J.M.

ELASTICITY

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Variation of g with latitude:

g at pole is 9.83 m/s^2
g at equator is 9.78 m/s^2
average value of g is 9.81 m/s^2

(Parinam) * FORCE AND ELASTICITY

*** Deforming force:-** The force applied on body which is responding to deform / change size and shape of the body) is called as deforming force.

Deforming ∝ deforming force

*** Restoring force:-** The force which is responsible to restrore original size and shape of the body is called restoring force.
Under deformed condition, every shifted molecule tries to achive its original position because of elastic property.

*** Elasticity:-** The property on account of which a body regains its original size and shape on removal of external deforming force is called as elasticity.

* Elastic body :- The body which regains its original size and shape on removal deforming force is called as elastic body.

Ex - equartz

* Plasticity :- The property on account of which a body easily deforms and does not regain its original size and shape on removal deforming force is called as plasticity.

* Plastic Body :- Such bodies do not regain their original size and shape even after the removed deforming force. These are called plastic bodies.

eg. Putty, salt, clay, chalk.

* Rigidity :- The property on account of which a body does not change its size and shape even when a large forse is applied on it, is called as rigidity.

* Rigid body :- A rigid body that does not deform or change shape. the distance between particles remains constant.

eg :-

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* **Stress:-** Stress is the internal elastic restoring force per unit cross-sectional area of a body.

$$\text{stress} = \frac{\text{Internal elastic restoring force}}{\text{cross-sectional area}}$$

~~Restoring force = Applied force~~

$$\text{Stress} = \frac{\text{Applied force}}{\text{cross-sectional Area}}$$

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

⇒ M.K.S or S.I unit of stress is N/m^2 or Pascal.

⇒ C.G.S unit of stress is $dyne/cm^2$

⇒ The dimensions of stress are $[M^1L^{-1}T^{-2}]$

* **types of stresses:-** Their are three types of stresses

- 1. Tensile stress (longitudinal stress)
- 2. compressive stress (volume stress)
- 3. shearing stress (shear stress)

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(तनाव) (अनुदैर्ध्य)

(1) Tensile stress or longitudinal stress:-

⇒ When applied force produces change in length of a elongated body then the corresponding stress is called tensile stress or longitudinal stress.

or

The stress that tends to change the length of a body is called longitudinal stress.

$$\text{Tensile stress} = \frac{\text{Applied force}}{\text{cross-sectional area}}$$

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

$$= \frac{mg}{\pi r^2}$$

⇒ M.K.S unit of tensile stress is N/m^2

⇒ C.G.S unit of tensile stress is $dyne/cm^2$

⇒ The dimensions of tensile stress are $[ML^{-1}T^{-2}]$

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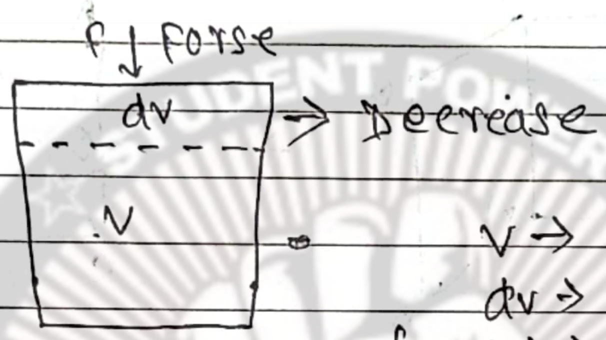
(2) Compressive stress or volumetric stress :-

⇒ The stress which compresses the given body is called as Compressive stress



$V \rightarrow$ original volume.
$dv \rightarrow$ Decrease in volume.
$(v - dv) \rightarrow$ New volume.

⇒ If a deforming force produces change in the volume of a body, then the corresponding stress is called as volume stress

$$\text{Volume Stress} = \frac{\text{Applied force}}{\text{Area}}$$

⇒ M.K.S unit of compressive stress is N/m^2

⇒ c.g.s unit of volume stress is $dyne/cm^2$

⇒ The dimension of volumetric stress is $M^1L^{-1}T^{-2}$

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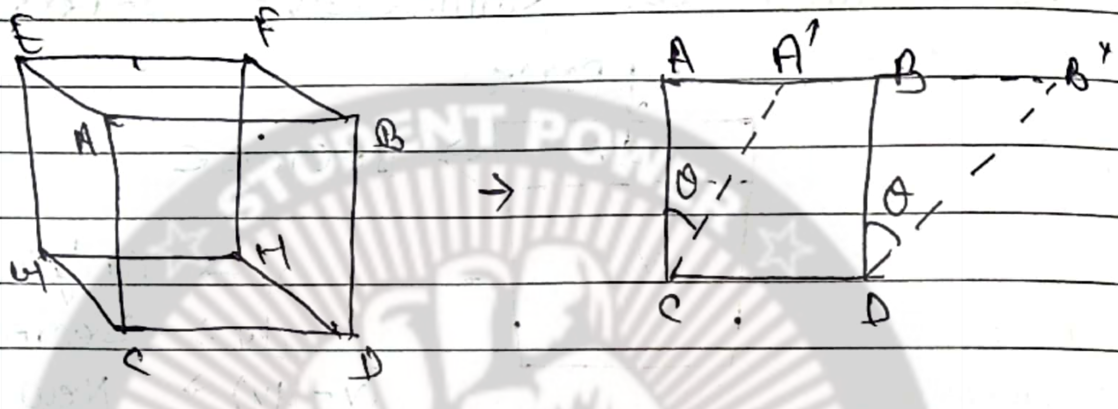
* Shear Stress :- The stress corresponding to change in shape of a body is called shear stress

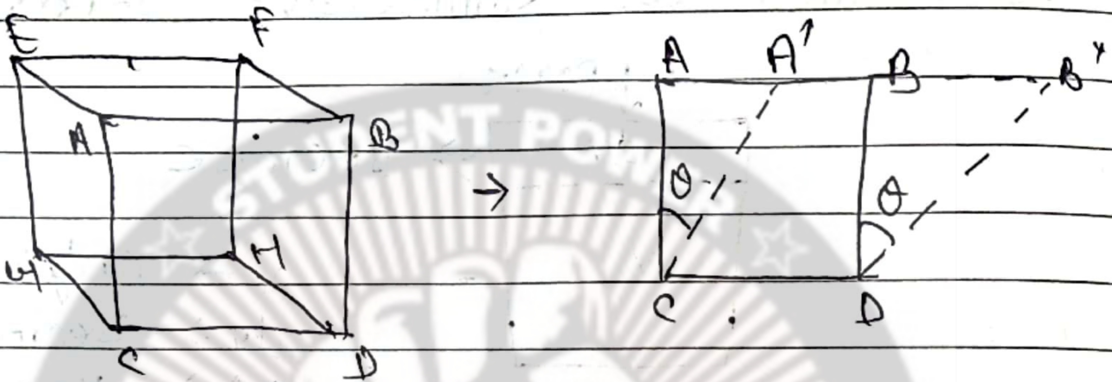


⇒ M·K·S unit of shear stress is N/m^2

⇒ C·G·S unit of shear stress is $dyne/cm^2$

⇒ Dimensions of shear stress are $M^1L^{-1}T^{-2}$

* **Shear Stress** :- The stress corresponding to change in shape of a body is called shear stress



⇒ M.K.S unit of shear stress is N/m^2

⇒ C.G.S unit of shear stress is $dyne/cm^2$

⇒ Dimensions of shear stress are $M^{1}L^{-1}T^{2}$

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* Elastic limit :- The stress corresponding to the limiting value of load, which when applied and subsequantly ~~reel~~ released, does not produce permanent deformation is called as elastic limit".

If this limit is crossed, the proportionali is lost and the stress is found to be less than what is expected and intramolecular structure of body collapses.

* Hooke's law :- It states that 'within elastic limit' strain is directly proportional to the stress.

~~Strain α stress~~ stress α strain

stress ~~Strain~~ = constant × ~~stress~~ strain

constant = ~~Strain / Stress~~ Stress / strain

The constant of proportionality is called as modulus of elasticity.

modulus of elasticity = ~~strain / stress~~ Stress / strain.

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⇒ S.I unit of modulus of elasticity is N/m^2

⇒ CGS unit is $dyne/cm^2$

⇒ Dimensions of modulus of elasticity are $[M^1 L^{-1} T^{-2}]$.

* Types of modulus of elasticity

As we have seen when a force is applied on a body, then its length changes or volume changes or shape of a body changes, Accordingly, there are three type of modulus of elasticity.

(i) Young's Modulus of Elasticity (Y) :-

within elastic limit, the ratio of tensile ~~strain~~ stress to tensile ~~stress~~ ~~strain~~ strain is called Young's modulus of elasticity (Y)

we have,

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

$$\frac{\text{Tensile stress}}{\text{Tensile strain}} = \text{young's modulus of elasticity}$$

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

$$Y = \frac{F/A}{l/L}$$

$$Y = \frac{mg/\pi r^2}{l/L}$$

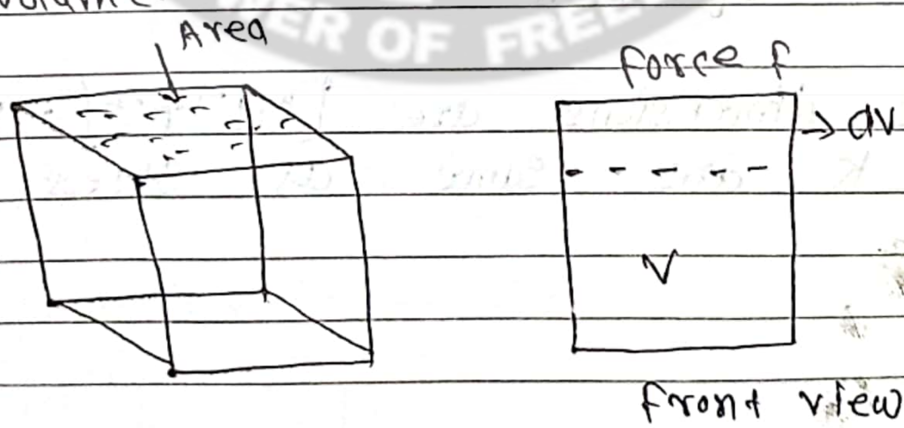
$$Y = \frac{mgL}{\pi r^2 l}$$

m = load attached
r = Radius of wire
L = original length of wire
l = Extension produced.

* **Bulk modulus of Elasticity (K) :-**

→ within elastic limit, the ratio of volume stress to volume strain is called Bulk modulus of elasticity 'K'.

Bulk modulus measurs the opposition (resistance) offered by a material during its change in volume.



Bulk modulus of elasticity

$$K = \frac{\text{volume stress}}{\text{volume strain}}$$

$$K = \frac{\text{Bulk stress}}{\text{Bulk strain}}$$

$$K = \frac{F/A}{dv/V}$$

$$K = \frac{dP}{dv/V}$$

$$K = \frac{dP \times V}{dV}$$

Where
V = original volume
F = applied force
dV = decrease in volume
dP = increase in pressure
A = area of cross section on which force is applied.

⇒ Its S.I or MKS unit is N/m^2 cgs unit is $dyne/cm^2$

⇒ Its dimensions are $[ML^{-1}T^{-2}]$ ∵ Dimensions of K are same as stress Y etc.

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* compressibility :- The reciprocal of bulk modulus of elastigity is called compressibility.

$$\text{compressibility} = \frac{1}{\text{Bulk modulus}}$$

$$\text{compressibility} = \frac{1}{K}$$

$$\text{compressibility} = \frac{1}{\frac{dp}{dv} \times V}$$

$$\text{compressibility} = \frac{dv}{dp \times V}$$

or

$$\text{compressibility} = \frac{\text{volume strain}}{\text{volume stress}}$$

⇒ The S.I unit of compressibility is m^2/N

⇒ The C.G.S unit of compressibity is $cm^2/dyne$

⇒ The Dimensions of compressibility are $[M^{-1}L^{1}T^{-2}]$.

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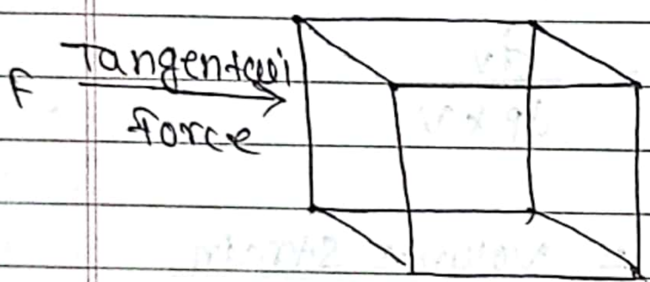
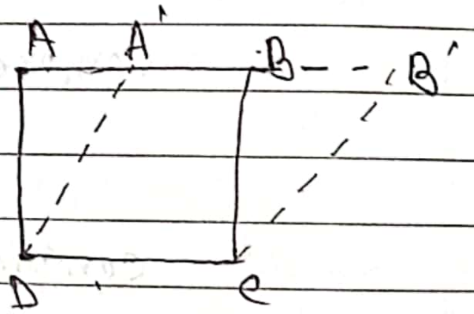
* Modulus of Rigidity (η)

⇒ Within elastic limit, the ratio of shearing stress to shearing strain is called modulus of rigidity 'n'.

Modulus of Elasticity measures the opposition (resistance) offered by a material for its change in shape.





Modulus of rigidity :-

$$\eta = \frac{\text{shearing stress}}{\text{shearing strain}}$$

$$\eta = \frac{F/A}{\left[\frac{\text{Lateral displacement layer}}{\text{its distance from fixed layer}}\right]}$$

$$\therefore \eta = \frac{F/A}{AA'/AD}$$

$$\eta = \frac{F/A}{\tan\theta} \qquad \left\{ \frac{AA'}{AD} = \tan\theta \right.$$

$$\eta = \frac{F}{A\tan\theta}$$

$$\eta = \frac{A}{A\theta} \qquad \left\{ \text{If } \theta \text{ is small put } \tan\theta = \theta \right.$$

⇒ The S.I unit of Modulus of Rigidity is N/M^2.

⇒ The CGS unit of modulus of Rigidity is dyne/ cm^2.

⇒ The Dimensions of modulus of Rigidity is $[M^1 L^{-1} T^{-2}]$.

* Relation between Y, K and η

For a given material, there is certain relation between Y, K and η which is given by, J.MY

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$$Y = \frac{9\eta K}{3K+\eta}, \quad Y = 2\eta(1+\sigma), \quad \sigma = \frac{3K-2\eta}{2\eta+6K}$$

$$Y = 3K(1-2\sigma)$$

or $$\frac{1}{Y} = \frac{1}{3\eta} + \frac{1}{9K}$$

Where Y = young's modulus of elasticity of material.

K = Bulk modulus.

η = modulus of rigidity.