PreDP revision questions for Section B of the exam

Unit 3 and 4: Forces and Pressure + Forces and Energy

(a) A man squeezes a pin between his thumb and finger, as shown in Fig. 6.1.

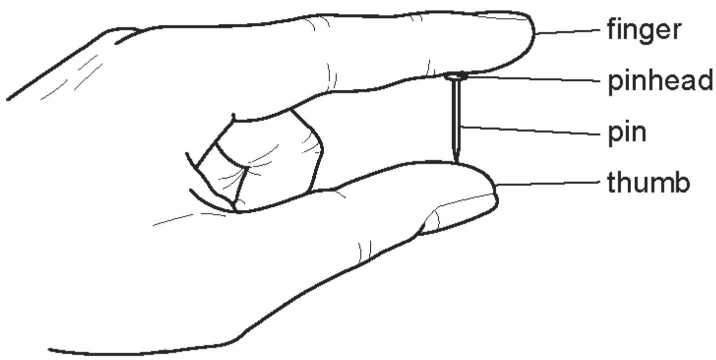


Fig. 6.1

The finger exerts a force of 84 N on the pinhead.

The pinhead has an area of $6.0 \times 10^{-5}\,m^2$.

(i) Calculate the pressure exerted by the finger on the pinhead.

pressure = ... [2]

(ii) State the value of the force exerted by the pin on the thumb.

.... [1]

(iii) Explain why the pin causes more pain in the man's thumb than in his finger.

....

.... [2]

(b) The density of the water in a swimming pool is 1000 kg / m^3. The pool is 3 m deep.

(i) Calculate the pressure of the water at the bottom of the pool.

pressure = ... [2]

(ii) Another pool has the same depth of water, but has twice the area.

State the pressure of the water at the bottom of this pool.

pressure = ... [1]

A student investigated the stretching of a spring by hanging various weights from it and measuring the corresponding extensions. The results are shown below.

weight / N	0	1	2	3	4	5
extension / mm	0	21	40	51	82	103

(a) On Fig. 3.1, plot the points from these results. Do not draw a line through the points yet. [2]

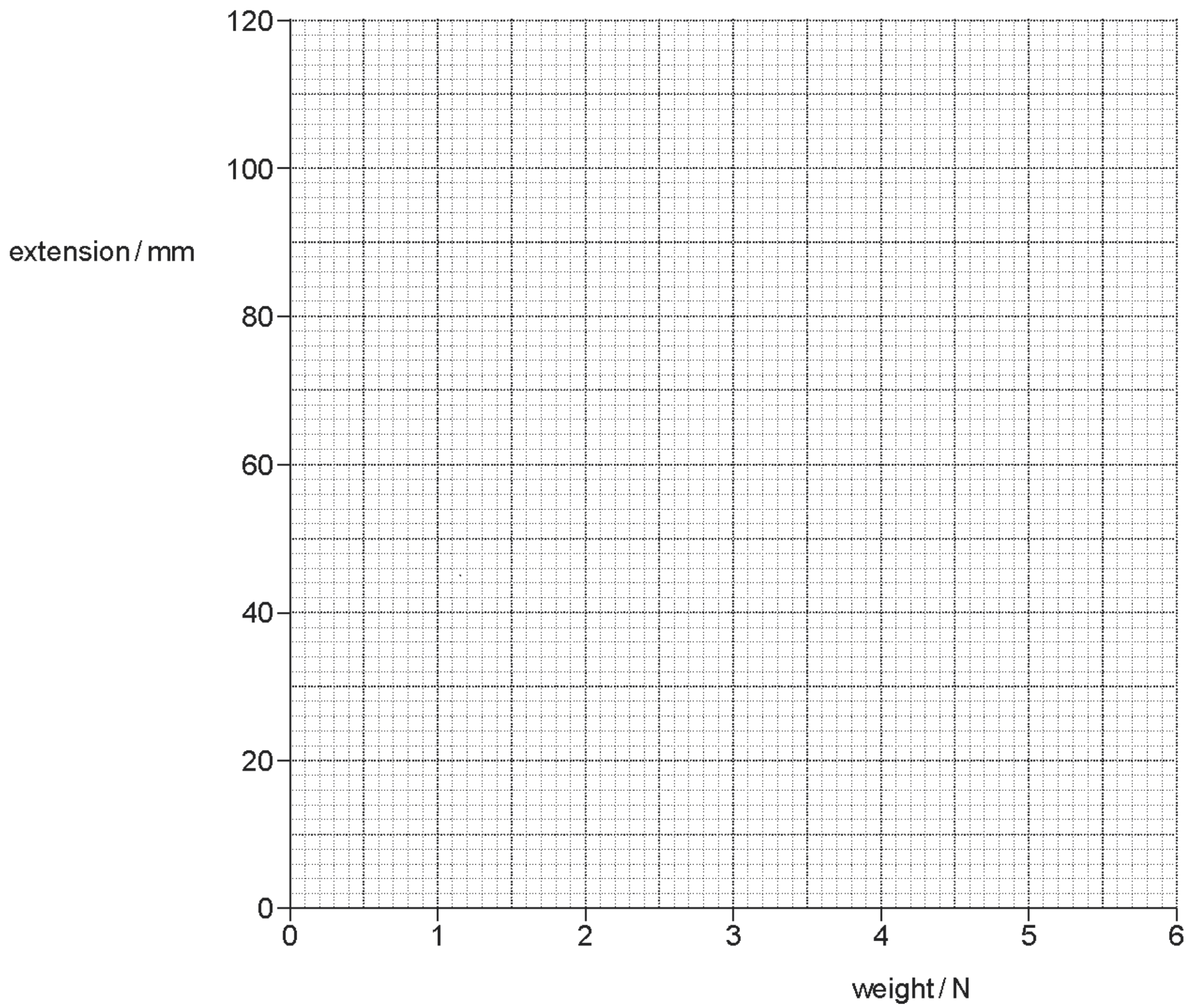


Fig. 3.1

(b) The student appears to have made an error in recording one of the results.

Which result is this?

.... [1]

(c) Ignoring the incorrect result, draw the best straight line through the remaining points. [1]

(d) State and explain whether this spring is obeying Hooke's Law.

....

....

....

....

.... [2]

(e) Describe how the graph might be shaped if the student continued to add several more weights to the spring.

....

....

....

.... [1]

(f) The student estimates that if he hangs a 45 N load on the spring, the extension will be 920 mm.

Explain why this estimate may be unrealistic.

....

elastic limit

....

....

.... [1]

Four students, A, B, C and D, each have a spring. They measure the lengths of their springs when the springs are stretched by different loads.

Their results are shown in Fig. 2.1.

	student A	student B	student C	student D
load / N	spring length / cm	spring length / cm	spring length / cm	spring length / cm
0.5	6.7	9.2	9.1	10.0
1.0	7.7	10.0	9.9	11.1
1.5	8.7	10.8	10.7	12.2
2.0	9.7	11.6	11.5	13.3
2.5	10.7	12.6	12.3	14.4
3.0	11.7	13.8	13.1	15.5
3.5	12.7	15.2	13.9	16.6
4.0	13.7	16.8	14.7	17.7

Fig. 2.1

(a) **(i)** State which student had loaded the spring beyond the limit of proportionality.

.... [1]

(ii) Explain how you obtained your answer to **(a)(i)**.

....

....

.... [2]

(b) For the spring used by student A, calculate

(i) the extra extension caused by each additional 0.5 N,

extra extension = ... [1]

(ii) the unloaded length of the spring.

unloaded length = ... [1]

(c) Student A obtains a second spring that is identical to his first spring. He hangs the two springs side by side, as shown in Fig. 2.2.

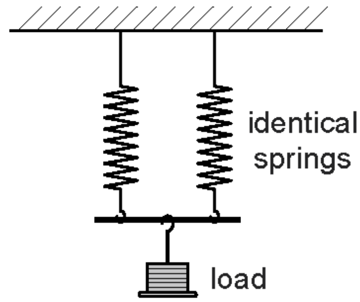


Fig. 2.2

Use the table to calculate the length of each of the springs when a load of 2.5 N is hung as shown in Fig. 2.2. Show your working.

length = ... [2]

(a) A loose uniform wooden floorboard weighs 160 N and rests symmetrically on four supports P, Q, R and S.

The supports are 0.50 m apart, as shown in Fig. 2.1.

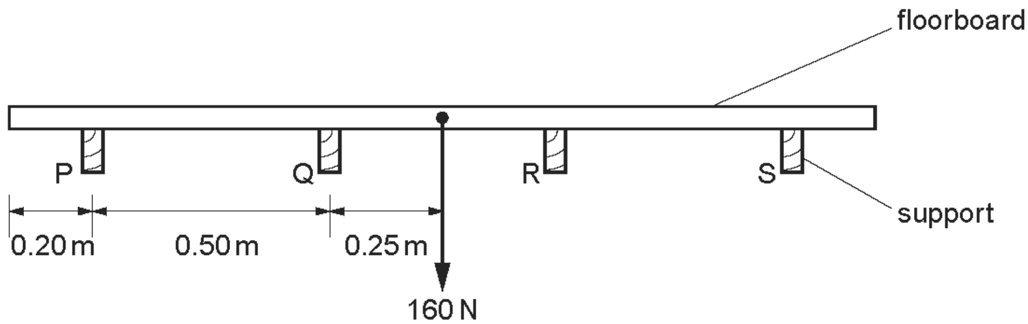


Fig. 2.1

Calculate the force exerted on the floorboard by each of the supports, and state the direction of these forces. One value is already given for you.

force exerted by P = ...

force exerted by Q = ...40 N..

force exerted by R = ...

force exerted by S = ...

direction = ... [2]

(b) A workman of weight W stands on the end of the floorboard described in **(a)**.

This just causes the floorboard to tip up, as shown in Fig. 2.2.

The supports are each 0.060 m thick.

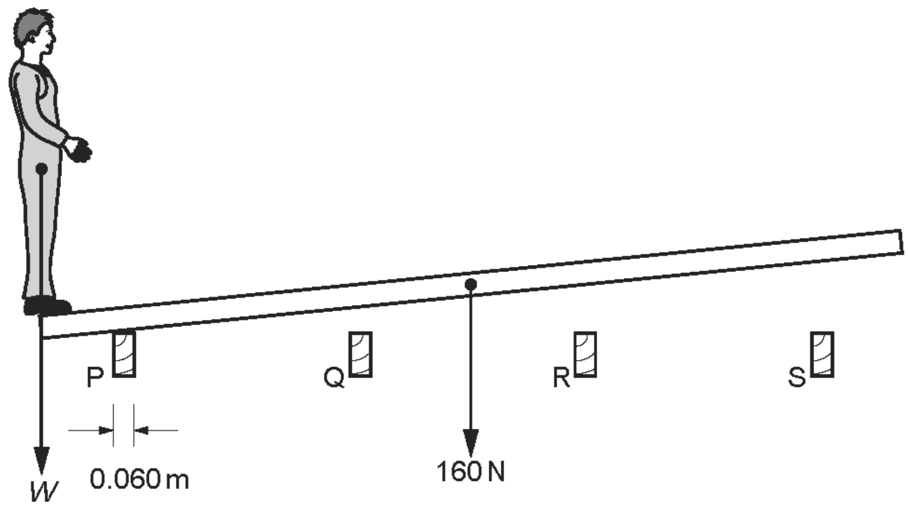


Fig. 2.2

(i) Calculate the weight W of the workman.

weight W = ... [3]

(ii) Calculate the force that each of the supports now exerts on the floorboard.

force exerted by P = ...

force exerted by Q = ...

force exerted by R = ...

force exerted by S = ... [2]

Fig. 3.1 shows a hydraulic lift in a car repair workshop.

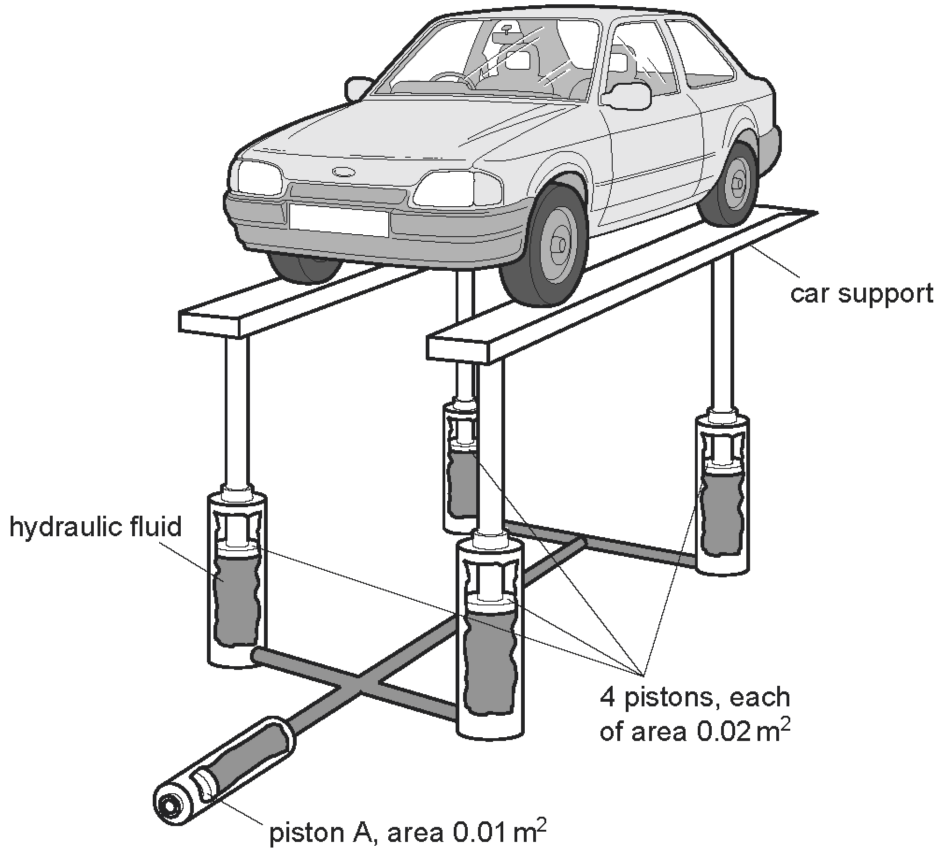


Fig. 3.1

The hydraulic fluid transmits the pressure, caused by piston A, equally to each of the four pistons holding up the car supports. The pressure throughout the fluid is the same.

A force of 1000 N on piston A is just enough to raise the car.

(a) Using values from Fig. 3.1, find

(i) the pressure caused by piston A on the fluid,

pressure = ... [2]

(ii) the total upward force caused by the fluid.

force = ... [3]

(b) The weight of each of the two car supports is 1000 N.

Calculate the mass of the car.

mass = ... [2]

(a) A uniform metre rule is pivoted at its centre, which is also the position of its centre of mass.

Three loads, 2.0 N, *F* and 3.0 N are positioned on the rule at the 20 cm, 30 cm and 90 cm marks respectively, as shown in Fig. 3.1.

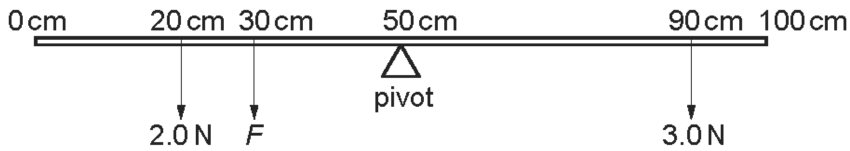


Fig. 3.1

(i) Calculate the moment of the 3.0 N load about the pivot.

moment = ... [1]

(ii) Calculate the moment of the 2.0 N load about the pivot.

moment = ... [1]

(iii) The force *F* maintains the metre rule in equilibrium on the pivot.

Calculate the value of *F*.

F = ... [3]

(b) The weight of the metre rule is 1.2 N and can be considered to act at the 50 cm mark.

All the weights in **(a)** are removed. The pivot is positioned under the 30 cm mark and the 2.0 N load is placed on the rule as shown in Fig. 3.2.

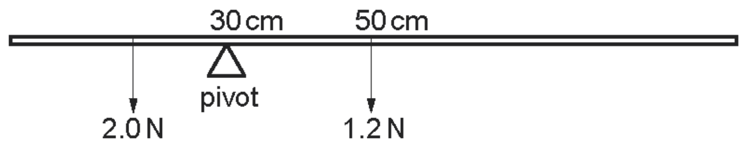


Fig. 3.2

The position of the 2.0 N load is adjusted until the metre rule is again in equilibrium.

Determine the position of the 2.0 N load.

2.0 N load is at the .... cm mark [3]

Fig. 3.1 shows a house brick of dimensions 21.0 cm × 10.0 cm × 7.00 cm.

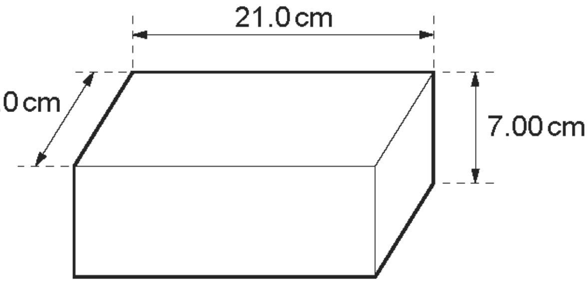


Fig. 3.1

The brick is held under water with its largest surfaces horizontal. The density of water is 1000 kg / m^3.

(a) Calculate the difference in pressure between the top and the bottom surfaces of the brick.

pressure difference = ... [2]

(b) Use your value from **(a)** to calculate the upward force exerted on the brick by the water.

upward force = ... [2]

(c) The mass of the brick is 3.09 kg. Calculate the acceleration of the brick when it is released.

acceleration = ... [3]

Fig. 2.1 shows a mobile bird sculpture that has been created by an artist.

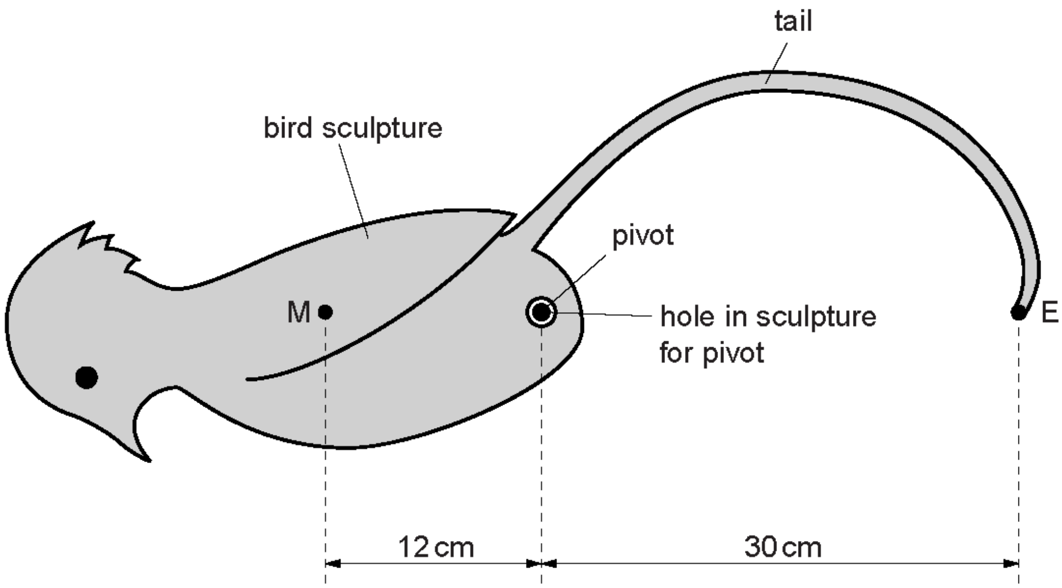


Fig. 2.1

M is the centre of mass of the bird sculpture, including its tail (but not including the counter-weight that will be added later). The mass of the bird and tail is 1.5 kg.

The bird sculpture is placed on a pivot.

The artist adds the counter-weight at the end E of the tail so that the bird remains stationary in the position shown.

(a) Calculate the mass of the counter-weight.

mass = ... [2]

(b) The centre of mass of the sculpture with counter-weight is at the pivot.

Calculate the upward force acting at the pivot.

force = ... [1]

(c) The sculpture is rotated clockwise to the position shown in Fig. 2.2. It is held still, then carefully released.

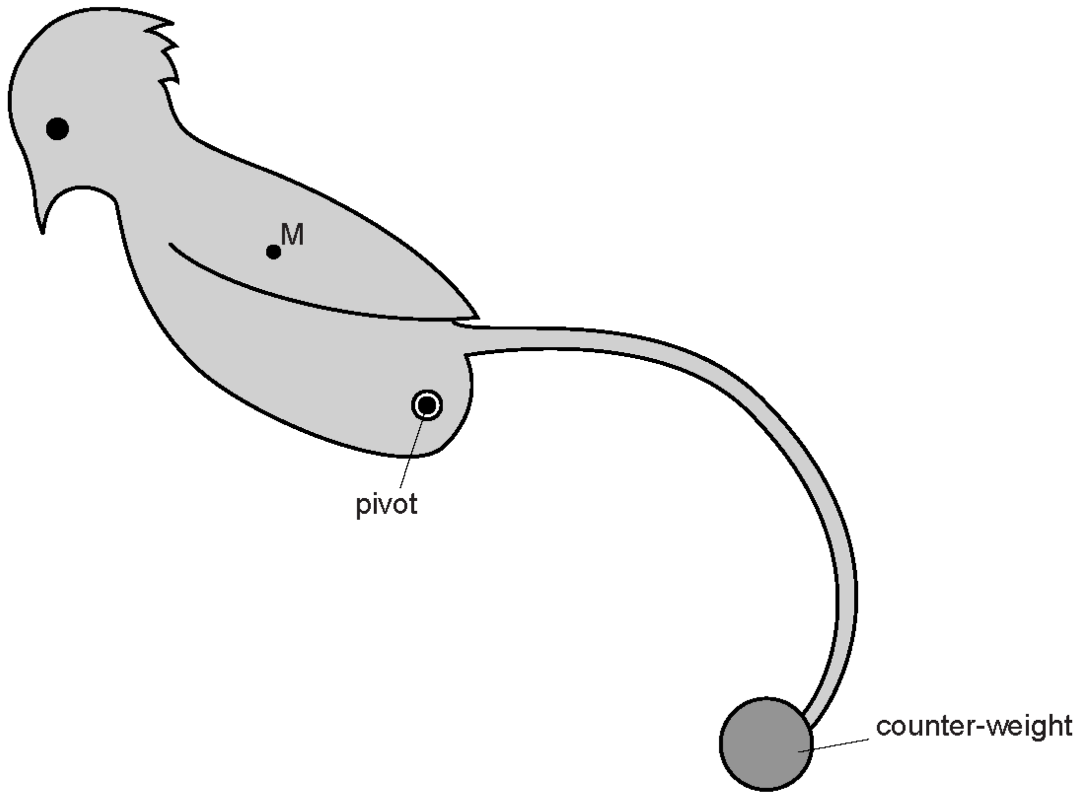


Fig. 2.2

(i) State whether the sculpture will stay in that position, rotate further clockwise or rotate back anticlockwise.

....

....

(ii) Explain your answer to **(i)**.

....

....

....

....

[3]

Fig. 4.1 represents part of the hydraulic braking system of a car.

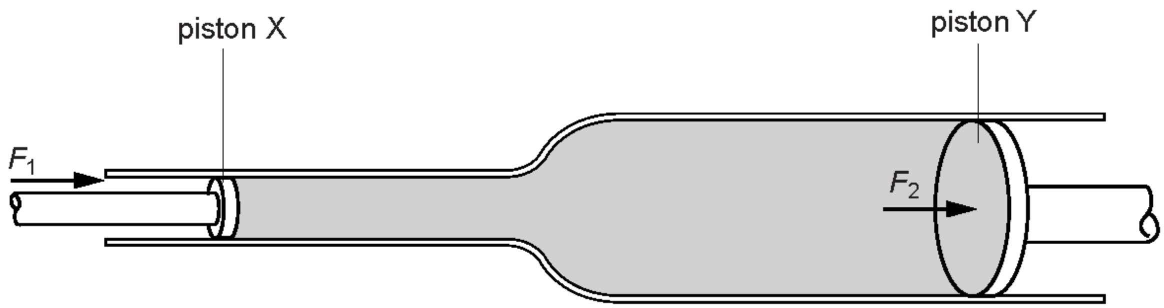


Fig. 4.1

The force F_1 of the driver's foot on the brake pedal moves piston X. The space between pistons X and Y is filled with oil which cannot be compressed. The force F_2 exerted by the oil moves piston Y. This force is applied to the brake mechanism in the wheels of the car.

The area of cross-section of piston X is 4.8 cm^2.

(a) The force F_1 is 90 N. Calculate the pressure exerted on the oil by piston X.

pressure = ... [2]

(b) The pressure on piston Y is the same as the pressure applied by piston X. Explain why the force F_2 is greater than the force F_1.

....

.... [1]

(c) Piston Y moves a smaller distance than piston X. Explain why.

....

....

.... [2]

(d) Suggest why the braking system does not work properly if the oil contains bubbles of air.

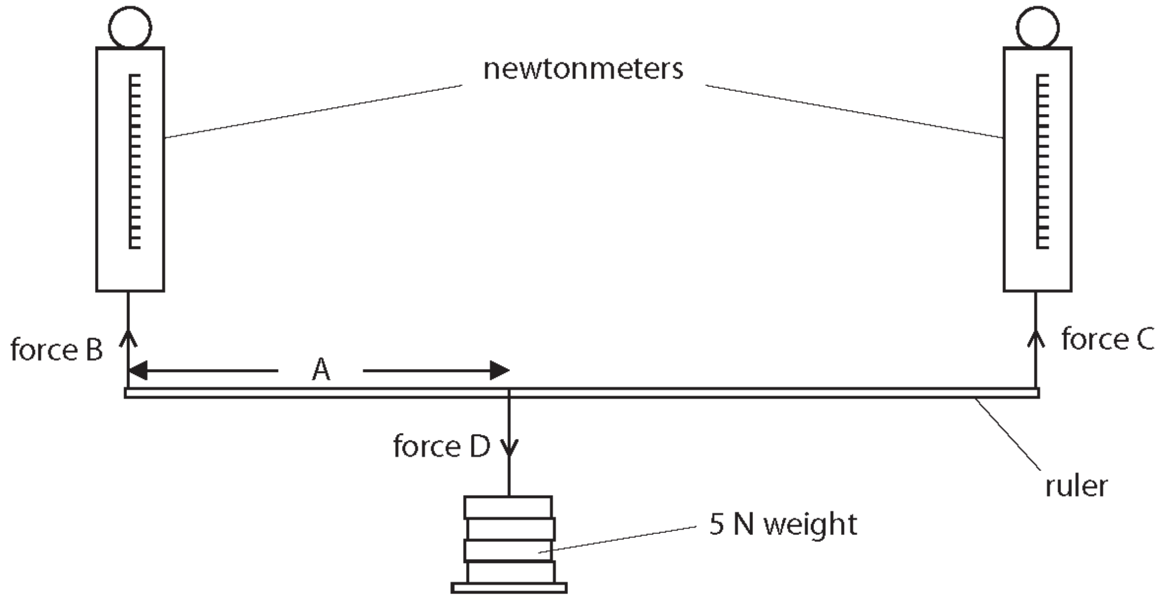
....

....

.... [2]

A student investigates the vertical forces acting on the ends of a horizontal ruler when it supports a load.

The ruler hangs from two newtonmeters with a weight suspended from it as shown.



(a) The student moves the weight along the ruler and records forces B and C by taking readings from the newtonmeters.

(i) Which of these is the independent variable in this investigation?

(1)

☒ **A** Distance A

☒ **B** Force B

☒ **C** Force C

☒ **D** Force D

(ii) Which of these is a controlled variable in this investigation?

(1)

☒ **A** Distance A

☒ **B** Force B

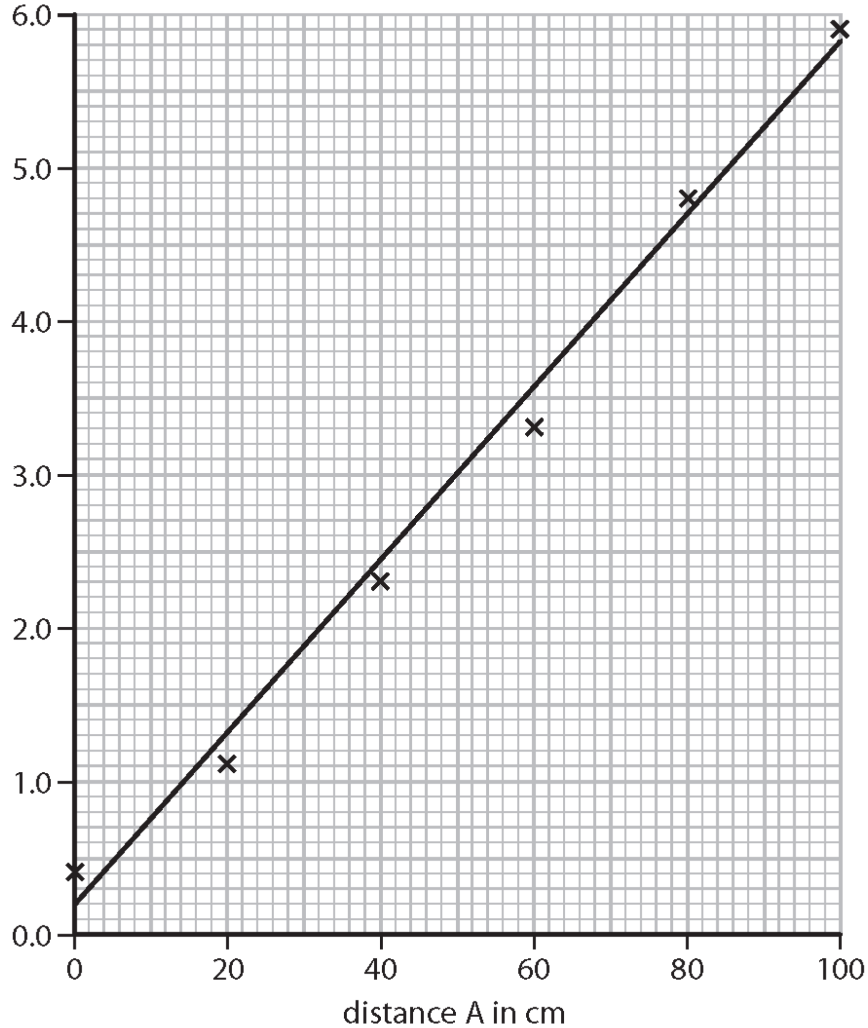
☒ **C** Force C

☒ **D** Force D

(b) The student records these readings.

Distance A in cm	Reading from newtonmeter of force B in N	Reading from newtonmeter of force C in N
0	5.1	0.4
20	4.0	1.1
40	2.9	2.3
60	2.0	3.3
80	1.1	4.8
100	0.2	5.9

She plots this graph to show how force C changes with distance A.



....

in ....

(i) Complete the student's graph by labelling the vertical axis.

(1)

(ii) Using the same grid and axes, plot a second line to show how force B varies with distance A.

(3)

(iii) Use the lines on the graph to find distance A for which force B and force C are equal.

(1)

Distance = ... cm

(c) Suggest why neither force B nor force C are ever zero during the investigation.

(1)

....

....

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

....

....[1]

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

....

....

....

....[3]

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

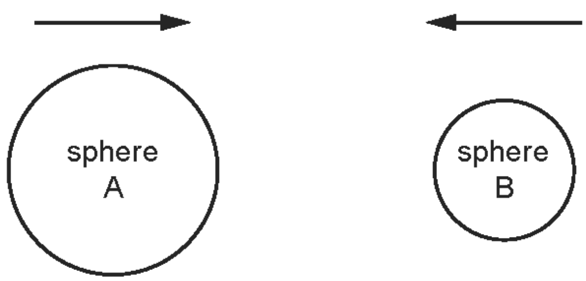


Fig. 3.1

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.

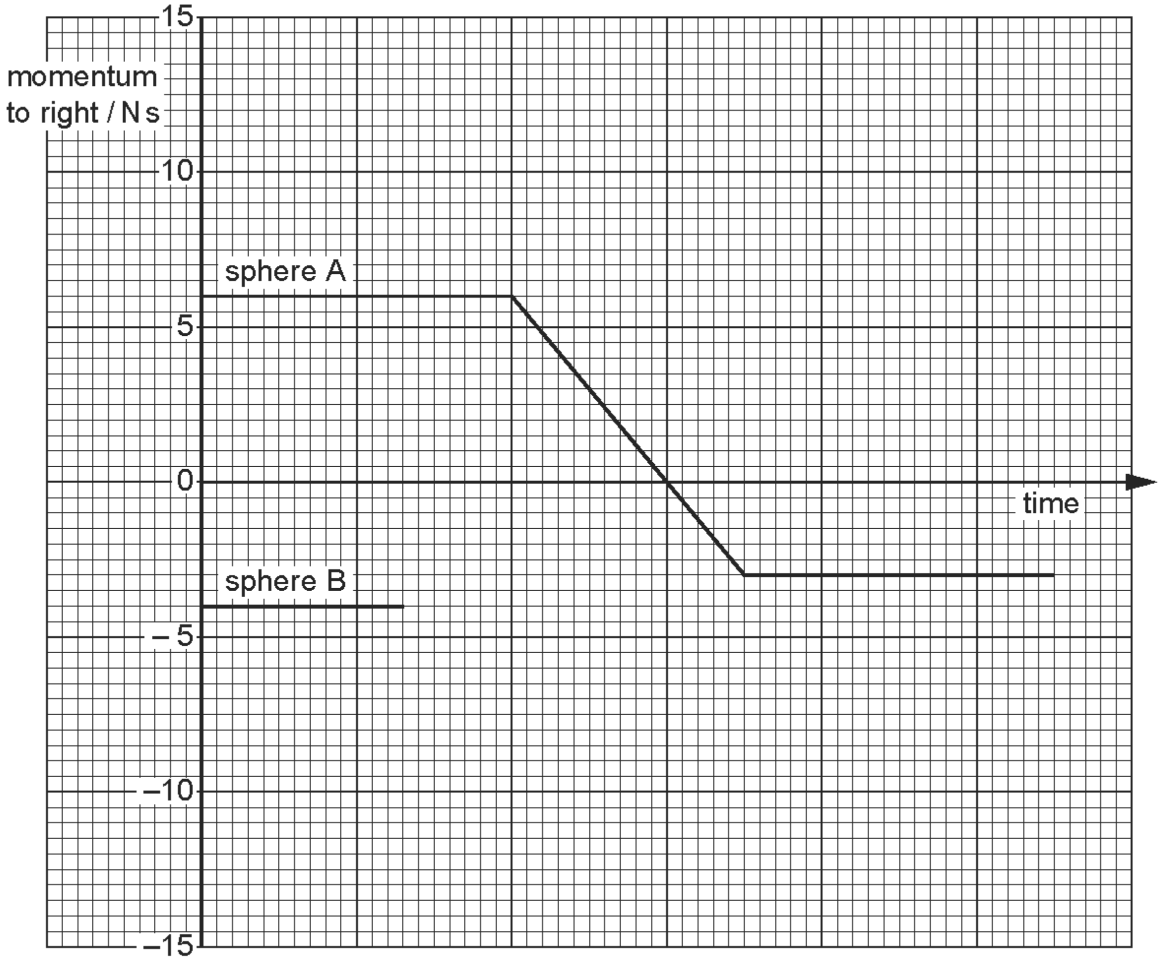


Fig. 3.2

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]

(a) State the relation between force and momentum.

.... [1]

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

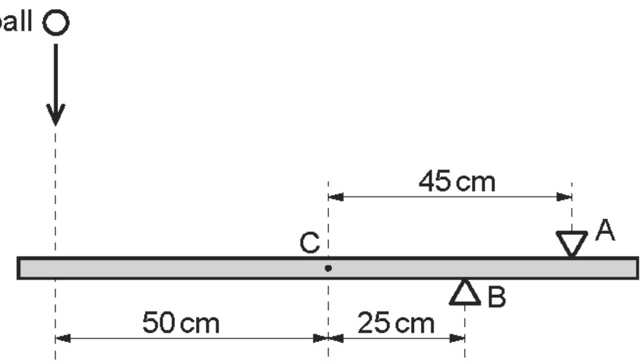
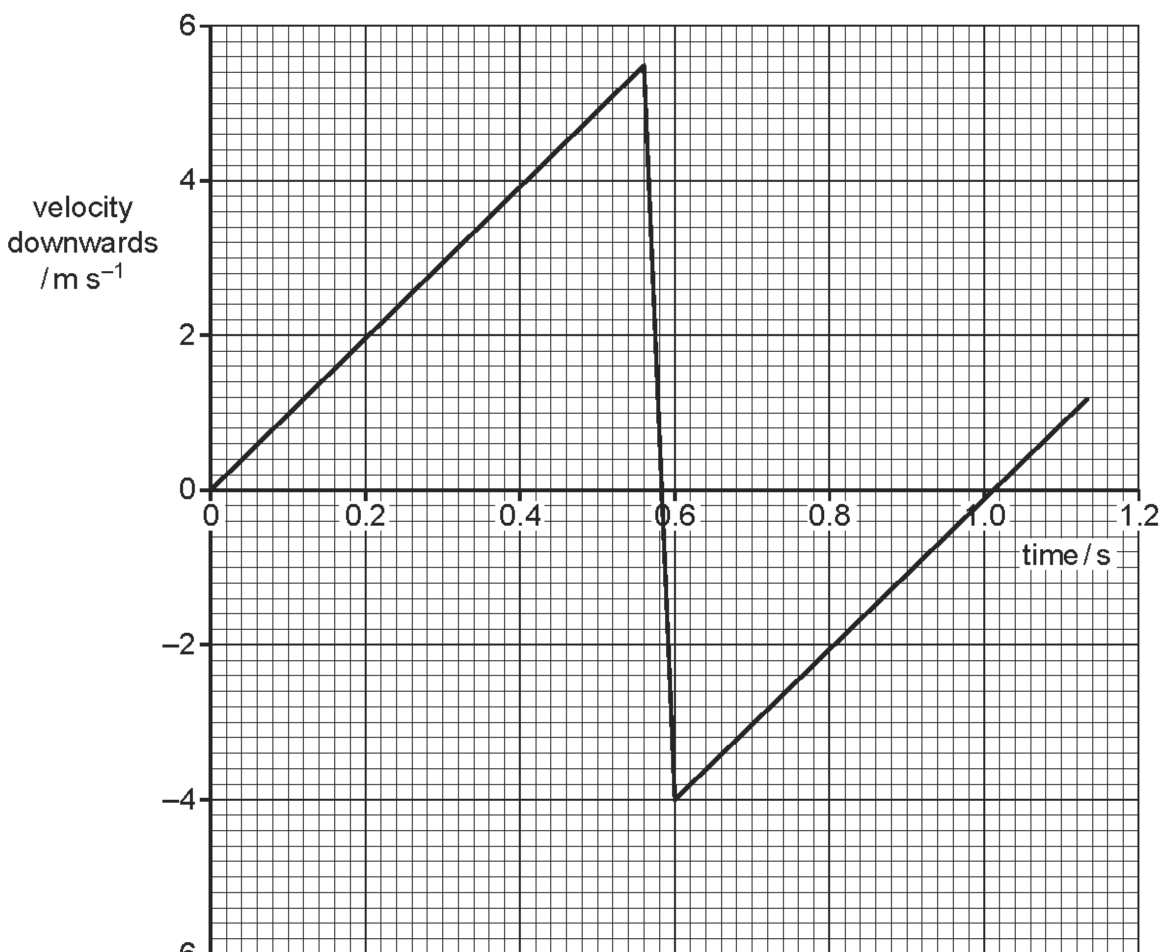


Fig. 3.1

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

A ball of mass 140 g falls vertically onto the bar such that it hits the bar at a distance of 50 cm 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.

(a) State what is meant by the *centre of gravity* of a body.

....

....

....[2]

(b) A uniform rectangular sheet of card of weight *W* is suspended from a wooden rod. The card is held to one side, as shown in Fig. 3.1.

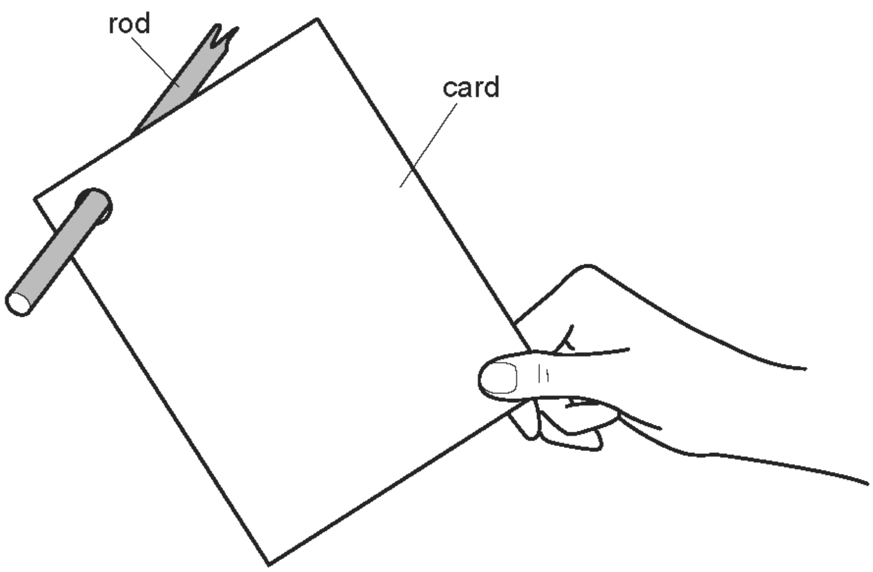


Fig. 3.1

On Fig. 3.1,

(i) mark, and label with the letter C, the position of the centre of gravity of the card, [1]

(ii) mark with an arrow labelled *W* the weight of the card. [1]

(c) The card in **(b)** is released. The card swings on the rod and eventually comes to rest.

(i) List the two forces, other than its weight and air resistance, that act on the card during the time that it is swinging. State where the forces act.

1. ....

....

2. ....

....
[3]

(ii) By reference to the completed diagram of Fig. 3.1, state the position in which the card comes to rest.
Explain why the card comes to rest in this position.

....

....

.... [2]

(a) Define *pressure*.

....

.... [1]

(b) Explain, in terms of the air molecules, why the pressure at the top of a mountain is less than at sea level.

....

....

....

....

.... [3]

(c) Fig. 3.1 shows a liquid in a cylindrical container.

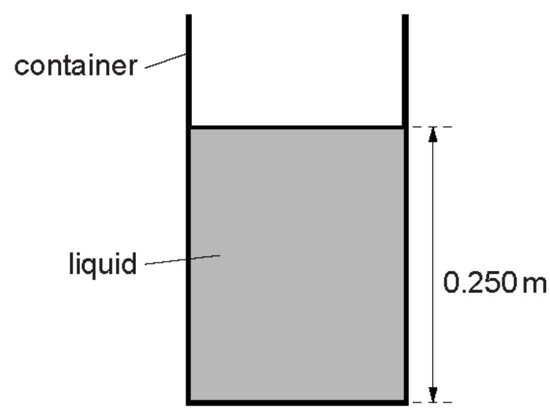


Fig. 3.1

The cross-sectional area of the container is $0.450\,m^2$. The height of the column of liquid is 0.250 m and the density of the liquid is $13\,600\,kg\,m^{-3}$.

(i) Calculate the weight of the column of liquid.

weight = ... N [3]

(ii) Calculate the pressure on the base of the container caused by the weight of the liquid.

pressure = ... Pa [1]

(iii) Explain why the pressure exerted on the base of the container is different from the value calculated in **(ii)**.

....

.... [1]

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.

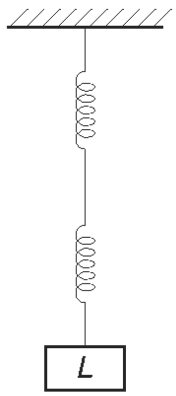
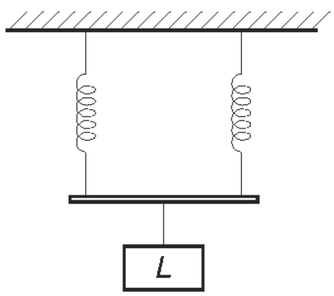
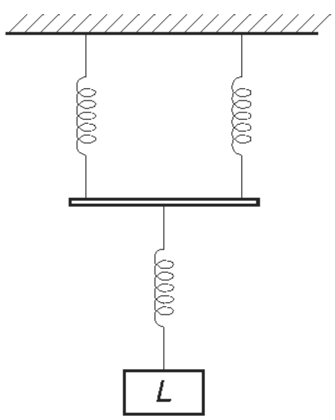
arrangement	total extension	spring constant of arrangement
	……………………	……………………
	……………………	……………………
	……………………	……………………

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]

(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.

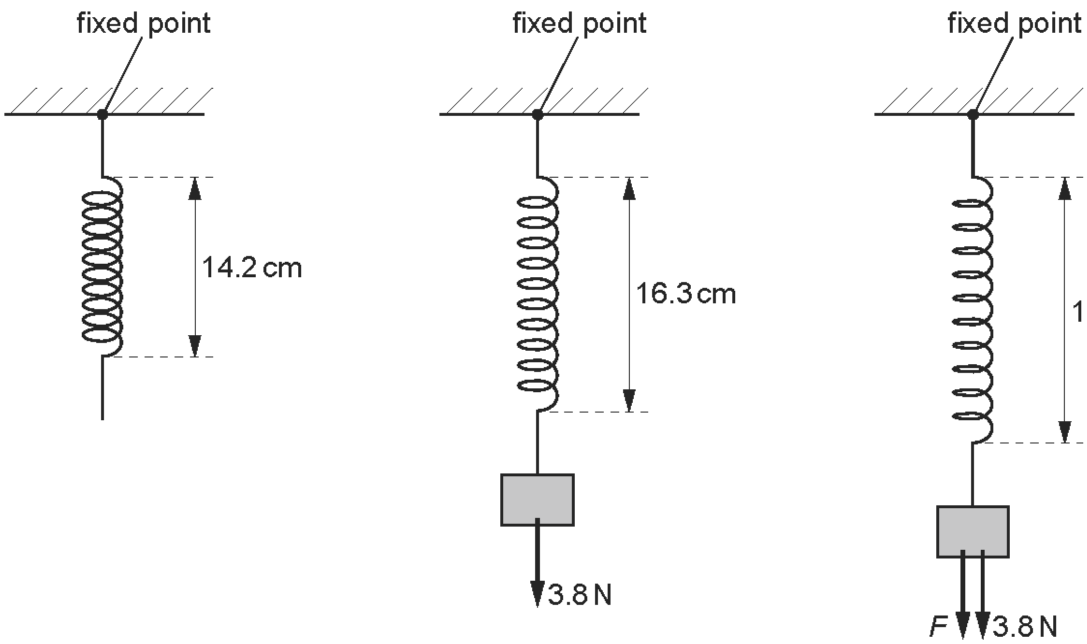


Fig. 4.1 **Fig. 4.2** **Fig. 4.3**

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]

(a) The variation with extension x of the tension F in a spring is shown in Fig. 3.1.

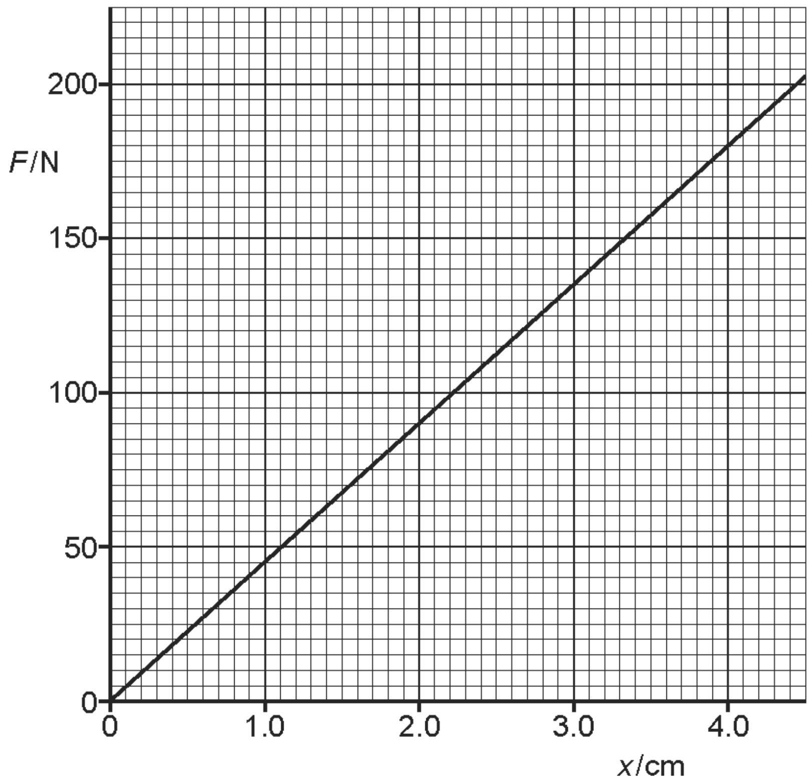


Fig. 3.1

Use Fig. 3.1 to calculate the energy stored in the spring for an extension of 4.0 cm.
Explain your working.

energy = ... J [3]

(b) The spring in **(a)** is used to join together two frictionless trolleys A and B of mass M_1 and M_2 respectively, as shown in Fig. 3.2.

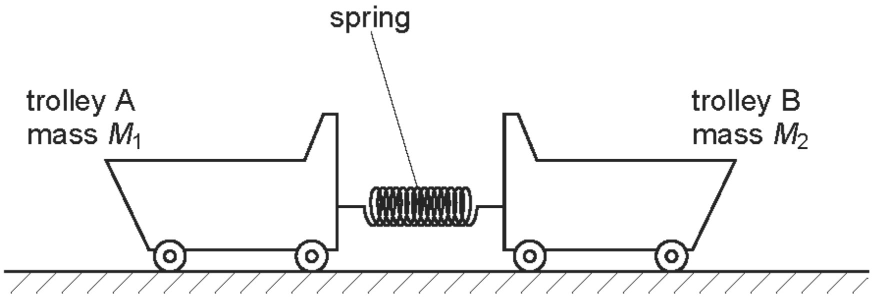


Fig. 3.2

The trolleys rest on a horizontal surface and are held apart so that the spring is extended.

The trolleys are then released.

(i) Explain why, as the extension of the spring is reduced, the momentum of trolley A is equal in magnitude but opposite in direction to the momentum of trolley B.

....

....

....

....[2]

(ii) At the instant when the extension of the spring is zero, trolley A has speed V_1 and trolley B has speed V_2.
Write down

1. an equation, based on momentum, to relate V_1 and V_2,

....

....[1]

2. an equation to relate the initial energy E stored in the spring to the final energies of the trolleys.

....

....[1]

(iii) 1. Show that the kinetic energy E_K of an object of mass m is related to its momentum p by the expression

$$E_K = \frac{p^2}{2m}.$$

[1]

2. Trolley A has a larger mass than trolley B.
Use your answer in **(ii) part 1** to deduce which trolley, A or B, has the larger kinetic energy at the instant when the extension of the spring is zero.

....

....[1]

A bullet of mass 2.0 g is fired horizontally into a block of wood of mass 600 g. The block is suspended from strings so that it is free to move in a vertical plane.
The bullet buries itself in the block. The block and bullet rise together through a vertical distance of 8.6 cm, as shown in Fig. 3.1.

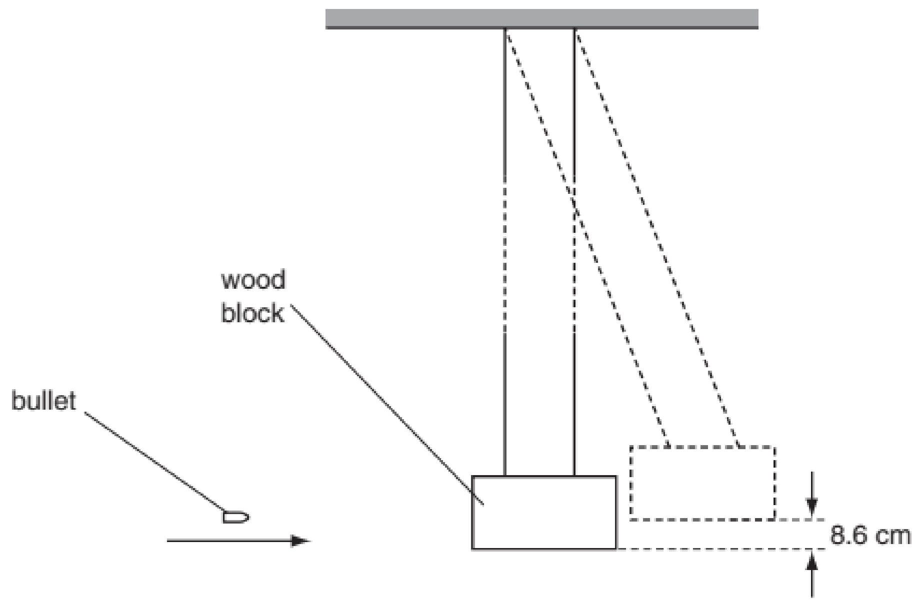


Fig. 3.1

(a) **(i)** Calculate the change in gravitational potential energy of the block and bullet.

change = ... J [2]

(ii) Show that the initial speed of the block and the bullet, after they began to move off together, was 1.3 m s^{-1}.

[1]

(b) Using the information in **(a)(ii)** and the principle of conservation of momentum, determine the speed of the bullet before the impact with the block.

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

(c) **(i)** Calculate the kinetic energy of the bullet just before impact.

kinetic energy = ... J [2]

(ii) State and explain what can be deduced from your answers to **(c)(i)** and **(a)(i)** about the type of collision between the bullet and the block.

....

....

....[2]

A lump of pure ice floats on pure water in a beaker, as shown in Fig. 4.1.

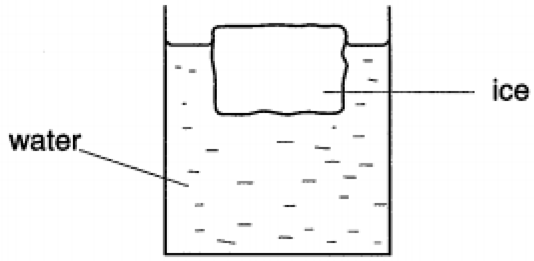


Fig. 4.1

(a) State, qualitatively, the relation between

(i) the mass of the ice and the mass of the displaced water,

....

(ii) the density of ice and the density of water.

....
[2]

(b) A student marks the level of the water surface in the beaker and then observes the level as the ice melts. State and explain qualitatively the change, if any, in this level during the melting.

....

....

....

.... [3]

(a) Expanded polystyrene has a density of $15\,kg\,m^{-3}$.

Calculate the volume of expanded polystyrene required as a buoyancy aid so that it provides a resultant upward force of 25 N when totally submerged in water of density $1.0 \times 10^3\,kg\,m^{-3}$.

volume = ... m^3 [3]

(b) A rowing boat has a cross-section as illustrated in Fig. 5.1.

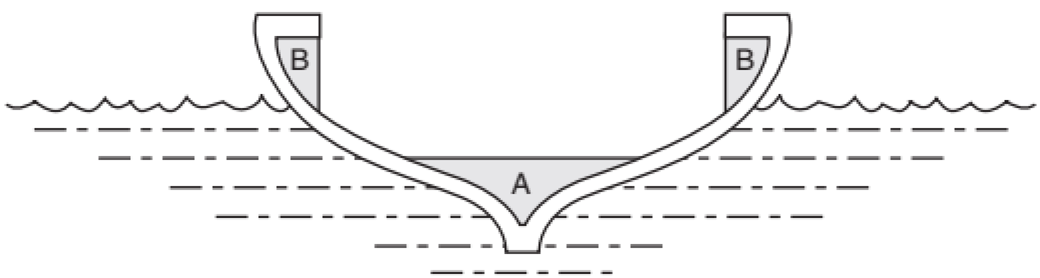


Fig. 5.1

In order to improve its buoyancy in the event that it turns over, expanded polystyrene blocks are to be fitted inside the boat.

Suggest, with a reason, whether the blocks should be fixed at position A on the keel or at the two positions marked B.

....

....

.... [2]

When a body is immersed in a fluid, it experiences an upthrust equal to the weight of fluid displaced. Explain

(a) what is meant by an *upthrust*,

....

....[1]

(b) the origin of the upthrust,

....

....

....[2]

(c) two conditions for the upthrust to be independent of the depth of immersion.

1. ....

....

2. ....

....[3]

The densities of liquids may be measured using hydrometers.
The hydrometer in Fig. 4.1 consists of a weighted bulb with a thin stem.

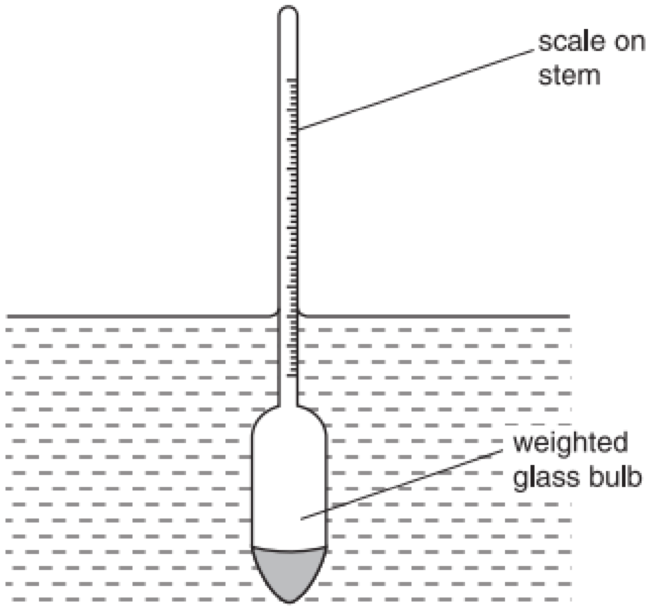


Fig. 4.1

The hydrometer is floated in the liquid and the density is read from a scale on its stem.

The hydrometer in Fig. 4.1 is designed to measure densities between $1.00\,g\,cm^{-3}$ and $1.10\,g\,cm^{-3}$.

(a) On Fig. 4.1, mark with the letter M the position on the scale of the $1.10\,g\,cm^{-3}$ graduation. [1]

(b) The hydrometer has a mass of 165 g and the stem has a uniform cross-sectional area of $0.750\,cm^2$.

Calculate

(i) the change in the submerged volume of the hydrometer when it is first placed in a liquid of density $1.00\,g\,cm^{-3}$ and then in a liquid of density $1.10\,g\,cm^{-3}$,

change = ... cm^3 [4]

(ii) the distance on the stem between the $1.00\,g\,cm^{-3}$ and the $1.10\,g\,cm^{-3}$ graduations.

distance = ... cm [1]

A hollow tube contains some sand. When placed in a liquid, the tube floats upright as illustrated in Fig. 6.1.

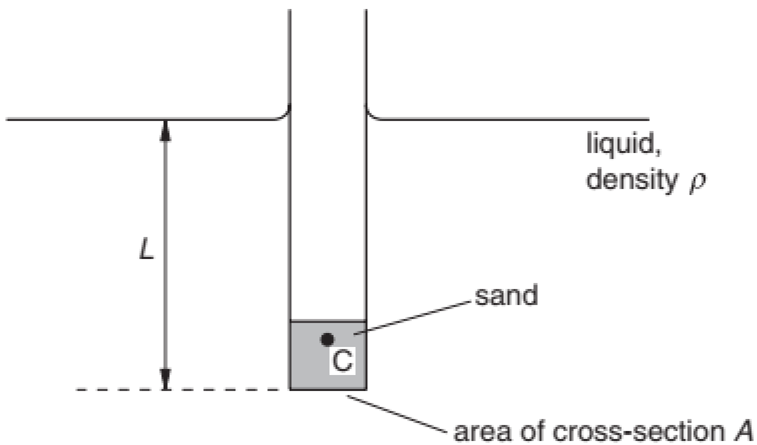


Fig. 6.1

The centre of mass of the tube and the sand is at C.

(a) Explain why the tube remains upright as it floats in the liquid.

....

....

.... [2]

(b) The tube and its contents have a total mass M. The tube, of uniform cross-section A, floats with length L submerged in a liquid of density ρ.

Show that the length L is given by the expression

$$L = \frac{M}{A\rho}.$$

(c) When placed in water of density 0.99 $g\,cm^{-3}$, the length L is 12.1 cm. The tube is then transferred to a liquid of density 1.11 $g\,cm^{-3}$. Calculate the change in the submerged length.

change in length = ... cm [3]

(a) A ball is thrown vertically down towards the ground and rebounds as illustrated in Fig. 2.1.

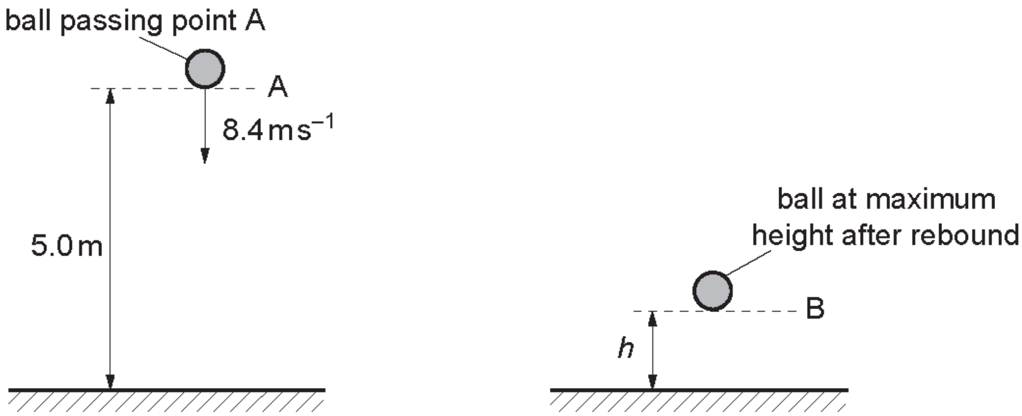


Fig. 2.1

As the ball passes A, it has a speed of 8.4 m s^{-1}. The height of A is 5.0 m above the ground. The ball hits the ground and rebounds to B. Assume that air resistance is negligible.

(i) Calculate the speed of the ball as it hits the ground.

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

(ii) Show that the time taken for the ball to reach the ground is 0.47 s.

[1]

(b) The ball rebounds vertically with a speed of $4.2\,\mathrm{m\,s^{-1}}$ as it leaves the ground. The time the ball is in contact with the ground is 20 ms. The ball rebounds to a maximum height *h*.

The ball passes A at time $t = 0$. On Fig. 2.2, plot a graph to show the variation with time *t* of the velocity *v* of the ball. Continue the graph until the ball has rebounded from the ground and reaches B.

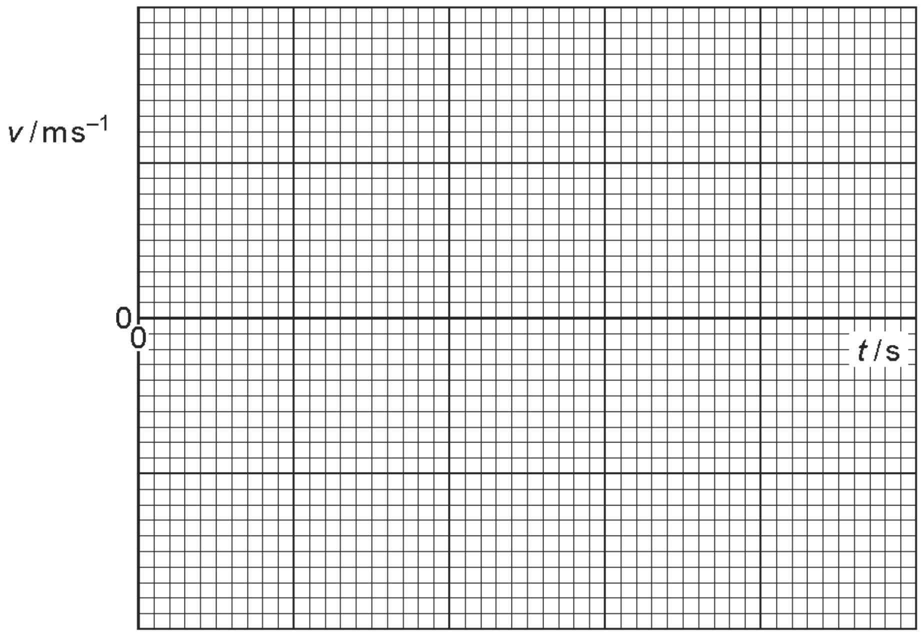


Fig. 2.2 [3]

(c) The ball has a mass of 0.050 kg. It moves from A and reaches B after rebounding.

(i) For this motion, calculate the change in

1. kinetic energy,

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

2. gravitational potential energy.

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

(ii) State and explain the total change in energy of the ball for this motion.

....

....

....

....[2]

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

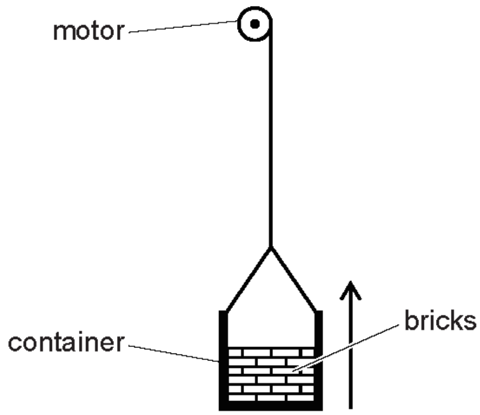


Fig. 5.1

The bricks start from rest and accelerate for 2.0 s. The bricks then travel at a constant speed of $0.64\,\text{m}\,\text{s}^{-1}$ 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]

A trolley T moves at speed 1.2 m s^{-1} along a horizontal frictionless surface. The trolley collides with a stationary block on the end of a fixed spring, as shown in Fig. 3.1.

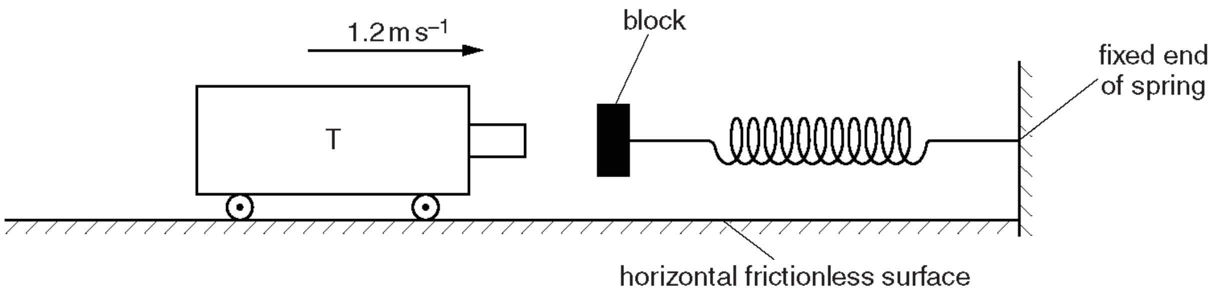


Fig. 3.1

The mass of T is 250 g. T compresses the spring by 5.4 cm as it comes to rest.
The relationship between the force F applied to the block and the compression x of the spring is shown in Fig. 3.2.

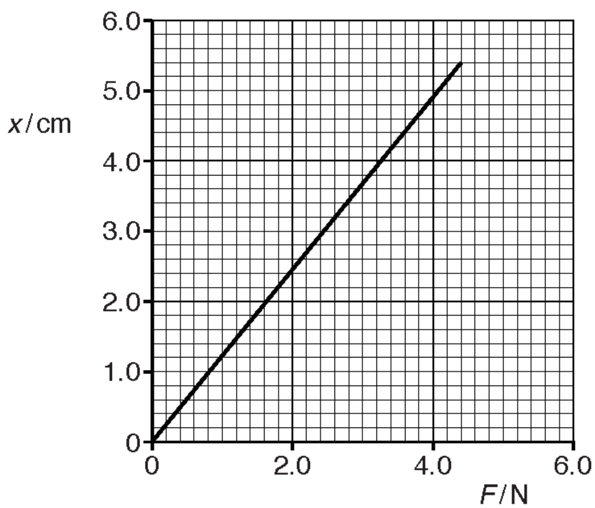


Fig. 3.2

(a) Use Fig. 3.2 to determine

(i) the spring constant of the spring,

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

(ii) the work done by T compressing the spring by 5.4 cm.

work done = ... J [2]

(b) The spring then expands and causes T to move in a direction opposite to its initial direction. At the time that T loses contact with the block, it is moving at a speed of $0.75\,\mathrm{m\,s^{-1}}$.

From the time that T is in contact with the block,

(i) describe the energy changes,

....

....

....

....[2]

(ii) determine the change in momentum of T.

change in momentum = ... N s [2]