely falling body would acquire in falling through a vertical distance equal to the depth of orifice below the free surface of liquid. The velocity is given by: $V = \sqrt{2gh}$

Magnus Effect: When a ball is given a spin when it is in a streamline of air molecules, it will follow a curved path which is convex towards the greater pressure side. This idea is the basis of the ball from spin bowlers in cricket getting a lift and aerodynamics.

After reading about the general properties of matter, we discussed mechanical properties of solids starting with defining some basic concepts and definitions about them. Then we discussed the concepts of stress, strain and the types of moduli of elasticity. Stay tuned for more.