Sunday, April 11, 2021

Loading & Unloading

Deformation of solid & Elasticity of materials – Module 3

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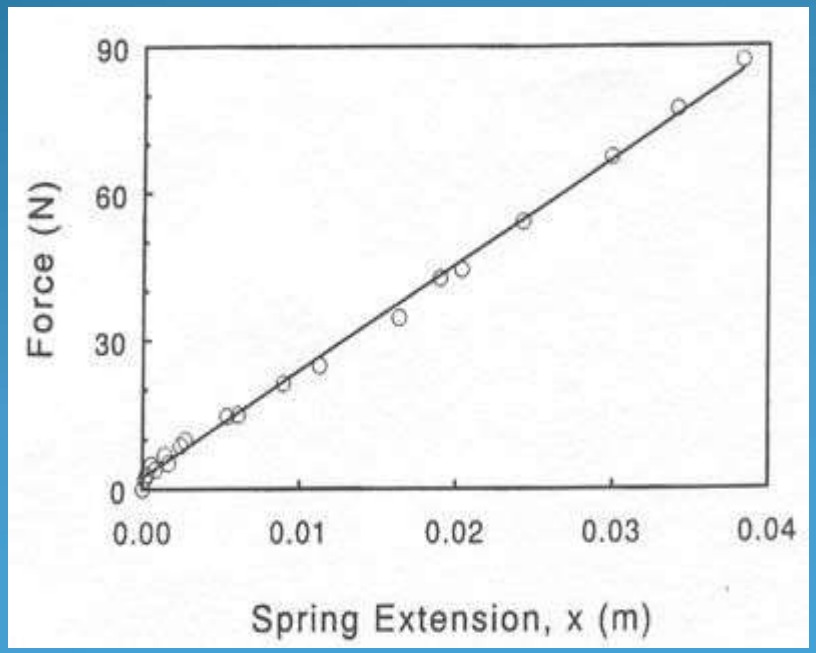
Materials : *Loading & Unloading*

Learning Objectives

1. To understand that once the elastic limit has been exceeded, the force-extension graphs for loading and unloading are unequal
2. To know that such curves are called hysteresis curves.
3. To be able to describe such graphs for different materials
4. To describe the energy changes during loading/unloading

Materials : Loading & Unloading

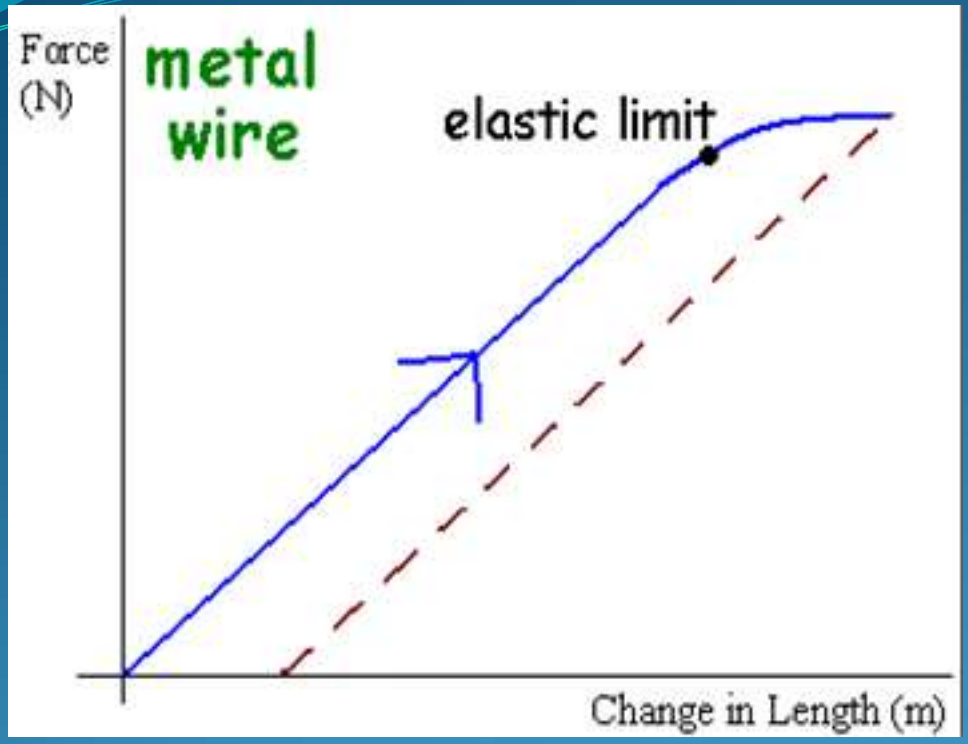
We have seen that providing the elastic limit of the material is not exceeded then Hooke's law is obeyed and the graph obtained during loading and unloading will be identical, that is when sample contracts it follows the same Force-Extension curve as when it was being stretched.



Elastic deformation ⇒ Reversible extension

However, once the limit of elasticity has been exceeded this is no longer true for the same body.

Materials : Metal

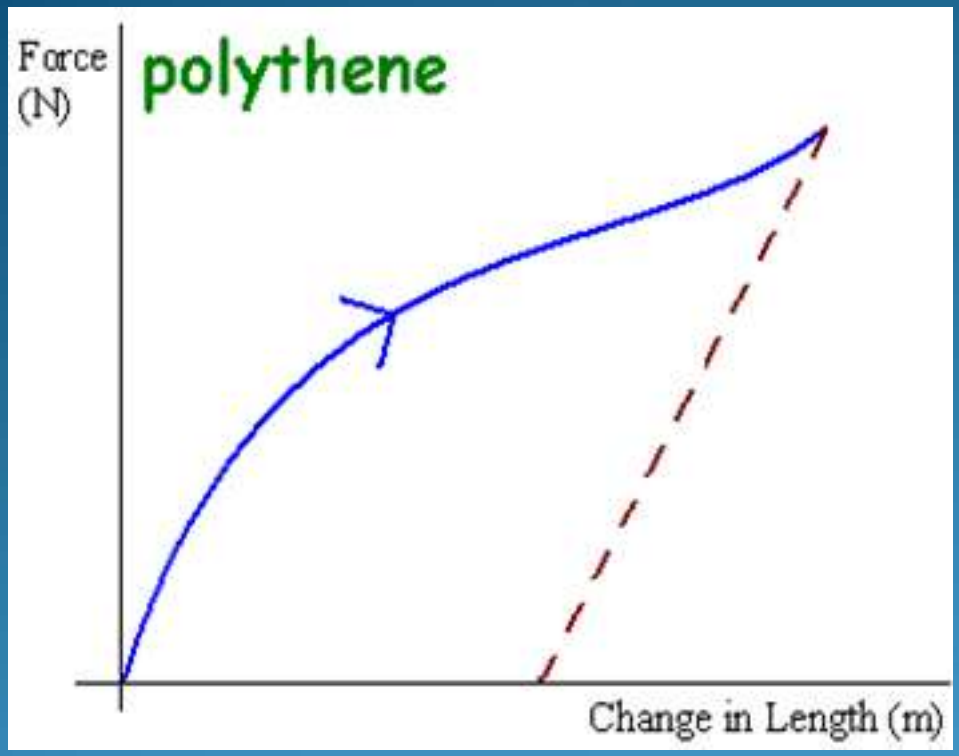


Such curves are called Hysteresis curves

For a material such as a metal wire, once the elastic limit has been exceeded, the curve obtained during unloading, (brown) follows parallel to the original loading curve (blue)

There has been a permanent extension!

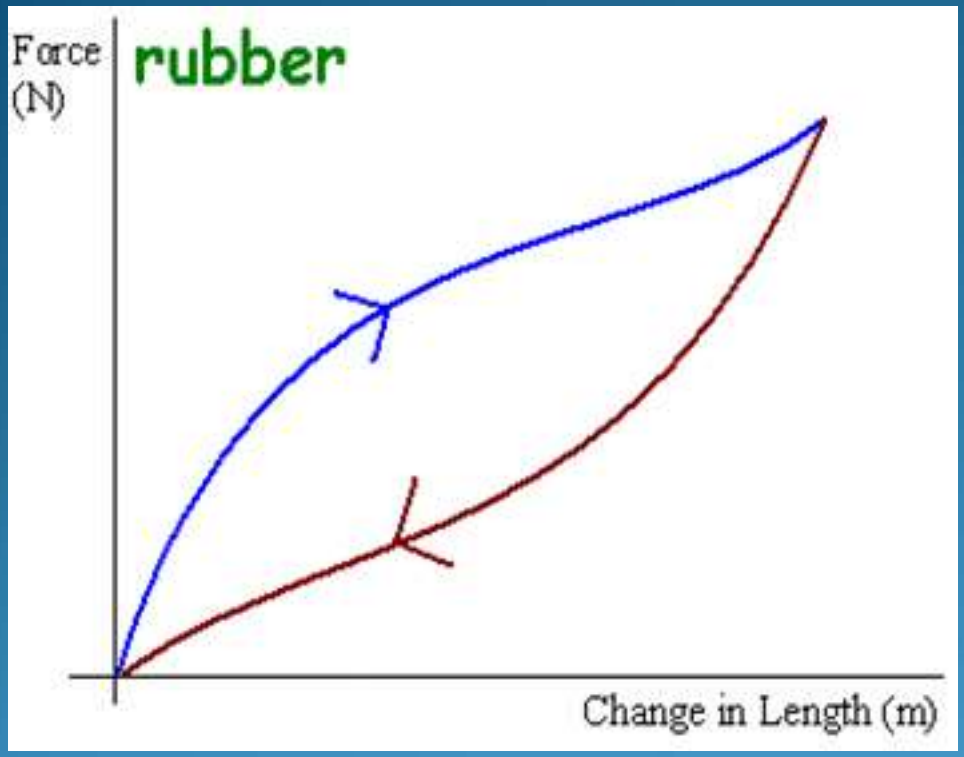
Materials : Polythene



Plastic deformation ⇒ Permanent extension

Tangled when unstretched, weak intermolecular cross links exist between the molecules. These break during stretching but new bonds reform when the tension is removed.

Materials : Rubber



Very low limit of proportionality

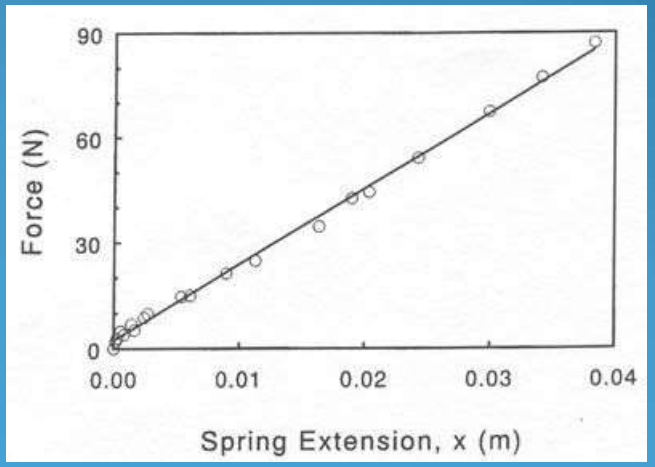
In contrast a very elastic material such as rubber, loads and unloads in a very different way

- **Curled when unstretched**
- **Uncurled when stretched**
- **Curling / uncurling is different**

Materials : *Strain Energy 1*

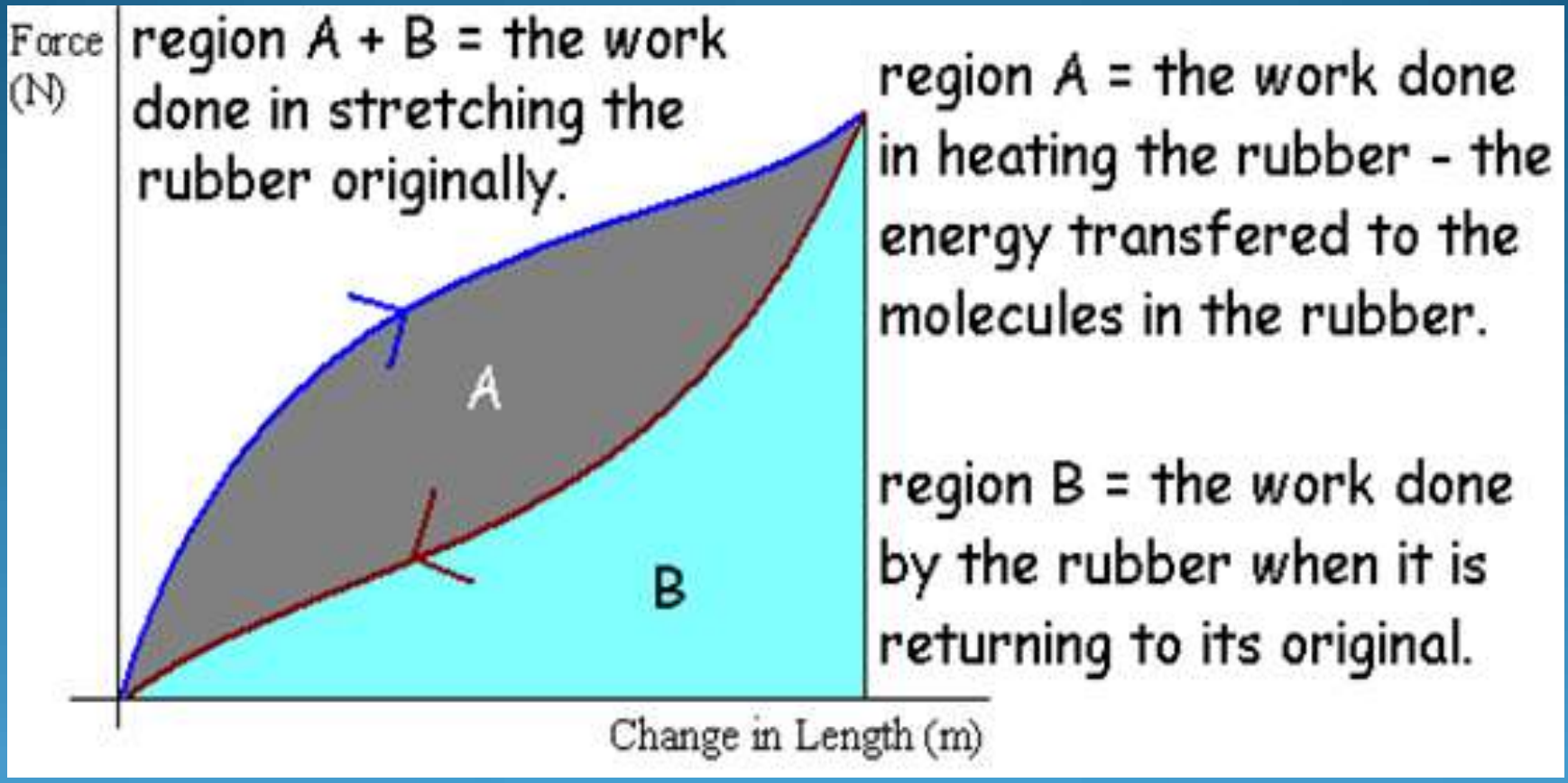
Earlier we saw that the area under a force-extension graph shows the work done to stretch the material. This is more correctly called the **strain energy**

When the graph is linear the work done during stretching is recovered when it is unloaded



Materials : *Strain Energy 2*

Hysteresis loop for rubber...

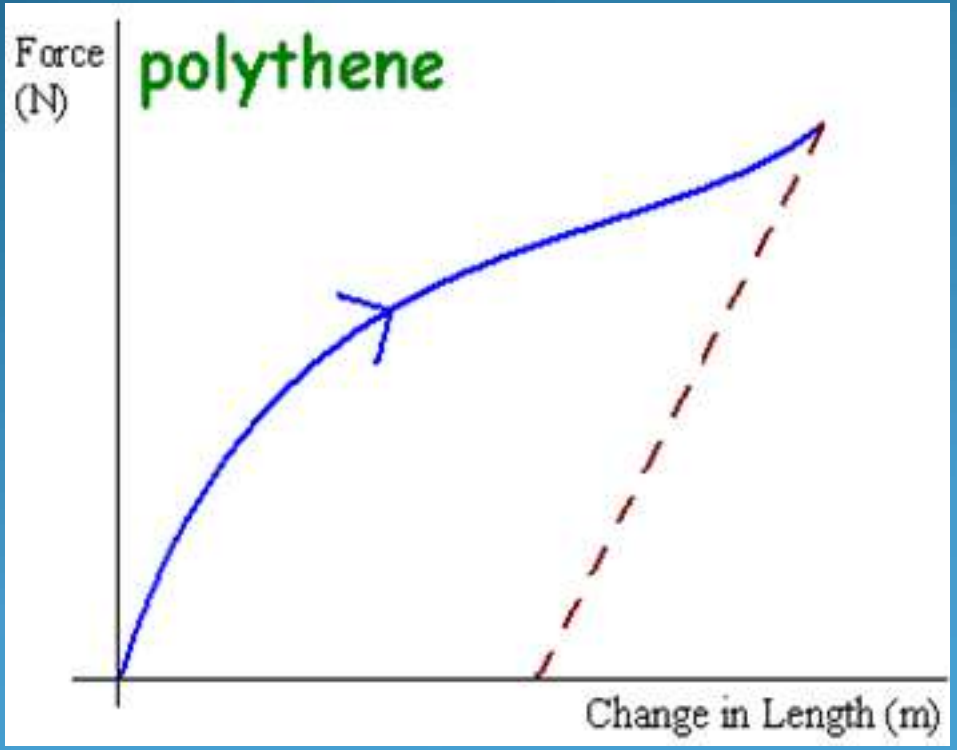


B – Recoverable energy

A – Unrecoverable energy due to permanent strain

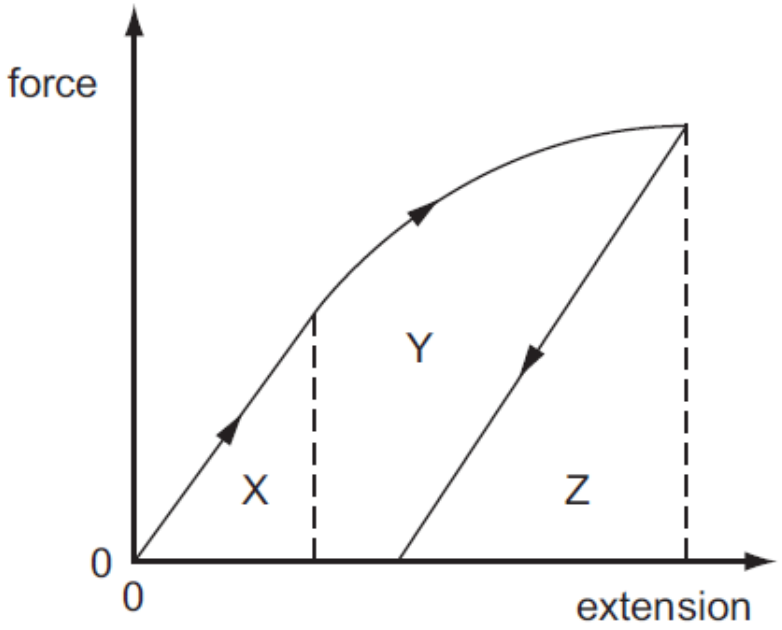
Materials : *Strain Energy 3*

In a material such as polythene, much of the work done during loading is used to deform the material permanently



Question

A ductile material is stretched by a tensile force to a point beyond its elastic limit. The tensile force is then reduced to zero. The graph of force against extension is shown below.



Which area represents the net work done on the sample?

A X **B** X + Y **C** Y + Z **D** Z

CIE A'Level Oct-Nov Paper 1 2005 Q 20

Problem-solving

- Hooke’s law

- Elastic potential energy

- Young’s modulus, tensile stress, tensile strain

Credits

Dr Poulton and Mr Moore
Ranelagh A level Physics Wikispace