WJEC England Physics A Level

Topic 2.5: Solids Under Stress

Flashcards

State Hooke's law.

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Extension (ΔL) is directly proportional to force applied (F), given that the environmental conditions are kept constant.

$$F = k\Delta L$$

k is the stiffness constant in Nm^-1

What is meant by tensile stress?

What is meant by tensile stress?

The force applied per unit cross sectional area:

Stress = F/A

Stress units: Nm^{-2}

$$\sigma = \frac{F}{A}$$

Force units: N

Cross sectional area units: m^2

What is tensile strain?

What is tensile strain?

A measure of how the material stretches: the extension (ΔL) divided by the original length (L), strain has no units.

Strain = ΔL/L

$$\varepsilon = \frac{\Delta l}{l}$$

What is the difference between elastic and plastic deformation?

What is the difference between elastic and plastic deformation?

Elastic deformation: when the force is removed the object will return to its original shape.

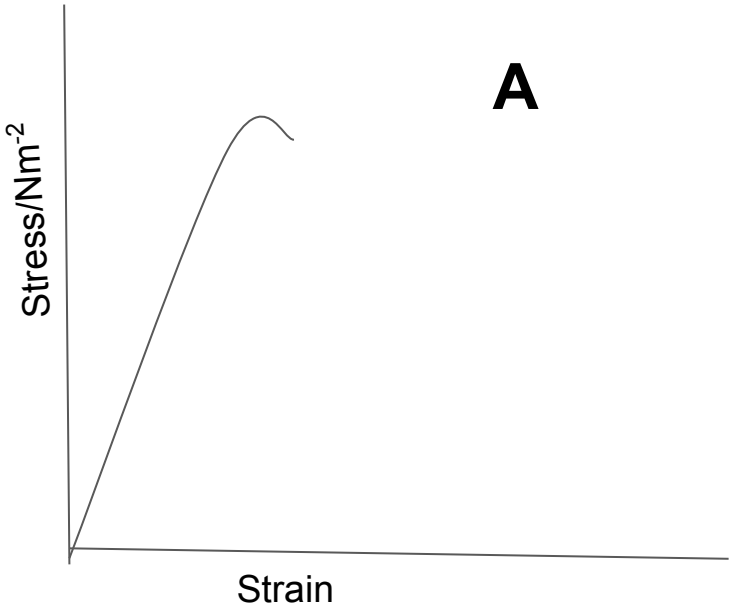
Plastic deformation: after the load is removed the object will not return to its original shape.

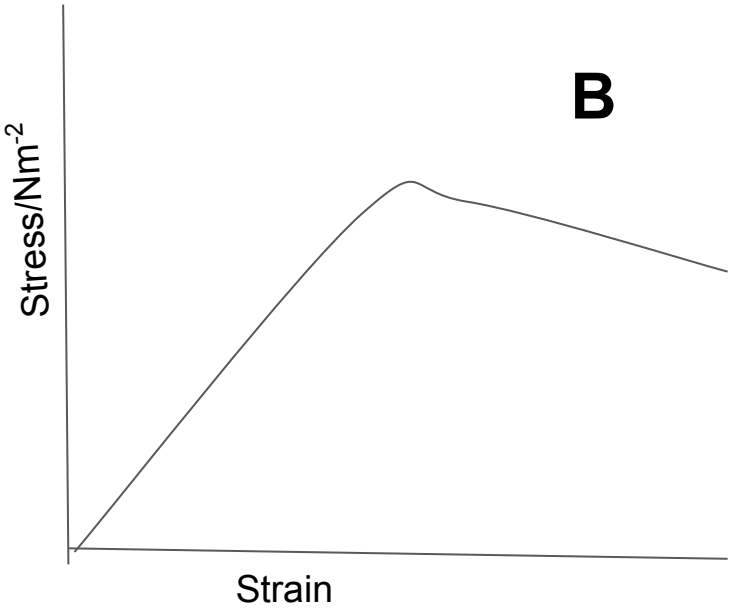
What is breaking stress?

What is breaking stress?

The minimum stress needed to break a material.

Which of these two graphs represents a brittle material?





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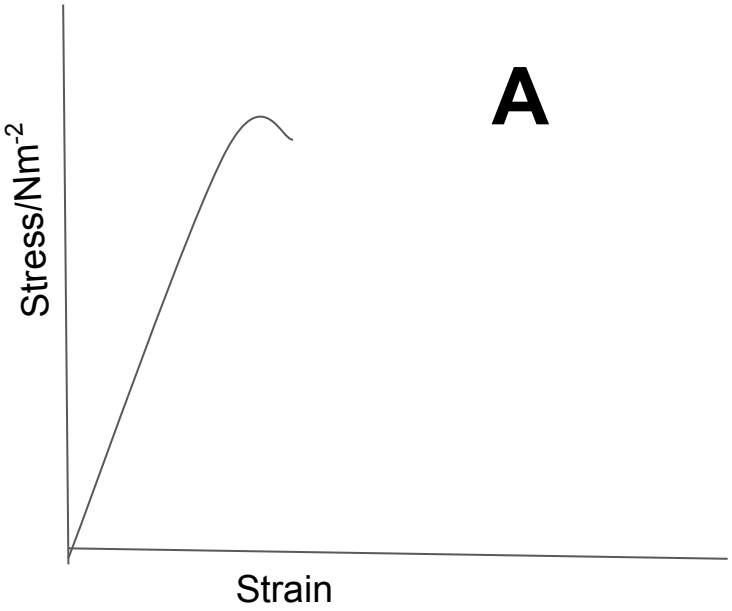
A



What is meant when a material is described as brittle?

What is meant when a material is described as brittle?

It doesn't deform plastically but breaks when the stress reaches a certain value.

What is the elastic limit?

What is the elastic limit?

The force above which the material will be plastically deformed (permanently stretched).

What does the area underneath a force - extension graph represent?

What does the area underneath a force - extension graph represent?

The work done to deform the material:

$$Work\ done = \frac{1}{2} \times F \times \Delta L$$

State the equation to calculate elastic strain energy from the spring constant and extension.

State the equation to calculate elastic strain energy from the spring constant and extension.

$$E = \frac{1}{2} k \Delta L^2$$

What is Young's modulus?

What is Young's modulus?

Young's modulus (E) = tensile stress / tensile strain

$$E = \frac{\sigma}{\varepsilon}$$

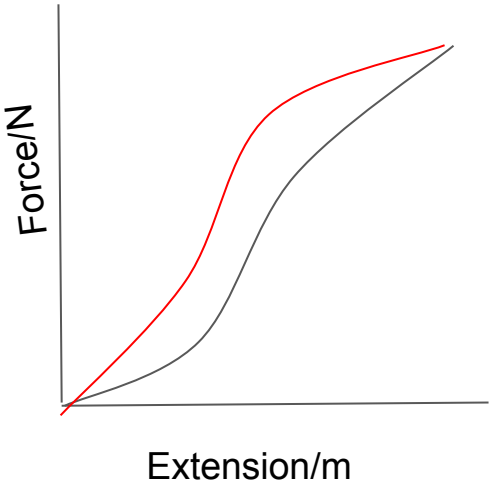
It describes the stiffness of a material.

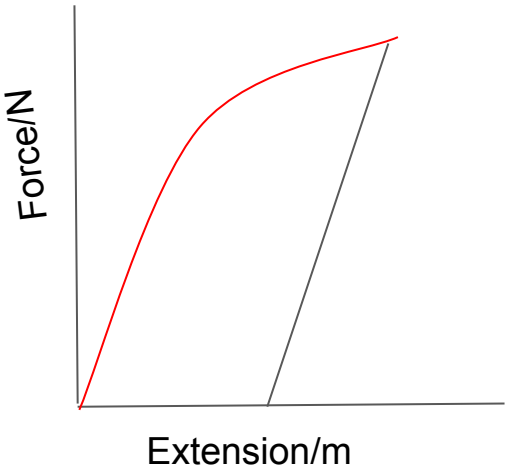
How do you find the Young's modulus from a stress-strain graph?

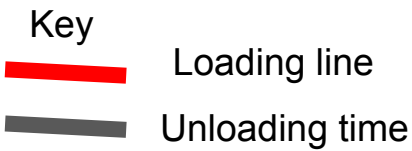
How do you find the Young's modulus from a stress-strain graph?

The gradient of the line.

Which of these graphs would represent a wire which has plastically deformed?

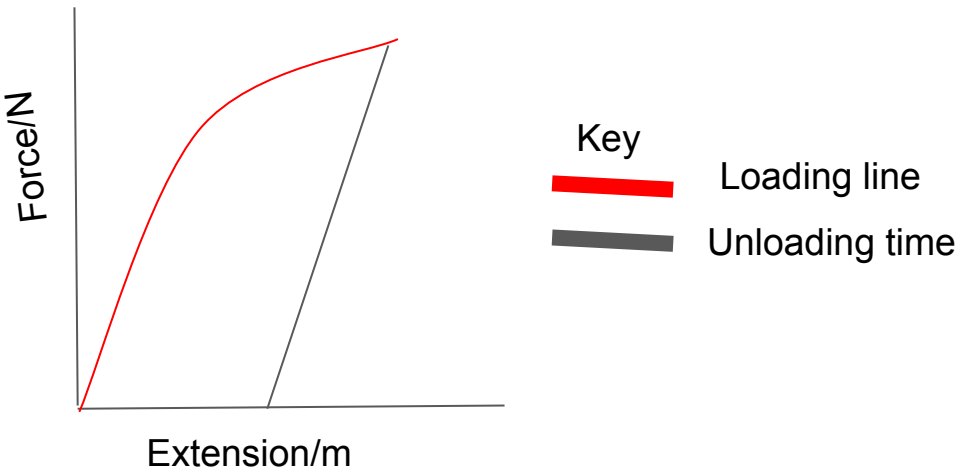






Which of these graphs would represent a wire which has plastically deformed?

The unloading line doesn't go through the origin as the material is permanently extended (stretched).



How can a force-extension graph show Hooke's Law is being obeyed?

How can a force-extension graph show Hooke's Law is being obeyed?

When it is a straight line through the origin ie. force and extension are directly proportional.

What is the limit of proportionality and what does it look like on a force-extension graph?

What is the limit of proportionality and what does it look like on a force-extension graph?

The point after which Hooke's law is no longer obeyed, it is shown by the line beginning to curve on a force-extension graph.

How is the work done to stretch or compress a material stored?

How is the work done to stretch or compress a material stored?

Elastic strain energy.

Why are the loading and unloading lines parallel on a force-extension graph for a plastically deformed material?

Why are the loading and unloading lines parallel on a force-extension graph for a plastically deformed material?

The stiffness constant (k) hasn't changed, the forces between the atoms are the same when loading and unloading.

Why isn’t all work done stored as elastic strain energy when a stretch is plastic?

Why isn't all work done stored as elastic strain energy when a stretch is plastic?

Work is done to move atoms apart, so energy is not stored as elastic strain energy but is dissipated as heat.

How is the dissipation of energy in plastic deformation used to design safer vehicles?

How is the dissipation of energy in plastic deformation used to design safer vehicles?

- Crumple zones deform plastically in a crash using the car's kinetic energy so less is transferred to the passengers.
- Seat belts stretch to convert the passenger's kinetic energy into elastic strain energy.

Outline the energy changes that occur when a spring fixed at the top is pulled down and released.

Outline the energy changes that occur when a spring fixed at the top is pulled down and released.

The work done in pulling the spring down (stretching it) is stored as elastic strain energy, when the spring is released this is converted to kinetic energy which is converted to gravitational potential energy as the spring rises.

Do stress-strain graphs show the behaviour of a material or a specific object?

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Material.

Where would you find the ultimate tensile stress on a stress-strain graph?

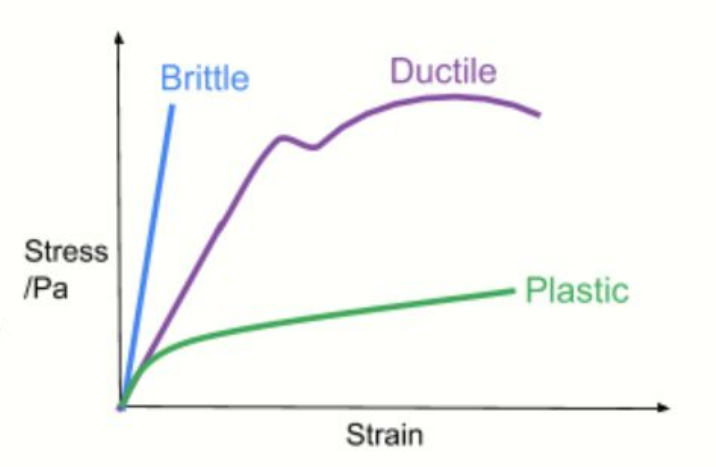
Where would you find the ultimate tensile stress on a stress-strain graph?

The highest point on a graph - it is the maximum stress a material can withstand.

What would the stress-strain graph for a ductile material look like?

What would the stress-strain graph for a ductile material look like?

A ductile material can undergo a large amount of plastic deformation before fracturing.



Define the spring constant.

Define the spring constant.

- The force per unit extension required to stretch a spring.
  - Denoted by ‘k’.
  - Inherent property of the spring.

State Hooke's law.

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Extension (denoted by ΔL or x) is directly proportional to force applied (F), given that the environmental conditions are kept constant.

$$F = k\Delta L$$

where k is the spring constant in Nm^{-1}

What is meant by tensile stress?

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The force applied per unit cross-sectional area:

$$\text{Stress, } \sigma = F/A$$

Stress units: Nm^{-2}

Force units: N

Cross-sectional area units: m^2

What is tensile strain?

What is tensile strain?

A measure of how a material stretches. It is equal to the extension (ΔL) divided by the original length (L). Since strain is a ratio, it has no units.

$$\text{Strain, } \varepsilon = \Delta L / L$$

What is the difference between elastic and plastic deformation?

What is the difference between elastic and plastic deformation?

Elastic deformation: when the force is removed the object will return to its original shape.

Plastic deformation: after the load is removed the object will not return to its original shape. It has been stretched beyond its elastic limit.

What is breaking stress?

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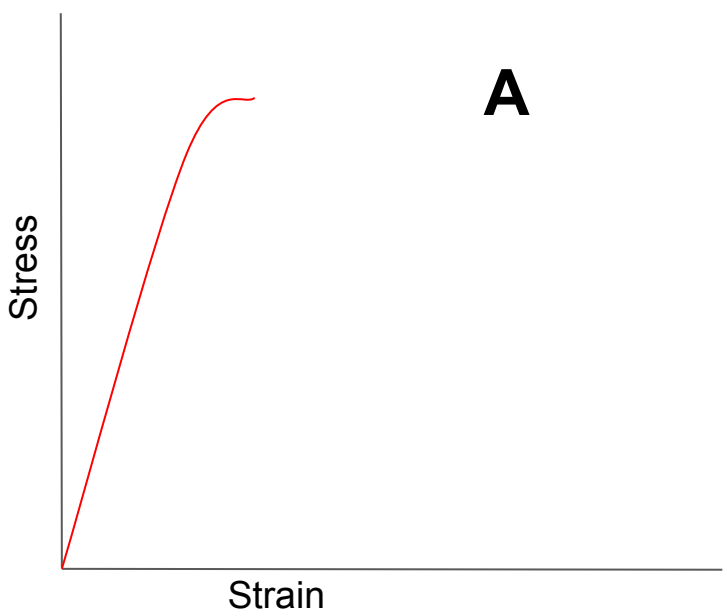
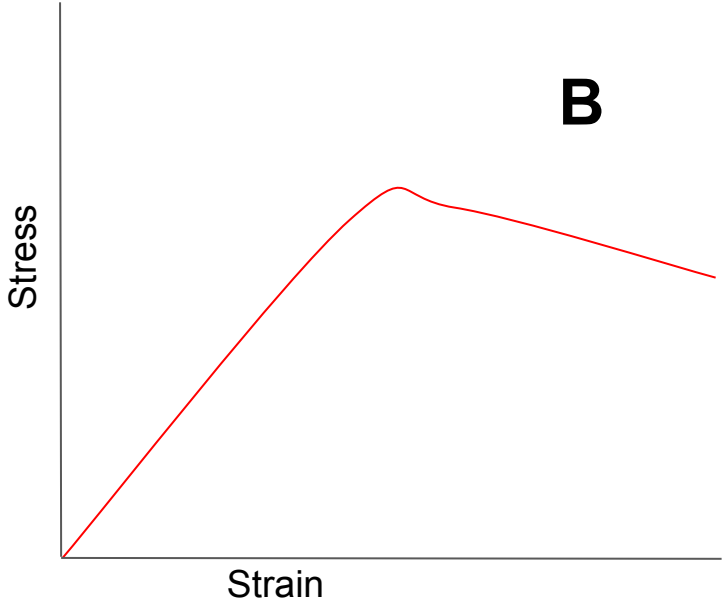
The minimum stress needed to break a material.

Which of these two graphs represents a brittle material?





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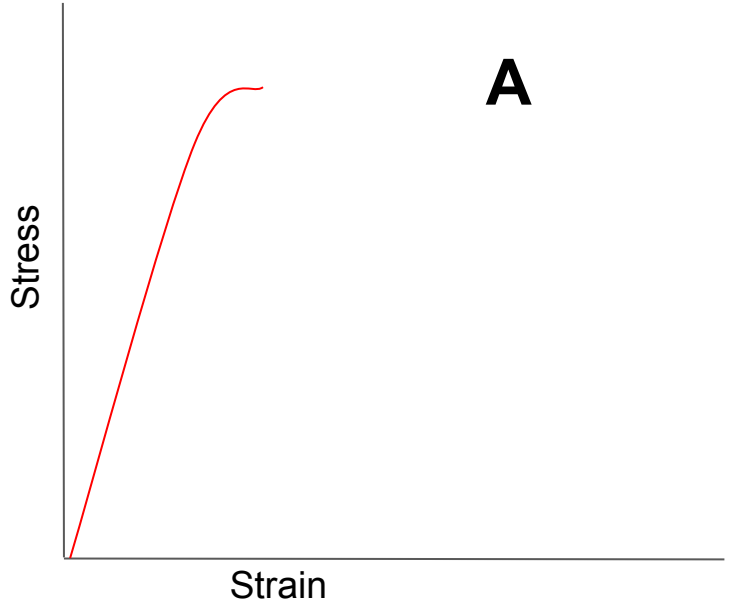
The material breaks without any noticeable yield.



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What is meant when a material is described as brittle?

It does not extend much when a force is applied (tensile strain stays low). The material tends to break rather than stretch under a large force.

What is the elastic limit?

What is the elastic limit?

The point after which plastic deformation occurs. It is also sometimes referred to as the ‘limit of proportionality’.

What does the area underneath a force-extension graph represent?

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The energy stored in the material.

Give the equation that calculates elastic strain energy in terms of the spring constant and extension.

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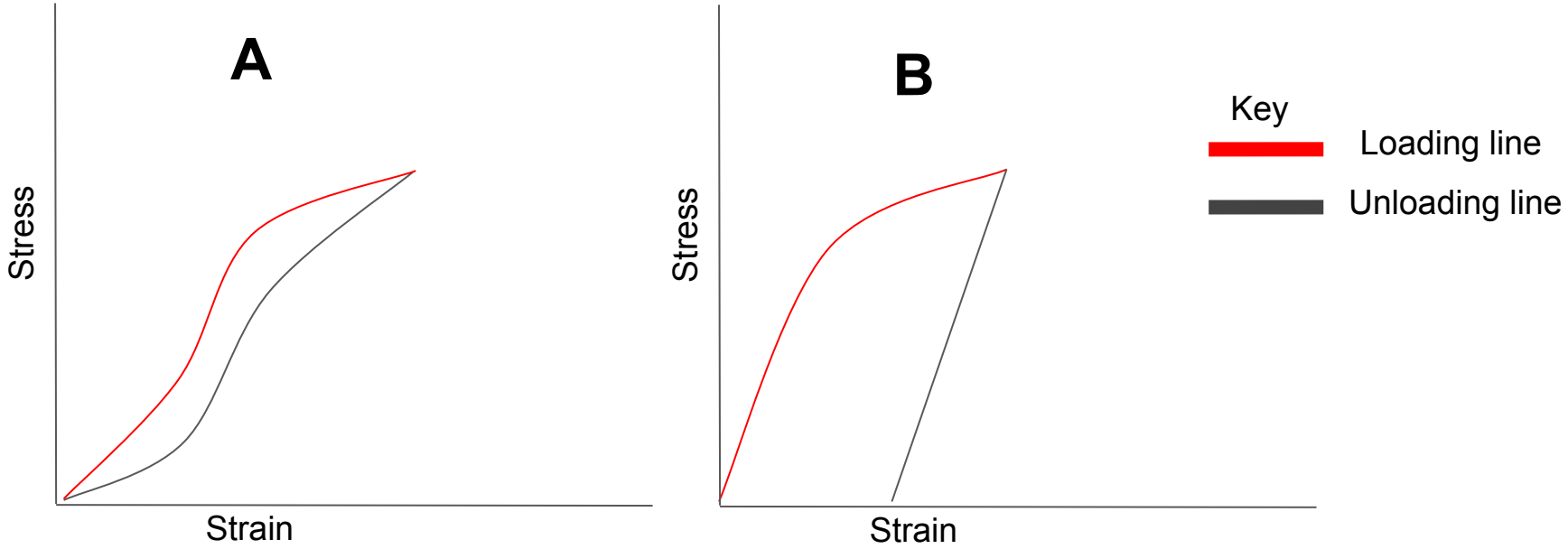

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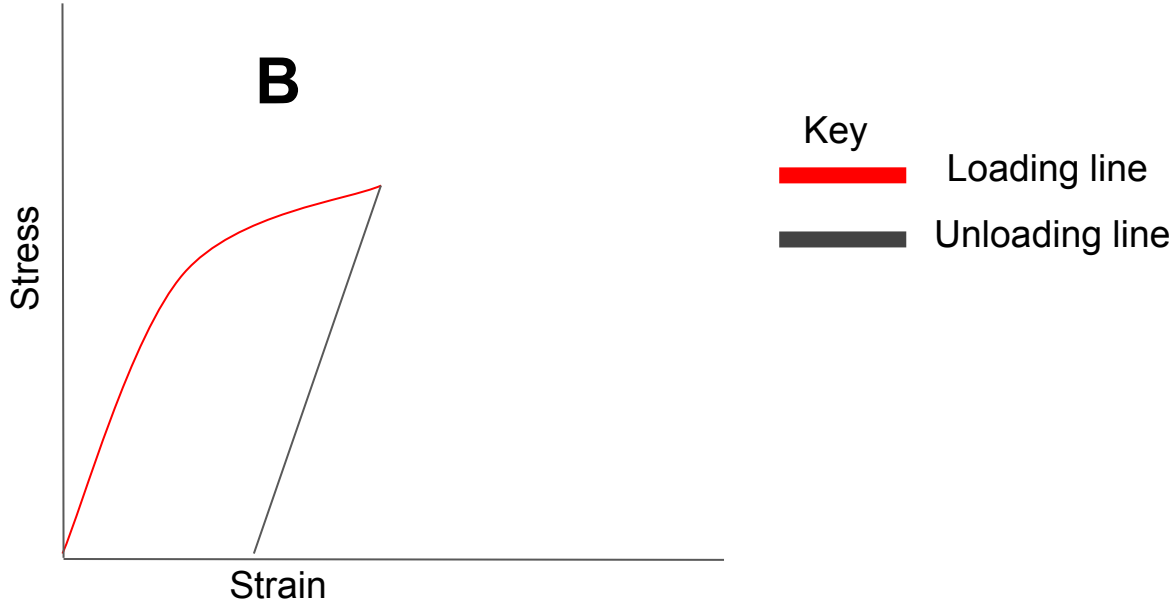

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What is meant by elastic strain?

What is meant by elastic strain?

Strain that disappears when a stress is removed – the material returns to its original shape.

What is meant by plastic (or inelastic) strain?

What is meant by plastic (or inelastic) strain?

Strain that decreases only slightly when stress is removed. The material does not return to its original shape.

How is the work done to stretch or compress a material stored?

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It is stored as elastic strain energy.

Why are the loading and unloading lines parallel on a force-extension graph for a plastically deformed material?

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The stiffness constant (k) has not changed - the forces between the atoms are the same when loading and unloading.

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What is a ductile material?

What is a ductile material?

A material that can be drawn out into a wire – plastic deformation occurs when there is enough stress.

What is meant by ductile fracture (necking)?

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The process of fracture in a ductile material: there is local thinning, which increases the stress (as the area decreases and stress = force / area), before the material breaks.

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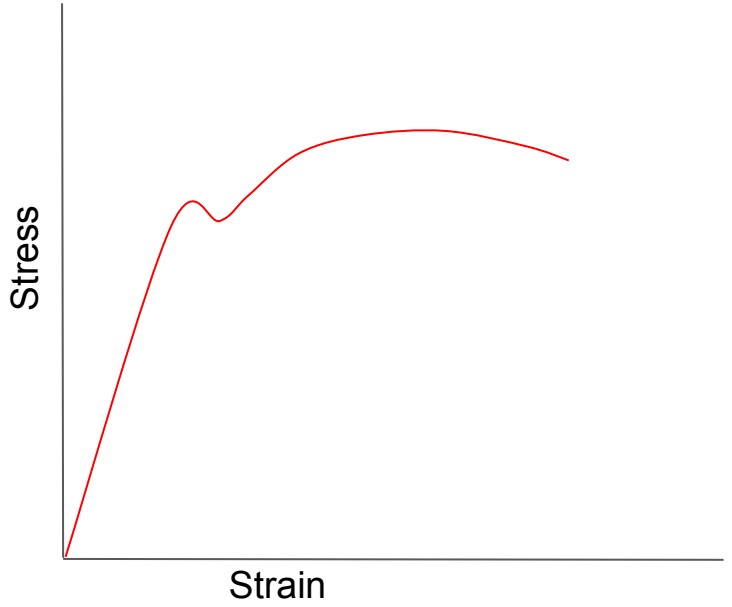

What is a brittle material?

What is a brittle material?

- A material that does not plastically deform.
  - Under tension, the material fractures.

What is meant by brittle fracture?

What is meant by brittle fracture?

- The fracture of brittle materials when they are put under tension.
- This occurs by cracks spreading throughout the material.

What is elastic hysteresis?

What is elastic hysteresis?

When a material (e.g. rubber) is put under stress and then the stress is removed, the stress-strain graphs for loading and unloading do not overlap but form a loop.

What is a crystal?

What is a crystal?

- A solid in which the atoms are arranged in a regular array.
- There is a long-range order, meaning that there is a pattern that repeats itself periodically over the entire crystal.

What is a crystalline solid?

What is a crystalline solid?

- A solid made of one or many crystals (usually arranged randomly).
- In cases where it is made of many crystals, it is called a polycrystalline solid (e.g. metals).

What is an amorphous solid?

What is an amorphous solid?

- A solid in which the atoms are arranged randomly.
- These are rare, so in practice, solids like glass or brick (that have no long-range order) are referred to as amorphous.

What is a polymeric solid?

What is a polymeric solid?

A solid that is made up of chain-like molecules.

What is meant by dislocations in crystals?

What is meant by dislocations in crystals?

Faults in crystal structures which reduce the stress required for planes of atoms to slide (if there are not too many faults).

What is meant by grain boundaries?

What is meant by grain boundaries?

The boundaries between crystals (grains) in a polycrystalline material.