Deformation of Solids

Question paper 4

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Deformation of Solids
Sub Topic	
Paper Type	Theory
Booklet	Question paper 4

Time Allowed: **57 minutes**

Score: **/47**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)** A uniform wire has length L and constant area of cross-section A.
The material of the wire has Young modulus E and resistivity ρ.
A tension F in the wire causes its length to increase by ΔL.

For this wire, state expressions, in terms of L, A, F, ΔL and ρ for

(i) the stress σ,

.... [1]

(ii) the strain ε,

.... [1]

(iii) the Young modulus E,

.... [1]

(iv) the resistance R.

.... [1]

(b) One end of a metal wire of length 2.6 m and constant area of cross-section $3.8 \times 10^{-7}\,\text{m}^2$ is attached to a fixed point, as shown in Fig. 4.1.

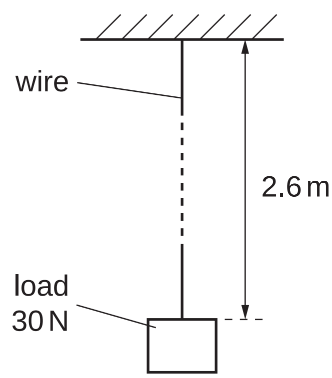

Fig. 4.1

The Young modulus of the material of the wire is 7.0×10^{10} Pa and its resistivity is 2.6×10^{-8} Ω m.
A load of 30 N is attached to the lower end of the wire. Assume that the area of cross-section of the wire does not change.
For this load of 30 N,

(i) show that the extension of the wire is 2.9 mm,

[1]

(ii) calculate the change in resistance of the wire.

change = ... Ω [2]

(c) The resistance of the wire changes with the applied load.
Comment on the suggestion that this change of resistance could be used to measure the magnitude of the load on the wire.

....

....

.... [2]

2 **(a)** A metal wire has spring constant *k*. Forces are applied to the ends of the wire to extend it within the limit of Hooke's law.
Show that, for an extension *x*, the strain energy *E* stored in the wire is given by

$$E = \tfrac{1}{2}kx^2.$$

[4]

(b) The wire in **(a)** is now extended beyond its elastic limit. The forces causing the extension are then removed.
The variation with extension *x* of the tension *F* in the wire is shown in Fig. 4.1.

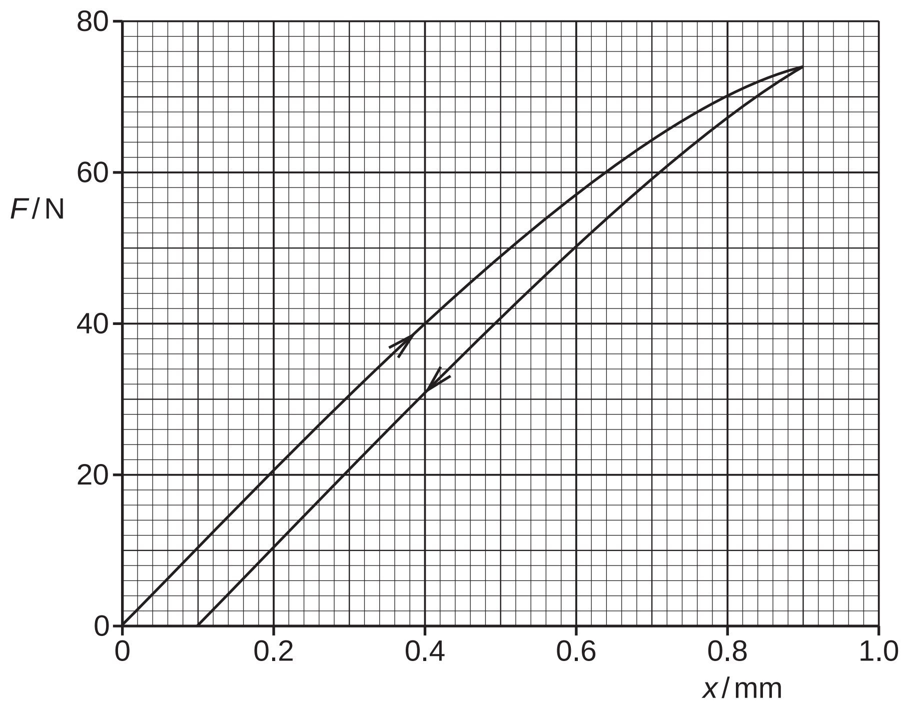

Fig. 4.1

Energy E_S is expended to cause a permanent extension of the wire.

(i) On Fig. 4.1, shade the area that represents the energy E_S. [1]

(ii) Use Fig. 4.1 to calculate the energy E_S.

E_S = ... mJ [3]

(iii) Suggest the change in the structure of the wire that is caused by the energy E_S.

....

....[1]

3 Briefly describe the structures of crystalline solids, polymers and amorphous materials.

crystalline solids ....

....

....

polymers ....

....

....

amorphous materials ....

....

....
[5]

4 A spring hangs vertically from a fixed point and a mass of 94 g is suspended from the spring, stretching the spring as shown in Fig. 5.1.

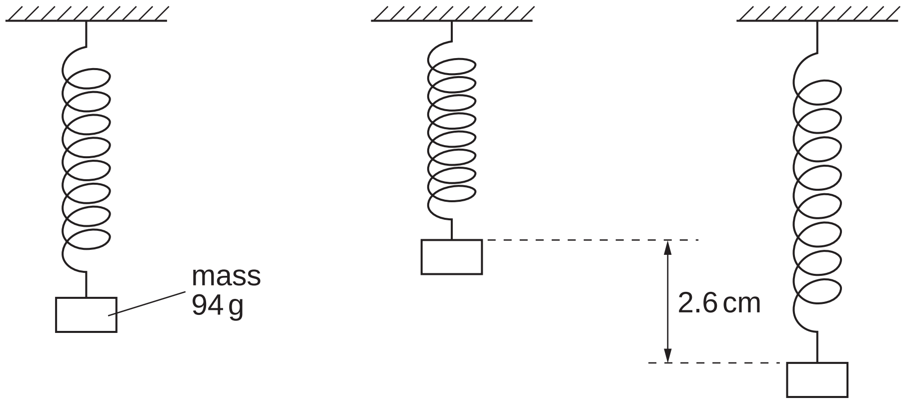

Fig. 5.1 **Fig. 5.2** **Fig. 5.3**

The mass is raised vertically so that the length of the spring is its unextended length. This is illustrated in Fig. 5.2.

The mass is then released. The mass moves through a vertical distance of 2.6 cm before temporarily coming to rest. This position is illustrated in Fig. 5.3.

(a) State which diagram, Fig. 5.1, Fig. 5.2 or Fig. 5.3, illustrates the position of the mass such that

(i) the mass has maximum gravitational potential energy,

.... [1]

(ii) the spring has maximum strain energy.

.... [1]

(b) Briefly describe the variation of the kinetic energy of the mass as the mass falls from its highest position (Fig. 5.2) to its lowest position (Fig. 5.3).

....

.... [1]

(c) The strain energy E stored in the spring is given by the expression

$$E = \frac{1}{2}kx^2$$

where k is the spring constant and x is the extension of the spring.

For the mass moving between the positions shown in Fig. 5.2 and Fig. 5.3,

(i) calculate the change in the gravitational potential energy of the mass,

change = ... J [2]

(ii) determine the extension of the spring at which the strain energy is half its maximum value.

extension = ... cm [3]

5 **(a)** The variation with extension *x* of the tension *F* in a spring is shown in Fig. 3.1.

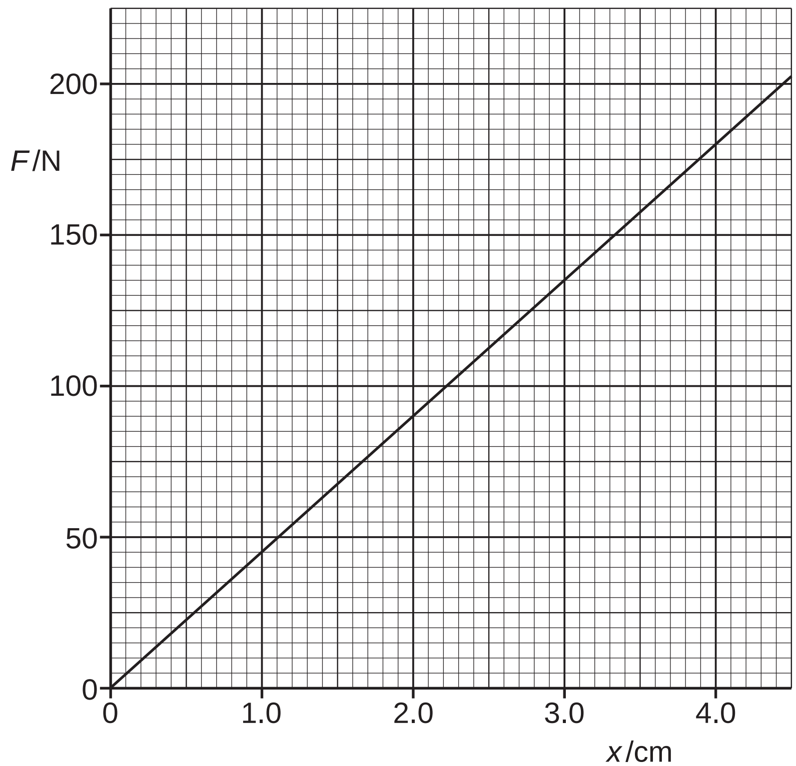

Fig. 3.1

Use Fig. 3.1 to calculate the energy stored in the spring for an extension of 4.0 cm.
Explain your working.

energy = ... J [3]

(b) The spring in **(a)** is used to join together two frictionless trolleys A and B of mass M_1 and M_2 respectively, as shown in Fig. 3.2.

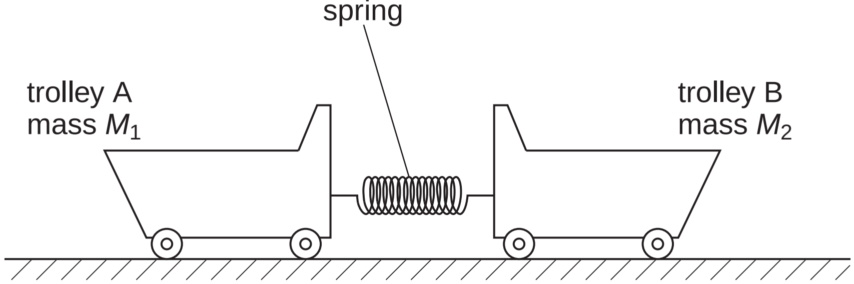

Fig. 3.2

The trolleys rest on a horizontal surface and are held apart so that the spring is extended.

The trolleys are then released.

(i) Explain why, as the extension of the spring is reduced, the momentum of trolley A is equal in magnitude but opposite in direction to the momentum of trolley B.

....

....

....

.... [2]

(ii) At the instant when the extension of the spring is zero, trolley A has speed V_1 and trolley B has speed V_2.
Write down

1. an equation, based on momentum, to relate V_1 and V_2,

....

.... [1]

2. an equation to relate the initial energy E stored in the spring to the final energies of the trolleys.

....

.... [1]

(iii) **1.** Show that the kinetic energy E_K of an object of mass m is related to its momentum p by the expression

$$E_K = \frac{p^2}{2m}.$$

[1]

2. Trolley A has a larger mass than trolley B.
Use your answer in **(ii) part 1** to deduce which trolley, A or B, has the larger kinetic energy at the instant when the extension of the spring is zero.

....

....[1]

6 **(a)** Tensile forces are applied to opposite ends of a copper rod so that the rod is stretched. The variation with stress of the strain of the rod is shown in Fig. 5.1.

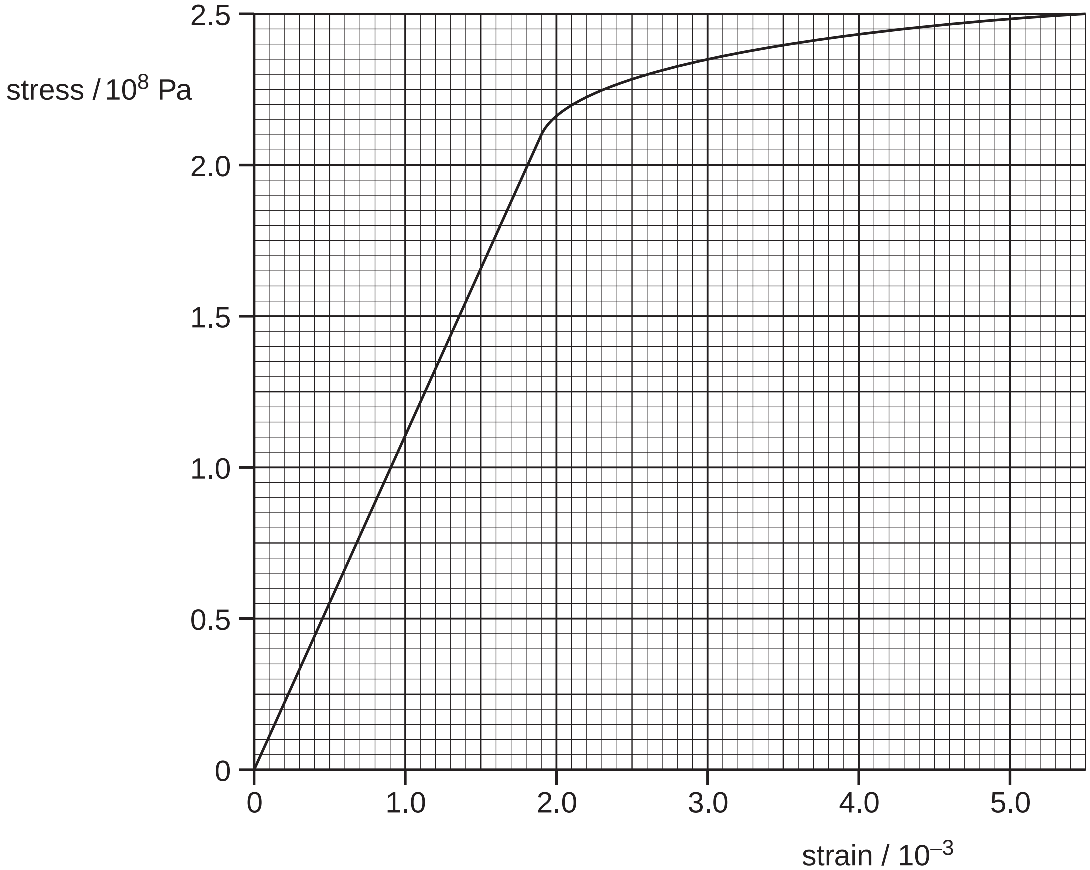

Fig. 5.1

(i) Use Fig. 5.1 to determine the Young modulus of copper.

Young modulus = ... Pa [3]

(ii) On Fig. 5.1, sketch a line to show the variation with stress of the strain of the rod as the stress is reduced from 2.5×10^6 Pa to zero. No further calculations are expected.

[1]

(b) The walls of the tyres on a car are made of a rubber compound.
The variation with stress of the strain of a specimen of this rubber compound is shown in Fig. 5.2.

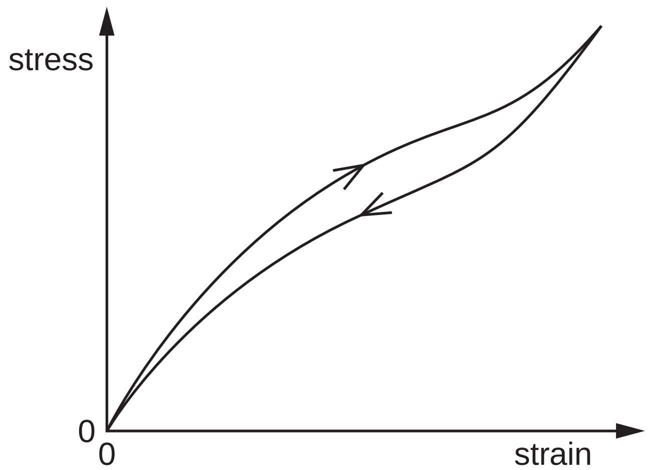

Fig. 5.2

As the car moves, the walls of the tyres bend and straighten continuously.

Use Fig. 5.2 to explain why the walls of the tyres become warm.

....

....

....

....[3]