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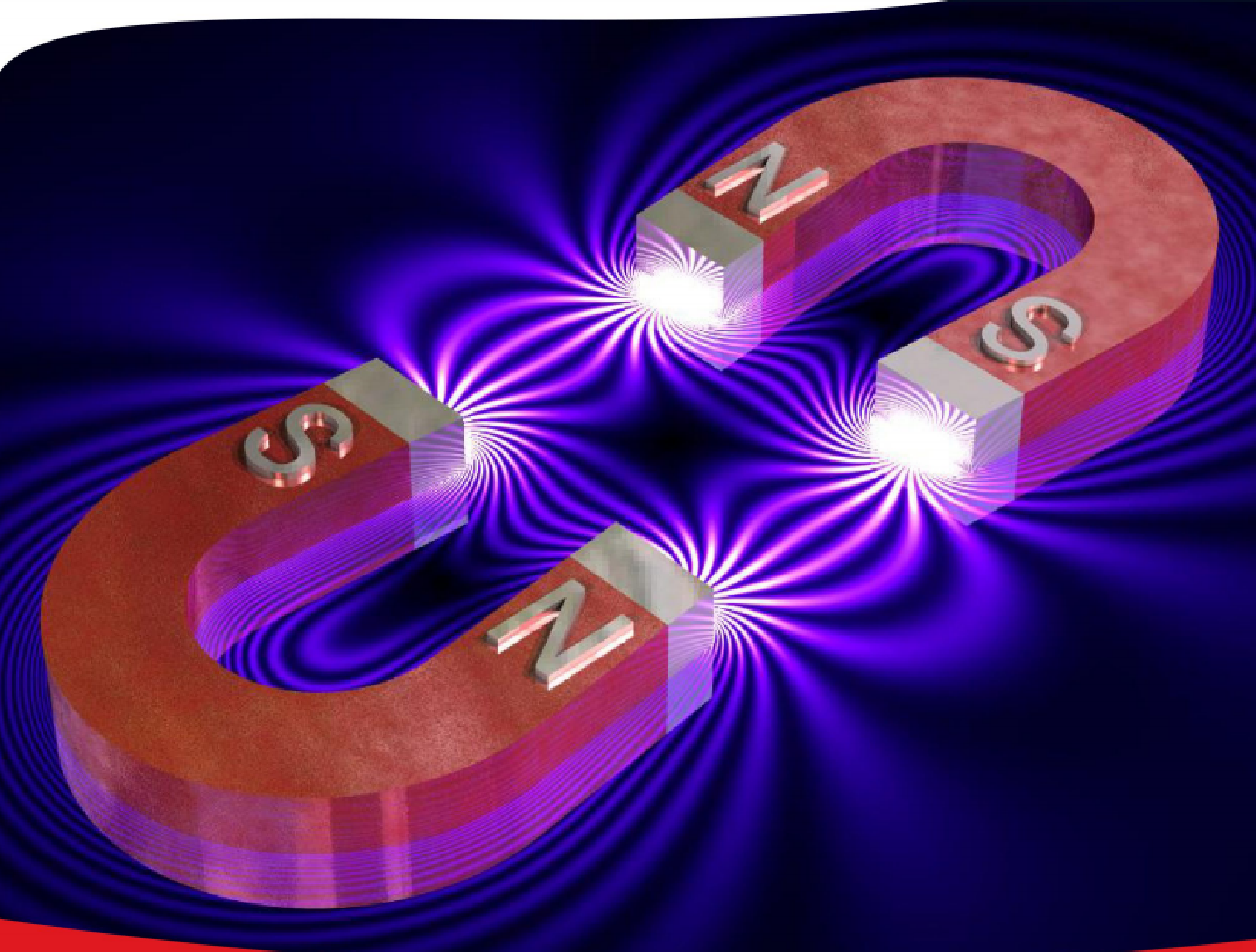
Cambridge International AS & A Level

PHYSICS (9702) P2

TOPIC WISE QUESTIONS + ANSWERS | COMPLETE SYLLABUS



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Chapter 7

Deformation of solids

7.1 Stress and strain

104. 9702_m20_qp_22 Q: 3

(a) State what is meant by *work done*.

....

....

.... [1]

(b) A skier is pulled along horizontal ground by a wire attached to a kite, as shown in Fig. 3.1.

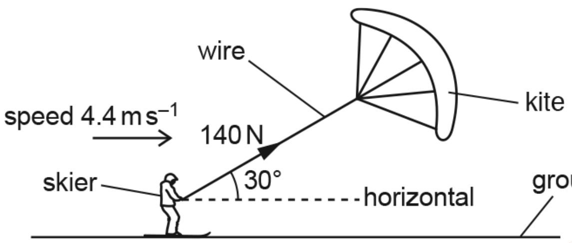


Fig. 3.1 (not to scale)

The skier moves in a straight line along the ground with a constant speed of $4.4\,\text{m s}^{-1}$. The wire is at an angle of 30° to the horizontal. The tension in the wire is 140 N.

(i) Calculate the work done by the tension to move the skier for a time of 30 s.

work done = ... J [3]

(ii) The weight of the skier is 860 N. The vertical component of the tension in the wire and the weight of the skier combine so that the skier exerts a downward pressure on the ground of 2400 Pa.

Determine the total area of the skis in contact with the ground.

area = ... m^2 [3]

(iii) The wire attached to the kite is uniform. The stress in the wire is 9.6×10^6 Pa.

Calculate the diameter of the wire.

diameter = ... m [2]

(c) The variation with extension *x* of the tension *F* in the wire in **(b)** is shown in Fig. 3.2.

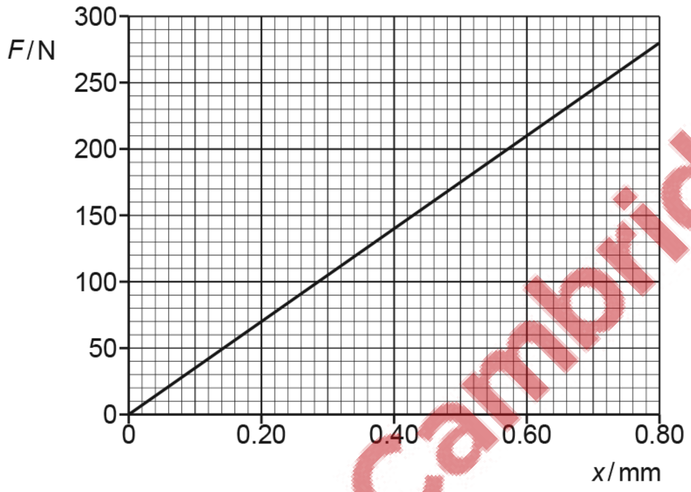


Fig. 3.2

A gust of wind increases the tension in the wire from 140 N to 210 N.

Calculate the change in the strain energy stored in the wire.

change in strain energy = ... J [3]

[Total: 12]

105. 9702_w19_qp_23 Q: 4

A ball X moves along a horizontal frictionless surface and collides with another ball Y, as illustrated in Fig. 4.1.

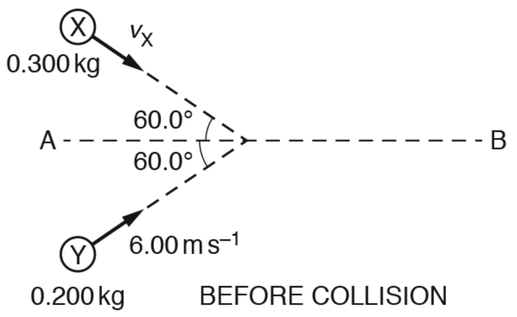


Fig. 4.1 (not to scale) **Fig. 4.2** (not to scale)

Ball X has mass 0.300 kg and initial velocity v_X at an angle of 60.0° to line AB.
Ball Y has mass 0.200 kg and initial velocity 6.00 m s^{-1} at an angle of 60.0° to line AB.
The balls stick together during the collision and then travel along line AB, as illustrated in Fig. 4.2.

(a) **(i)** Calculate, to three significant figures, the component of the initial momentum of ball Y that is perpendicular to line AB.

component of momentum = ... kg m s^{-1} [2]

(ii) By considering the component of the initial momentum of each ball perpendicular to line AB, calculate, to three significant figures, v_X.

v_X = ...m s^{-1} [1]

(iii) Show that the speed of the two balls after the collision is 2.4 m s^{-1}.

[2]

(b) The two balls continue moving together along the horizontal frictionless surface towards a spring, as illustrated in Fig. 4.3.

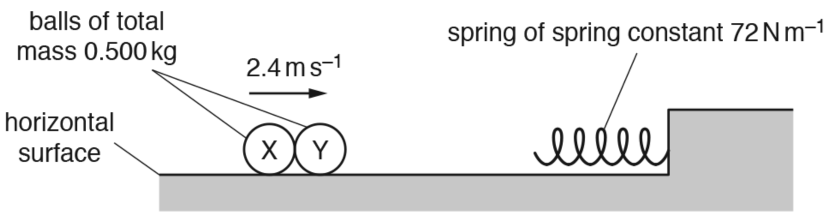


Fig. 4.3

The balls hit the spring and remain stuck together as they decelerate to rest. All the kinetic energy of the balls is converted into elastic potential energy of the spring. The energy E stored in the spring is given by

$$E = \frac{1}{2}kx^2$$

where k is the spring constant of the spring and x is its compression.
The spring obeys Hooke's law and has a spring constant of 72 N m^{-1}.

(i) Determine the maximum compression of the spring caused by the two balls.

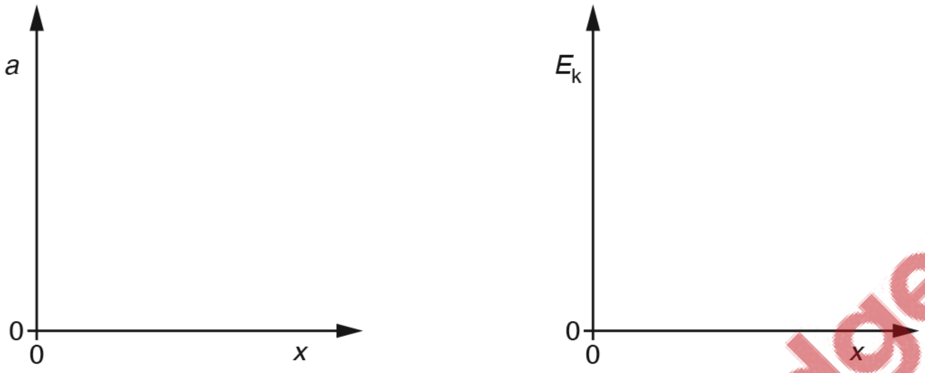
maximum compression = ... m [3]

(ii) On Fig. 4.4, sketch graphs to show the variation with compression x of the spring, from zero to maximum compression, of:

1. the magnitude of the deceleration a of the balls

2. the kinetic energy E_k of the balls.

Numerical values are not required.



[3]

Fig. 4.4

[Total: 11]

106. 9702_m18_qp_22 Q: 3

(a) For the deformation of a wire under tension, define

(i) *stress*,

....

....[1]

(ii) *strain*.

....

....[1]

(b) A wire is fixed at one end so that it hangs vertically. The wire is given an extension *x* by suspending a load *F* from its free end. The variation of *F* with *x* is shown in Fig. 3.1.

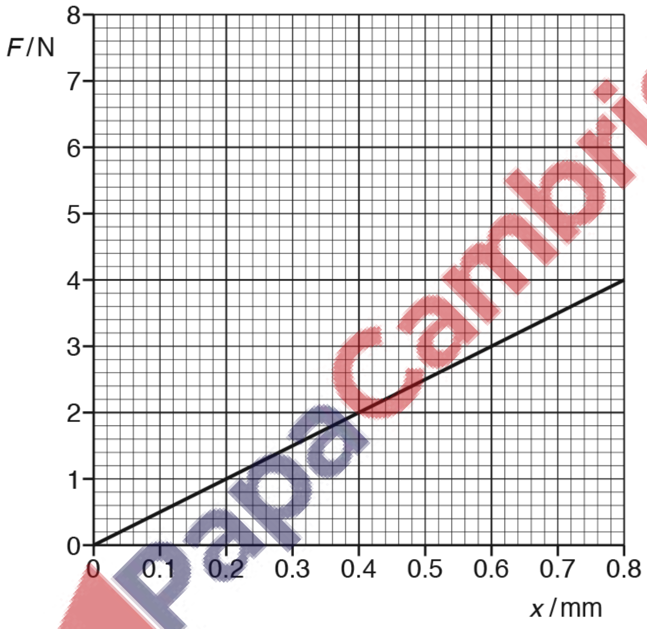


Fig. 3.1

The wire has cross-sectional area $9.4 \times 10^{-8}\,\text{m}^2$ and original length 2.5 m.

(i) Describe how measurements can be taken to determine accurately the cross-sectional area of the wire.

....

....

....

....

....[3]

(ii) Determine the Young modulus *E* of the material of the wire.

E = ... Pa [2]

(iii) **Use Fig. 3.1** to calculate the increase in the energy stored in the wire when the load is increased from 2.0 N to 4.0 N.

increase in energy = ... J [2]

(c) The wire in **(b)** is replaced by a new wire of the same material. The new wire has twice the length and twice the diameter of the old wire. The new wire also obeys Hooke's law.

On Fig. 3.1, sketch the variation with extension *x* of the load *F* for the new wire from *x* = 0 to *x* = 0.80 mm. [2]

[Total: 11]

107. 9702_s18_qp_21 Q: 2

(a) State Newton's first law of motion.

....

....[1]

(b) A block of weight 15 N hangs by a wire from a remotely controlled aircraft, as shown in Fig. 2.1.

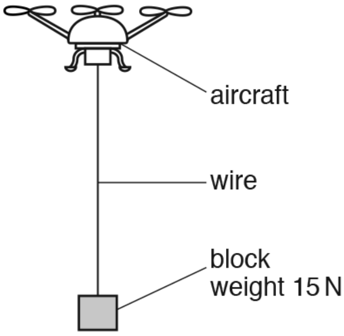


Fig. 2.1

The aircraft is used to move the block only in a vertical direction. The force on the block due to air resistance is negligible.

The variation with time t of the vertical velocity v of the block is shown in Fig. 2.2.
The velocity is taken to be positive in the upward direction.

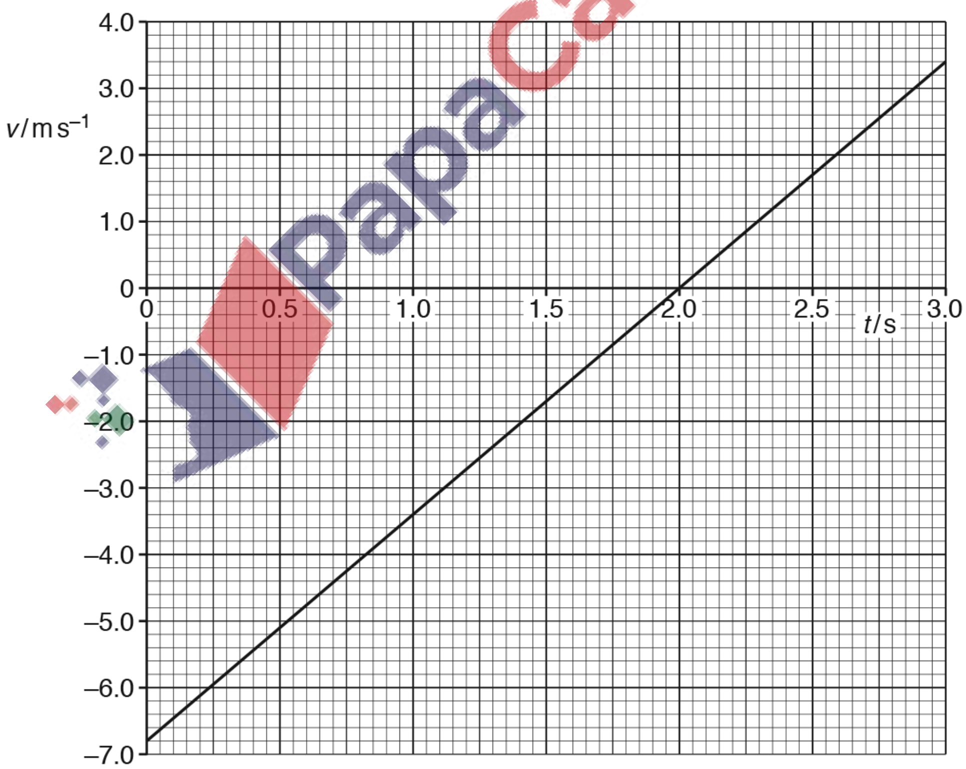


Fig. 2.2

(i) Determine, for the block,

1. the displacement from time $t = 0$ to $t = 3.0$ s,

magnitude of displacement = ... m

direction of displacement ....
[3]

2. the change in gravitational potential energy from time $t = 0$ to $t = 3.0$ s.

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

(ii) Calculate the magnitude of the acceleration of the block at time $t = 2.0$ s.

acceleration = ... m s^{-2} [2]

(iii) Use your answer in **(b)(ii)** to show that the tension T in the wire at time $t = 2.0$ s is 20 N.

(iv) The wire has a cross-sectional area of $2.8 \times 10^{-5}\,m^2$ and is made from metal of Young modulus 1.7×10^{11} Pa. The wire obeys Hooke's law.

Calculate the strain of the wire at time $t = 2.0$ s.

strain = ... [3]

(v) At some time after $t = 3.0$ s the tension in the wire has a constant value of 15 N.

State and explain whether it is possible to deduce that the block is moving vertically after $t = 3.0$ s.

....

....

....

....[2]

[Total: 15]

108. 9702_s18_qp_22 Q: 5

A solid cylinder is lifted out of oil by a wire attached to a motor. Fig. 5.1 shows two different positions X and Y of the cylinder during the lifting process.

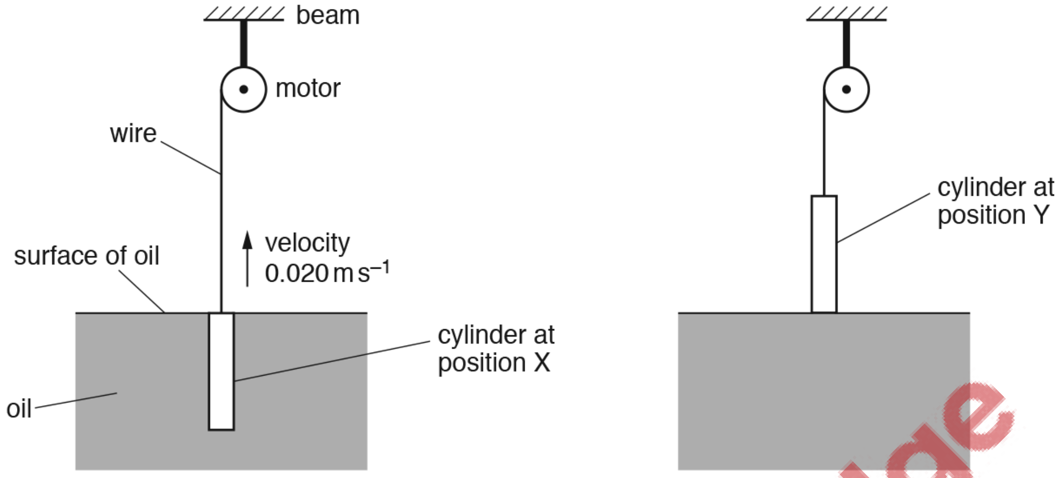


Fig. 5.1

The motor is fixed to an overhead beam.
The cylinder has cross-sectional area $0.018\,m^2$, length 1.2 m and weight 560 N.
The density of the oil is $940\,kg\,m^{-3}$.

Throughout the lifting process, the cylinder moves vertically upwards with a constant velocity of $0.020\,m\,s^{-1}$. The viscous force of the oil acting on the cylinder is negligible.

(a) Calculate the density of the cylinder.

density = ... $kg\,m^{-3}$ [2]

(b) For the cylinder at position X, show that the upthrust due to the oil is 200 N.

[2]

(c) Calculate, for the moving cylinder at position X,

(i) the tension in the wire,

tension = ... N [1]

(ii) the power output of the motor.

power = ... W [2]

(d) The cylinder is raised with constant velocity from position X to position Y.

(i) State and explain the variation, if any, of the power output of the motor as the cylinder is raised. Numerical values are not required.

....

....

....

....

....[3]

(ii) The rate of energy output of the motor is less than the rate of increase of gravitational potential energy of the cylinder. Without calculation, explain this difference.

....

....[1]

[Total: 11]

109. 9702_w18_qp_23 Q: 1

(a) Mass, length and time are all SI base quantities.

State two other SI base quantities.

1. ....

2. ....
[2]

(b) A wire hangs between two fixed points, as shown in Fig. 1.1.

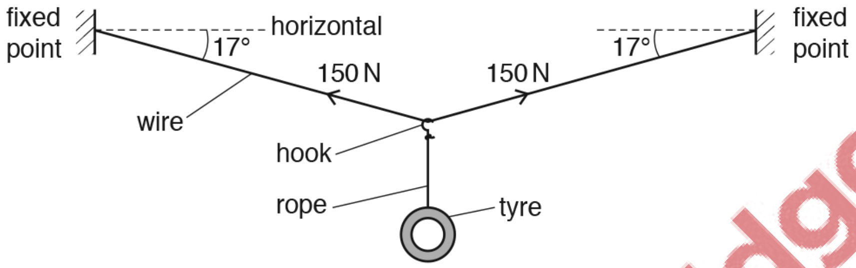


Fig. 1.1 (not to scale)

A child's swing is made by connecting a car tyre to the wire using a rope and a hook. The system is in equilibrium with the wire hanging at an angle of 17° to the horizontal. The tension in the wire is 150 N. Assume that the rope and hook have negligible weight.

(i) Determine the weight of the tyre.

weight = ... N [2]

(ii) The wire has a cross-sectional area of 7.5 mm^2 and is made of metal of Young modulus 2.1×10^{11} Pa. The wire obeys Hooke's law.

Calculate, for the wire,

1. the stress,

stress = ... Pa [2]

2. the strain.

strain = ... [2]

[Total: 8]

110. 9702_s17_qp_22 Q: 3

The Young modulus of the material of a wire can be determined using the apparatus shown in Fig. 3.1.

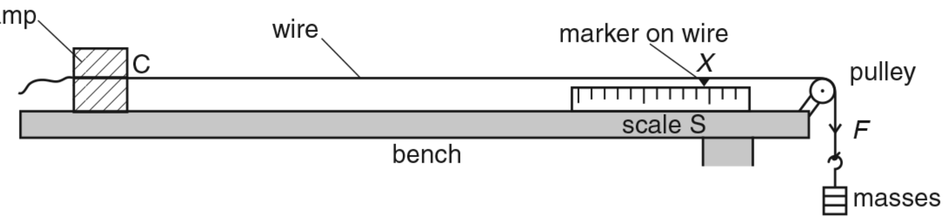


Fig. 3.1

One end of the wire is clamped at C and a marker is attached to the wire above a scale S. A force to extend the wire is applied by attaching masses to the other end of the wire.

The reading *X* of the marker on the scale S is determined for different forces *F* applied to the end of the wire. The variation with *X* of *F* is shown in Fig. 3.2.

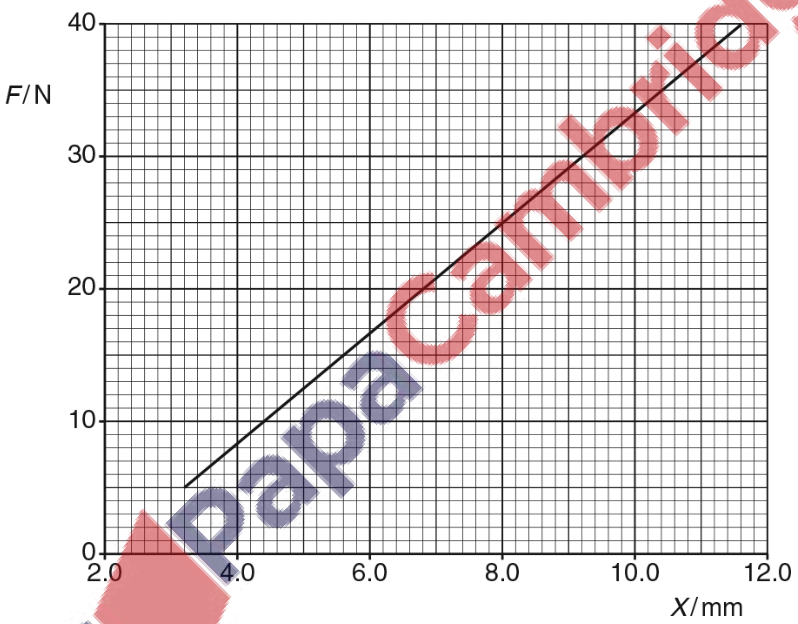


Fig. 3.2

(a) The length of the wire from C to the marker for $F = 0$ is 3.50 m. The diameter of the wire is 0.38 mm.

Use the gradient of the line in Fig. 3.2 to determine the Young modulus E of the material of the wire in TPa.

E = ... TPa [3]

(b) The experiment is repeated with a thicker wire of the same material and length.

State how the range of the force F must be changed to obtain the same range of scale readings as in Fig. 3.2.

....

....

....[1]

[Total: 4]

111. 9702_w17_qp_21 Q: 4

(a) Define *strain*.

....

....[1]

(b) A wire is designed to ensure that its strain does not exceed 4.0×10^{-4} when a force of 8.0 kN is applied. The Young modulus of the metal of the wire is 2.1×10^{11} Pa. It may be assumed that the wire obeys Hooke's law.

For a force of 8.0 kN, calculate, for the wire,

(i) the maximum stress,

maximum stress = ... Pa [2]

(ii) the minimum cross-sectional area.

minimum cross-sectional area = ... m^2 [2]

[Total: 5]

112. 9702_w17_qp_22 Q: 3

A spring is attached at one end to a fixed point and hangs vertically with a cube attached to the other end. The cube is initially held so that the spring has zero extension, as shown in Fig. 3.1.

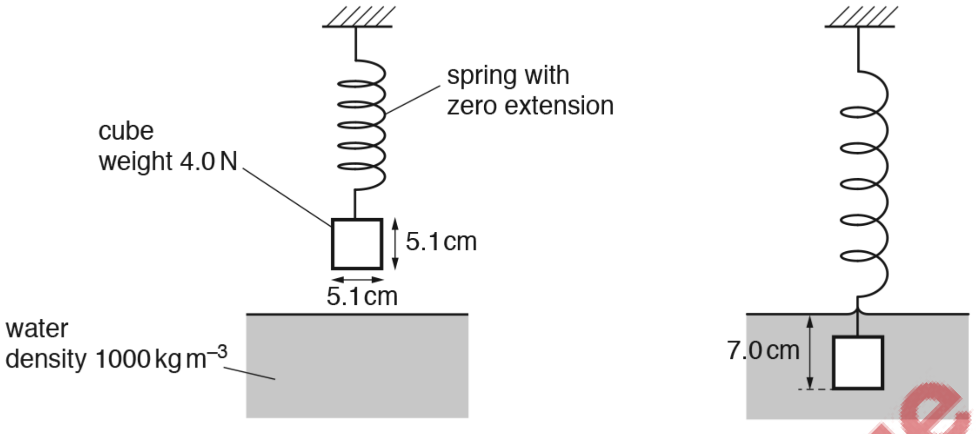


Fig. 3.1 **Fig. 3.2**

The cube has weight 4.0N and sides of length 5.1cm. The cube is released and sinks into water as the spring extends. The cube reaches equilibrium with its base at a depth of 7.0cm below the water surface, as shown in Fig. 3.2.
The density of the water is 1000kgm^{-3}.

(a) Calculate the difference in the pressure exerted by the water on the bottom face and on the top face of the cube.

difference in pressure = ... Pa [2]

(b) Use your answer in **(a)** to show that the upthrust on the cube is 1.3N.

[2]

(c) Calculate the force exerted on the spring by the cube when it is in equilibrium in the water.

force = ... N [1]

(d) The spring obeys Hooke's law and has a spring constant of $30\,\text{N}\,\text{m}^{-1}$.

Determine the initial height above the water surface of the base of the cube before it was released.

height above surface = ... cm [3]

(e) The cube in the water is released from the spring.

(i) Determine the initial acceleration of the cube.

acceleration = ...$\text{m}\,\text{s}^{-2}$ [2]

(ii) Describe and explain the variation, if any, of the acceleration of the cube as it sinks in the water.

....

....

....[2]

[Total: 12]

113. 9702_s16_qp_22 Q: 3

(a) Define the *Young modulus*.

....

....[1]

(b) The Young modulus of steel is 1.9×10^{11} Pa. The Young modulus of copper is 1.2×10^{11} Pa.

A steel wire and a copper wire each have the same cross-sectional area and length. The two wires are each extended by equal forces.

(i) Use the definition of the Young modulus to determine the ratio

$$\frac{\text{extension of the copper wire}}{\text{extension of the steel wire}}.$$

ratio = ...[3]

(ii) The two wires are each extended by a force. Both wires obey Hooke's law.

On Fig. 3.1, sketch a graph for each wire to show the variation with extension of the force.

Label the line for steel with the letter **S** and the line for copper with the letter **C**.

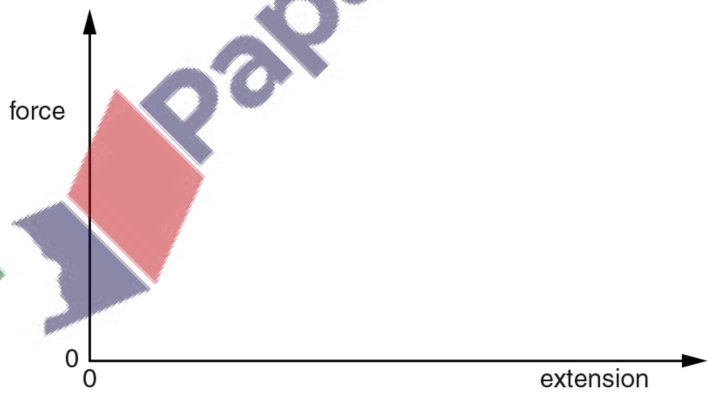


Fig. 3.1

[1]

[Total: 5]

114. 9702_w16_qp_22 Q: 3

(a) State the two conditions for an object to be in equilibrium.

1. ....

....

2. ....

.... [2]

(b) A uniform beam AC is attached to a vertical wall at end A. The beam is held horizontal by a rigid bar BD, as shown in Fig. 3.1.

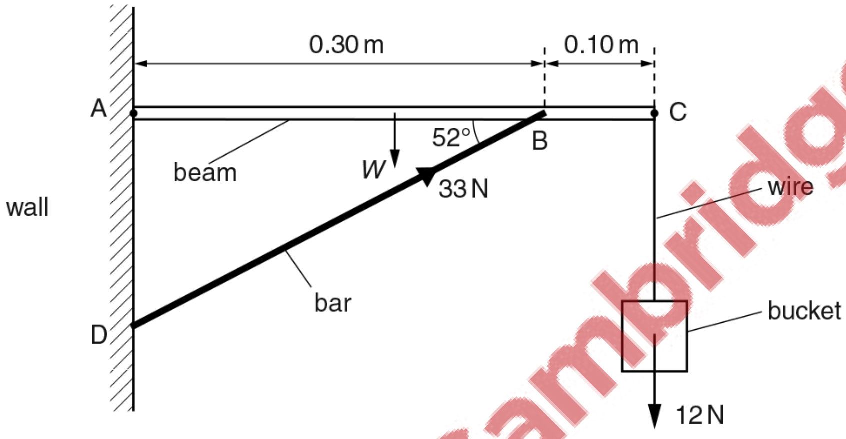


Fig. 3.1 (not to scale)

The beam is of length 0.40 m and weight *W*. An empty bucket of weight 12 N is suspended by a light metal wire from end C. The bar exerts a force on the beam of 33 N at 52° to the horizontal. The beam is in equilibrium.

(i) Calculate the vertical component of the force exerted by the bar on the beam.

component of the force = ... N [1]

(ii) By taking moments about A, calculate the weight *W* of the beam.

W = ... N [3]

(c) The metal of the wire in **(b)** has a Young modulus of 2.0×10^{11} Pa.
Initially the bucket is empty. When the bucket is filled with paint of weight 78 N, the strain of the wire increases by 7.5×10^{-4}. The wire obeys Hooke's law.

Calculate, for the wire,

(i) the increase in stress due to the addition of the paint,

increase in stress = ... Pa [2]

(ii) its diameter.

diameter = ... m [3]

[Total: 11]

7.2 Elastic and plastic behaviour

115. 9702_s20_qp_23 Q: 3

(a) State the principle of moments.

....

....

.... [2]

(b) In a bicycle shop, two wheels hang from a horizontal uniform rod AC, as shown in Fig. 3.1.

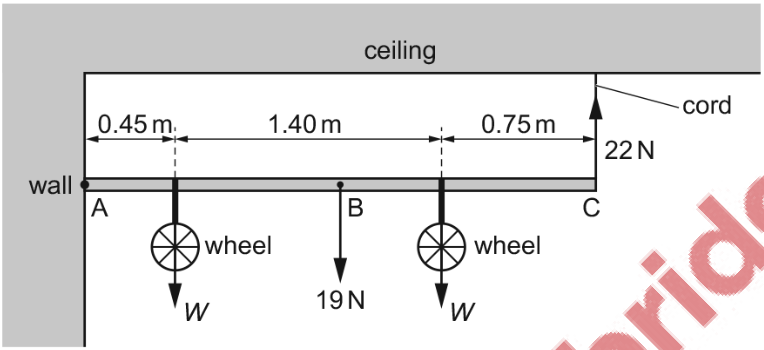


Fig. 3.1 (not to scale)

The rod has weight 19 N and is freely hinged to a wall at end A. The other end C of the rod is attached by a vertical elastic cord to the ceiling. The centre of gravity of the rod is at point B. The weight of each wheel is *W* and the tension in the cord is 22 N.

(i) By taking moments about end A, show that the weight *W* of each wheel is 14 N.

[2]

(ii) Determine the magnitude and the direction of the force acting on the rod at end A.

magnitude = ... N

direction ....
[2]

(c) The unstretched length of the cord in **(b)** is 0.25 m. The variation with length *L* of the tension *F* in the cord is shown in Fig. 3.2.

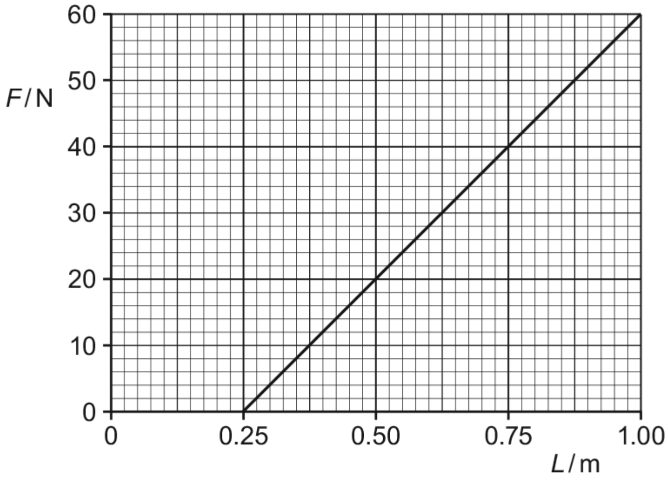


Fig. 3.2

(i) State and explain whether Fig. 3.2 suggests that the cord obeys Hooke's law.

....

....

.... [2]

(ii) Calculate the spring constant *k* of the cord.

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

(iii) On Fig. 3.2, shade the area that represents the work done to extend the cord when the tension is increased from $F = 0$ to $F = 40\,\text{N}$. [1]

[Total: 11]

116. 9702_w20_qp_21 Q: 4

(a) Define, for a wire:

(i) *stress*

....

.... [1]

(ii) *strain*.

....

.... [1]

(b) **(i)** A school experiment is performed on a metal wire to determine the Young modulus of the metal. A force is applied to one end of the wire which is fixed at the other end. The variation of the force F with extension x of the wire is shown in Fig. 4.1.

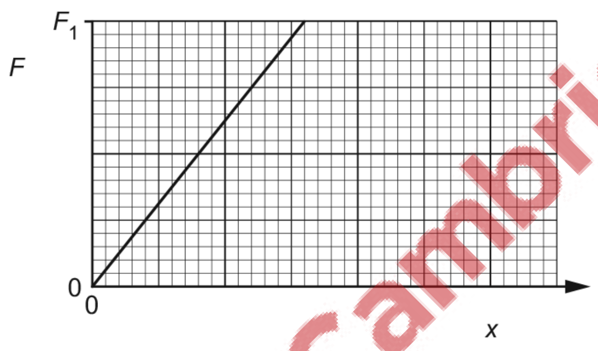


Fig. 4.1

The maximum force applied to the wire is F_1.

The gradient of the graph line in Fig. 4.1 is G. The wire has initial length L and cross-sectional area A.

Determine an expression, in terms of A, G and L, for the Young modulus E of the metal.

E = ... [2]

(ii) A student repeats the experiment in **(b)(i)** using a new wire that has twice the diameter of the first wire. The initial length of the wire and the metal of the wire are unchanged.

On Fig. 4.1, draw the graph line representing the new wire for the force increasing from $F = 0$ to $F = F_1$. [2]

(iii) Another student repeats the original experiment in **(b)(i)**, increasing the force beyond F_1 to a new maximum force F_2. The new graph obtained is shown in Fig. 4.2.

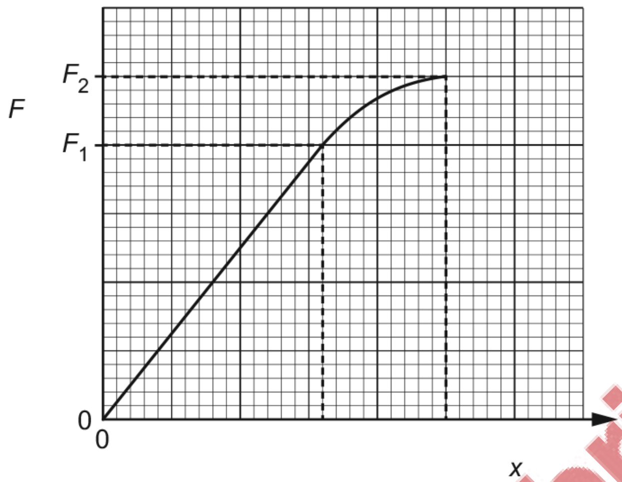


Fig. 4.2

1. On Fig. 4.2, shade an area that represents the work done to extend the wire when the force is increased from F_1 to F_2. [1]

2. Explain how the student can check that the elastic limit of the wire was not exceeded when force F_2 was applied.

....

....

.... [1]

(iv) Each student in the class performs the experiment in **(b)(i)**. The teacher describes the values of the Young modulus calculated by the students as having high accuracy and low precision.

Explain what is meant by *low precision*.

....

.... [1]

[Total: 9]

117. 9702_w20_qp_22 Q: 3

(a) A spring is fixed at one end and is compressed by applying a force to the other end. The variation of the force F acting on the spring with its compression x is shown in Fig. 3.1.

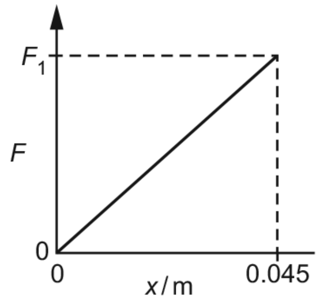


Fig. 3.1

A compression of 0.045 m is produced when a force F_1 acts on the spring. The spring has a spring constant of 800 N m^{-1}.

(i) Determine F_1.

F_1 = ... N [2]

(ii) Use Fig. 3.1 to show that, for a compression of 0.045 m, the elastic potential energy of the spring is 0.81 J.

[2]

(b) A child's toy uses the spring in **(a)** to launch a ball of mass 0.020 kg vertically into the air. The ball is initially held against one end of the spring which has a compression of 0.045 m. The spring is then released to launch the ball. The kinetic energy of the ball as it leaves the toy is 0.72 J.

(i) The toy converts the elastic potential energy of the spring into the kinetic energy of the ball. Use the information in **(a)(ii)** to calculate the percentage efficiency of this conversion.

efficiency = ... % [1]

(ii) Determine the initial momentum of the ball as it leaves the toy.

momentum = ... N s [3]

(c) The ball in **(b)** leaves the toy at point A and moves vertically upwards through the air. Point B is the position of the ball when it is at maximum height *h* above point A, as illustrated in Fig. 3.2.

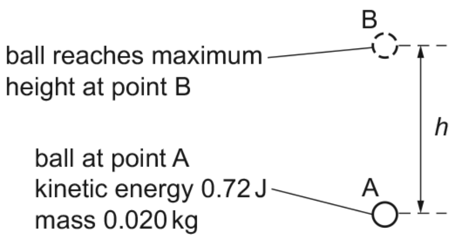


Fig. 3.2 (not to scale)

The gravitational potential energy of the ball increases by 0.60 J as it moves from A to B.

(i) Calculate *h*.

h = ... m [2]

(ii) Determine the average force due to air resistance acting on the ball for its movement from A to B.

average force = ... N [2]

(iii) When there is air resistance, the ball takes time *T* to move from A to B.

State and explain whether the time taken for the ball to move from A to its maximum height will be more than, less than or equal to time *T* if there is **no** air resistance.

....

.... [1]

[Total: 13]

118. 9702_w20_qp_23 Q: 4

(a) State Hooke's law.

....

.... [1]

(b) A spring is fixed at one end. A compressive force *F* is applied to the other end. The variation of the force *F* with the compression *x* of the spring is shown in Fig. 4.1.

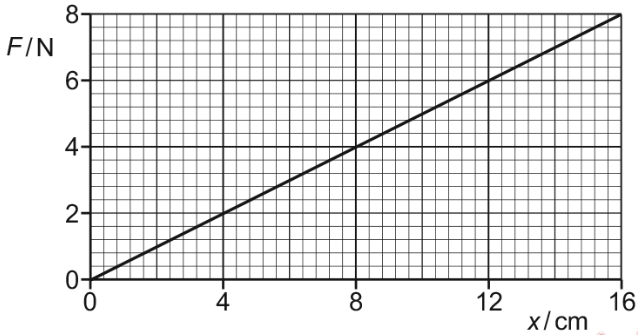


Fig. 4.1

Show that the elastic potential energy of the spring is 0.64 J when its compression is 16.0 cm.

[2]

(c) The spring in **(b)** is used to project a toy car along a track from point X to point Y, as illustrated in Fig. 4.2.

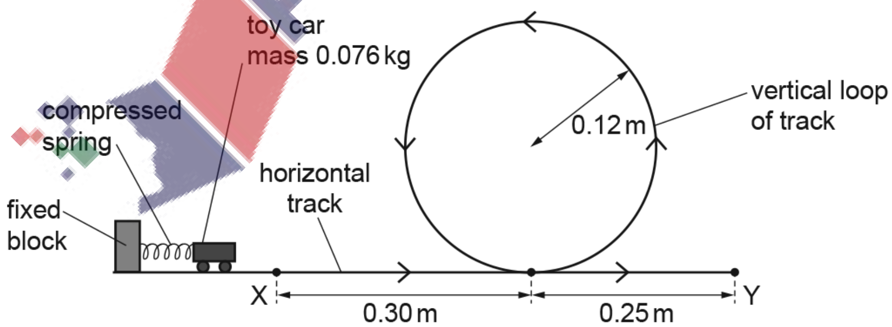


Fig. 4.2 (not to scale)

The spring is initially given a compression of 16.0 cm. The car of mass 0.076 kg is held against one end of the compressed spring. When the spring is released it projects the car forward. The car leaves the spring at point X with kinetic energy that is equal to the initial elastic potential energy of the compressed spring.

The car follows the track around a vertical loop of radius 0.12 m and then passes point Y. Assume that friction and air resistance are negligible.

Calculate:

(i) the speed of the car at X

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

(ii) the kinetic energy of the car when it is at the top of the loop

kinetic energy = ... J [3]

(iii) the speed of the car at Y.

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

(d) In practice, a resistive force due to friction and air resistance acts on the car so that its kinetic energy at Y is 0.23 J less than its kinetic energy at X.

Determine the average resistive force acting on the car for its movement from X to Y.

average resistive force = ... N [3]

[Total: 12]

119. 9702_s19_qp_21 Q: 3

The variation with extension x of the force F acting on a spring is shown in Fig. 3.1.

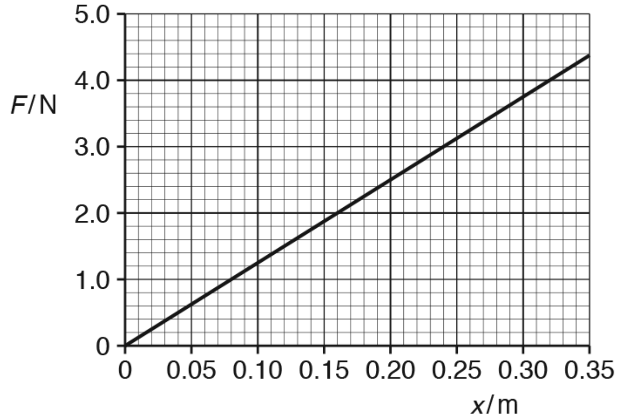


Fig. 3.1

The spring of unstretched length 0.40 m has one end attached to a fixed point, as shown in Fig. 3.2.

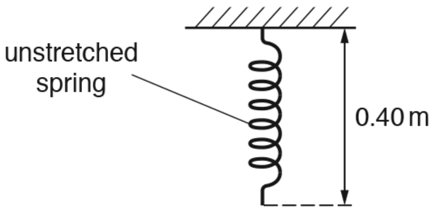


Fig. 3.2

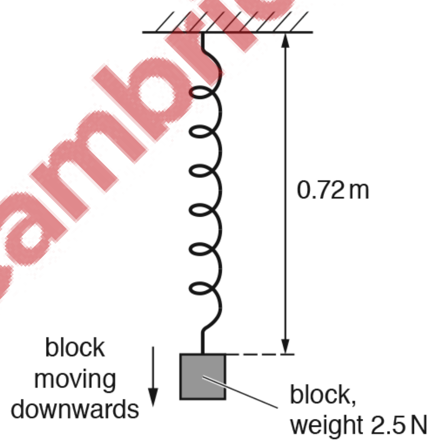


Fig. 3.3

A block of weight 2.5 N is then attached to the spring. The block is then released and begins to move downwards. At one instant, as the block is continuing to move downwards, the spring has a length of 0.72 m, as shown in Fig. 3.3.

Assume that the air resistance and the mass of the spring are both negligible.

(a) For the change in length of the spring from 0.40 m to 0.72 m:

(i) use Fig. 3.1 to show that the increase in elastic potential energy of the spring is 0.64 J

[2]

(ii) calculate the decrease in gravitational potential energy of the block of weight 2.5 N.

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

(b) Use the information in **(a)(i)** and your answer in **(a)(ii)** to determine, for the instant when the length of the spring is 0.72 m:

(i) the kinetic energy of the block

kinetic energy = ... J [1]

(ii) the speed of the block.

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

[Total: 7]

120. 9702_s18_qp_23 Q: 4

(a) Define the *Young modulus* of a material.

....

....[1]

(b) A metal rod is compressed, as shown in Fig. 4.1.

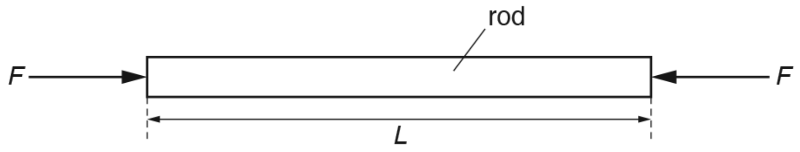


Fig. 4.1

The variation with compressive force F of the length L of the rod is shown in Fig. 4.2.

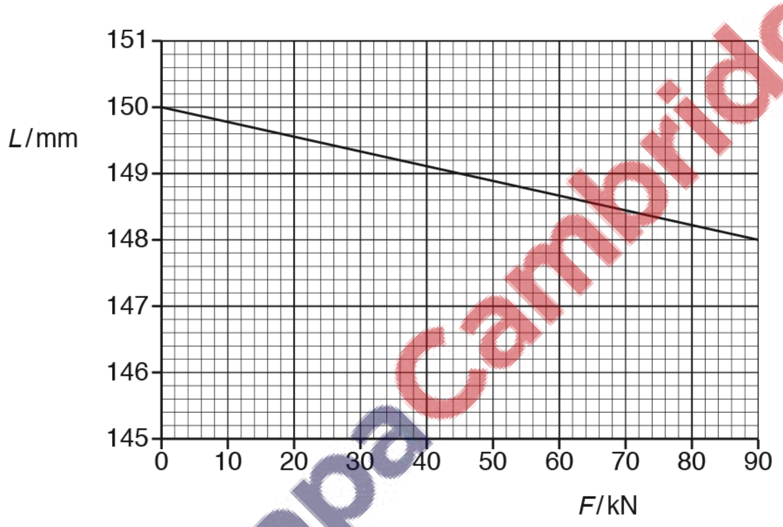


Fig. 4.2

Use Fig. 4.2 to

(i) determine the spring constant k of the rod,

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

(ii) determine the strain energy stored in the rod for $F = 90\,\text{kN}$.

strain energy = ... J [3]

(c) The rod in **(b)** has cross-sectional area A and is made of metal of Young modulus E. It is now replaced by a new rod of the same original length. The new rod has cross-sectional area $A/3$ and is made of metal of Young modulus $2E$. The compression of the new rod obeys Hooke's law.

On Fig. 4.2, sketch the variation with F of the length L for the new rod from $F = 0$ to $F = 90\,\text{kN}$. [2]

[Total: 8]

121. 9702_m17_qp_22 Q: 2

(a) State the *principle of conservation of momentum.*

....

....

....[2]

(b) Two blocks, A and B, are on a horizontal frictionless surface. The blocks are joined together by a spring, as shown in Fig. 2.1.

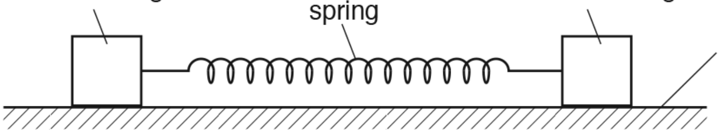


Fig. 2.1

Block A has mass 4.0 kg and block B has mass 6.0 kg.

The variation of the tension *F* with the extension *x* of the spring is shown in Fig. 2.2.

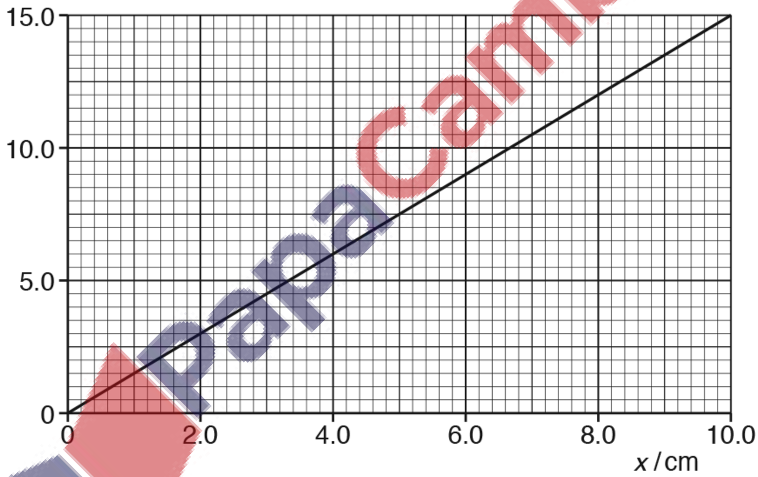


Fig. 2.2

The two blocks are held apart so that the spring has an extension of 8.0 cm.

(i) Show that the elastic potential energy of the spring at an extension of 8.0 cm is 0.48 J.

[2]

(ii) The blocks are released from rest at the same instant. When the extension of the spring becomes zero, block A has speed v_A and block B has speed v_B.

For the instant when the extension of the spring becomes zero,

1. use conservation of momentum to show that

$$\frac{\text{kinetic energy of block A}}{\text{kinetic energy of block B}} = 1.5$$

[3]

2. use the information in **(b)(i)** and **(b)(ii)1** to determine the kinetic energy of block A. It may be assumed that the spring has negligible kinetic energy and that air resistance is negligible.

kinetic energy of block A = ... J [2]

(iii) The blocks are released at time $t = 0$.

On Fig. 2.3, sketch a graph to show how the momentum of block A varies with time t until the extension of the spring becomes zero.
Numerical values of momentum and time are not required.

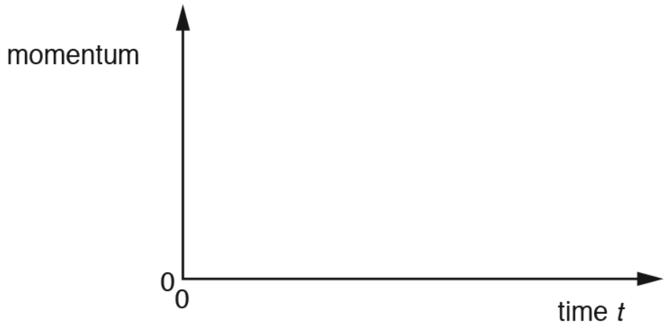


Fig. 2.3

[2]

[Total: 11]

122. 9702_s17_qp_23 Q: 4

A spring is supported so that it hangs vertically, as shown in Fig. 4.1.

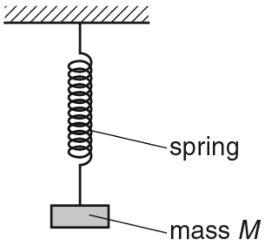


Fig. 4.1

Different masses are attached to the lower end of the spring. The extension x of the spring is measured for each mass M. The variation with x of M is shown in Fig. 4.2.

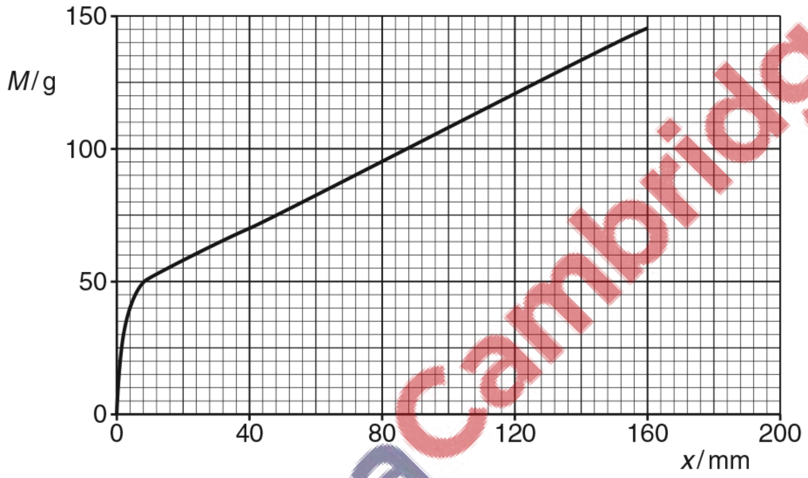


Fig. 4.2

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

....

....[1]

(b) State the form of energy stored in the spring due to the addition of the masses.

....[1]

(c) Describe how to determine whether the extension of the spring is elastic.

....

....[1]

(d) Calculate the work done on the spring as it is extended from $x = 40.0\,\text{mm}$ to $x = 160\,\text{mm}$.

work done = ... J [3]

[Total: 6]

123. 9702_m16_qp_22 Q: 3

(a) State what is meant by

(i) *work done*,

....

.... [1]

(ii) *elastic potential energy*.

....

.... [1]

(b) A block of mass 0.40 kg slides in a straight line with a constant speed of 0.30 m s^{-1} along a horizontal surface, as shown in Fig. 3.1.

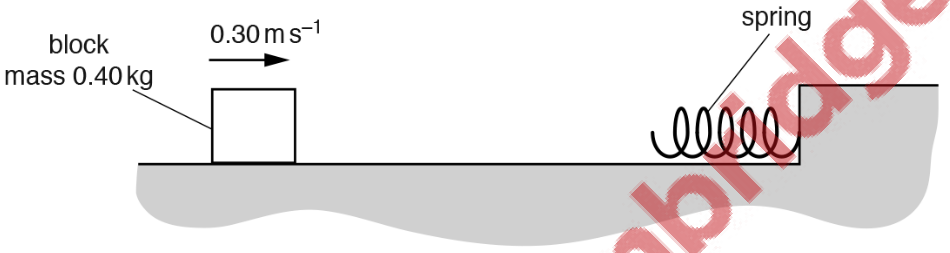


Fig. 3.1

The block hits a spring and decelerates. The speed of the block becomes zero when the spring is compressed by 8.0 cm.

(i) Calculate the initial kinetic energy of the block.

kinetic energy = ... J [2]

(ii) The variation of the compression x of the spring with the force F applied to the spring is shown in Fig. 3.2.

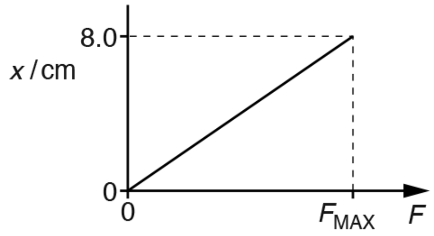


Fig. 3.2

Use your answer in **(b)(i)** to determine the maximum force F_{MAX} exerted on the spring by the block.
Explain your working.

F_{MAX} = ... N [3]

(iii) Calculate the maximum deceleration of the block.

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

(iv) State and explain whether the block is in equilibrium

1. before it hits the spring,

....

....

2. when its speed becomes zero.

....

....
[2]

(c) The energy E stored in a spring is given by

$$E = \frac{1}{2}kx^2$$

where k is the spring constant of the spring and x is its compression.

The mass m of the block in **(b)** is now varied. The initial speed of the block remains constant and the spring continues to obey Hooke's law.

On Fig. 3.3, sketch the variation of the maximum compression x_0 of the spring with mass m.

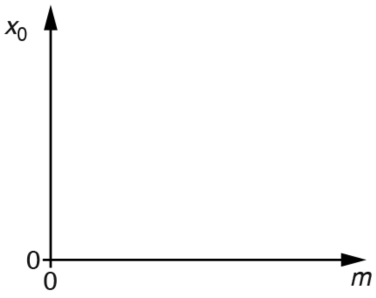


Fig. 3.3 [2]

[Total: 12]

124. 9702_s16_qp_21 Q: 4

(a) State what is meant by *elastic potential energy*.

....

....[1]

(b) A spring is extended by applying a force. The variation with extension x of the force F is shown in Fig. 4.1 for the range of values of x from 20 cm to 40 cm.

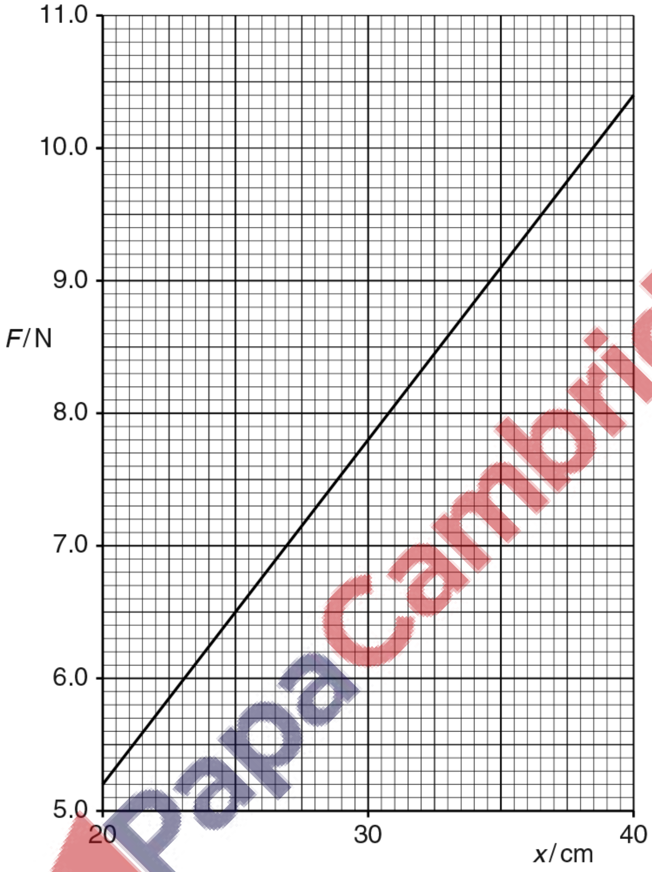


Fig. 4.1

(i) Use data from Fig. 4.1 to show that the spring obeys Hooke's law for this range of extensions.

....

....

....[2]

(ii) Use Fig. 4.1 to calculate

1. the spring constant,

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

2. the work done extending the spring from $x = 20\,cm$ to $x = 40\,cm$.

work done = ... J [3]

(c) A force is applied to the spring in **(b)** to give an extension of 50 cm.

State how you would check that the spring has not exceeded its elastic limit.

....

....[1]

[Total: 9]

125. 9702_w16_qp_21 Q: 3

(a) State Hooke's law.

....

....[1]

(b) The variation with compression x of the force F acting on a spring is shown in Fig. 3.1.

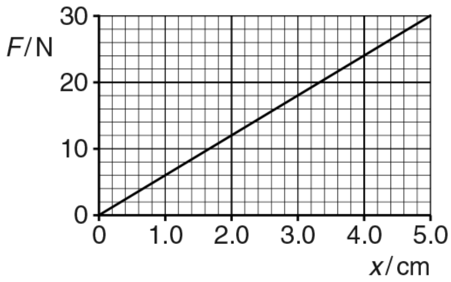


Fig. 3.1

The spring is fixed to the closed end of a horizontal tube. A block is pushed into the tube so that the spring is compressed, as shown in Fig. 3.2.

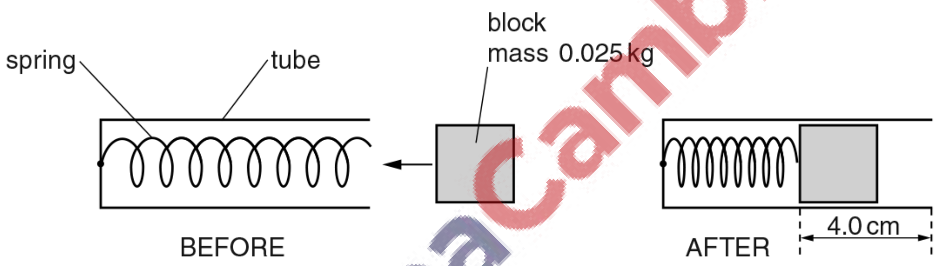


Fig. 3.2 (not to scale)

The compression of the spring is 4.0 cm. The mass of the block is 0.025 kg.

(i) Calculate the spring constant of the spring.

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

(ii) Show that the work done to compress the spring by 4.0 cm is 0.48 J.

[2]

(iii) The block is now released and accelerates along the tube as the spring returns to its original length. The block leaves the end of the tube with a speed of 6.0 m s^{-1}.

1. Calculate the kinetic energy of the block as it leaves the end of the tube.

kinetic energy = ... J [2]

2. Assume that the spring has negligible kinetic energy as the block leaves the tube. Determine the average resistive force acting against the block as it moves along the tube.

resistive force = ... N [3]

(iv) Determine the efficiency of the transfer of elastic potential energy from the spring to the kinetic energy of the block.

efficiency = ... [2]

[Total: 12]

126. 9702_w16_qp_23 Q: 3

(a) State Hooke's law.

....

....[1]

(b) The variation with compression x of the force F acting on a spring is shown in Fig. 3.1.

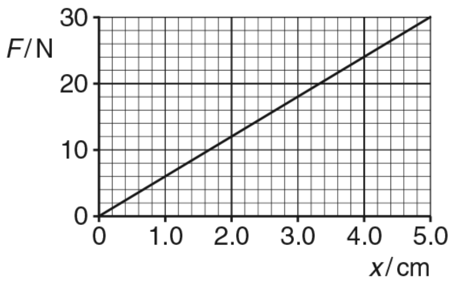


Fig. 3.1

The spring is fixed to the closed end of a horizontal tube. A block is pushed into the tube so that the spring is compressed, as shown in Fig. 3.2.

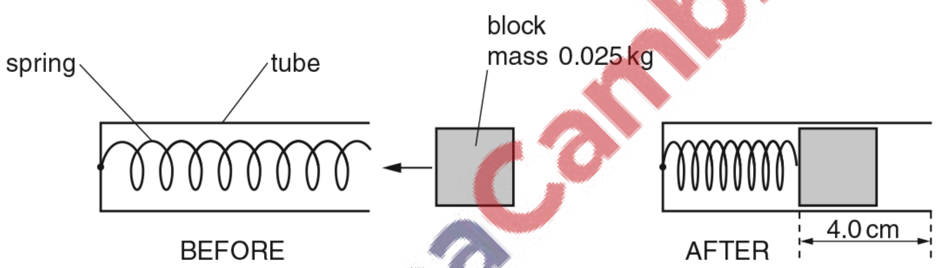


Fig. 3.2 (not to scale)

The compression of the spring is 4.0 cm. The mass of the block is 0.025 kg.

(i) Calculate the spring constant of the spring.

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

(ii) Show that the work done to compress the spring by 4.0 cm is 0.48 J.

[2]

(iii) The block is now released and accelerates along the tube as the spring returns to its original length. The block leaves the end of the tube with a speed of 6.0 m s^{-1}.

1. Calculate the kinetic energy of the block as it leaves the end of the tube.

kinetic energy = ... J [2]

2. Assume that the spring has negligible kinetic energy as the block leaves the tube. Determine the average resistive force acting against the block as it moves along the tube.

resistive force = ... N [3]

(iv) Determine the efficiency of the transfer of elastic potential energy from the spring to the kinetic energy of the block.

efficiency = ... [2]

[Total: 12]

127. 9702_s15_qp_21 Q: 4

A spring is kept horizontal by attaching it to points A and B, as shown in Fig. 4.1.

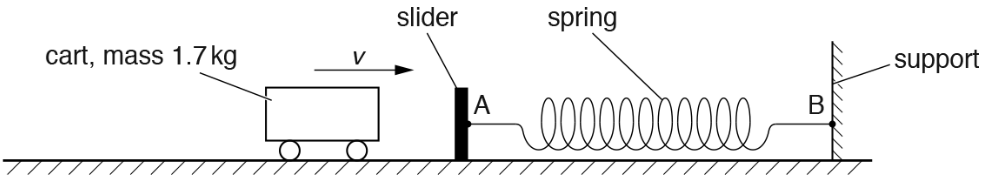


Fig. 4.1

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.

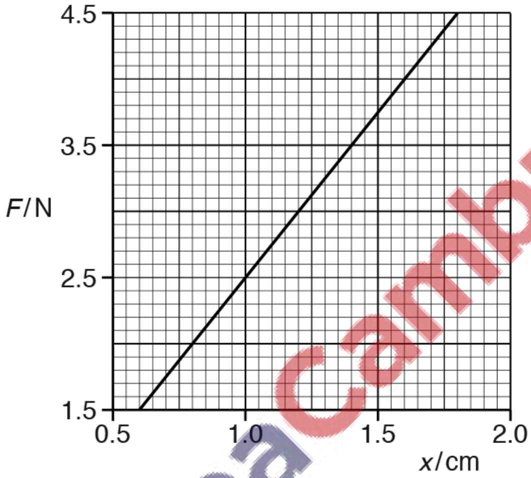


Fig. 4.2

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 E_P stored in the spring due to the cart being brought to rest.

E_P = ... J [3]

(b) Calculate the speed *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]

128. 9702_w15_qp_22 Q: 3

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.

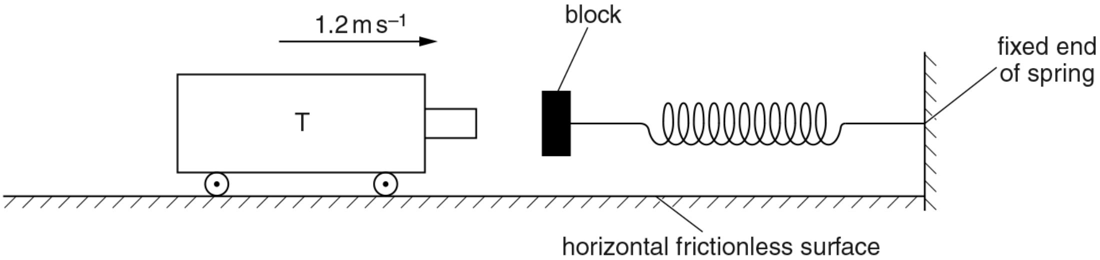


Fig. 3.1

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.

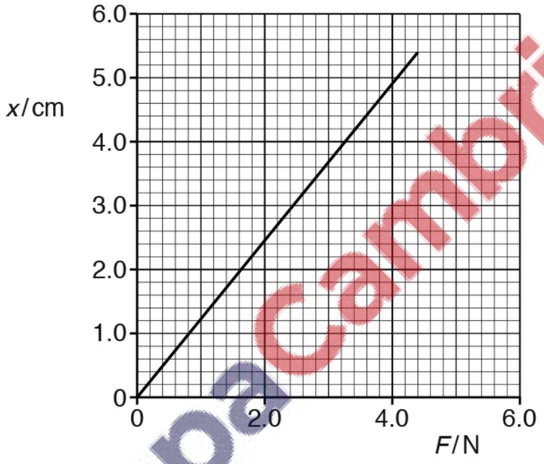


Fig. 3.2

(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 $m s^{-1}$.

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]