Q. Describe an experiment to plot the graph between stress acting and strain produced on a metallic wire. How do you calculate the Young's modulus of the material of the wire. Explain the different regions of the graph.

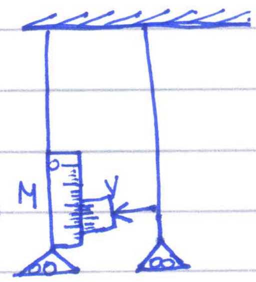
Consider an experimental wire held vertically from a rigid support with a vernier scale V. The original length L and area of cross-section A are measured. A reference wire attached with a main scale is held close to it as shown.

The experimental wire is attached with different known masses (m) and the corresponding extensions (ΔL) are measured.

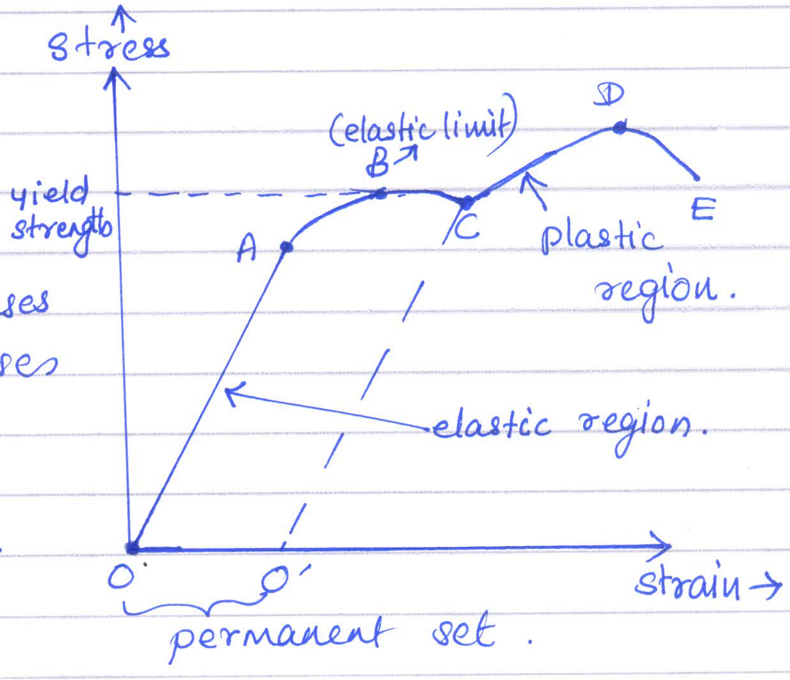
$$\text{Stress} = F/A = \frac{mg}{\pi r^2}.$$

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

$Y = \frac{FL}{\pi r^2 \Delta l}$ can be calculated.



The stress and strain are found in each case and a graph is plotted as shown.



The different regions can be explained as given.

Region OA.

As stress increases strain also increases upto a maximum stress. The wire obeys Hookes law.

Region AB.

Here greater strain is obtained for a given stress. Hookes law is not obeyed. But if the load is removed, it comes back to the original position o. B is called yield point or elastic limit. The corresponding strength is yield strength.

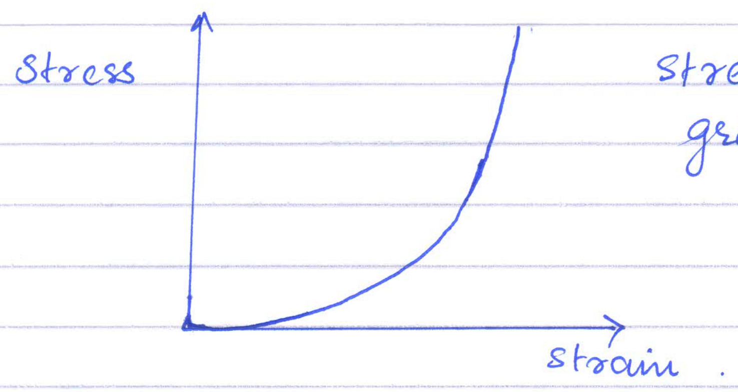
Region BC.

Here even for small stress, large strain is produced. Once the stress is removed completely, the body does not come back to the original position. Instead it comes back to a new position O′.

The point D is called ultimate tensile strength of the material. Beyond this point, even for less stress, the wire breaks. If D & E are close the material is brittle. ie, it will break easily. If they are far apart, the material is ductile. ie, can be made into thin wires.

The region B-E is called plastic region.

Elastomers are substances that can be stretched to large values of strain. Eg. tissues of iorta, rubber.



Stress - strain graph for elastomers.

Elastic fatigue - the loss of elastic property due to continuous and repeated use. Due to elastic fatigue bridges are declared unsafe after a long time of use.

Derive an expression for elastic P.E stored in a stretched wire.

Consider a wire of length L and area of cross-section A. Let a force F be applied to stretch the wire by l.

$$\text{stress} = \frac{F}{A} \qquad \text{strain} = \frac{l}{L}.$$

$$Y = \frac{FL}{Al}. \qquad \therefore F = \frac{YA}{L} l.$$

Let dw be the work done to stretch the wire through dl.

$$W = \int dw = \int F . dl . = \int \frac{YA}{L} l \, dl$$

$$= \frac{YA}{L} \int_0^l l \, dl.$$

$$= \frac{YA}{L} \left[\frac{l^2}{2}\right]_0^l = \frac{YAl^2}{2L}$$

$$W = \frac{1}{2} \frac{YAl}{L} \times l$$

$$= \frac{1}{2} \times \text{load} \times \text{extension}.$$

This work will store as P.E.

$$\therefore \text{P.E} = \frac{1}{2} \text{load} \times \text{extension}.$$

Also P.E stored / unit volume $= \dfrac{1}{2} \dfrac{\text{load} \times \text{extension}}{A \times L}.$

$$= \frac{1}{2} \text{stress} \times \text{strain}$$

Q. A steel wire is stretched by a weight of 400 N. If the radius of the wire is doubled how will the youngs modulus of the material of the wire change.

It will not change.