ELASTICITY

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

STRESS

Stress is a force F is applied to a surface of area A,

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

Its SI unit is the pascal (Pa).

STRAIN

Strain is measured as the ratio of the change in some dimension of a body to the original dimension in which the change occurred.

$$\text{Strain} = \frac{\Delta l}{l}$$

Strain has no units .

HOOKE'S LAW

If the system obeys Hooke's law, then

stress $\propto$ strain.

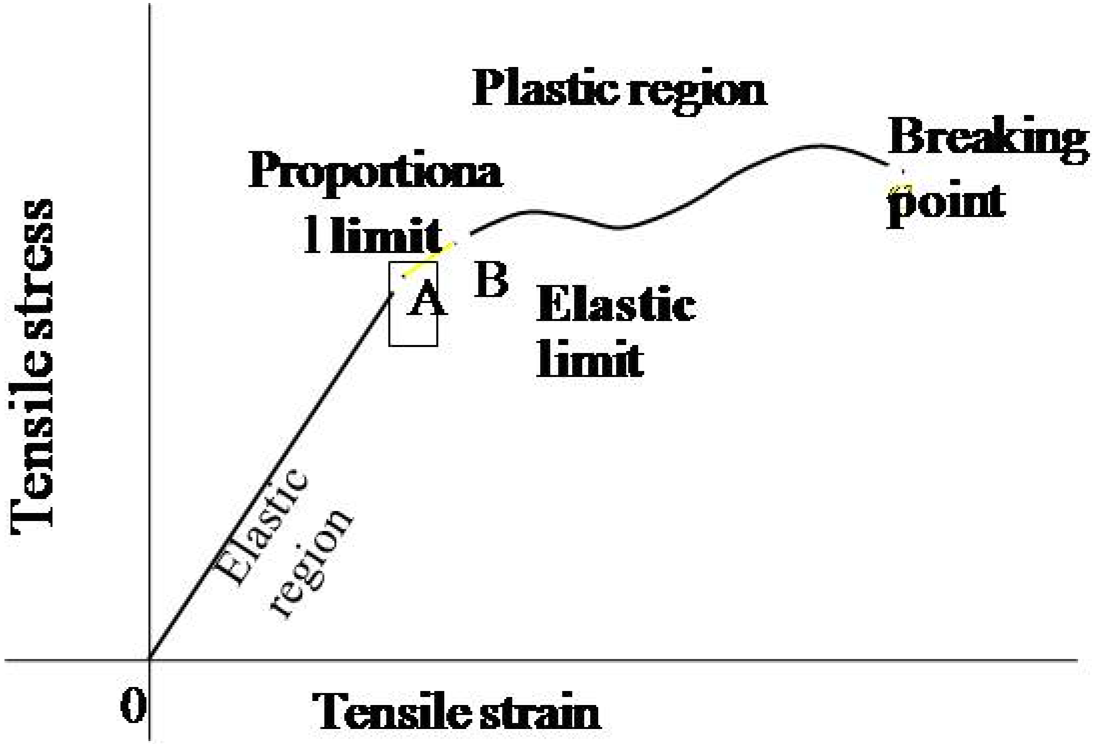
$$\text{Modulus of elasticity} = \frac{\text{Stress}}{\text{Strain}}$$

The modulus has the same units as stress. A large modulus means that a large stress is required to produced a given strain.

THE ELASTIC LIMIT

Elastic limit of a body is the smallest stress that will produce a permanent distortion in the body .

The Elastic limit

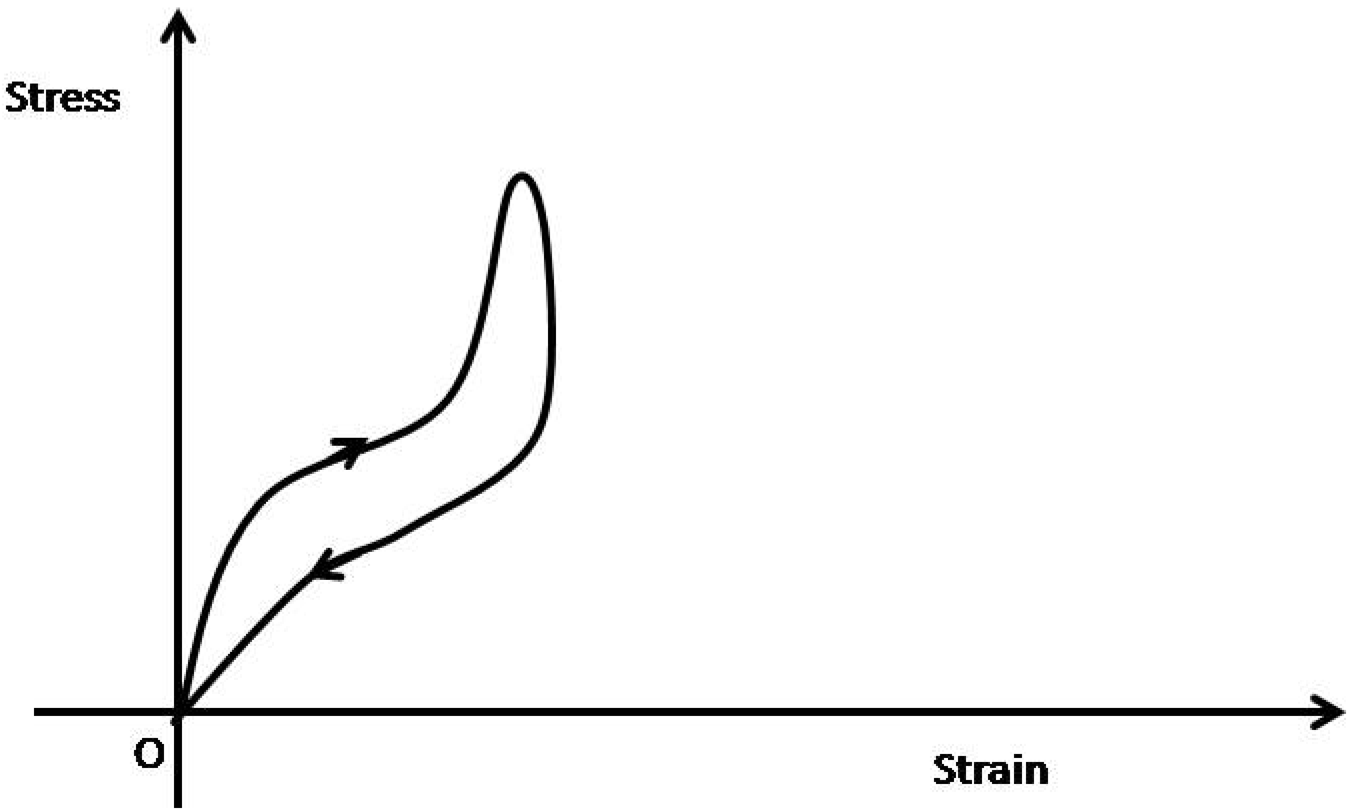


THE YOUNG'S MODULUS (or tensile modulus)

The Young's modulus (or tensile modulus, Y)

describes the length elasticity of a material.

$$Y = \frac{\text{Stress}}{\text{Strain}} = \frac{Fl}{A \Delta L}$$


Stress
O
Strain

The lack of coincidence of the curves for increasing and decreasing stress is known as elastic hysteresis. The area of the hysteresis loop is proportional to the energy (per unit volume) dissipated within the elastic material.

Applications

1. Sutures made from horse hair, catgut or silk, are all materials with elastic properties which increase when they are wet.

2. The natural elasticity of the skin, ligaments and tendons.

3. The elastic property of the lung and chest wall.

1. $F = ?$

$$d = 0.1\ \text{cm} = 1 \times 10^{-3}\ \text{m}$$

$$r = \frac{1 \times 10^{-3}}{2} = 5 \times 10^{-4}\ \text{m}$$

$$A = p\, r^2 = 3.14 \times (5 \times 10^{-4})^2 = 78.5 \times 10^{-8}\ \text{m}^2$$

$$\text{stress} = 8 \times 10^{7}\ \text{Nm}^{-2}$$

$$\text{stress} = \frac{F}{A}$$

$$F = \text{Stress} \times A$$

$$= 8 \times 10^{7} \times 78.5 \times 10^{-8} = 62.8\ \text{N}$$

$$L = 5m$$

$$\Delta L = ?$$

$$Y = 0.7 \times 10^{11} \text{ Pa}$$

$$Y = \frac{\text{stress}}{\text{strain}} = \frac{\text{stress}}{\Delta L / L}$$

$$\Delta L = \frac{\text{stress} \times L}{Y} = \frac{8 \times 10^{7} \times 5}{0.7 \times 10^{11}}$$

$$= 57.1 \times 10^{-4} \text{ m}$$

$F_1 = 25\ N$

$\Delta L = 5\ cm = 5 \times 10^{-2}\ m$

$L_1 = 0.2\ cm = 2 \times 10^{-3}\ m$

$A = 50\ cm^2 = 50 \times 10^{-4}\ m^2$

$Y_1 = ?$

$$Y_1 = \frac{F_1\ L}{A\ \Delta L} = \frac{25 \times 0.2}{50 \times 10^{-4} \times 5}$$

$$= 2 \times 10^{2}\ Pa$$

$50 \times 10^{-4} \times 5 \times 10^{-2}$

$F_2 = 500\ N$

$\Delta L = 5\ cm = 5 \times 10^{-2}\ m$

$L = 0.2\ cm = 2 \times 10^{-3}\ m$

$A = 50\ cm^2 = 50 \times 10^{-4}\ m^2$

$Y_2 = ?$

$$Y_2 = \frac{F_2 L}{A\ \Delta L} = \frac{500 \times 0.2}{50 \times 10^{-4} \times 5}$$

$$= 4 \times 10^3\ Pa$$