PHY 102: DYNAMICS AND ELASTICITY

Chapter:3

Elasticity

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Elasticity

- Elasticity is a property of material, which it a change in shape or size under the action of deforming force and regained its original position when deforming force are removed is called elasticity.

  e.g.metal spring,rubber ,iron,wood,etc.are the elastic material.
- For example:- A spring .If we stretch a spring it changes its shape and when the external force is removed spring comes back to its original position.

Spring

Rubber Band

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When deforming force applied on the body it suffer change in shape but removal of the deforming force the body can not regained its original position is called plasticity. e.g. wax, mud, plasticine, modeling clay, etc. practically no material body is perfectly elastic or plastic.

Strain - it is defined as the ratio of change in dimension to the original dimension. There are three types

1)Tensile strain (Longitudinal strain)-The ratio of change in length to the original length is called tensile strain

Tensile strain=Change in length/original length=l/L

Volume strain - when the volume of the material body change by the amount v, the ratio of change in volume to the original volume strain.

volume strain=change in volume/original volume

Shearing strain - when material of the body is sheared through an angle θ the is called shearing strain

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Deforming force- external force is used to produced deformation in the material body is called deforming force

Stress- it is a internally developed restoring force per unit area is called stress it is either normal or tangential to the surface

Tensile stress-it is also called longitudinal stress ,applied force/area

- Plasticity is reverse of elasticity.
- Property means permanent deformation.
- The object never regains its original shape even when the external force is removed. These types of objects are called as plastics.
- For example:- Toys, Buckets made up of plastics.

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Stress:-

- Stress is the restoring force per unit area.
- Whenever we apply an external force on the body to change its shape there is a restoring force that develops in the body in the opposite direction.
- For example:-
  - When we apply an external force to a rubber ball at the same instant of time some force develops in the ball which acts in the opposite direction.
  - This opposite force which develops in the ball when an external force is applied is known as restoring force.
  - Both the forces are equal in magnitude.
- Mathematically:-
- **Stress = F/A**
- Where F= restoring force develops in the body because of force we apply.
- A=area
- S.I. Unit :- N/m^2 or Pascal(Pa)
- Dimensional formula is $[ML^{-1}T^{-2}]$.

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Strain

- Strain is a measure of deformation representing the displacement between particles in the body to a reference length.
- It tells us how and what changes takes place when a body is subjected to strain.
- Mathematically:- **Strain = ΔL/L ,** where ΔL=change in length L= original length
- It is dimensionless quantity because it is a ratio of two quantities.
- For example: - If we have a metal beam and we apply force from both sides the shape of the metal beam will get deformed.
- This change in length or the deformation is known as Strain.

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Hooke's law.

•Robert Hooke was the scientist who gave Hooke's law.
•Hooke's law states that within the elastic limit, stress developed is directly proportional to the strain produced in a body.
•Consider a scenario where we apply external force to the body. As a result stress develops in the body due to this stress there will be a strain produced in the body which implies that there will be some deformation in the body.
•Because of stress, strain is produced.
•According to Hooke's law, if strain increases the stress will increase and vice-versa.
•The Hooke's law is applicable to all elastic substances.
•It does not apply to plastic deformation.
•Mathematically :
•stress $\propto$ strain
•stress = k × strain
•Where k is the proportionality constant and is known as modulus of elasticity.

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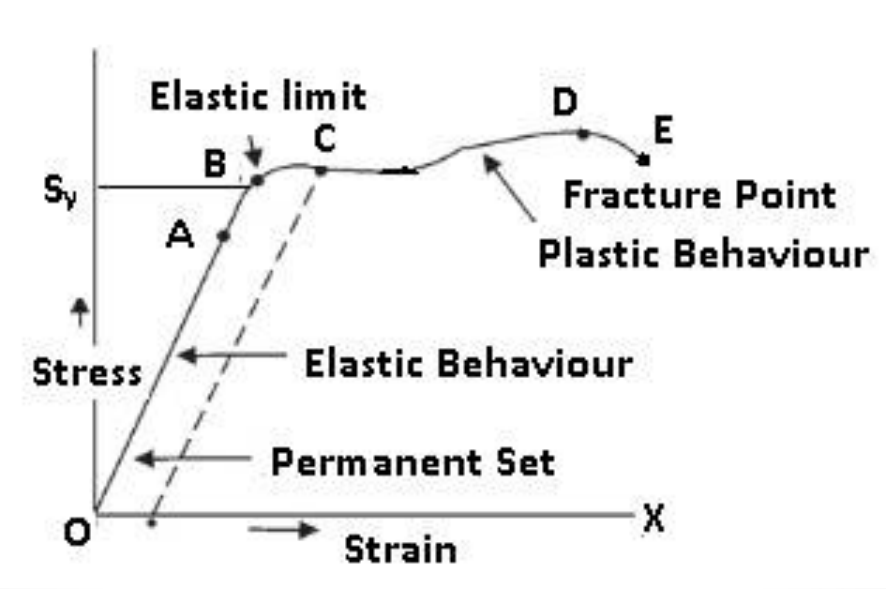
Stress- Strain Curve



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Poisson's Ratio.

When a long bar is stretched by a force along its length then its length increases and the radius decreases as shown in the figure.

Lateral strain : The ratio of change in radius to the original radius is called lateral strain.

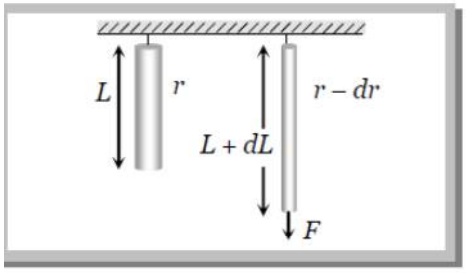
Longitudinal strain : The ratio of change in length to the original length is called longitudinal strain.

The ratio of lateral strain to longitudinal strain is called Poisson's ratio (□). i.e.

i.e.

$$\sigma = \frac{\text{Lateral strain}}{\text{Longitudin al strain}}$$

$$\sigma = \frac{-dr/r}{dL/L}$$



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Elastic Modulus

- Elastic modulus is ratio of stress and strain.
- Elastic modulus is a characteristic value of each material. This means gold will have specific value of elastic modulus and rubber will have specific value of elastic modulus etc.
- k=Stress/Strain where k= Elastic modulus.

Types of Elastic Modulus

1.Young's Modulus
2.Shear Modulus
3.Bulk Modulus

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Modulus of Rigidity.

Within limits of proportionality, the ratio of tangential stress to the shearing strain is called modulus of rigidity of the material of the body and is denoted by η, i.e.

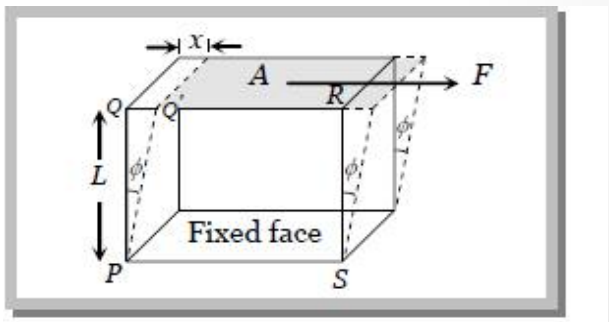
$$\eta = \frac{\text{Shearing stress}}{\text{Shearing strain}}$$

In this case the shape of a body changes but its volume remains unchanged. Consider a cube of material fixed at its lower face and acted upon by a tangential force F at its upper surface having area A. The shearing stress, then, will be

$$\text{Shearing stress} = \frac{F_{\parallel}}{A} = \frac{F}{A}$$

$$\text{Shearing strain} = \phi = \frac{QQ'}{PQ} = \frac{x}{L}$$

$$\eta = \frac{\text{shear stress}}{\text{shear strain}} = \frac{F/A}{\phi} = \frac{F}{A\phi}$$



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Thank You

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