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EDEXCEL GCSE PHYSICS: QUESTIONS BY TOPIC

Motion and Forces (2)

GCSE Physics (Higher) Topic 2

18 questions · 184 marks · Mark schemes included

Pearson Edexcel GCSE (9-1) Physics 1PH0, Higher Tier, June 2018 - June 2025

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HOW TO USE THIS BOOKLET

Questions run from the lowest mark tariff to the highest, so similar questions sit together.

Click any row below to jump straight to that question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

18 questions · 184 marks · lowest tariff first



7-MARK QUESTIONS

1 question in this booklet



- 3 (a) Figure 5 is a speed limit sign from a European motorway.

The speeds shown are in km/h (kilometres per hour).

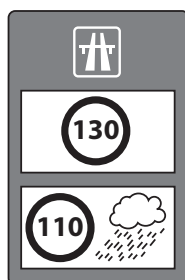


Figure 5

- (i) The sign tells drivers to drive at a slower speed in wet weather.

Explain why it is safer for drivers to drive at a slower speed in wet weather.

(2)

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- (ii) Show that a speed of 31 m/s is less than a speed of 130 km/h.

(2)



(iii)

The driver's reaction time is the time between the driver seeing an emergency and starting to brake.

A car is travelling at a speed of 31 m/s.

The car travels 46 m between the driver seeing an emergency and starting to brake.

Calculate the driver's reaction time.

Give your answer to 2 significant figures.

(3)

driver's reaction time s

(Total for Question 3 = 7 marks)



9-MARK QUESTIONS

6 questions in this booklet



3 (a) Which of these is a vector?

(1)

- ☐ A energy
- ☐ B force
- ☐ C mass
- ☐ D work

(b) (i) State the equation that relates acceleration to change in velocity and time taken.

(1)

(ii) A van accelerates from a velocity of 2 m/s to a velocity of 20 m/s in 12 s.
Calculate the acceleration of the van.

(2)

acceleration = ... m/s²



(c) Figure 3 is a velocity / time graph for 15 s of a cyclist's journey.

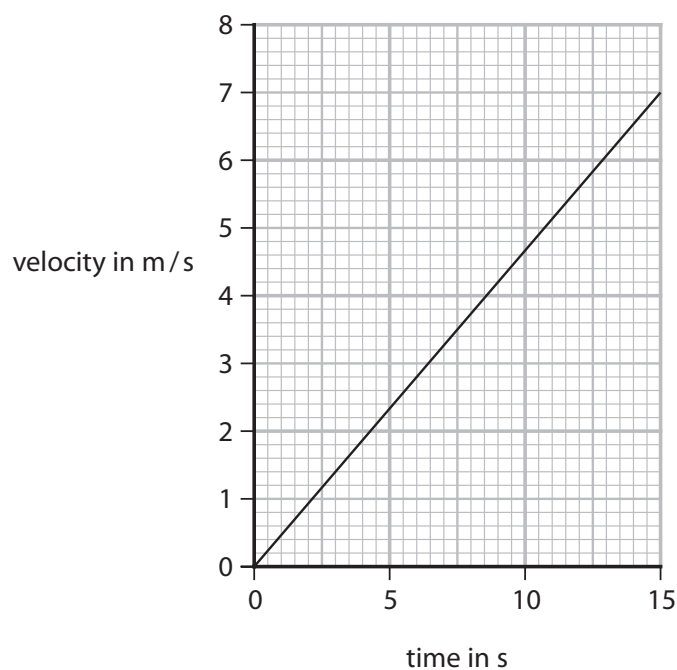


Figure 3

(i) Calculate the distance the cyclist travels in the 15 s.

(3)

distance = ... m

(ii) Another cyclist starts from rest, but his acceleration decreases as time increases.

Sketch the velocity / time graph for this cyclist on Figure 3.

(2)

(Total for Question 3 = 9 marks)



- 5 (a) (i) An aircraft starts from rest and accelerates along the runway for 36 s to reach take-off velocity.

Take-off velocity for this aircraft is 82 m/s.

Show that the acceleration of the aircraft along the runway is about 2 m/s².

Assume the acceleration is constant.

(2)

- (ii) Calculate the distance the aircraft travels along the runway before take-off.

Use the equation

$$v^2 - u^2 = 2ax$$

(3)

distance = ... m



- (iii) Suggest **one** reason why the length of the runway used is always much longer than the calculated distance that the aircraft travels along the runway before take-off.

(1)

- (b) (i) The aircraft lands with a velocity of 71 m/s.

The mass of the aircraft is 3.6×10^5 kg.

Calculate the kinetic energy of the aircraft as it lands.

(2)

kinetic energy of aircraft = ... J

- (ii) When the aircraft has come to a stop, all the kinetic energy has been transferred to the surroundings.

Give **one** way that the energy has been transferred to the surroundings.

(1)

(Total for Question 5 = 9 marks)



2 (a) Which of these is a scalar quantity?

(1)

- ☐ A acceleration
- ☐ B distance
- ☐ C force
- ☐ D weight

(b) A student has some cupcake cases.

One cupcake case is shown in Figure 2.



(Source: © Anton Starikov/Shutterstock)

Figure 2

The student drops a stack of cupcake cases with the base facing downwards, as shown in Figure 3.



(Source: © Elena Schweitzer/Shutterstock)

Figure 3

The speed of the falling stack of cupcake cases depends on the number of cupcake cases in the stack.

- (i) The student also has a stop clock and a metre rule.

Describe an investigation to show how the speed of the falling stack of cupcake cases depends on the number of cupcake cases in the stack.

(4)

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- (ii) A stack of cupcake cases has a mass of 0.005 kg.

Calculate the weight, in newtons, of the stack of cupcake cases.

Gravitational field strength = 10 N/kg

(2)

Use the equation

$$W = mg$$

weight = ... N



Figure 4 shows a cupcake case that is falling at a constant velocity.

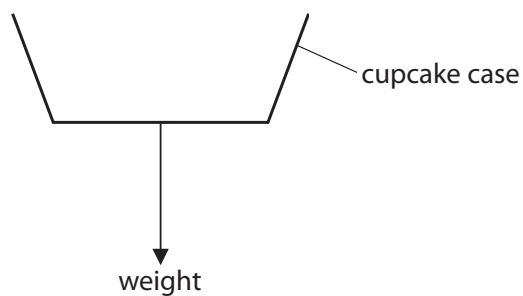


Figure 4

(iii) Draw an arrow on Figure 4 to show the force due to air resistance on the cupcake case.

(1)

(iv) State the value of the acceleration of the cupcake case when it is falling at a constant velocity.

(1)

(Total for Question 2 = 9 marks)

5 Figure 8 is a velocity/time graph for a lift moving upwards in a tall building.

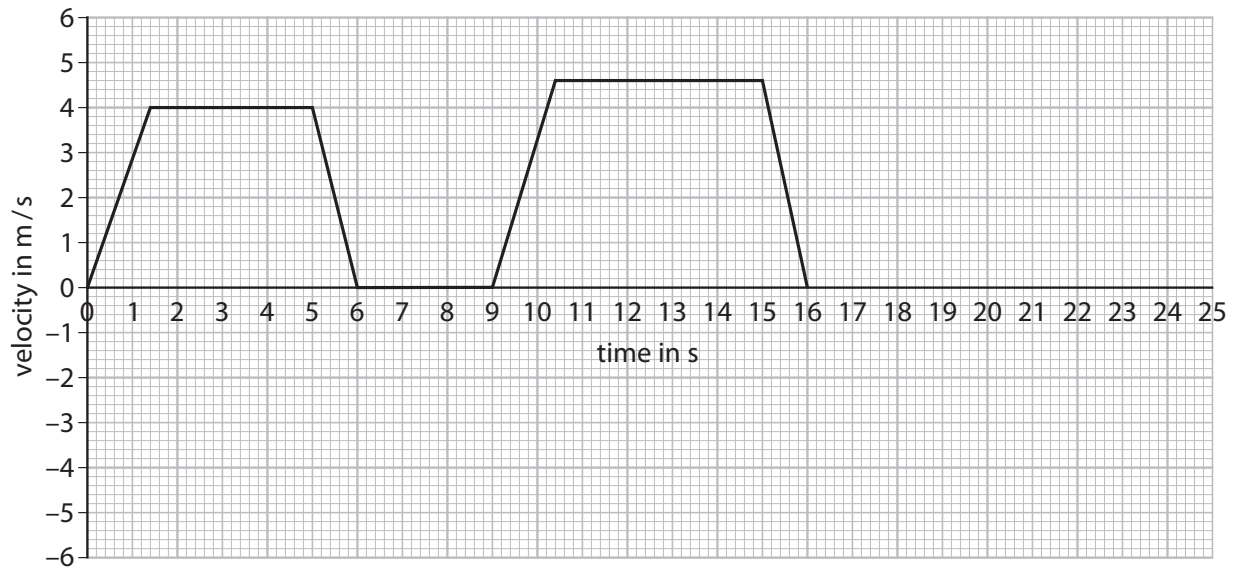


Figure 8

(a) For what length of time is the lift at rest during the first 16 s?

(1)

- ☒ A 1.4 s
- ☒ B 3.0 s
- ☒ C 3.6 s
- ☒ D 4.0 s

(b) Use the graph in Figure 8 to determine the maximum velocity of the lift during the first 16 s.

(1)

maximum velocity = ... m/s

(c) Use the graph in Figure 8 to determine the acceleration of the lift during the first 1.4 s.

(3)

acceleration = ... m/s²

- (d) Use the graph in Figure 8 to determine the distance that the lift travelled during the first 6.0 s.

(3)

distance = ... m

- (e) At 18 s, the lift starts to move downwards.

Sketch a line on the graph in Figure 8 to show the lift moving downwards after 18 s.

(1)

(Total for Question 5 = 9 marks)



- 3 (a) Two people, L and M, have a 100 m race.

L starts running before M.

Figure 4 shows a distance/time graph of the race.

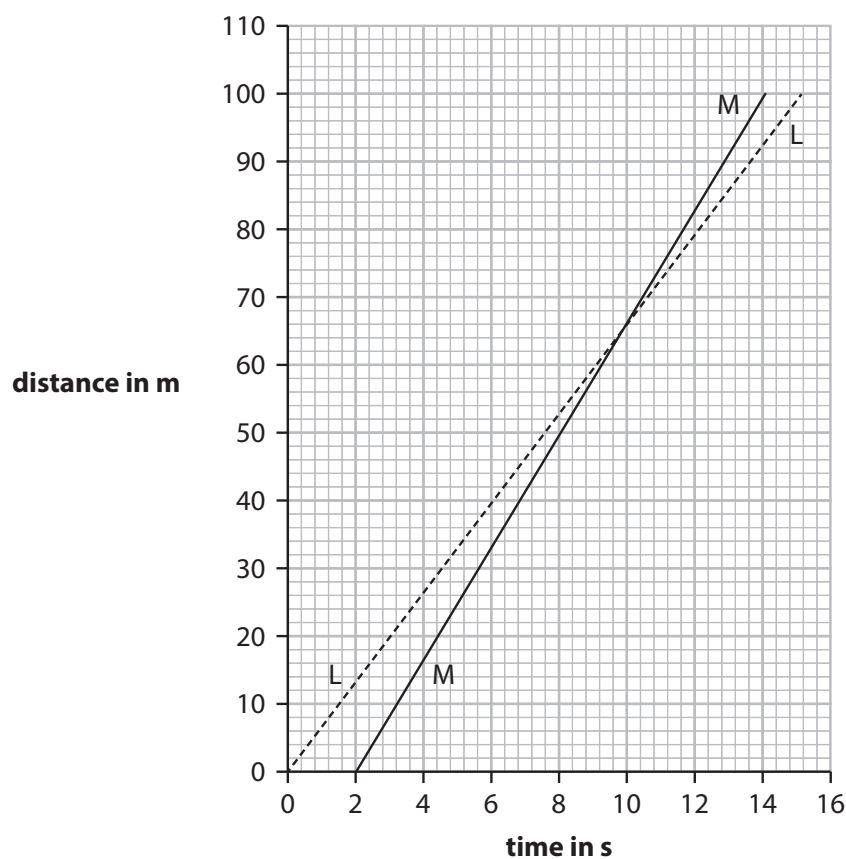


Figure 4

- (i) State the **distance** that L has run when M overtakes.

(1)

distance = ... m

- (ii) Calculate the velocity of L when running the 100 m race.

(2)

velocity = ... m/s



(b) A motorcycle is travelling at a velocity of 6.2 m/s.

The motorcycle accelerates at 2.5 m/s^2 until its velocity is 10 m/s.

(i) Calculate the time taken for this acceleration.

Use the equation

$$\text{time taken} = \frac{\text{change in velocity}}{\text{acceleration}} \quad (2)$$

time taken = ... s

(ii) The motor cycle now decelerates (slows down) from 10 m/s to a stop.

The deceleration is at a constant rate of 4.4 m/s^2 .

Calculate the distance the motorcycle travels as it slows down to a stop.

Use the equation

$$v^2 - u^2 = 2 \times a \times x \quad (2)$$

distance = ... m



(c) A car collides with a barrier on a road.

The time of the collision is very short.

Explain **one** factor, other than the time of the collision, that would affect the force on the car in the collision.

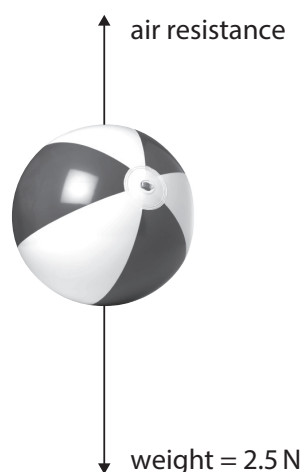
Your explanation should refer to an equation in the Equation Booklet.

(2)

(Total for Question 3 = 9 marks)



- 2 (a) Figure 2 shows the two forces acting on a beach ball as it falls through the air.



(Source: © Stepan Bormotov/Shutterstock)

Figure 2

The resultant of these two forces is 0.92 N downwards.

- (i) The mass of the beach ball is 0.25 kg.

Calculate the acceleration of the beach ball as it falls.

Use the equation

$$F = m \times a$$

(3)

acceleration = ... m/s²

- (ii) Calculate the size of the air resistance force on the beach ball.

(1)

air resistance = ... N



(b) Some students are investigating forces.

They use a newton meter to keep a trolley stationary on a sloping runway, as shown in Figure 3.

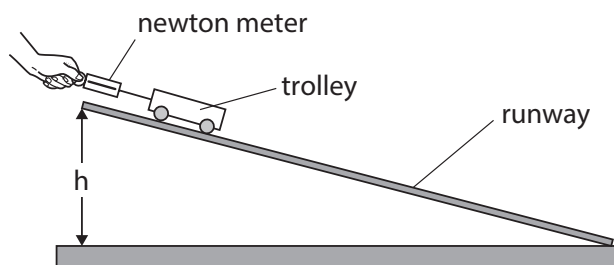


Figure 3

They measure the force needed to keep the trolley stationary on the sloping runway.

(i) They do this at four different places on the runway.

When the height, h , of the runway is 0.60 m, their four readings for force are

2.1 N 2.7 N 2.5 N 2.2 N

Calculate the mean value of these forces.

(1)

mean force = ... N

The students then measure values of the force, F , for several different values of h , the height of the runway.

Figure 4 is a graph of F against h .

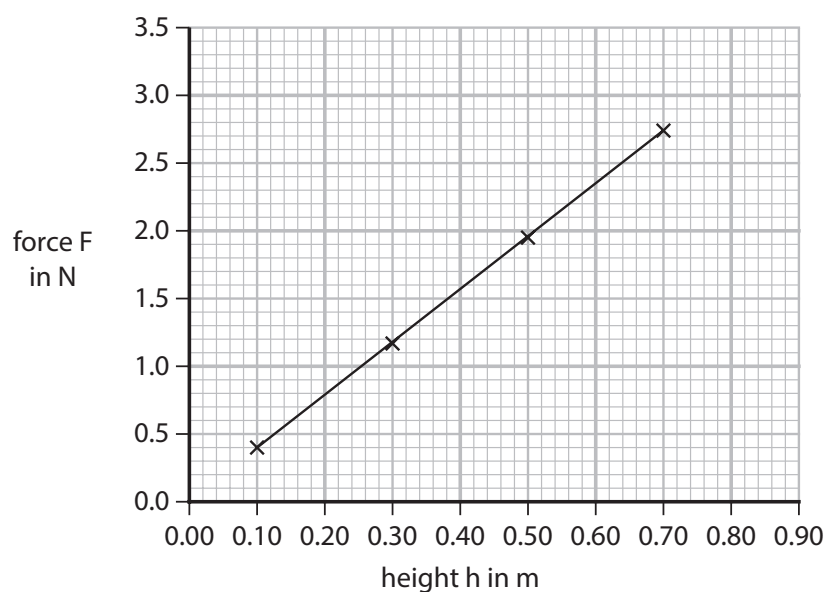


Figure 4

(ii) Use the graph in Figure 4 to determine the value of F when $h = 0.80$ m.

(2)

$F = \dots\dots\dots$ N

(iii) Determine the gradient of the graph in Figure 4.

(2)

gradient = $\dots\dots\dots$ N/m

(Total for Question 2 = 9 marks)

10-MARK QUESTIONS

3 questions in this booklet



- 6 (a) The symbol ' g ' can be used to refer to the acceleration due to gravity.

The acceleration due to gravity ' g ' has the unit of m/s^2 .

' g ' can also have another unit.

Which of these is also a unit for g ?

(1)

- ☐ A J/kg
☐ B J/kg^2
☐ C N/kg
☐ D N/kg^2

- (b) Two students try to determine a value for g , the acceleration due to gravity.

- (i) They measure the time, t , for a small steel ball to fall through a height, h , from rest.

They measure t to be 0.74 s , using a stopwatch.

They measure h to be 2.50 m , using a metre rule.

Calculate a value for g from the students' measurements.

Use the equation

$$g = \frac{2h}{t^2}$$

(2)

$g = \dots\dots\dots \text{m/s}^2$

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- (ii) They record the time t for two more drops from the same height.

The three values for time t are

0.74 s, 0.69 s, 0.81 s.

Calculate the average value of time t to an appropriate number of significant figures.
(2)

average value of time t = ... s

- (c) Explain **one** way the students could improve their procedure to obtain a more accurate value for g .
(2)

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- (d) A car travelling at 15 m/s comes to rest in a distance of 14 m when the brakes are applied.

Calculate the deceleration of the car.

Use an equation selected from the list of equations at the end of this paper.
(3)

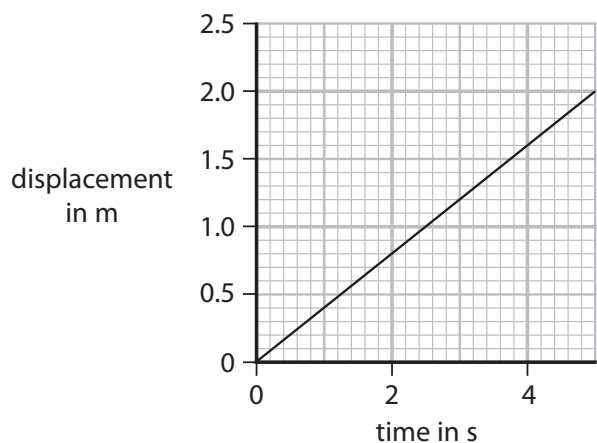
deceleration = ... m/s²

(Total for Question 6 = 10 marks)

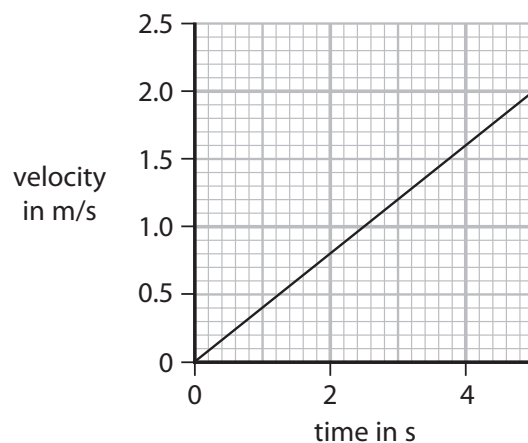


- 6 (a) Which of these graphs represents an object moving with a constant velocity of 2 m/s? (1)

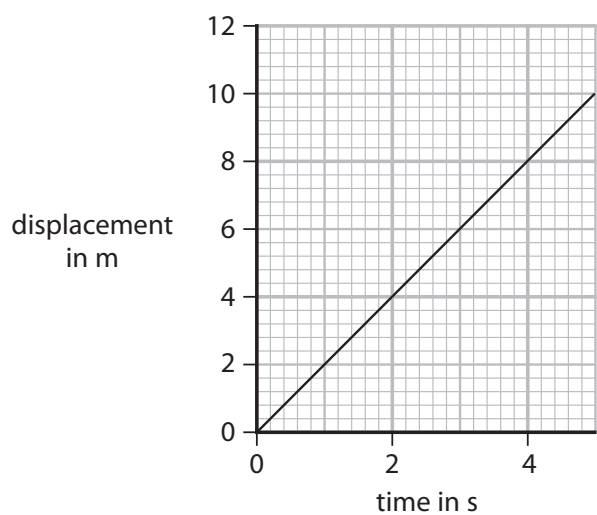
☒ A



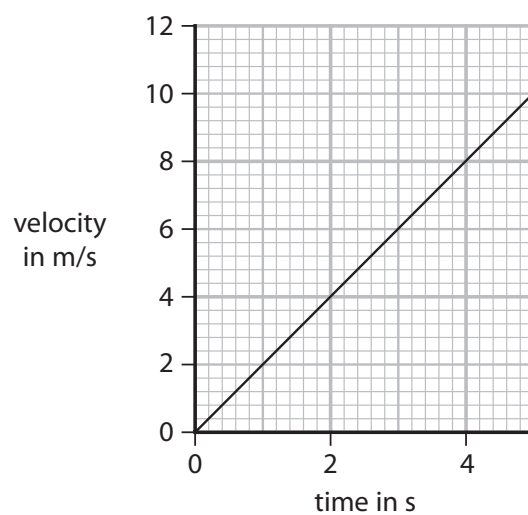
☒ B



☒ C



☒ D



(b) Figure 8 is a velocity/time graph showing a 34 s part of a train's journey.

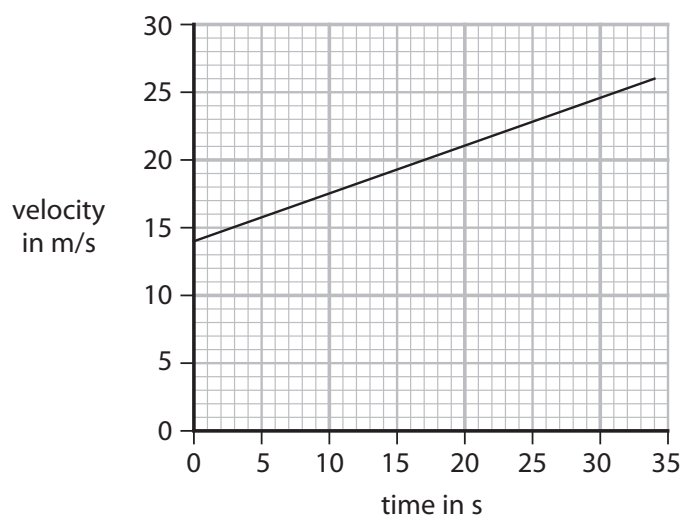


Figure 8

(i) Calculate the acceleration of the train in the 34 s.

Give your answer to an appropriate number of significant figures.

(3)

acceleration = ... m/s^2

(ii) Calculate the distance the train travels in the 34 s.

(3)

distance m



(c) Figure 9 shows a rocket soon after it takes off from the ground.



(Source: © Alones/Shutterstock)

Figure 9

The force that the rocket engines produce remains constant during the first few seconds after take-off.

Explain what happens to the acceleration during the first few seconds.

(3)

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(Total for Question 6 = 10 marks)

- 6 (a) Figure 10 shows a skier sliding down a slope.

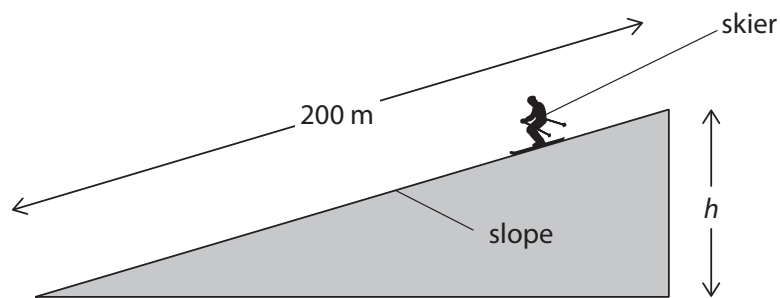


Figure 10

- (i) The gravitational potential energy of the skier decreases by 39 000 J between the top and the bottom of the slope.

The mass of the skier is 70 kg.

Calculate the height, h of the slope.

The value of g is 10 N/kg.

Use the equation

$$\Delta GPE = m \times g \times h$$

(2)

$$h = \dots\dots\dots \text{ m}$$

- (ii) The skier starts from rest at the top of the slope.

The velocity of the skier at the bottom of the slope is 27 m/s.

Using information from Figure 10, calculate the acceleration of the skier along the slope.

(3)

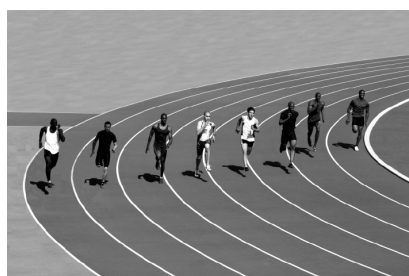
$$\text{acceleration} = \dots\dots\dots \text{ m/s}^2$$

- (iii) When the skier slides from the top to the bottom of the slope, some energy is dissipated.

Explain how to determine the amount of energy dissipated.

(2)

- (b) Figure 11 shows athletes running at a constant speed on a curved section of a track.



(Source: © Photo and Co/Getty Images)

Figure 11

- (i) Even though they are running at a constant speed, the velocity of each athlete is changing.

State why the velocity of each athlete is changing.

(1)

(ii) The athletes start the race on a straight section of track.

Figure 12 shows a distance / time graph for one of the athletes.

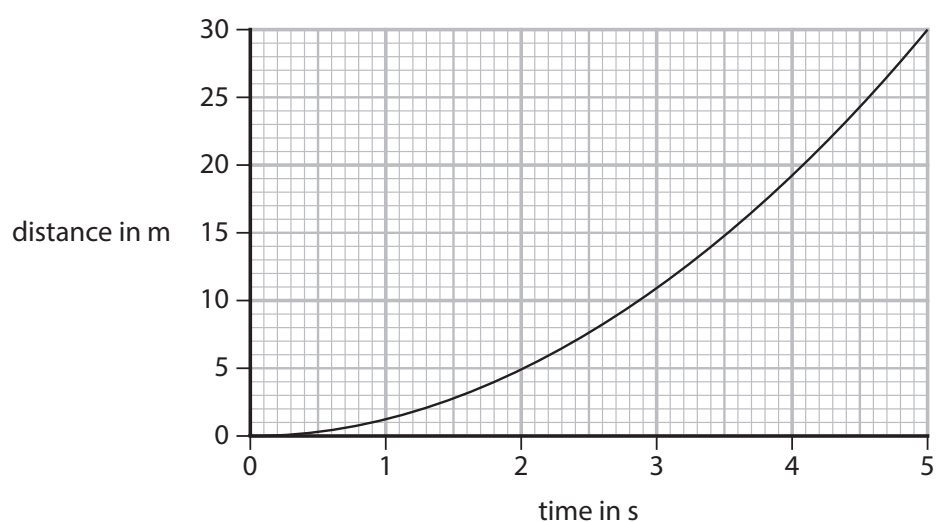


Figure 12

Determine the gradient of this graph at a time of 2.5 s.

(2)

gradient = ... m/s

(Total for Question 6 = 10 marks)



11-MARK QUESTIONS

4 questions in this booklet



7 (a) Which of these is a unit of momentum?

(1)

- ☐ A kg m/s
- ☐ B kg/m/s
- ☐ C kg m/s^2
- ☐ D kg/m/s^2

(b) Students investigate conservation of momentum using two identical trolleys.

A card is then added to trolley A.

Some of the apparatus is set up as shown in Figure 8.

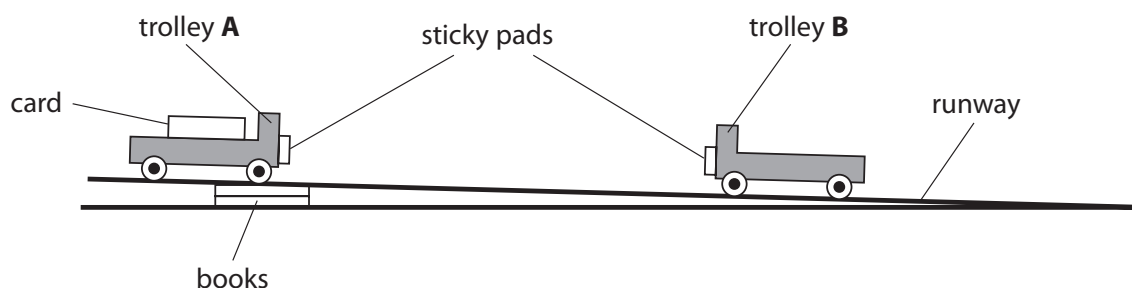


Figure 8

(i) Describe an investigation the students could carry out to show that momentum is conserved when these two trolleys collide.

You may add to the diagram to help with your answer.

(4)

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(ii) Give a reason for the runway being at a slope.

(1)

(c) Figure 9 shows a racket and a tennis ball.

The tennis ball is travelling towards the racket at a velocity of 8.2 m/s.

The ball is hit back in the opposite direction at a velocity of 15 m/s.

The ball has a mass of 0.075 kg.

The ball is in contact with the racket for 12 ms.

(i) Calculate the average force exerted by the ball on the racket.

Use the equation

$$F = \frac{mv - mu}{t}$$

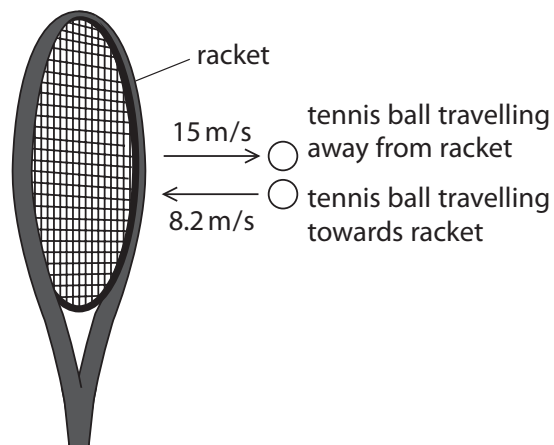


Figure 9

(3)

force = ... N

(ii) Describe how Newton’s Third Law of Motion applies to the collision between the racket and the ball.

(2)

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(Total for Question 7 = 11 marks)



- 7 (a) A car starts from rest and then travels for 70 s as shown on the graph in Figure 11.

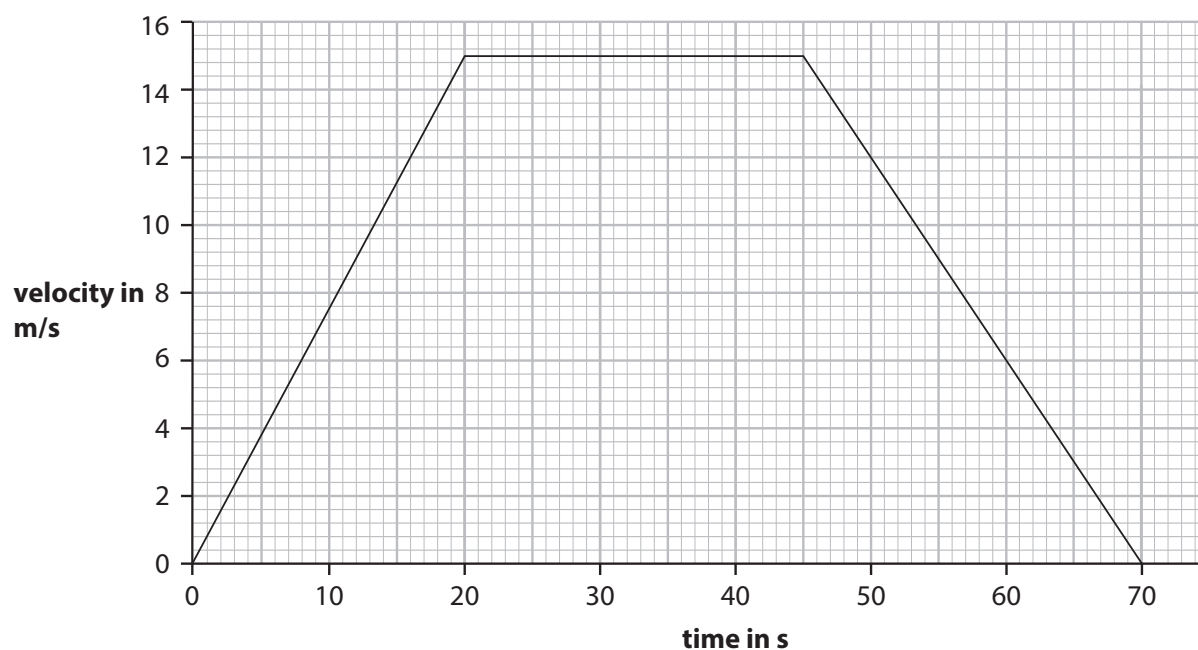


Figure 11

- (i) Complete the sentence using data from Figure 11.

(1)

The car is travelling at constant velocity from s
to s.

- (ii) Use data from the graph in Figure 11 to show that the car travels a total distance of about 710 m in 70 s.

(3)

- (iii) Calculate the average speed of the car for the total distance travelled.

(1)

average speed = ... m/s

- (b) The **inertial** mass of an object is a measure of how difficult it is to change the velocity of the object.

A force of 450 N acts on a car to give the car an acceleration of 0.35 m/s^2 .

Calculate the **inertial** mass of the car.

(2)

inertial mass of car kg



(c) Figure 12 shows a different velocity/time graph.

This straight line graph can be represented by the equation

$$y = mx + c$$

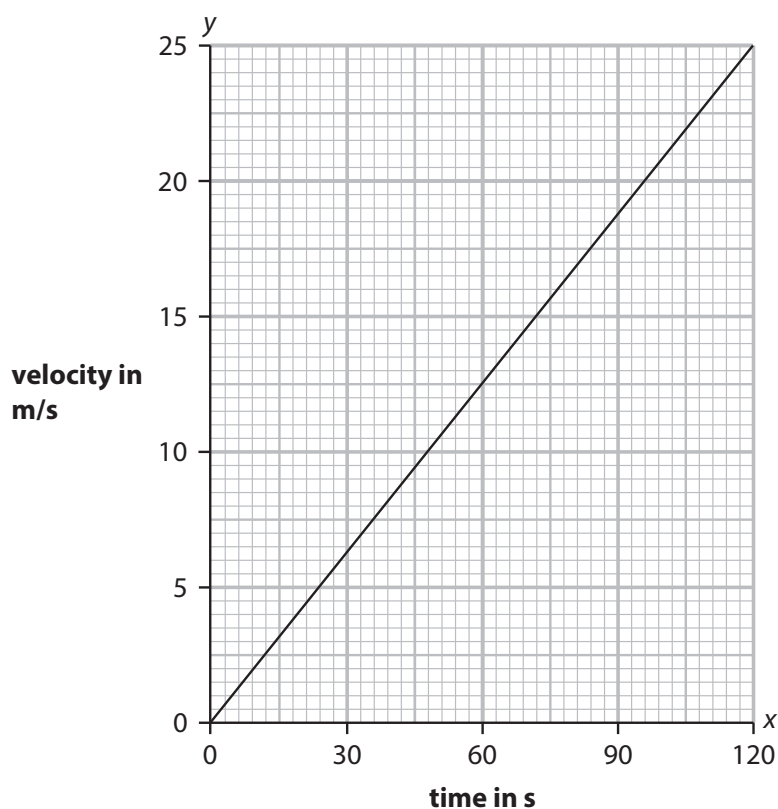


Figure 12

(i) Give the quantities that x and y represent in the equation.

(1)

x represents

y represents

(ii) Calculate the value of m from the graph in Figure 12.

(2)

$m = \dots\dots\dots \text{m/s}^2$

(iii) State the value of c from the graph in Figure 12.

(1)

value of $c = \dots\dots\dots$

(Total for Question 7 = 11 marks)



- 9 (a) Figure 13 shows a ball being rotated in a horizontal circle.

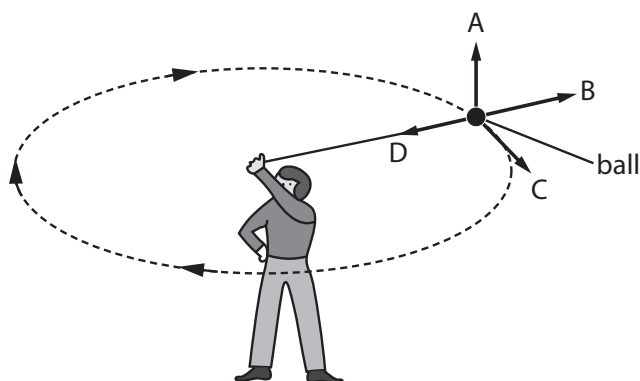


Figure 13

- (i) Which arrow in Figure 13 shows the direction of the centripetal force on the ball?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

- (ii) The ball is moving at constant speed. Give **one** reason why the velocity of the ball is continuously changing.

(1)

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(b) Figure 14 shows a gymnast landing on a mat and coming to rest.

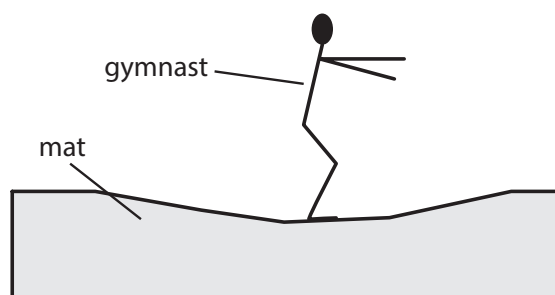


Figure 14

The gymnast has a mass of 53 kg.

The gymnast lands on the mat with a velocity of 4.0 m/s.

The average force exerted by the mat on the gymnast is 3500 N.

Calculate the time taken for the gymnast to come to rest.

Give your answer to an appropriate number of significant figures.

Use the equation

$$\text{force} = \frac{\text{change in momentum}}{\text{time}}$$

(3)

time = ... s

- 8 (a) Figure 14 shows a footballer and a ball.



(Source: © GelgelNasution/Shutterstock)

Figure 14

The ball is stationary before it is kicked.

The mass of the ball is 0.43 kg.

The kick exerts a force of 2700 N on the ball.

The velocity of the ball just after it has been kicked is 36 m/s.

- (i) Calculate the momentum of the ball just after it has been kicked.

State the unit for momentum.

(3)

momentum = ...

unit

- (ii) Calculate the amount of time that the footballer's kicking foot is in contact with the ball.

(2)

time = ... s

- (iii) Explain how Newton's third law applies to the interaction between the kicking foot and the football.

(3)



- (b) Figure 15 shows a system consisting of two toy trolleys, **S** and **T**, on a straight, horizontal track.

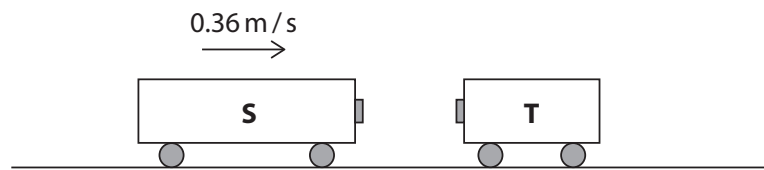


Figure 15

T is not moving.

S is moving with a velocity of 0.36 m/s towards **T**.

S collides with **T**.

The trolleys stick together and move off together.

With reference to the momentum of the system, explain why the velocity of the trolleys after the collision is less than the velocity of **S** before the collision.

(3)

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(Total for Question 8 = 11 marks)

12-MARK QUESTIONS

3 questions in this booklet



- 9 (a) A student investigates the relationship between force and acceleration for a trolley on a runway.

Figure 12 shows some of the apparatus the student uses.

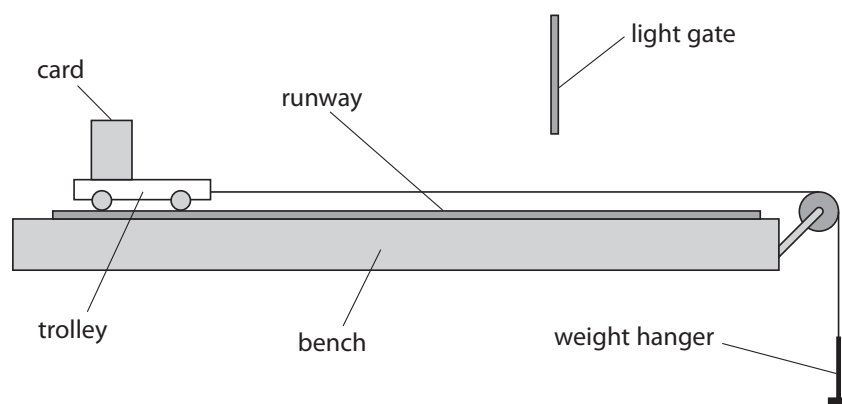


Figure 12

- (i) Describe how the student could increase the accelerating force applied to the trolley. (2)

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- (ii) Describe how the mass of the moving system can be kept constant. (2)

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(iii) Explain how the student could improve the procedure to compensate for the effects of frictional forces acting on the trolley.

(2)



27



*(b) Figure 13 shows two objects, Q and R, before and after they collide.



Figure 13

The arrows show the direction of movement of the objects.
The arrows are not to scale.

Explain how momentum is conserved in the collision.

Use Newton's third law and Newton's second law in your answer.

Newton's second law can be written as

$$\text{force} = \frac{\text{change in momentum}}{\text{time}}$$

(6)

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(Total for Question 9 = 12 marks)

- 7 (a) Figure 10 shows a small steel ball held at a height, h , above the ground.

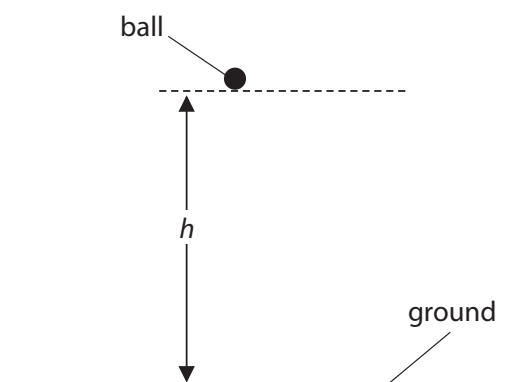


Figure 10

The ball is released and allowed to fall to the ground.

The height h is 1.4 m.

Calculate the time, t , for the ball to reach the ground.

Use the equation

$$t^2 = \frac{2h}{g}$$

$$g = 10 \text{ m/s}^2$$

(2)

$t = \dots\dots\dots \text{ s}$

(b) Two students use the arrangement shown in Figure 10.

They use a stopwatch to time the ball falling through the height of 1.4 m.

The students repeat the measurement many times, but their average value for t is different from the calculated value.

(i) Suggest a reason why the students' value for t is different from the calculated value. (1)

(ii) Suggest **one** improvement the students could make to their procedure so that their value for t is closer to the calculated value. (1)



(c) Figure 11a shows a box falling towards a hard floor.

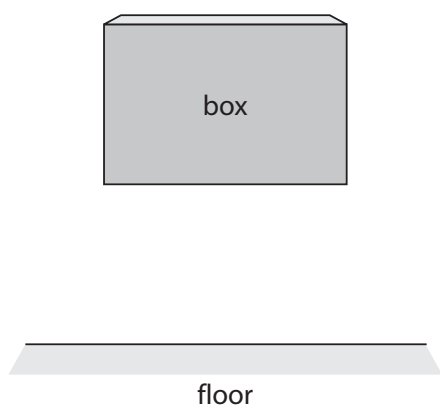


Figure 11a

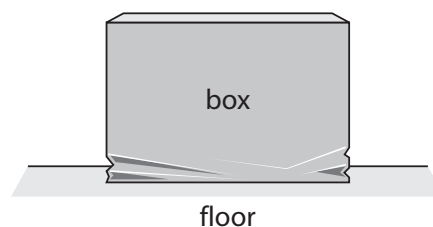


Figure 11b

The box hits the floor and crumples a little before it comes to rest as shown in Figure 11b.

The momentum of the box just before it hits the floor is 8.7 kg m/s .

The box comes to rest 0.35 s after it first hits the floor.

(i) Calculate the magnitude of the force exerted by the floor on the box.

Use an equation selected from the list of equations at the end of this paper.

(2)

force exerted by the floor on the box = ... N

(ii) State the magnitude and direction of the force exerted by the box on the floor.

(2)

magnitude

direction

(d) Figure 12 shows a ball held in a clamp at **R**, above the ground.

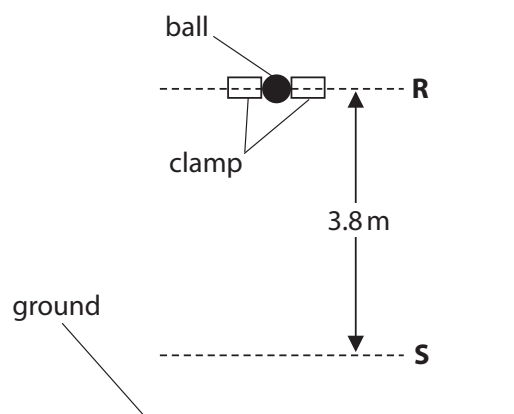


Figure 12

The ball is released from the clamp and falls.

S is 3.8 m below **R**.

At **S** the momentum of the ball is 0.40 kg m/s.

Calculate the mass of the ball.

Acceleration due to gravity, g , = 10 m/s²

(4)

mass of the ball kg

(Total for Question 7 = 12 marks)

- 9 (a) An atom of mass 6.6×10^{-26} kg is moving with a velocity of 480 m/s.

Calculate the momentum of the atom.

(3)

momentum = ... kg m/s

- (b) Figure 18 shows a ball before and after it collides with a wall.

The arrows show the direction of movement of the ball.

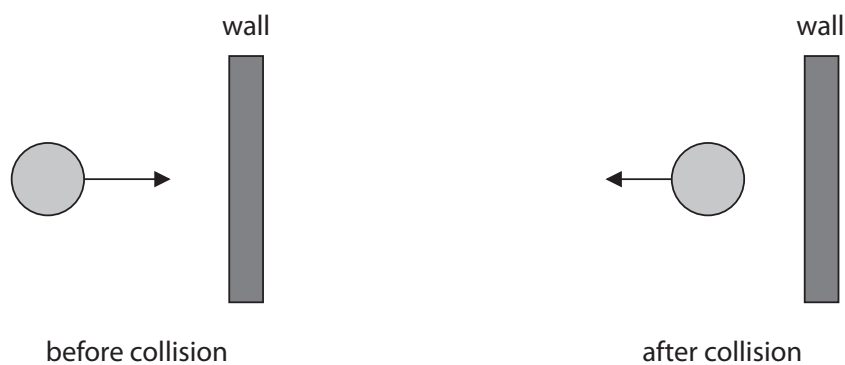


Figure 18

Before the collision, the momentum of the ball is 0.80 kg m/s.

After the collision, the momentum of the ball is 0.60 kg m/s in the opposite direction.

The ball is in contact with the wall for a time of 70 ms during the collision.

Calculate the force exerted on the ball by the wall.

(3)

Use an equation selected from the list of equations at the end of the paper.

force = ... N

*(c) Newton's second law can be stated as

$$\text{force} = \text{mass} \times \text{acceleration}$$

A student is provided with a trolley and a runway on a bench, as shown in Figure 19, and access to other equipment.

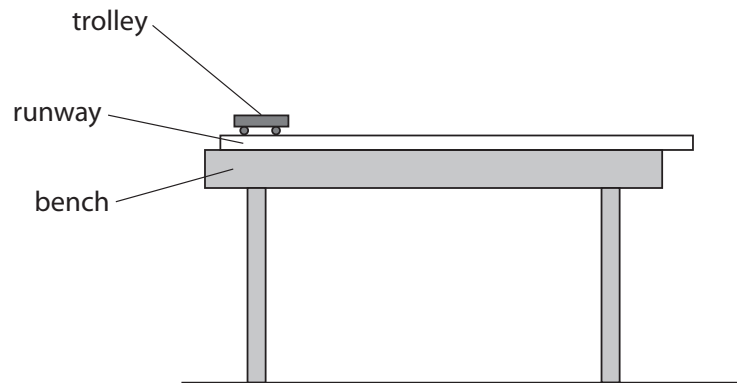


Figure 19

Describe a procedure the student could use to investigate how the acceleration of the trolley depends on the force applied to the trolley.

You may add to the diagram in Figure 19 to help your answer.

(6)

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(Total for Question 9 = 12 marks)

13-MARK QUESTIONS

1 question in this booklet



- 9 (a) Figure 12 is a diagram showing a rocket that is sent into space to try and change the path of a small asteroid.

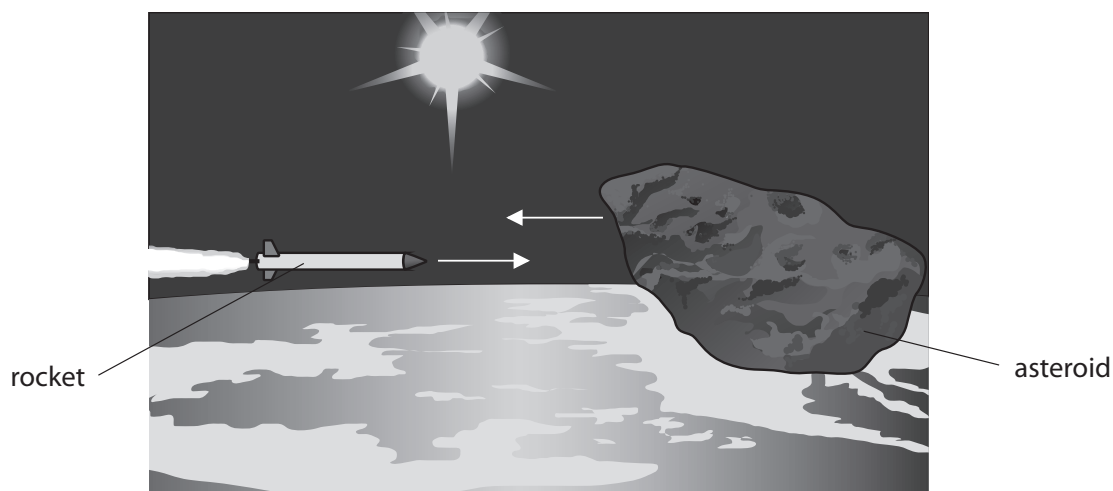


Figure 12

- (i) The rocket has a mass of $5.5 \times 10^5 \text{ kg}$ and is travelling to the right at 14 km/s .
Which of these is a correct calculation of the momentum of the rocket in kg m/s ?
Use the equation

$$p = m \times v \quad (1)$$

- ☐ A $7.7 \times 10^3 \text{ kg m/s}$
☐ B $7.7 \times 10^6 \text{ kg m/s}$
☐ C $7.7 \times 10^9 \text{ kg m/s}$
☐ D $7.7 \times 10^{12} \text{ kg m/s}$

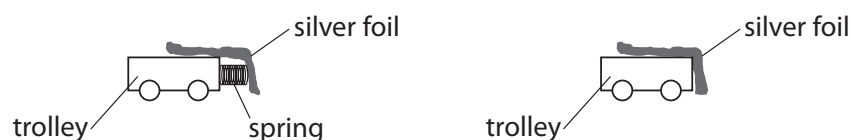
- (ii) The asteroid has a momentum of $7.5 \times 10^{10} \text{ kg m/s}$ and a mass of $8.0 \times 10^6 \text{ kg}$.
Calculate the speed of the asteroid.

(2)

speed of the asteroid = ... m/s

*(b) A student investigates the effect of a crumple zone on the force exerted during a collision.

The student has one trolley with a spring at the front and another trolley without a spring.



The student uses the arrangement in Figure 13.

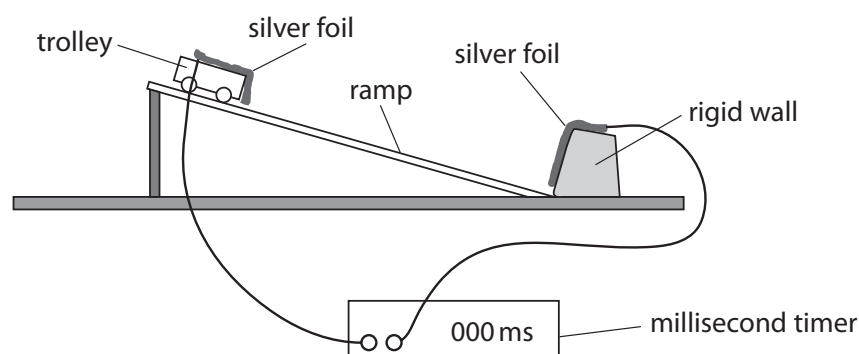


Figure 13

After a trolley is released, it accelerates down a slope and bounces off a rigid wall.

The speed of a trolley can be measured just before a collision with the wall and just after a collision with the wall.

The silver foils are connected to a millisecond timer.

The silver foils make contact with each other during the collision, so the time they are in contact can be read from the millisecond timer.

Explain how the student could investigate the effect of a crumple zone on the average force exerted during the collision.

Your explanation should include:

- how to determine the force (you may wish to refer to an equation from the list of equations at the end of this paper)
- how the effect of crumple zones may be shown in the investigation
- precautions that may be necessary to achieve accurate results.

(6)

Handwriting practice area with 20 horizontal dotted lines.



- (c) Newton's third law, when applied to the collision of the rocket and the asteroid as shown in Figure 12, can be stated as follows:

The force exerted by the rocket on the asteroid is equal and opposite to the force exerted by the asteroid on the rocket.

Explain how this statement links to the conservation of momentum in the collision.

(4)

(Total for Question 9 = 13 marks)



MARK SCHEMES

official Pearson Edexcel mark schemes



3(a)(i)	an explanation linking two from: (wet road means) less / no friction (between tyres and road) (1) (wet weather means) increased stopping distance (1) (slower speed means) shorter braking / stopping distance (1) (dry weather / slower speed) reduces possibility of skidding / sliding / idea of losing control / crashing (1)	accept reverse arguments throughout accept (road) more slippery / less grip accept idea of reduced visibility accept braking or thinking distance in this context accept takes longer to slow down / stop ignore harder to brake	(2) AO1
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	Answer	Additional guidance	Mark
3(a)(ii)	convert either distance or time (1) $(31 \text{ m} \Rightarrow \frac{31}{1000} \text{ (km)})$ or 0.031 (km) OR $(1 \text{ s} \Rightarrow \frac{1}{3600} \text{ (h)}) = \frac{1}{60 \times 60} \text{ (h)}$ or 0.000 28 (h) evaluation (1) $(31 \text{ m/s} \Rightarrow 110 \text{ (km/h)})$	$(130 \text{ km} \Rightarrow 130 \times 1000 \text{ (m)})$ or 130 000 (m) OR $(1 \text{ h} \Rightarrow 60 \times 60 \text{ (s)})$ or 3600 (s) $(130 \text{ km/h} \Rightarrow 36(.1) \text{ (m/s)})$ accept 111.6 or 112 (km/h) for 2 marks if no other marks awarded accept <u>1860 m/min</u> and <u>2167 m/min</u> for 1 mark each award full marks for the correct answer without working	(2) AO2

	Answer	Additional guidance	Mark
3(a)(iii)	select and substitute into distance travelled = average speed x time (1) $46 = 31 \times t$ rearrangement and evaluation (1) $(t =) 1.48(3) \text{ (s)}$ evaluation given to 2 sf (1) $(t =) 1.5 \text{ (s)}$	$31 = \frac{46}{t}$ $(t =) \frac{46}{31}$ award two marks for the correct evaluation without working any answer written to 2 sf independent mark 1.5 scores 3 marks 1.4 scores 2 marks 1.50 scores 2 marks 0.67 scores 2 marks 1400 scores 2 marks 0.673(9) scores 1 mark 1426 scores 1 mark	(3) AO2

Total for Question 3 = 7 marks

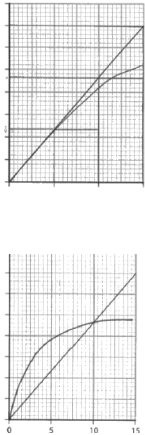


Question number	Answer	Mark
3 (a)	☒ B force Options A, C and D are all scalars.	(1)

Question number	Answer	Additional guidance	Mark
3 (b)(i) CLIP WITH bii	acceleration = $\frac{\text{change in velocity}}{\text{time (taken)}}$	$a = \frac{v-u}{t}$ $a = \frac{\Delta v}{t}$ $\frac{v}{t}$ allow correct rearrangements seen here or in bii	(1) grad

Question number	Answer	Additional guidance	Mark
3 (b)(ii) CLIP WITH bi	substitution (1) $\frac{20 - 2}{12}$ evaluation (1) 1.5 (m/s ²)	$\frac{18}{12}$ -1.5 (m/s ²) award full marks (1 in bi and 2 in bii) for the correct answer without working, award 1 mark if 20-2 or 18 or 2-20 is seen and no other marks are scored If (incorrectly) $a = \frac{v^2 - u^2}{t}$ given in 3bi $a = \frac{20^2 - 2^2}{12}$ OR = 33 scores 1 mark	(2)

Question number	Answer	Additional guidance	Mark
3 (c)(i) CLIP WITH GRAPH	distance = area under graph (1) $\frac{1}{2} \times 7 \times 15$ (1) 52(.5) (m) (1)	attempt to find area seen on graph correct area(s) identified including calculation 53 (m) allow 7×15 or 105 for 1 mark only award full marks for the correct answer with no working	(3)

Question number	Answer	Additional guidance	Mark
3 (c)(ii) CLIP WITH GRAPH H paper	(curve) <u>starting</u> from 0,0 (1) of decreasing gradient (1)	curve can be above or below the line both of these are acceptable 	(2)

Total for Question 3 = 9 marks

5(a)(i)	selection and substitution (1) $(a =) \frac{82(-0)}{36}$ evaluation (1) 2.3 (m/s²)	note: this is a “show that” question accept any value that rounds to 2.3 (m/s²) accept 2.2 (m/s²) for 1 mark maximum answer of 2 (m/s²) without a substitution scores 0 marks	(2) AO2
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	Answer	Additional guidance	Mark
5(a)(ii)	substitution (1) $82^2(-0^2) = 2 \times 2.3 \times x$ rearrangement (1) $(x) = \frac{82^2(-0^2)}{2 \times 2.3}$ evaluation (1) 1500 (m)	allow substitution and rearrangement in either order accept 2, 2.2, 2.27, 2.3 for “a” throughout $(x) = \frac{v^2(-u^2)}{2 \times a}$ ignore sign accept 1460 (m) allow answers in the ranges: 1460 (m) to 1482 (m) 1520 (m) to 1530 (m) 1680 (m) to 1700 (m) award full marks for correct answer without working	(3) AO2

	Answer	Additional guidance	Mark
5(a)(iii)	one statement from take off aborted (1) mechanical/engine failure (1) acceleration reduced (1) weather related reasons (1) larger mass / heavier plane / extra passengers (1) (longer runway required) for landing (1)	any other sensible suggestion	(1) AO3

	Answer	Additional guidance	Mark
5(b)(i)	selection and substitution (1) $(KE) = \frac{1}{2} \times 3.6 \times 10^5 \times 71^2$ evaluation (1) $9.1 \times 10^8 \text{ (J)}$	accept $9.07 \times 10^8 \text{ (J)}$ accept 907 380 000 (J) award full marks for correct answer without working do not award a power of ten error	(2) AO2

	Answer	Additional guidance	Mark
5(b)(ii)	any one from: mechanically (to the thermal store) (1) (heating) due to air resistance / friction (1) thermally (1)	allow dissipated thermal (store) / heat (energy)	(1) AO2

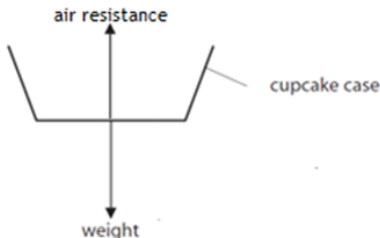
Total for Question 5 = 9 marks



Question Number	Answer	Additional guidance	Mark
2 (a)	B distance A, C and D are incorrect as these are vector quantities		(1) AO1

Question number	Answer	Additional guidance	Mark
2 (b)(i)	A description to include any 4 from: measure height (1) measure time of fall (1) use (average) speed=distance ÷ time (1) repeat with different number of cupcake cases in the stack/more cupcake cases (1) repeat and average time (of fall for each stack of cupcake cases) (1) plot a graph (speed of fall against number of cupcake cases dropped) (1)	allow 'keep same height' allow in this context hold against (fixed point on) metre rule allow 'time it' accept cupcakes for cupcake cases	(4) AO1

Question Number	Answer	Additional guidance	Mark
2 (b)(ii)	substitution (1) $(W=)0.005 \times 10$ evaluation (1) 0.05 (N)	$5 \times 10^{-2} \text{ (N)}$ do not allow power of ten error award full marks for the correct answer with no working give full credit for use of $g=9.8$ or 9.81 N/kg	(2) AO2

Question number	Answer	Additional guidance	Mark
2 (b)(iii)	 air resistance arrow (1)	Judge by eye any vertical upward arrow outside or inside the cupcake case ignore length of arrow arrow need not touch cupcake holder ignore label on arrow	(1) AO2

Question number	Answer	Additional guidance	Mark
2 (b) (iv)	zero / there is none / 0 / it has no acceleration	ignore 'constant' ignore units	(1) AO2

Total for question 2 = 9 marks

5(a)	B 3.0 s A, C and D are incorrect as they are the wrong time.	(1) AO3
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	Answer	Additional guidance	Mark
5(b)	4.6 (m/s)	allow any value between 4.5 and 4.7 (m/s) inclusive	(1) AO3

	Answer	Additional guidance	Mark
5(c)	correct data point(s) seen (1) (accel =) $\frac{\Delta v}{t}$ (1) evaluation (1) 2.9 (m/s ²)	allow MP1 and MP2 in either order any data point(s) on the line e.g. (1.4,4) allow 'gradient' allow e.g. $\frac{4}{1.4}$ for 2 marks allow values that round to 2.9 (m/s ²) (e.g. 2.857...) award full marks for the correct answer without working	(3) AO3

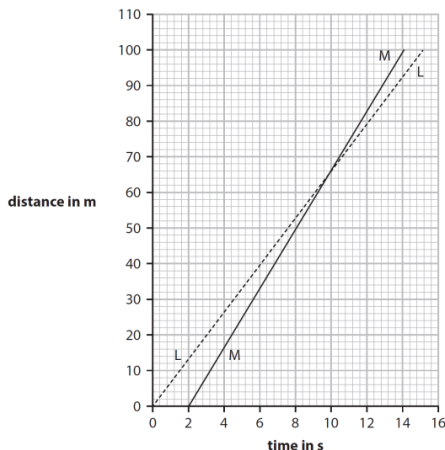
	Answer	Additional guidance	Mark
5(d)	(distance =) area (under graph) (1) substitution (1) $\frac{1}{2}(1.4 \times 4) + (3.6 \times 4) + \frac{1}{2}(1 \times 4)$ evaluation (1) 19 (m)	may be seen on graph $2.8 + 14.4 + 2.0$ $\frac{1}{2} \times [3.6 + 6] \times 4$ allow values that round to 19 (m) (e.g. 19.2.. award full marks for the correct answer without working if no other marks scored allow $(4 \times 6 =) 24$ (m) for 1 mark	(3) AO3

	Answer	Additional guidance	Mark
5(e)	graph continued below time axis, starting at 18 s	do not accept vertical line do not accept line extending to left of 18 s	(1) AO3

Total for Question 5 = 9 marks.

	Answer	Additional guidance	Mark
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Question number	Answer	Additional guidance	Mark
3 (ai)	66 (m)	allow values between 64 and 68 inclusive	1 AO3.2
		allow values between 32 and 36 inclusive as the distance L has to run after M overtakes in this context	

Question number	Answer	Additional guidance	Mark
3 (aii)	select (1) $v = \frac{x}{t}$	allow any identifiable distance from graph divided by any identifiable time from graph e.g. $\frac{100}{15.2}$ 	2 AO2.1
	evaluation (1) 6.6 (m/s)	allow values that round to between 6.5 (m/s) and 6.7 (m/s) for example 6.666 (m/s) or 6.579 (m/s)	

Question number	Answer	Additional guidance	Mark
3 (bi)	substitution (1) $(t =) \frac{10 - 6.2}{2.5}$	$\frac{3.8}{2.5}$ allow $\frac{6.2 - 10}{2.5}$ or $\frac{-3.8}{2.5}$	2 A02.1
	evaluation (1) (t =) 1.5 (s)	1.52 (s) allow -1.5(2) (s) award full marks for correct answer without working	

Question number	Answer	Additional guidance	Mark
3 (bii)	substitution OR rearrangement (1) $(-)10^2 = 2 \times (-) 4.4 \times x$	$(x =) \frac{v^2 - u^2}{2 \times a}$ $(x =) \frac{(-)10^2}{2 \times (-) 4.4}$	2 A02.1
	evaluation (1) (x =) 11 (m)	allow values that round to 11	

Question	Answer	Additional guidance	Mark
3 (c)	explanation linking mass/(change of/initial/final) velocity/(change of) momentum (1) with a consistent equation linking chosen factor to force (1)	accept speed/acceleration do not accept weight second marking point dependent on first marking point relevant equations are: $F = ma$ $F = \frac{mv - mu}{t}$ $F = \frac{\Delta p}{t}$ $F = \frac{m\Delta v}{t}$	2 AO2.1

Total question 3=9 marks

Question Number	Answer	Additional guidance	Mark
2(a)(i)	use of $(F=)0.92$ (N) (1) substitution and rearrangement (1) (acceleration) = $\frac{0.92}{0.25}$ evaluation (1) (acceleration) = 3.7 (m/s²)	allow 0.92×0.25 OR $\frac{0.25}{0.92}$ allow MP2 for use of incorrect force giving $\frac{2.5}{0.25}$ OR $\frac{3.42}{0.25}$ OR $\frac{1.58}{0.25}$ OR $\frac{0.46}{0.25}$ allow values that round to 3.7 e.g. 3.68 allow values that round to 3.7×10^{-3} or 0.0037 for 2 marks (g instead of kg) allow for 2 marks an evaluation of 10(.0) OR 14 OR 13.7 OR 6.3(2) OR 1.8(4) (use of incorrect force) award full marks for the correct answer without working ignore negative values throughout if no other marks scored allow 1 mark for $a = \frac{F}{m}$	(3) AO2.1

Question Number	Answer	Additional guidance	Mark
2(a)(ii)	1.6 (N) OR 1.58 (N)		(1) AO3.1

Question Number	Answer	Additional guidance	Mark
2(b)(i)	2.4 (N) OR 2.375 (N) OR 2.38 (N)		(1) AO2.2

Question Number	Answer	Additional guidance	Mark
2(b)(ii)	straight line extended to meet h = 0.80 m axis (1) 3.1 (N) (1)	judge by eye allow 3.05 to 3.20 inclusive award full marks for the correct answer without working	(2) AO2.2

Question Number	Answer	Additional guidance	Mark
2(b)(iii)	select two points on the line (1) evaluation (1) 3.90 ± 0.10 (N/m)	allow triangle drawn on graph award full marks for the correct answer without working	(2) AO2.2

Total for Question 2 = 9 marks

Question Number	Answer	Mark
6(a)	C N/kg is the only correct answer A J/kg is not dimensionally the same as m/s^2 B J/kg² is not dimensionally the same as m/s^2 D N/kg² is not dimensionally the same as m/s^2	(1) AO 1 1

Question Number	Answer	Additional guidance	Mark
6(b)(i)	substitution (1) $\frac{2 \times 2.5}{0.74^2}$ evaluation (1) 9.1(3) (m/s^2)	$\frac{5}{0.5476}$ award full marks for the correct answer with no working	(2) AO 2 1

Question Number	Answer	Additional guidance	Mark
6(b)(ii)	$(0.74 + 0.69 + 0.81) \div 3$ (1) 0.7(5) (1)	accept 0.7 or 0.75 award full marks for the correct answer with no working 0.746 or 0.747 or 0.750 scores 1 mark	(2) AO 3 2a AO 3 2b

Question Number	Answer	Additional guidance	Mark
6(c)	an explanation linking: use an electronic timer / (1) to eliminate reaction time (1)	light gate/ data logger there are other options which should be judged to this pattern (e.g. increase distance to reduce effect of reaction time)	(2) AO 3 3b

Question Number	Answer	Additional guidance	Mark
6(d)	rearrangement (1) $a = \frac{(v^2 -)u^2}{2x}$ substitution (1) $a = \frac{(-)15^2}{2 \times 14}$ evaluation (1) deceleration = 8(.04) (m/s²)	rearrangement and substitution in either order 225/28 for 2 marks accept – 8(.04) award full marks for the correct answer with no working	(3) AO 2 1

(Total for Question 6 = 10 marks)



Question number	Answer	Mark
6 (a) CS4	[x] C A is not correct because it shows a constant velocity of 0.4 m/s B and D are not correct because they show constant acceleration.	(1) AO3

Question number	Answer	Additional guidance	Mark
6 (b)(i) CS4	attempt to use correct data from graph or equation (1) substitution (1) $(a =) \frac{26 - 14}{34}$ evaluation to 2 sf (1) 0.35 (m/s²)	quoting $a = \frac{(\Delta)v}{t}$ or $a =$ gradient (of line) 0.3529... scores mp1 and mp2 $\frac{26}{34}$ scores mp1 independent mark award full marks for correct answer without working.	(3) AO2

Question number	Answer	Additional guidance	Mark
6 (b)(ii) CS4	attempt to calculate area under the line (1) calculates EITHER area of triangle OR area of rectangle (1) 204 (m) or 476 (m) evaluation (1) 680 (m)	accept count squares use of $v^2 - u^2 = 2ax$ $x = \frac{v^2 - u^2}{2a}$ allow ecf from b(i) award full marks for correct answer without working award 1 mark for final answer 408 (m)	(3) A02

Question number	Answer	Additional guidance	Mark
6 (c) CS4	An explanation linking three of: acceleration increases (1) as $F = ma$ (1) (and) mass decreases (1) due to burning/using fuel (1)	independent mark	(3) A01

Question number	Answer	Additional guidance	Mark
6(a)(i)	rearrangement (1) $h = \frac{\Delta GPE}{m \times g}$ evaluation (1) $(h) = 56 \text{ (m)}$	$h = \frac{39\,000}{70 \times 10}$ allow numbers that round to 56 (m) e.g. 55.71 allow numbers that round to 57 (m) e.g. 56.85 (use of $g=9.8 \text{ N/kg}$) award full marks for correct answer without working	(2) AO3.2

Question number	Answer	Additional guidance	Mark
6(a)(ii)	selection of $v^2 - u^2 = 2 \times a \times x$ (1) rearrangement (1) $a = \frac{v^2 - u^2}{2 \times x}$ evaluation (1) $1.8 \text{ (m/s}^2\text{)}$ ALTERNATIVE METHOD calculation of time = 14.814 using time = distance / average speed (1) substitution (1) $a (= (v-u) / t) = \frac{27(-0)}{14.814}$ evaluation (1) $1.8 \text{ (m/s}^2\text{)}$	$27^2 - 0^2 = 2 \times a \times 200$ allow $27^2 - 0^2 = 2 \times a \times \text{their (a)(i)}$ $a = \frac{27^2 - 0^2}{2 \times 200}$ allow $a = \frac{27^2 - 0^2}{2 \times \text{their (a)(i)}}$ no ecf for evaluation allow numbers that round down to $1.8 \text{ (m/s}^2\text{)}$ e.g. 1.8225 award full marks for correct answer without working.	(3) AO3.2

Question number	Answer	Additional guidance	Mark
6(a)(iii)	An explanation linking (measure) GPE at top/start and KE at bottom/end (1) energy (at top) subtract energy (at bottom) (1)	allow subtraction of any energies allow difference for subtraction award 2 marks for GPE at top subtract KE at bottom allow for 2 marks 39 000 – 25 515 OR 13485	(2) A03.3a

Question number	Answer	Additional guidance	Mark
6(b)(i)	Any one from: direction is changing (1) velocity is a vector (1)	allow velocity has magnitude and direction ignore acceleration ignore reference to centripetal force ignore speed is changing	(1) A02.1

Question number	Answer	Additional guidance	Mark
6(b)(ii)	tangent drawn to curve (at 2.5 s) (1) evaluation of gradient (1) (gradient =) 6.0 ± 1.0 (m/s)	accept hypotenuse of triangle dependent on MP1	(2) A03.2

Total for Question 6 = 10 marks



Question Number	Answer	Mark
Q7(a)	A kg m/s <i>B is not correct it is mass divided by velocity</i> <i>C is not correct because it is the product of mass and acceleration</i> <i>D is not correct because it is mass divided by acceleration</i>	(1) AO1

	Answer	Additional guidance	Mark
7(b)(i)	a description using any four of the following points in a logical order: measure the mass / weight of the trolley(s) / weigh the trolley(s) (1) determine the speed of trolley A (1) put one light gate (connected to data logger) further down the runway than trolley A and another beyond trolley B (1) trolleys A and B stick together (1) measure combined velocity / speed of A and B (1) calculate momentum of trolley A before collision and A and B after collision (1) check for equality / velocity after collision is half that before collision (1) repeat and take mean / average (1)	allow determine / find / calculate use (average) speed = distance / time to calculate speed of trolley A may be shown on diagram measure distance and time in appropriate places calculate (total) momentum before and after collision (total) momentum before equals (total) momentum after	(4) AO1

	Answer	Additional guidance	Mark
7 (b)(ii)	{compensating for / reducing effect of / overcoming / balancing / cancelling effect of} friction OR so that trolley A travels at a constant speed / doesn't slow down	do not accept reducing / cancelling friction do not accept so trolley accelerates down slope	(1) A03

	Answer	Additional guidance	Mark
7 (c)(i)	conversion of time to s (1) (t =) 0.012 OR 12×10^{-3} OR 1.2×10^{-2} substitution (1) (F=) $\frac{(0.075 \times -15.0) - (0.075 \times 8.2)}{0.012}$ OR (F=) $\frac{(0.075 \times 15.0) - (0.075 \times -8.2)}{0.012}$ OR (F=) $\frac{0.075 \times (15.0 + 8.2)}{0.012}$ evaluation (1) (-)150 (N)	substitution and conversion in either order ignore signs on velocity accept time to any power of ten for substitution mark (F=) $\frac{(1.125) + (0.615)}{0.012}$ 145 (N) scores 3 marks 145 (N) to any other power of ten scores 2 marks maximum 42.5 (N) scores 2 marks maximum 42.5 (N) to any other power of ten scores 1 mark maximum 93.75 (N) or 51.25(N) 1.933 scores 1 mark maximum award full marks for correct answer without working	(3)

	Answer	Additional guidance	Mark
7 (c)(ii)	Any two from: (forces are) equal / same size (1) (forces are) opposite (direction) (1) (forces) act on different bodies (1) same type of force (1)	no marks awarded for answers in terms of energy (forces are) one to the left, one to the right one (force) acts on racket, one acts on ball both are contact forces if no other marks awarded, allow action and reaction (acting) for 1 mark	(2) AO1

Total for Question 7 = 11 marks

	Answer	Additional guidance	Mark
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7(a)(i)	from 20 s to 45 s		1 AO1.1
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Question	Answer	Additional guidance	Mark
7(a)(ii)	use of area from graph (1) process (1) EITHER calculation of area of trapezium OR calculation of area triangle and rectangle and triangle e.g. $\text{area} = \frac{[25 + 70] \times 15}{2}$ OR e.g. area triangle = $\frac{15 \times 20}{2} = 150$ (m) area rectangle = $15 \times 25 = 375$ (m) area triangle = $\frac{15 \times 25}{2} = 187.5$ (m) evaluation (1) 712.5 (m)	allow evidence of counting squares and area of one square accept 712 (m) or 713 (m) do not accept 710 (m) award full marks for the correct answer without	3 AO2.1

Question	Answer	Additional guidance	Mark
7(b)	identification of equation and substitution (1) $450 = m \times 0.35$ rearrangement and evaluation (1) $(m =) \frac{450}{0.35}$ 1300 (kg)	accept values which round to 1300 (kg) e.g. 1286 (kg) award full marks for the correct answer without working	2 AO2.1

Question	Answer	Additional guidance	Mark
7c (i)	x represents time OR t y represents velocity OR v	both correct in correct place for 1 mark ignore units	1 AO1.1

Question	Answer	Additional guidance	Mark
7c(ii)	attempt to find a gradient of the line that would give an answer between 0.18 and 0.24 (1) evaluation(1) 0.21 (m/s ²)	e.g. $\frac{12.5}{60}$ or $\frac{10}{42}$ values that are between 0.20 and 0.22 (m/s ²) e.g. 0.2083 do not allow fractions in the answer line for evaluation mark award full marks for the correct answer without working	2 AO2.1

Question	Answer	Additional guidance	Mark
7c (iii)	0	zero	1 AO2.1

Total question 7=11 marks

Question	Answer	Mark
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9(a)(i)	D A is not correct there is no vertical force B the centripetal force acts inward C is not correct there is no force acting at right angles to the radius	1 AO1.1
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Question	Answer	Additional guidance	Mark
9(a)(ii)	any one from:- direction (of ball is) (continuously) changing (1) there is a resultant force acting on the ball (1) velocity/it is a vector (1)	ignore changing force / acceleration / centripetal force velocity/it has direction	1 AO1.1

Question	Answer	Additional Guidance	Mark
9 (b)	substitution or rearrangement (1) $3500 = \frac{53 \times 4 (- 53 \times 0)}{\text{time}}$ or (time=) $\frac{\text{change in momentum}}{\text{force}}$	in either order $3500 = \frac{212}{\text{time}}$ (time =) $\frac{53 \times 4}{3500}$ (time =) $\frac{212}{3500}$ (t =) $\frac{mv - mu}{F}$	3 AO2.1

	evaluation (1) 6.06×10^{-2} (s) or 0.0606 (s) rounded to 2sf (1) 6.1×10^{-2} (s) or 0.061 (s)	accept 0.06057 (s) 0.06 (s) accept their calculation rounded to 2sf 0.060 scores 2 marks (truncation) award three marks for the correct answer given to 2sf without working	
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Question number	Indicative content	Mark
*9(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. momentum • momentum is product of mass and velocity • $p=mv$ • momentum is a vector quantity • momentum of P = mv • momentum of Q = $-mv$ • total momentum before collision is zero • $mv_p + (-mv_q) = 0$ • momentum after collision must be zero • total momentum before = total momentum after energy • before collision each trolley has kinetic energy • $KE = \frac{1}{2}mv^2$ • total KE before collision is sum of KE of both trolleys • KE after collision is zero • KE transferred to thermal (store) • KE transferred by heating and by sound • energy dissipated to surroundings Ignore references to equal and opposite forces and the laws of motion	6 AO1.2 AO2.2

Command verb: Explain

AO targeting 3 marks AO1 strand 1 and 3 marks AO2 strand 1

Level	Mark	Descriptor
	0	No awardable content
Level 1	1-2	• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3-4	• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5-6	• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)



Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> isolated fact(s) about the momentum and/or energy of trolleys, before or after collision	<u>Possible candidate responses</u> momentum before collision equals momentum after collision momentum is mass x velocity momentum is a vector energy cannot be created or destroyed $KE = \frac{1}{2}mv^2$
Level 2	3–4	<u>Additional guidance</u> limited description of conservation of momentum and limited description of conservation of energy OR detailed description of either conservation of energy or conservation of momentum	<u>Possible candidate responses</u> momentum/velocities of trolleys is equal and opposite before collision / zero before collision/zero after collision. trolleys have kinetic energy before collision OR the trolleys have kinetic energy before the collision which is transferred to thermal energy after the collision.
Level 3	5–6	<u>Additional guidance</u> detailed description of conservation of momentum before and after collision and limited description of conservation of energy OR detailed description of energy conservation and limited description of conservation of momentum	<u>Possible candidate responses</u> momentum of trolleys before collision is equal and opposite giving zero, and momentum is zero after collision so momentum is conserved energy is dissipated thermally after collision OR the trolleys have kinetic energy before the collision which is transferred to thermal energy after the collision. momentum of trolleys is equal and opposite before collision / zero before
			collision/zero after collision.

Total for question 9 = 11 marks



Question number	Answer	Additional guidance	Mark
8(a)(i)	selection of (p =) $m \times v$ (1) evaluation (1) (momentum =) 15 unit (1) kg m/s	(momentum =) 0.43×36 allow numbers that round to 15 e.g. 15.48 allow 15.5 award 2 marks for the correct value without working kg m s⁻¹ allow N s	(3) AO2.1

Question number	Answer	Additional guidance	Mark
8(a)(ii)	selection of force = <u>change in momentum</u> (1) time evaluation (1) 0.0056 (s) ALTERNATIVE METHOD selection of $F=ma$ and $a=(v-u)/t$ (1) evaluation (1) 0.0057 (s)	$2700 = \frac{15}{\text{time}}$ OR $2700 = \frac{\text{their (a)(i)}}{\text{time}}$ OR $(\text{time}) = \frac{15}{2700}$ OR $(\text{time}) = \frac{\text{their (a)(i)}}{2700}$ allow numbers that round to 0.0056 e.g. 0.005555 (using $\Delta p=15$) or numbers that round to 0.0057 e.g. 0.005733 (using $\Delta p=15.48$) allow ECF from their (a)(i) for 2 marks without working allow numbers that round to 0.0057 e.g. 0.00573 award full marks for the correct value without working	(2) exp AO2.1

Question number	Answer	Additional guidance	Mark
8(a)(iii)	explanation linking equal and opposite forces (1) (which are) force exerted by the foot (on the ball) (1) (and) force exerted by the ball (on the foot) (1)	accept action and reaction are equal and opposite (which are) force exerted (by the foot) on the ball (1) (and) force exerted (by the ball) on the foot (1) award 2 marks for force on ball = force on foot award 3 marks for force on ball = force on foot but in opposite direction ignore references to other named forces and energy	(3) AO2.1

Question number	Answer	Additional guidance	Mark
8(b)	explanation linking (total) momentum of the system is constant (1) (therefore as) momentum = mass x velocity (1) (and) more <u>mass</u> (is moving after collision) (1)	momentum before collision = momentum after collision momentum is conserved / stays the same $p = mv$	(3) AO1.1

Total for Question 8 = 11 marks



Question Number	Answer	Additional guidance	Mark
9(a)(i)	a description to include: add weight / mass (1) to the weight hanger (1)	ignore references to friction here by inclining runway allow (component of) gravity to act on trolley	(2) AO 1 2

Question Number	Answer	Additional guidance	Mark
9(a)(ii)	a description to include: transfer mass (1) between trolley and hanger (1)	allow weight(s) for mass mass removed from trolley = mass added to hanger for 2 marks	(2) AO 1 2

Question Number	Answer	Additional guidance	Mark
9(a)(iii)	an explanation that links: raise one end of the runway (1) (so that) trolley (not attached to weight hanger) rolls at constant speed / just starts to move / (force of) gravity (on the trolley) balances forces of friction (1)	credit methods for reducing friction directly (e.g. oil wheels, runway etc.) to reduce (effects of) friction allow credit for identifying magnitude of frictional forces and subtracting or using graph	(2) AO 3 3b

Question Number	Answer	Mark
9(b)*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 (6 marks) • momentum = mass × velocity • action and reaction are equal and opposite (N 3) • force of R on Q = -force of Q on R • $\frac{\text{change in momentum of Q}}{\text{time}} = -\frac{\text{change in momentum of R}}{\text{time}}$ • time of collision same for both • change in momentum of Q = - change in momentum of R • no overall change in momentum • R accelerates because of force from Q • transfer of momentum between Q and R	(6) AO 1 1

Level	Mark	Descriptor
	0	• No rewardable material.
Level 1	1-2	• An explanation that demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	• An explanation that demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	• An explanation that demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

(Total for Question 9 = 12 marks)



Question number	Answer	Additional guidance	Mark
7(a) CS5	substitution (1) $(t^2 =) \frac{2 \times 1.4}{10}$ evaluation (1) $(t =) 0.53 \text{ (s)}$	0.28 allow numbers that round to 0.53 e.g. 0.52915 award full marks for correct answer without working.	(2) AO2

Question number	Answer	Additional guidance	Mark
7(b)(i) CS5	(students') reaction time (is significant compared with recorded time) (1)	g is really 9.8	(1) AO2

Question number	Answer	Additional guidance	Mark
7(b)(ii) CS5	One from use light gates (1) use automatic timer (1) Use time lapse/ stroboscopic photography (1) drop from greater height (1)	ignore repeats or more people	(1) AO3

Question number	Answer	Additional guidance	Mark
7(c)(i)	substitution (1) (force =) $\frac{8.7}{0.35}$ evaluation (1) 25 (N)	use of force = $\frac{\text{change in momentum}}{\text{time}}$ allow numbers that round to 25 e.g 24.8571 award full marks for correct answer without working.	(2) AO2

Question number	Answer	Additional guidance	Mark
7(c)(ii)	(magnitude) 25 (N) (1) (direction) down(wards)/ towards floor (1)	ecf from 7bi allow arrow drawn pointing down "south"	(2) AO3

Question number	Answer	Additional guidance	Mark
7(d)	Two stage calculation substitution₁ (1) $(v^2 - 0 =) 2 \times 10 \times 3.8$ evaluation of v (1) $(v =) 8.7 \text{ (m/s)}$ substitution₂ (1) $0.40 = m \times 8.7$ rearrangement and evaluation (1) $(m =) 0.046 \text{ (kg)}$	use of $v^2 - u^2 = 2ax$ OR $\frac{1}{2} mv^2 = mgh$ 76 allow numbers that round to 8.7 e.g. 8.718 use of $p = mv$ allow numbers that round to 0.046 e.g. 0.04598 award full marks for correct answer without working.	(4) AO2

Total for Question 7 = 12 marks)

	Answer	Mark
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9(a)	selection (1) $p = m \times v$ substitution (1) $6.6 (\times 10^{-26}) \times 480$ evaluation (1) 3.2×10^{-23} (kgm/s)	allow mom(entum) = mass x velocity allow numbers that round to 3.2×10^{-23} e.g. 3.168×10^{-23} award full marks for the correct answer without working $6.6 (\times 10^{-26}) \times 480$ seen scores MP1 and MP2, 2 marks 3.2 to any other power of ten scores MP1 and MP2, 2 marks	(3) AO2
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	Answer	Additional guidance	Mark
9(b)	attempt to find momentum change (Δp) (1) (Δp) = ± 1.4 substitution in to $F = \frac{\Delta p}{t}$ (1) $\frac{\pm 1.4}{70 \times 10^{-3}}$ evaluation (1) ($\pm$) 20 (N)	$\pm 0.8 \pm 0.6$ allow (Δp) = ± 0.2 allow $\frac{\pm 0.2}{70 \times 10^{-3}}$ answers which round to ($\pm$) 20 to any other power of 10 score 2 marks answers which round to ($\pm$) 2.9 scores 2 marks answers which round to ($\pm$) 2.9 to any other power of 10 score 1 mark award full marks for the correct answer without working	(3) AO2

Question number	Indicative content	Mark
9c	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 isolated statements • weights on hanger • weights added to trolley • light gate(s) / ticker(tape) timer / ultrasonic transducer • datalogger • (interrupter) card on trolley • sloping runway • weigh trolley • use newtonmeter • use $a = (v-u)/t$ • measure distance and time • use stopclock and ruler • use (average) speed = distance / time • use $a = (v^2-u^2)/2s$ • plot graph of F against a detail of procedure • suspend weights from weight hanger to produce force • changing weights on hanger • keeping mass constant by moving weights between hanger and trolley • light gates/ticker(tape) timer/ultrasonic transducer used to measure acceleration/velocity/time • runway on slope so no (effect of) friction /so trolley rolls at constant speed (with no weights/force) • increase angle of slope to increase force • interrupter card for time through gate • final speed = 2 x average speed	(6) AO1

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1) Presents a description which is not logically ordered and with significant gaps. (AO1)
Level 2	3–4	Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1) Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing. (AO1)
Level 3	5–6	Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1) Presents a description that has a well-developed structure which is clear, coherent and logical. (AO1)



Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> isolated facts mention at least 2 isolated statements evidence may be seen in the diagram	<u>Possible candidate responses</u> add weights and use light gates
Level 2	3–4	<u>Additional guidance</u> limited procedure 1 detail of procedure and mention 1 other isolated statement evidence may be seen in the diagram	<u>Possible candidate responses</u> use light gates to measure acceleration/velocity/time and add weights
Level 3	5–6	<u>Additional guidance</u> detailed procedure 2 details of procedure and mention 1 other isolated statement evidence may be seen in the diagram	<u>Possible candidate responses</u> use light gates to measure acceleration/velocity/time and suspend weights from weight hanger to produce force and sloping runway

Total for Question 9 = 12 marks

	Answer	Additional guidance	Mark
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Question number	Indicative content		Mark
9 (b)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO2 (strand 2) (6 marks) <u>Determining force</u> • Use of $F = (mv - mu)/t$ or $F = ma$ • mass (of trolley(s)) needed • and times during impact (t) <u>Showing effect of crumple zone</u> • experiment repeated with and without the spring • (note) difference in contact times • use of spring as crumple zone • with spring, time for contact greater, less impact force <u>Precautions or controls</u> • times repeated and average taken • careful controls – same starting position / same angle of slope / release without pushing etc.		(6)Exp
Level	Mark	Descriptor	
	0	• No awardable content	
Level 1	1-2	• The explanation attempts to link and apply knowledge and understanding of scientific enquiry, techniques and procedures, flawed or simplistic connections made between elements in the context of the question. • Lines of reasoning are unsupported or unclear. (AO2)	
Level 2	3-4	• The explanation is mostly supported through linkage and application of knowledge and understanding of scientific enquiry, techniques and procedures, some logical connections made between elements in the context of the question. • Lines of reasoning mostly supported through the application of relevant evidence. (AO2)	
Level 3	5-6	• The explanation is supported throughout by linkage and application of knowledge and understanding of scientific enquiry, techniques and procedures, logical connections made between elements in the context of the question.	

		Lines of reasoning are supported by sustained application of relevant evidence. (AO2)
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SUMMARY, for guidance

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> Elements of physics present i.e. isolated knowledge of techniques and procedures – two unconnected statements from any section	<u>Possible candidate responses</u> Use $F = (mv - mu)/t$ Use $F = ma$ keep slope the same repeat and average use spring as crumple zone
Level 2	3–4	<u>Additional guidance</u> Some knowledge of techniques and procedures with a logical connection made in one section and statement from one more section	<u>Possible candidate responses</u> Measurements (difference in contact times) with and without the spring Use $F = ma$ in finding the force
Level 3	5–6	<u>Additional guidance</u> Detailed knowledge of techniques and procedures with logical connections made in two sections and statement from one more section	<u>Possible candidate responses</u> Measure the trolley mass(es)/ velocities/ impact time(s) and use $F = ma$ in finding the force Measurements (difference in contact times) with and without the spring Same starting place for trolley each time.

Question number	Answer	Additional guidance	Mark
9 (c)	An explanation linking any four from force(s) associated with change(s) in momentum (use of Newton's second law) (1) detail of momentum changes, involving time (1) time of collision is same for both (1) (therefore) momentum change is the same for both (1) equal and opposite forces mean equal and opposite momentum changes (1) (total) momentum before a collision = (total) momentum after collision (1) (conservation of momentum requires) no external forces acting (1)	$F = \frac{(mv - mu)}{t}$ $F = ma$ $\frac{m_1 v_1 - m_1 u_1}{t} = - \frac{(m_2 v_2 - m_2 u_2)}{t}$ with explanation leading to $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$ for both marks	(4) Exp

Total for Question 9 = 13 marks

