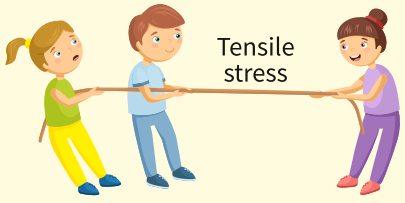
8. MECHANICAL PROPERTIES OF SOLIDS

STRESS & ITS TYPES

(1) Stress is restoring force per unit area
(2) Stress = $\frac{F}{A}$
(3) It is neither scalar nor vector
(4) It's unit is N/m^2.

Normal Stress

(1) **Tensile stress** is produced when axial force acts per unit Area.
This stress results in Elongation.
(2) **Compressive stress** is produced when force compresses object per unit area.
This stress results in Compression.



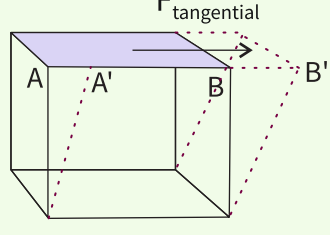
Volumetric Stress

When object is immersed inside the liquid, the hydrostatic pressure decreases the volume of an object, that results volumetric stress.
Volumetric stress = $\frac{F_{ext}}{A}$

Shear Stress

(1) Shear stress is produced when force acts tangentially to a surface area.
(2) Deforming force acts tangentially to the surface.

$\tau = \frac{F_{tangential}}{A}$

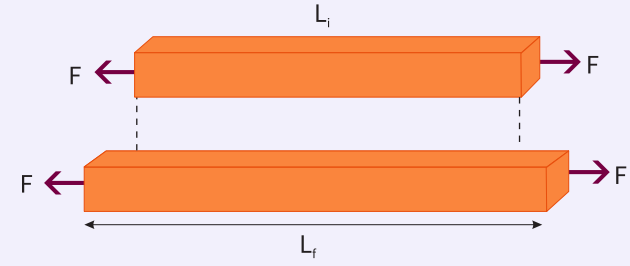


STRAIN & ITS TYPES

Ratio of change in configuration to original configuration of body.
It is a unitless quantity.
Strain = $\frac{\text{change in configuration}}{\text{original configuration}}$

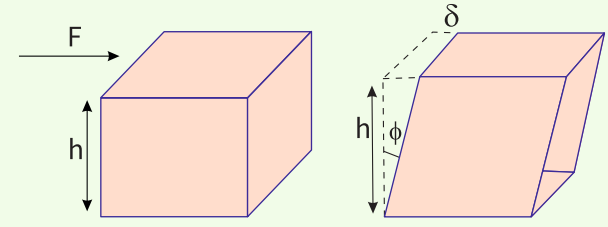
Linear Strain

(1) Linear strain is the ratio of change in length to original length.
(2) $\varepsilon_a = \frac{L_f - L_i}{L_i} = \frac{\Delta L}{L_i}$



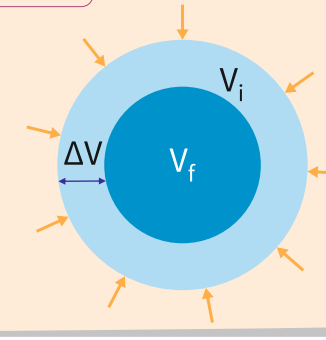
Shear Strain

(1) Angular deformation caused by shearing force is shearing strain.
(2) $\tan\varphi = \frac{\delta}{h}$
(3) For small change, $\varphi = \frac{\delta}{h}$



Volumetric Strain

(1) Ratio of change in volume to original volume,
(2) $\varepsilon_V = \frac{V_f - V_i}{V_i} = \frac{\Delta V}{V_i}$



Types of Elastic Constants

Young's Modulus

Property of material, that tells how easily it can be stretched.

$$Y = \frac{\text{longitudinal stress}}{\text{longitudinal strain}} = \frac{FL}{A\Delta L}$$

Shear Modulus

- Ratio of shear stress by shear strain.
- Unit is Pascal (Pa).

$$G = \frac{F}{A\phi}$$

Bulk Modulus

- Measure of ability of material to withstands the change in volume.
- Negative sign indicates decrease in volume.

$$B = \frac{-\Delta P}{\Delta V/V}$$

Isothermal Bulk Modulus

$B = P$

Adiabatic Bulk Modulus

$B = \gamma P$, γ = Adiabatic constant

Compressibility

- Reciprocal of Bulk modulus.
- Value depends on nature, density and chemical composition of the material.

HOOKE'S LAW

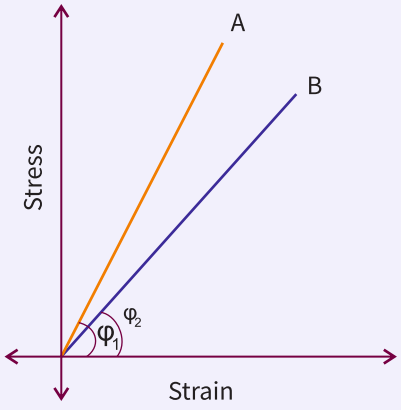
Within elastic limit, stress is directly proportional to the strain for many materials. This is known as Hooke's law.

Stress $\propto$ Strain $\Rightarrow \frac{\text{Stress}}{\text{Strain}}$ = Constant (E)

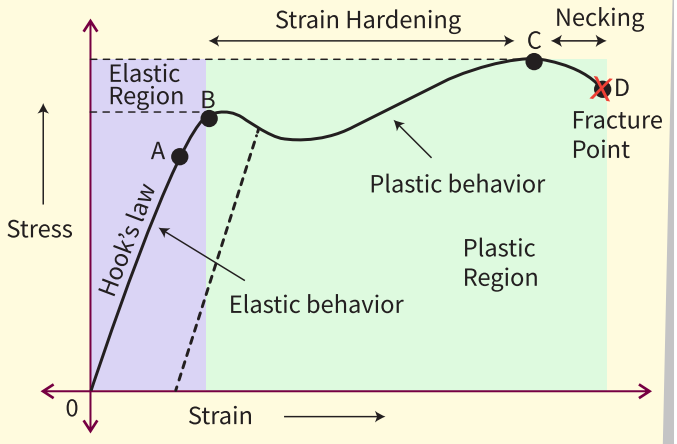
E = Modulus of Elasticity

Stress-Strain Graph

The slope gives **modulus of elasticity** of the material.



Stress-Strain Curve



Concept of Strain Energy

(i) energy stored due to elastic deformation.

(ii) Strain Energy density is energy per unit volume.

(iii) strain Energy per unit Volume = $U = \frac{1}{2} \times \text{stress} \times \text{strain}$

(iv) strain Energy per unit Volume = $U = \frac{1}{2} \times \frac{(\text{Stress})^2}{Y}$