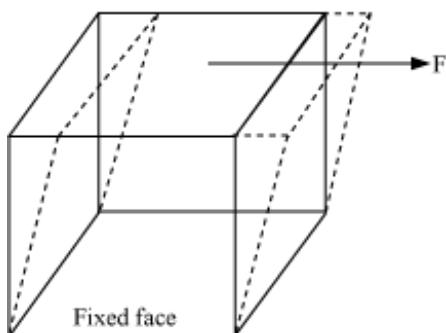


## Mechanical Properties Of Solids

- **Elasticity:** It is the property of a body by virtue of which it tends to regain its original size and shape after the applied force is removed.
- **Plasticity:** It is the inability of a body in regaining its original status on the removal of the deforming forces.
- **Elastic deformation:** After withdrawal of force, the material regains its original shape and size.
  - **Plastic deformation:** After withdrawal of force, the material does not regain its original size and shape.
  - **Stress:** Restoring force per unit area

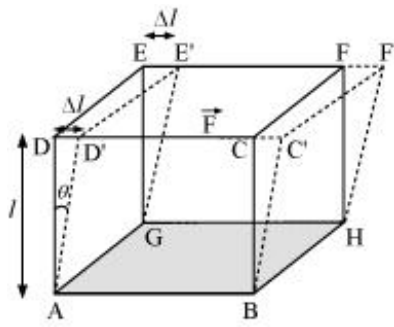
### Types of Stress

- **Normal Stress:** When the elastic restoring force or deforming force acts perpendicular to the area, the stress is called normal stress. Normal stress can be sub-divided into the following categories:
  - **Tensile Stress:** When there is an increase in the length or the extension of the body in the direction of the force applied, the stress set up is called tensile stress.
  - **Compressive Stress:** When there is a decrease in the length or the compression of the body due to the force applied, the stress set up is called compressive stress.
- **Tangential or Shearing Stress:** When the elastic restoring force or deforming force acts parallel to the surface area, the stress is called tangential stress.



- **Strain :** Deformation amount/original dimension  $\left( \frac{\Delta L}{L}, \frac{\Delta V}{V} \right)$

Shear strain =  $\frac{\Delta l}{l}$



Within elastic limits,  $\theta$  is small.

Therefore, Shear strain =  $\tan \theta \approx \theta$

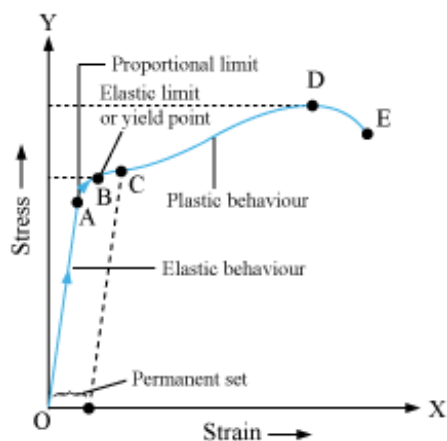
- **Hooke's law:** Stress is proportional to Strain

$$\text{Stress} = k \times \text{Strain}$$

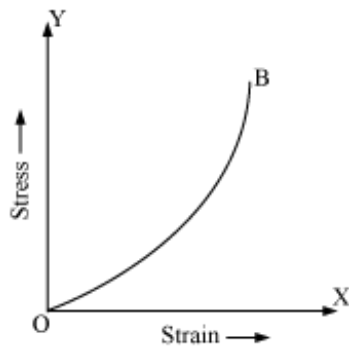
[Where,  $k$  = Modulus of elasticity]

## Stress-strain graph

- For a wire



- When the material does not regain its original dimension, it is said to have a permanent set, and the deformation is said to be plastic deformation.
- Stress-strain curve for elastomers:



- They do not obey Hooke's law, and always return to their original shape.

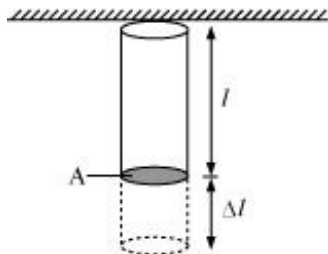
- **Young's modulus of elasticity ( $Y$ )**

$$Y = \frac{\text{Longitudinal stress}}{\text{Longitudinal strain}}$$

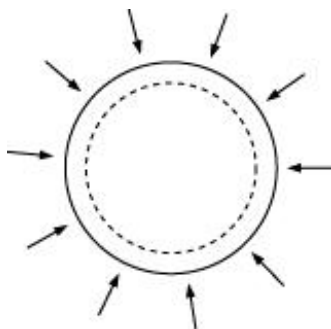
$$Y = \frac{\frac{F}{A}}{\frac{\Delta l}{l}} = \frac{Fl}{A\Delta l}$$

The Young's modulus of an experimental wire is given by

$$\therefore Y = \frac{MgL}{\pi r^2 l}$$



- **Bulk modulus of elasticity ( $B$ )**



$$B = \frac{\text{Normal stress}}{\text{Volumetric strain}} = \frac{\Delta P}{-\frac{\Delta V}{V}} = -V \frac{\Delta P}{\Delta V}$$

- **Compressibility:** It is the reciprocal of bulk modulus.

- **Modulus of rigidity ( $\eta$ )**

$$\eta = \frac{\text{Tangential stress}}{\text{Shear strain}} = \frac{\frac{F}{A}}{\frac{\Delta l}{l}} \Rightarrow \eta = \frac{F}{A\theta} \text{ or } \eta = \frac{F}{A\theta}$$

- Poisson's ratio( $\sigma$ ) = lateral strain/longitudinal strain
- Poisson's ratio( $\sigma$ ) is a unitless and dimensionless quantity.
- A metallic rod expands on heating and the thermal strain developed in the rod is given by  $\frac{L-L_0}{L_0} = \alpha \Delta t$ .
- When a rod, fixed at both the ends by supports, is heated, it exerts a force on both the supports. The force exerted on the supports is given by  $F = Y\alpha\Delta t \times A$ .

### Application of Elasticity

- The metallic parts in machinery are never subjected to stress beyond their elastic limits; else, they may get permanently deformed.
- The thickness of the metallic rope used in cranes depends on the elastic limit of the material of the rope and the factor of safety.
- Bridges are designed in such a way that they do not bend much or break under the load of heavy traffic, force of strong wind or their own weights.

### Poisson's ratio

$$\sigma = \frac{\text{Lateral strain}}{\text{Longitudinal strain}} = \frac{\frac{\Delta d}{d}}{\frac{\Delta l}{l}}$$

### Elastic energy is given by:

Elastic energy stored in the wire on elongating it by a length  $l = \frac{1}{2} \times \text{load} \times \text{extension}$