MATERIALS MECHANICS PAST PAPERS QUESTIONS OCR A LEVEL YEAR 1

1.

(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 $1.4 \times 10^{-7}\,\text{m}^2$ and the Young modulus of the metal is $1.9 \times 10^{11}\,\text{Pa}$.

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.

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.... **[2]**

[Total: 9]

2.

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 $3.0\,kg\,m^{-1}$.

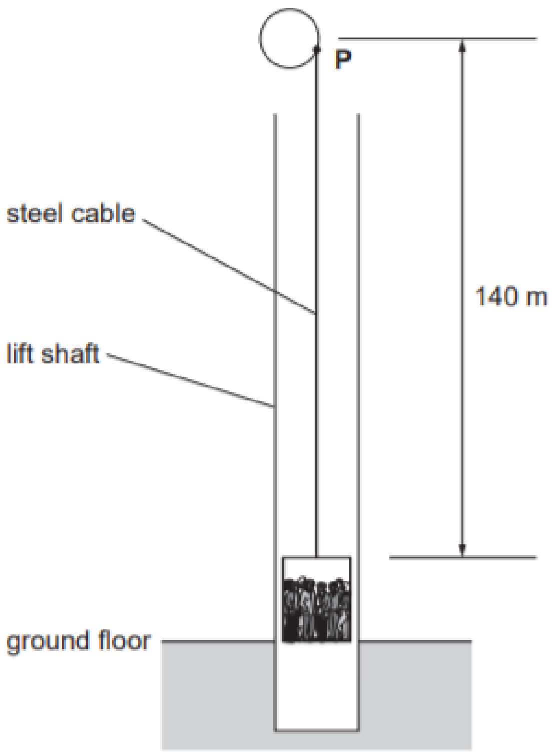

Fig. 3.1

(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]

3.

The force against length graph for a spring is shown in Fig. 6.1.

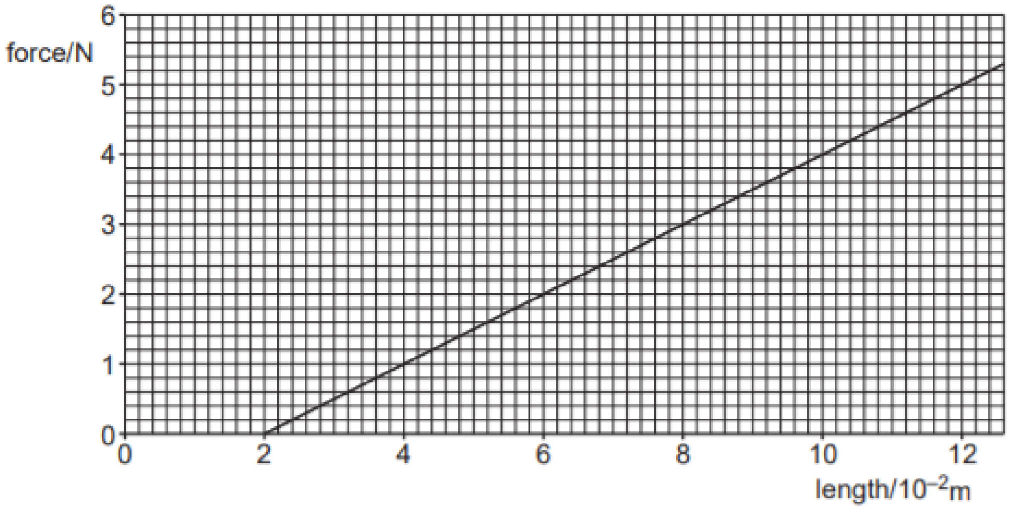

Fig. 6.1

(a) Explain why the graph does not pass through the origin.

....

.... **[1]**

(b) State what feature of the graph shows that the spring obeys Hooke's law.

....

.... **[1]**

(c) The gradient of the graph is equal to the force constant *k* of the spring. Determine the force constant of the spring.

force constant = ... $N m^{-1}$ **[2]**

(d) Calculate the work done on the spring when its length is increased from 2.0×10^{-2} m to 8.0×10^{-2} m.

work done = ... J **[2]**

(e) One end of the spring is fixed and a mass is hung vertically from the other end. The mass is pulled down and then released. The mass oscillates up and down. Fig. 6.2 shows the displacement *s* against time *t* graph for the mass.

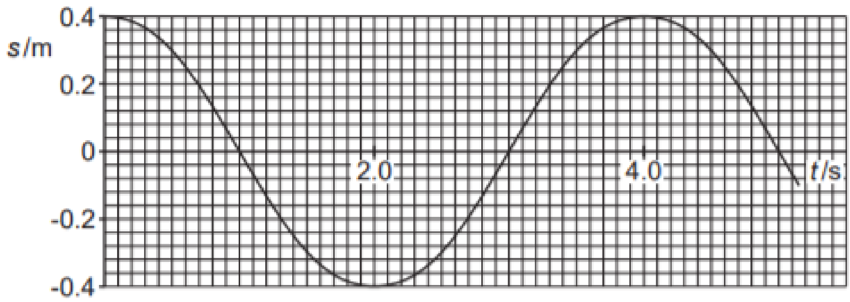

Fig. 6.2

Explain how you can use Fig. 6.2 to determine the **maximum** speed of the mass. You are not expected to do the calculations.

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....

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.... **[2]**

[Total: 8]

4.

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

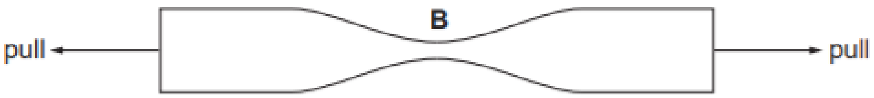

Fig. 7.1

(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.

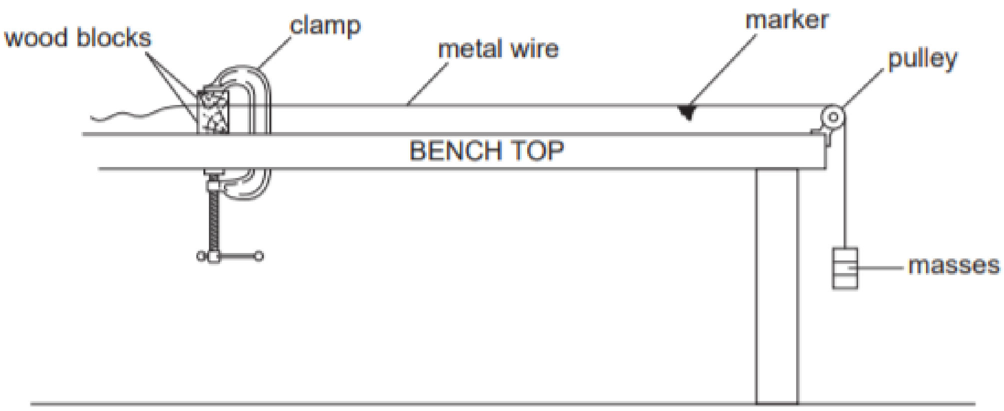

Fig. 7.2

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.

....

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

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

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....

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

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....

[8]

5.

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

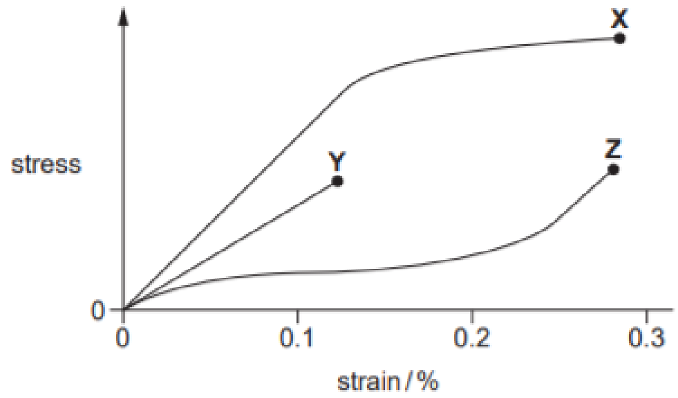

Fig. 7.1

(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]

6.

6 **(a)** State *Hooke's law*.

....

.... **[1]**

(b) Fig. 6.1 shows a force against extension graph for a spring.

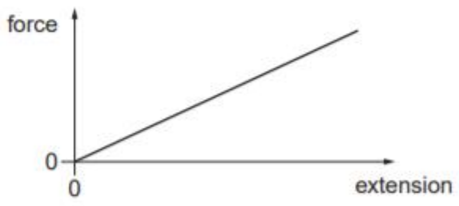

Fig. 6.1

Describe how such a force against extension graph can be used to determine

(i) the *force constant* of the spring

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

....

.... **[1]**

(ii) the *work done* on the spring.

....

.... **[1]**

(c) Two identical springs are connected end-to-end (series). The force constant of each spring is k. The free ends of the springs are pulled apart as shown in Fig. 6.2.

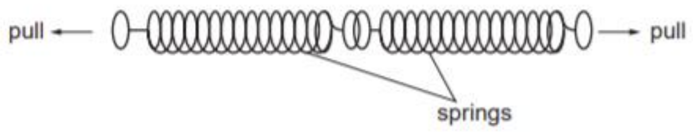

Fig. 6.2

Explain why the force constant of this combination of two springs in series is $\frac{k}{2}$.

....

....

.... **[2]**

(d) **(i)** Define the *Young modulus* of a material and state the condition when it applies.

....

....

.... **[2]**

(ii) A guitar string has length 0.70 m and cross-sectional area 0.20 mm^2. A constant tension of 4.2 N is applied to the string causing a strain of 0.015. Calculate

1 the stress in the string

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

2 the Young modulus of the material of the string

Young modulus = ... Pa **[2]**

3 the elastic potential energy (stored energy) in the string.

energy = ... J **[3]**

7.

A sample of wire is tested in the laboratory. Fig. 8.1 shows the force, F against extension, x graph for this wire.

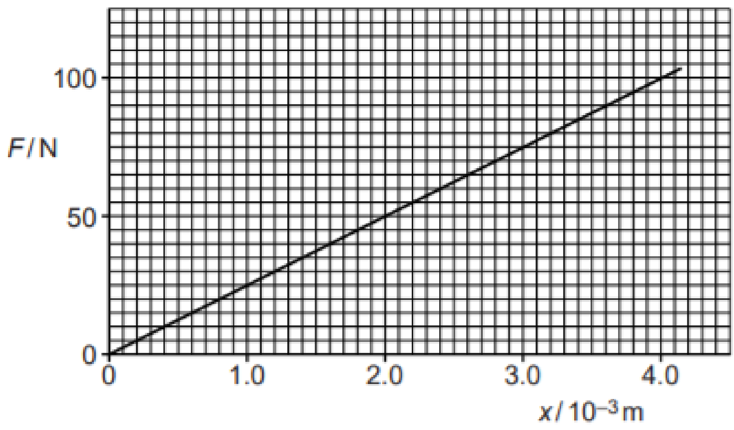

Fig. 8.1

(a) Explain how the graph shows that the wire obeys Hooke's law.

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

....

.... **[1]**

(b) State what the gradient of the graph represents.

.... **[1]**

(c) The initial length of the wire is 1.60 m. The radius of the wire is 2.8×10^{-4} m. Use the graph and this information to determine the Young modulus of the material of the wire.

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

(d) The test is repeated for another wire made from the same material, having the same length but **half** the diameter. Explain how the force against extension graph for this wire will differ from the graph of Fig. 8.1.

....

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.... **[2]**

(e) It is very dangerous if the wire under stress suddenly breaks. The elastic potential energy of the strained wire is converted into kinetic energy. Show that the 'whiplash' speed v of the wire is directly proportional to the extension x of the wire.

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.... **[2]**

[Total: 9]