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

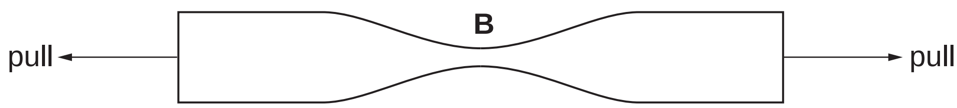

Fig. 7.1

(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.

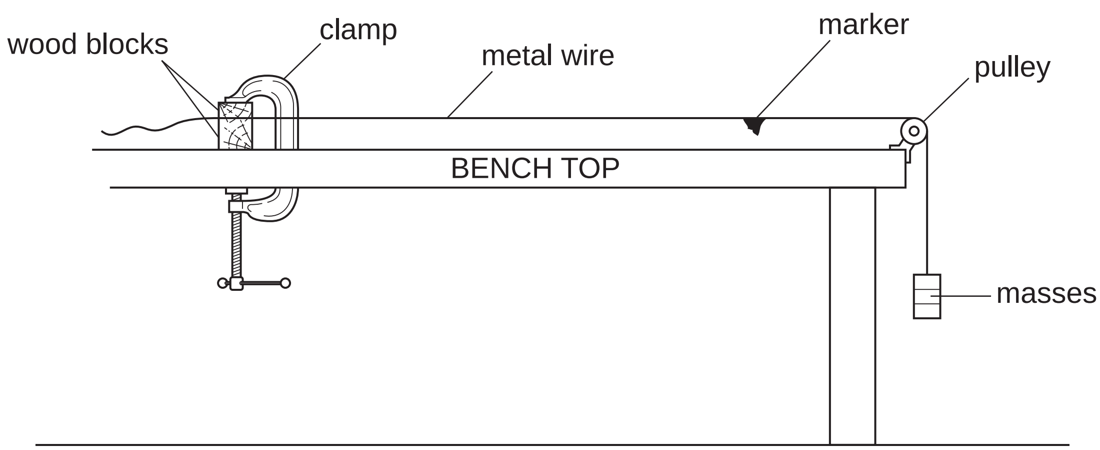

Fig. 7.2

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]

[Total: 10]

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

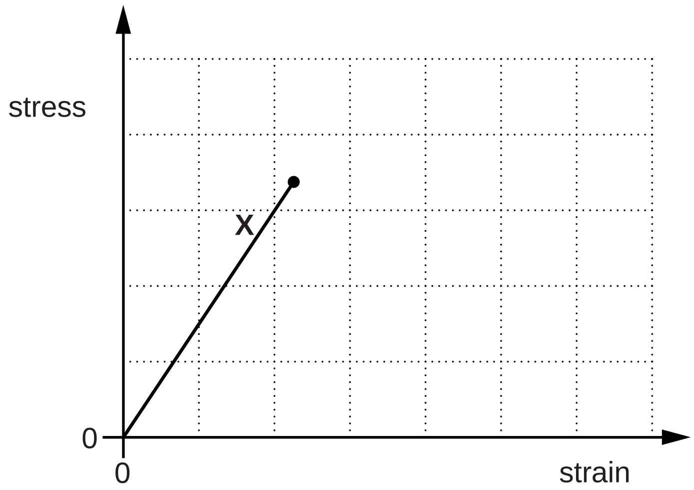

Fig. 3.1

(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.

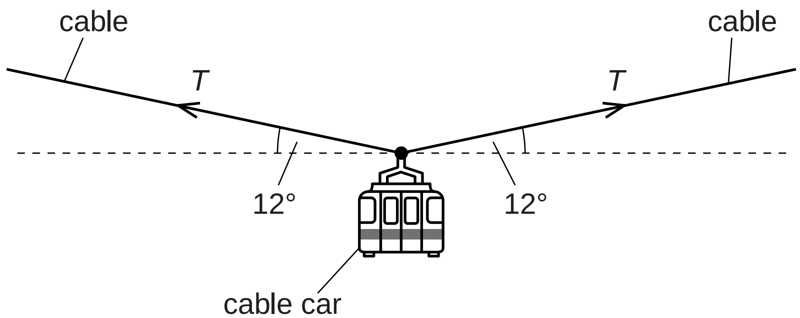

Fig. 3.2

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]

4 **(a)** Define the *force constant* of a spring.

....

.... **[1]**

(b) Fig. 3.1 shows a trolley attached by two **stretched** springs **A** and **B** to fixed supports.

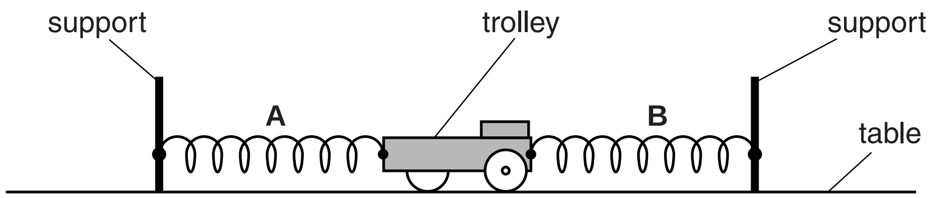

Fig. 3.1

The trolley is on a horizontal table and at rest. The springs **A** and **B** are identical.

(i) On Fig. 3.1, draw an arrow to show the direction of the force exerted by spring **A** on the trolley. Label this arrow **F**. **[1]**

(ii) The mass of the trolley is 0.80 kg. The force constant of each spring is $14\,N\,m^{-1}$. A student pulls the trolley to the left as shown in Fig. 3.2.

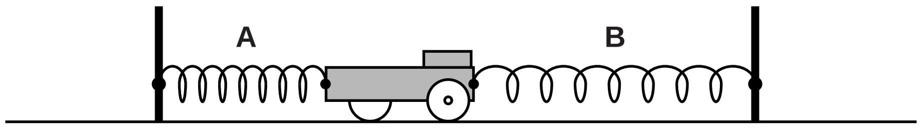

Fig. 3.2

The extension of spring **A** is 0.30 m and the extension of spring **B** is 0.50 m. The student releases the trolley. Calculate the **initial** values of

1 the acceleration of the trolley

acceleration = ... $m\,s^{-2}$ **[3]**

2 the ratio

$$\frac{\text{elastic potential energy for spring } \mathbf{B}}{\text{elastic potential energy for spring } \mathbf{A}}.$$

ratio = ... **[2]**

(iii) Explain why the acceleration of the trolley decreases as it travels a small distance to the right.

....

.... **[1]**

(iv) State and explain how the acceleration in your answer to **(ii)1** would be different when a heavy object is fixed to the trolley.

....

....

....

.... **[2]**

[Total: 10]

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

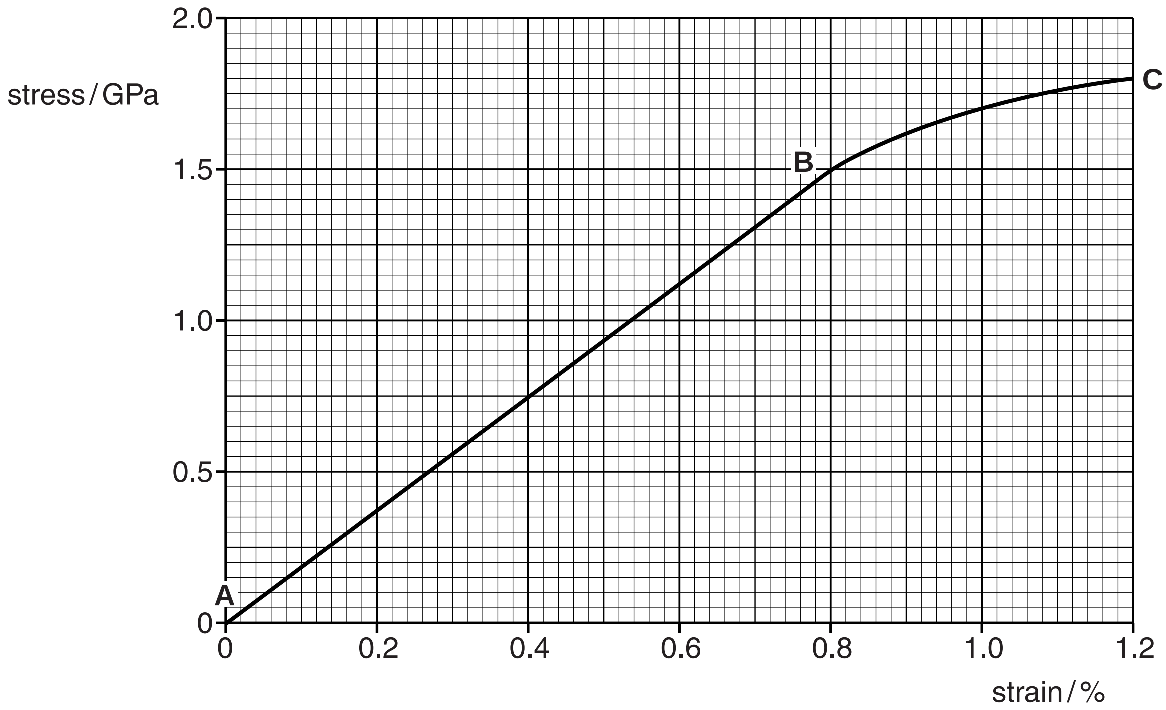

Fig. 8.1

(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).

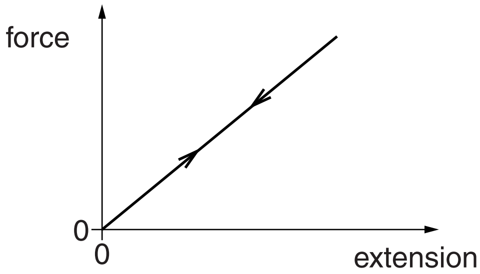

Fig. 8.2

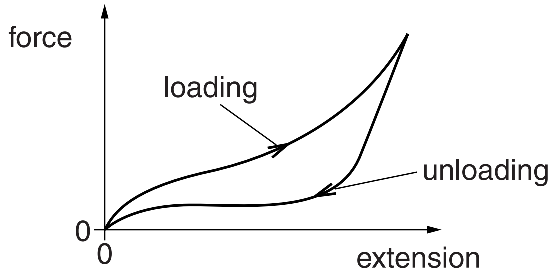

Fig. 8.3

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]