Deformation of Solids

Question paper 1

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Deformation of Solids
Sub Topic	
Paper Type	Theory
Booklet	Question paper 1

Time Allowed: **59 minutes**

Score: **/49**

Percentage: **/100**

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

1 A spring is kept horizontal by attaching it to points A and B, as shown in Fig. 4.1.

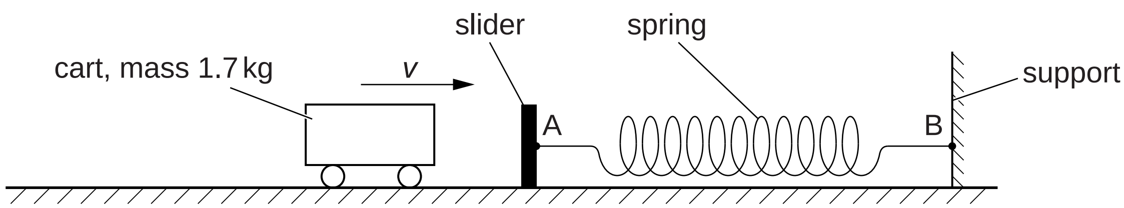

Fig. 4.1

Point A is on a movable slider and point B is on a fixed support. A cart of mass 1.7 kg has horizontal velocity *v* towards the slider. The cart collides with the slider. The spring is compressed as the cart comes to rest. The variation of compression *x* of the spring with force *F* exerted on the spring is shown in Fig. 4.2.

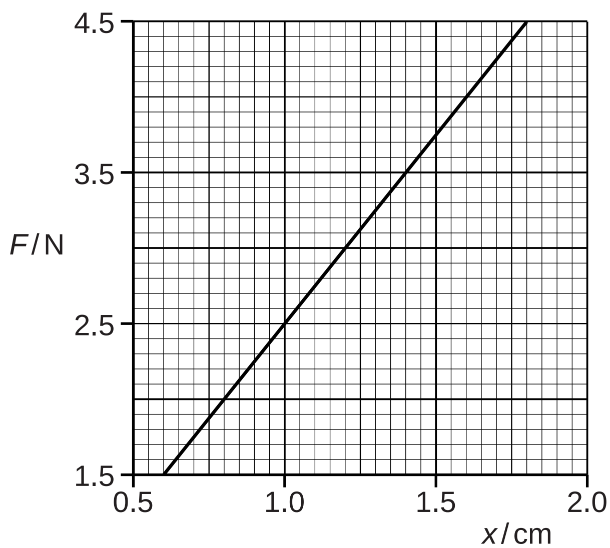

Fig. 4.2

Fig. 4.2 shows the compression of the spring for *F* = 1.5 N to *F* = 4.5 N. The cart comes to rest when *F* is 4.5 N.

(a) Use Fig. 4.2 to

(i) show that the compression of the spring obeys Hooke's law,

....

....

.... [2]

(ii) determine the spring constant of the spring,

spring constant = ... $N\,m^{-1}$ [2]

(iii) determine the elastic potential energy E_P stored in the spring due to the cart being brought to rest.

E_P = ... J [3]

(b) Calculate the speed v of the cart as it makes contact with the slider. Assume that all the kinetic energy of the cart is converted to the elastic potential energy of the spring.

speed = ... $m\,s^{-1}$ [2]

2 Fig. 4.1 shows the values obtained in an experiment to determine the Young modulus *E* of a metal in the form of a wire.

quantity	value	instrument
diameter *d*	0.48 mm	
length l	1.768 m	
load *F*	5.0 N to 30.0 N in 5.0 N steps	
extension *e*	0.25 mm to 1.50 mm	

Fig. 4.1

(a) (i) Complete Fig. 4.1 with the name of an instrument that could be used to measure each of the quantities. [3]

(ii) Explain why a series of values of *F*, each with corresponding extension *e*, are measured.

....

....[1]

(b) Explain how a series of readings of the quantities given in Fig. 4.1 is used to determine the Young modulus of the metal. A numerical answer for *E* is not required.

....

....

....

....[2]

3 **(a)** Compare the molecular motion of a liquid with

(i) a solid,

....

....[2]

(ii) a gas.

....

....[1]

(b) **(i)** A ductile material in the form of a wire is stretched up to its breaking point. On Fig. 4.1, sketch the variation with extension *x* of the stretching force *F*.

ductile material

Fig. 4.1 [1]

(ii) On Fig. 4.2, sketch the variation with extension *x* of the stretching force *F* for a brittle material up to its breaking point.

brittle material

Fig. 4.2 [1]

(c) Describe a similarity and a difference between ductile and brittle materials.

similarity: ....

....

difference: ....

....
[2]

4 **(a)** Define the *Young modulus*.

....

.... [1]

(b) Two wires P and Q of the same material and same original length l_0 are fixed so that they hang vertically, as shown in Fig. 5.1.

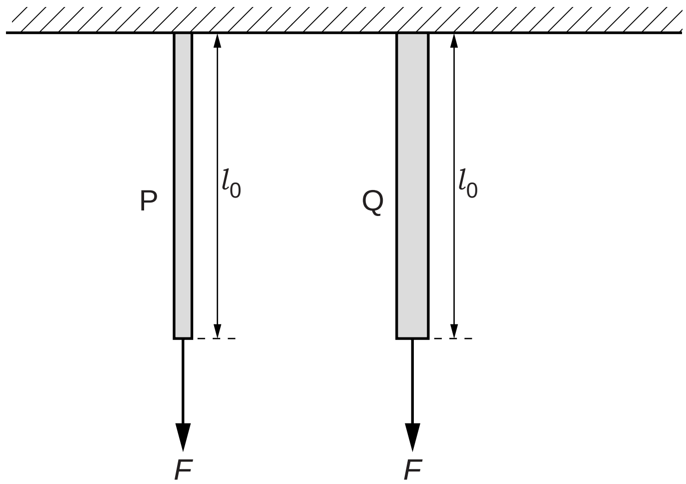

Fig. 5.1 (not to scale)

The diameter of P is d and the diameter of Q is $2d$. The same force F is applied to the lower end of each wire.

Show your working and determine the ratio

(i) $\dfrac{\text{stress in P}}{\text{stress in Q}}$,

ratio = ... [2]

(ii) $\dfrac{\text{strain in P}}{\text{strain in Q}}$.

ratio = ... [2]

5 A spring hangs vertically from a point P, as shown in Fig. 4.1.

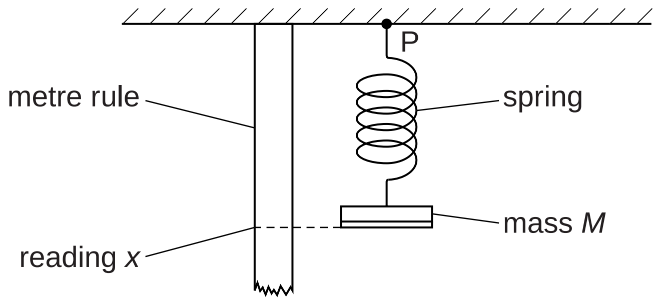

Fig. 4.1

A mass *M* is attached to the lower end of the spring. The reading *x* from the metre rule is taken, as shown in Fig. 4.1. Fig. 4.2 shows the relationship between *x* and *M*.

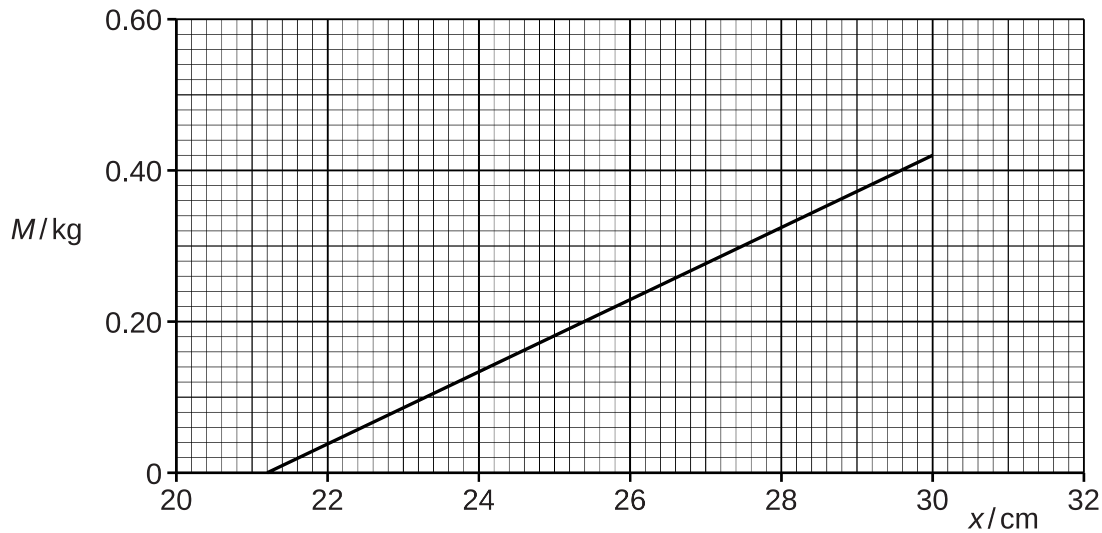

Fig. 4.2

(a) Explain how the apparatus in Fig. 4.1 may be used to determine the load on the spring at the elastic limit.

....

....

....

.... [2]

(b) State and explain whether Fig. 4.2 suggests that the spring obeys Hooke's law.

....

....

.... [2]

(c) Use Fig. 4.2 to determine the spring constant, in N m^{-1}, of the spring.

spring constant = ... N m^{-1} [3]

6 Energy is stored in a metal wire that is extended elastically.

(a) Explain what is meant by *extended elastically*.

....

.... [2]

(b) Show that the SI units of energy per unit volume are $kg\,m^{-1}\,s^{-2}$.

[2]

(c) For a wire extended elastically, the elastic energy per unit volume X is given by

$$X = C\varepsilon^2 E$$

where C is a constant,
ε is the strain of the wire,
and E is the Young modulus of the wire.

Show that C has no units.

[3]

7 **(a)** Define

(i) stress,

.... [1]

(ii) strain.

.... [1]

(b) The Young modulus of the metal of a wire is 0.17 TPa. The cross-sectional area of the wire is 0.18 mm^2.

The wire is extended by a force *F*. This causes the length of the wire to be increased by 0.095 %.

Calculate

(i) the stress,

stress = ... Pa [4]

(ii) the force *F*.

F = ... N [2]