

3 An object is falling at terminal velocity.

Which of the following is **not** a valid conclusion from this statement?

- A The acceleration of the object is zero.
- B There is a resistive force acting on the object.
- C There is a resultant force acting on the object.
- D The object has weight.

(Total for Question 3 = 1 mark)

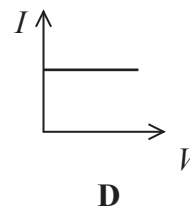
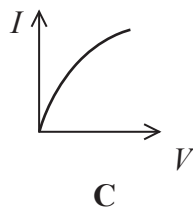
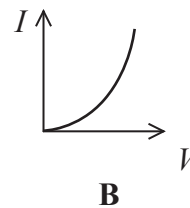
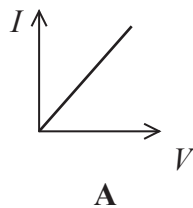
4 A light dependent resistor is connected across a cell of negligible internal resistance. The light intensity is increased.

Which of the following statements about the current is correct?

- A It decreases because there is an increase in the number of conduction electrons.
- B It increases because there is an increase in the number of conduction electrons.
- C It decreases because the amplitude of lattice vibrations decreases.
- D It increases because the amplitude of lattice vibrations increases.

(Total for Question 4 = 1 mark)

5 Which of the following graphs shows how the current varies with potential difference for a filament lamp?

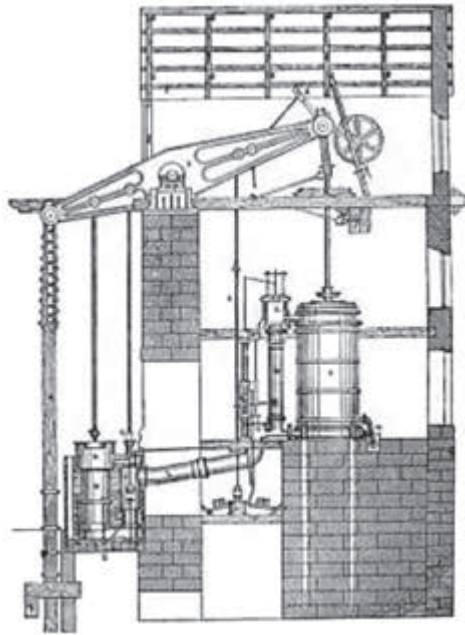


- A
- B
- C
- D

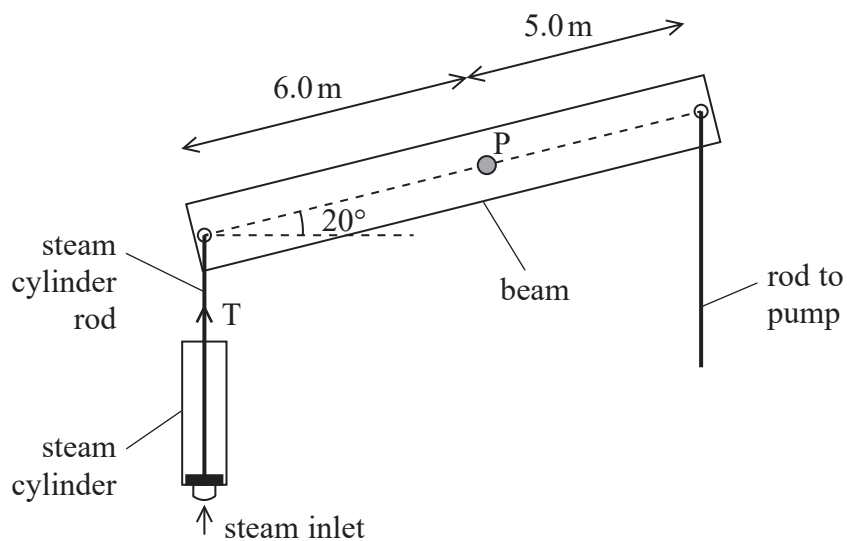
(Total for Question 5 = 1 mark)



- 13 Beam engines contributed to powering the Industrial Revolution in Britain in the 18th century. A beam engine consisted of a beam which could rock to and fro around a well-oiled pivot. Attached to the beam there are two rods, one connected to a piston in a steam cylinder and the other connected to a pump.



The diagram below shows a simplified arrangement of a beam engine.



- (a) The beam has a constant thickness and a mass of  $3.05 \times 10^4$  kg. The length of the beam is 11.0 m. The pivot P is positioned 6.0 m from the steam cylinder end of the beam.

In its resting position the steam cylinder rod is supported by the base of the steam cylinder with the beam at an angle of  $20^\circ$  to the horizontal.



The steam cylinder rod exerts a force  $T$  on the beam. The force exerted on the beam by the pump rod can be neglected.

Calculate the force  $T$ .

(4)

$T = \dots\dots\dots$

(b) The engine, which ran continuously, could lift a mass of 2500 kg of water through 12 m each minute.

The engine used 1250 kg of coal a day. 1 kg of coal can release 22.3 MJ of energy. The beam engine was said to have an efficiency of 10 %.

Deduce whether this claim for efficiency was correct.

(5)

(Total for Question 13 = 9 marks)

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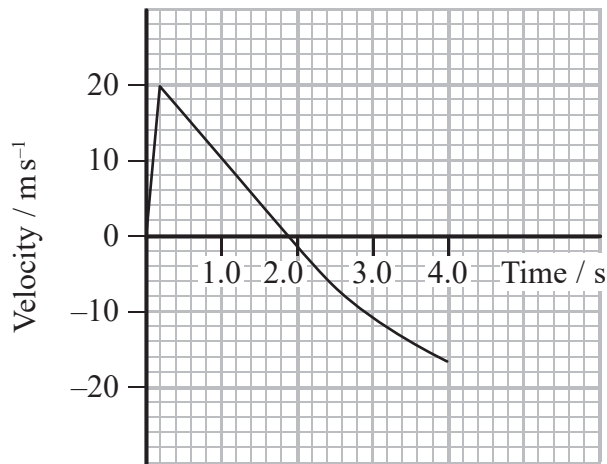
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- 14 A physics class made a toy rocket. A drinks bottle was partially filled with water and inverted over a valve. An air pump delivered air to the bottle until the pressure forced the bottle from the valve and the water was ejected from the bottle at high speed.



A velocity-time graph for the bottle for the first 4 s after take-off is shown.



- (a) Determine the height to which the rocket travelled.

(2)

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Height = .....

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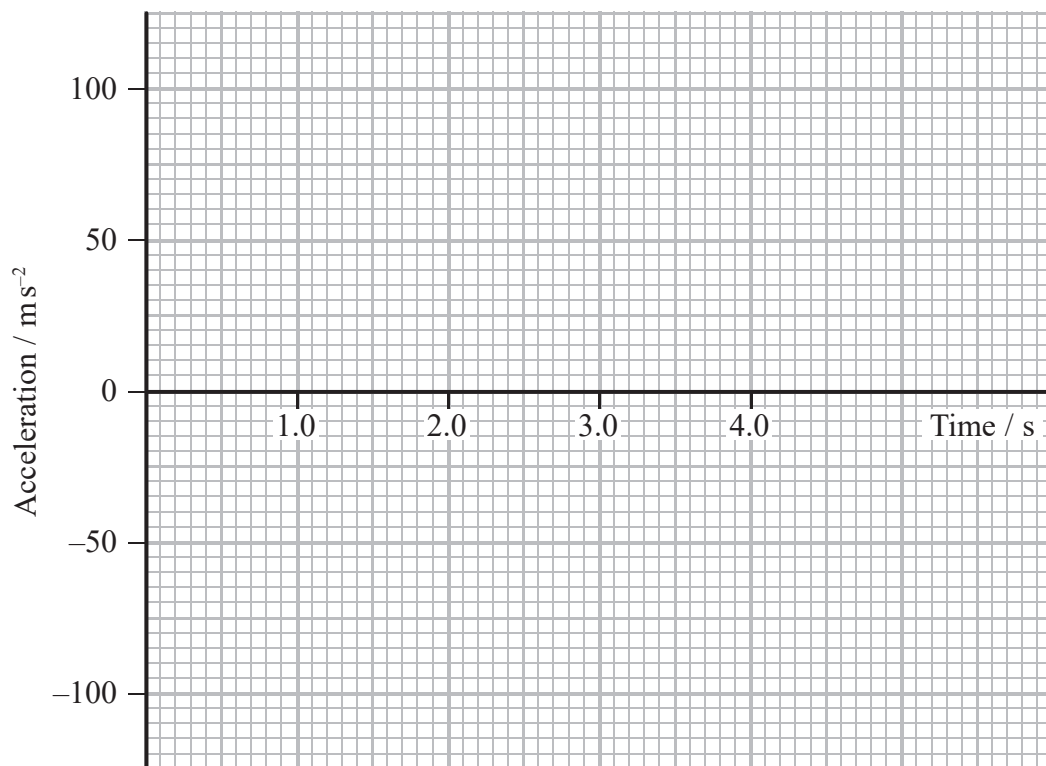
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(b) Sketch the corresponding acceleration-time graph on the axes below.

(5)



(Total for Question 14 = 7 marks)

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## Answer ALL questions.

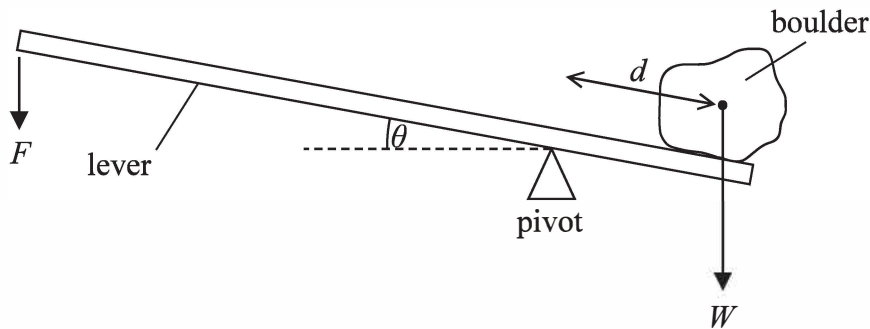
All multiple choice questions must be answered with a cross  $\boxtimes$  in the box for the correct answer from A to D. If you change your mind about an answer, put a line through the box  $\boxtimes$  and then mark your new answer with a cross  $\boxtimes$ .

1 Which of the following particles is an example of a fundamental particle?

- A nucleus
- B neutrino
- C pion
- D proton

(Total for Question 1 = 1 mark)

2 A person uses a pivoted lever to lift a boulder of weight  $W$  as shown.



The centre of gravity of the boulder is a distance  $d$  from the pivot. The angle of the lever to the horizontal is  $\theta$ .

Which expression is equal to the moment of  $W$  about the pivot?

- A  $Wd$
- B  $Wd \cos \theta$
- C  $Wd \sin \theta$
- D  $Wd \tan \theta$

(Total for Question 2 = 1 mark)



- 3 A space rocket lifts off vertically.



The rocket lifts off because

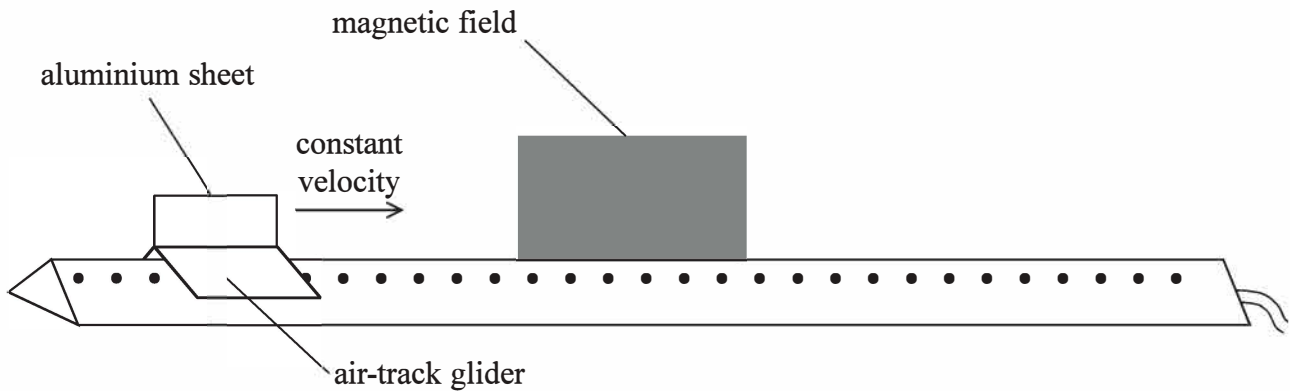
- A the exhaust gases exert a force on the ground.
- B the exhaust gases exert a force on the rocket.
- C the ground exerts a force on the rocket.
- D the rocket exerts a force on the ground.

(Total for Question 4 = 1 mark)



- 9 A rectangular sheet of aluminium is attached to an air-track glider as shown.

The glider moves towards a region of uniform magnetic field at a constant velocity. When the glider enters the magnetic field, the magnetic flux is perpendicular to the aluminium sheet.



Which row of the table describes the velocity of the glider as it enters the magnetic field, when it is completely within the magnetic field and as it leaves the magnetic field?

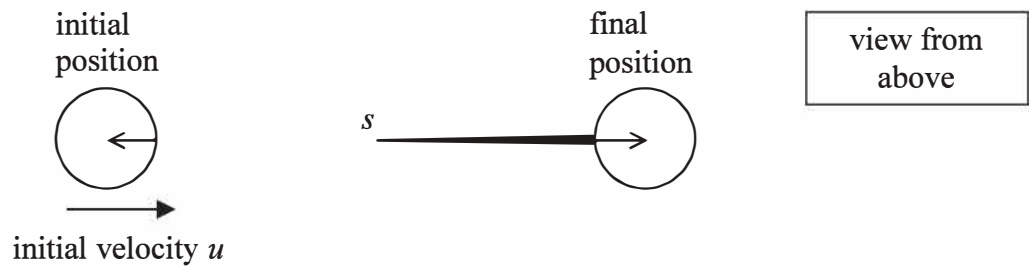
	Enters the magnetic field	Within the magnetic field	Leaves the magnetic field
<input type="checkbox"/> A	constant	decreasing	constant
<input type="checkbox"/> B	decreasing	constant	increasing
<input type="checkbox"/> C	decreasing	constant	decreasing
<input type="checkbox"/> D	decreasing	decreasing	decreasing

(Total for Question 9 = 1 mark)



14 A student carried out an experiment with coins.

- (a) She gave a 2p coin a sharp tap, so that it slid along a horizontal surface and came to rest as shown.



The student recorded the distance  $s$  moved by the coin.

She then replaced the 2p coin with a 1p coin and repeated the process.

The student read that the frictional force between an object and a surface is directly proportional to the mass of the object. She suggested that, in her experiment,  $u$  is directly proportional to  $\sqrt{s}$  and is independent of the mass of the coin.

Discuss the validity of this suggestion.

(6)

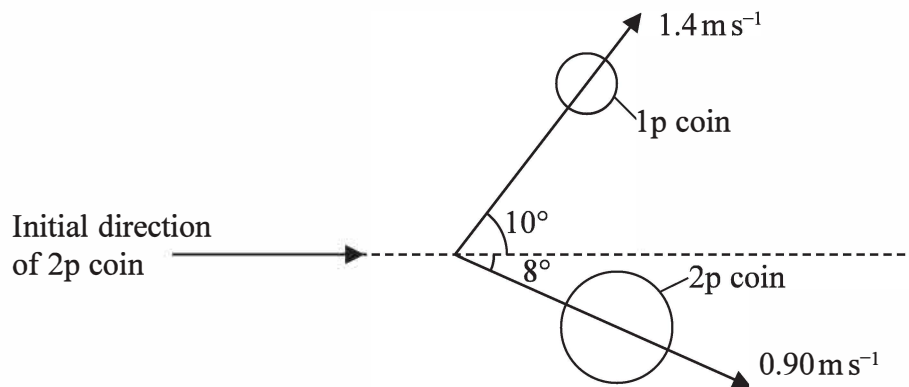
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- (b) She arranged a collision between a 2p coin and a stationary 1p coin. She noted the directions in which the coins moved after the collision and determined their velocities.



- (i) Show that the velocity of the 2p coin just before the collision was about  $2 \text{ m s}^{-1}$ .

mass of 2p coin = 7.1 g

mass of 1p coin = 3.6 g

(4)

- (ii) Show that the collision was inelastic.

(2)

(Total for Question 14 = 12 marks)



**Answer All questions.**

All multiple choice questions must be answered with a cross  in the box for the correct answer from A to D. If you change your mind about an answer, put a line through the box  and then mark your new answer with a cross .

1 Which of the following is an example of a scalar quantity?

- A displacement
- B energy
- C momentum
- D velocity

(Total for Question 1 = 1 mark)

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- 

3 The distance between a proton and an electron is  $r$ . The electrostatic force is  $F$ .

The distance between the proton and electron is doubled.

Which of the following is equal to the electrostatic force at this separation?

- A  $2F$
- B  $\frac{F}{2}$
- C  $\frac{F}{3}$
- D  $\frac{F}{4}$

(Total for Question 3 = 1 mark)

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4 Which of the following is a base SI unit?

- A ampere
- B coulomb
- C joule
- D newton

(Total for Question 4 = 1 mark)

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(Total for Question 5 = 1 mark)

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- 10 Two gliders, X and Y, are placed on an air track. The gliders are pushed towards each other as shown.



The gliders collide and continue to move after the collision.

Which row of the table could show the velocities of X and Y, in  $\text{ms}^{-1}$ , after the collision?

	X	Y
<input type="checkbox"/> A	-1.0	0.5
<input type="checkbox"/> B	-1.0	-0.5
<input type="checkbox"/> C	-2.0	-1.0
<input type="checkbox"/> D	-2.0	2.0

(Total for Question 10 = 1 mark)

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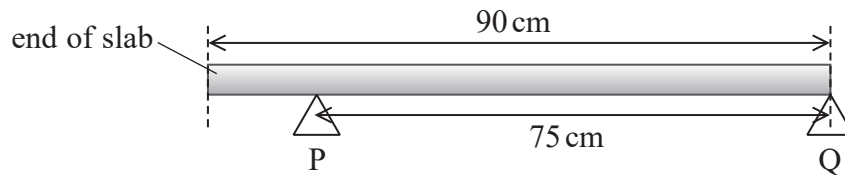


11 A uniform paving slab is to be used as a garden step.

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

(1)

(b) The paving slab has a weight of 310 N and a length of 90 cm and will be supported at two points, P and Q, as shown. The distance between P and Q will be 75 cm.



This might be unsafe because a person who places all their weight at the end of the slab might tip the slab.

A person of mass 70 kg stands at the end of the slab.

Deduce whether the slab will tip.

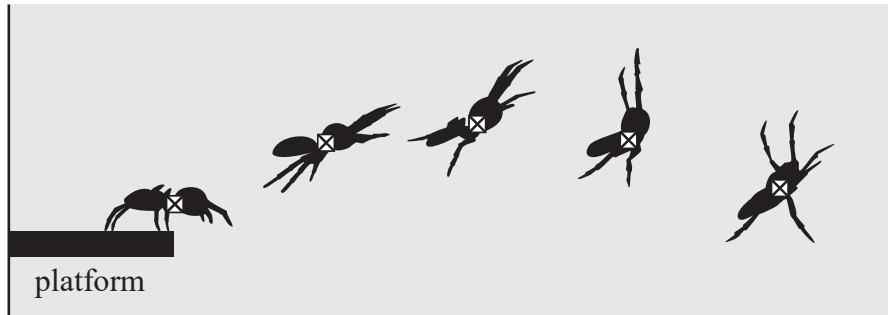
(4)

(Total for Question 11 = 5 marks)



16 Scientists have been studying a type of jumping spider that can jump up to six times its body length.

- (a) The scientists photographed a spider at 0.02s intervals, during a jump. The picture is taken from the photograph and is shown actual size.



- (i) Deduce whether the images show that the motion in the  $x$ -direction is independent of the motion in the  $y$ -direction. You should take measurements using the cross marking the centre of gravity of the spider.

(4)

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(ii) Show that the initial velocity of the spider at the start of the jump is about  $1 \text{ m s}^{-1}$ .  
You should take measurements using the cross marking the centre of gravity of the spider.

(5)

(iii) The spider achieves this jump by extending its two back legs by 3.0 mm.  
Calculate the average force the spider exerts in each leg to achieve the jump.

mass of spider = 150 mg

(3)

Average force = .....

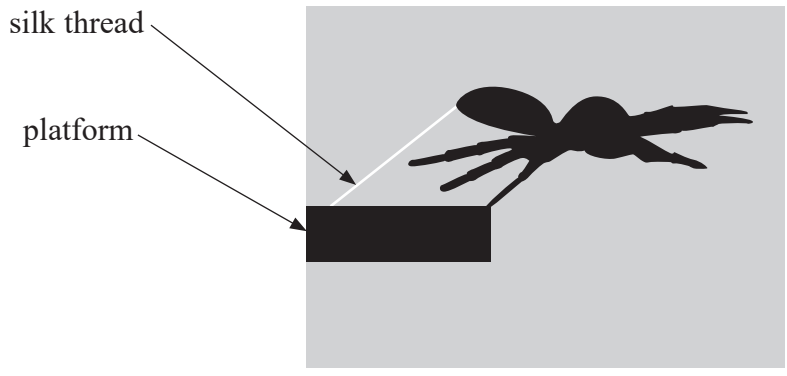
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(b) Just as the spider starts the jump, it fixes a silk thread to the platform. It is thought that the thread acts as a safety line in case the spider falls.



A student makes the comment:

‘If the silk thread can withstand a tension equal to the weight of the spider then this safety system should work.’

Deduce whether this statement is correct.

(2)

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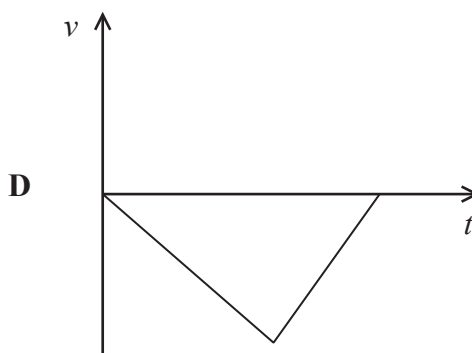
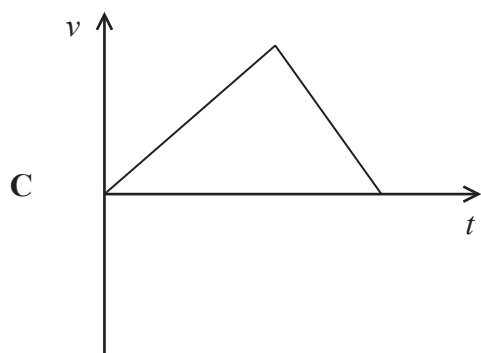
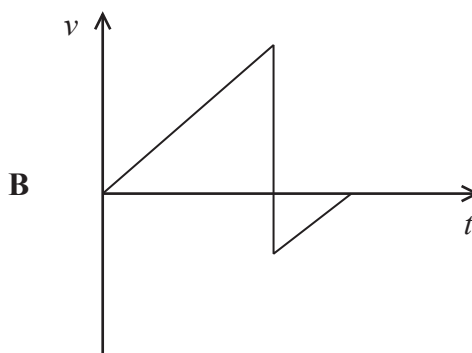
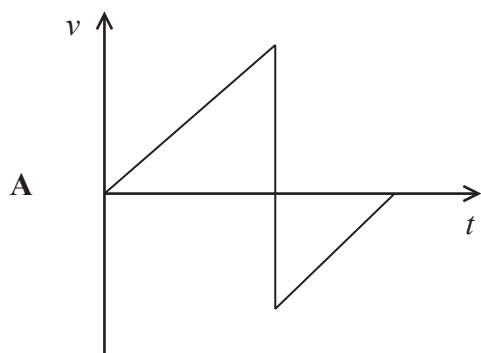
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**(Total for Question 16 = 14 marks)**



- 3 A ball was dropped from rest, from a height above the ground. The ball bounced back up to about half its initial height.

Which graph shows how the velocity  $v$  of the ball varied with time  $t$ ?

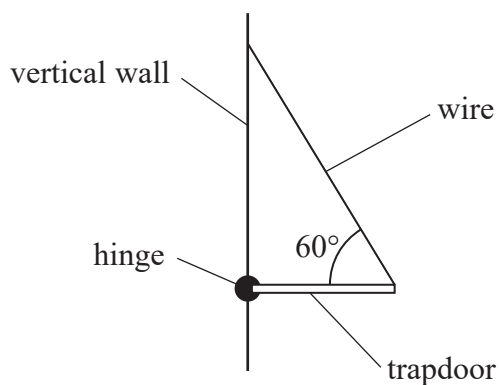


- A
- B
- C
- D

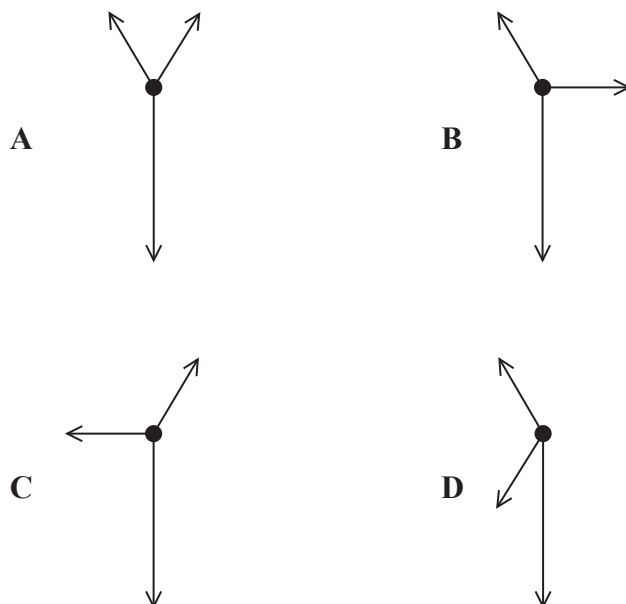
(Total for Question 3 = 1 mark)



- 6 A trapdoor is fixed to a vertical wall with a hinge. A wire is attached to the other end of the trapdoor and inclined at an angle of  $60^\circ$ , as shown. The wire holds the trapdoor horizontal.



Which of the following shows the free-body force diagram for the trapdoor?



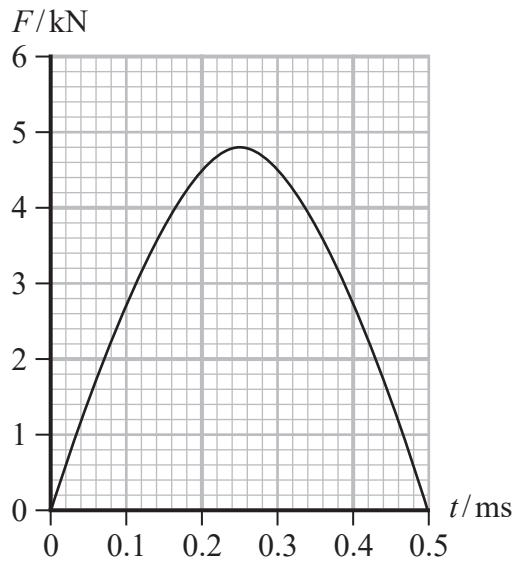
- A
- B
- C
- D

(Total for Question 6 = 1 mark)



- 12 In the game of golf a stationary ball is hit by a club. One of the aims of the game is to land the ball on a patch of ground called the green.

The graph shows how the force  $F$  exerted by the club on the ball varies with time  $t$  as the ball is hit.



- (a) State why the area under the graph represents impulse.

(1)

- (b) (i) Show that the velocity of the ball is about  $30 \text{ m s}^{-1}$  immediately after it is hit by the club.

mass of ball =  $0.046 \text{ kg}$

(3)

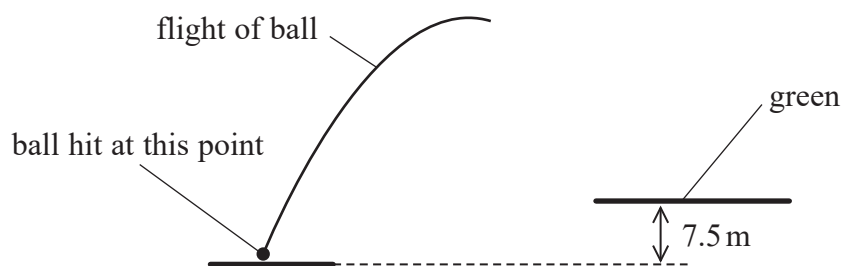
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- (ii) The ball has a time of flight of 3.5 s before landing. The green is a vertical distance of 7.5 m above the point at which the ball was hit, as shown. The green is about seventy metres away from where the ball is hit.



Deduce whether, if air resistance is ignored, the ball could land on the green after a flight time of 3.5 s.

(5)

(Total for Question 12 = 9 marks)



## Answer ALL questions.

All multiple choice questions must be answered with a cross  $\boxtimes$  for the correct answer from A to D. If you change your mind about an answer, put a line through the box  $\boxtimes$  and then mark your new answer with a cross  $\boxtimes$ .

- 1 A particle has a mass of 1 u and a charge of  $-1.6 \times 10^{-19}$  C.

Which of the following could be the particle?

- A antiproton  
 B electron  
 C neutron  
 D positron

(Total for Question 1 = 1 mark)

- 2 The velocity  $v$  of a non-relativistic particle can be expressed in terms of combinations of the following quantities: kinetic energy  $E_k$ , momentum  $p$  and mass  $m$ .

Which of the following expressions is correct?

- A  $v = \frac{p^2}{m}$   
 B  $v = \sqrt{\frac{2E_k}{m}}$   
 C  $v = \frac{E_k}{2p}$   
 D  $v = \frac{2E_k}{pm}$

(Total for Question 2 = 1 mark)

- 3 A ball is thrown with an initial horizontal component of velocity  $u$  and an initial vertical component of velocity  $v$ . The effects of air resistance are negligible.

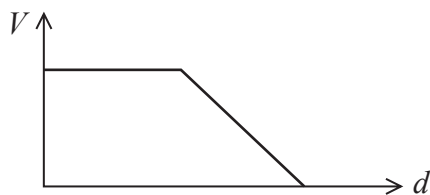
Which of the following statements about the motion of the ball is **not** correct?

- A The magnitude of the acceleration in the vertical plane is  $g$ .  
 B The horizontal component of velocity is constant.  
 C The time taken for the ball to reach its maximum height is equal to  $\frac{v}{g}$ .  
 D The maximum height of the ball depends on the values of  $u$  and  $v$ .

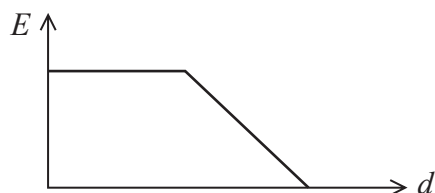
(Total for Question 3 = 1 mark)



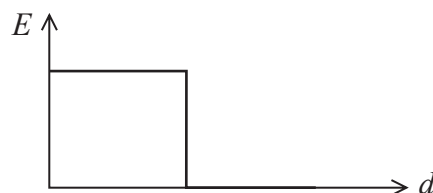
- 6 The graph shows how the potential  $V$  varies with distance  $d$  in an electric field.



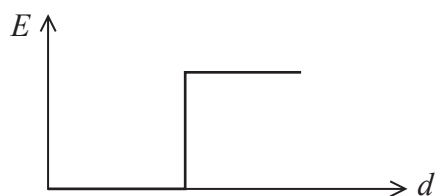
Which of the following shows the corresponding variation in electric field strength  $E$ ?



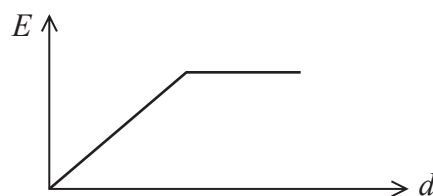
A



B



C



D

(Total for Question 6 = 1 mark)

- 7 Which of the following quantities is a vector?

- A charge
- B mass
- C momentum
- D time

(Total for Question 7 = 1 mark)



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**11** A student drives a go-kart up a slope.

- (a) The slope is at an angle of  $5.7^\circ$  to the horizontal. The go-kart moves with a constant velocity of  $2.8 \text{ m s}^{-1}$ .

Calculate the power of the go-kart.

mass of go-kart and driver =  $60 \text{ kg}$   
 resistive force on the go-kart =  $18 \text{ N}$

(4)

Power = .....

- (b) The go-kart is powered by a battery connected to a motor. The rate of thermal energy transfer by the wiring in the motor is  $55 \text{ W}$ .

Calculate the resistance of the wiring in the motor.

current in motor =  $24 \text{ A}$

(2)

Resistance of the wiring in the motor = .....

**(Total for Question 11 = 6 marks)**

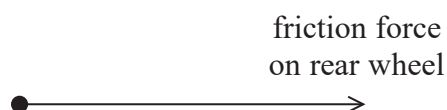


12 The photograph shows a cyclist cycling at a constant velocity on horizontal ground.



- (a) Complete the free-body force diagram to show the four forces acting on the bicycle. Treat the bicycle and cyclist as a single object. One force has been added for you.

(3)



- (b) The cyclist stops pedalling and comes to rest in a time of 5.2 s.

- (i) Sketch a graph to show how the cyclist's velocity changes during this time.

Assume the deceleration is constant.

(2)



(ii) The cyclist travels 7.80 m while coming to rest.

Calculate the average resistive force on the cyclist and bicycle.

mass of cyclist and bicycle = 28.0 kg

(4)

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Average resistive force = .....

**(Total for Question 12 = 9 marks)**

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- 6 In a boiler, energy is transferred to water at a rate of 40 kW. The corresponding power loss from the boiler to the surroundings is 4.0 kW.

Which of the following is the efficiency of this boiler?

- A 0.10
- B 0.11
- C 0.90
- D 0.91

(Total for Question 6 = 1 mark)

- 7 A car is fitted with an airbag which will inflate if the car stops very suddenly.



(Source: © KAIROS, LATIN STOCK/SCIENCE PHOTO LIBRARY)

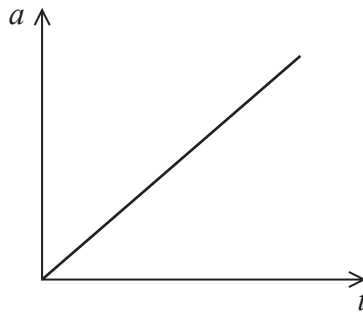
Which of the following is increased if the airbag inflates because the car suddenly stops?

- A change in momentum of the driver
- B change in velocity of the driver
- C force on the driver
- D time that the driver takes to stop

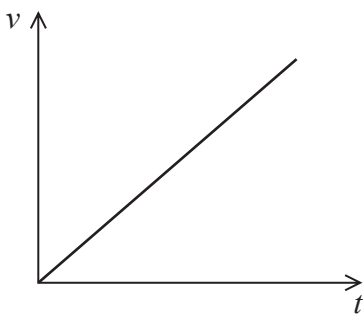
(Total for Question 7 = 1 mark)



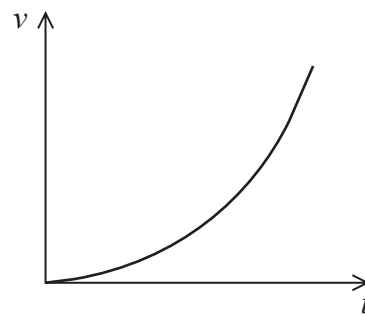
10 An object moves from rest. The graph shows how the acceleration  $a$  varies with time  $t$ .



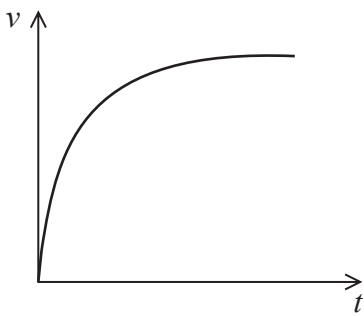
Which of the following graphs best shows how the velocity  $v$  of the object varies with  $t$  over the same time interval?



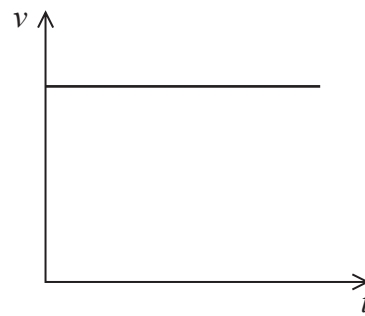
A



B



C



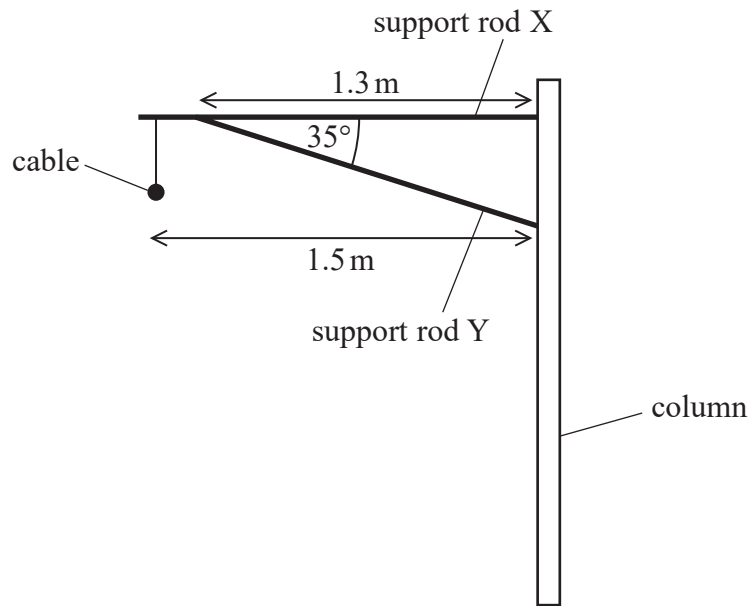
D

(Total for Question 10 = 1 mark)



14 Overhead electricity cables for railway lines are supported by structures like the one shown.

An electric cable of mass 45 kg is suspended from a support rod X. A second support rod Y is attached to X. X and Y are attached at one end to a column.



The masses of support rods X and Y are negligible.

(a) (i) Determine, by taking moments, the force exerted on rod X by rod Y.

(4)

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Force = .....

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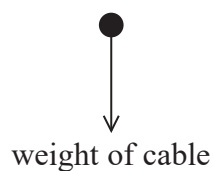
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(ii) Complete the free-body force diagram for support rod X.

(2)



(b) A website gives a value of the electric field strength  $E$ , at two distances from the electric cable.

Distance / m	$E / \text{NC}^{-1}$
3	1200
25	100

Deduce whether these data are consistent with an inverse square law.

(3)

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(Total for Question 14 = 9 marks)

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(b) The ball was bowled. Just after the bat hit the ball, the ball had a velocity of  $23.8 \text{ ms}^{-1}$  at an angle of  $50^\circ$  to the horizontal.

(i) Show that the magnitude of the momentum of the ball, after it was hit, was about  $3.3 \text{ N s}$ .

mass of cricket ball =  $0.140 \text{ kg}$

(1)

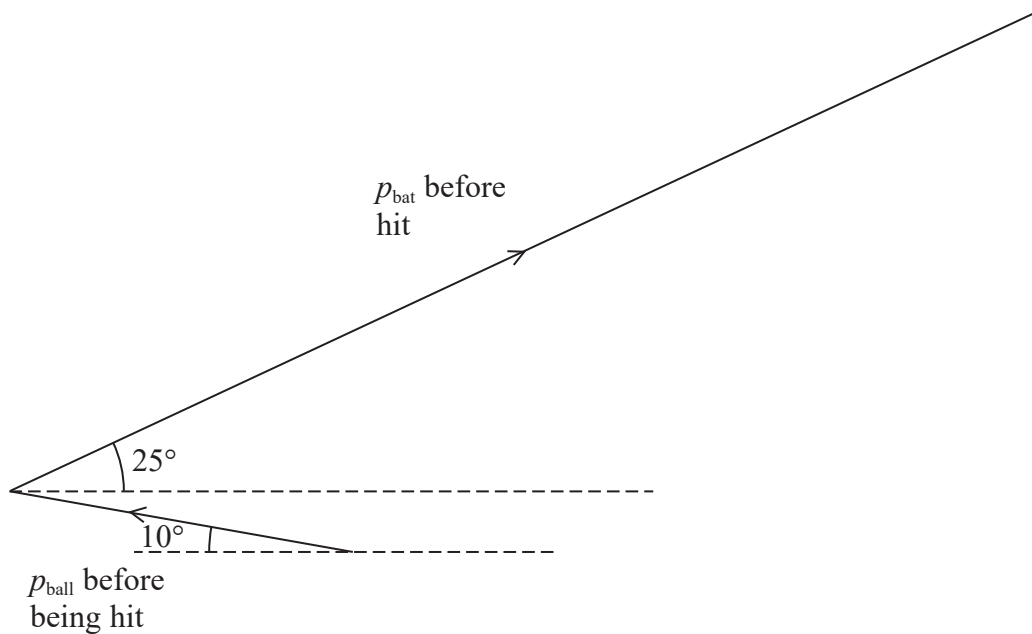
(ii) The vector diagram below shows, accurately to scale, the momentum of the ball and the momentum of the bat before the hit.

Determine, by completing the vector diagram, the momentum of the bat after it hit the ball.

momentum of bat before hitting ball =  $15.0 \text{ N s}$  at  $25^\circ$  to the horizontal

momentum of ball before hitting bat =  $4.6 \text{ N s}$  at  $10^\circ$  to the horizontal

(5)



Momentum of bat after hitting ball = .....

at an angle of ..... to the horizontal

(Total for Question 17 = 11 marks)

