Deformation of Solids

Question paper 5

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Deformation of Solids
Sub Topic	
Paper Type	Theory
Booklet	Question paper 5

Time Allowed: **62 minutes**

Score: **/51**

Percentage: **/100**

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

1 A uniform wire has length L and area of cross-section A.
The wire is fixed at one end so that it hangs vertically with a load attached to its free end, as shown in Fig. 4.1.

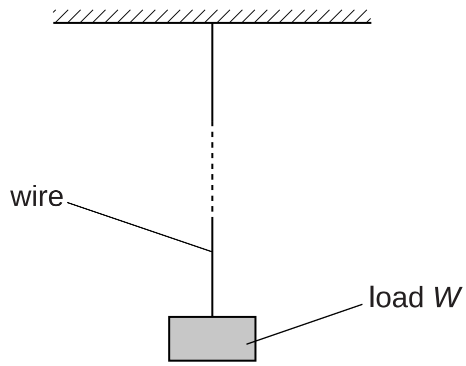


Fig. 4.1

When the load of magnitude W is attached to the wire, it extends by an amount e. The elastic limit of the wire is not exceeded.

The material of the wire has resistivity ρ.

(a) **(i)** Explain what is meant by extends *elastically*.

....

....

.... [2]

(ii) Write down expressions, in terms of L, A, W, ρ and e for

1. the resistance R of the unstretched wire,

R = ... [1]

2. the Young modulus E of the wire.

E = ... [1]

(b) A steel wire has resistance 0.44 Ω. Steel has resistivity 9.2×10^{-8} Ω m.

A load of 34 N hung from the end of the wire causes an extension of 7.7×10^{-4} m.

Using your answers in **(a)(ii)**, calculate the Young modulus *E* of steel.

E = ... Pa [3]

2 **(a)** Explain what is meant by *strain energy* (*elastic potential energy*).

....

....

.... [2]

(b) A spring that obeys Hooke's law has a spring constant k.

Show that the energy E stored in the spring when it has been extended elastically by an amount x is given by

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

[3]

(c) A light spring of unextended length 14.2 cm is suspended vertically from a fixed point, as illustrated in Fig. 4.1.

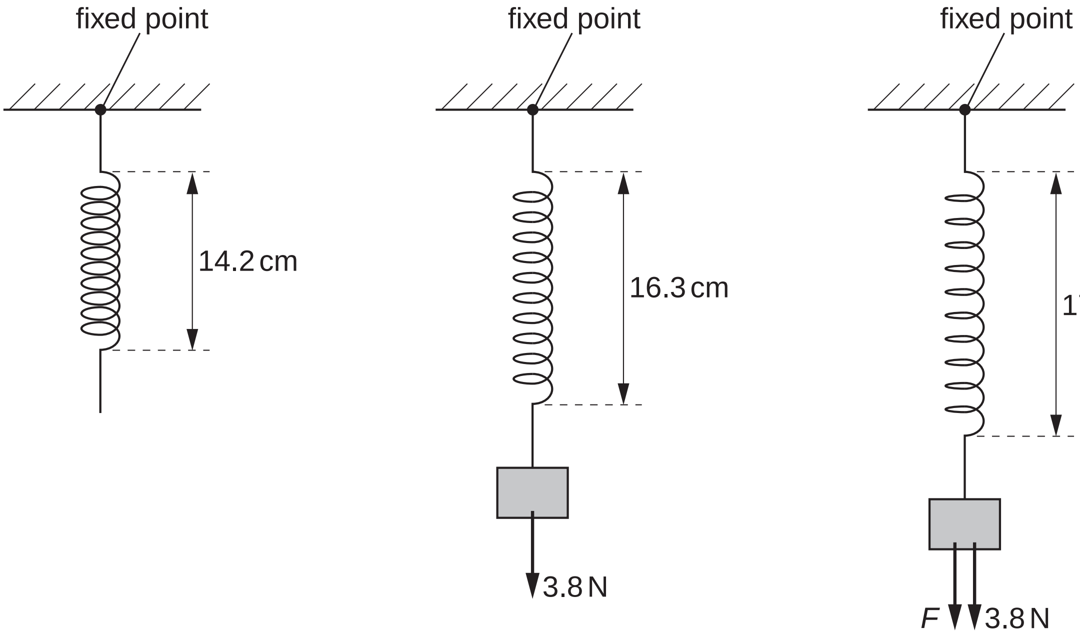


Fig. 4.1 **Fig. 4.2** **Fig. 4.3**

A mass of weight 3.8 N is hung from the end of the spring, as shown in Fig. 4.2. The length of the spring is now 16.3 cm.

An additional force *F* then extends the spring so that its length becomes 17.8 cm, as shown in Fig. 4.3.

The spring obeys Hooke's law and the elastic limit of the spring is not exceeded.

(i) Show that the spring constant of the spring is 1.8 N cm^{-1}.

[1]

(ii) For the extension of the spring from a length of 16.3 cm to a length of 17.8 cm,

1. calculate the change in the gravitational potential energy of the mass on the spring,

change in energy = ... J [2]

2. show that the change in elastic potential energy of the spring is 0.077 J,

[1]

3. determine the work done by the force *F*.

work done = ... J [1]

3 A spring having spring constant k hangs vertically from a fixed point. A load of weight L, when hung from the spring, causes an extension e. The elastic limit of the spring is not exceeded.

(a) State

(i) what is meant by an *elastic deformation*,

....

....

.... [2]

(ii) the relation between k, L and e.

.... [1]

(b) Some identical springs, each with spring constant *k*, are arranged as shown in Fig. 4.1.

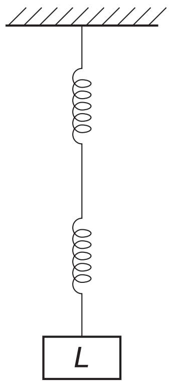
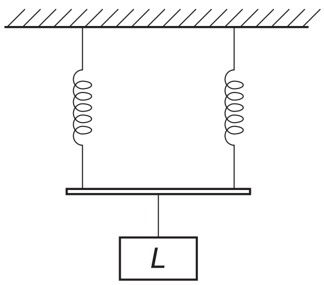
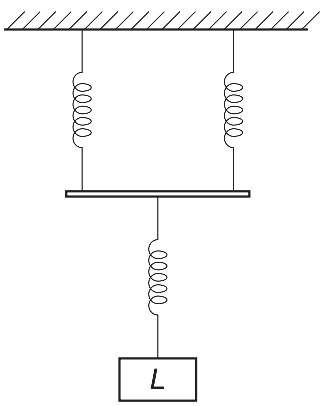
arrangement	total extension	spring constant of arrangement
	....	....
	....	....
	....	....

Fig. 4.1

The load on each of the arrangements is *L*.

For each arrangement in Fig. 4.1, complete the table by determining

(i) the total extension in terms of *e*,

(ii) the spring constant in terms of *k*.

[5]

4 A spring is placed on a flat surface and different weights are placed on it, as shown in Fig. 2.1.

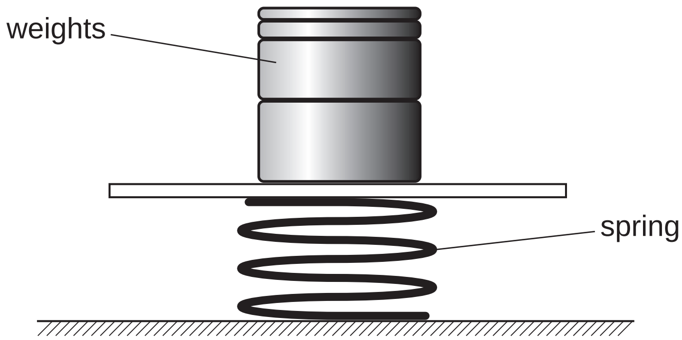


Fig. 2.1

The variation with weight of the compression of the spring is shown in Fig. 2.2.

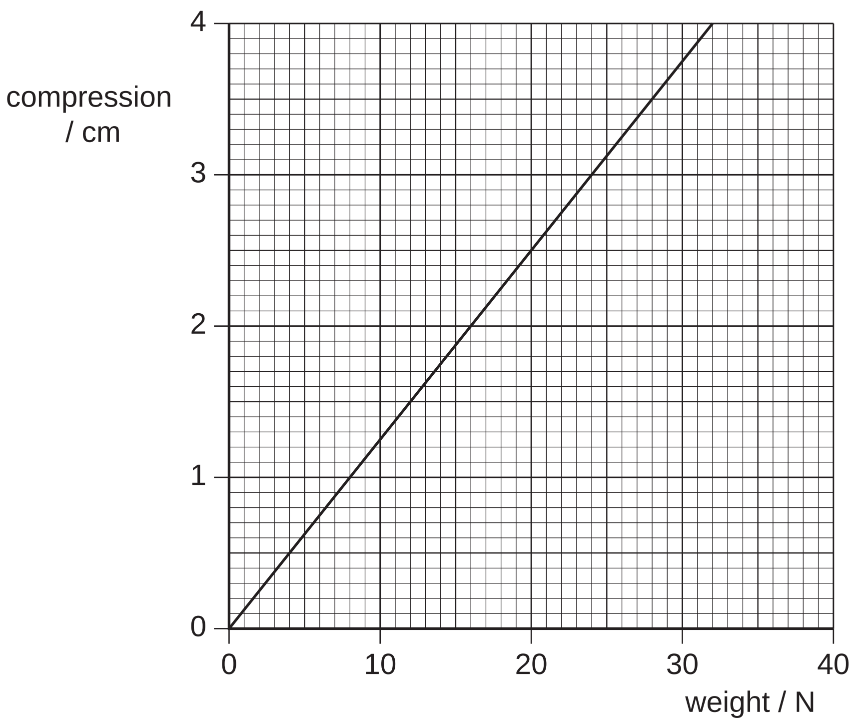


Fig. 2.2

The elastic limit of the spring has not been exceeded.

(a) (i) Determine the spring constant k of the spring.

k = ... N m^{-1} [2]

(ii) Deduce that the strain energy stored in the spring is 0.49 J for a compression of 3.5 cm.

[2]

(b) Two trolleys, of masses 800 g and 2400 g, are free to move on a horizontal table. The spring in **(a)** is placed between the trolleys and the trolleys are tied together using thread so that the compression of the spring is 3.5 cm, as shown in Fig. 2.3.

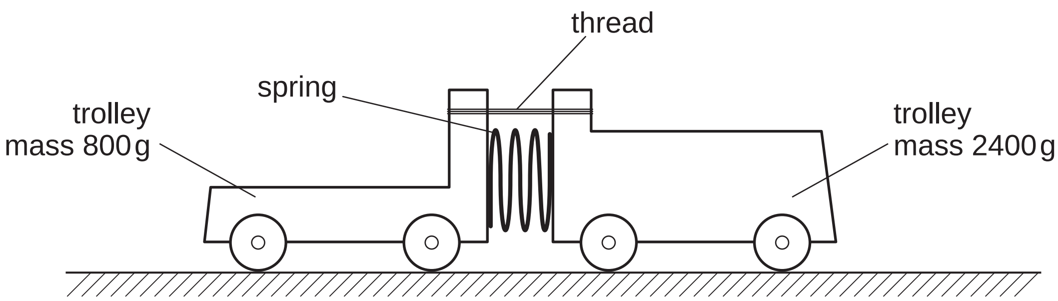


Fig. 2.3

Initially, the trolleys are not moving.
The thread is then cut and the trolleys move apart.

(i) Deduce that the ratio

$$\frac{\text{speed of trolley of mass 800 g}}{\text{speed of trolley of mass 2400 g}}$$

is equal to 3.0.

[2]

(ii) Use the answers in **(a)(ii)** and **(b)(i)** to calculate the speed of the trolley of mass 800 g.

speed = ... $m\,s^{-1}$ [3]

5 **(a)** **(i)** Define the terms

1. tensile stress,

....

.... [1]

2. tensile strain,

....

.... [1]

3. the Young modulus.

....

.... [1]

(ii) Suggest why the Young modulus is not used to describe the deformation of a liquid or a gas.

....

.... [1]

(b) The change ΔV in the volume V of some water when the pressure on the water increases by Δp is given by the expression

$$\Delta p = 2.2 \times 10^9 \frac{\Delta V}{V},$$

where Δp is measured in pascal.
In many applications, water is assumed to be incompressible.
By reference to the expression, justify this assumption.

....

....

.... [2]

(c) Normal atmospheric pressure is 1.01×10^5 Pa.

Divers in water of density $1.08 \times 10^3\,kg\,m^{-3}$ frequently use an approximation that every 10 m increase in depth of water is equivalent to one atmosphere increase in pressure. Determine the percentage error in this approximation.

error = ... % [3]

6 A sample of material in the form of a cylindrical rod has length *L* and uniform area of cross-section *A*. The rod undergoes an increasing tensile stress until it breaks.
Fig. 4.1 shows the variation with stress of the strain in the rod.

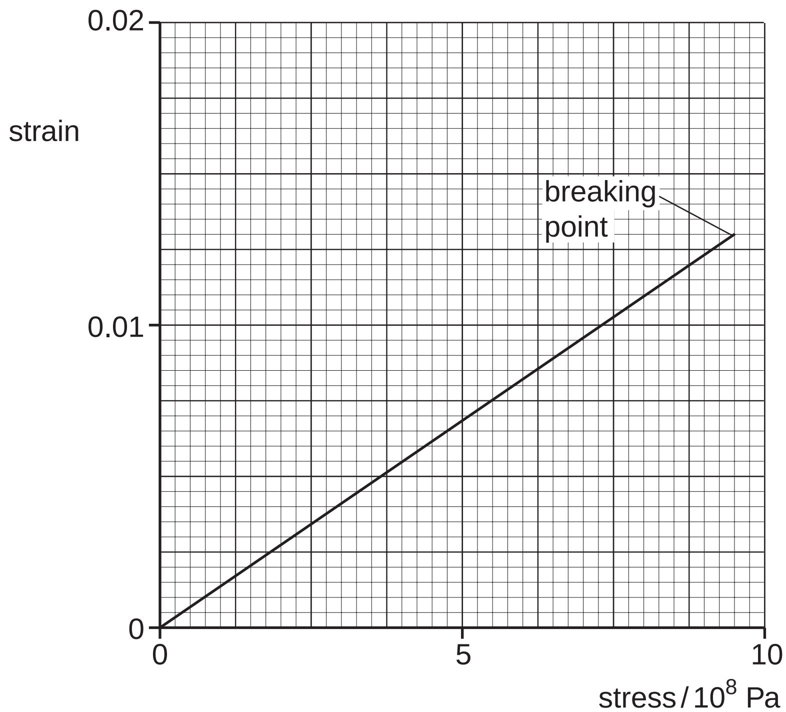


Fig. 4.1

(a) State whether the material of the rod is ductile, brittle or polymeric.

.... [1]

(b) Determine the Young modulus of the material of the rod.

Young modulus = ... Pa [2]

(c) A second cylindrical rod of the same material has a spherical bubble in it, as illustrated in Fig. 4.2.

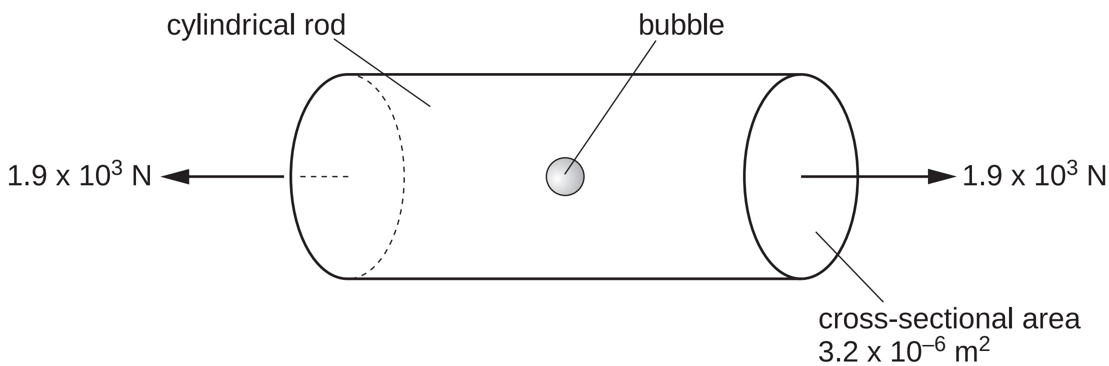


Fig. 4.2

The rod has an area of cross-section of $3.2 \times 10^{-6}\,m^2$ and is stretched by forces of magnitude $1.9 \times 10^3\,N$.
By reference to Fig. 4.1, calculate the maximum area of cross-section of the bubble such that the rod does not break.

area = ... m^2 [3]

(d) A straight rod of the same material is bent as shown in Fig. 4.3.

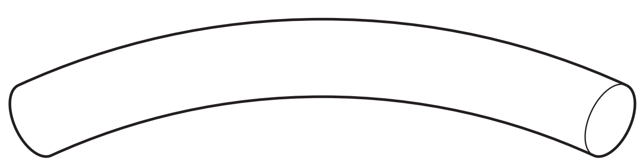


Fig. 4.3

Suggest why a thin rod can bend more than a thick rod without breaking.

....

....

.... [2]