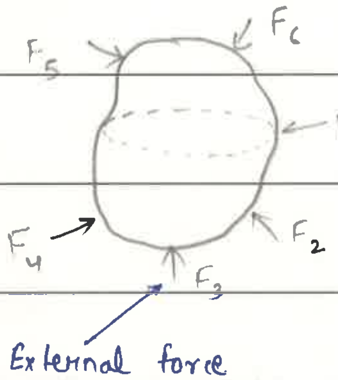
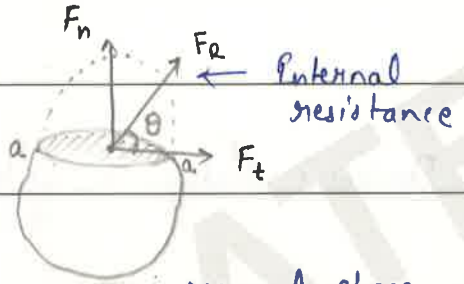
Stress : Stress is defined as the internal resistance of a body subjected to external loads, per unit area.



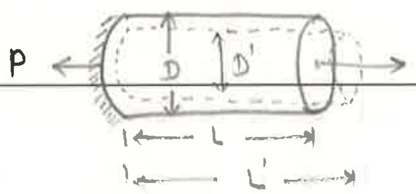


$$\text{Normal stress} = \frac{F_R \sin\theta}{\text{Area of plane aa}}$$

$$\text{Shear stress} = \frac{F_R \cos\theta}{\text{Area of plane aa}}$$

Normal stress pointing away from the plane is tensile stress and normal stress pointing towards the plane is compressive stress.

Strain : Any body subjected to loading, will result in change of dimensions. Let us consider a cylinder subjected to axial tensile force. There will be increase in length and decrease in diameter.



Change in length $= L' - L = \delta L\,(+ve)$

Change in diameter $= D - D' = \delta D\,(-ve)$

Axial strain in bar, $\varepsilon_a = \frac{\delta L}{L}$ (+ve) (also called longitudinal strain)

Lateral strain in bar, $\varepsilon_L = \frac{\delta D}{D}$ (−ve)

Poisson's ratio $= \frac{\text{Lateral strain}}{\text{Axial strain}}$

Poisson's effect : Axial loading causing strain in axial as well as in lateral direction. Getting strain in lateral direction because of axial load or vice-versa is called poisson's effect.

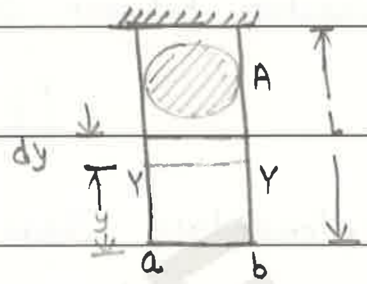
Note : If length is increasing, diameter is decreasing or vice-versa. It doesn't mean volume of body remains constant.

Material	Mild steel	Brass/Bronze	Al	Cast iron	Glass
ν	0.3	0.35	0.33	0.22	0.20

Range of ν — $-1 < \nu < 0.5$ For isotropic materials

$0 < \nu < 0.5$ For engineering material

Extension under self weight of bar :



Normal stress on section YY,

$$\sigma_y = \frac{Ay\omega}{A} = y\omega$$

$$\epsilon_y = \frac{\omega y}{E} \quad (\omega \rightarrow \text{weight density of bar})$$

Change over length dy , $\delta dy = \frac{\omega y dy}{E}$

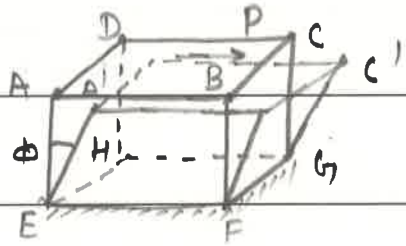
Total change in length $\delta L = \frac{\omega}{E}\int_0^L y\,dy = \frac{\omega L^2}{2E}$

$$\boxed{\delta L = \frac{\omega L^2 A}{2AE} = \frac{WL}{2AE}}$$

where $W = \omega L A$
total weight of bar

Shear stress and shear strain :

Stress and strain produced by a force tangential to the surface of a body are known as shear stress and shear strain respectively.



Shear stress , $\tau = \frac{P}{\text{Area}(ABCD)}$

Shear strain, $\phi = \frac{\text{Displacement } AA'}{AE} = \tan\phi$ [If ϕ is very small $\tan\phi = \sin\phi \simeq \phi$]

Relationship between shear stress and shear strain is given by :

$$\tau = G\phi$$ where G is shear modulus

Complementary Shear stress :

Whenever a shear stress τ is applied on a plane of body an equal and opposite shear stress τ' acts on another plane perpendicular to the plane of τ, so as to maintain equilibrium of the body.

Complementary shear stress τ' always act at an angle of 90° to the applied shear stress.

Volumetric stress and volumetric strain :

A body subjected to a stress of equal magnitude in all the directions, is said to be subjected to volumetric stress or hydrostatic stress.

$$P = K \cdot \varepsilon_v$$

P → volumetric stress

ε_v → volumetric strain because of change in volume $\left(\frac{\delta V}{V}\right)$

K → Bulk modulus or modulus of compressibility