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.

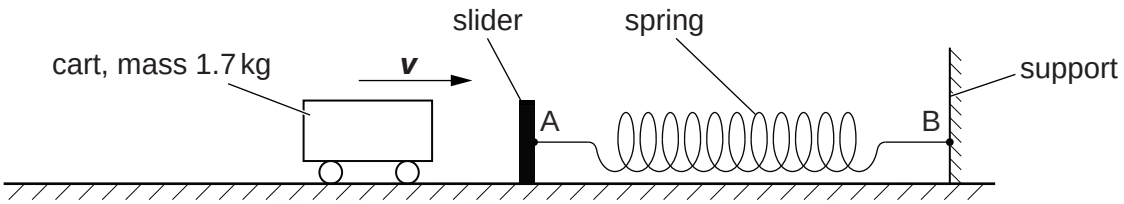

Fig. 4.1

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.

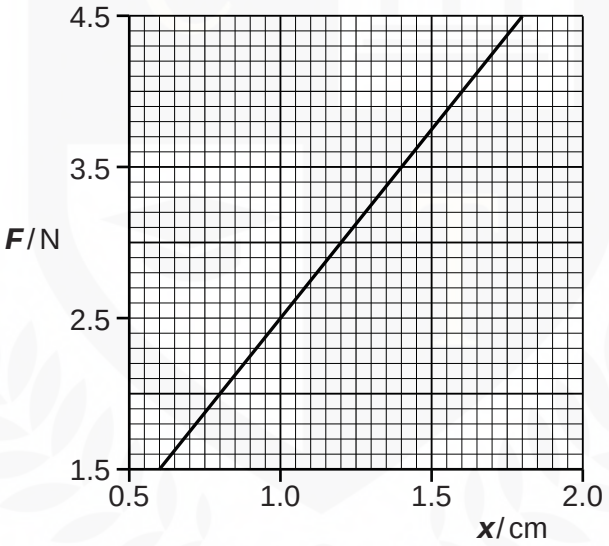

Fig. 4.2

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 $\boldsymbol{E}_P$ stored in the spring due to the cart being brought to rest.

$\boldsymbol{E}_P$ = ... J [3]

(b) Calculate the speed $\boldsymbol{v}$ 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***.

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.

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.

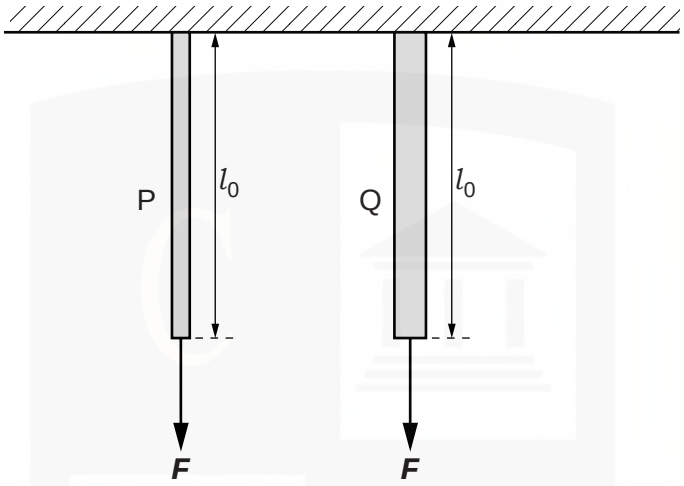

Fig. 5.1 (not to scale)

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

Show your working and determine the ratio

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

ratio = ... [2]

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

ratio = ... [2]

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

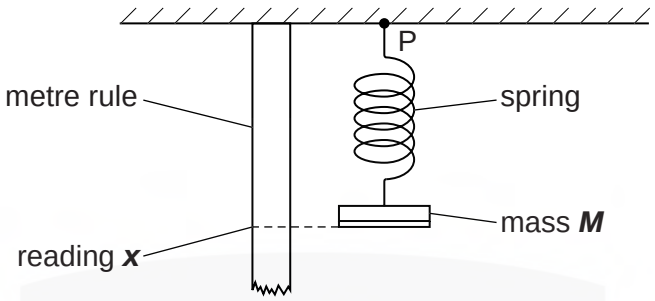

Fig. 4.1

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***.

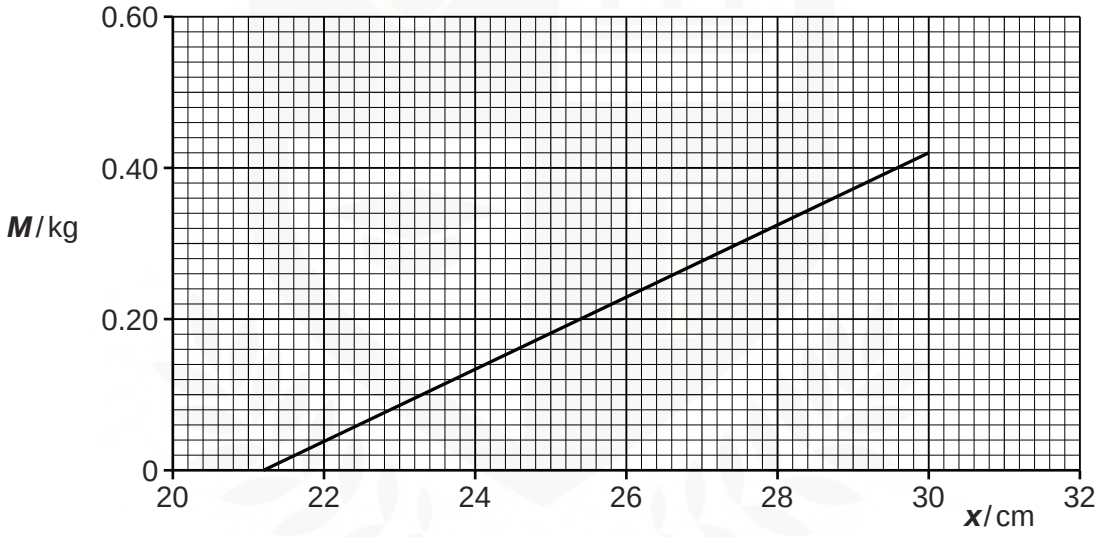

Fig. 4.2

(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

$$\boldsymbol{X} = \boldsymbol{C}\varepsilon^2\boldsymbol{E}$$

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]