Beckfoot

Subject: A-level Physics	Topic: Materials	Year Group: 12

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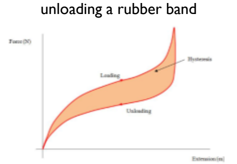
Springs

1	The spring (or stiffness) constant measures a materials resistance to being pulled apart. The bigger the constant, the stiffer the material.
2	Gradient of a force-extension graph = stiffness constant.
3	A stretched spring stores energy called elastic strain energy. The amount of energy stored is equal to the work done when stretching the spring.
4	Elastic strain energy = area under a force-extension graph.
5	Sometimes when stretching materials some energy is transferred to the internal energy of the object (it heats up).

6

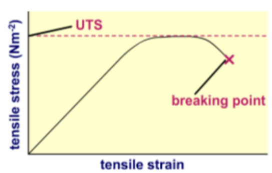
F-ΔL graph for loading and unloading a rubber band



Work done in stretching = area under loading curve.
Elastic strain energy recovered = area below unloading curve.
The shaded area is the energy transferred to the rubber as internal energy.

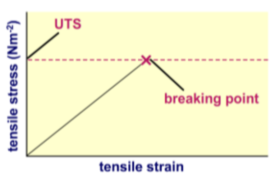
Stress-strain graphs

1



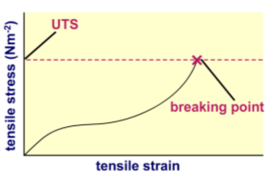
Ductile material – e.g. copper. Maintain their shape when stretched beyond their elastic limit.

2



Brittle material – e.g. glass. Have a linear stress-strain graph until they fracture. They do not undergo any plastic deformation.

3



Polymeric material – e.g. rubber. Materials made of polymers. They do not have a linear stress-strain graph.

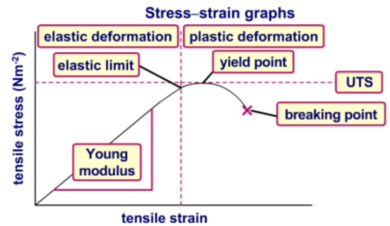
Key equations

1	Density (kgm^{-3})	$\rho = \frac{m}{V}$
2	Stiffness/spring constant (Nm^{-1})	$k = \frac{F}{\Delta L}$
3	Energy stored (J)	$E = \frac{1}{2}F\Delta L$
4	Young modulus (Pa)	$E = \frac{tensile\ stress}{tensile\ strain} = \frac{FL}{A\Delta L}$

Young modulus

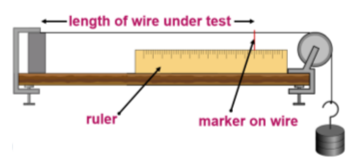
1 It is a measure of the stiffness of a material.

2 It is given by the gradient of a stress-strain curve.



Young modulus required practical

1 Use this set-up.



2 Measure diameter of wire using a micrometre then calculate the cross-sectional area.
Apply different forces to the wire and for each force determine the extension of the wire by subtracting the original wire length from the new length.
Determine the stress (F/A) and strain (Δl/l) for each force.
Plot a stress-strain graph. Gradient=young modulus.

Key Vocabularly

1	Density	Defined as mass divided by volume.
2	Hooke's law	The extension of a spring, Δl, is directly proportional to the force applied (up to the limit of proportionality).
3	Elastic limit	The point beyond which a material will no longer return to its original size when the force is removed.
4	Limit of proportionality	The point beyond which the material no longer obeys Hooke's law.
5	Tensile stress	The stretching force applied per unit cross-sectional area.
6	Tensile strain	Extension divided by original length.
7	Elastic strain energy	The energy stored in an elastic material that has been stretched.
8	Breaking stress	The largest tensile stress that can be applied to a material before it breaks.
9	Elastic material	Materials that return to their original length once the force is removed.
10	Plastic material	Materials that remain deformed once the force is removed.
11	Brittle	Materials that show very little plastic deformation before breaking.
12	Ductile	Materials that have large plastic deformations before breaking (can be drawn into wires).
13	Young modulus	Young modulus = tensile stress / tensile strain.