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MECHANICS

SUB. CODE-BSPH1102

For B.Sc.(Physics & Chemistry)

Elasticity

Different types of elasticity

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ELASTICITY

- Under the application of external forces, the body may get deformed and development of restoring force tends to get its original or natural shape back again, after the removal of deforming forces, the extent of restore varies from material to material.
- The property of the material to restore the original shape or to oppose the deformation is called as elasticity.



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Stress

Stress: The restoring force per unit cross sectional area is called stress.

$$\text{Stress} = \frac{\text{Restoring force}}{\text{Area of cross section}} = \frac{F}{A}$$

Units: N/m^2

Types of stress:

1. **Longitudinal stress** : Restoring force normal to cross sectional area and along the length.
2. **Bulk Stress** : Equal restoring force acting normal to all faces.
3. **Shear stress or tangential stress** : Restoring force parallel to the surface.



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Strain

Strain is defined as the ratio of the change in dimension of the material to original dimension.

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

Strain is a dimension less quantity. It has no unit.

Types of strain:

1. Linear strain : Change in length per unit length
2. Volume strain : Change in volume per unit volume
3. Shear strain or Shear : Angular deformation



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Hooke's Law of Elasticity

Statement of the Hooke's law :-At low stress values, the stress in a body is directly proportional to the corresponding strain.

i.e. $\text{Stress} \propto \text{Strain}$ or $\text{Stress} = E \times \text{Strain}$

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

Where , E = Proportionality constant. It is a constant quantity for the given material.

Unit of E : Pascal or N/m^2 .

This constant is also known as modulus of elasticity or stiffness constant.



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Young's modulus of elasticity

□ **Young's modulus** is defined as the ratio of longitudinal stress to longitudinal strain.

i.e.

$$Y = \frac{\sigma_{long}}{\epsilon_{long}}$$

Or simply,

$$Y = \frac{F/A}{\Delta L/L_0} = \frac{FL_0}{A\Delta L}$$

It's value for a material is affected by factors like bonding character, temperature, anisotropy etc.



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Bulk Modulus of Elasticity

The **bulk modulus** is defined as the ratio of volume (bulk) stress to volume (bulk) strain

$$\text{i.e. } K = \frac{dP}{dV/V}$$

Where, dP = Increase in pressure,

dV = Change in volume,

V = Original volume

Sometimes negative sign is used because the volume decreases with increase in pressure.

Compressibility is defined as the reciprocal of the bulk modulus.

$$\text{i.e. } K = \frac{1}{B} = -\frac{1}{V} \frac{dV}{dP}$$



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Rigidity Modulus

Shear modulus or **modulus of rigidity** (or torsional modulus) is defined as the ratio of shearing stress to strain developed by shearing the material.

i.e. G or

$$n = \frac{\textit{Tangential stress}}{\textit{Shear Strain}} = \frac{F/A}{x/h} = \frac{Fh}{Ax}$$



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Poisson's Ratio

When a force of deformation is applied on the wire of length l and radius r , its length increases by an amount dl and the radius decreases by dr .

Therefore, two types of strain are produced:

i) Longitudinal strain ($\Delta l/l$)

ii) Lateral strain ($-\Delta r/r$)



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Poisson's Ratio

The ratio of lateral strain per unit stress to the longitudinal strain per unit stress is known as Poisson's ratio (σ).

$$\sigma = \frac{\textit{lateral strain}}{\textit{longitudinal strain}} = \frac{-\Delta r / r}{\Delta l / l}$$

It has no units. Practical values of σ lies between 0.2 to 0.5.



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Reference

Mechanics by *D. S. Mathur*, S. Chand, chp-6.9

