A Level Physics
Summer Independent Learning Activity

Welcome to A Level Physics, please complete the following tasks ready for your first day at New College. You can either write on the document electronically, print the document out or write your notes and answers on paper to bring in for your first lesson in September.

The activity is split into 4 sections:

TASK 1: GCSE Motion and Momentum Review

TASK 2: GCSE Motion and Momentum Questions

TASK 3: A Level Motion and Momentum Notes

TASK 4: A Level Motion and Momentum Exam Questions

TASK 5: Optional additional reading

Mark Schemes to the questions are found at the end of the document

Please be aware that you will have an **assessment** on these topics shortly after beginning your A level Physics course and the knowledge covered is essential to understanding the subsequent content.

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TASK 1: GCSE Motion and Momentum Review

Part 1. Read through the Bitesize pages on Motion.

https://www.bbc.co.uk/bitesize/guides/zwc7pbk/revision/1

Part 2. Read through the notes on Momentum.

https://www.bbc.co.uk/bitesize/guides/zytb8mn/revision/1

Part 3. Complete the notes on Motion and Momentum

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TASK 1: GCSE Motion and Momentum Review

2.01
Things that are described as being scalars have ……………………………………………………………………

2.02
Things that are described as being vectors have ……………………………………………………………………

2.03
The difference between a scalar and a vector is ……………………………………………………………………

………..

2.04
Are the following quantities scalars or vectors?

Acceleration	……….	Displacement	……….	Distance	……….	Energy	……….
Force	……….	Mass	……….	Momentum	……….	Power	……….
Speed	……….	Time	……….	Velocity	……….	Weight	……….

2.05
The difference between speed and velocity is that:

Speed has ………………………………

Velocity has ……………………………… and ……………………………………

A negative velocity would mean ………………………………………………………………………………………

………..

2.06
The equation that links the distance, speed and time taken for a moving object is:

1		d	Distance Travelled	
		s	Speed	
		t	Time Taken	

A high speed would mean ………………………………………………………………………………………

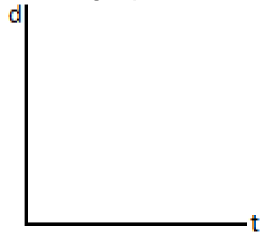
………..

A low speed would mean ……………………..……………………..……………………………………………

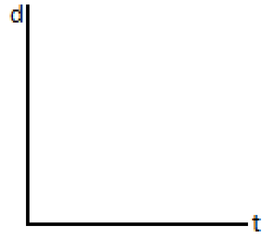
………..

2.07

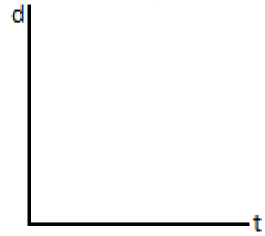
Distance-time graphs show us what happens to the distance travelled by an object as time passes.



Stationary



Constant Speed



Constant Acceleration

The gradient of a distance-time graph tells us ……………………………………………………………….…

2.08

The equation that links the acceleration, change in velocity and time taken for a moving object is:

2		a	Acceleration	
		Δv	Change in Velocity	
		t	Time Taken	

A negative acceleration would mean …………………………………………..…………………………………

………..

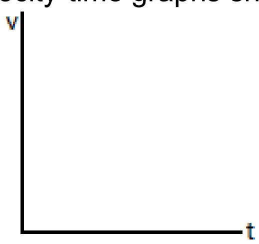
2.09

We can use the following equation:

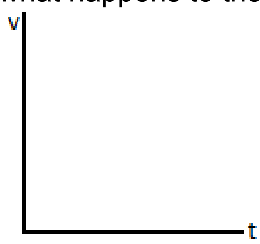
22	$v^2 - u^2 = 2 \times a \times d$	a	Acceleration	
		d	Distance	
		v	Final Velocity	
		u	Start Velocity	

2.10

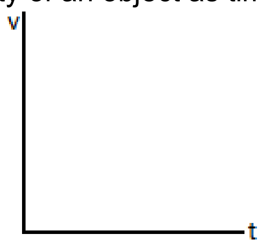
Velocity-time graphs show us what happens to the velocity of an object as time passes.



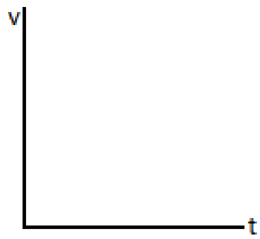
Stationary



Constant Velocity



Constant Acceleration



Constant Deceleration

The gradient of a velocity-time graph tells us ……………………………………………………………….…

The area under a velocity-time graph tells us ……………………………………………………………….…

You can work out the gradient (or steepness) of a line by ……………………………………………………

………..……..

The formula for working out the area of a triangle is …………………………………………………………………

2.11

You can calculate the average speed that something is travelling at by measuring the distance travelled with a ……………………………. and the time taken with a ……………………………. .

The biggest source of error using this method is ……….……………………………………………….…………

……….……..

You can also use light gates connected to a computer. When the object passes through the first light gate an electronic timer ………………. and when it passes through the second it …………………. the timer. We would also need to measure the ………………………………………………………………………………

2.12

Match these typical speeds to the correct movements, they are all in m/s.

1.3	3	4.6	6	30	70	250	330

Aeroplanes	……………..	Car	……………..	Cycling	……………..	Running	……………..
Sound in air	……………..	Trains	……………..	Walking	……………..	The wind	……………..

2.13

When an object is dropped we say that it is in freefall and it's acceleration, g, is roughly …………….. m/s^2.

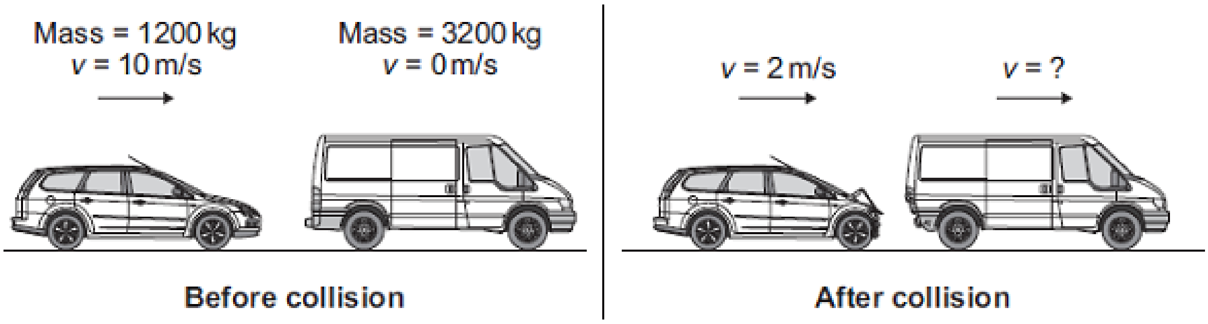
2.24

The equation that links mass, momentum and velocity is:

5		m	Mass	
		p	Momentum	
		v	Velocity	

Momentum depends on velocity so it is a ………………………………………… quantity.

2.25*



The momentum of the car before the collision is ……………………………………………………………….

The momentum of the van before the collision is ……………………………………………………………….

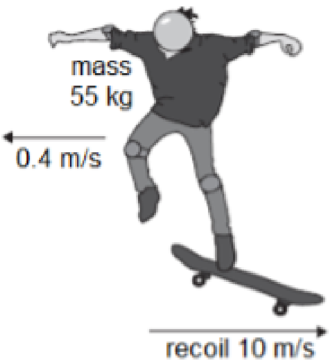
The total momentum before the collision is ……………………………………………………………….

The total momentum after the collision is ……………………………………………………………….

The momentum of the car after the collision is ……………………………………………………………….

The momentum of the van after the collision is ……………………………………………………………….

The velocity of the van after the collision is ……………………………………………………………….



The skateboarder is stationary before jumping off of the skateboard.

The momentum before he jumps off is …………

The total momentum of the skateboarder and skateboard after is …………

The skateboard moves at a higher speed than the skateboarder because

…………………………………………………………………………………………

…………………………………………………………………………………………

The momentum of the skateboarder after he jumps off is …………………………………………………………..

The mass of the skateboard is ……………………………………………………………………………………

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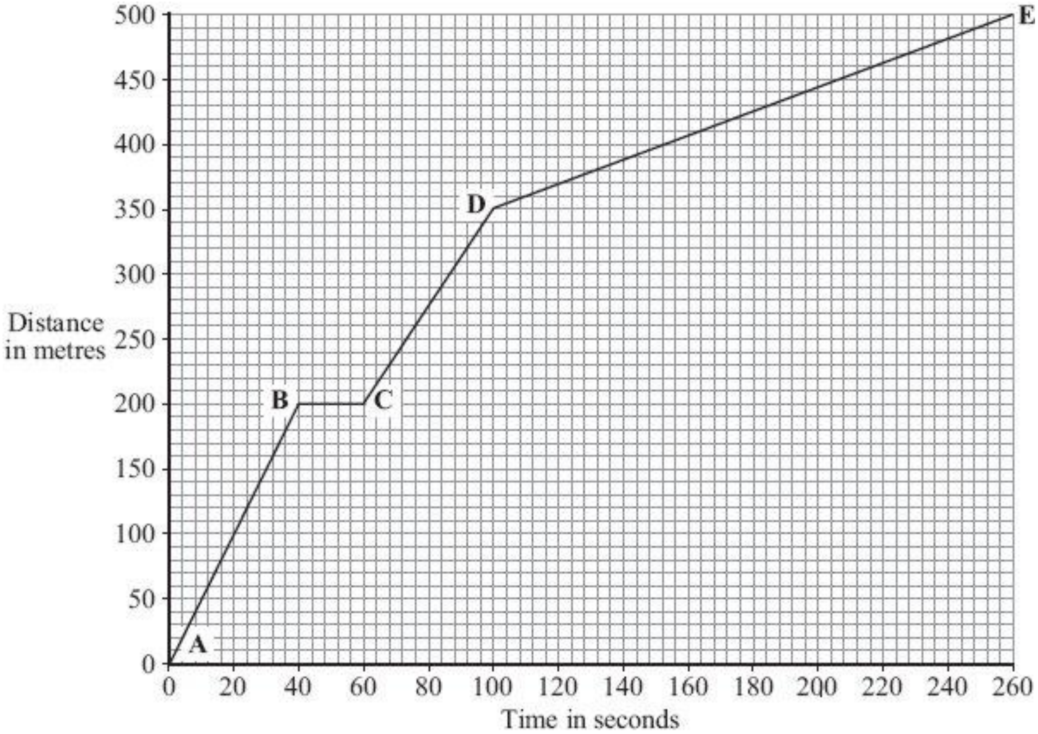
TASK 2: GCSE Motion and Momentum Questions

Motion

Q1. Part of a bus route is along a high street.

The distance – time graph shows how far the bus travelled along the high street and how long it took.



Q1(a) The bus travels the **slowest** between points **D** and **E**.

How can you tell this from the graph?

....

.... **(1)**

Q1(b) Between which two points was the bus travelling the **fastest**?

Put a tick (✓) in the box next to your answer.

Points	
A – B	
B – C	
C – D	

(1)

Q1(c) There is a bus stop in the high street. This is marked as point **B** on the graph.

Q1(ci) What is the distance between point **A** on the graph and the bus stop?

Distance .... metres **(1)**

Q1(cii) How long did the bus stop at the bus stop? Show clearly how you work out your answer.

....

Time = ... seconds **(2)**

Q1(d) A cyclist made the same journey along the high street.
The cyclist started at the same time as the bus and completed the journey in 200 seconds. The cyclist travelled the whole distance at a constant speed.

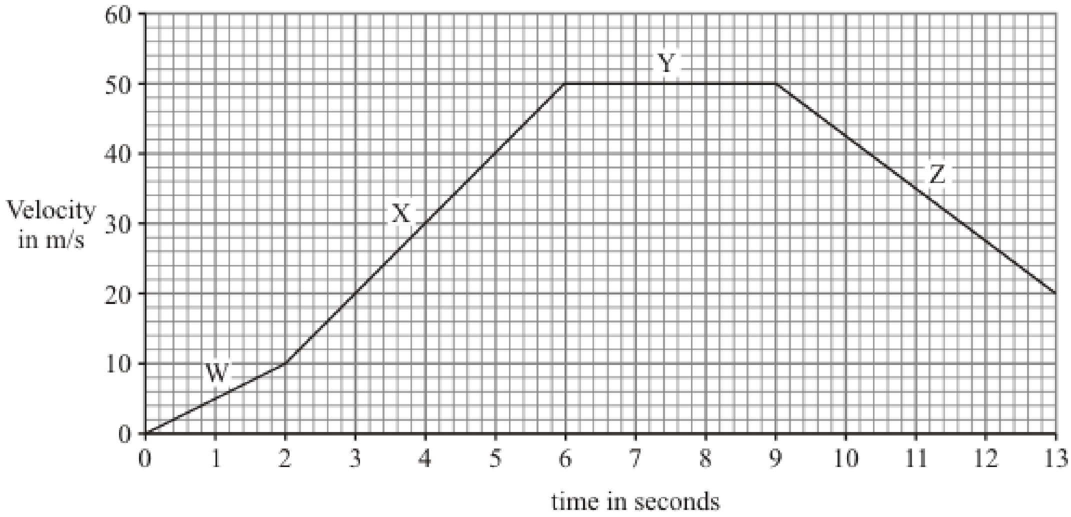
Q1(di) Draw a line on the graph to show the cyclist's journey.

(2)

Q1(dii) After how many seconds did the cyclist overtake the bus?

The cyclist overtook the bus after .... seconds. **(1)**
(Total 8 marks)

Q2. The graph shows changes in the velocity of a racing car.



Q2(a) Describe the motion of the racing car during:

Q2(ai) the period labelled **W**;

....

.... **(1)**

Q2(aii) the period labelled **Y**.

....

.... **(1)**

Q2(b) Calculate the acceleration of the racing car during the period labelled **X**.
Show clearly how you work out your answer and give the unit.

....

....

....

....

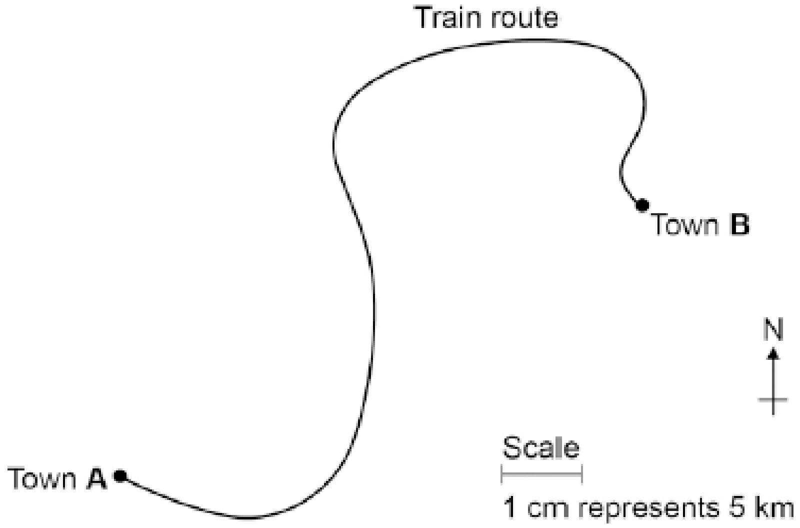
....

Acceleration = ... **(4)**

Q2(c) A train travels from town **A** to town **B**.

Figure 1 shows the route taken by the train. **Figure 1** has been drawn to scale.

Figure 1



Q2(ci) The distance the train travels between **A** and **B** is not the same as the displacement of the train.
What is the difference between distance and displacement?

....

.... **(1)**

Q2(cii) Use **Figure 1** to determine the displacement of the train in travelling from **A** to **B**.
Show how you obtain your answer.

....

....

Displacement = ... km Direction = ... **(2)**

Q2(ciii) There are places on the journey where the train accelerates without changing speed.
Explain how this can happen.

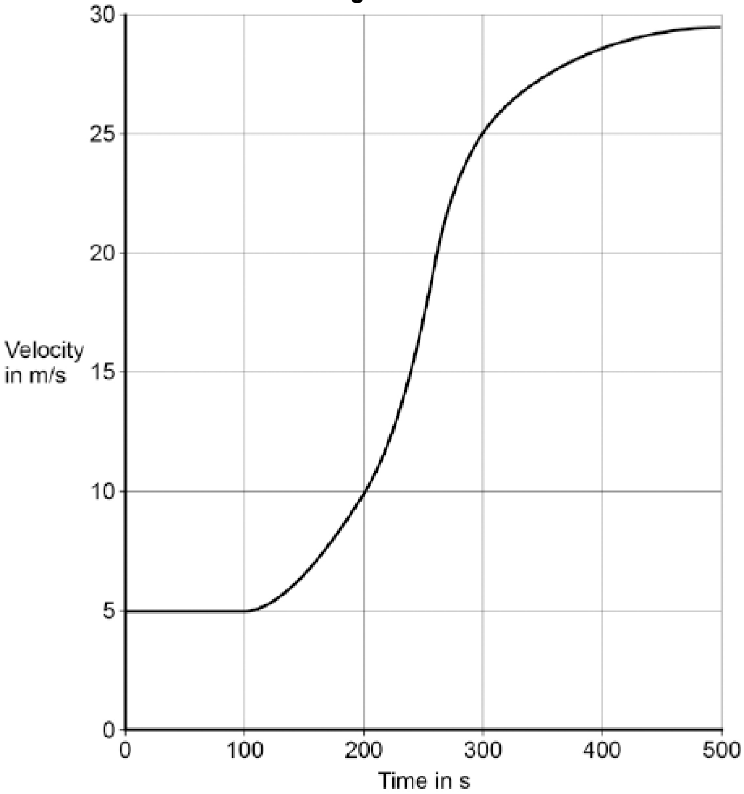
....

....

.... **(2)**

Q2(civ) **Figure 2** shows how the velocity of the train changes with time as the train travels along a straight section of the journey.

Figure 2



Estimate the distance travelled by the train along the section of the journey shown in **Figure 2**.

To gain full marks you must show how you worked out your answer.

....

....

....

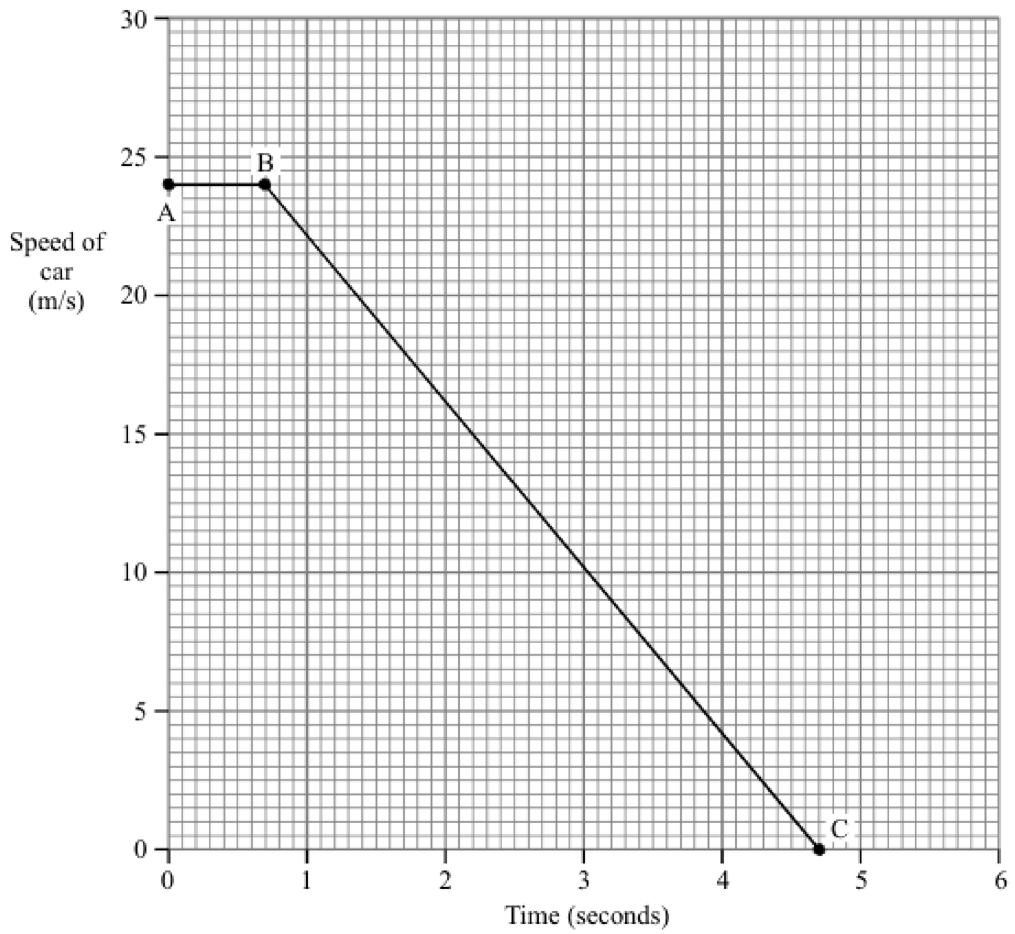
....

Distance = ... m **(3)**

(Total 14 marks)

Q3. A car driver sees a dog on the road ahead and has to make an emergency stop.

The graph shows how the speed of the car changes with time after the driver first sees the dog.



Q3(ai) What is the thinking time of the driver?

Time .... seconds **(1)**

Q3(aii) Calculate the distance travelled by the car in this thinking time.

....

....

....
....

Distance .... m **(3)**

Q3(b) Calculate the acceleration of the car after the brakes are applied.

....

....

....

....

Acceleration .... **(4)**

Q3(c) Calculate the distance travelled by the car during braking.

....

....

....

....

Distance .... m **(3)**

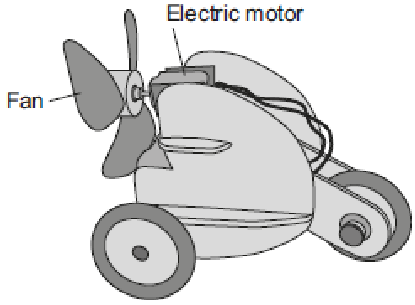
(Total 11 marks)

Momentum and Collisions

Q1. The diagram shows an air-driven toy.

When the electric motor is switched on the fan rotates.

The fan pushes air backwards making the toy move forwards.



Q1(ai) The toy has a mass of 0.15 kg and moves forward with a velocity of 0.08 m/s.

How is the momentum of the toy calculated? Tick (✓) **one** box.

$0.15 + 0.08 = 0.230$ ☐

$0.15 \div 0.08 = 1.875$ ☐

$0.15 \times 0.08 = 0.012$ ☐

(1)

Q1(aii) What is the unit of momentum? Tick (✓) one box.

kg m/s ☐ m/s^2 ☐ kg/m/s ☐

(1)

Q1(aiii) Use the correct answer from the box to complete the sentence.

less than	**equal to**	**more than**

The momentum of the air backwards is .... the momentum of the toy forwards. **(1)**

Q1(b) The electric motor can rotate the fan at two different speeds.

Explain why the toy moves faster when the fan rotates at the higher of the two speeds.

....

....

.... **(2)**

Q1(c) A paintball gun is used to fire a small ball of paint, called a paintball, at a target.

The figure below shows someone just about to fire a paintball gun. The paintball is inside the gun.

Q1(ci) What is the momentum of the paintball before the gun is fired?

....

Give a reason for your answer.

....

.... **(2)**

Q1(cii) The gun fires the paintball forwards at a velocity of 90 m / s. The paintball has a mass of 0.0030 kg.

Calculate the momentum of the paintball just after the gun is fired.

....

....

Momentum = ... kg m / s **(2)**

Q1(ciii) The momentum of the gun and paintball is conserved.

Use the correct answer from the box to complete the sentence.

equal to	**greater than**	**less than**

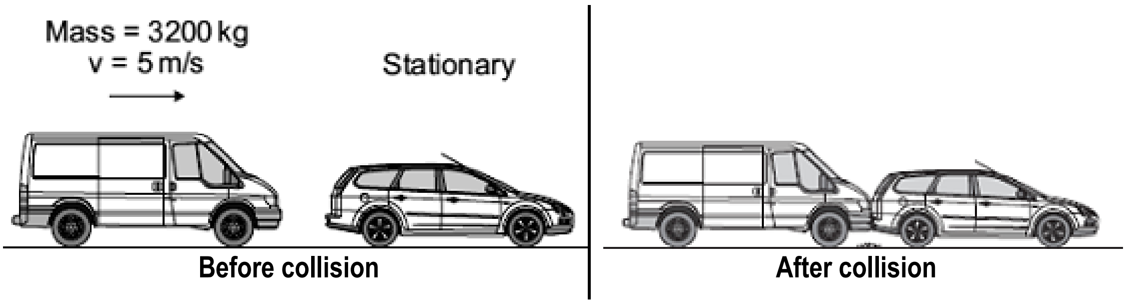
The total momentum of the gun and paintball just after the gun is fired will be ....

the total momentum of the gun and paintball before the gun is fired.

(1)

(Total 10 marks)

Q2(a) A van has a mass of 3200 kg. The diagram shows the van just before and just after it collides with the back of a car.



Just before the collision, the van was moving at 5 m/s and the car was stationary.

Q2(ai) Calculate the momentum of the van just before the collision.

Show clearly how you work out your answer.

....

....

Momentum = ... kg m/s **(2)**

Q2(aii) The collision makes the van and car join together.

What is the total momentum of the van and the car just after the collision?

Momentum = ... kg m/s **(1)**

Q2(aiii) Complete the following sentence by drawing a ring around the correct line in the box.

The momentum of the car before the collision is	more than the same as less than	the momentum of the car after the collision.

(1)

Q2(b) A seat belt is one of the safety features of a car. In a collision, wearing a seat belt reduces the risk of injury.

Use words or phrases from the box to complete the following sentences.

decreases	**stays the same**	**increases**

In a collision, the seat belt stretches. The time it takes for the person held by the seat belt to lose momentum compared

to a person not wearing a seat belt, ...

The force on the person's body .... and so reduces the risk of injury.

(2)

Q2(c) Complete the following sentence.

The momentum of a moving object has a magnitude, in kg m/s, and a .... **(1)**

Q2(d) A car being driven at 9.0 m/s collides with the back of a stationary lorry.

The car slows down and stops in 0.20 seconds. The total mass of the car and driver is 1200 kg.

Calculate the average force exerted by the lorry on the car during the collision.

Show clearly how you work out your answer.

....

....

Force = ... N **(2)**

Q2(e) Within 0.04 s of the car hitting the back of the lorry, the car driver's airbag inflates.

The airbag deflates when it is hit by the driver's head.

Use the idea of momentum to explain why the airbag reduces the risk of the drive sustaining a serious head injury.

....

....

....

....

....

....

.... **(3)**

(Total 12 marks)

Q3(a) In any collision, the total momentum of the colliding objects is usually conserved.

Q3(ai) What is meant by the term 'momentum is conserved'?

....

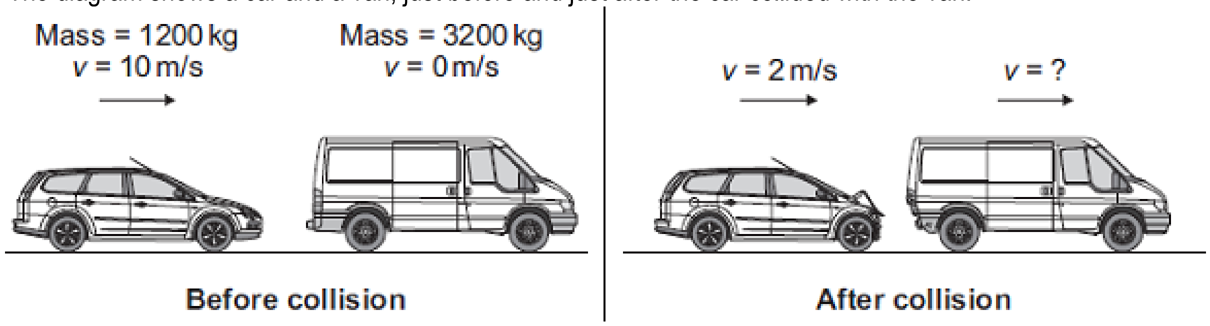
.... **(1)**

Q3(aii) In a collision, momentum is **not always** conserved. Why?

....

.... **(1)**

Q3(b) The diagram shows a car and a van, just before and just after the car collided with the van.



Q3(bi) Use the information in the diagram to calculate the **change** in the momentum of the car.
Show clearly how you work out your answer and give the unit.

....

....

....

Change in momentum = ... **(3)**

Q3(bii) Use the idea of conservation of momentum to calculate the velocity of the van when it is pushed forward by the collision.
Show clearly how you work out your answer.

....

....

....

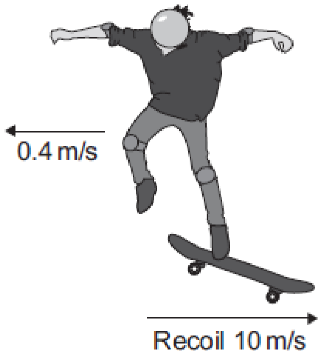
Velocity = ... m/s forward **(2)**

Q3(c) The picture shows two teenagers riding identical skateboards.
The skateboards are moving at the same speed and the teenagers have the same mass.

Why do the teenagers **not** have the same momentum?

.... **(1)**

Q3(d) One of the skateboards slows down and stops. The teenager then jumps off the skateboard, causing it to recoil and move in the opposite direction.



The momentum of the teenager and skateboard is conserved.

Q3(di) What is meant by 'momentum being conserved'?

....

.... **(1)**

Q3(dii) The teenager, of mass 55 kg, jumps off the skateboard at 0.4 m/s causing the skateboard to recoil at 10 m/s. Calculate the mass of the skateboard.

....

....

....

Mass = ... kg **(3)**

Q3(e) Once the skateboard starts to recoil, it soon slows down and its kinetic energy decreases. Explain why.

....

....

....

.... **(2)**

(Total 14 marks)

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TASK 3: A Level Motion and Momentum Notes

Read through the notes on Motion and Momentum.

Make some recap notes in the space provided.

The following videos will also support you:

Motion Graphs
https://www.youtube.com/watch?v=ChznfOdMQp4&list=PLvIMtj4KguoutIk9Xs6vKzvbu6Z4P9tLs&index=3

Momentum calculations
https://www.youtube.com/watch?v=ggH-0WdL2tg&list=PLPGeQVIY9RvNhMAqUqiifyc-L_fDovpH_&index=22

Momentum Theory
https://www.youtube.com/watch?v=xrK4LCL8oZY&list=PLGvD8d3gDHUVgyxA8evex35dWdWpl47k3&index=9

Motion

Distance is the length of a journey but displacement is the shortest distance from the start to the finish.
Speed is the distance covered in each second but velocity is the displacement covered in each second.
Distance and speed are scalar quantities whereas displacement and velocity are vector quantities.

Velocity

Velocity is the rate of change of displacement; it can be calculated using the equation:

$$v = \frac{\Delta s}{\Delta t}$$

- Δs is the change in displacement, measured in metres, m.
- Δt is the time taken (to cover this displacement), measured in seconds, s.
- v is the velocity, measured in metres per second, m s^{-1}.

A negative velocity means that the velocity is in the opposite direction compared to a positive velocity.

Acceleration

Acceleration is the rate of change of velocity; it can be calculated using the equation:

$$a = \frac{\Delta v}{\Delta t}$$

- Δv is the change in velocity, measured in metres per second, m s^{-1}.
- Δt is the time taken (to change the velocity), measured in seconds, s.
- a is the acceleration, measured in metres per second squared, m s^{-2}.

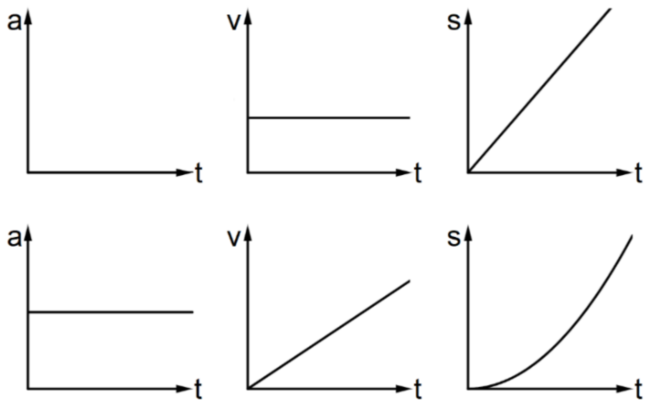
A negative acceleration would mean acceleration in the negative direction or could be thought of as deceleration in the positive direction.

When an object moves in a circle at a constant speed it is accelerating.
Since the object is changing direction it is changing its velocity.
Since it is changing its velocity (in a certain amount of time) it is accelerating.

Uniform acceleration is when the velocity changes by the **same** amount every second; acceleration has a constant value.

Non-uniform acceleration is when the velocity changes by a **different** amount every second; acceleration does not have a constant value.

Graphs



The **gradient** of a displacement-time graph is equal to the velocity at that time.

The **gradient** of a velocity-time graph is equal to the acceleration at that time.

The **area under** a velocity-time graph is equal to the change in displacement during that time.

The **area under** an acceleration-time graph is equal to the change in velocity during that time.

Average and Instantaneous

The average velocity over a journey is calculated using the total displacement and dividing by the total time.
The instantaneous velocity is the velocity at a certain instant; it is how fast the object is moving at that moment. It is calculated from the gradient of a displacement-time graph at that time (or moment).
To calculate the gradient from a curved section you first need to draw a tangent at the appropriate time value and then calculate the gradient of your tangent.

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My notes on **Motion**	
Questions (2. After writing your notes, what questions could you be asked?)	My notes (1. Write your notes here)
Summary (3. Definitions I must learn, key ideas I must remember).	

Momentum and Collisions

Momentum is a quantity that moving objects have and can be calculated using the equation:

$$p = mv$$

p is the momentum, measured in kilogram metres per second, kg m s^{-1}.

m is the mass of the object, measured in kilograms, kg.

v is the velocity the object is moving at, measured in metres per second, m s^{-1}.

Momentum is a vector quantity so a negative momentum means a momentum in the opposite direction to a positive momentum.

Conservation of Momentum

The total momentum before* is equal to the total momentum after*. * a collision or an explosion.

The conservation of momentum applies when no external forces act or 'in a closed system'.

The total momentum can be calculated by calculating the individual momentums of each object and adding them together.

Collisions

If two objects collide in an **elastic** collision the momentum and the kinetic energy are conserved.

If two objects collide in an **inelastic** collision the momentum in conserved but the **kinetic energy** isn't.

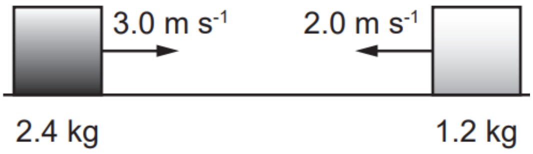
Exam questions might show a wide range of scenarios but the conservation of momentum will be able to be applied in every one. Remember that one direction is positive and the other is negative.
ne object collides with a stationary object.

* One object catches up to another object and collides into the back of it.
* Two objects collide head-on.

After:

* The objects move in opposite directions.
* The objects move in the same direction.
* The objects join together (and move in the same direction).
* The colliding object is now stationary.

Example

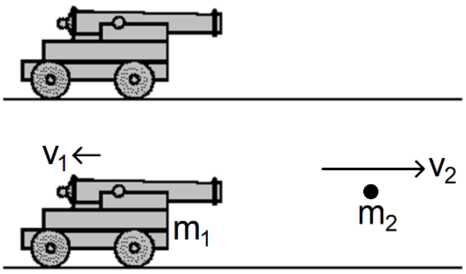


The dark and light blocks collide into each other head-on. Let us have moving to the right as having a positive velocity.

Total momentum before = (m × v for dark block) + (m × v for light block)
= (2.4 × 3.0) + (1.2 × –2.0) = 7.2 – 3.2 = 4 kg m s^{-1}

Regardless of how the blocks move after the collision the total momentum of the two blocks will be 4 kg m s^{-1}; the same as the total momentum before the collision.

Explosions



The total momentum before the explosion is zero since the cannon and the ball are stationary.

The positive momentum gained by the ball is equal in size to the negative momentum gained by the cannon.

$$0 = (m_1 \times -v_1) + (m_2 \times v_2) \;\rightarrow\; m_1 v_1 = m_2 v_2$$

The kinetic energy comes from the chemical energy of the gun powder exploding.

A person jumping from a skateboard would be classed as an explosion in terms on momentum; the person would move in one direction and the skateboard in the other, each with the same magnitude of momentum.

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My notes on **Momentum and Collisions**	
Questions (2. After writing your notes, what questions could you be asked?)	My notes (1. Write your notes here)
Summary (3. Definitions I must learn, key ideas I must remember).	

TASK 4: A Level Motion and Momentum Exam Questions

Motion

Q1. A girl jogs at 2.0 m s^{-1} in a straight line for 30 seconds, turns around and returns to her starting point 20 seconds later.

What is her average velocity and average speed?

	Average velocity/m s^{-1}	Average speed/m s^{-1}	
A	0 m s^{-1}	2.4 m s^{-1}	⬭
B	0 m s^{-1}	2.5 m s^{-1}	⬭
C	1.0 m s^{-1}	2.0 m s^{-1}	⬭
D	2.5 m s^{-1}	2.5 m s^{-1}	⬭

(Total 1 mark)

Q2. A horse starts walking from point **X** on a circular track of circumference 60 m. The speed of the horse is a constant 2.0 m s^{-1}.

What is the horse's displacement from **X** after 45 s?

A 19 m ⬭

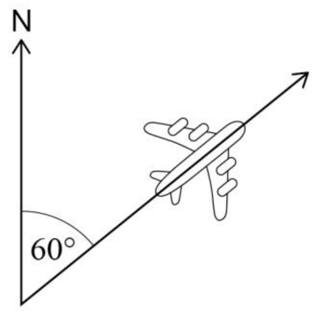
B 30 m ⬭

C 38 m ⬭

D 90 m ⬭

(Total 1 mark)

Q3. An aeroplane flies horizontally at 150 m s^{-1} along a bearing 60° east of north.



How far north from its starting position is the aeroplane after one hour?

A 270 km ⬭

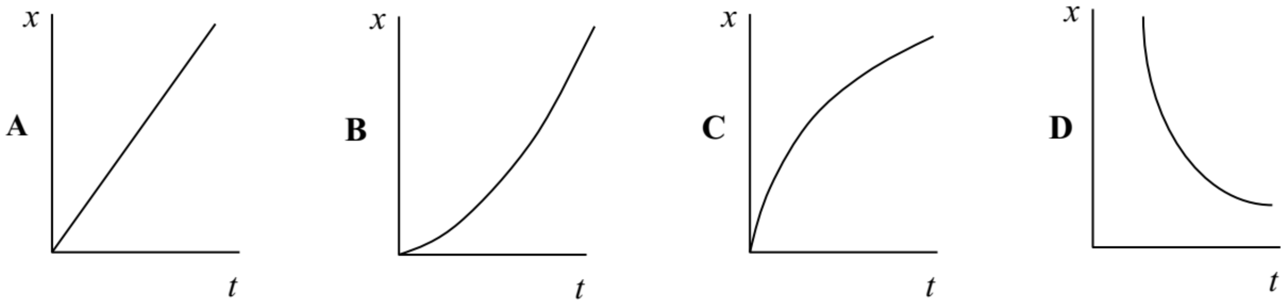
B 470 km ⬭

C 510 km ⬭

D 540 km ⬭

(Total 1 mark)

Q4. A car accelerates uniformly from rest along a straight road. Which graph shows the variation of displacement x of the car with time t?



A ☐

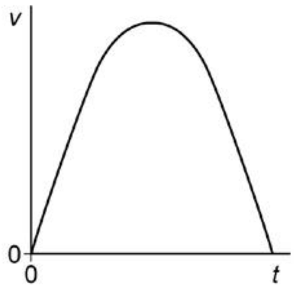
B ☐

C ☐

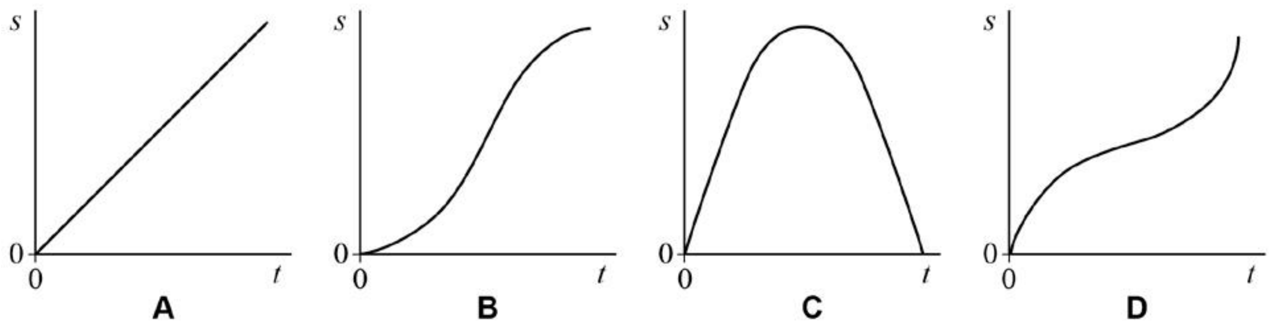
D ☐

(Total 1 mark)

Q5. A body travels with speed v, which varies with time t as shown in the graph.



Which one of the graphs, **A** to **D**, shows how the distance s covered by the body varies with time t?



A ☐

B ☐

C ☐

D ☐

(Total 1 mark)

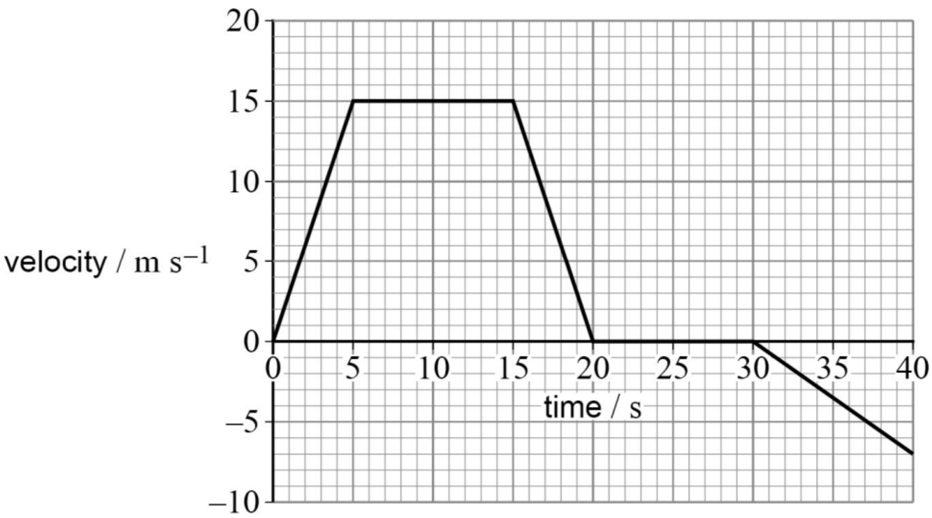
Q6. Which row gives two features of graphs that provide the same information?

	Feature 1	Feature 2	
A	Gradient of a displacement–time graph	Area under a velocity–time graph	⬭
B	Gradient of a displacement–time graph	Area under an acceleration–time graph	⬭
C	Gradient of a velocity–time graph	Area under a displacement–time graph	⬭
D	Gradient of a velocity–time graph	Area under an acceleration–time graph	⬭

(Total 1 mark)

Q7. A vehicle travels on a straight road, starting at time t = 0

The graph shows how its velocity varies with time.



What is the distance of the vehicle from its start position when t = 40 s?

A	115 m	⬭
B	190 m	⬭
C	260 m	⬭
D	370 m	⬭

(Total 1 mark)

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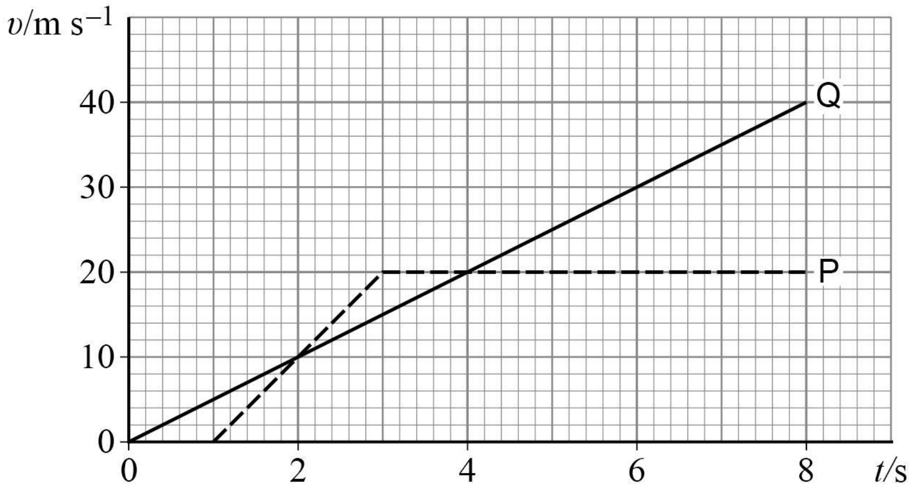
Q8. Two cars **P** and **Q** leave from the same point and travel in the same direction.

Q leaves at time t = 0 and **P** leaves one second later.

The figure shows the velocity–time graph for **P** and **Q**.

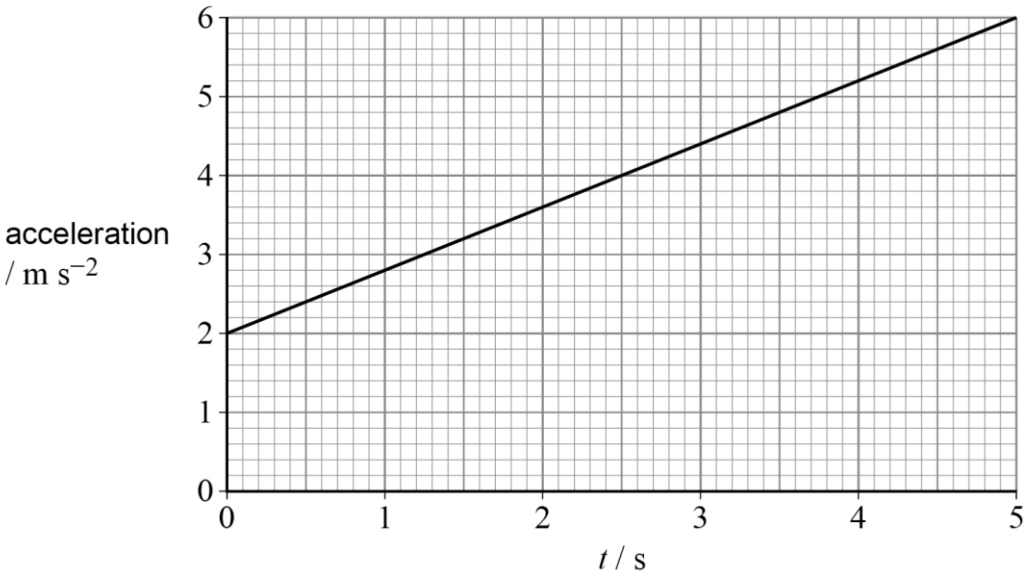


What is the distance between **Q** and **P** when t = 8 s?

A	40 m	⬭
B	80 m	⬭
C	160 m	⬭
D	180 m	⬭

(Total 1 mark)

Q9. The graph shows the variation with time t of the acceleration of an object moving in a straight line.



When t = 0 the speed of the object is 4.0 m s^{-1}.

What is the speed of the object when t = 5.0 s?

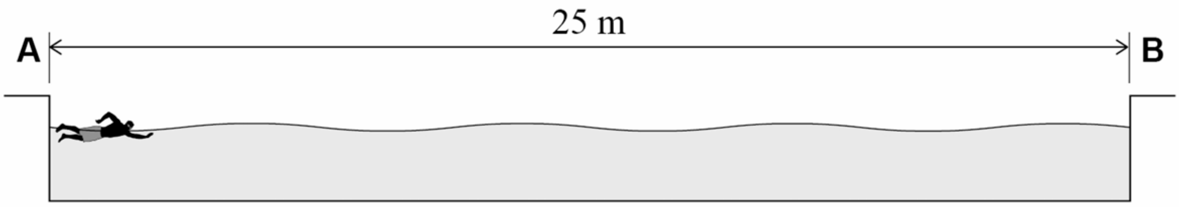
A	10 m s^{-1}	⬭
B	14 m s^{-1}	⬭
C	20 m s^{-1}	⬭
D	24 m s^{-1}	⬭

(Total 1 mark)

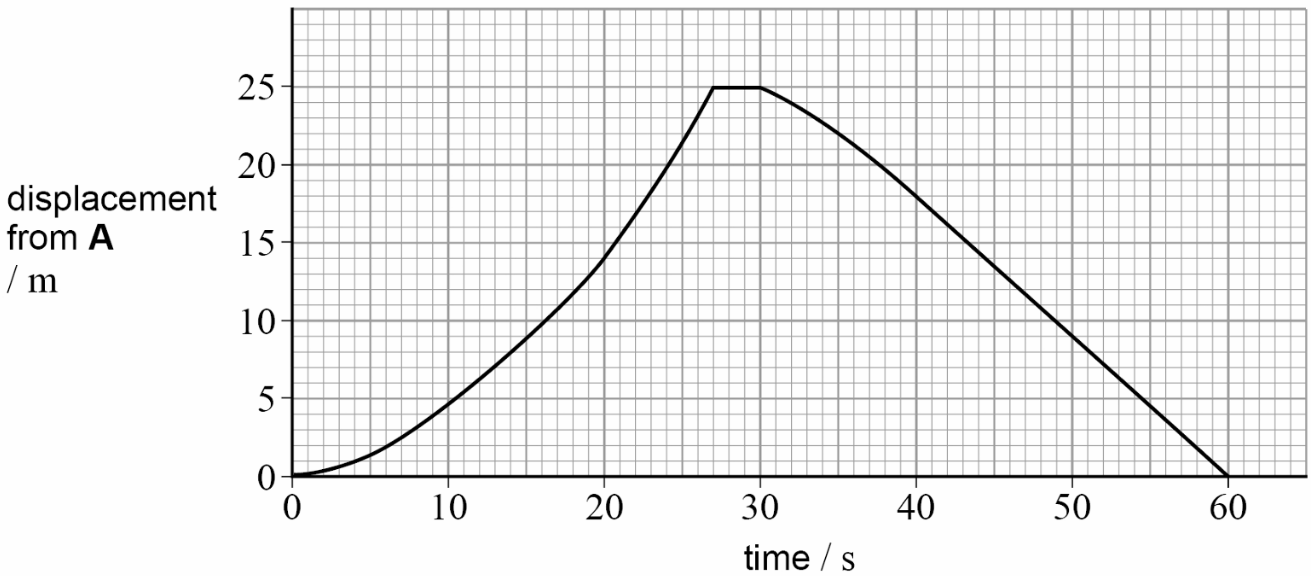
Q10 The diagram shows a boy swimming in a pool.

The boy swims in a straight line from point **A** to point **B** and then returns.

The distance from **A** to **B** is 25 m.



The graph shows the variation with time of the boy's displacement from **A**.



Calculate the average speed and average velocity of the boy during the first 50 s of his swim.

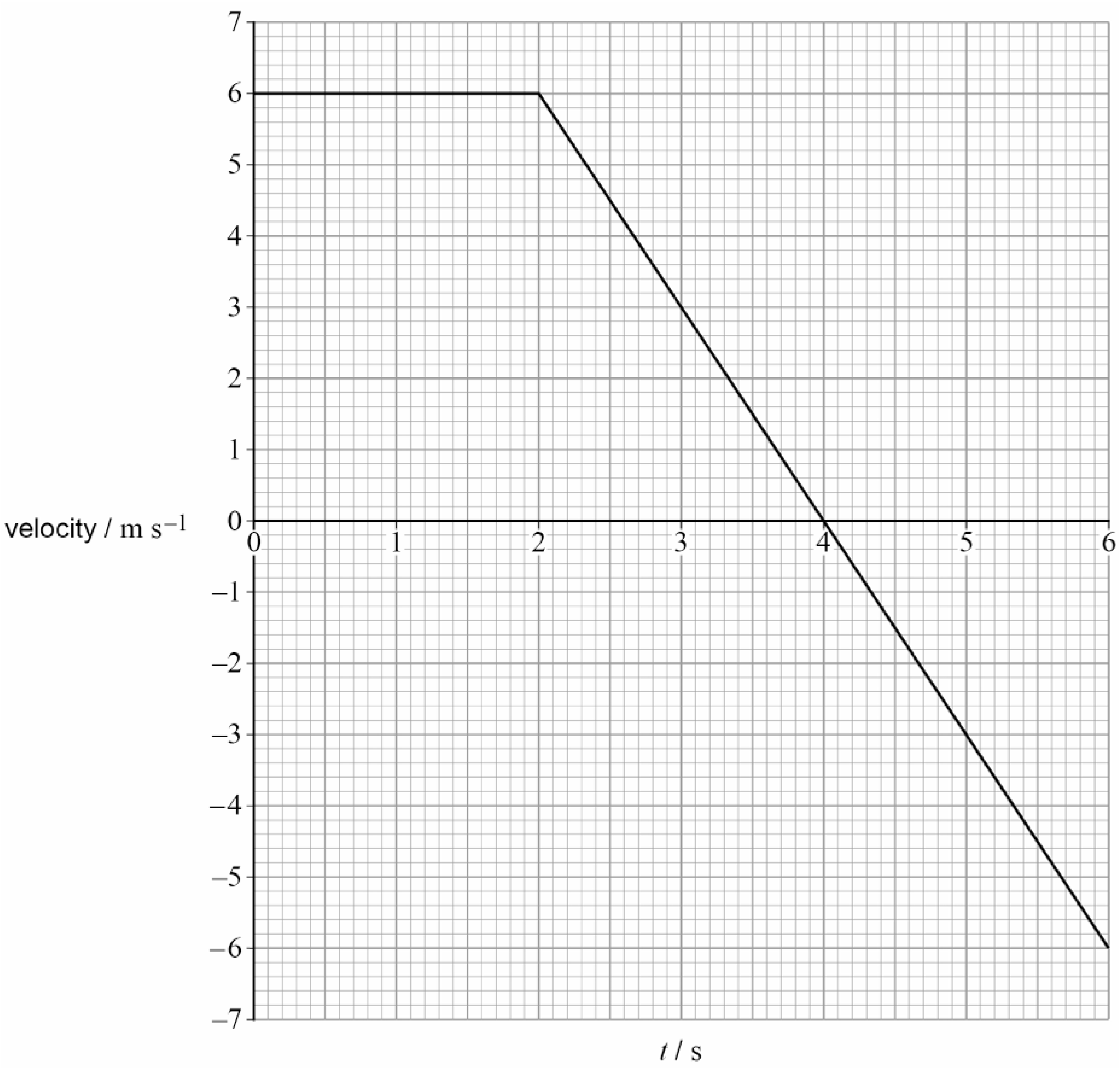
average speed = ______________________ m s^{-1}

magnitude of average velocity = ______________________ m s^{-1}

direction of average velocity = ______________________ **(5)**

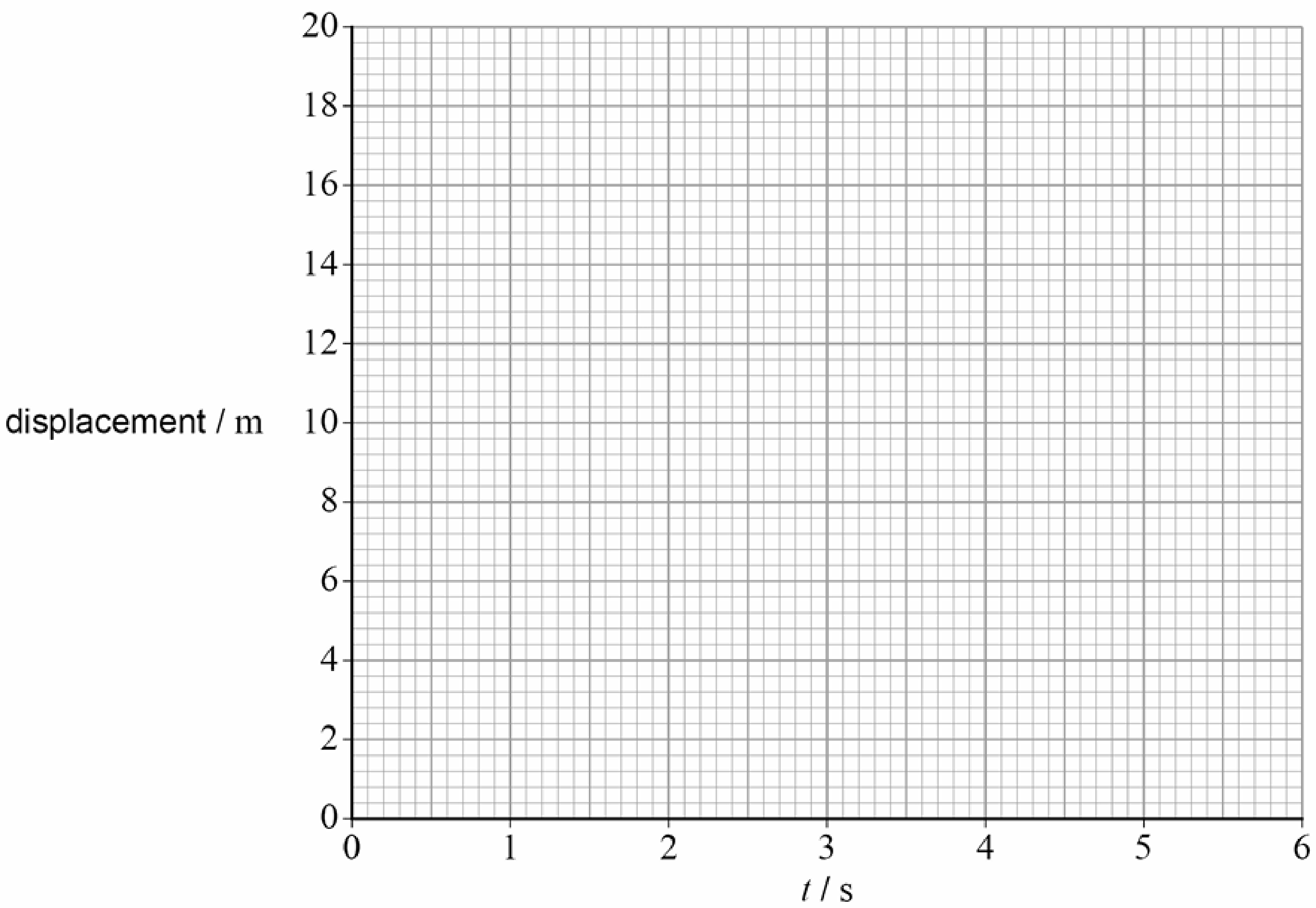
Q11 **Figure 1** is a velocity–time graph for a moving object. The displacement of the object is zero at time t = 0

Figure 1



Plot, on **Figure 2**, the displacement–time graph for the object between 0 and 6 s.

Figure 2

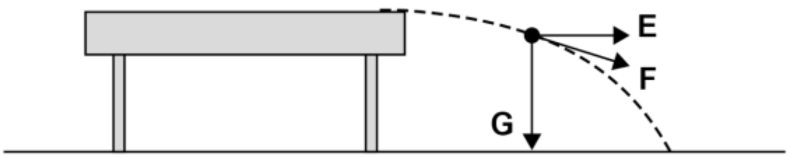


(4)

Momentum

Q1. A coin is projected horizontally from the top of a desk.

The diagram shows the coin at one point in its path. The air resistance is negligible.



The arrows **E**, **F** and **G** represent different directions.

Which row gives the direction of the acceleration and the direction of the momentum of the coin at this point?

	Acceleration	Momentum	
A	**F**	**F**	⬭
B	**F**	**E**	⬭
C	**G**	**F**	⬭
D	**G**	**E**	⬭

(Total 1 mark)

Q2. Which row is true for an elastic collision between two objects in an isolated system?

	Kinetic energy	Momentum	
A	conserved	conserved	⬭
B	not conserved	conserved	⬭
C	conserved	not conserved	⬭
D	not conserved	not conserved	⬭

(Total 1 mark)

Q3. What is true for an inelastic collision between two isolated objects?

A Both total momentum and total kinetic energy are conserved. ⬭

B Neither total momentum nor total kinetic energy is conserved. ⬭

C Only total kinetic energy is conserved. ⬭

D Only total momentum is conserved. ⬭

(Total 1 mark)

Q4. A railway truck of mass 2000 kg travelling horizontally at 1.5 m s^{-1} collides with a stationary truck of mass 3000 kg.

After the collision they move together.

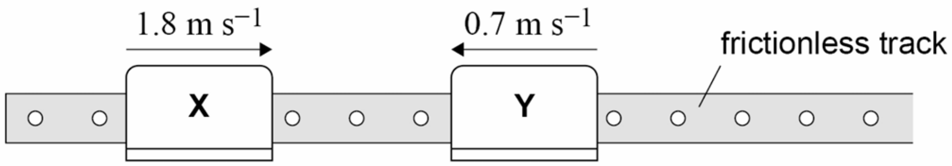
Which row is correct?

	Speed of the trucks immediately after collision / m s^{-1}	Effect of collision on total kinetic energy	
A	0.6	no change	⬭
B	0.6	decrease	⬭
C	1.0	no change	⬭
D	1.0	decrease	⬭

(Total 1 mark)

Q5. Glider **X** of mass 400 g travels at 1.8 m s^{-1} to the right on a horizontal, frictionless track.

Glider **Y** of mass 300 g travels towards **X** at 0.7 m s^{-1}.



X and **Y** collide.

Immediately after the collision, **Y** travels to the right at a speed of 0.9 m s^{-1}.

What are the speed and direction of movement of **X** immediately after the collision?

A 0.6 m s^{-1} to the left ⬭

B 0.6 m s^{-1} to the right ⬭

C 1.7 m s^{-1} to the left ⬭

D 1.7 m s^{-1} to the right ⬭

(Total 1 mark)

Q6. A car of mass 580 kg collides with the rear of a stationary van of mass 1200 kg.

Following the collision, the van moves with a velocity of 6.20 m s^{-1} and the car recoils in the opposite direction with a velocity of 1.60 m s^{-1}.

What is the initial speed of the car?

A	5.43 m s^{-1}	⬭
B	11.2 m s^{-1}	⬭
C	12.8 m s^{-1}	⬭
D	14.4 m s^{-1}	⬭

(Total 1 mark)

Q7. A bullet of mass 10 g is fired with a velocity of 100 m s^{-1} from a stationary rifle of mass 4.0 kg. Consider the rifle and bullet to be an isolated system.

What are the recoil velocity of the rifle and the total momentum of the rifle and bullet just after firing?

	Recoil velocity / m s^{-1}	Total momentum / kg m s^{-1}	
A	0.25	0	⬭
B	0.25	1.0	⬭
C	0.40	0	⬭
D	0.40	1.0	⬭

(Total 1 mark)

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TASK 5: Optional Additional Reading

An interesting read beyond the specification

Regenerative Brakes

Reynolds Number

Important people connected to this topic

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Task 1 Mark Schemes

2.01

Things that are described as being scalars have a size

2.02

Things that are described as being vectors have a size and a direction

2.03

The difference between a scalar and a vector is vectors have direction but scalars don't

2.04

Are the following quantities scalars or vectors?

Acceleration	V	Displacement	V	Distance	S	Energy	S
Force	V	Mass	S	Momentum	V	Power	S
Speed	S	Time	S	Velocity	V	Weight	V

2.05

The difference between speed and velocity is that:

Speed has size

Velocity has size and direction

A negative velocity would mean the object is moving in the opposite direction

2.06

The equation that links the distance, speed and time taken for a moving object is:

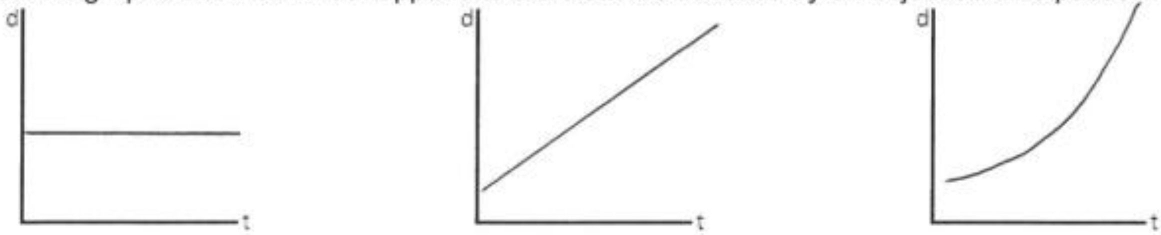
1	$s = \frac{d}{t}$	d	Distance Travelled	m
		s	Speed	m/s
		t	Time Taken	s

A high speed would mean a large distance travelled in a short time

A low speed would mean a small distance travelled in a large time

2.07

Distance-time graphs show us what happens to the distance travelled by an object as time passes.



Stationary | Constant Speed | Constant Acceleration

2.08

The equation that links the acceleration, change in velocity and time taken for a moving object is:

2	$a = \frac{\Delta v}{t}$	a	Acceleration	m/s^2
		Δv	Change in Velocity	m/s
		t	Time Taken	s

A negative acceleration would mean the object is decelerating / the object is slowing down / the object is speeding up in the opposite direction

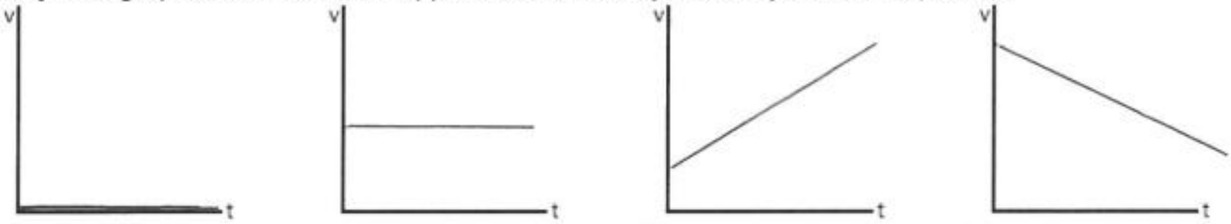
2.09

We can use the following equation:

22	$v^2 - u^2 = 2 \times a \times d$	a	Acceleration	m/s^2
		d	Distance	m
		v	Final Velocity	m/s
		u	Start Velocity	m/s

2.10

Velocity-time graphs show us what happens to the velocity of an object as time passes.



Stationary | Constant Velocity | Constant Acceleration | Constant Deceleration

The gradient of a velocity-time graph tells us the acceleration

The area under a velocity-time graph tells us the distance travelled

You can work out the gradient (or steepness) of a line by the change in the y axis divided by the change in the x axis

The formula for working out the area of a triangle is $\frac{1}{2} \times$ base $\times$ height

2.11

You can calculate the average speed that something is travelling at by measuring the distance travelled with a ...tape measure... and the time taken with a ...stop clock...........

The biggest source of error using this method is ...starting and stopping the stopclock at the correct time...

You can also use light gates connected to a computer. When the object passes through the first light gate an electronic timer ...starts..... and when it passes through the second it ...stops...... the timer. We would also need to measure the ...distance between the light gates...

2.12

Match these typical speeds to the correct movements, they are all in m/s.

1.3 3 4.6 6 30 70 250 330

Aeroplanes	...250...	Car	...30...	Cycling	...6...	Running	...3...
Sound in air	...330...	Trains	...70...	Walking	...1.3...	The wind	...4.6...

2.13

When an object is dropped we say that it is in freefall and it's acceleration, g, is roughly .....10...... m/s^2.

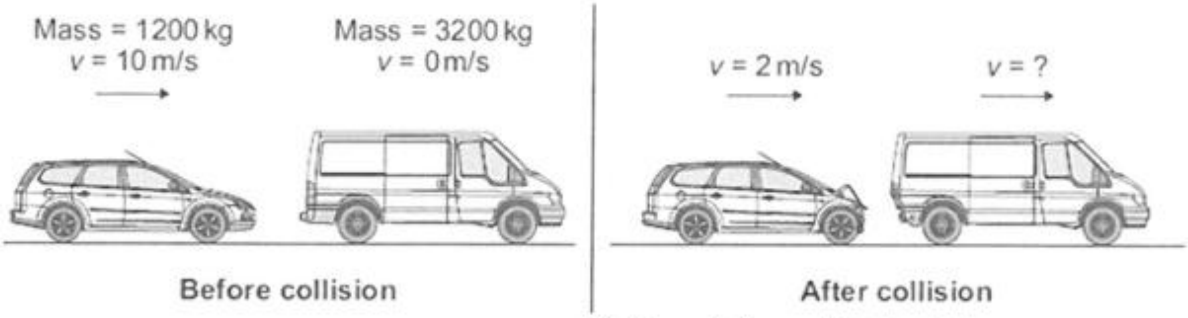
2.24

The equation that links mass, momentum and velocity is:

5	$p = m \times V$	m	Mass	kg
		p	Momentum	kgm/s
		v	Velocity	m/s

Momentum depends on velocity so it is a ....vector.... quantity.

2.25*



The momentum of the car before the collision is 1200 x 10 = 12000 kgm/s

The momentum of the van before the collision is 3200 x 0 = 0 kgm/s

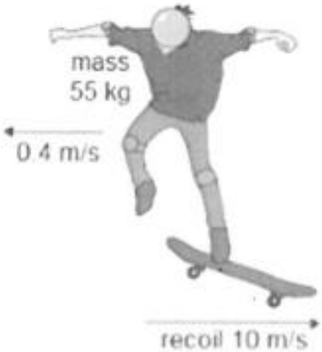
The total momentum before the collision is 12000 kgm/s

The total momentum after the collision is 12000 kgm/s

The momentum of the car after the collision is 1200 x 2 = 2400 kgm/s

The momentum of the van after the collision is 12000 - 2400 = 9600 kgm/s

The velocity of the van after the collision is 9600 = 3200 x v v = 3 m/s



The skateboarder is stationary before jumping off of the skateboard.

The momentum before he jumps off is ...0...

The total momentum of the skateboarder and skateboard after is ...0...

The skateboard moves at a higher speed than the skateboarder because they gain the same momentum but the skateboarder has a higher mass.

The momentum of the skateboarder after he jumps off is 55 x 0.4 = 22 kgm/s

The mass of the skateboard is 22 = 10 x m m = 2.2 kg

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Task 2 Mark Schemes

Motion

Q1. (a) shallowest slope/ gradient

accept smallest distance in biggest time
accept longest time to travel the same distance
accept the line is not as steep
accept it is a less steep line
*do **not** accept the line is not steep*

1

(b) **A – B**

If 2 or 3 boxes are ticked no mark

1

(c) (i) 200 m

1

(ii) 20 s

*allow **1** mark for correctly identifying 60 s or 40 s from the graph*

2

(d) (i) straight line starting at origin

accept within one small square of the origin

1

passing through t = 200 and d = 500

1

(ii) 166

accept any value between 162 and 168
accept where their line intersects
given graph line correctly read ± 3 s

1

[8]

Q2. (a) (i) acceleration / speeding up

do not accept acceleration increases

1

(ii) constant / steady velocity

accept constant / steady speed

1

(b) 10

3

m/s^2 or ms^{2-}

reject ms^2
if answer not correct then allow 1 mark for

acceleration = $\frac{\text{change in velocity}}{\text{time taken for change}}$

and allow 1 mark for $\frac{40\,(m/s)}{4(s)}$

1

(c) (i) distance is a scalar and displacement is a vector

or distance has magnitude only, displacement has magnitude and direction

1

(c) (ii) 37.5 km

accept any value between 37.0 and 38.0 inclusive

1

062° or N62°E

accept 62° to the right of the vertical

1

accept an angle in the range 60° −64°
accept the angle correctly measured and marked on the diagram

(c) (iii) train changes direction so velocity changes

1

acceleration is the rate of change of velocity

1

(c) (iv) number of squares below line = 17

accept any number between 16 and 18 inclusive

1

each square represents 500 m

1

distance = number of squares × value of each square correctly calculated − 8500 m

1

[14]

Q3. (a) (i) 0.7

for 1 mark each

1

(ii) 16.8

gains 2 marks

2

but correct working
(d = v.t, d = 24 × 0.7, or in terms of area under graph)

gains 1 mark

1

(b) a = (v-u)/t
= 24/4
= 6
m/s^2

(see marking of calculations)

(can work in terms of graph gradient)

4

(c) d = v.t
= 24/2 × 4
= 48

(see marking of calculations)

(can work in terms of area under graph)

3

[11]

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Momentum and Collisions

Q1. (a) (i) $0.15 \times 0.08 = 0.012$

1

(ii) kg m/s

1

(iii) equal to

1

(b) momentum of the air increases
or
force backwards increases

accept air moves faster
accept momentum backwards increases
accept pushes more air back(wards)

1

so momentum of the toy must increase
or
the force forwards (on the toy) increases

accept momentum forwards must increase
it = toy

1

(c) (i) Zero / 0

Accept none
Nothing is insufficent

1

velocity / speed = 0

accept it is not moving
paintball has not been fired is insufficient

1

(c) (ii) 0.27

*allow **1** mark for correct substitution, ie $p = 0.003(0) \times 90$ provided no subsequent step*

2

(c) equal to

1

[10]

Q2. (a) (i) 16 000

*allow **1** mark for correct substitution ie 3200×5*

2

(ii) 16 000 or their (a)(i)

1

(iii) less than

1

(b) increases

1

decreases

correct order only

1

(c) direction

1

(d) 54 000

*allow **1** mark for calculating and identifying momentum as 10 800*

or

*allow **1** mark for correct substitution into second equation*

ie $\frac{1200 \times 9}{0.2}$

2

(e) increases the time taken (for head) to stop

accept increases impact time

*do **not** accept reference to slowing down time unless qualified*

1

decreases rate of change in momentum

accept reduces acceleration / deceleration

*accept increases the time taken to reduce momentum to zero is worth **2** marks*

reduces momentum is insufficient

1

reduces the <u>force</u> (on the head)

1

[12]

Q3. (a) (i) momentum before = momentum after

accept no momentum is lost

accept no momentum is gained

or

(total) momentum stays the same

1

(ii) an external force acts (on the colliding objects)

accept colliding objects are not isolated

1

(b) (i) 9600

allow 1 mark for correct calculation of momentum before or after ie 12000 or 2400

or

correct substitution using change in velocity = 8 m/s

ie 1200 × 8

2

kg m/s

or

Ns

this may be given in words rather than symbols

*do **not** accept nS*

1

(ii) 3 or their (b)(i) 3200 correctly calculated

allow 1 mark for stating momentum before = momentum after

or

clear attempt to use conservation of momentum

2

(c) (moving in) different / opposite directions

accept one has positive momentum the other negative momentum

accept they have different velocities

1

(d) (i) momentum before = momentum after

or

(total) momentum stays the same

accept no momentum is lost

accept no momentum is gained

1

(ii) 2.2

*allow **1** mark for calculation of teenagers' momentum as 22 (kgm/s) and*

*allow **1** mark for correct statement, eg momentum before = momentum after*

or

*allow **2** marks for a numerical expression of above, eg*

55 × 0.4 = m × 10

***or** 0 = (55 × 0.4) + (m × (-10))*

3

(e) any **two** from:

- work is done
- (against) friction

  any reference to increasing friction negates this marking point
- (transforming) (kinetic) energy into heat

2

[14]

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Task 4 Mark Schemes
Motion

Q1. A

Q2. A

Q3. A

Q4. B

Q5. B

Q6. B

Q7. B

Q8. A

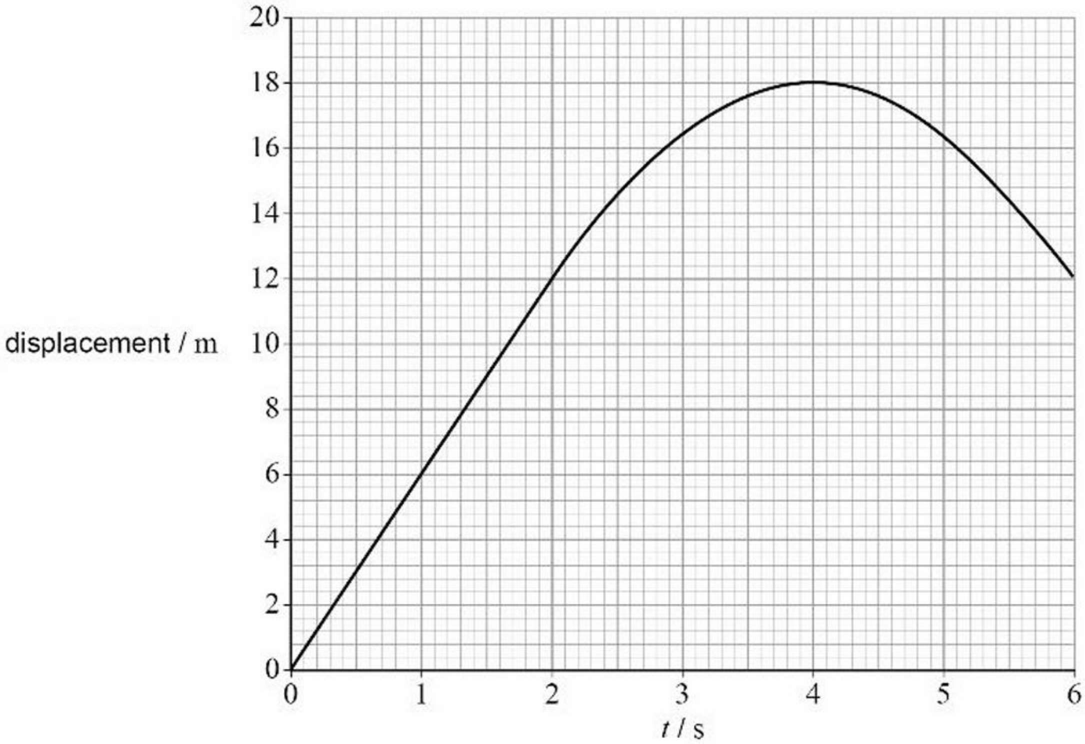
Q9. D

Q10.

Correctly reads off displacement at 50 s (= 9 m) ✓
Calculates total distance travelled = 41 m ✓
This would also gain MP1
Use of average speed = total distance / total time to give 41 / 50 = 0.82 (m s^{-1}) ✓
Use of velocity = displacement / time to give 9 / 50 = 0.18 (m s^{-1}) ✓
Direction: towards B / to the right OWTTE ✓

Q11.

Diagonal line to 2 s and smooth (symmetric) curve ending at 6 s ✓
Turning point (of curve) at 4.0 s within ½ grid square ✓
Displacements of 18 m at 4.0 s and 12 m at 6.0 s ✓
Displacement of 16.5 m at 3.0 s and 5.0 s ✓



Momentum

Q1. C

Q2. A

Q3. D

Q4. B

Q5. B

Q6. B

Q7. A