* Deformation of solids

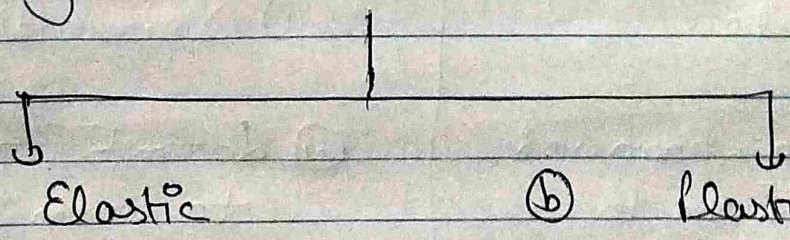
- Deformation means change in the size and shape of an object due to application of force

- It is a measure of the rate at which the shape of body changes as deformation occurs internal inter molecular force arises that oppose the applied force

- if applied force is not that much greater than internal forces are sufficient to completely resist the applied force.

- Allow object to a new equilibrium state and returns to its orignal state when force is removed.

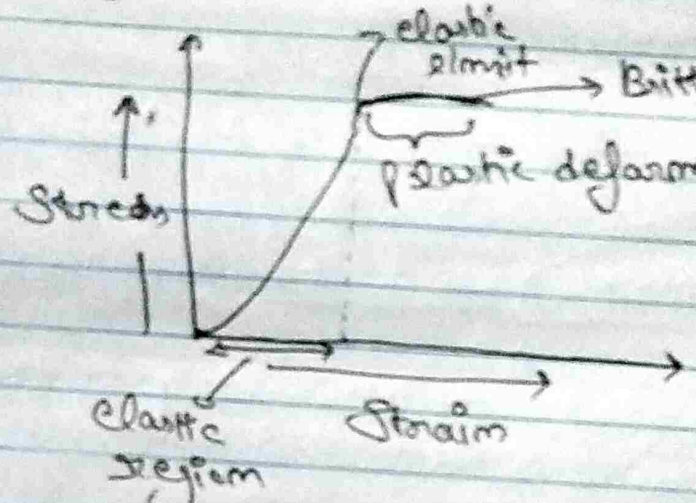
- But if greater force is applied may leads to a permanent deformation of object ~~use~~ ~~en~~ which can't able to return its orignal state.



(a) Elastic / Ideal deformation.
— because takes place instantly on application of force and desappear completely on removal of force.
Such deformation in solids obey Hooke's law. i.e $\sigma = E\varepsilon$ ← resulting strain
↓ applied force, ↑ material constant / Young's modulus constant

(b) Plastic deformation-

- irreversible, permanent deformation
- ~~stress object to plastic deformation first~~ undergoes elastic deformation then undergoes plastic deformation.
- The transition from elastic state to plastic state is characterized by yield strength of the material.



Difference between Elastic & Plastic deformation :-

Elastic	Plastic
(i) Reversible	(i) Irreversible
(ii) When force removed material return to original state	(ii) doesn't return to original state.
(iii) Not a permanent deformation	(iii) permanent deformation.
(iv) Chemical bond undergo stretching & bending	(iv) chemical bonds are break

(i) occurs within the elastic limit	(ii) occurs beyond plastic limit
(iii) Time dependent	(iv) Time independent

(iii) Stress & Strain ⇒

→ Stress → denote by (σ)

σ — The force per unit area that applies to an object to deform it.

$$\sigma = \frac{\text{force}}{\text{Area}}$$

Units ⇒ N/cm² ; pascal (Pa)

Types

(i) Direct (ii) Indirect (iii) Combined

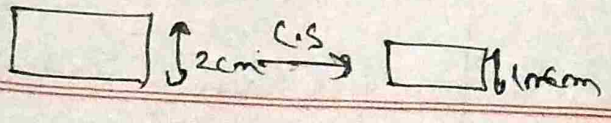
(i) Direct stress-

(a) Tensile stress - defined as tensile force per unit area of the body it is a type of force which produce extension or elongate the dimension of the body.

- It is the ratio of change in length to original length

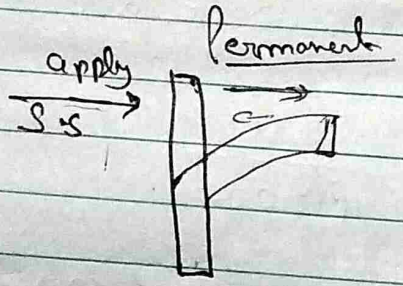
(b) Compressive stress - defined as compressive force acting per unit area of the body and opposite to each other and this type of force compress the

dimensions of body.



(i) Shear stress :-

defined as shear force acting per unit area of the body when we applied the force on the surface of the body. Body develop some resistance opposite to the direction of force applied.



(ii) Indirect Stress-

This stress occurs due to torque produced in the body

(iii) Combined Stress-

Combination of Direct & Indirect stress

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Strain =>

It is the measurement of amount of deformation

denoted by ε

$$\varepsilon = \frac{\Delta L}{L}$$

ΔL — change in length

L — original length

→ it has no units.

Types ⇒

(i) Tensile strain – ratio of increase in length to the original length.

(ii) Compressive strain – ratio of decrease in length to original length.

(iii) Shear strain – produced by shear force

⇒ Elastic Modulus :–

It is a term used to explain the stress and strain. and ratio of stress to the strain.

$$E = \frac{\text{Stress}}{\text{Strain}}$$

elastic modulus determine amount of force (stress) required per unit deform-ation.

E.M ∝ Stress | E.M ∝ $\frac{1}{\text{Strain}}$

⇒ Heckel Equation ⇒

is given by Heckel in 1961

Heckel analysis is most useful method for estimating volume reduction under the

Compression pressure (Compression of tablets)

Heckle plot can be affected by time of compression, degree of lubrication & size of die

The densification of bulk powder on application of force obey first order kinetics and Heckle eqn is expressed as,

$$\ln \frac{1}{1-D} = KP + A$$

D = Density of tablet
P = Pressure (compression P)
K = Constant related to powder
A = Constant of machine.
1-D can also be written as ε

$$1 - D = \varepsilon \text{ (Porosity)}$$

$$\ln\left[\frac{1}{\varepsilon}\right] = KP + A$$

Pressure ↑ = Porosity ↓