Lecture : 10

B. Sc. (Hon.) Part-I

Paper - I

Physics Course: Mechanics and Properties of Matter

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I. ELASTICITY

Elasticity is the property by which an object returns to its original size and shape when the forces that deformed it are removed.

II. STRESS

Stress is a quantity that is proportional to the force causing a deformation; more specifically, stress σ is the external force F acting on an object per unit cross-sectional area A.

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

III. STRAIN

Strain is a measure of the degree of deformation resulting from strain. It is measured as the ratio of change in some dimension of an object to the original dimension.

IV. ELASTIC LIMIT

The elastic limit of a substance is defined as the maximum stress that can be applied to the substance before it becomes permanently deformed and does not return to its initial length.

V. ELASTIC MODULUS

For sufficiently small stresses, strain is proportional to stress; the constant of proportionality depends on the material being deformed and on the nature of the deformation.

We call this proportionality constant the elastic modulus.

There are three types of deformation and corresponding elastic modulus.

A. Young's Modulus: Elasticity in Length

Young's modulus (modulus of elasticity) measures the resistance of a solid to a change in its length.

We define the tensile stress as the ratio of the magnitude of the external force F to the cross-sectional area A. The tensile strain is defined as the ratio of the change in length ΔL to the original length L.

The ratio of tensile stress and tensile strain is called the Young's modulus:

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

Young's modulus is typically used to characterize a rod or wire stressed under either tension or compression.

B. Shear Modulus: Elasticity of Shape

Shear stress is defined as the ratio of the tangential force F to the area A of the face being sheared. Here, the force vector lies in the plane of the area rather than perpendicular to it.

The shear strain is defined as the ratio of the horizontal distance Δx that the sheared face moves and h is the height of the object.

The ratio of shear stress and shear strain is called the shear modulus or the torsion modulus:

$$S = \frac{F/A}{\Delta x/h}$$

Shearing occurs in rotating shafts under load and in bone fractures due to bending.

C. Bulk Modulus: Volume Elasticity

The volume stress is defined as the ratio of the magnitude of the total force F exerted on a surface to the area A of the surface. The quantity $P = F/A$ is called pressure.

The volume strain is equal to the change in volume ΔV divided by the initial volume V.

The ratio of volume stress and volume strain is called the bulk modulus :

$$B = -\frac{P}{\Delta V/V}$$

The negative sign inserted to ensure the positive bulk modulus.

The reciprocal of bulk modulus is called the compressibility of the body.