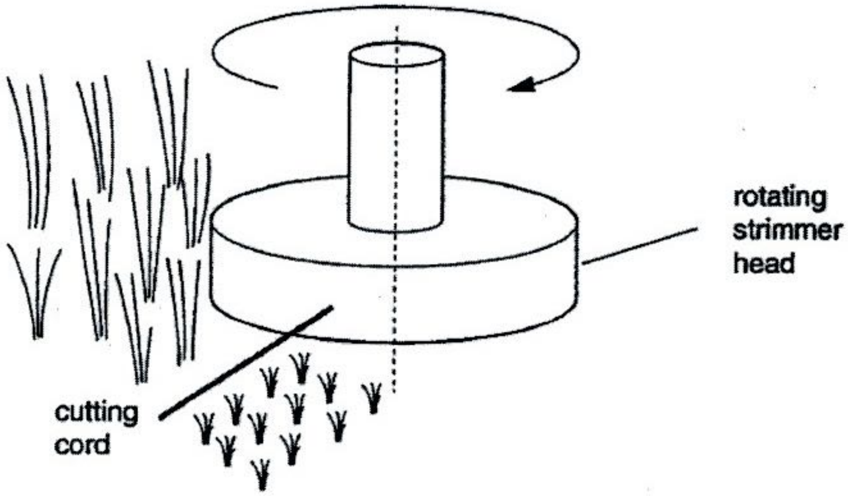
t test : Materials 1

1 This question is about choosing a material, to be used as the cutting cord of a motorised lawn cutter (strimmer). This is illustrated in Fig. 11.1.



The strimmer head is rotated at high speed and the taut plastic cord slices the grass.

Fig. 11.1

(a) Suggest one reason why the material of the cord needs to be tough.

So it does not break on impact with grass or stones

[1]

The table, Fig. 11.2, shows mechanical properties for three different polymers.

Polymer	density / kg m^{-3}	Young modulus / GPa	toughness / J m^{-2}	yield stress / MPa	hardness / MPa
Nylon 6	1200	1.8	2600	48	130
Polypropylene	900	1.3	2800	26	77
Polystyrene	1100	2.6	370	35	110

Fig. 11.2

(b) (i) Explain the terms: toughness, yield stress and hardness.

Toughness: Propagation of cracks requires a lot of energy.

Yield stress: Stress at which plastic deformation starts (once elastic limit has been exceeded)

Hardness: Does not scratch easily (Does not dent easily)

[3]

(ii) Which of the three materials in Fig. 11.2 would be the best choice for the strimming cord?

Nylon 6

[1]

(iii) Give three reasons for your choice of material.

Has highest hardness & toughness & good stiffness

Polystyrene will break as it has low toughness

Polypropylene has low yeild stress so will deform easily.

[3]

(iv) Rapid rotation of the strimmer sets up tensile stress in the cord. The tensile stress is kept below half the yield stress.
Calculate the maximum strain on the cord.
Use data for the material you selected in (b)(i).

$$YM = \frac{\text{stress}}{\text{strain}} \quad \text{so} \quad \text{strain} = \frac{\text{stress}}{YM}$$

$$\text{Max strain} = \frac{\frac{1}{2}\text{ yield stress}}{YM} = \frac{\frac{1}{2} \times 48\text{ MPa}}{1.8\text{ GPa}} = \frac{24 \times 10^6}{1.8 \times 10^9} =$$

maximum strain = 0.013 [2]

10 A lift operates in a building 80 m tall. The cage of the lift weighs 4 000 N and is designed to carry a maximum additional load of 6 400 N. It is supported by a steel cable.

(a) **(i)** What is the maximum total tensile load acting on the cable?

4000N + 6400N

tension in cable = ...10 400........ N [1]

(ii) The steel cable that supports the lift has a tensile strength of 600 MPa. The Young modulus for steel is 200 GPa. Calculate the strain at the yield point.

$YM = \frac{\text{stress}}{\text{strain}}$ ∴ $\text{strain} = \frac{\text{stress}}{YM} = \frac{600\,MPa}{200\,GPa} = \frac{600 \times 10^6}{200 \times 10^9} =$

breaking strain = ...0·0030........ [3]

(iii) Sketch the shape of the stress/strain graph for steel on Fig. 10.
Mark on your graph the point where the steel yields.

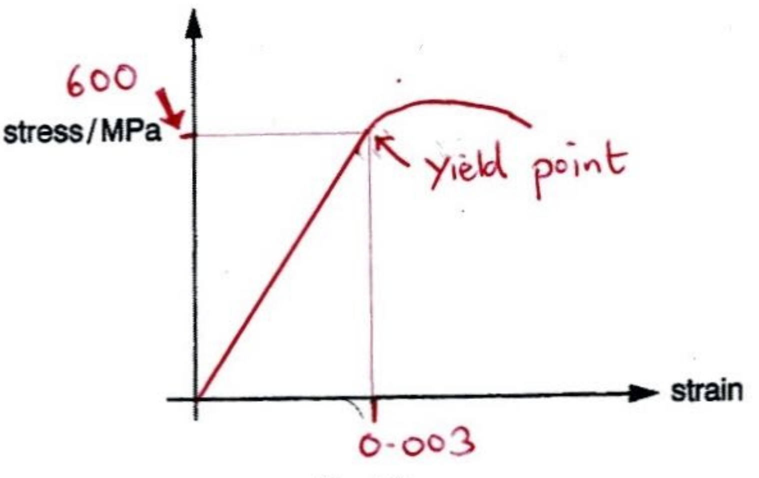


Fig. 10

[3]

(b) In choosing the thickness of the cable needed, the maximum static tensile stress should be ¼ of the tensile strength.
How much extension will this cause in the 80 m cable?

max $\text{strain} = \frac{0 \cdot 003}{4} = 7 \cdot 5 \times 10^{-4}$

$\text{strain} = \frac{\text{extension}}{\text{orig. length}}$

extension = ...0·06........ m [4]

∴ ext = strain × orig. length

$= 7 \cdot 5 \times 10^{-4} \times 80\,m =$

t test : Materials 3

2 The material chosen for a hip joint replacement needs to be strong.

(a) State **one** other **mechanical** property that is important for this use of the material, and explain its meaning.

mechanical property: .... Stiff OR tough ....

meaning of property: .... load has small effect on length / resistant to fracture / cracks can't propagate easily ....[2]

(b) Explain the importance of the property to this use of the material.

won't bend under load and make running difficult. (balance)

won't break under impact e.g. landing after jump

[1]

The graph in Fig. 3.1 shows how the stress in a rubber cord varies with strain, up to the breaking stress of 30 MPa.

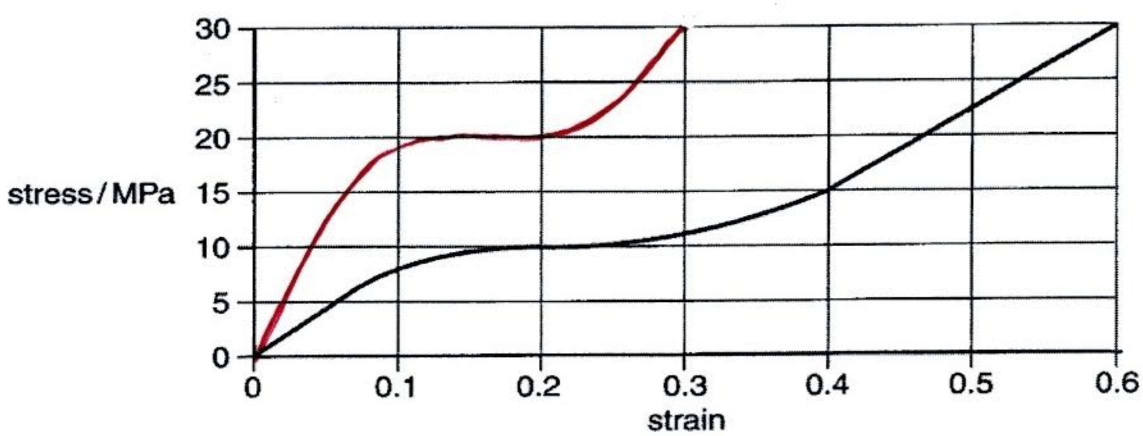


Fig. 3.1

The rubber cord is cooled to well below room temperature. It is found that it becomes much stiffer, finally breaking at the same stress, but at half the original breaking strain.

Sketch this variation for the cooled rubber cord on the graph of Fig. 3.1. [3]

Here is a list of five units for physical quantities:

$N\,m^{-2}$ D J $\Omega\,m$ $S\,m^{-1}$

From the list:

(a) Write down the unit for the power of a lens. .... D ....[1]

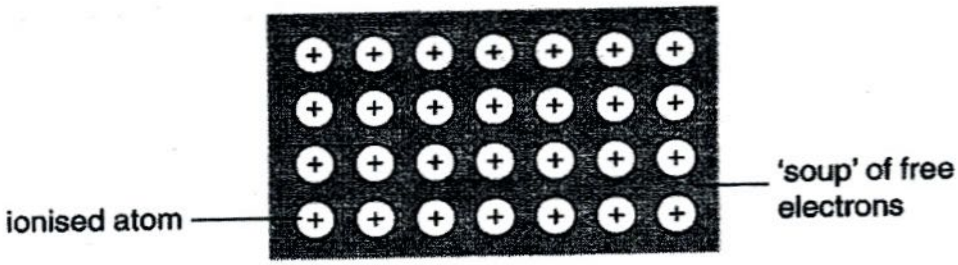
(b) Write down the unit for electrical conductivity. .... Sm^{-1} ....[1]

3 The diagrams below illustrate the microstructure of three different types of material.
Here is a list of different types of material.

glass ionic crystal metal rubber

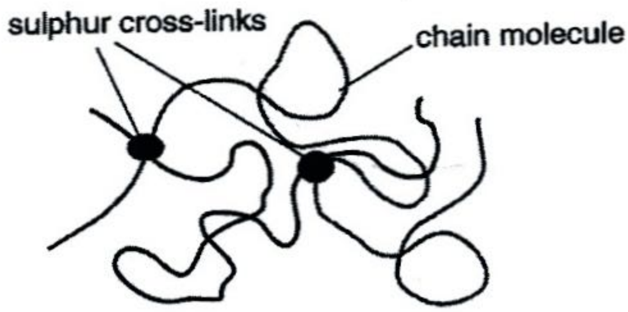
Choose from the list the type of material that best matches each microstructure.

(a)



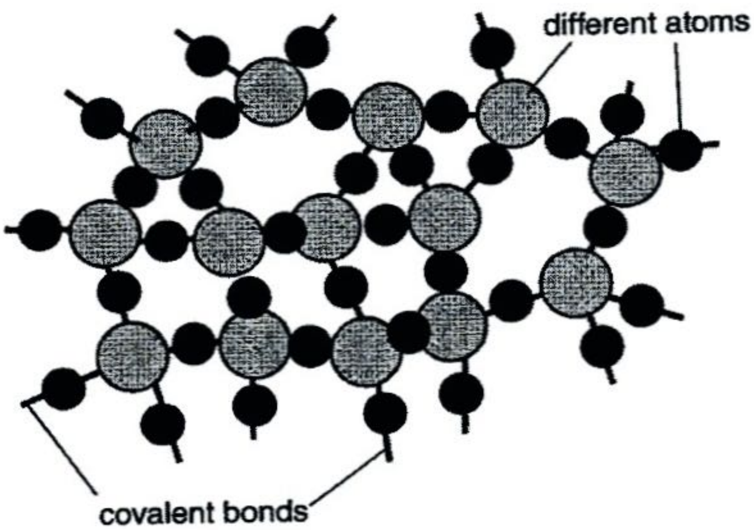
material metal

(b)



material rubber

(c) Covalent bonds share electrons between neighbouring atoms. These bonds are directional: they lock atoms in place like scaffolding.



material glass

[3]

11 This question is about steel wires in tension.

Guitar strings can be made from tensile steel wire. A sample of steel wire is tested in the laboratory. Fig. 11.1 shows the force-extension graph obtained when the wire is stretched.

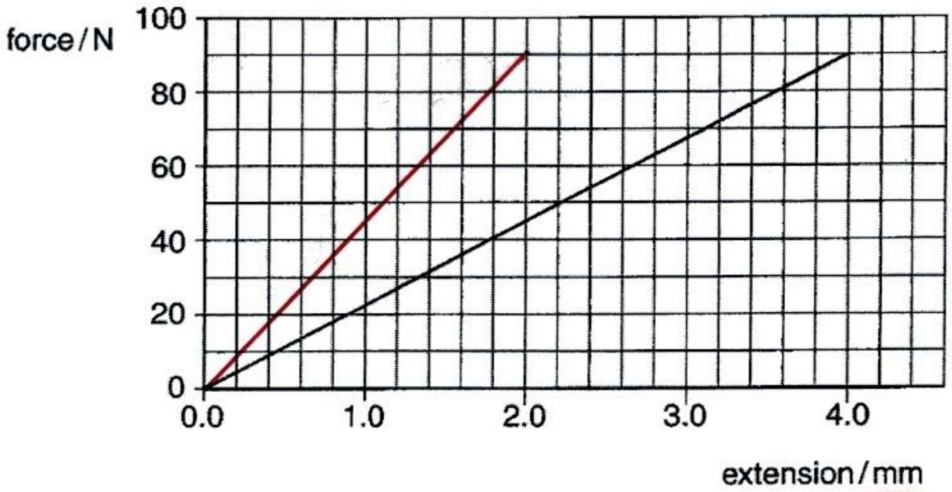


Fig. 11.1

(a) Describe how the extension varies as the force is increased.

extension $\propto$ force (proportional) or vice versa [1]

(b) The area under the force against extension graph equals the energy stored in the stretched wire.

(i) Calculate the energy stored when the force in the wire is 90 N.

$\left(E = \frac{1}{2}kx^2\right)$ = area under line

$= \frac{1}{2} \times 90 \times 4.0 \times 10^{-3}$

energy = 0.18 unit J (or Nm)

[3]

(ii) This sample of steel wire had an original length of 2.0 m and cross-sectional area of $2.5 \times 10^{-7}\,\text{m}^2$.

Use these facts and information from the graph, to calculate the Young modulus of the steel.

$$Y.M = \frac{\text{stress}}{\text{strain}} = \frac{F/A}{x/L} = \frac{90/2.5\times10^{-7}}{4\times10^{-3}/2.0}$$

Young modulus = 1.8×10^{11} N m^{-2}

[5]

(c) The test is repeated using another sample of the same wire, but of only **half** the original length.

(i) **Sketch on the axes of Fig. 11.1** the force-extension graph you would expect for this wire, as the force is increased to 90 N.

[1]

(ii) How does the Young modulus for this wire compare with that of the sample used in the first test?
Explain your reasoning.

The same - its the same material and YM is a material property.

[2]

10 This question is about two methods of estimating the size of a molecule.

(a) This is the first method.
The field of view of an STM (scanning tunnelling microscope) is 20 nm wide. It is possible to resolve 14 molecules across it, as shown in Fig. 10.1.

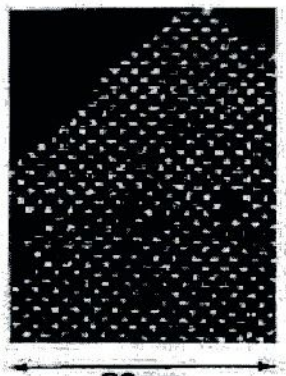


Fig. 10.1

Estimate the size of a molecule using this information.

$20 \times 10^{-9} / 14$

molecular size = 1.4×10^{-9} m [2]

(b) Another method is to allow one drop of oil to spread out on a water surface.

(i) The oil drop has a diameter of 0.50 mm. ~~Ok~~ = 0.50 mm^3 ∴ r = 0.25 mm
Show that the volume of oil in the drop is about 0.07 mm^3.

volume of sphere = $\frac{4}{3}\pi r^3$ $= \frac{4}{3}\pi \times (0.25)^3$

$= 0.0654$ mm^3

[2]

(ii) When the oil spreads out on the water surface, it forms a circular patch.
This is assumed to be one molecule thick. Therefore the thickness of the patch gives an estimate of the size of the molecule.
The diameter of the patch can be measured because the oil has moved aside powder scattered on the water surface as illustrated in Fig. 10.2.

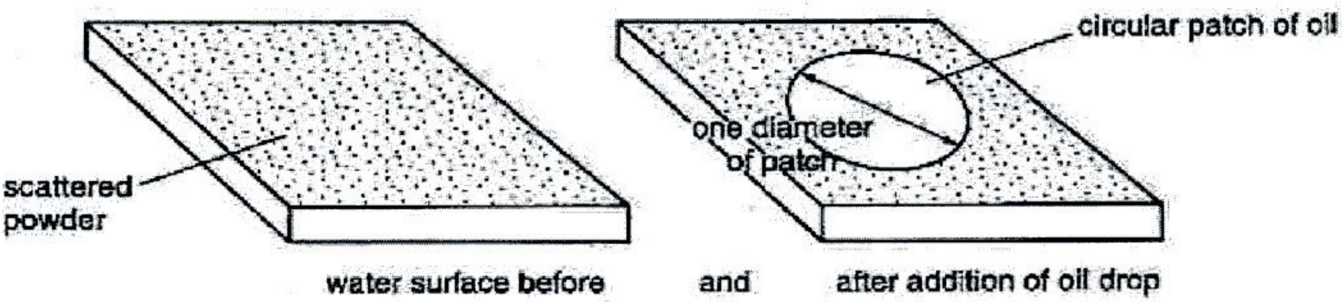


Fig. 10.2

The diameter of the patch is measured in four different directions.
The results are given below.

diameter / mm	300	280	280	260

Calculate the mean diameter of the patch from these measurements.

$300+280+280+260/4$

mean diameter = 280 mm [1]

(iii) Use the mean radius of the circular patch to show that its surface area is about 6.2×10^4 mm^2.

area of circle $A = \pi R^2$ $R = 140$ mm

$A = \pi(140)^2 = 6.16 \times 10^4$ mm^2

[2]

(iv) The method assumes that the oil drop and the circular patch have the same **volume.**
For a patch of area A and thickness h the volume = $A\,h$

Calculate the thickness of the patch using the data from parts **(b)(i)** and **(b)(iii)**.

This is your estimate of molecular size.

$V = Ah = \frac{4}{3}\pi r^3$

$\therefore h = \frac{4/3\,\pi r^3}{A} = \frac{0.0654 \text{ mm}^3}{6.16 \times 10^4 \text{ mm}^2} = 1.062 \times 10^{-6}$ mm

$= 1.062$ nm

estimate of molecular size = 1.1 unit nm [3]

OR 1.1×10^{-6} mm [Total: 10]

OR 1.1×10^{-9} m etc.

10 This question is about materials that have been used to build railway tracks.

Railway tracks must withstand the effects of metal train wheels running along them. The first metal tracks, which were made of cast iron, were **hard** but also **brittle** and often broke. These were replaced by wrought iron, which is **stronger** and **tougher**.

(a) State what is meant by the following words from the passage.

brittle

cracks propagate easily so shatters on impact

hard

difficult to scratch (or dent)

strong

large breaking stress

tough

large energy needed for cracks to propagate or to break.

[4]

(b) More recently, steel has replaced wrought iron as the material for railway tracks. The table gives data for wrought iron and steel.

material	toughness / $J\,m^{-2}$	strength / $MN\,m^{-2}$
wrought iron	4000	350
steel	16000	430

(i) Look at the data in the table.

State the **main** reason why steel replaced wrought iron as the preferred material for railway tracks.

much tougher (×4)

[1]

(ii) Suggest why toughness is measured in units $J\,m^{-2}$.

Energy per unit area ← new surface made by crack.

[2]

(c) Fig. 10.1 shows how stress varies with strain for the three materials, cast iron, wrought iron and steel.

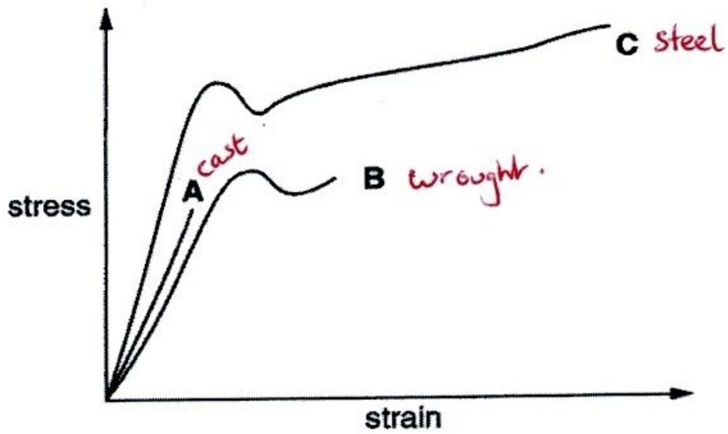


Fig. 10.1

(i) State which graph, **A, B** or **C**, best represents wrought iron ......B.......... [1]

(ii) Explain your choice of graph.

Yield / Fracture stress is in middle of the 3 materials

[1]

[Total: 9]

1 A particular material breaks after plastic deformation. It requires a large energy to create new surface area, but does **not** fracture by crack propagation.

Here is a list of four different mechanical properties.

stiff strong tough hard

Write down the **one** word from the list that best describes this material.

..........tough.......... [1]

Fig. 1.1 shows a plot of strength against toughness for different materials. Four areas have been shaded and labelled **A, B, C** and **D.**

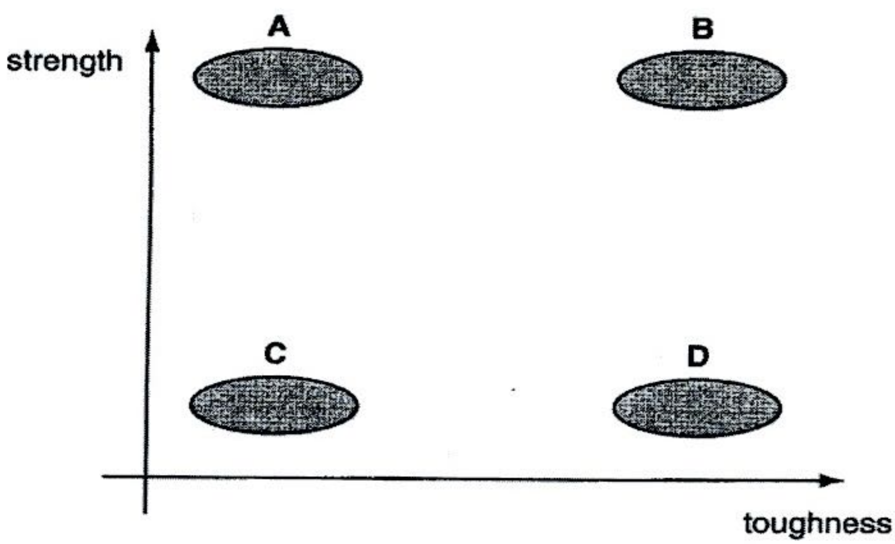


Fig. 1.1

Select the area of the graph, **A, B, C** or **D**, that best fits each of the following materials.

a material suitable for car bodies e.g. steel ....B..........

a weak material that is easy to snap e.g. biscuit ....C..........

a brittle metal e.g. cast iron under tension ....A.......... [3]

This question is about selecting materials for sports equipment.

Fig. 3.1 shows, on a plot of the Young modulus against density, ranges of values for different classes of material.

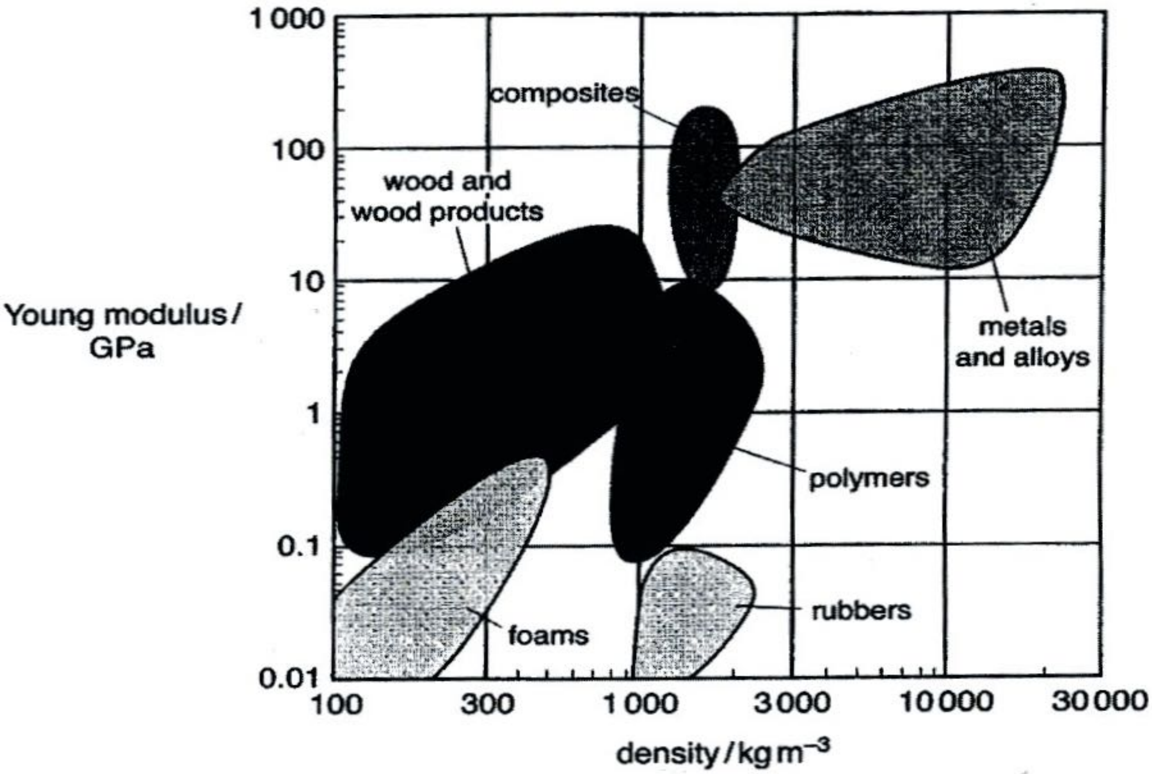


Fig. 3.1

(a) Foams are used for filling landing mats for high jumpers.

Explain this choice of material using information from Fig. 3.1.

Low YM means it's flexible so soft to land on.
Low density means it's light so easy to carry.

[2]

(b) Some sports rackets are now made of a composite material rather than of metal.

Suggest and explain a reason for this change using information from Fig. 3.1.

Lower density means they are lighter but have the same stiffness.

(lighter for same stiffness)

[2]

Read the paragraph below about the properties of spider silk.

Spider silk is a very strong material. It also requires a large energy to create new surface area or to break it. It is twice as strong as stainless steel, having a breaking stress of $2.0 \times 10^9\,N\,m^{-2}$. Yet, it can be stretched by more than one third of its original length and recover without permanent distortion.

(a) Here is a list of words describing mechanical properties of materials

elastic **hard** **plastic** **tough**

Choose **two words from this list** that best state the mechanical properties of spider silk as described in the paragraph.

........elastic........ and ....tough........ [2]

(b) A 'spiderwoman' weighs 550 N.

Calculate the **minimum** cross-sectional area of spider silk needed to support her weight.

$stress = \frac{F}{A} \therefore A = F/stress = \frac{550N}{2.0 \times 10^9\,Nm^{-2}} =$

cross-sectional area = ...2.8×10^{-7}........ m^2 [2]

(c) **(i)** Explain the meaning of *elastic limit* for a material.

stress / strain at which plastic deformation begins & elastic deformation ends.

[1]

(ii) At the elastic limit of spider silk, the strain is 0.35 and the stress is $1.6 \times 10^9\,N\,m^{-2}$.

Estimate the Young modulus for spider silk.

$Y.M. = \frac{stress}{strain} = \frac{1.6 \times 10^9}{0.35} =$

Young modulus = ...4.6×10^9........ $N\,m^{-2}$ [2]

(d) Spider silk consists of long chain polymer molecules.

Spider silk can 'be stretched by more than one third of its original length and recover without permanent distortion'.

(i) Sketch and label diagrams of a possible molecular structure for spider silk before and during stretching.

diagram of molecules before the silk is stretched

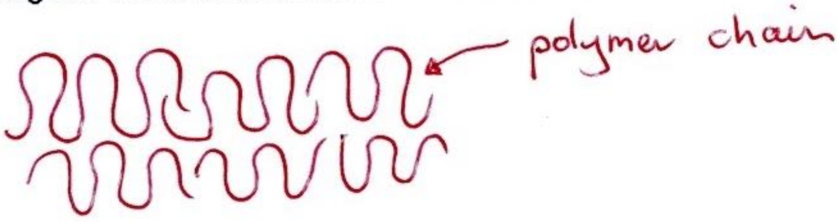
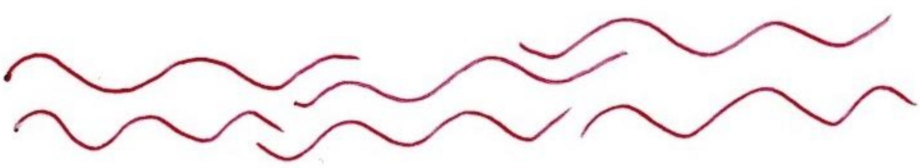


diagram of molecules while the silk is stretched



(ii) Describe how your proposed structure does enable spider silk to be stretched as described above.

bond rotation allows molecules to change shape

[3]

[Total: 10]

11 This question is about the mechanical properties of human hair.

A single hair recovers almost completely elastically when strains of up to 25% are removed.

The table gives typical data for human hair.

diameter	50 μm
Young modulus	5.0×10^9 Pa
breaking stress	3.0×10^8 Pa
breaking strain	25%

(a) Up to 5% strain, the stress is directly proportional to the strain. At greater than 5% strain the relationship becomes non-linear.

Show that the stress at 5% strain is 2.5×10^8 Pa.

$5\% = 5/100 = 0.05$

$YM = \frac{\text{stress}}{\text{strain}}$ stress = YM × strain $= 5.0 \times 10^9 \times 0.05$

$= 2.5 \times 10^8$ Pa (250 MPa) [1]

(b) Sketch the stress against strain graph for hair, up to its breaking point, on the axes of Fig. 11.1.

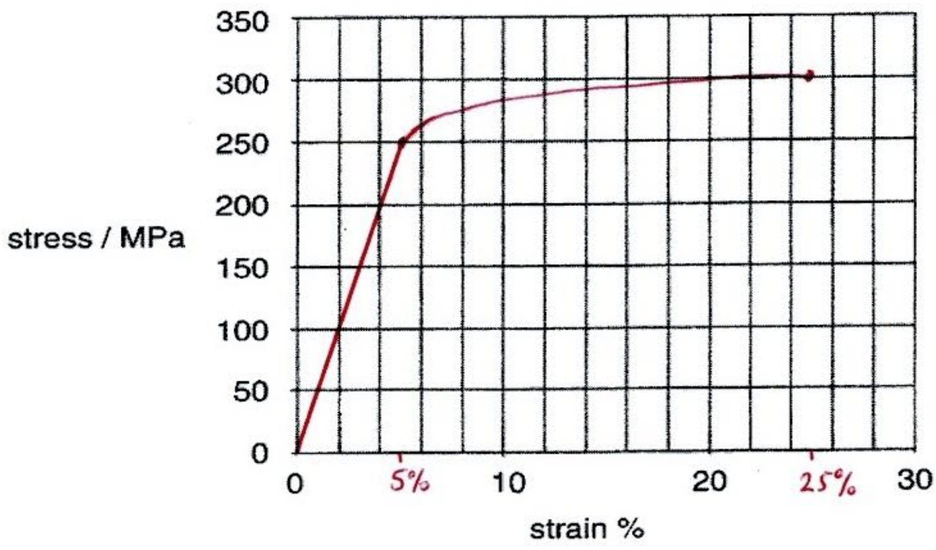


Fig. 11.1 [2]

(c) (i) Show that the cross-sectional area of a typical hair is about 2×10^{-9} m^2.

$A = \pi r^2 = \pi \times \left(\frac{50 \times 10^{-6}}{2}\right)^2$ [1]

$= 1.96 \times 10^{-9}$ m^2

(ii) Calculate the force that breaks such a hair.

stress = F/A

F = stress × A $= 3.0 \times 10^8 \times 1.96 \times 10^{-9}$

$= 0.589$

force = 0.59 N .... N [2]

(d) Hair is a composite material. Its microscopic structure influences its mechanical behaviour.

(i) Hairs are made of bundles of strong protein fibres, embedded in an amorphous protein matrix (Fig. 11.2). Strong sulphur bonds glue the bundles of fibres to the amorphous matrix.

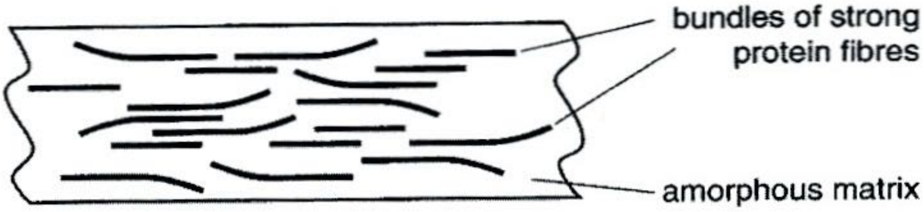


Fig. 11.2

Suggest and explain one mechanical property that hair is likely to have as a result of this composite microstructure.

strong due to fibres and tough due to amorphous matrix

[2]

(ii) The protein fibres are made of long coiled protein molecules (Fig. 11.3).

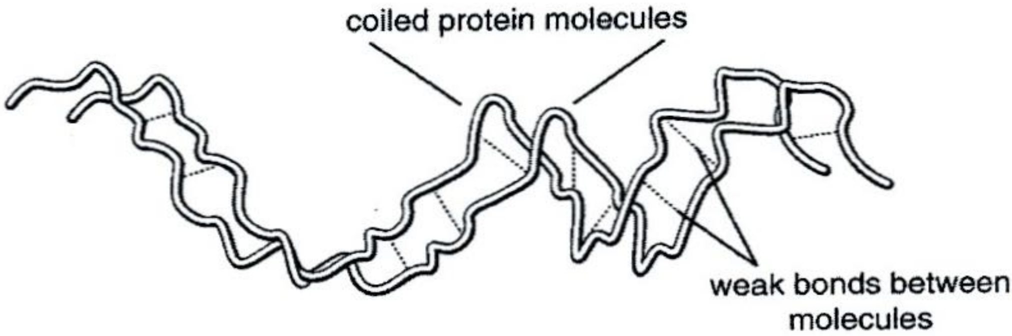


Fig. 11.3

Bundles of protein fibres consist of several protein molecules coiling around each other. Weak bonds hold the protein molecules to their neighbours, giving the fibres large flexibility.

Suggest how hair can recover almost completely elastically up to strains of 25% as a result of this microstructure.

coiled protein molecules can uncoil and re-coil when stress added and removed respectively because the weak bonds between the molecules can break & reform.

[2]

[Total: 10]

Fig. 6.1 shows the microstructure on the surface of a brass specimen.

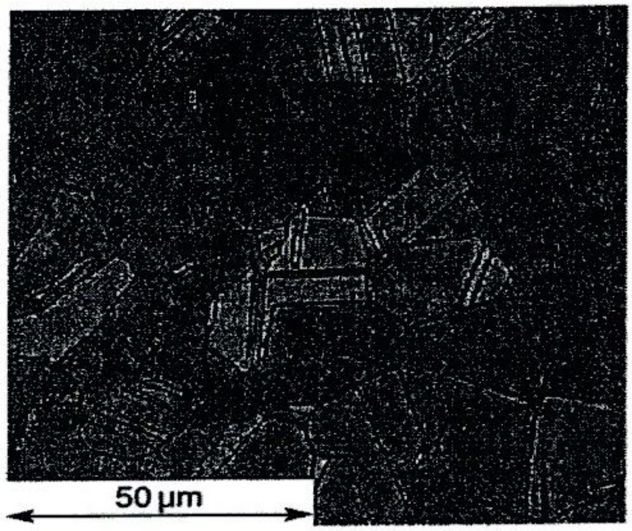
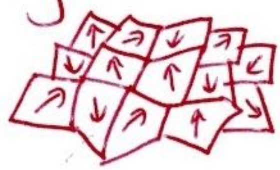


Fig. 6.1

The polycrystalline grain structure of the brass can be seen.

Explain the meaning of the term *polycrystalline*.

lots of small crystals with different orientations



[2]

A wine glass can support large compressive stress, but may shatter, by crack propagation, if dropped a small distance onto a hard surface.

Here is a list of some mechanical properties of materials.

brittle **elastic** **plastic** **strong** **tough**

Write down the two properties of glass from the list that best fit the statement about the wine glass.

.........strong......... and ....brittle......... [2]

Here is a list of units.

$kg\,m^{-3}$ $J\,m^{-2}$ $N\,m$ $N\,m^{-2}$

Choose the correct unit for

(a) Young modulus Nm^{-2}

(b) density. kgm^{-3} [2]

This question is about some properties of materials.

Fig. 4.1 shows, on a plot of the compressive strength against toughness, ranges of values for different classes of material.

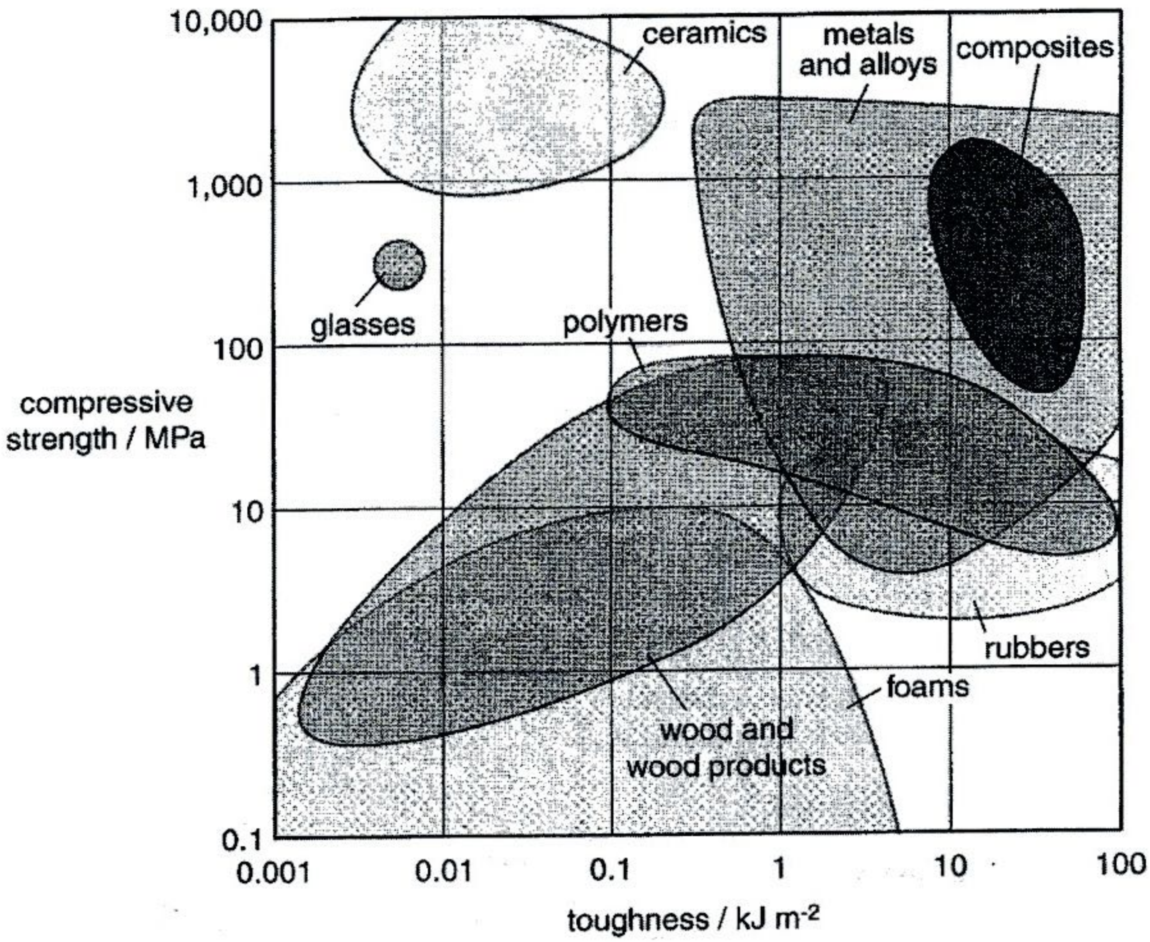


Fig. 4.1

(a) State the class of materials shown in Fig. 4.1 that has the greatest average strength in compression.

ceramics [1]

(b) State what is meant by the compressive strength of a material.

compressive stress needed to break

[1]

(c) The head of a hammer needs to be strong.

Explain whether the class of material you named in **(a)** might be suitable for constructing the head of a hammer.

No it is brittle (low toughness) so will shatter

[1]

Fig. 5.1 shows an STM image of 34 iron atoms arranged in a rectangle on a copper surface.

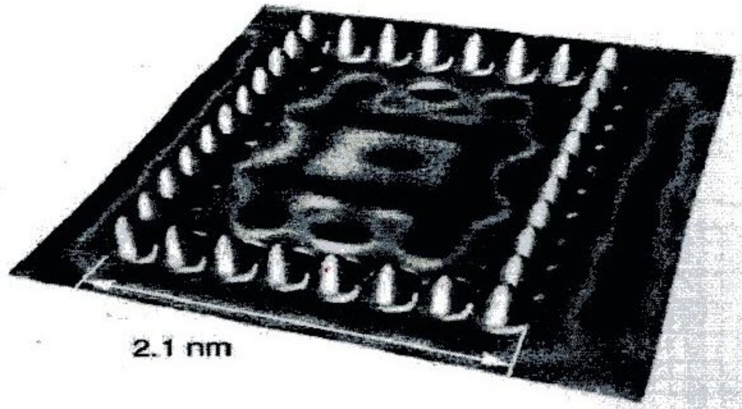


Fig. 5.1

The length of the front row of iron atoms is 2.1 nm.

Calculate the diameter of an iron atom.
Give your answer to 2 significant figures.
Show your working clearly.

$2.1 \times 10^{-9}\,m / 8$ =

diameter of iron atom = 2.6×10^{-10} m [2]

Here is a list of mechanical properties of materials.

brittleness **plasticity** **stiffness** **strength**

(a) For each of the descriptions below write down the word from the list that is being described:

a measure of the stress a material can take before yielding ...strength...

a measure of a material's resistance to stretching or bending ...stiffness...

the tendency of a material to break by crack propagation ...brittleness...

[3]

(b) State the meaning of the remaining property that you have not chosen above.

plasticity = material deforms permanetly (ie is not elastic)

[1]

This question is about the behaviour of a metal alloy.
Fig. 10.1 shows the stress against strain graphs to breaking point for samples of a pure metal and one of its alloys.

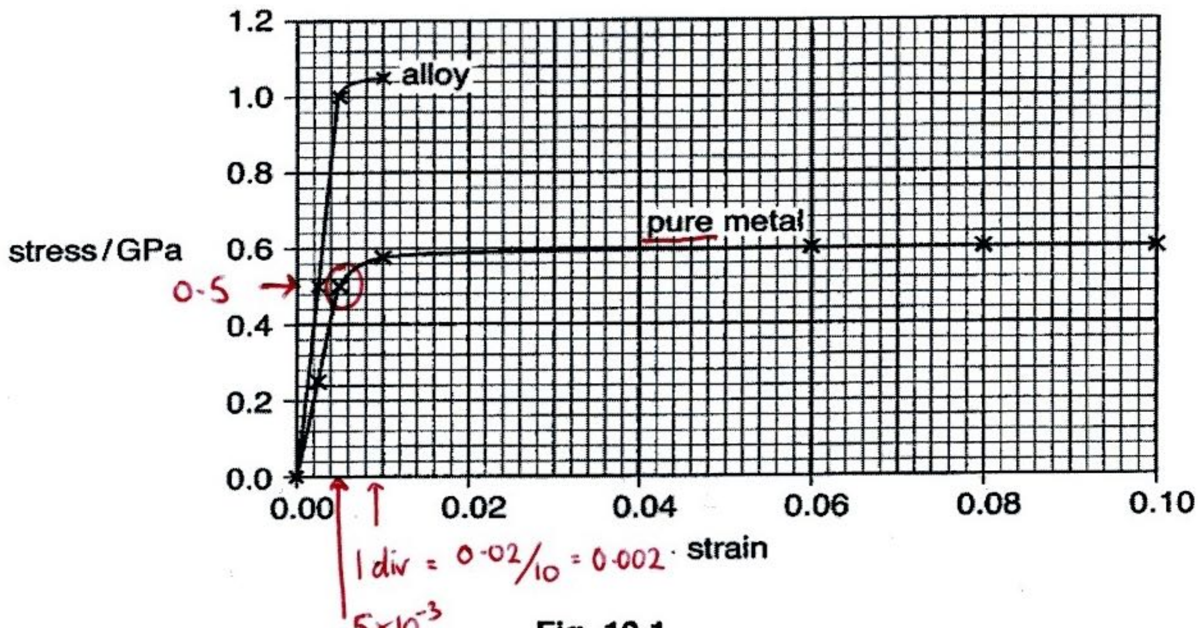


Fig. 10.1

(a) (i) Use data from Fig. 10.1 to calculate the Young modulus of the pure metal. Make your method clear.

$YM = \frac{\text{stress}}{\text{strain}} = \frac{0.5\text{ GPa}}{5\times10^{-3}} = 100\text{ GPa}$

↑ during elastic deformation

Young modulus = 100 GPa [3]

(ii) Explain how the graphs show that the alloy is stiffer and stronger but less ductile than the pure metal.

stiffer

gradient is higher

stronger

yield stress is higher
(or breaking)

less ductile

breaks at lower strain

[3]

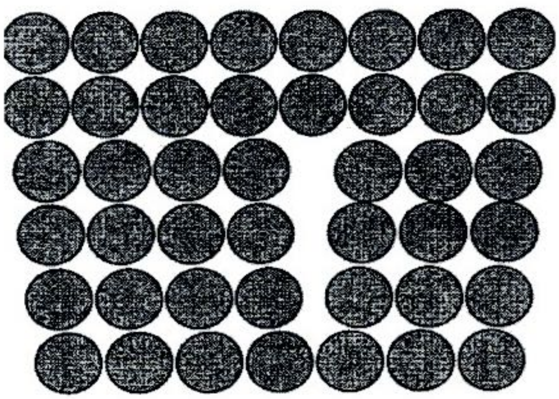
(b) Girders to support the floors in buildings are made from this alloy rather than the pure metal.

Suggest why the properties of this alloy make it more suitable than the pure metal for girders.

Increased stiffness means floors don't sag
(+ stronger so less likely to fail)

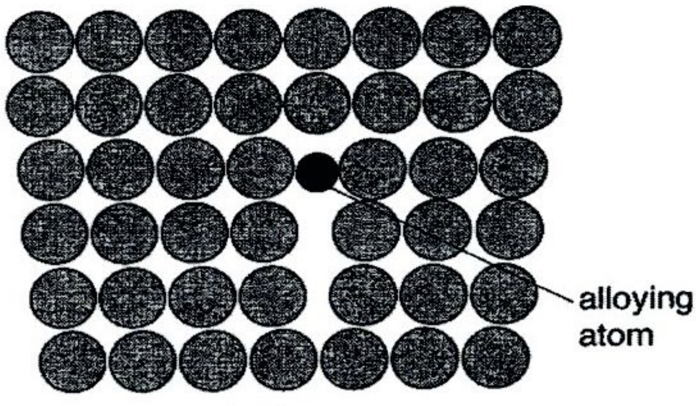
[1]

(c) The microstructure of the pure metal is shown in Fig. 10.2.



pure metal

Fig. 10.2



alloy

Fig. 10.3

The alloy microstructure is shown in Fig. 10.3.
The alloying metal atoms randomly replace a few of the host metal atoms in the structure. The alloying atoms are smaller than the host atoms.

Use the information above about the microstructures, to suggest and explain why the alloy is less ductile than the pure metal.

Regular structure of layers of atoms in pure metal with dislocations (missing layers) means that the dislocation can move as one layer at a time shifts into the dislocation (slip) allowing plastic deformation. The alloying atom 'pins' the dislocation stopping slip and reducing plastic deformation & hence ductility.

[3]

[Total: 10]

This question is about the height h of a column of solid material that can support its own weight without yielding under compression.

(a) Fig. 10.1 shows a vertical column of a solid material.

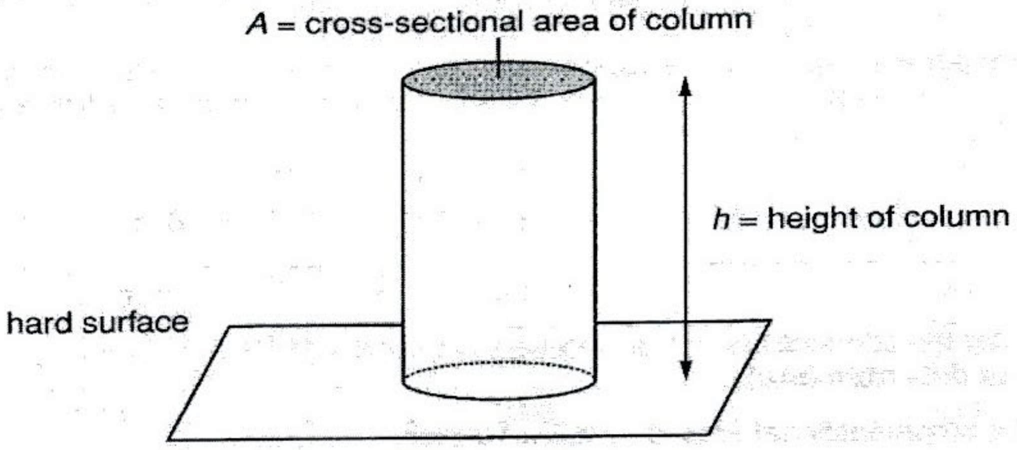


Fig. 10.1

F/A

(i) The stress at the base of the column $= h\rho g$

where ρ = density of material and g = gravitational field strength.

Derive this expression, by completing the following algebraic reasoning. Fill the boxes, using the symbols given above.

volume of column $= A \times h$

mass of column = $A h \rho$

weight of column = $A h \rho g$

stress at base of column $= \dfrac{\text{weight}}{\text{area}} = \dfrac{A h \rho g}{A}$

$= h\rho g$ [3]

(ii) Explain why the failure of a tall column of solid material is most likely to occur at its base.

Stress is greatest at base (h = max)

[1]

(iii) Explain why columns of the same material fail at the **same value** of h regardless of their cross-sectional area.

Area cancels out. It's not in stress formula.

[1]

(b) (i) The compressive stress at which rock yields is about $2.4 \times 10^8\,N\,m^{-2}$.

Show that the maximum height h of a column of rock that could support its own weight on Earth is about 9 km.

density of surface rock on Earth = $2700\,kg\,m^{-3}$

gravitational field strength on Earth = $9.8\,N\,kg^{-1}$

stress = $h\rho g$ ∴

$h = \frac{stress}{\rho g} = \frac{2.4 \times 10^8\,Nm^{-2}}{2700\,kgm^{-3} \times 9.8\,NKg^{-1}} = 9.1\ Km$

[2]

(ii) Everest is the highest mountain on Earth. It is about 8.8 km high.
On the planet Mars the highest point is the volcano Olympus Mons, shown in Fig. 10.2, which is about 22 km high.

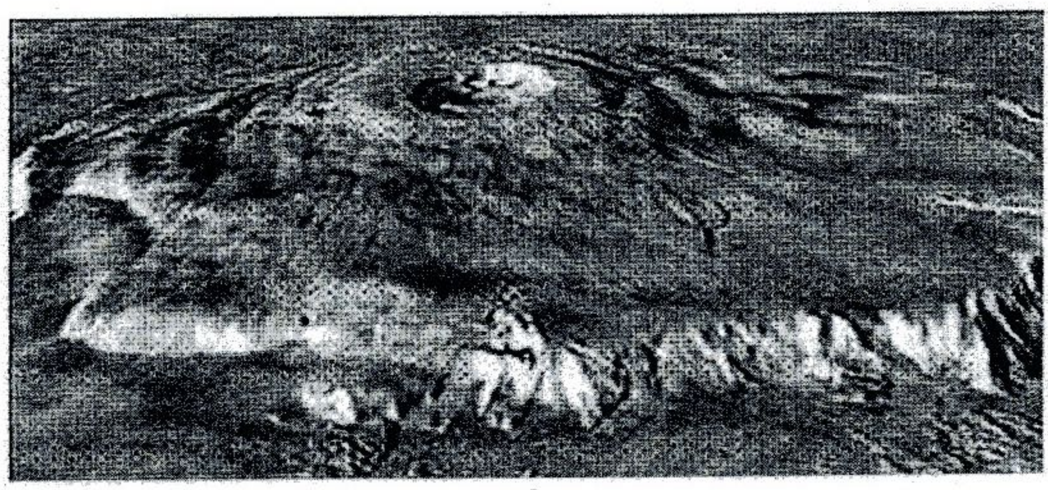


Fig. 10.2

Suggest explanations why no mountain higher than Everest exists on Earth and why Olympus Mons can be so much higher.

Rock at base of mountains taller than Everest would fail. g is lower on Mars so h can be higher before rock fails.

crumble

[3]

(Mars rock might be stronger in compression)

[Total: 10]

9 Fig. 9.1 shows a diagram of part of a suspension bridge.

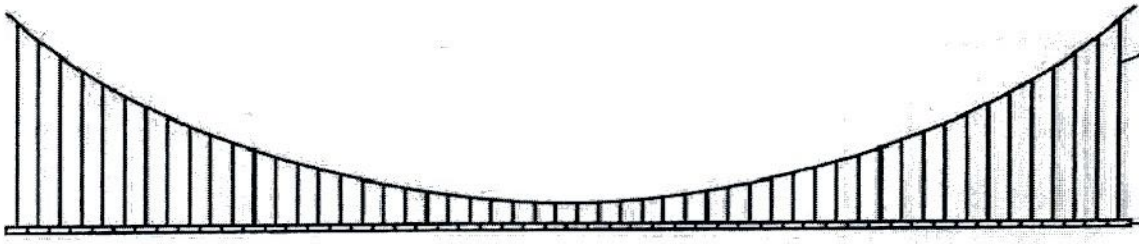


Fig. 9.1

(a) (i) Bridge sections are hung from uniform vertical steel cables.

State **one** mechanical property of steel that makes it a suitable material for these vertical cables.

strong / tough ....[1]

(ii) Explain why this property is important.

does not break   does not crack

[1]

(b) Two vertical cables support each bridge section as shown in Fig. 9.2.

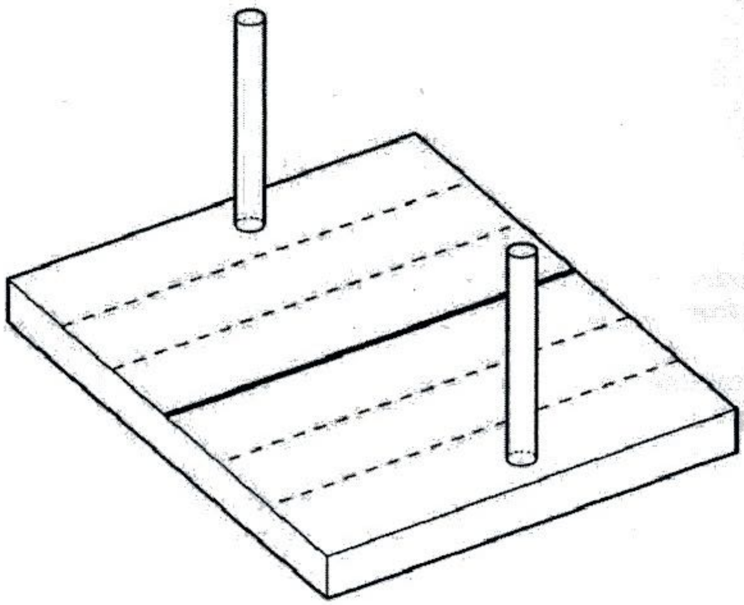


Fig. 9.2

(i) Each bridge section weighs 1.8 MN. → 0.9MN per cable
This weight causes a stress in each cable of 1.3×10^8 Pa.

Show that the cross-sectional area of **each** cable is about $7 \times 10^{-3}\,m^2$.

$$\text{stress} = \frac{F}{A} \quad \therefore \quad A = \frac{F}{\text{stress}} = \frac{0.9 \times 10^6}{1.3 \times 10^8} = 6.9 \times 10^{-3}\,m^2$$

[3]

(ii) The longest vertical cables of the bridge are 150 m in length.

Calculate the extension of these cables when the bridge section is attached.

The Young modulus for steel = 2.1×10^{11} Pa.

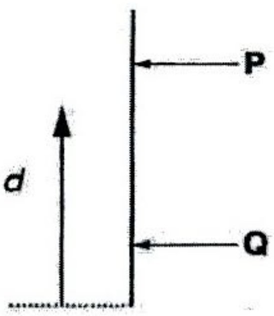
$YM = \frac{stress}{strain}$ ∴ $strain = \frac{stress}{YM} = \frac{1.3 \times 10^{8}}{2.1 \times 10^{11}} = 6.19 \times 10^{-4}$

$strain = \frac{x}{L}$ ∴ $x = strain \times L = 6.19 \times 10^{-4} \times 150\,m =$

extension = ...0.093...... m [3]

) **(i)** Fig. 9.3 shows one freely hanging uniform vertical cable **before the bridge section is added.**

Suggest why the stress in the cable at **P** is greater than the stress at **Q**.



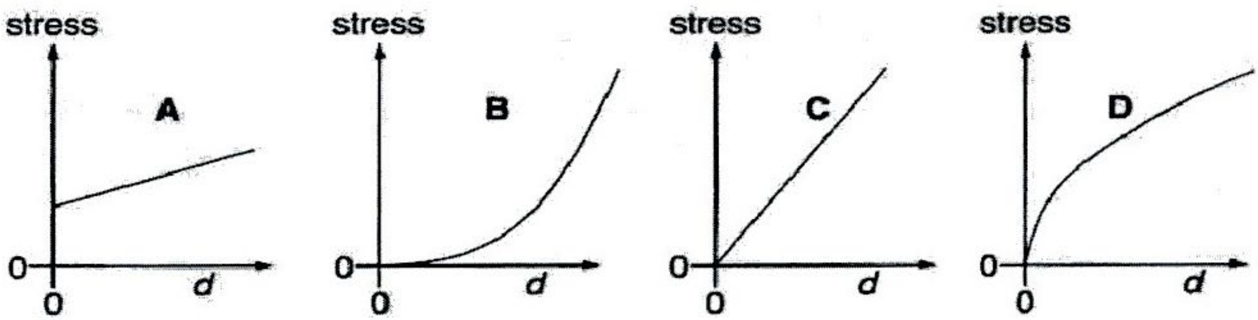
due to the weight of the cable itself.

[1]

Fig. 9.3

(ii) Here are four graphs, **A, B, C, D.**

Select the graph which best represents how the stress in the vertical cable (y-axis) varies with distance *d* from the **bottom** of the cable (x-axis) **before the bridge section is added.**



answer ......C...... [1]

[Total: 10]

This question is about steel wires in tension.

A sample of steel wire is tested in the laboratory. Fig. 8.1 shows the force-extension graph obtained when the wire is stretched elastically.

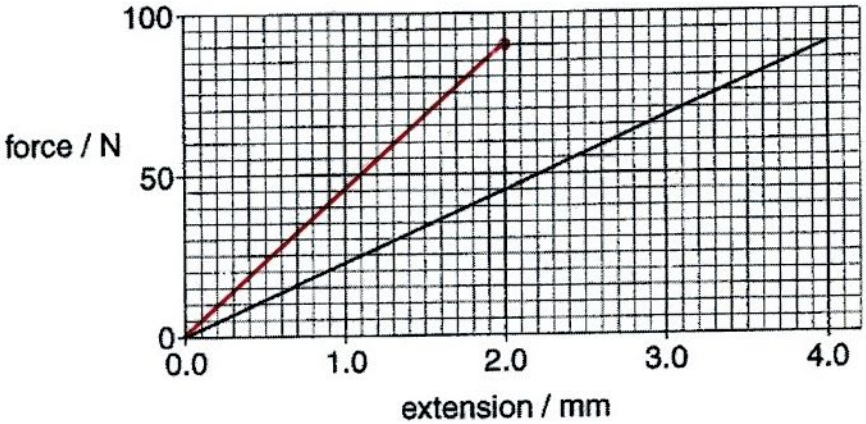


Fig. 8.1

(a) (i) Describe how the extension varies as the force is increased.

Force ∝ extension
↑ proportional

[1]

(ii) The test is repeated using another sample of the same wire, but of only **half** the original length. — so extension is half.

Draw on the axes of Fig. 8.1 the force-extension graph for this wire, as the force is increased to 90 N. [1]

(iii) Explain why both wires have the **same** value for the Young modulus.

YM is property of the material not the object.

[1]

(b) (i) The original steel wire has an unstretched length of 2.0 m and a cross-sectional area of 2.5×10^{-7} m^2.

Use these facts and information from the graph to calculate the stress and strain in the wire at a force of 90 N.

stress = F/A = $90\text{N} / 2.5 \times 10^{-7}\text{m}^2$ =

stress = 3.6×10^{8} Pa [2]

strain = $\frac{x}{L}$ = $\frac{4 \times 10^{-3}}{2}$ =

strain = 2.0×10^{-3} [2]

(ii) Calculate the Young modulus of the steel.
State the unit.

YM = $\frac{\text{stress}}{\text{strain}}$ = $\frac{3.6 \times 10^{8}}{2.0 \times 10^{-3}}$

Young modulus = 1.8×10^{11} unit Pa [2]

[Total: 9]

or Nm^{-2}