Physics Notes

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Class:10+1

Unit: VII-A

Topic: Properties of Bulk Matter

SYLLABUS: UNIT-VII

Elastic behavior, Stress-stain relationship, Hooke's law, Young's modulus, bulk modulus, shear, modulus of rigidity. } 7A

Pressure due to a fluid column; Pascal's law and its applications (hydraulic lift and hydraulic brakes). Effect of gravity on fluid pressure.
Surface energy and surface tension, angle of contact, application of surface tension ideas to drops, bubbles and capillary rise. } 7B

Viscosity, Stokes law, terminal velocity, Reynolds's number, streamline and turbulent flow, Bernoulli's theorem and its applications. } 7C

Heat, temperatures, thermal expansion; specific heat-calorimetry; change of state- latent heat. } 7D

Heat transfer-conduction, convection and radiation, thermal conductivity, Newton's law of cooling. } 7E

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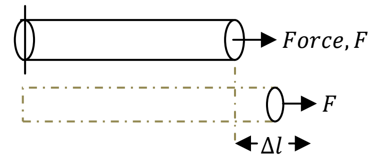
Q.1. Define

a) Deforming Force
b) Elasticity
c) Perfectly Elastic Body
d) Perfectly Plastic Body



Ans.a) Deforming Force:-

Deforming force is one, which when applied changes the shape of body.

b) Elasticity:-

The property of object by virtue of which it tends to regains its original size and shape, is called *Elasticity*.

c) Perfectly elastic body:-

A body which regains its original configuration immediately and completely after the removal of deforming force, is called *Perfectly Elastic Body*.

Example:- Quartz, Phosphor, Bronze.

d) Perfectly Plastic Body:-

A Body which does not regains its original configuration at all on the removal of deforming force, however small the deforming force may be is called *Perfectly Plastic Body*.

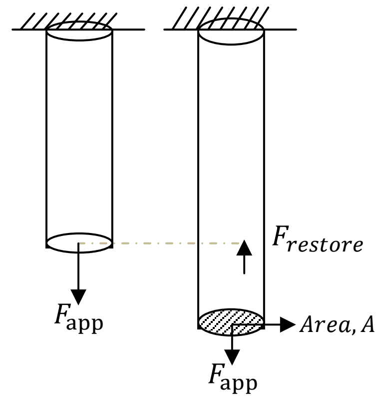
Example:- Putty, mud and paraffin wax.

Q.2. Define

a) Stress? Units? Dimensions? Scalar or Vector

b) Types of stress

Ans.a) Stress $= \dfrac{F_{restore}}{Area}$



"Restoring Force developed per unit area."

Units:- N/m^2

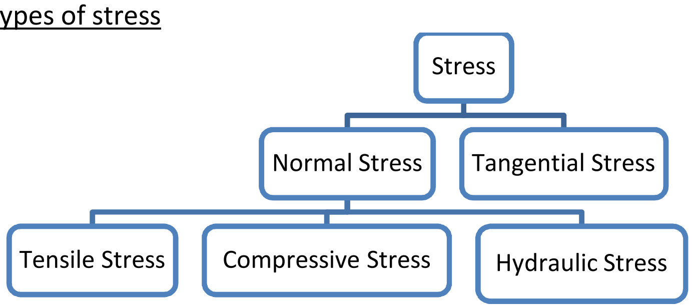
Dimensions:- [stress] = [force] / [Area]

$$= \left[\frac{M^1\,L^1\,T^{-2}}{L^2}\right] \qquad = [M^1\,L^{-1}\,T^{-2}]$$

Scalar or Vector:-

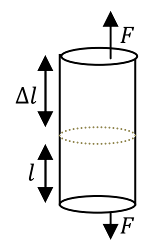
Neither scalar nor vector, Stress is **tensor**.

b) Types of stress



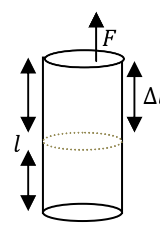
i) Normal Stress :-

When a deforming force, acts normally over an surface area of the body, then the restoring force set up per unit area on the body, is called *Normal Stress*.



Tensile Stress :-

If there is an increase in length and extension of the body in the direction of force applied, then the stress set up is called *Tensile Stress*.

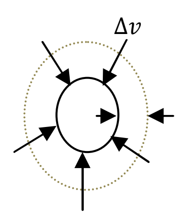


Compressive Stress :-

If there is a decrease in length of wire and compression of the body due to force applied, then the stress set up is called *Compressive Stress*.

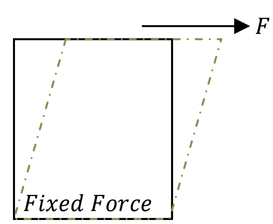
Hydraulic Stress :-

When a solid body undergoes a change in its geometrical shape and applying on it perpendicular to every point on the surface of body, then the restoring force set up per unit area is called *Hydraulic Stress*.



ii) Tangential Stress :-

When a restoring force acts tangentially to the surface of body, produces a change in shape of the body, without any change in volume, then the stress set up in the body is called *Tangential Stress*.



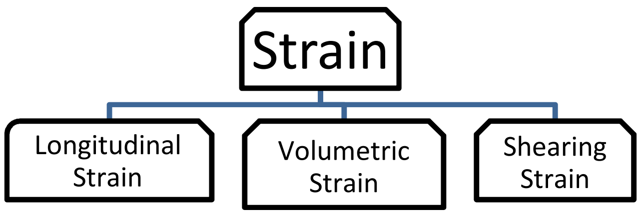
Q.3. a) What is strain?
b) Types of Strain?

Ans. Strain:-

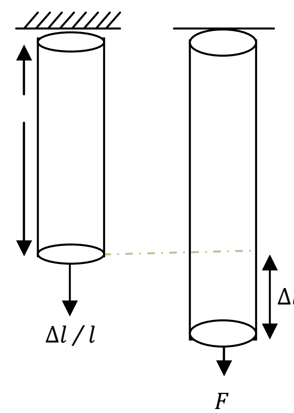
The ratio of change in configuration to the original configuration is called strain

$$Strain = \frac{Change\ in\ Configuration}{Original\ Configuration}$$

Types of Strain:-



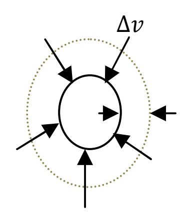
a) Longitudinal Strain:-



If a restoring force produces a change in length then the strain produced in the body is called *Longitudinal Strain*.

$$\text{Longitudinal Strain} = \frac{Change\ in\ Length}{Original\ Length} = \frac{\Delta l}{l}$$

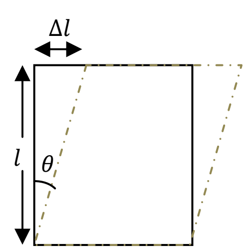
b) Volumetric Strain:-



If a restoring force produces a change in volume then the strain produced in the body is called *Volumetric Strain*.

$$Volumetric\ Strain = \frac{Change\ in\ Volume}{Original\ \text{Volume}} = \frac{\Delta V}{V}$$

c) Shearing Strain:-



If a restoring force produces a change in shape without changing its volumes then the strain produced in the body is called *Shearing Strain*

$$\text{Shearing strain} = \theta = \frac{\Delta L}{L}$$

Q.4. Define

a) Elastic Limit.

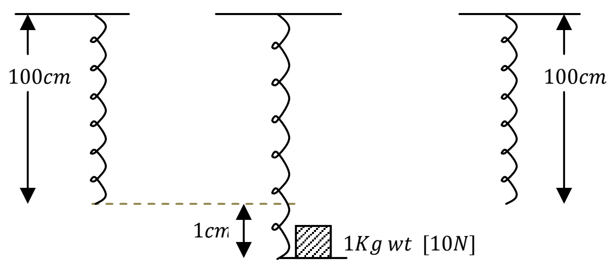
b) Hooke's Law.

c) Stress – staring graph for a wire.

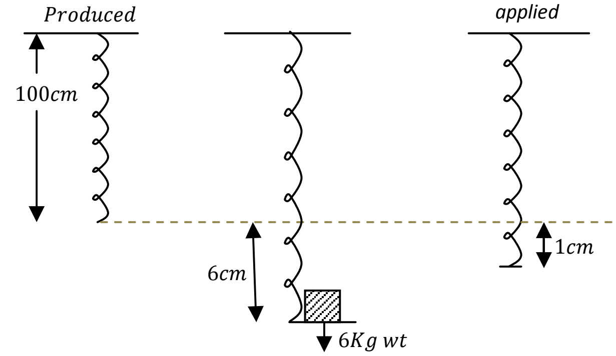
Ans.a) **Elastic limit**:-

Elastic limit is the upper limit of deforming force up to which if deforming force is removed, the body regains its original form completely and beyond which if deforming force is increased the body loses its property of elasticity and gets permanently deformed.

1. Spring regains original length upto 5kg wt.



2. -



Elastic Limit → 5Kg wt (50 N)

b) **Hooke's Law**:-

"Extension produced is directly proportional to load applied"

Extension ∝ load applied

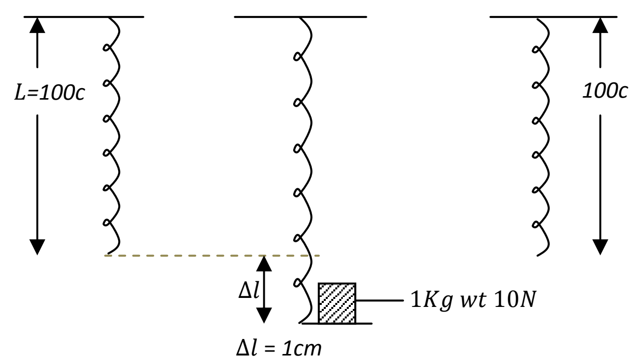
$$\Delta l \propto F$$

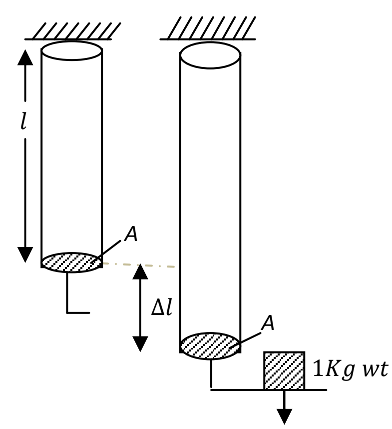
$$\frac{\Delta l}{l} \propto \frac{F}{A}$$

Stress ∝ Strain

Strain ∝ Stress

"Stress is proportional to strain" (within elastic limit).





c) **<u>Stress – stain graph for a wire</u>**:

STRESS- STRAIN RELATIONSHIP IN A WIRE

A corresponds to ***elastic limit*** and *OA represents* ***elastic range***.

a) If the wire is unloaded at point B, the graph between stress and strain will not follow the path BAO but it traces a dotted line BO_1
Permanent set. In the portion ABP of the graph, Hooke's law fails and the extension in the wire is partly elastic and partly plastic in behavior.

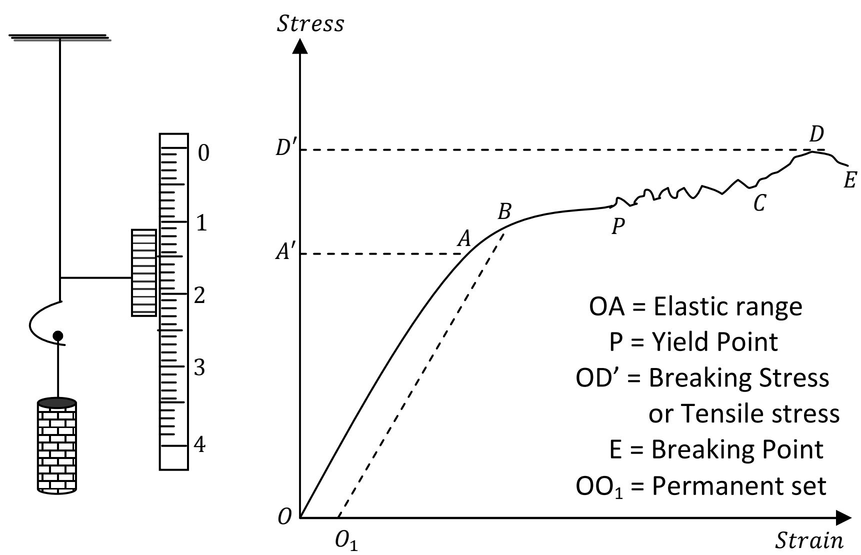
b) P to C here, the wire shows increase in strain without any increase in stress., *The point P at which the wire yields to the applied stress and begins to flow down is called* ***yield point****.*

c) A little load beyond P, the thinning of the wire starts and the necks and waists are developed at few weaker portions in the wire and finally the wire breaks there which is shown by point E. The stress corresponding to point D is called breaking stress or ultimate stress or tensile stress of the wire.

(1) **Ductile materials.** These are those materials which show large plastic range beyond elastic limit.

(2) **Brittle materials.** These are those materials which show very small plastic range beyond elastic limit

(3) **Elastomers.** These are those materials for which stress and strain variation is not straight line within elastic limit and strain produced is much large than the stress applied, rubber



Q.5. Define
a) Modulus of Elasticity?
b) Three types of Modulus of Elasticity?

Ans.a) Modulus of Elasticity:-

$$\left(\frac{\Delta l}{l}\right) \propto \left(\frac{F}{A}\right)$$

Stress ∝ Strain
Strain ∝ Stress
Stress = (E) Strain

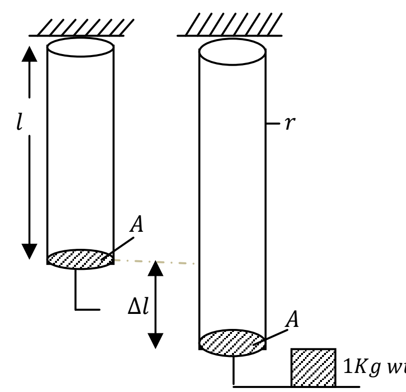
$$\boxed{E = \frac{Stress}{Strain}}$$

"E is the ratio of stress to strain".

b) Types of Modulus of Elasticity

i) Young's Modulus of Elasticity

Y is the ratio of Normal Stress to Longitudinal Strain



$$Y = \frac{Normal\ Stress}{Longitudinal\ Strain}$$

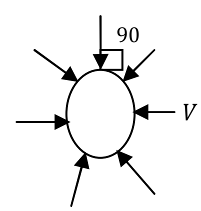
$$= \frac{F/A}{\Delta l/l}$$

$$= \frac{F/\pi R^2}{\Delta l/l}$$

Units:- Y $= N/m^2$

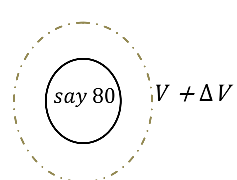
Dimensions:- $[Y] = [M^1 L^{-1} T^{-2}]$

Note:- Greater the value of Young's modulus of a material, larger is the stability. Therefore steel is more elastic than copper.



ii) Bulk's Modulus of Elasticity, *B*

$$B = \frac{Normal\ Stress}{Volumetric\ \ Strain}$$



"It is defined as the ratio of Normal Stress to Volumetric Strain"

$$= \frac{Normal\ Stress}{-\Delta v/v}$$

$$= \frac{\Delta p}{-\Delta v/v}$$

Units:- N/m²

Compressibility:

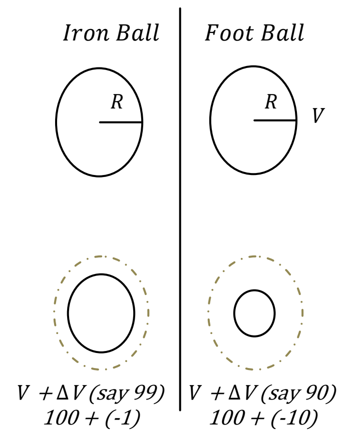
Compressibility, $K = \frac{1}{B}$ $\left[\frac{1}{Bulk\ modulus}\right]$

$$B = \frac{\Delta p}{-\Delta v/V}$$

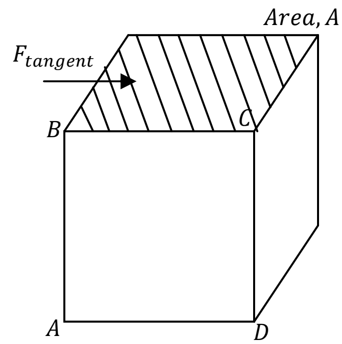
$$K = \frac{-\Delta v/V}{\Delta p}$$

Compressibility ∝ change in volume.

Football is more compressible than iron ball as shown in *Fig*.



iii) Modulus of Rigidity, ŋ

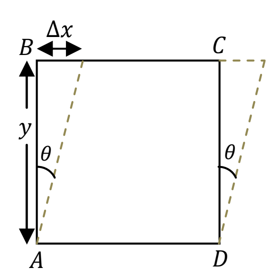


$$ŋ = \frac{Tangential\ Stress}{Shearing\ Strain}$$

$$ŋ = \frac{F_{t/A}}{\Delta n/y} = \frac{F_{t/A}}{\Delta x/y}$$

$$ŋ = \frac{F_{t/A}}{Tan\theta}$$

$$\boxed{ŋ = \frac{F_{t/A}}{\theta}} \quad \left[\begin{matrix} Tan\theta \approx \theta \\ for\ small\ \theta \end{matrix}\right]$$

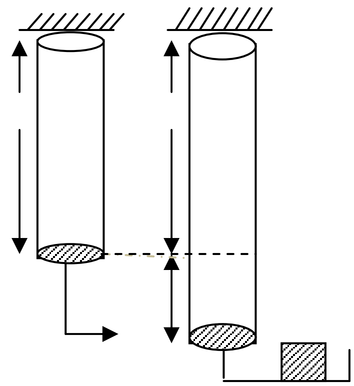


Q6. Prove Elastic Potential Energy per unit volume in a stretched wire is

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

Ans.

For a wire



$$\gamma = \frac{stress}{strain}$$

$$= \frac{F/A}{\Delta L/L}$$

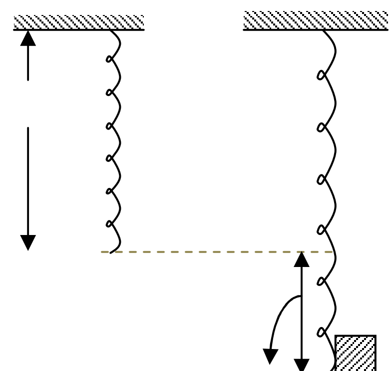
$$\boxed{F = \left(\frac{\gamma A}{L}\right) . \Delta L} \quad \text{-------------} \ (1)$$

$$F = K \ \Delta L$$

Where $K = \frac{\gamma A}{L}$ equivalent spring constant of a wire

$$\boxed{F_{restoring} = -k\,x}$$

Now,



$$u = \frac{energy}{volume}$$

$$= \frac{1/2\,(spring\ constant)\,(extension)^2}{(Area) \times L}$$

$$= \frac{1/2\left(\frac{\gamma \cancel{A}}{L}\right) .\Delta L .\Delta L}{(\cancel{Area}) \times L}$$

$$= \frac{1}{2}\gamma \times \left(\frac{\Delta L}{L}\right)^2$$

Energy = $\frac{1}{2} kx^2$

$$\boxed{u = \frac{1}{2} . \gamma . (strain)^2}$$

OR

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

OR

$$\boxed{u = \frac{1}{2} . \frac{(stress)^2}{\gamma}} \qquad \left[As\ strain = \frac{stress}{\gamma}\right]$$