1)

A lift has a mass of 500 kg. It is designed to carry a maximum of 8 people of total mass 560 kg. The lift is supported by a steel cable of cross-sectional area $3.8 \times 10^{-4}\,m^2$. When the lift is at ground floor level the cable is at its maximum length of 140 m, as shown in Fig. 3.1. The mass per unit length of the cable is $3.0\,kg\,m^{-1}$.

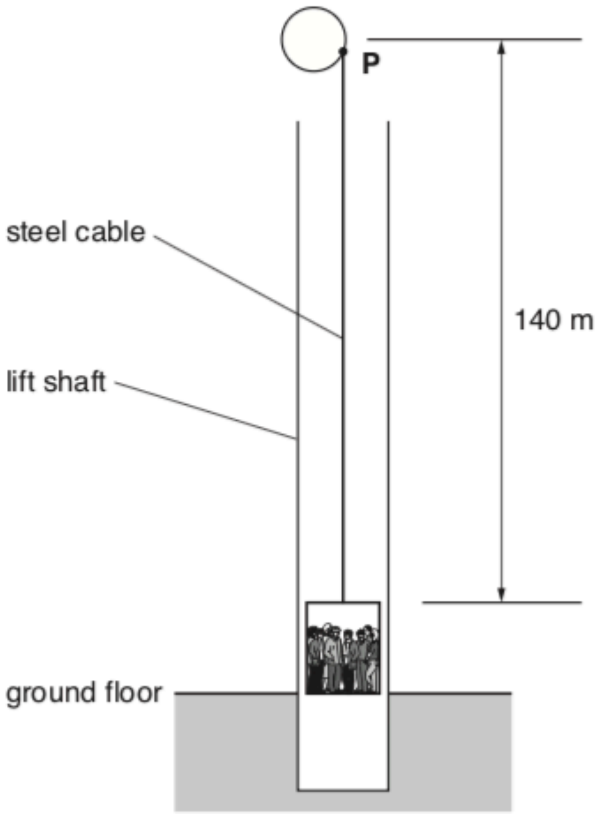

Fig. 3.1

(a) Show that the mass of the 140 m long steel cable is 420 kg.

[1]

(b) **(i)** The lift with its 8 passengers is stationary at the ground floor level. The initial upward acceleration of the lift and the cable is $1.8\,\text{m}\,\text{s}^{-2}$. Show that the **maximum** tension in the cable at point **P** is $1.7 \times 10^4\,\text{N}$.

[4]

(ii) Calculate the maximum stress in the cable.

stress = ... Pa **[2]**

[Total: 7]

2)

(a) In what form is energy stored when a metal wire is extended by a force?

.... **[1]**

(b) A metal wire of length 1.2 m is clamped vertically. A weight is hung from the lower end of the wire. The extension of the wire is 0.35 mm. The cross-sectional area of the wire is $1.4 \times 10^{-7}\,m^2$ and the Young modulus of the metal is 1.9×10^{11} Pa.

Calculate

(i) the strain of the wire

strain = ... **[1]**

(ii) the tension in the wire.

tension = ... N **[2]**

(c) There is great excitement at the moment about structures known as carbon nanotubes (CNTs). CNTs are cylindrical tubes of carbon atoms. These cylindrical tubes have diameter of a few nanometres and can be several millimetres in length. Carbon nanotubes are one of the strongest and stiffest materials known. Recently a carbon nanotube was tested to have an ultimate tensile strength of about 60 GPa. In comparison, high-carbon steel has an ultimate tensile strength of about 1.2 GPa. Under excessive tensile stress, the carbon nanotubes undergo plastic deformation. This deformation begins at a strain of about 5%. Carbon nanotubes have a low density for a solid. Carbon nanotubes have recently been used in high-quality racing bicycles.

(i) **1** The diameter of CNTs is a *few nanometres*. What is one nanometre in metres?

.... **[1]**

2 Explain what is meant by *plastic deformation*.

....

....

.... **[1]**

(ii) How many times stronger are CNTs than high-carbon steel?

....

.... **[1]**

(iii) State two advantages of making a bicycle frame using CNT technology rather than high-carbon steel.

....

....

.... **[2]**

[Total: 9]

3)

(a) Fig. 7.1 shows a length of tape under tension.

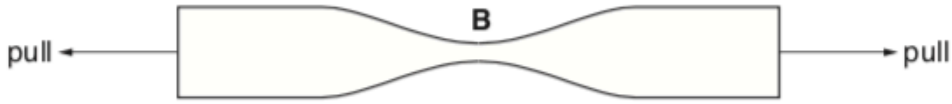

Fig. 7.1

(i) Explain why the tape is most likely to break at point **B**.

....

.... **[1]**

(ii) Explain what is meant by the statement:

'the tape has gone beyond its elastic limit'.

....

....

.... **[1]**

(b) Fig. 7.2 shows one possible method for determining the Young modulus of a metal in the form of a wire.

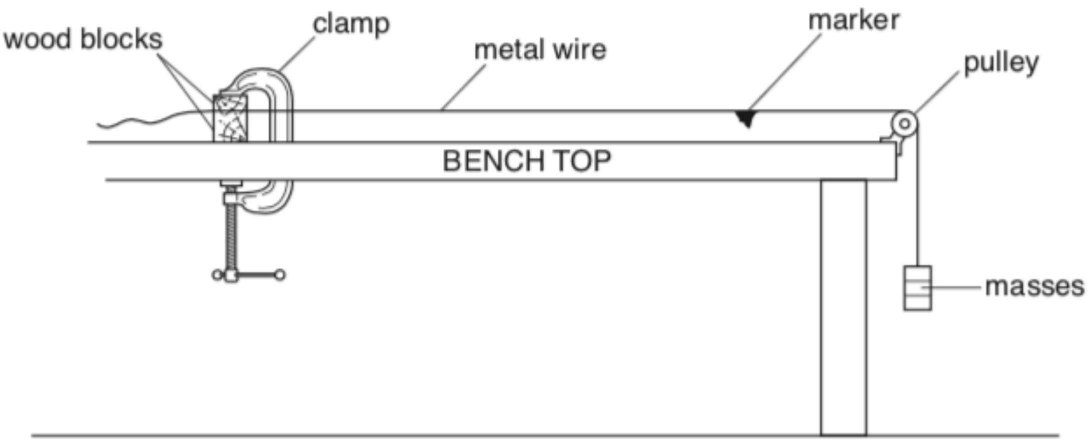

Fig. 7.2

Describe how you can use this apparatus to determine the Young modulus of the metal. The sections below should be helpful when writing your answers.

The **measurements** to be taken:

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

....

....

....

....

The **equipment** used to take the measurements:

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

....

....

....

....

How you would **determine** Young modulus from your measurements:

....

....

....

....

....

....

[8]

4)

(a) Fig. 7.1 shows stress against strain graphs for materials **X**, **Y** and **Z** up to their breaking points.

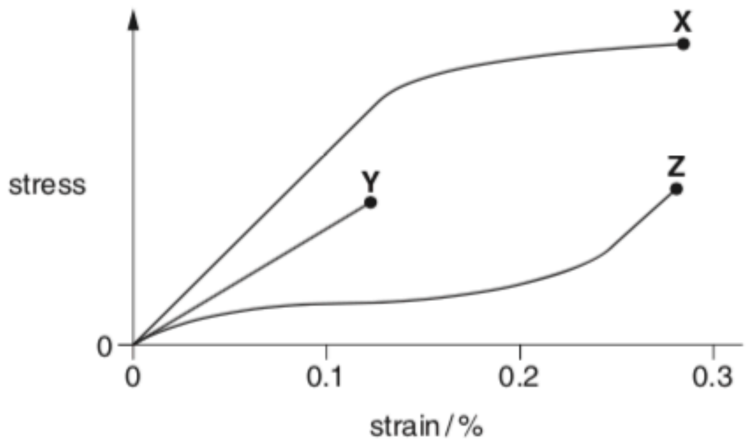

Fig. 7.1

(i) State which of these three materials is brittle.

.... **[1]**

(ii) State one similarity between the properties of materials **X** and **Y** for strains less than 0.05%.

....

.... **[1]**

(iii) State and explain which material has the greatest value for the Young modulus.

....

....

.... **[2]**

(b) Engineers are testing a new material to be used as support cables for a bridge. In a laboratory test, the breaking force for a sample of the material of diameter 0.50 mm is 240 N. Estimate the breaking force for a cable of diameter 15 mm made from the same material.

breaking force = ... N **[2]**

[Total: 6]

5)

(a) Fig. 7.1 shows stress against strain graphs for two materials **X** and **Y** up to their breaking points.

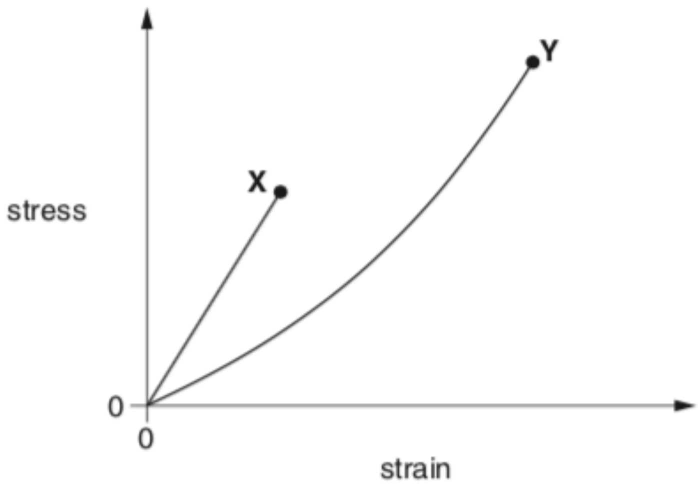

Fig. 7.1

Put a tick (✓) in the appropriate column if the statement applies to the material.

Statement	X	Y
This material is brittle.		
This material has greater breaking stress.		
This material obeys Hooke's Law.		

[1]

(b) Kevlar is one of the strongest man-made materials. It is used in reinforcing boat hulls, aircraft, tyres and bullet-proof vests. Sudden impacts cause this material to undergo plastic deformation.

(i) Explain what is meant by *plastic deformation*.

....

....

.... **[1]**

(ii) One particular type of Kevlar has breaking stress 3.00×10^9 Pa and Young modulus 1.30×10^{11} Pa. For a Kevlar thread of cross-sectional area $1.02 \times 10^{-7}\,m^2$ and length 0.500 m, calculate

1 the maximum breaking force

force = ... N

2 the extension of the thread when the stress is 1.20×10^9 Pa.

extension = ... m

[4]

[Total: 6]

6)

6 **(a)** Fig. 6.1 shows the stress against strain graphs of two materials **X** and **Y**.

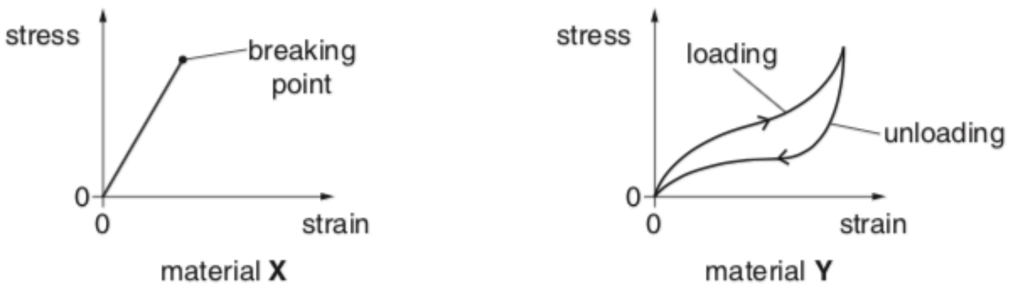

Fig. 6.1

Describe the properties of materials **X** and **Y**.

In your answer, you should use appropriate technical terms, spelled correctly.

material **X** ....

....

....

....

....

material **Y** ....

....

....

....

.... **[5]**

(b) You are given a spring, a metre rule and a 100 g mass. Describe how you would determine the force constant *k* of the spring.

....

....

....

....

.... **[3]**

7)

7 **(a)** Atoms in a solid are held in position by electrical forces. These electrical forces can be represented by an imaginary 'interatomic spring' between neighbouring atoms, see Fig. 7.1.

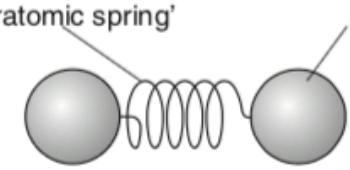

Fig. 7.1

The interatomic spring obeys *Hooke's law* and has a *force constant* just as a normal spring in the laboratory. Researchers in America have recently managed to determine the force experienced by an individual atom of cobalt when the atoms are squeezed together. The researchers found that a force of 210 pN changed the separation between a pair of atoms by a distance of 0.16 nm.

(i) State *Hooke's law.*

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

.... **[1]**

(ii) Calculate the force constant of the interatomic spring for a pair of cobalt atoms.

force constant = ... $N\,m^{-1}$ **[3]**

(b) Fig. 7.2 shows a stress against strain graph for a metal wire up to its breaking point.

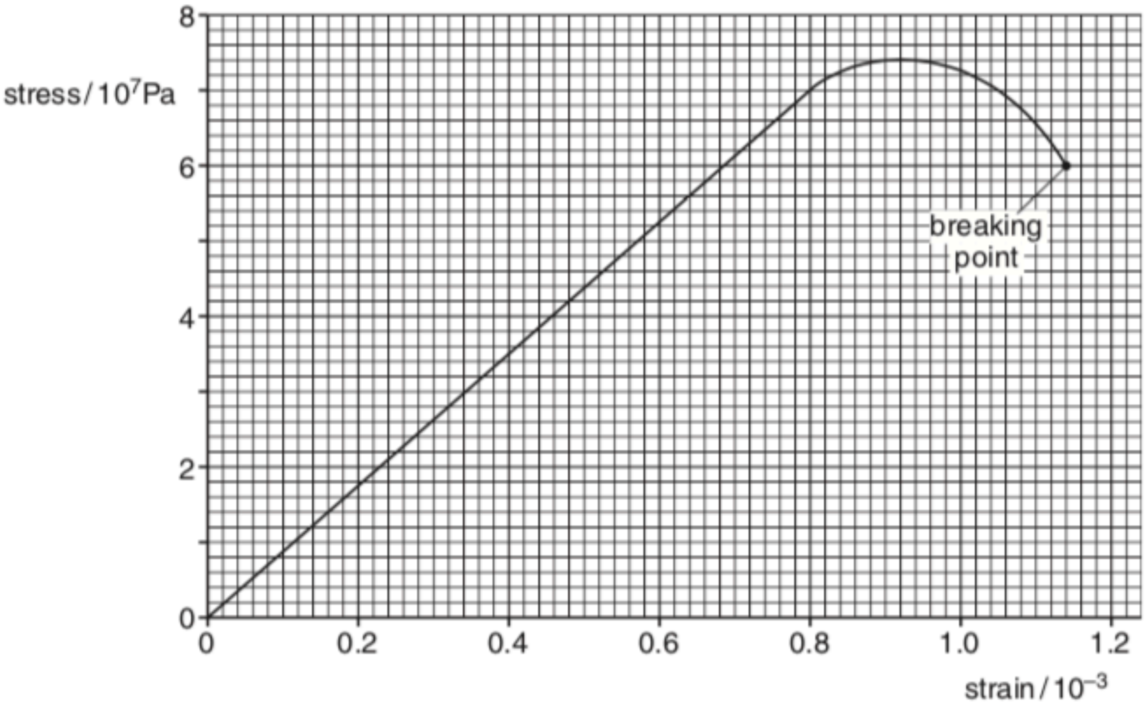

Fig. 7.2

(i) Use the graph to determine the Young modulus of the metal.

Young modulus = ... unit ....**[3]**

(ii) The wire breaks when a force of 19 N is applied. Use the graph to determine the cross-sectional area of the wire at the breaking point.

area = ... m^2 **[2]**

[Total: 9]

(a) Fig. 8.1 shows the stress against strain graph obtained from a test on a sample of wire of a ductile material.

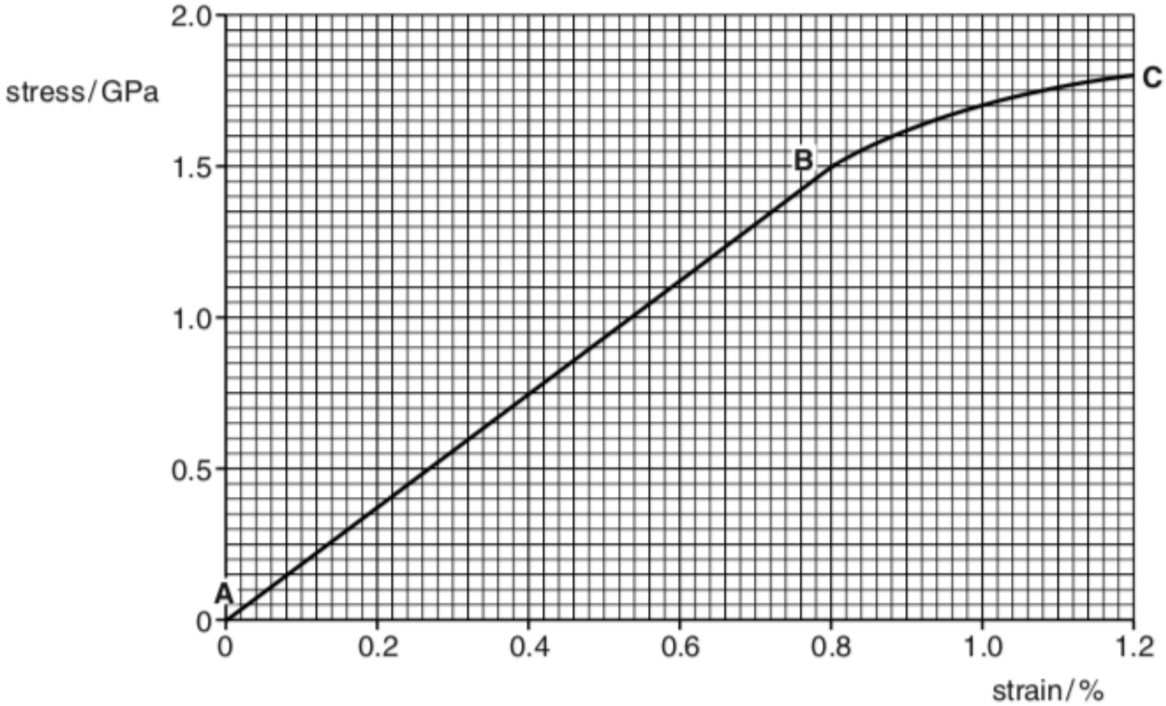

Fig. 8.1

(i) Use Fig. 8.1 to determine the Young modulus of the material.

Young modulus = ... Pa **[3]**

(ii) Use Fig. 8.1 to describe the behaviour of the material

1 in section **AB**

....

.... **[1]**

2 in section **BC**.

....

.... **[1]**

(iii) State and explain the effect on the linear section **AB** of the graph when a sample of the same wire, but of twice the original length is used.

....

....

.... **[2]**

(b) Fig. 8.2 shows a force against extension graph for an elastic material. The work done on this material during loading (upward arrow) is equal to the energy returned by the material when the load is removed (downward arrow).

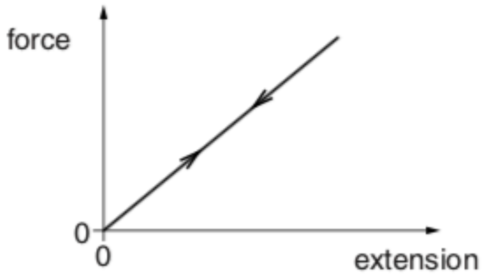

Fig. 8.2

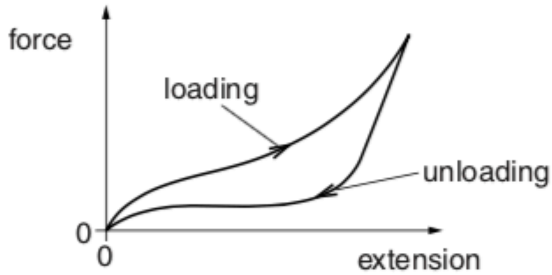

Fig. 8.3

Fig. 8.3 shows the force against extension graph for a material used to make aeroplane tyres. Aeroplane tyres experience sudden impact forces during landing.

Identify the type of material from Fig. 8.3. Describe the properties of this material and suggest why this material is suitable for aeroplane tyres.

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

....

....

....

....

....

....

....

.... **[3]**

[Total: 10]

9)

(a) Fig. 3.1 shows the stress against strain graph for a metal **X** up to its breaking point.

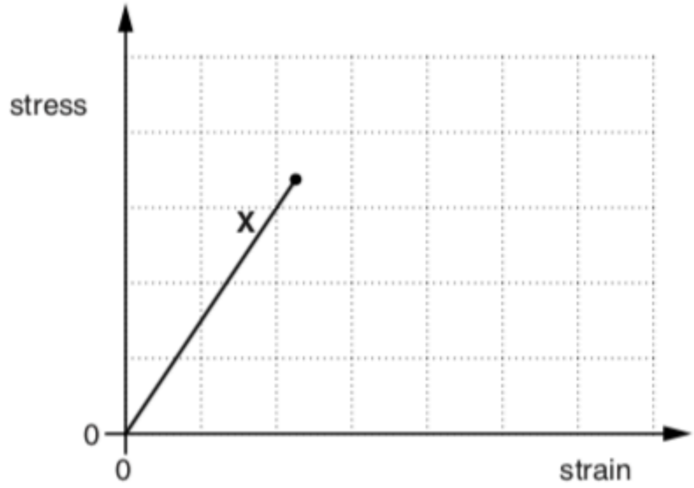

Fig. 3.1

(i) Use Fig. 3.1 to state the physical properties of this metal.

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

....

.... **[2]**

(ii) On the axes of Fig. 3.1, sketch a graph for a ductile material, having a larger Young modulus value than the metal **X**, up to its breaking point. **[2]**

(b) Fig. 3.2 shows a stationary cable car.

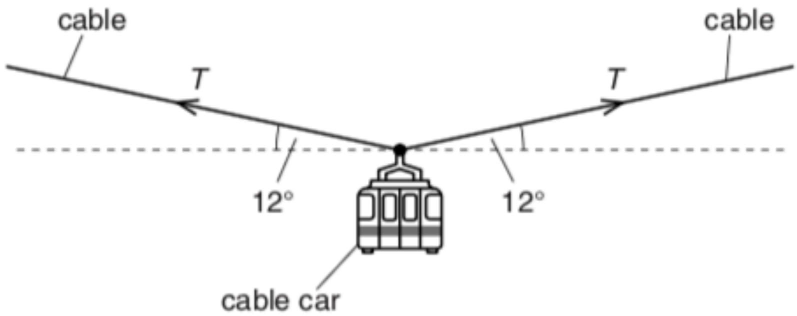

Fig. 3.2

The cable on both sides of the car is at an angle of 12° to the horizontal. The radius of the cable is 2.6×10^{-2} m. The stress in the cable is 1.8×10^{7} Pa. The Young modulus of the material of the cable is 2.0×10^{11} Pa.

(i) Calculate the strain experienced by the cable.

strain = ... **[2]**

(ii) Calculate the tension *T* in the cable.

T = ... N **[2]**

(iii) Calculate the weight of the cable car.

weight = ... N **[3]**

[Total: 11]

10)

(a) *Energy* and *work done* are scalar quantities and have the same unit as each other.

State **two** other scalar quantities in physics that have the same unit as each other.

....

.... **[1]**

(b) Two forces **A** and **B** act through the same point in an object. These two forces are shown in Fig. 2.1. No other forces act on the object.

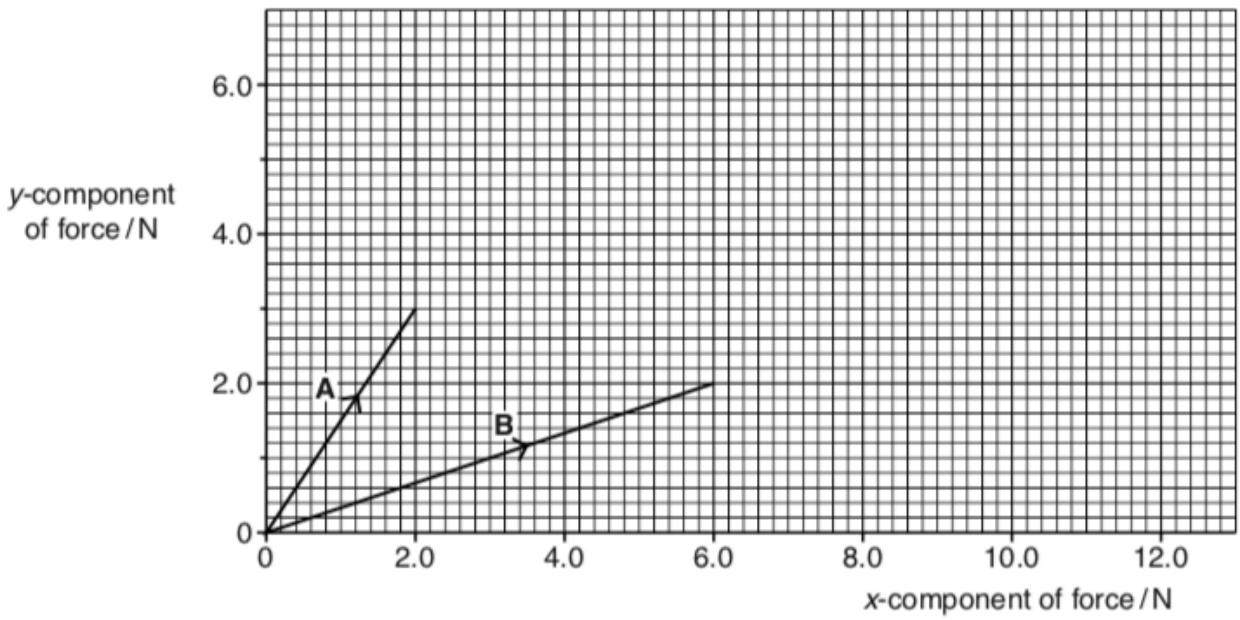

Fig. 2.1

(i) Use Fig. 2.1 to determine the *x*- and *y*- components of the force **B**.

x-component = ... N

y-component = ... N
[1]

(ii) Use Fig. 2.1 to determine the magnitude of the resultant of the two forces **A** and **B**.

resultant force = ... N **[3]**

11)

(a) Fig. 8.1 shows a graph of stress against strain for rubber.

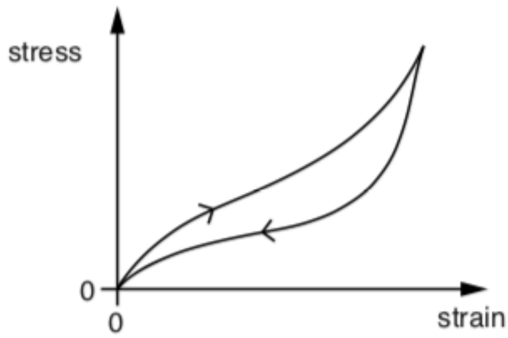

Fig. 8.1

Use Fig. 8.1 to describe the main physical properties of this material.

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

....

....

....

....

.... **[3]**

(b) Fig. 8.2 shows a metal strip pulled from its ends until it breaks.

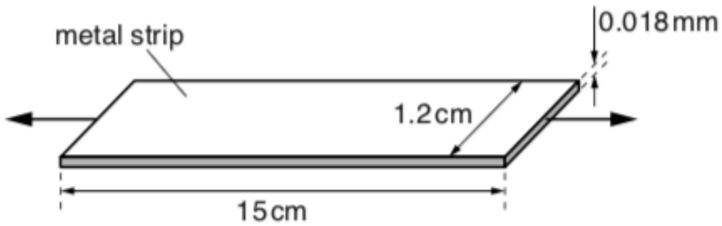

Fig. 8.2

The strip is 15 cm long, 1.2 cm wide and 0.018 mm thick. The breaking force for this strip is 16 N. The Young modulus of the metal is 7.1×10^{10} Pa.

(i) Calculate the extension of the metal strip when it breaks. State one assumption made in your calculation.

extension = ... m **[3]**

assumption: ....

.... **[1]**

(ii) Calculate the breaking force of a rod of radius 0.60 cm made from the same metal.

breaking force = ... N **[2]**

12)

A crane is used to lift a shipping container. The container has a mass of 2.8×10^4 kg and is lifted by **four** identical steel cables attached to the container as shown in Fig. 7.1.

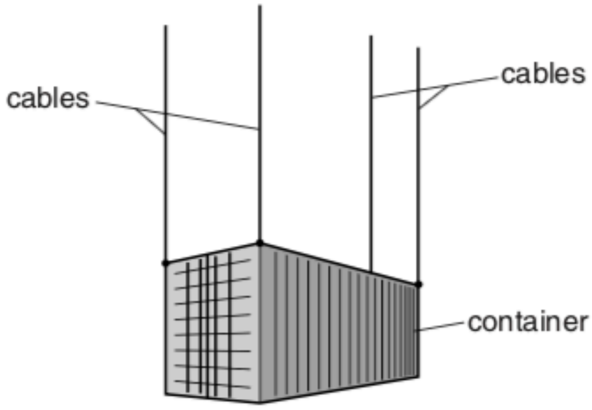

Fig. 7.1

Each cable has length 32 m and cross-sectional area 4.5×10^{-4} m^2. The container is lifted vertically at a **constant velocity**. The Young modulus of steel is 2.1×10^{11} Pa.

(a) Calculate the extension in mm of each cable.

extension = ... mm **[4]**

(b) The container is suddenly accelerated upwards. Explain the effect, if any, on the extension of the cables.

....

....

....

.... **[2]**