PRACTICE QUESTIONS FOR TEST 2

Forces, momentum and energies

1

(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.

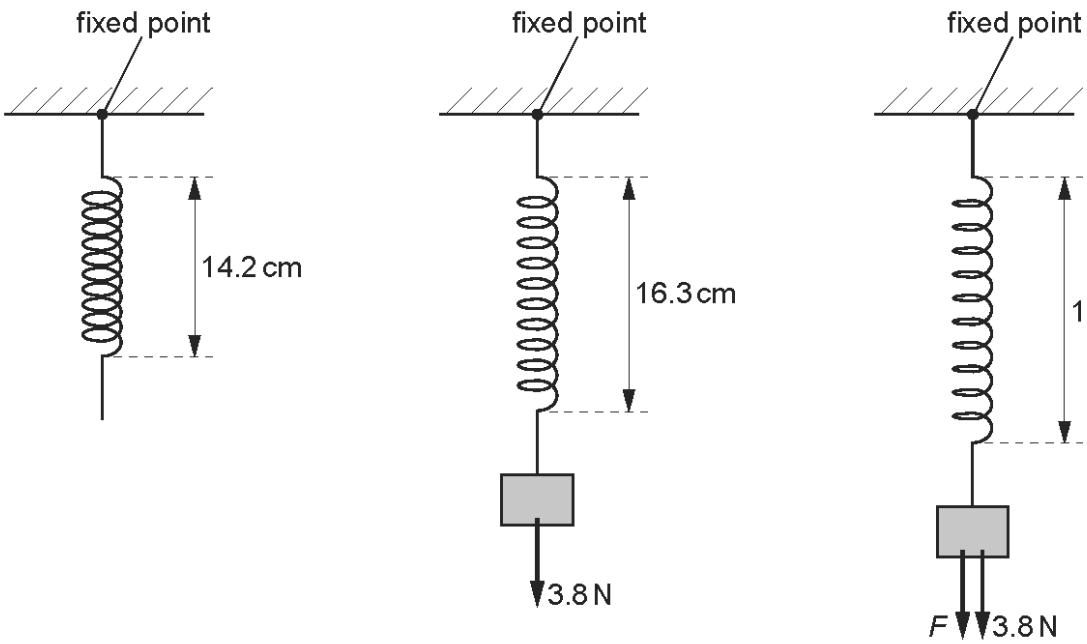

Fig. 4.1 **Fig. 4.2** **Fig. 4.3**

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]

2 **(a)** **(i)** Define *force*.

....

....[1]

(ii) State Newton's third law of motion.

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....[3]

(b) Two spheres approach one another along a line joining their centres, as illustrated in Fig. 3.1.

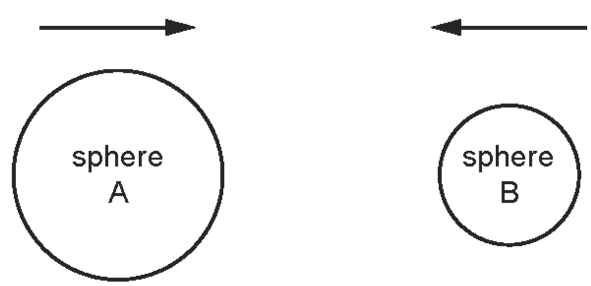


Fig. 3.1

When they collide, the average force acting on sphere A is F_A and the average force acting on sphere B is F_B.

The forces act for time t_A on sphere A and time t_B on sphere B.

(i) State the relationship between

1. F_A and F_B,

....[1]

2. t_A and t_B.

....[1]

(ii) Use your answers in **(i)** to show that the change in momentum of sphere A is equal in magnitude and opposite in direction to the change in momentum of sphere B.

....

....[1]

(c) For the spheres in **(b)**, the variation with time of the momentum of sphere A before, during and after the collision with sphere B is shown in Fig. 3.2.

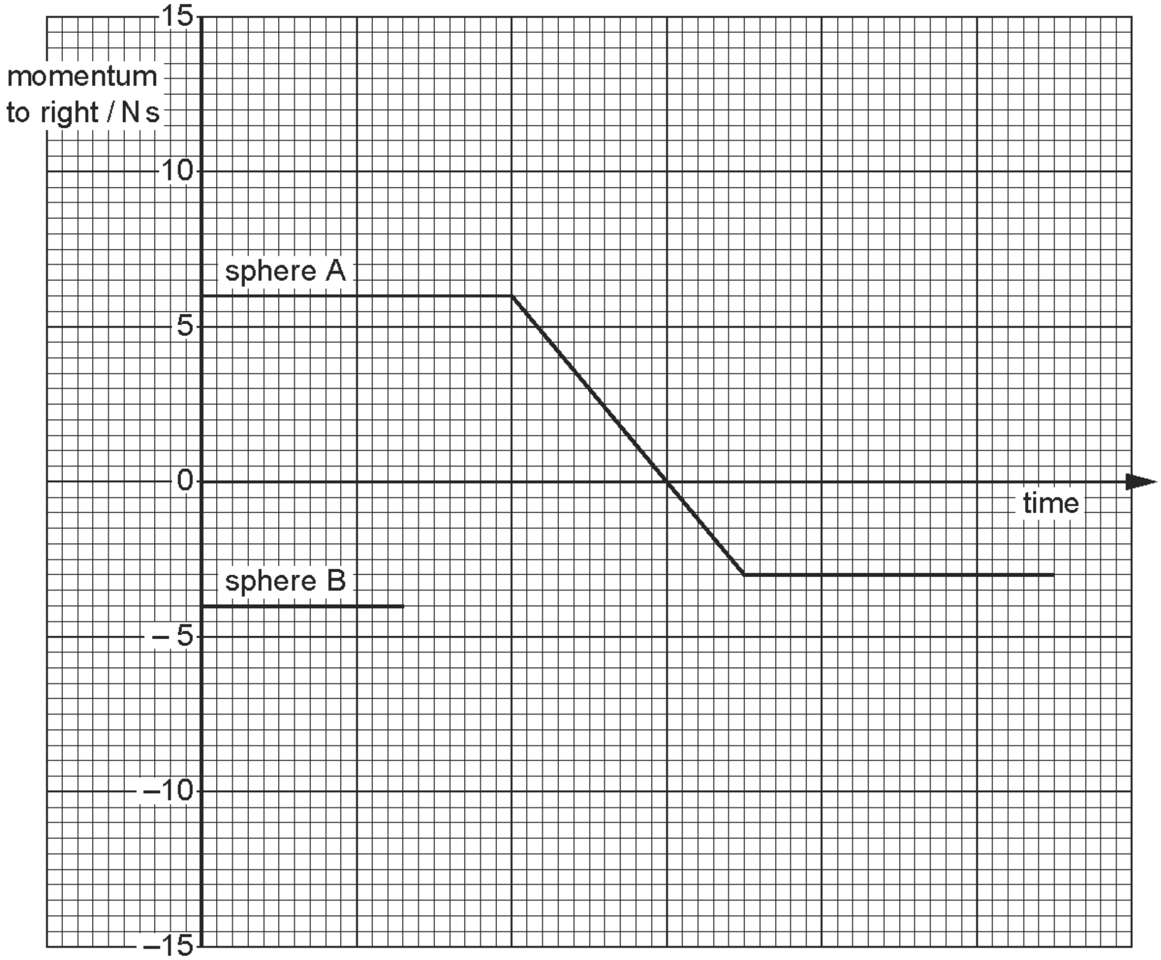


Fig. 3.2

The momentum of sphere B before the collision is also shown on Fig. 3.2.

Complete Fig. 3.2 to show the variation with time of the momentum of sphere B during and after the collision with sphere A. [3]

3

(a) State the relation between force and momentum.

.... [1]

(b) A rigid bar of mass 450g is held horizontally by two supports A and B, as shown in Fig. 3.1.

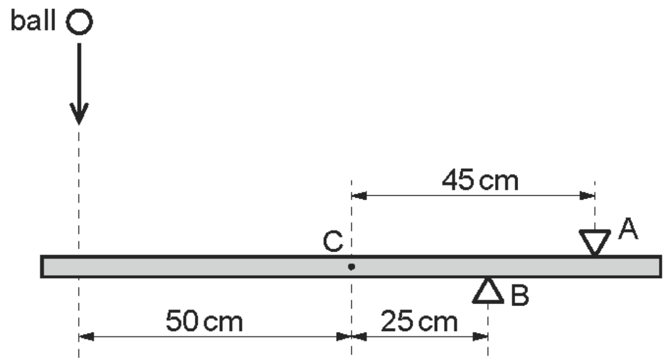
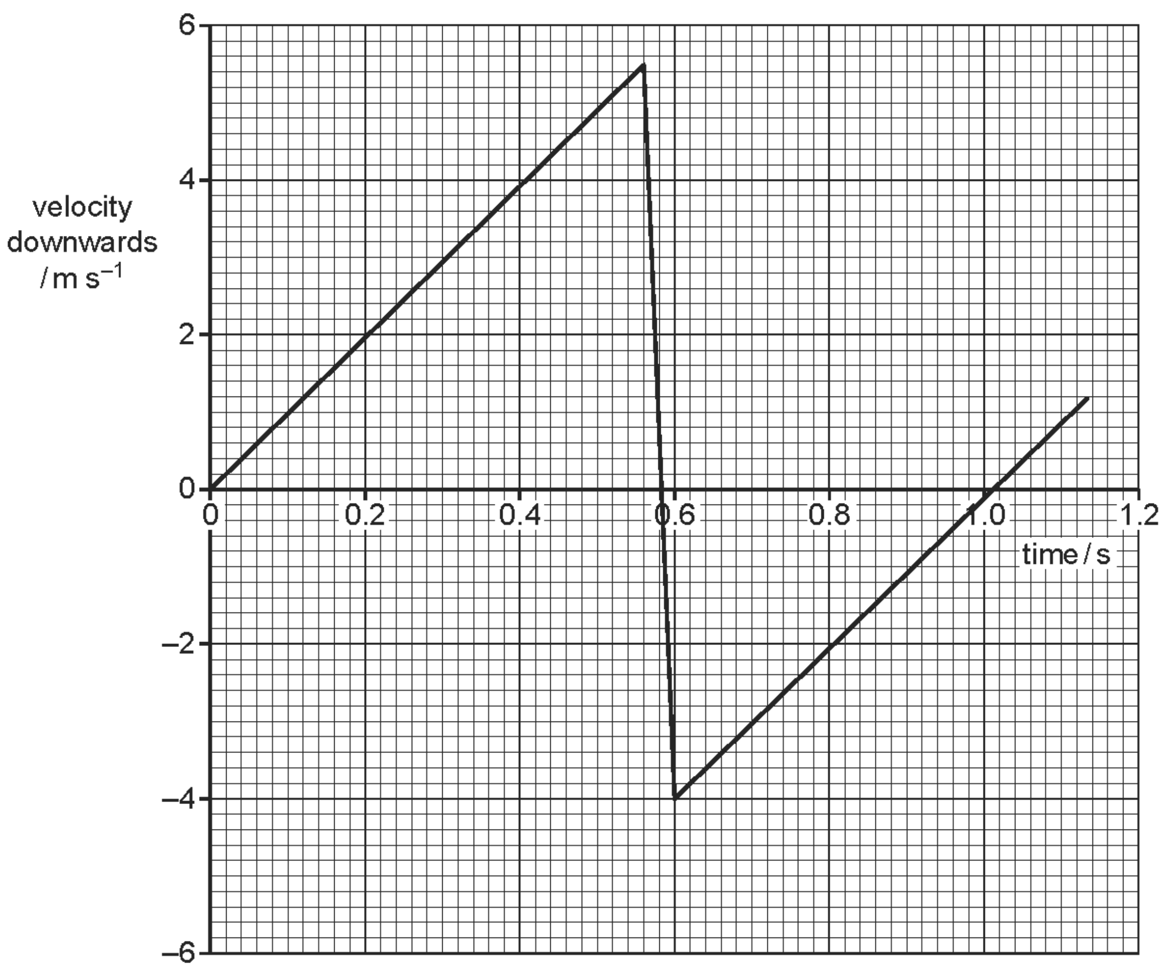


Fig. 3.1

The support A is 45cm from the centre of gravity C of the bar and support B is 25cm from C.

A ball of mass 140g falls vertically onto the bar such that it hits the bar at a distance of 50cm from C, as shown in Fig. 3.1.
The variation with time *t* of the velocity *v* of the ball before, during and after hitting the bar is shown in Fig. 3.2.



For the time that the ball is in contact with the bar, use Fig. 3.2

(i) to determine the change in momentum of the ball,

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

(ii) to show that the force exerted by the ball on the bar is 33 N.

[1]

(c) For the time that the ball is in contact with the bar, use data from Fig. 3.1 and **(b)(ii)** to calculate the force exerted on the bar by

(i) the support A,

force = ... N [3]

(ii) the support B.

force = ... N [2]

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.

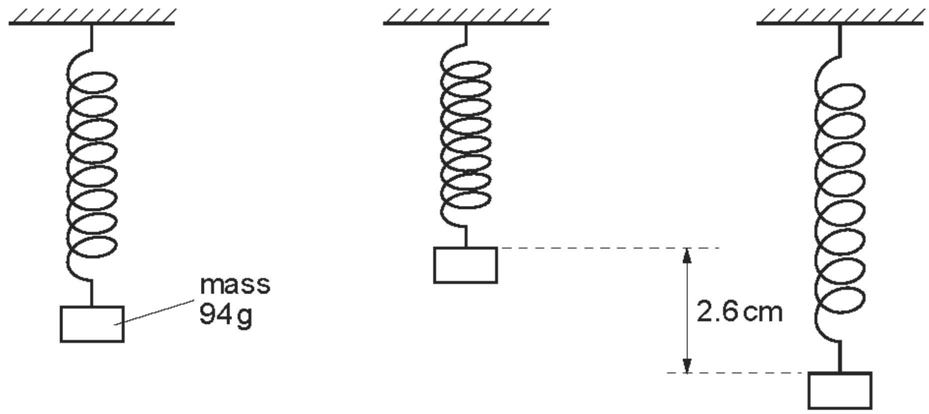


Fig. 5.1 **Fig. 5.2** **Fig. 5.3**

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)** Explain what is meant by *work done*.

....

.... [1]

(b) A car is travelling along a road that has a uniform downhill gradient, as shown in Fig. 2.1.

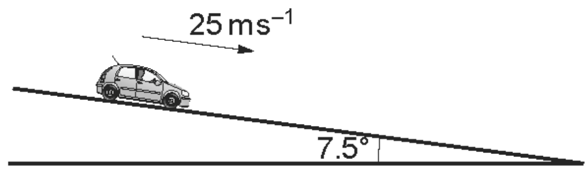


Fig. 2.1

The car has a total mass of 850 kg. The angle of the road to the horizontal is 7.5°.

Calculate the component of the weight of the car down the slope.

component of weight = ... N [2]

(c) The car in **(b)** is travelling at a constant speed of $25\,\text{m}\,\text{s}^{-1}$. The driver then applies the brakes to stop the car. The constant force resisting the motion of the car is 4600 N.

(i) Show that the deceleration of the car with the brakes applied is $4.1\,\text{m}\,\text{s}^{-2}$.

[2]

(ii) Calculate the distance the car travels from when the brakes are applied until the car comes to rest.

(iii) Calculate

1. the loss of kinetic energy of the car,

loss of kinetic energy = ... J [2]

2. the work done by the resisting force of 4600 N.

work done = ... J [1]

(iv) The quantities in **(iii) part 1** and in **(iii) part 2** are not equal. Explain why these two quantities are not equal.

....

.... [1]

A motor is used to move bricks vertically upwards, as shown in Fig. 5.1.

6

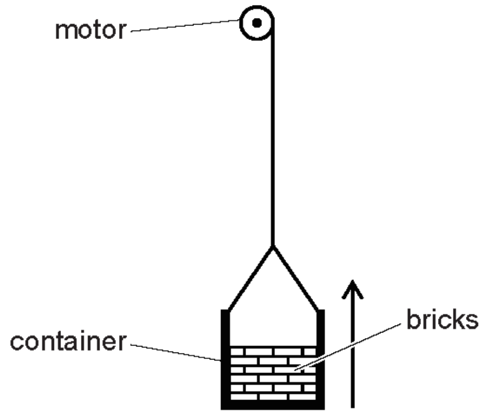


Fig. 5.1

The bricks start from rest and accelerate for 2.0 s. The bricks then travel at a constant speed of 0.64 $m s^{-1}$ for 25 s. Finally the bricks are brought to rest in a further 3.0 s.

The total mass of the bricks is 25 kg.

(a) Determine the change in kinetic energy of the bricks

(i) in the first 2.0 s,

change in kinetic energy = ... J [2]

(ii) in the next 25 s,

change in kinetic energy = ... J [1]

(iii) in the final 3.0 s.

change in kinetic energy = ... J [1]

(b) The bricks are in a container. The weight of the container and bricks is 350 N.

Calculate, for the lifting of the bricks and container when travelling at constant speed,

(i) the gain in potential energy,

energy gain = ... J [3]

(ii) the power required.

power = ... W [2]

7 **(a)** State Hooke's law.

....

.... [1]

(b) The variation with extension x of the force F for a spring A is shown in Fig. 6.1.

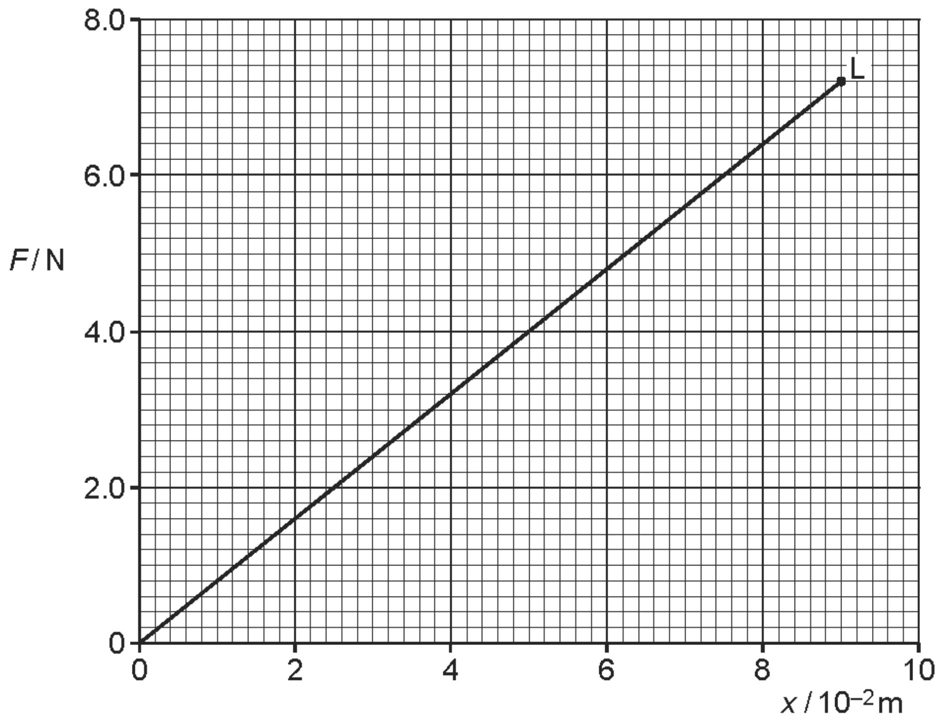


Fig. 6.1

The point L on the graph is the elastic limit of the spring.

(i) Describe the meaning of *elastic limit*.

....

....

.... [1]

(ii) Calculate the spring constant k_A for spring A.

k_A = ... $N\,m^{-1}$ [1]

(iii) Calculate the work done in extending the spring with a force of 6.4 N.

work done = ... J [2]

(c) A second spring B of spring constant $2k_A$ is now joined to spring A, as shown in Fig. 6.2.

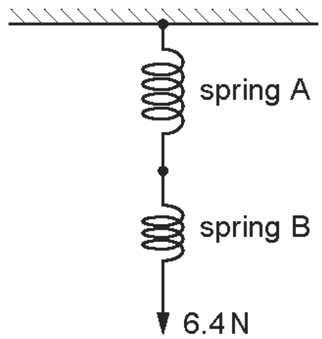


Fig. 6.2

A force of 6.4 N extends the combination of springs.

For the combination of springs, calculate

(i) the total extension,

extension = ... m [1]

(ii) the spring constant.

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

One end of a spring is fixed to a support. A mass is attached to the other end of the spring. The arrangement is shown in Fig. 3.1.

8

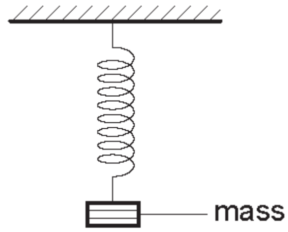


Fig. 3.1

(a) The mass is in equilibrium. Explain, by reference to the forces acting on the mass, what is meant by equilibrium.

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....[2]

(b) The mass is pulled down and then released at time $t = 0$. The mass oscillates up and down. The variation with t of the displacement of the mass d is shown in Fig. 3.2.

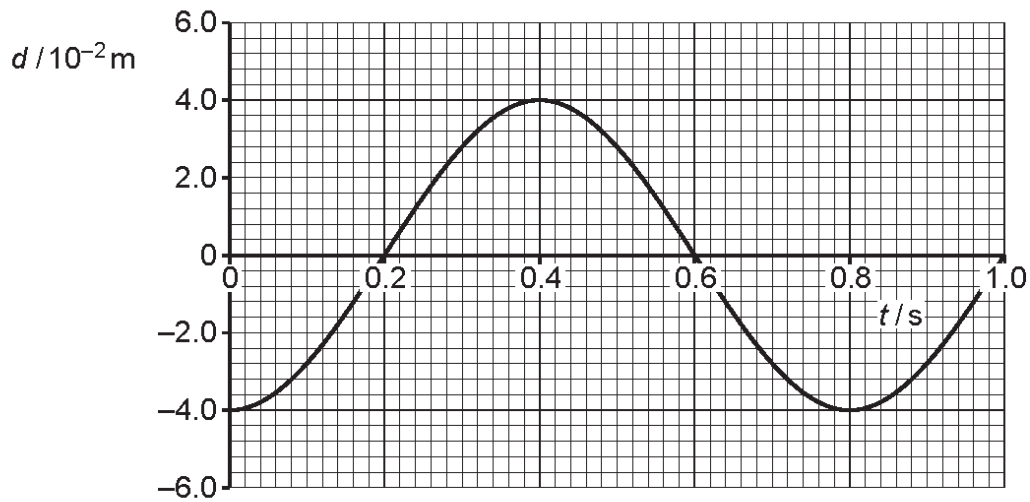


Fig. 3.2

Use Fig. 3.2 to state a time, one in each case, when

(i) the mass is at maximum speed,

time = ... s [1]

(ii) the elastic potential energy stored in the spring is a maximum,

time = ... s [1]

(iii) the mass is in equilibrium.

time = ... s [1]

(c) The arrangement shown in Fig. 3.3 is used to determine the length l of a spring when different masses M are attached to the spring.

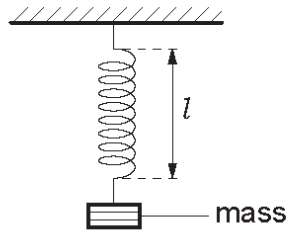


Fig. 3.3

The variation with mass M of l is shown in Fig. 3.4.

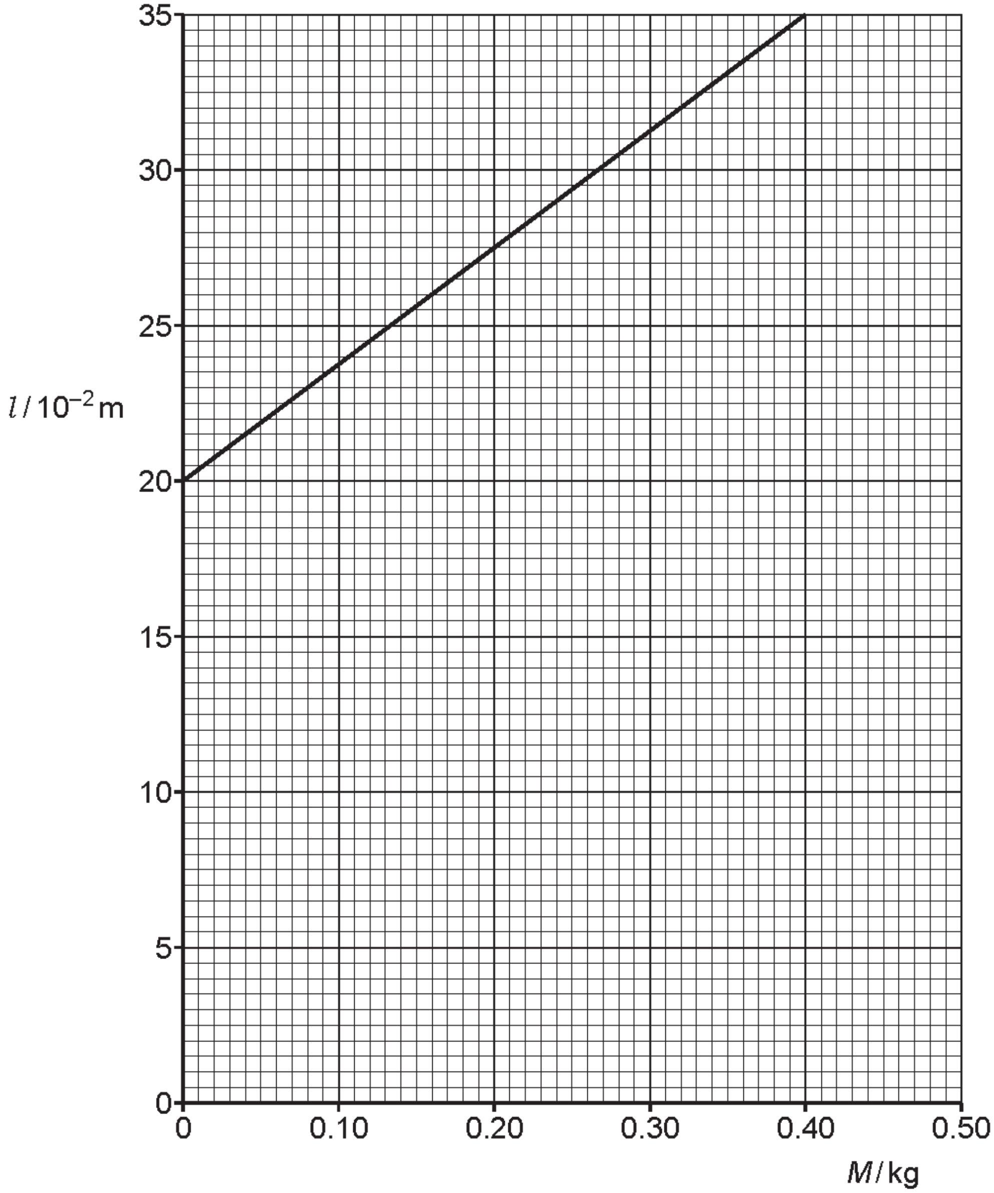


Fig. 3.4

(i) State and explain whether the spring obeys Hooke's law.

....

....

....[2]

(ii) Show that the force constant of the spring is 26 N m^{-1}.

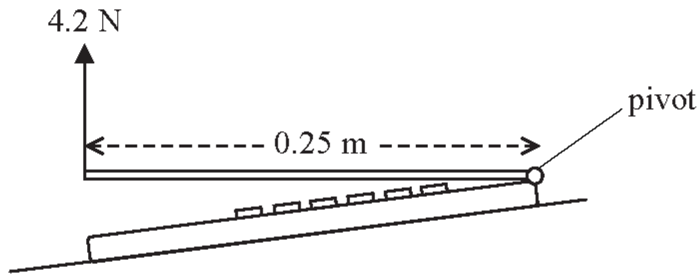
[2]

(iii) A mass of 0.40 kg is attached to the spring. Calculate the energy stored in the spring.

energy = ... J [3]

9

The diagram shows the side view of a laptop computer.



A student opens the computer with an upward force of 4.2 N.

The force is applied 0.25 m from the pivot.

(a) (i) State the equation linking moment, force and distance.

(1)

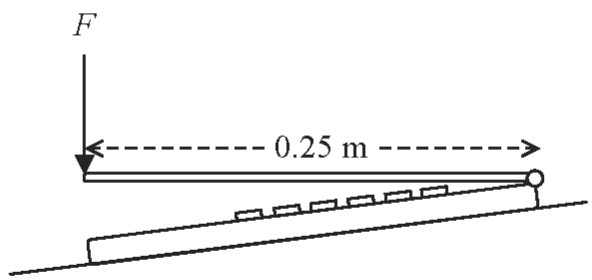
(ii) Calculate the moment of the force that opens the computer.

(2)

Moment = ... N m

(b) The student finds that 4.2 N is the **minimum** upward force needed to open the computer.

Then the student applies a downward force, F, to close the computer.



Explain why the minimum force needed to close the computer is likely to be **less** than 4.2 N.

(2)

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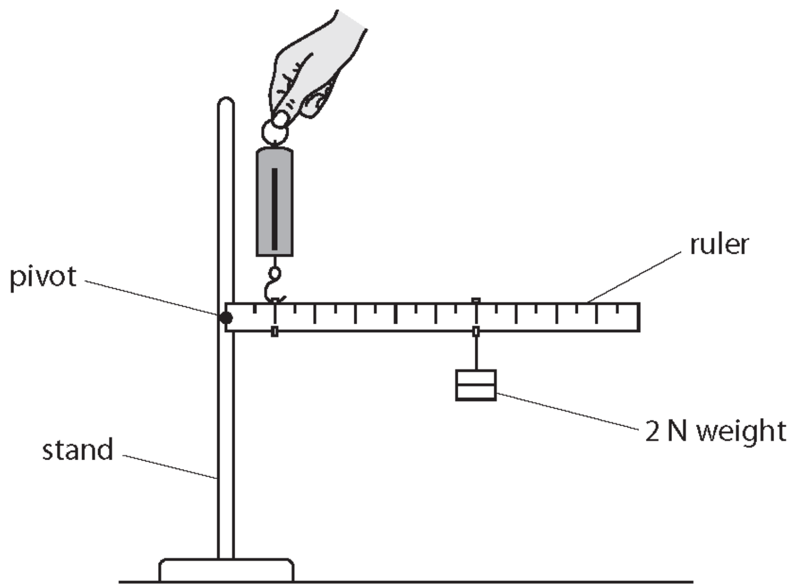
A student investigates the principle of moments.

He connects a ruler to a stand with a pivot.

10 He hangs a 2 N weight from the 60 cm mark on the ruler.

He uses a forcemeter to hold the ruler horizontal.

The scale on the forcemeter reads from 0 N to 10 N.



(a) How could the student check that the ruler is horizontal?

(2)

....

....

....

....

(b) (i) State the equation linking moment, force and distance from the pivot.

(1)

(ii) Calculate the moment of the 2 N weight.

State the unit.

(3)

Moment = ... Unit ....

(c) The student holds the ruler horizontal with the forcemeter at the 10 cm mark.

He expects the reading on the forcemeter to be 12 N.

The actual reading is 10 N.

(i) Explain why the correct reading should be **larger** than 12 N.

(2)

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....

(ii) Explain why the actual reading is only 10 N.

(1)

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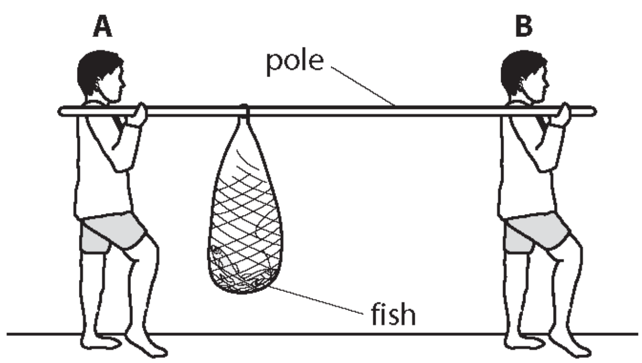
(d) A picture in the student's textbook shows two fishermen using a pole to carry some fish.



Fisherman **A** and fisherman **B** feel different forces on their shoulders.

Use ideas about moments to explain why fisherman **A** feels the larger force.

(3)

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