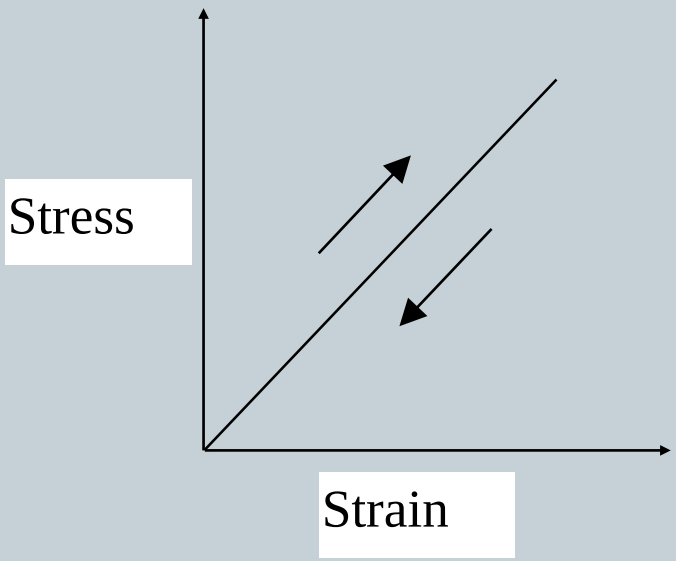
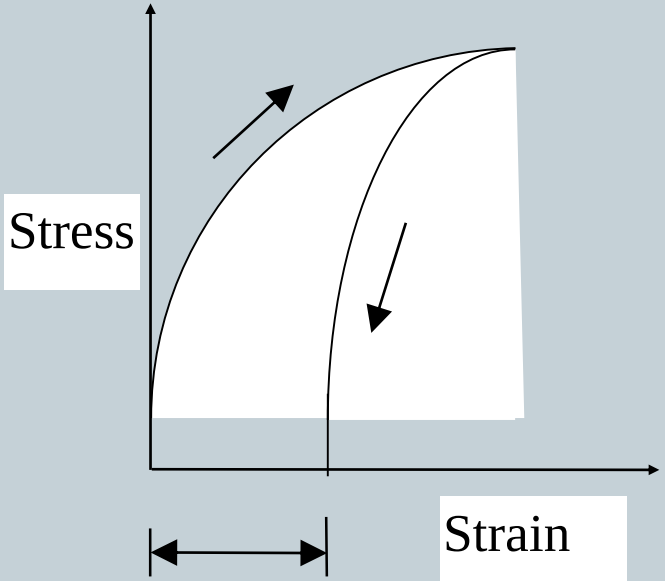
Elastic and Plastic deformation



Elastic deformation



Plastic deformation

Modulus of Elasticity

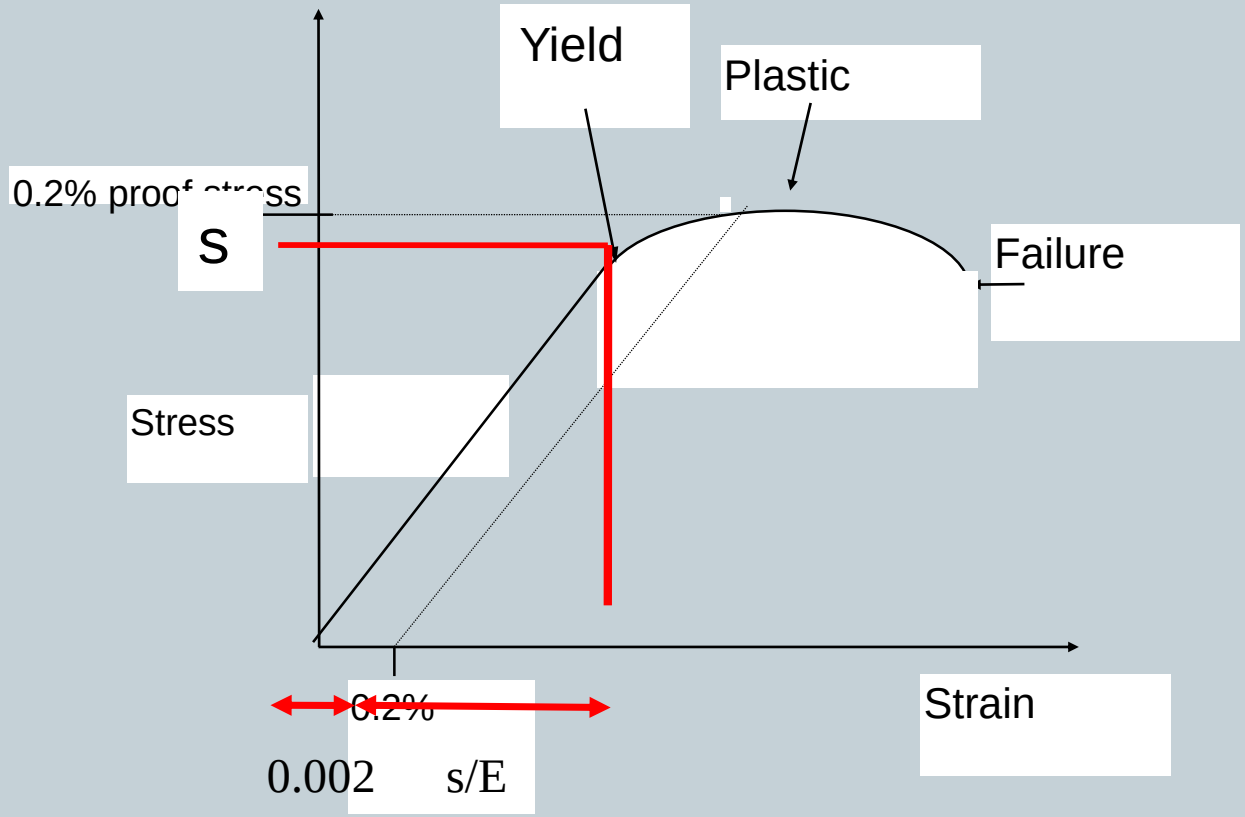
If the strain is "elastic" Hooke's law may be used to define

$$\text{Youngs Modulus } E = \frac{\text{Stress}}{\text{Strain}} = \frac{W}{x} \times \frac{L}{A}$$

Young's modulus is also called the modulus of elasticity or stiffness and is a measure of how much strain occurs due to a given stress. Because strain is dimensionless Young's modulus has the units of stress or pressure

How to calculate deflection if the proof stress applied and then partially removed.

If a sample is loaded up to the 0.2% proof stress and then unloaded to a stress s the strain x = 0.2% + s/E where E is the Young's modulus



Volumetric Strain

- Hydrostatic stress refers to tensile or compressive stress in all dimensions within or external to a body.
- Hydrostatic stress results in change in volume of the material.
- Consider a cube with sides x, y, z. Let dx, dy, and dz represent increase in length in all directions.
- i.e. new volume = (x + dx) (y + dy) (z + dz)

Volumetric Strain Contd.

- Neglecting products of small quantities:
- New volume = x y z + z y dx + x z dy + x y dz
- Original volume = x y z
- = z y dx + x z dy + x y dz
- Volumetric strain $\varepsilon_v = \frac{\Delta V}{x\,y\,z} = \frac{z\,y\,dx + x\,z\,dy + x\,y\,dz}{x\,y\,z}$
- ε_v = dx/x + dy/y + dz/z

$$\varepsilon_v = \varepsilon_x + \varepsilon_y + \varepsilon_z$$

Elasticity and Hooke's Law

- All solid materials deform when they are stressed, and as stress is increased, deformation also increases.
- If a material returns to its original size and shape on removal of load causing deformation, it is said to be **elastic**.
- If the stress is steadily increased, a point is reached when, after the removal of load, not all the induced strain is removed.
- This is called the elastic limit.

Hooke's Law

- States that providing the limit of proportionality of a material is not exceeded, the stress is directly proportional to the strain produced.
- If a graph of stress and strain is plotted as load is gradually applied, the first portion of the graph will be a straight line.
- The slope of this line is the constant of proportionality called modulus of Elasticity, E or Young's Modulus.
- It is a measure of the stiffness of a material.

Hooke's Law

Modulus of Elasticity, E = $\frac{Direct\ stress}{Direct\ strain} = \frac{\sigma}{\varepsilon}$

Also: For Shear stress: Modulus of rigidity or shear modulus, G = $\frac{Shear\ stress}{Shear\ strain} = \frac{\tau}{\gamma}$

Also: Volumetric strain, ε_v is proportional to hydrostatic stress, σ within the elastic range

i.e. : $\sigma / \varepsilon_v = K$ called **bulk modulus**.