A-level Physics (7407/7408)

Materials Test

Name:

Class:

Author:

Date:

Time: **30 min**

Marks: **25**

Comments:

Q1. A stone is projected horizontally by a catapult consisting of two rubber cords. The cords, which obey Hooke's law, are stretched and released. When each cord is extended by x, the stone is projected with a speed v. Assuming that all the strain energy in the rubber is transferred to the stone, what is the speed of the stone when each cord is extended by $2x$?

A v

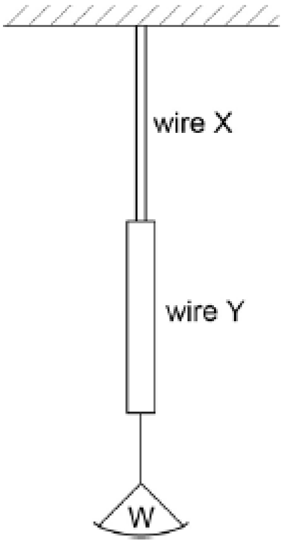
B $\sqrt{2v}$

C $2v$

D $4v$

(Total 1 mark)

Q2. Two vertical copper wires X and Y of equal length are joined as shown. Y has a greater diameter than X. A weight W is hung from the lower end of Y.



Which of the following is correct?

A The strain in X is the same as that in Y.

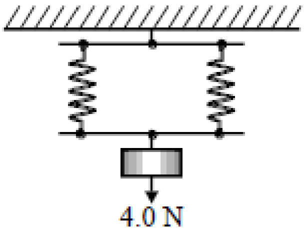
B The stress in Y is greater than that in X.

C The tension in Y is the same as that in X.

D The elastic energy stored in X is less than that stored in Y.

(Total 1 mark)

Q3. A load of 4.0 N is suspended from a parallel two-spring system as shown in the diagram.



The spring constant of each spring is 20 N m^{-1}. The elastic energy, in J, stored in the system is

A 0.1

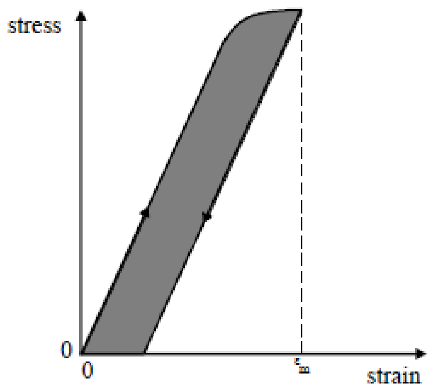
B 0.2

C 0.4

D 0.8

(Total 1 mark)

Q4. The graph shows the variation of stress with strain for a ductile alloy when a specimen is slowly stretched to a maximum strain of ε_m and the stress is then slowly reduced to zero.



The shaded area

A represents the work done per unit volume when stretching the specimen

B represents the energy per unit volume recovered when the stress is removed

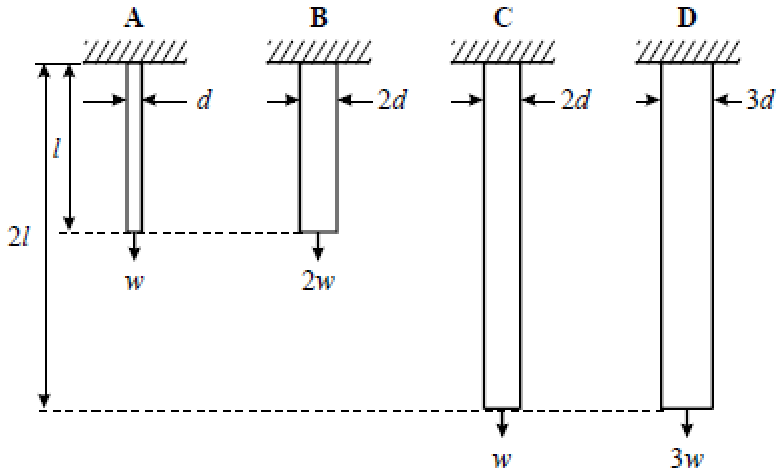
C represents the energy per unit volume which cannot be recovered

D has units of J m^{-1}

(Total 1 mark)

Q5. The four bars **A**, **B**, **C** and **D** have diameters, lengths and loads as shown. They are all made of the same material.

Which bar has the greatest extension?



(Total 1 mark)

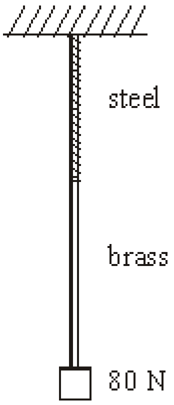
Q6. (a) State *Hooke's law* for a material in the form of a wire and state the conditions under which this law applies.

....

....

(2)

(b) A length of steel wire and a length of brass wire are joined together. This combination is suspended from a fixed support and a force of 80 N is applied at the bottom end, as shown in the figure below.



Each wire has a cross-sectional area of 2.4×10^{-6} m^2.

length of the steel wire = 0.80 m
length of the brass wire = 1.40 m
the Young modulus for steel = 2.0×10^{11} Pa
the Young modulus for brass = 1.0×10^{11} Pa

(i) Calculate the total extension produced when the force of 80 N is applied.

....

....

....

....

....

....

(ii) Show that the mass of the combination wire = 4.4×10^{-2} kg.

density of steel = 7.9×10^3 kg m^{-3}
density of brass = 8.5×10^3 kg m^{-3}

....

....

....

....

....

(7)

(c) A single brass wire has the same mass and the same cross-sectional area as the combination wire described in part (b). Calculate its length.

....

....

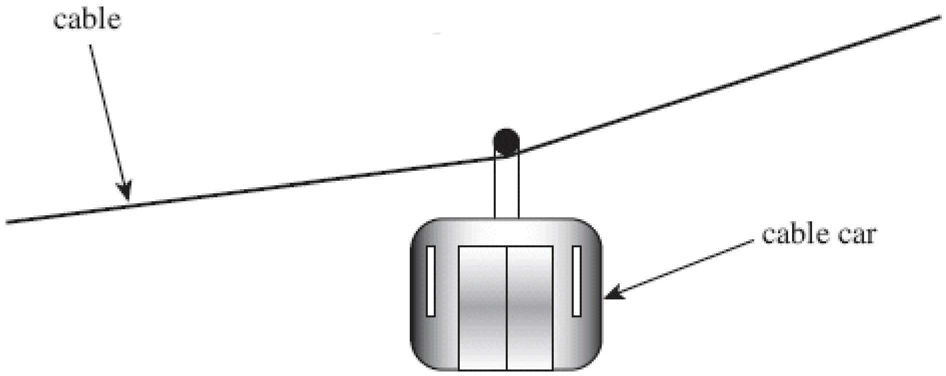
....

....

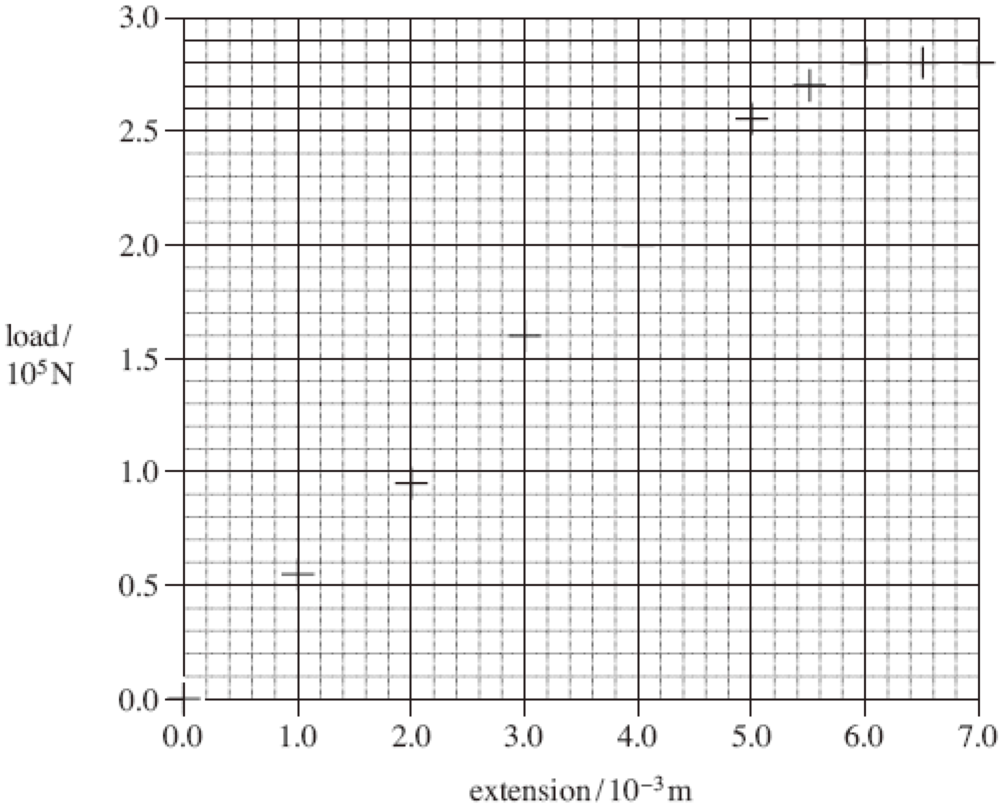
....

(2)
(Total 11 marks)

Q7. A cable car system is used to transport people up a hill. The figure below shows a stationary cable car suspended from a steel cable of cross-sectional area 2.5×10^{-3} m^2.



(a) The graph below is for a 10 m length of this steel cable.



(i) Draw a line of best fit on the graph.

(2)

(ii) Use the graph to calculate the initial gradient, *k,* for this sample of the cable.

answer = ... N m^{-1}

(2)

(b) The cable breaks when the extension of the sample reaches 7.0 mm. Calculate the breaking stress, stating an appropriate unit.

answer = ...

(3)

(c) In a cable car system a 1000 m length of this cable is used. Calculate the extension of this cable when the tension is 150 kN.

answer = ...m

(2)
(Total 9 marks)

M1.C

[1]

M2.C

[1]

M3.B

[1]

M4.C

[1]

M5.A

[1]

M6. (a) Hooke's law: the extension is proportional to the force applied **(1)**
up to the limit of proportionality or elastic limit
[or for small extensions] **(1)**

2

(b) (i) (use of $E = \frac{F}{A}\frac{l}{\Delta L}$ gives) $\Delta L_s = \frac{80 \times 0.8}{2.0 \times 10^{11} \times 2.4 \times 10^{-6}}$ **(1)**

$= 1.3 \times 10^{-4}$ (m) **(1)** (1.33×10^{-4} (m))

$\Delta L_b = \frac{80 \times 1.4}{1.0 \times 10^{11} \times 2.4 \times 10^{-6}} = 4.7 \times 10^{-4}$ (m) **(1)** (4.66×10^{-4} (m)) total extension = 6.0×10^{-4} m **(1)**

(ii) $m = \rho \times V$ **(1)**
$m_s = 7.9 \times 10^3 \times 2.4 \times 10^{-6} \times 0.8 = 15.2 \times 10^{-3}$ (kg) **(1)**
$m_b = 8.5 \times 10^3 \times 2.4 \times 10^{-6} \times 1.4 = 28.6 \times 10^{-3}$ (kg) **(1)**
(to give total mass of 44 or 43.8×10^{-3} kg)

7

(c) (use of $m = \rho A l$ gives) $l = \dfrac{44 \times 10^{-3}}{8.5 \times 10^3 \times 2.4 \times 10^{-6}}$ **(1)**

= 2.2 m **(1)** (2.16 m)

(use of mass = 43.8×10^{-3} kg gives 2.14 m)

2

[11]

M7. (a) (i) straight best fit line from 0 → (at least) extension of 4.0×10^{-3} m **(1)**

smooth curve near points after 5.0×10^{-3} m **(1)**

2

(ii) $\left(k = \dfrac{\Delta F}{\Delta l} = \dfrac{2.55(\times 10^5)}{5.0(\times 10^{-3})}\right)$ their $\dfrac{\Delta F}{\Delta l}$ (ignore powers of ten) **(1)**

= 5.1×10^7

and *x* axis interval ≥ 3.0 **(1)** (5.06 to 5.14×10^7 N m^{-1}) ecf from graph

allow error in calculation ± 2%

2

(b) load = 2.8×10^5 or $\left(\text{stress} = \dfrac{F}{A}\right) = \dfrac{2.8(\times 10^5)}{2.5 \times 10^{-3}}$ **(1)** 2.8 only

= 1.1×10^8 (Pa) 110 (MPa) **(1)** (1.12×10^8)

(M)Pa, pascals, N m^{-2} **(1)**

3

(c) (Δl = $\frac{F}{k}$) = $\frac{150000}{5.1 \times 10^{7}}$ **(1)** (= 2.94×10^{-3} m for 10 m)

gives 0.29(4) (m) **(1)** ecf

or reads a reasonable extension for 150 kN from the graph **(1)**

and multiples by 100 (= 0.29) (ecf) **(1)**

2

[9]

E6. Hooke's law, in part (a), was generally known to candidates although many did not state the condition under which it applied. Many introduced temperature into the argument.

The calculation in part (b) was usually correct with comparatively few candidates adding the two lengths or adding the values of the Young moduli to perform just one calculation. Questions on density, similar to those in part (b) (ii), are usually done well, and this question was no exception. Full marks were quite common in part (b).

Part (c) also proved to be relatively easy with the large majority of candidates obtaining the correct answer. Those who failed were usually those who tried to tackle it from a Young modulus point of view.

E7. In part (a) (i), the line of best fit had to start very near to the origin and go between the fifth and sixth points on the graph. Most candidates did this very well. Very few candidates who attempted a freehand line made their line smooth or straight enough to gain the first mark. A smooth curve was expected for the last few points on the graph. Most candidates knew that this is how a spring is likely to behave and assumed a curve would be more appropriate than another straight section.

Many candidates did not get the powers of ten correct or simply ignored them when calculating the gradient in part (a) (ii). There was a general lack of care with the precision of the gradient measurement. Often a line would not go exactly through the origin and this would not be taken into account by the candidate. Gradients were often calculated from less than half of the available length of the line.

Part (b) was done well. However, a surprising number of candidates misread the force as 2.6 or 2.7 or 2.85×10^5 N. Marks were often lost on the unit. The unit (Pa or N m^{-2}) needed to have a capital 'N' or 'P' and a lowercase 'm' or 'a'.

For part (c), many candidates successfully used Hooke's law to find the extension of a 10 m length of the cable with a force of 150 kN. Many did not realise that they then needed to multiply by 100 to get the extension of a 1000 m section. Some multiplied by 1000 instead of 100. A considerable number thought they needed to divide by 1000. Surprisingly, very few realised they simply could read off the extension from the graph for a 10 m length at 150 kN and then multiply by 100. It was also common to see the Young modulus equation used, but this was unnecessarily complicated and rarely yielded the correct answer. The suspicion is that this question caught many candidates out, because a certain amount of manipulation of numbers was necessary, in addition to substitution into an equation. This is a skill that will be essential for those continuing to A2.