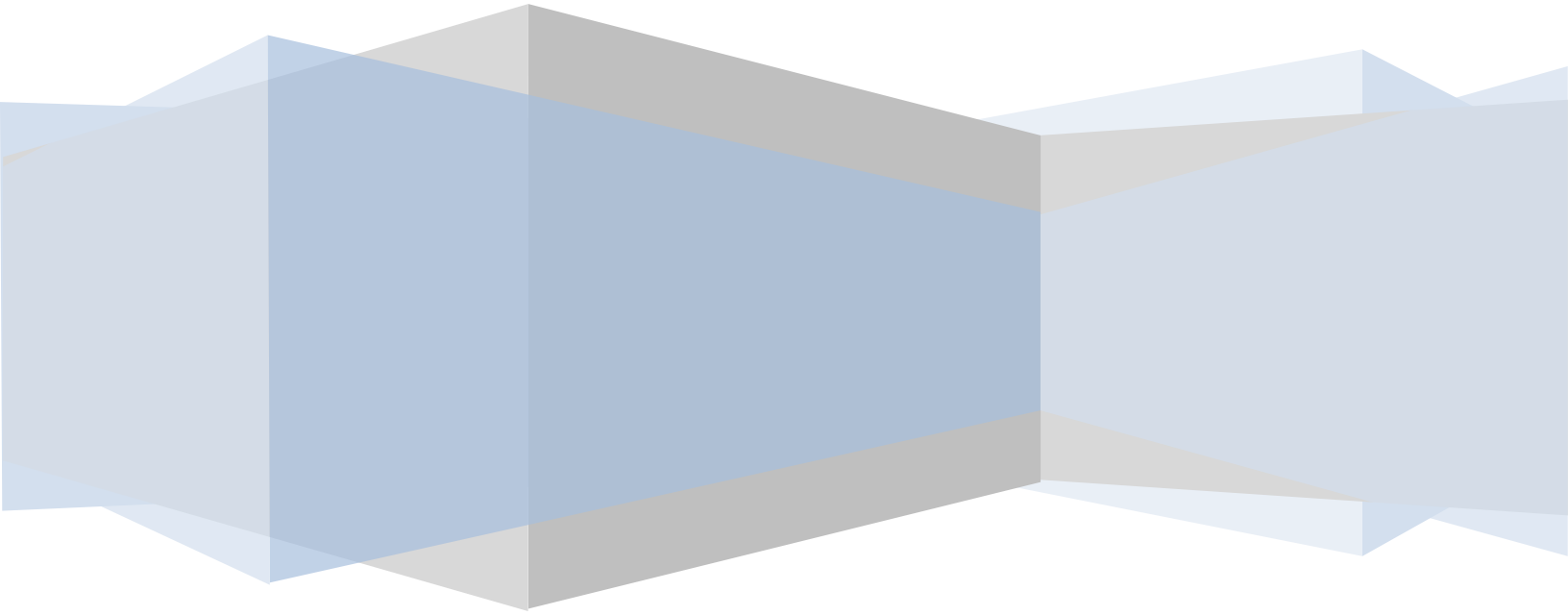
Properties of materials and Hooks law

Problems by Topic



4 A glass fibre of length 0.24 m and area of cross-section $7.9 \times 10^{-7}\,m^2$ is tested until it breaks. The variation with load F of the extension x of the fibre is shown in Fig. 4.1.

June 2005

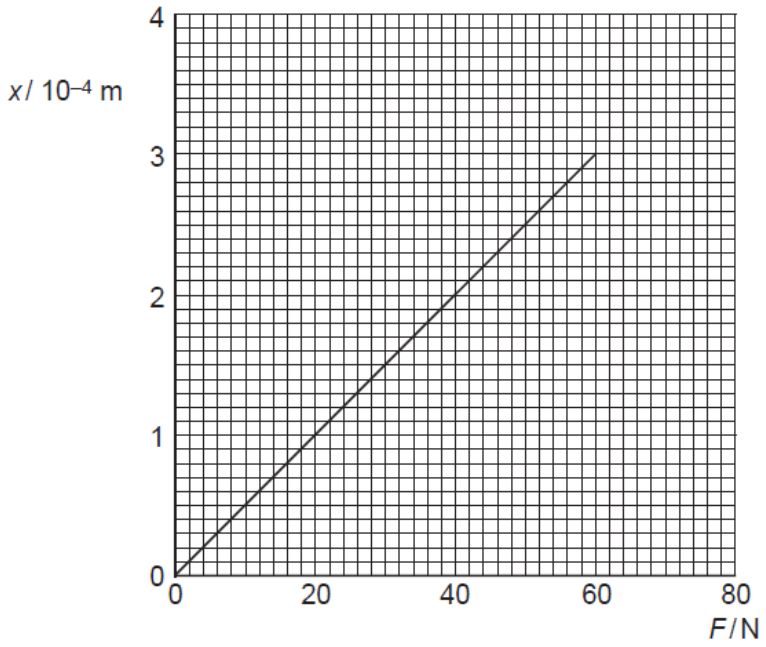


Fig. 4.1

Fig. 4.1

(a) State whether glass is ductile, brittle or polymeric.

.....[1]

(b) Use Fig. 4.1 to determine, for this sample of glass,

(i) the ultimate tensile stress,

ultimate tensile stress = ... Pa [2]

(ii) the Young modulus,

Young modulus = ... Pa [3]

(iii) the maximum strain energy stored in the fibre before it breaks.

maximum strain energy = ... J [2]

(c) A hard ball and a soft ball, with equal masses and volumes, are thrown at a glass window. The balls hit the window at the same speed. Suggest why the hard ball is more likely than the soft ball to break the glass window.

.....

.....

.....

.....[3]

5 Fig. 5.1 shows the variation with force F of the extension x of a spring as the force is increased to F_3 and then decreased to zero.

June 2006

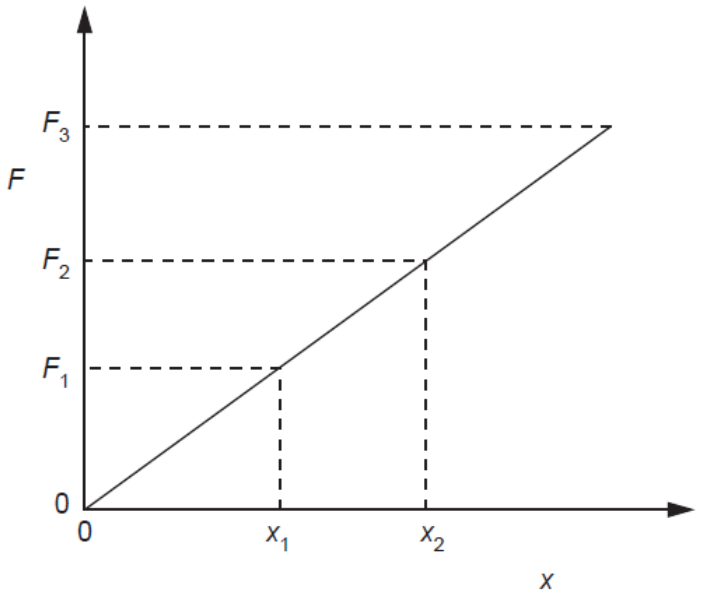


Fig. 5.1

(a) State, with a reason, whether the spring is undergoing an elastic change.

June 2006

.....

..... [1]

(b) The extension of the spring is increased from x_1 to x_2.

Show that the work W done in extending the spring is given by

$$W = \tfrac{1}{2}k(x_2^2 - x_1^2),$$

where k is the spring constant.

[3]

(c) A trolley of mass 850 g is held between two fixed points by means of identical springs, as shown in Fig. 5.2.

June 2006

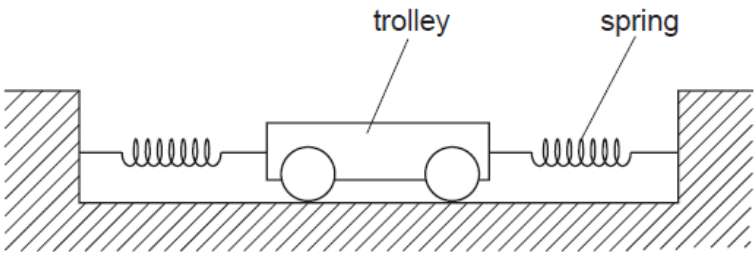


Fig. 5.2

When the trolley is in equilibrium, the springs are each extended by 4.5 cm. Each spring has a spring constant 16 N cm^{-1}.

The trolley is moved a distance of 1.5 cm along the direction of the springs. This causes the extension of one spring to be increased and the extension of the other spring to be decreased. The trolley is then released. The trolley accelerates and reaches its maximum speed at the equilibrium position.

Assuming that the springs obey Hooke's law, use the expression in **(b)** to determine the maximum speed of the trolley.

speed = ... m s^{-1} [4]

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

June 2008

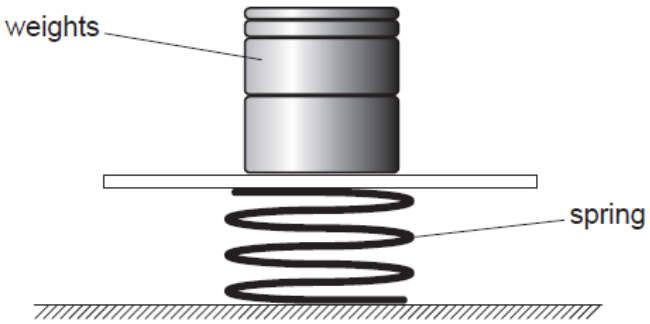
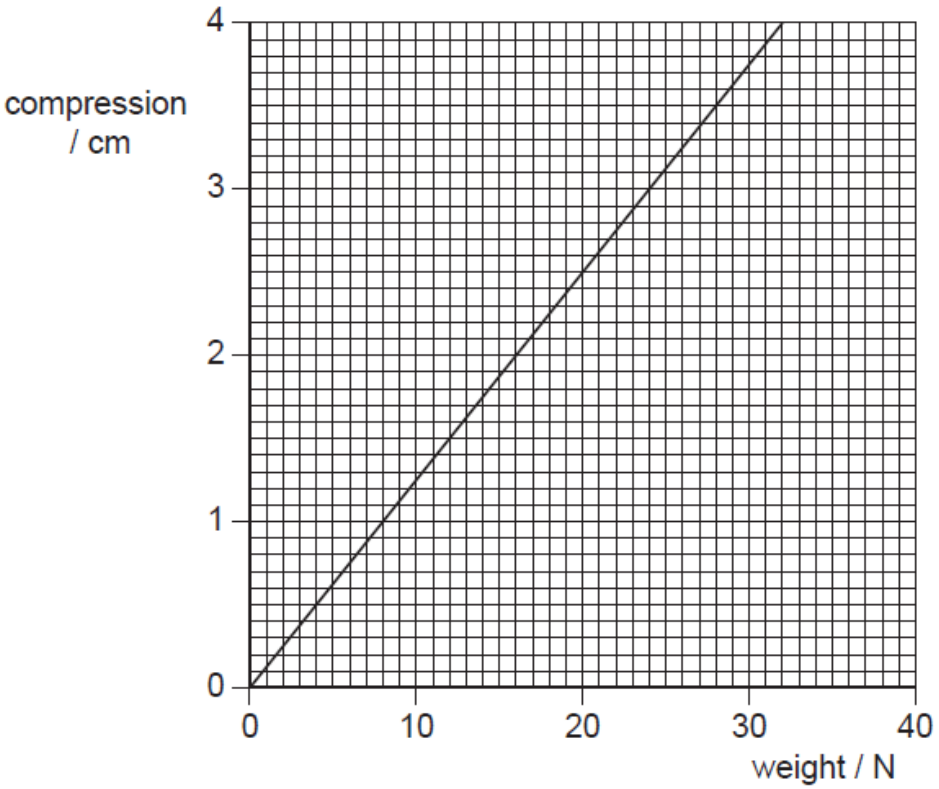


Fig. 2.1

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



The elastic limit of the spring has not been exceeded.

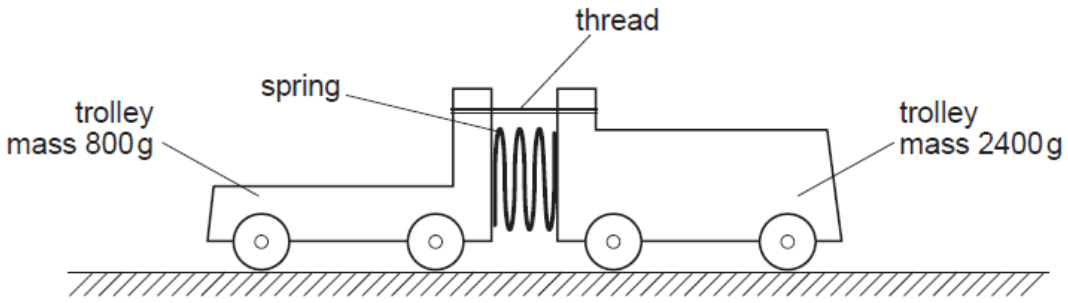
(a) (i) Determine the spring constant k of the spring.

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.



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.

(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]

June 2008

4 **(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 $1.08 \times 10^3 \text{ kg m}^{-3}$ 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]

4 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.

June 2009

(a) State

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

.....

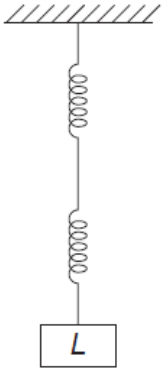
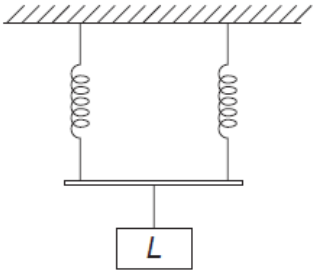
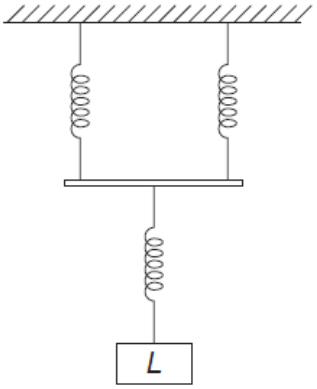
.....

..... [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
	.....	.....
	.....	.....
	.....	.....

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 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.

June 2009/22

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

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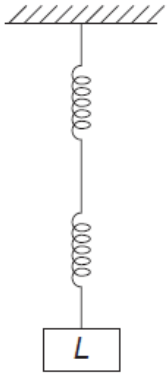
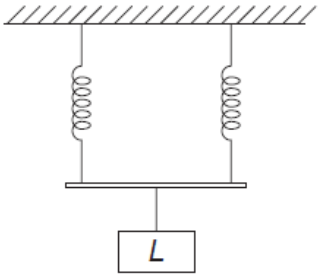
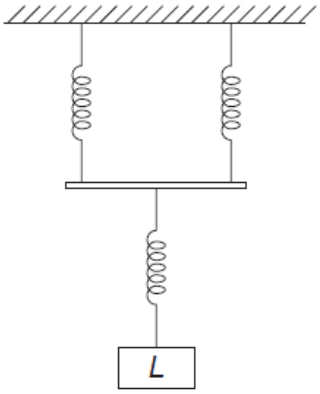
	.....	.....
	.....	.....
	.....	.....

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[5]