Concept of STRESS (1), STRAIN (2) AND YOUNG MODULUS (3)

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The above terms are used in relation with any WIRE / ROD / MATERIAL when a FORCE is applied on it.

side note.

Materials

Spring. ROD/WIRE

copper, Iron

Force → Stress

extension → Strain

Spring Const. → Young's Modulus

① Stress is an alternate name for Pressure ∴ same definition, same formula same units hence

Stress = force per unit Area

$$\text{Stress} = \frac{\text{force}}{\text{Area}}$$

units Nm^{-2} or Pa.

② Strain is defined as change in length upon original length of the material or extension upon original length

Strain does not have any units (i.e it is a dimensionless Quantity). It is given by the formula

$$\text{Strain} = \frac{\text{Change in length}}{\text{original length}}.$$

$$\text{Strain} = \frac{\Delta L}{L} \rightarrow ①$$

no units i.e units Cancels out. hence Strain is a pure number. [can be +ve or -ve].

$$\text{Strain} = \frac{\text{extension}}{\text{original length}}$$

$$\text{Strain} = \frac{e}{L} \rightarrow ②.$$

③ Young's Modulus :. It is defined as the ratio of Stress over Strain. Hence

$$\text{Young's Modulus} = \frac{\text{Stress}}{\text{Strain}}$$

Stress → same units as Pressure

Strain → no units

Young's Modulus is denoted by the symbol E.

It is measured in units of Pascals (Pa) or (Nm^{-2})

$$E = \frac{\text{Stress}}{\text{Strain}}$$

$$E = \frac{\frac{F}{A}}{\frac{e}{L}} \quad \therefore \quad E = \frac{FL}{Ae}$$

k

based on Hooke's law i.e $F = ke$ or $k = \frac{F}{e}$

$$E = \frac{k \cdot L}{A}$$

$E \propto k$

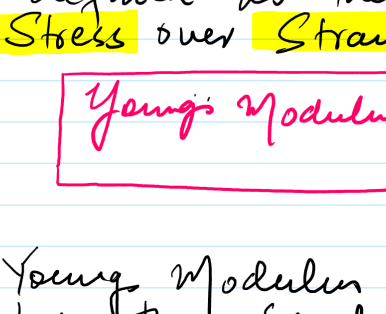
E HIGH → k RIGID

E LOW → k FLEXIBLE

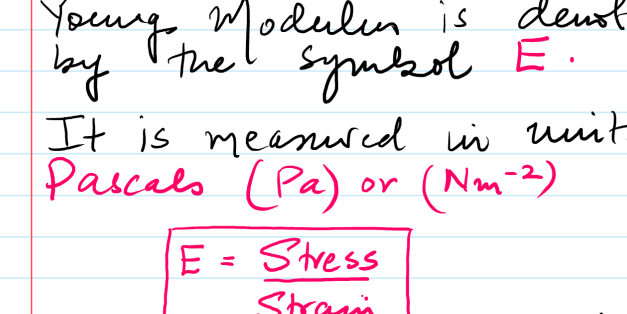
E Const → k Const

Young's Modulus (E) is Constant for a given material

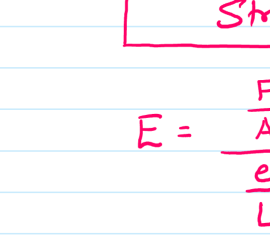
- E_{HIGH} [for materials which are difficult to undergo extension]
- E_{LOW} [for materials which are easier to undergo extension].

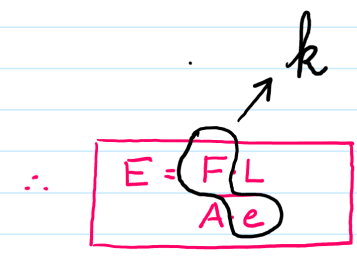


Springs



Rod





Area under the graph represents Strain Energy i.e $\frac{1}{2} \times F \times e$.

What will the shaded area represent ?

$$\text{Area} = \frac{1}{2} \times \text{Stress} \times \text{Strain}$$

$$= \frac{1}{2} \times \frac{F}{A} \times \frac{e}{L}$$

$$= \frac{\text{Strain Energy}}{\text{Volume}}$$

Area under Stress vs Strain graph represents Strain Energy per unit Volume