# SHREE H. N. SHUKLA GROUP OF COLLEGES

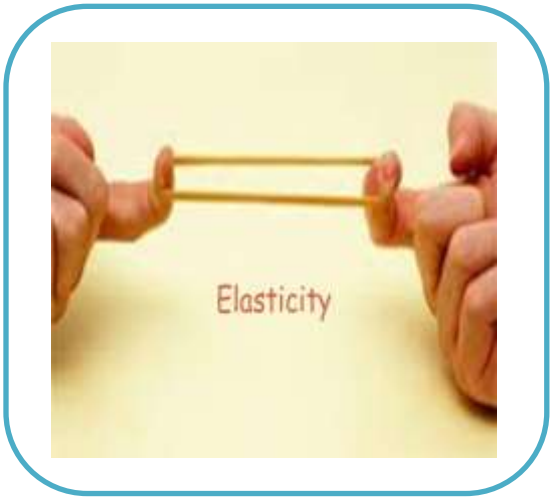
# F.Y.B.Sc. SEM – I

## Subject: Physics

## Paper- 101

## Unit -5

# ELASTICITY




- Introduction
- Elasticity
- Strain & Stress
- Hook's law
- Modulus of rigidity
- Poison's ratio

## INTRODUCTION:

- "When an external force is applied on a body, which is not free to move, the shape and size of the body change. The force applied is called **deforming force**. "
- "When the deforming forces are removed, the body tends to regain its original shape and size due to a force developed within the body. The force developed within the body, which is equal and opposite to deforming force is called **restoring force**."
- "Bodies, which completely regain their original size and shape after the removal of the deforming force, are called **elastic bodies**. "
- "Bodies which change the shape and size on the application of force and which do not regain their original condition on removal of the deforming forces are said to be plastic bodies. Bodies which do not change their shape and size on application of force are called **rigid bodies**."
- "The property by virtue of which a body tends to regain its original shape and size after removal of the deforming force is known as **elasticity**."

## STRESS :

When an external force is acting on an elastic body, it causes deformation (change in shape or in size or both). At the same time, due to elastic property, a force is developed within the material, which is equal and opposite to the applied force, to bring the body to its original shape and size. This force is 'restoring force'.

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

The stress is defined as the restoring force acting on unit area.

Since the applied force and the restoring force are equal in magnitude, the 'stress' is measured as the applied force acting per unit area.

The unit for stress is newton metre$^{-2}$ with symbol N m$^{-2}$ or 'pascal' with symbol 'Pa'.

When the applied force tends to compress the body, the stress is compressive. When it tends to increase the length in the direction of the force, it is tensile and when it acts parallel to the surface of a body, the stress is tangential stress.

## STRAIN :

**"Change in dimensions to original dimensions is known as Strain."**

***(1) Linear Strain:***

When a wire or bar is subjected to two equal and opposite forces, namely pulls, at its ends, there is an increase in the length. If the forces are tensile, the body is elongated. If the forces are compressive, the length is shortened in the direction of the forces. This is called the 'linear strain'.

The linear strain is defined as the ratio of change in length to the original length. If the change (increase or decrease) in length is ' l ' in a wire or bar of original length L,

As the linear strain is ratio of lengths, it has no unit.

$$\text{linear strain} = \frac{\text{Change in length}}{\text{original length}} = \frac{l}{L}$$

***(2) Bulk (or) Volume Strain:***

When a force is applied uniformly and normally to the entire surface of the body, there is a change in volume of the body, without any change in its shape. This strain is called 'bulk or volume strain'.

Volume strain is defined as the ratio of change in volume to the original volume. It has also no unit. If 'v' is the change in volume produced in a body of original volume 'V',

$$\text{bulk or volume strain} = \frac{\text{Change in volume}}{\text{original volume}} = \frac{v}{V}$$

***(3) Shearing (or) Rigidity strain:***

When a force is applied parallel to one face of a body, the opposite side being fixed, there is a change in shape but not in size of the body. This strain is called the shearing strain.

Solids alone can have a shearing strain. It is measured by the angle of the shear 'θ' in radian.

## HOOK'S LAW :

Within the elastic limits, the strain produced in a body is directly proportional to the stress which causes it.

i.e., strain $\propto$ stress

or stress $\propto$ strain

$\therefore \frac{\text{stress}}{\text{strain}} = \text{a constant}$

This constant is called 'modulus of elasticity'.

| SRNO | QUESTION | ANSWER |
|---|---|---|
| 1 | Elasticity known as a _____. | **Deforming force** |
| 2 | _____ is opposite to restoring force. | **Deforming force** |
| 3 | _____ is not change their shape and size due to force . | **Rigid body** |
| 4 | The property by virtue of which a body tends to regain its original shape and size after removal of the deforming force is known as_____. | **Elasticity** |
| 5 | _____ is defined as restoring force acting on unit area. | **Stress** |
| 6 | Stress = _____ | **Force/area** |
| 7 | Unit of stress _____. | **$N/m^2$** |
| 8 | Unit of stress _____. | **Pascal** |
| 9 | Change in dimensions to original dimensions is known as_____. | **Strain** |
| 10 | Linear strain = _____. | **Change in length /original length** |
| 11 | Volume strain = _____. | **Change in volume/original volume** |
| 12 | Shearing strain = _____. | **Change in shape** |
| 13 | Unit of shearing strain =_____. | **θ** |
| 14 | Modulus of elasticity is known as _____. | **Hook's law** |

## MODULUS OF RIGIDITY:

There are three types of modulii depending upon the three kinds of strain.

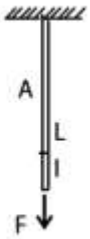
***(a) Young's modulus (E):***

It is defined as the ratio of linear stress to linear strain.

Let a wire of initial length L and cross-sectional area ' A', undergo an extension l, when a stretching force 'F', is applied in the direction of its length.

The modulus of elasticity, in this case, is called Young's modulus and is given by

$$\text{i.e., Young's modulus ( E ) } = \frac{\text{Linear stress}}{\text{Linear strain}}$$




$$\text{Then, longitudinal or linear stress } = \frac{F}{A}$$

$$\text{and longitudinal strain } = \frac{l}{L}$$

$$E = \frac{\text{Linear stress}}{\text{Linear strain}} = \frac{F/A}{l/L} = \frac{F.L}{A.l}$$

The unit for Young's modulus is newton metre-2 with symbol N $m^{-2}$. The single term unit which is widely used for Young's modulus is 'pascal' with symbol 'Pa'.

***(b) Bulk (or) Volume modulus (k):***

It is defined as the ratio of bulk stress to bulk strain.

When a body is subjected to a uniform compressive force, its volume decreases and the strain produced is a bulk or volume strain.

If 'v' is the change in volume and V is the original volume, then

If F is the total compressive force acting on a total area A, then bulk stress = F/A = P

$$\text{Bulk modulus (k)} = \frac{\text{Bulk stress}}{\text{Bulk strain}}$$

If P is the stress applied i.e. (force/unit area) then,

$$\text{bulk strain} = \frac{v}{V}$$

$$\text{bulk modulus k} = \frac{P}{v/V} = \frac{P.V}{v}$$

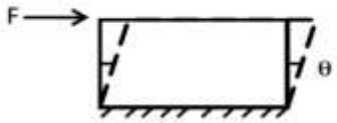
The unit for bulk modulus is 'newton metre$^{-2}$' with symbol N $m^{-2}$. The single term unit which is widely used for bulk modulus is 'pascal' with symbol 'Pa'.

***(c) Shearing (or) Rigidity modulus 'n':***

The ratio of the shearing stress applied to the body to the shearing strain produced is called the rigidity modulus and denoted by the letter 'n'.

If T is the tangential force/unit area and if θ is the angle of shear measured in radian, then

$$\text{rigidity modulus } n = \frac{T}{\theta} = \frac{F}{A\theta}$$




## POISSON'S RATIO :

When a tensile stress is applied to a wire, the wire undergoes not only an extension of length in the direction of the force but also a contraction in its thickness. The ratio of decrease in thickness to the original thickness in lateral direction is known as lateral contraction.

The ratio of lateral contraction to linear elongation is called Poisson's ratio.

$$\text{Poisson's ratio } \sigma = \frac{\text{Lateral contraction}}{\text{Linear elongation}}$$

| SRNO | QUESTION | ANSWER |
|---|---|---|
| 1 | Young modulus known as a _____. | **Linear stress/strain** |
| 2 | Unit of young's modulus_____. | **Newton/m²** |
| 3 | Bulk modulus known as a _____. | **Bulk stress/strain** |
| 4 | Unit of young's modulus_____. | **Pascal** |
| 5 | _____ is defined as restoring force acting on unit area. | **Stress** |
| 6 | Shearing Stress = _____ | **T/ θ** |
| 7 | Rigidity modulus n = _____. | **T/ θ** |
| 8 | Unit of stress _____. | **Pascal** |
| 9 | Poisson's ratio = _____. | **Lateral contraction/linear elongation.** |
| 10 | Linear strain = _____. | **Change in length /original length** |