STRESS, STRAIN, & YOUNG'S MODULUS: DEFORMATION OF SOLIDS

- The above terms are used in relation with any wire/rod/material when a force is applied on it

Stress:

Stress is an alternate name for pressure.
Same definition, formula, and units
Hence,

$$\text{Stress} = \frac{\text{Force}}{\text{Area}} \quad \left[\frac{\text{Force per unit}}{\text{Area}}\right]$$

$$\text{Stress} = \frac{F}{A} \quad [\text{in Pa or } Nm^{-2}]$$

Strain

- Ratio of change in length (extension) to the original length of the material
- Strain does not have any units (bc. it's a ratio). Hence, it is a dimensionless quantity
- It is given by the formula:

$$\left[\text{Strain} = \frac{\Delta l}{l}\right] \text{ or } \left[\text{Strain} = \frac{e}{l}\right]$$

where e or Δl = extension
l = original length

Young's Modulus

- It is defined as the ratio of stress to strain
- It is measured in Pa or Nm^{-2}
- It is denoted by the symbol "E"

$$\left[\text{Young's Modulus} = \frac{\text{Stress}}{\text{Strain}}\right]$$

$$E = \frac{F}{A} \times \frac{l}{e}$$

when dealing with rods/wires/materials, etc. $E \propto Fl$, $E \propto \frac{1}{Ae}$

$$\left[E = \frac{Fl}{Ae}\right]$$

OR

when dealing with springs

$$\left[E = \frac{kl}{A}\right]$$

$E \propto k$

where E = Young's Modulus
F = Force applied
l = unstretched length
A = Area (from stress)
e = extension
k = Spring constant

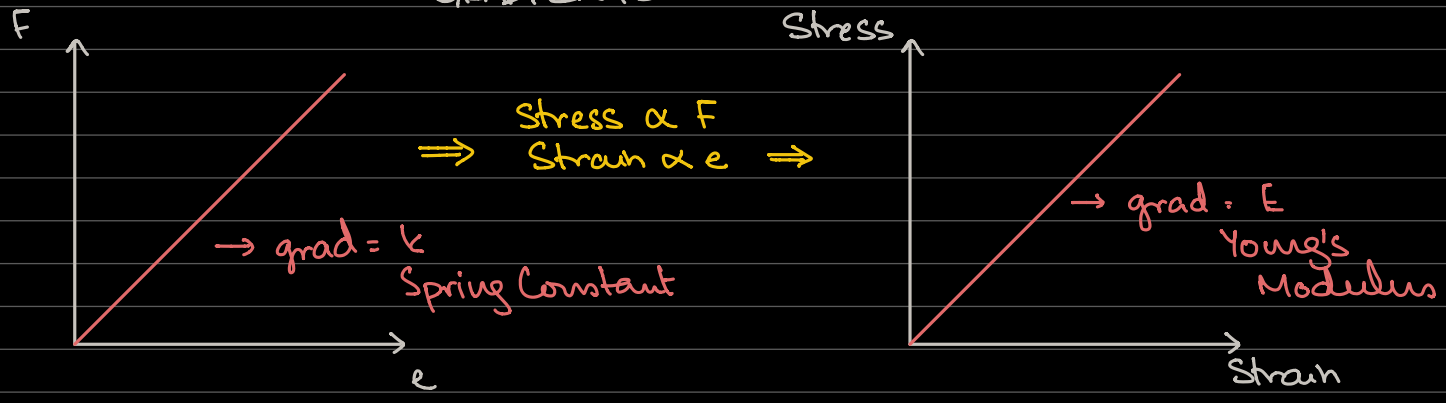
- Young's Modulus (E) is constant for a given material

Also note:

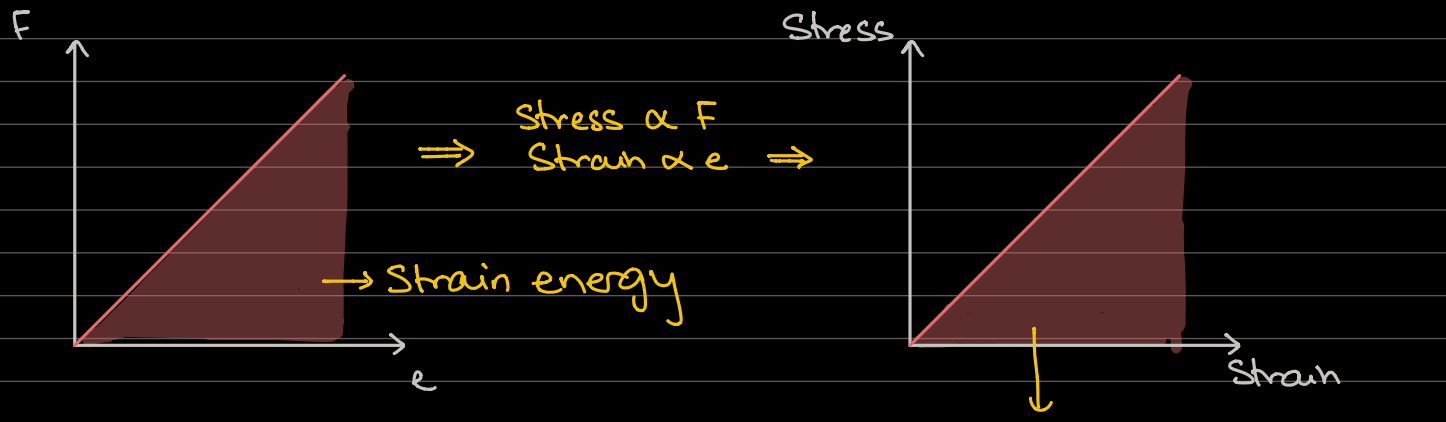
- Materials which are difficult to stretch / "extend" will have a High Young's Modulus Value (E).

↳ And vice versa

GRADIENTS:



AREAS UNDER



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

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

$= \frac{\text{Strain Energy}}{A \times L}$

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

↳ "Strain energy per unit volume" of the material