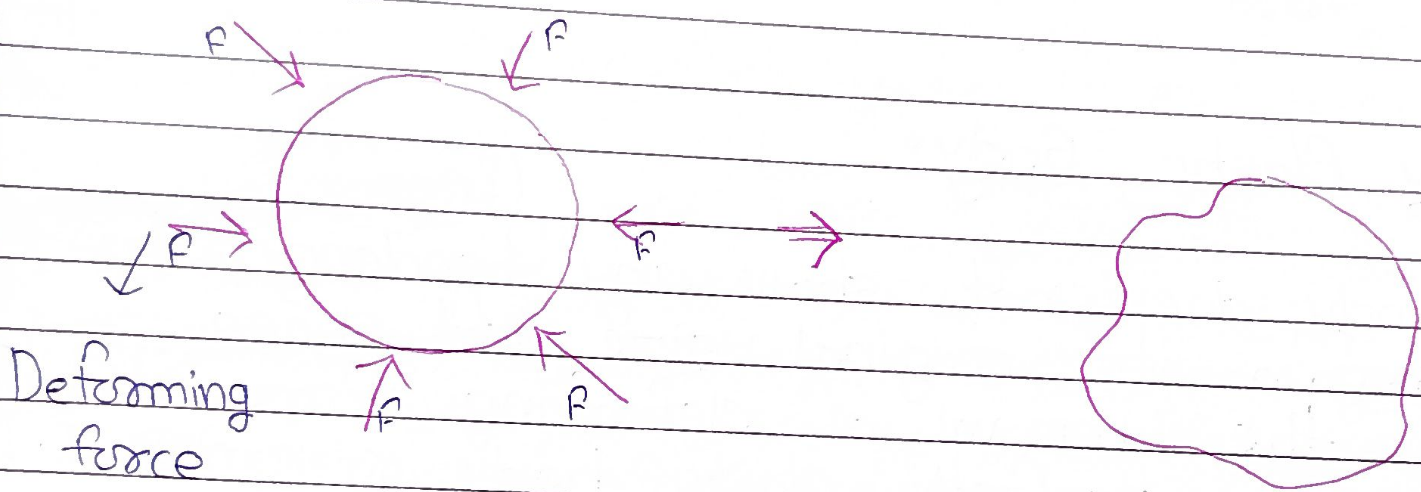
✡ Mechanical Properties of solid

○ Deforming force :

A force which changes the size or shape of a body is called a deforming force



○ Elasticity :

If a body regain its original size and shape after the removal of deforming force, it is said to be elastic body and this property is called elasticity

E.g = Rabber, steel wire, etc

○ Perfectly Elastic :

If a body regain its original size and shape completely and immediatly after the removal of deforming force, it is said to be a perfectly elastic body

E.g Quartz fibre.

Plasticity :

If a body does not regain its original size and shape after the removal of deforming force, it is said to be a plastic body this property is called plasticity.

Eg: Chewingum

Perfectly Plastic Body:

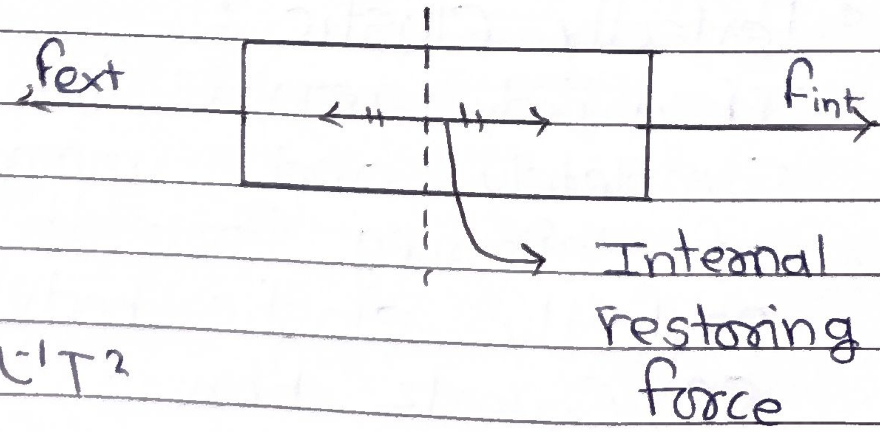
If a body does not show any tendency to ~~regic~~ regain its original size and shape after the removal of deforming force, it is said to be perfectly plastic body.

Eg: wall putty, wax, etc,

Stress :

The internal restoring force per unit area of cross section of the deforming body is ~~said to be p~~ called Stress.

$$\text{Stress} = \frac{f}{A} \ N/m^2$$

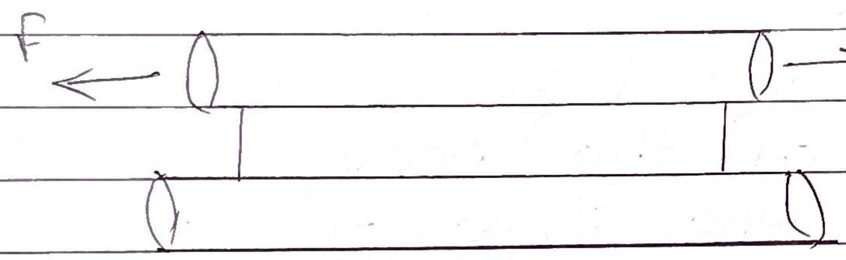


D. formula = $\frac{MLT^2}{L^2} = ML^{-1}T^2$

Types of Stress :

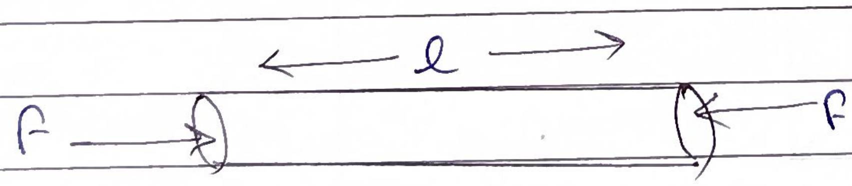
1. Tensile Stress :

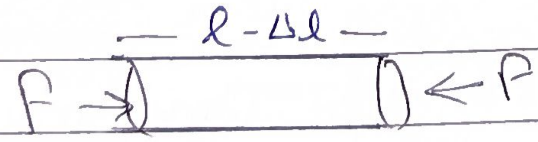
It is the restoring force setup per unit cross section of a body when the length of the body increases in the direction of the deforming force is also known, as Tensile.



2. Compressionel Stress :

It is the restoring force setup per unit cross-sectional area of a body when its length decreases under a deforming force



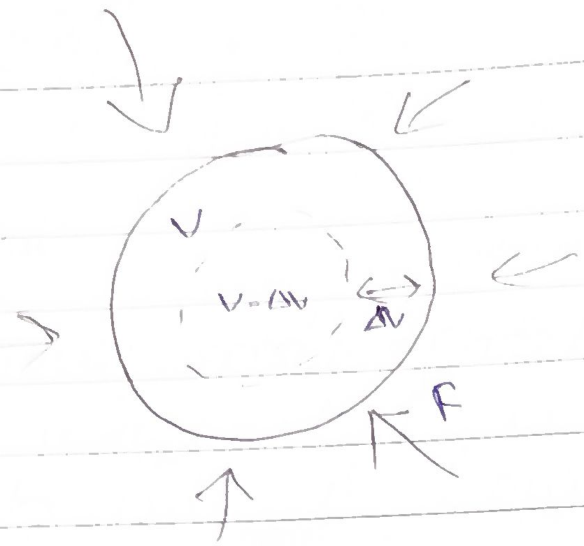


Compressional Stress $= \frac{F}{A}$

3. Hydrostatic Stress :

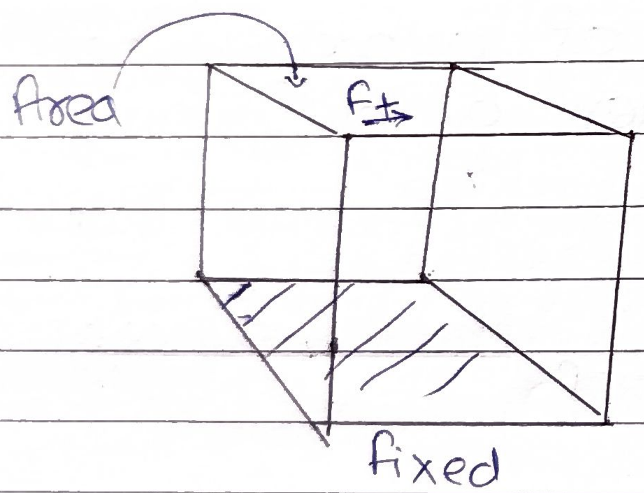
If a body is subjected to a uniform force from all side; then the corresponding stress is called hydrostatic stress.

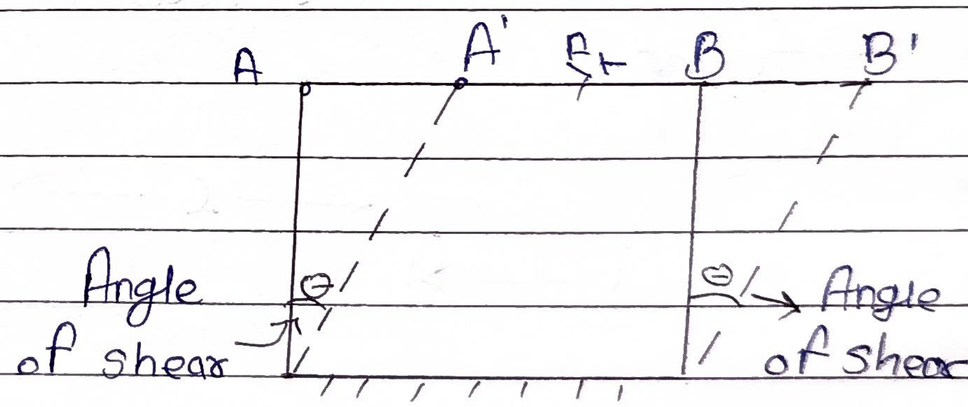
$$\text{Hydrostatic stress} = \frac{F}{A}$$



4. Tangential or shearing stress

When a deforming force act tangential to the surface of the body, it produces a change in the shape of the body. The Tangential force applied per unit area is equal to the tangential stress.





$$\text{Tangential stress} = \frac{F_t}{A}$$

Strain :

The ratio of the change in any dimension produced in the body to the original dimension is called strain.

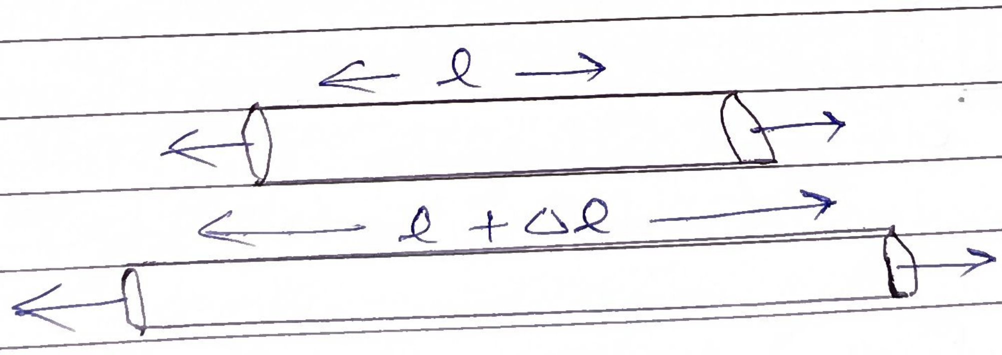
$$\text{Strain} = \frac{\text{change in dimension}}{\text{original dimension}}$$

It has no dimension or ~~on~~ no unit.

types of strain :

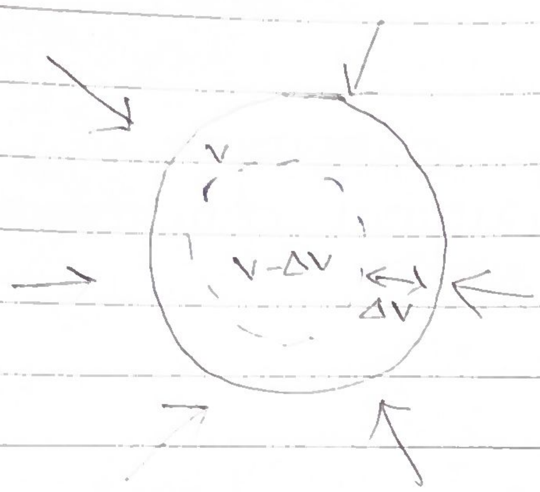
1) Longitudinal Strain :

It is defined as the increases in length per unit original length when the body is deformed by an external force



| longitudinal strain = $\Delta l / l$ |

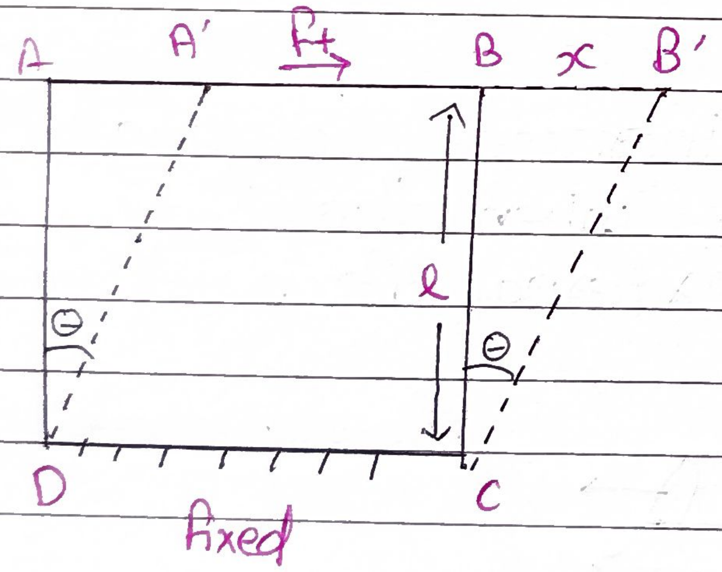
2. Volumetric strain ;
It is defined as the change in volume per unit original volume when the body is deformed by external force.



Volumetric Strain = $\Delta V / V$

3. Shear Strain (θ):

It is defined as the angle θ (in radian) through which a face originally perpendicular to the fixed face got turned on applying tangential deforming force.



Shear strain $\approx \theta \approx \tan\theta$

$= \frac{x}{l}$

Elastic Limit:

The maximum stress within which the body regain its original size and shape after the removal of deforming force is called elastic limit.

Hooke's Law :

Within the elastic limit the stress is directly proportional to strain.

$$(\text{Stress}) \propto (\text{Strain})$$

$$\frac{\text{Stress}}{\text{Strain}} = \text{constant (elastic constant)}$$

The constant of proportionality is called modulus of elasticity or coefficient of elasticity of the material. Its value depend on the nature of the material of the body and the manner in which it is deformed.

Modulus of Elasticity :

The modulus of elasticity or coefficient of elasiticity of a body is defined as the ratio of stress to the strain within elastic limit.

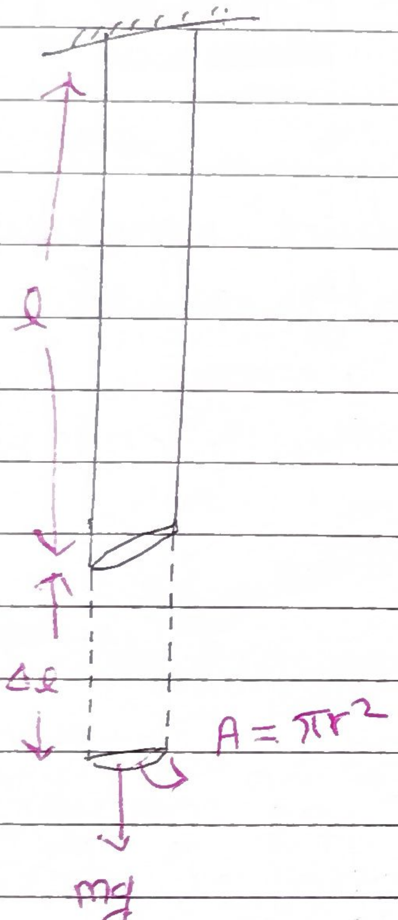
$$(\text{stress}) \propto (\text{strain})$$

$$\frac{\text{stress}}{\text{strain}} = \text{constant (modulus of elasticity)}$$

* Types of modulus of elasticity :

1) Young's modulus of elasticity

Within elastic limit, the ratio of longitudinal stress to the longitudinal strain is called Young's modulus of elasticity of the material of the the wire.



Longitudinal stress $= \frac{F}{A} = \frac{mg}{A}$

Longitudinal strain $= \frac{\Delta l}{l}$.

$Y = \frac{\text{Longi. stress}}{\text{Longi. strain}} = \frac{mg/A}{\Delta l / l}$

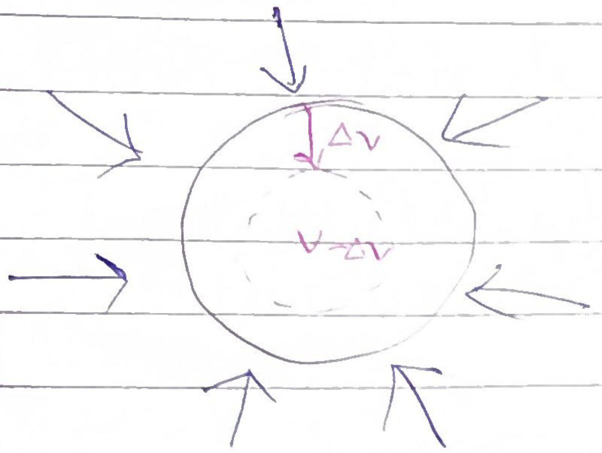
$Y = \frac{mgl}{A \Delta l}$

Unit = N/m2 or Pascal

dimension = $[ML^{-1}T^{-2}]$

2) Bulk Modulus of Elasticity :

Within the elastic limit the ratio of normal stress to the volumetric strain is called Bulk modulus of elasticity.



Normal Stress = F/A

Volumetric Strain = $-\frac{\Delta V}{V}$

$K = \frac{\text{Normal stress}}{\text{Volumetric strain}} = \frac{F/A}{-\Delta V/V}$

$K = \frac{P}{\left(\frac{-\Delta V}{V}\right)} = \boxed{K = \frac{-PV}{\Delta V}}$

Unit = N/m^2
dimension = $[ML^{-1}T^{-2}]$

* Compressibility :-

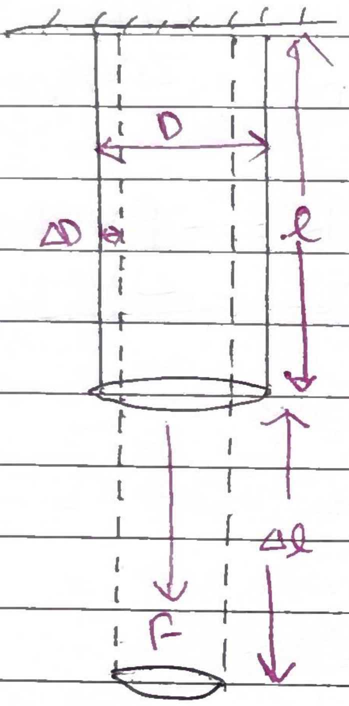
The reciprocal of the bulk ~~mod~~ modulus of a material is called its compressibility.

Compressibility = $1/K$

SI unit = m^2/N
Dimension = $[M^{-1}L^{1}T^{2}]$

Poisson's Ratio :-

Within the elastic limit the ratio of lateral strain to the longitudinal strain, is called Poisson's ratio :-



$$\text{Lateral Strain} = -\frac{\Delta D}{D}$$

~~lat~~ $$\text{longitudinal strain} = \frac{\Delta \ell}{\ell}$$

$$\text{Poisson's Ratio}(\sigma) = -\frac{\Delta D / D}{\Delta \ell / \ell} = -\left(\frac{\ell}{D}\right)\left(\frac{\Delta D}{\ell}\right)$$

Elastic Potential Energy :-

The workdone in stretching the wire is stored in it as its elastic potential energy :

$$W = \text{Average force} \times \text{displacement}$$

$$W = \left(\frac{0+F}{2}\right) \times \Delta l$$

$$\boxed{W = \frac{1}{2} F \Delta l}$$

$$\therefore U = \frac{1}{2} F \Delta l$$

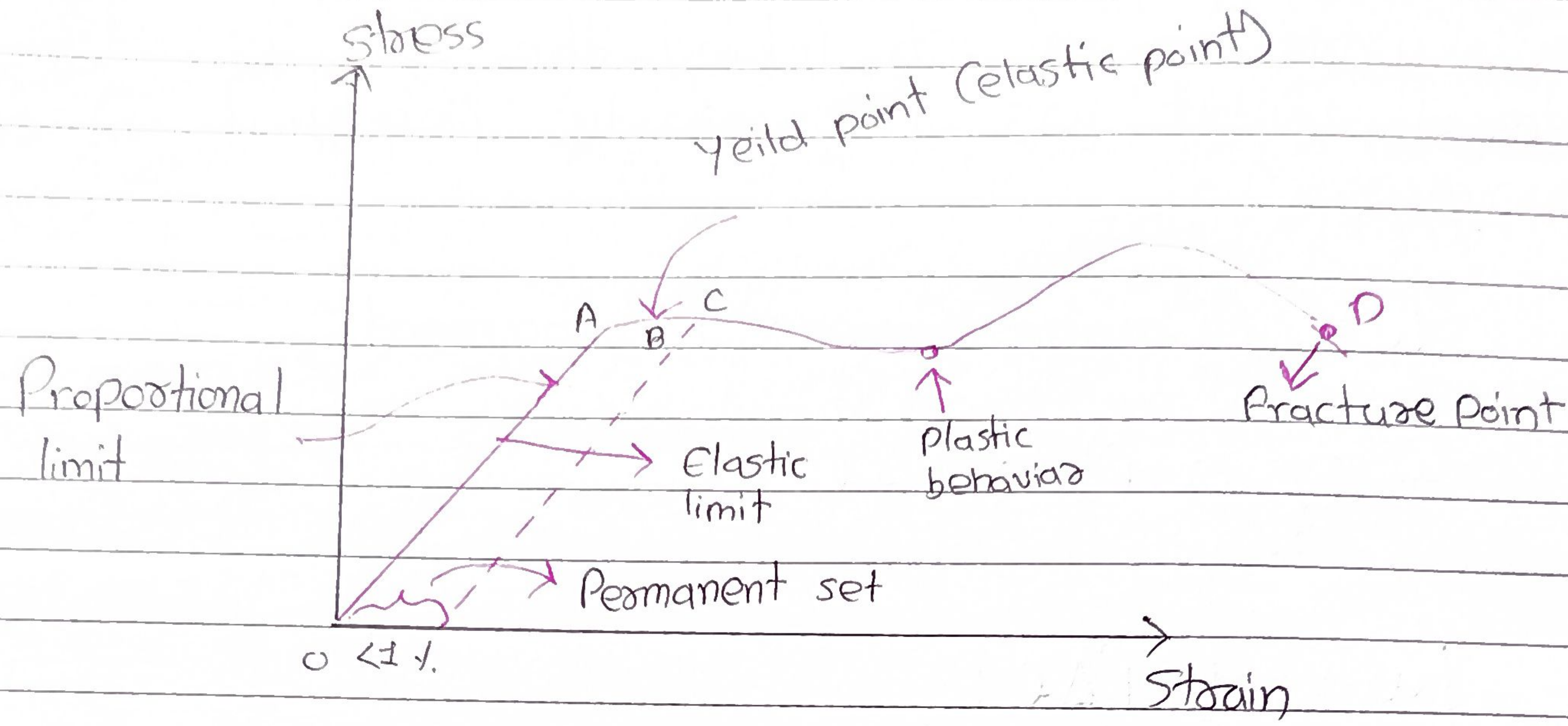
$$U = \frac{1}{2} \left(\frac{F}{A}\right) \left(\frac{\Delta l}{l}\right) (Al)$$

$$\boxed{U = \frac{1}{2} \times \text{stress} \times \text{strain} \times \text{volume}}$$

Energy stored per unit volume

$$\boxed{u = \frac{1}{2} \times \text{stress} \times \text{strain}}$$

Stress - strain Curve :



The portion OB of the graph is called elastic region and the point B is called elastic limit or ~~yeil~~ yield point. The stress corresponding to the yield point is called yield strength (S_y)

Elastic After Effect :-

The delay in regaining the original state by a body on the removal of the deforming force is called elastic after effect.

Elastic fatigue ;

Elastic fatigue is defined as loss in the ~~body~~ on the the strength of a material caused due to repeated alternating strain to which the material is subjected

Elastic Hysteresis :-

Following figures shows the stress-strain curve force a rubber sample when loaded and then unloaded. For increasing load the stress-strain curve is OAB and for decreasing load the curve is BCO. The fact that the stress-strain curve is not retraced on reversing the strain is known as elastic hysteresis.