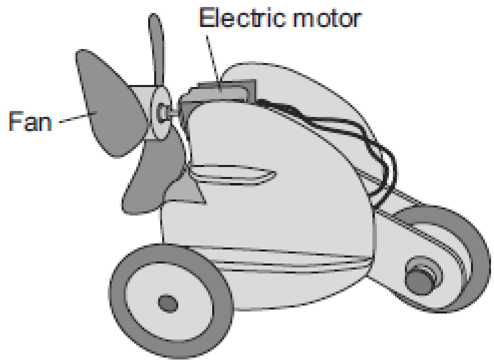
MOMENTUM

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.



(a) (i) 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 ÷ 0.08 = 1.875 ☐

0.15 × 0.08 = 0.012 ☐

(1)

(ii) What is the unit of momentum?

Tick (✔) **one** box.

kg m/s ☐ m/s^2 ☐ kg/m/s ☐

(1)

(iii) 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)

(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)

(Total 5 marks)

Q2.

Quantities in physics are either scalars or vectors.

(a) Use the correct answers from the box to complete the sentence.

acceleration	**direction**	**distance**	**speed**	**time**

Velocity is ___________________________ in a given ________________ .

(2)

(b) Complete the table to show which quantities are scalars and which quantities are vectors.

Put **one** tick (✓) in each row.

The first row has been completed for you.

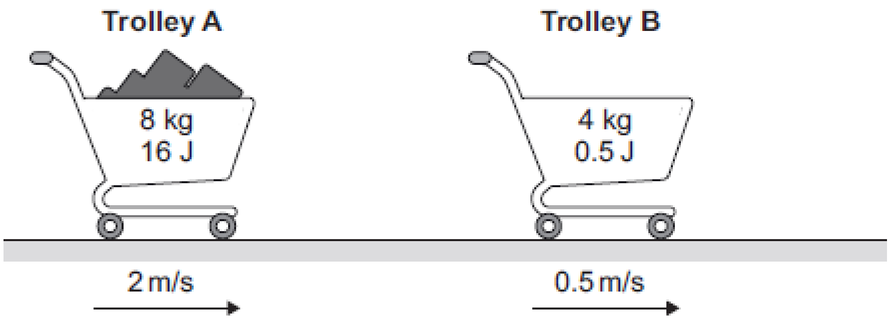
Quantity	**Scalar**	**Vector**
Momentum		✓
Acceleration		
Distance		
Force		
Time		

(3)

(c) The diagram shows two supermarket trolleys moving in the same direction.

Trolley **A** is full of shopping, has a total mass of 8 kg and is moving at a velocity of 2 m / s with a kinetic energy of 16 J.

Trolley **B** is empty, has a mass of 4 kg and is moving at a velocity of 0.5 m / s with a kinetic energy of 0.5 J.



(i) Calculate the momentum of both trolley **A** and trolley **B**.

Give the unit.

____

____

Momentum of trolley **A** = ________________

Momentum of trolley **B** = ________________

Unit ___________

(4)

(ii) The trolleys in the diagram collide and join together. They move off together.

Calculate the velocity with which they move off together.

____

____

____

____

Velocity = ________________ m / s

(3)

(iii) In a different situation, the trolleys in the digram move at the same speeds as before but now move towards each other.

Calculate the total momentum and the total kinetic energy of the two trolleys before they collide.

____

____

Total momentum = ___________________

____

____

Total kinetic energy = ________________ J

(2)

(Total 14 marks)

Q3.

(a) A car driver sees the traffic in front is not moving and brakes to stop his car.

The stopping distance of a car is the thinking distance plus the braking distance.

(i) What is meant by the 'braking distance'?

____

____

(1)

(ii) The braking distance of a car depends on the speed of the car and the braking force.

State **one** other factor that affects braking distance.

____

____

(1)

(iii) How does the braking force needed to stop a car in a particular distance depend on the speed of the car?

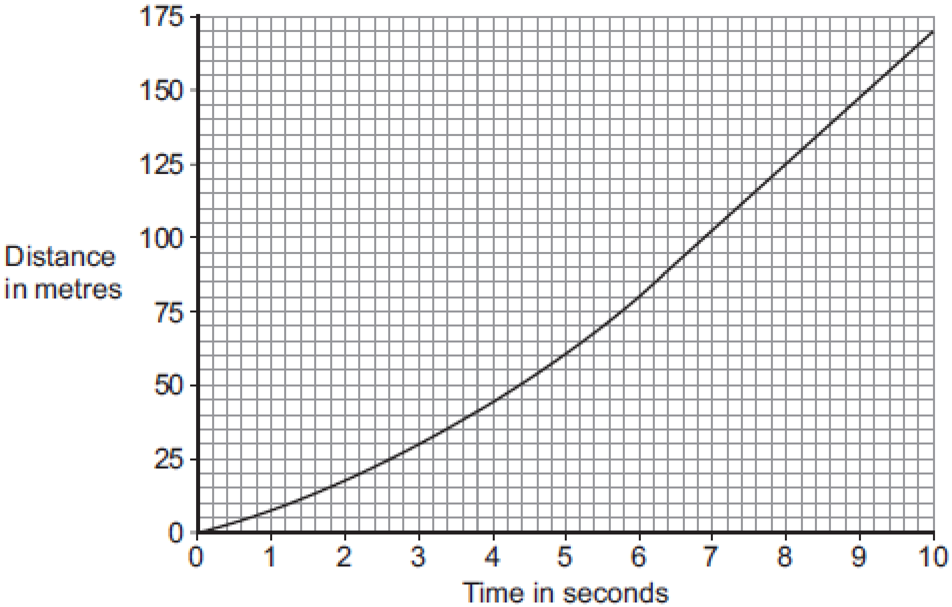
____

____

(1)

(b) **Figure 1** shows the distance−time graph for the car in the 10 seconds before the driver applied the brakes.

Figure 1



Use **Figure 1** to calculate the maximum speed the car was travelling at.
Show clearly how you work out your answer.

____

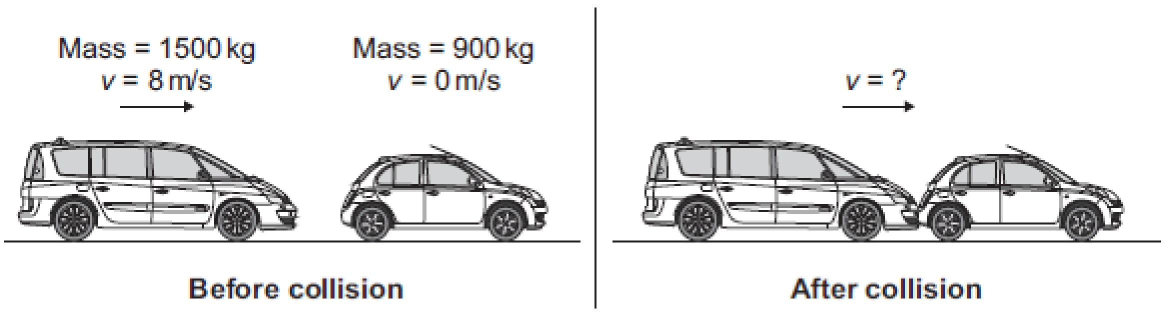
Maximum speed = _______________ m / s

(2)

(c) The car did not stop in time. It collided with the stationary car in front, joining the two cars together.

Figure 2 shows both cars, just before and just after the collision.

Figure 2



(i) The momentum of the two cars was conserved.

What is meant by the statement 'momentum is conserved'?

___

___

(1)

(ii) Calculate the velocity of the two joined cars immediately after the collision.

___

___

___

___

___

Velocity = __________________ m / s

(3)

(d) Since 1965, all cars manufactured for use in the UK must have seat belts.

It is safer for a car driver to be wearing a seat belt, compared with not wearing a seat belt, if the car is involved in a collision.

Explain why.

___

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(4)

(Total 13 marks)

Q4.

An investigation was carried out to show how thinking distance, braking distance and stopping distance are affected by the speed of a car.

The results are shown in the table.

Speed in metres per second	**Thinking distance in metres**	**Braking distance in metres**	**Stopping distance in metres**
10	6	6	12
15	9	14	43
20	12	24	36
25	15	38	53
30	18	55	73

(a) Draw a ring around the correct answer to complete each sentence.

As speed increases, thinking distance

- decreases.
- increases.
- stays the same.

As speed increases, braking distance

- decreases.
- increases.
- stays the same.

(2)

(b) One of the values of stopping distance is incorrect.

Draw a ring around the incorrect value in the table.

Calculate the correct value of this stopping distance.

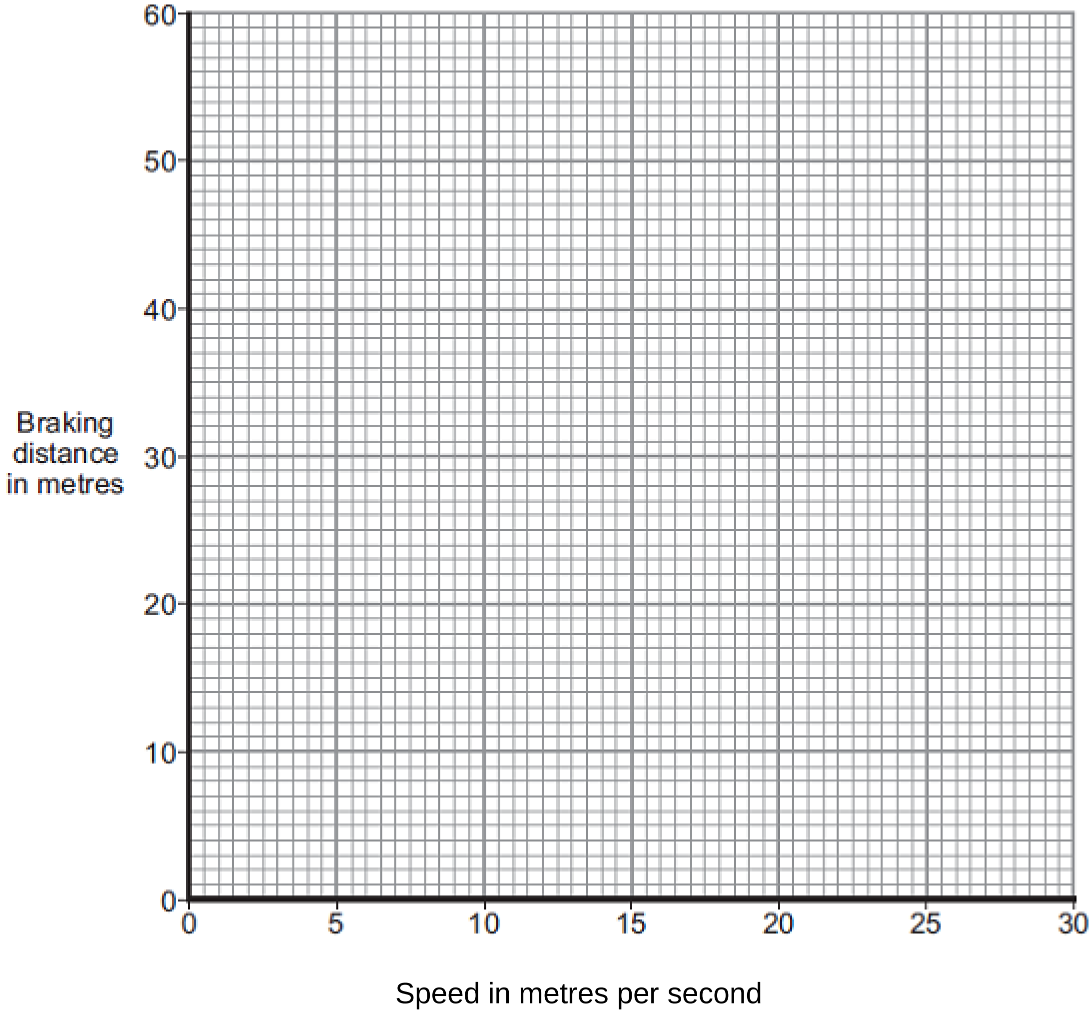
___

Stopping distance = ____________ m

(2)

(c) (i) Using the results from the table, plot a graph of braking distance against speed.

Draw a line of best fit through your points.



(3)

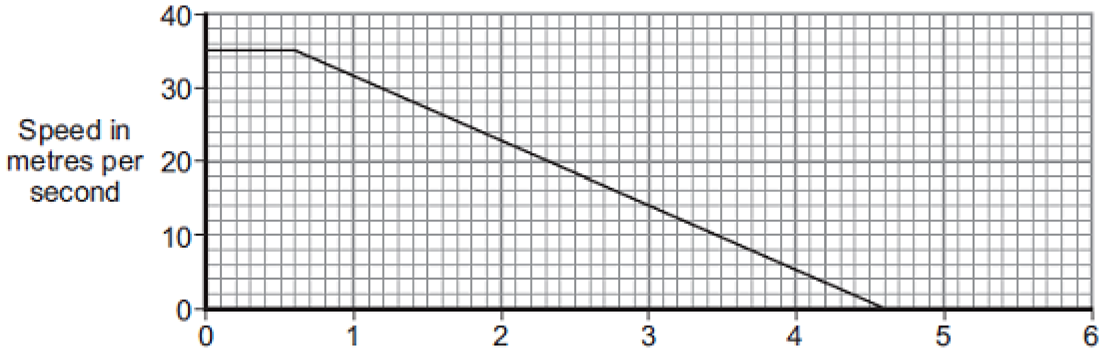
(ii) Use your graph to determine the braking distance, in metres, at a speed of 22 m / s.

Braking distance = _______________ m

(1)

(d) The speed–time graph for a car is shown below.

While travelling at a speed of 35 m / s, the driver sees an obstacle in the road at time t = 0. The driver reacts and brakes to a stop.



Time in seconds

(i) Determine the braking distance.

____

____

____

____

Braking distance = ________________ m

(3)

(ii) If the driver was driving at 35 m / s on an icy road, the speed–time graph would be different.

Add another line to the speed–time graph above to show the effect of travelling at 35 m / s on an icy road and reacting to an obstacle in the road at time t = 0.

(3)

(e) A car of mass 1200 kg is travelling with a velocity of 35 m / s.

(i) Calculate the momentum of the car.

Give the unit.

____

____

____

Momentum = ______________________

(3)

(ii) The car stops in 4 seconds.

Calculate the average braking force acting on the car during the 4 seconds.

____

____

Force = ________________ N

(2)

(Total 19 marks)

Q5.

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.

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

____

Give a reason for your answer.

____

____

(2)

(b) 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)

(c) 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 5 marks)

Q6.

The figure below shows a skateboarder jumping forwards off his skateboard.

The skateboard is stationary at the moment the skateboarder jumps.

(a) The skateboard moves backwards as the skateboarder jumps forwards.

Explain, using the idea of momentum, why the skateboard moves backwards.

____

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____

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____

____

(3)

(b) The mass of the skateboard is 1.8 kg and the mass of the skateboarder is 42 kg.

Calculate the velocity at which the skateboard moves backwards if the skateboarder jumps forwards at a velocity of 0.3 m / s.

____

____

____

____

____

____

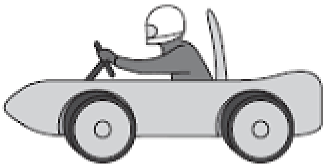
Velocity of skateboard = ____________________ m / s

(3)

(Total 6 marks)

Q7.

Some students designed and built an electric-powered go-kart.
The go-kart is shown below.



(a) Suggest **two** changes that could be made to the design of the go-kart to increase its top speed.

1. ____

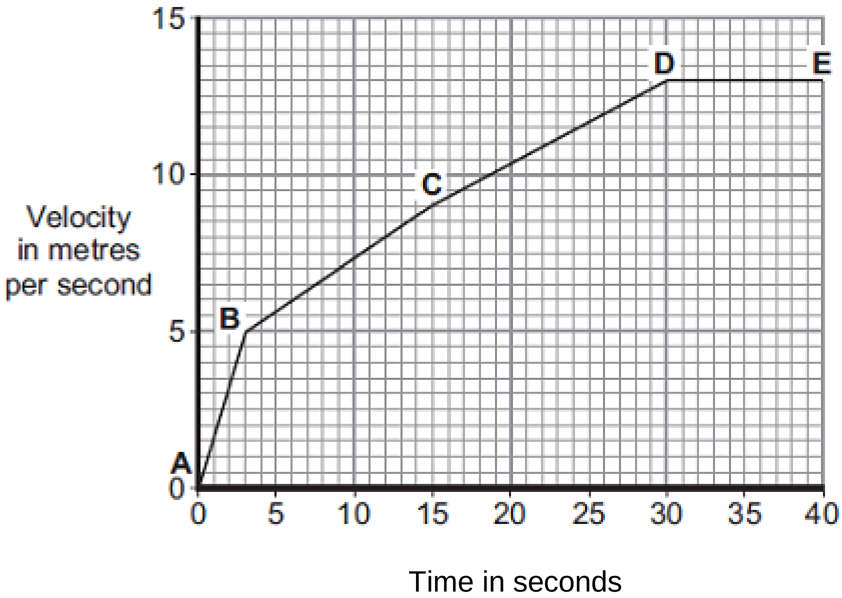
____

2. ____

____

(2)

(b) A go-kart with a new design is entered into a race.
The velocity-time graph for the go-kart, during the first 40 seconds of the race, is shown below.



(i) Between which **two** points did the go-kart have the greatest acceleration?

Tick (✓) **one** box.

A–B ☐

B–C ☐

C–D ☐

Give a reason for your answer.

____

(2)

(ii) The go-kart travels at a speed of 13 m/s between points **D** and **E**.
The total mass of the go-kart and driver is 140 kg.

Calculate the momentum of the go-kart and driver between points **D** and **E**.

____

____

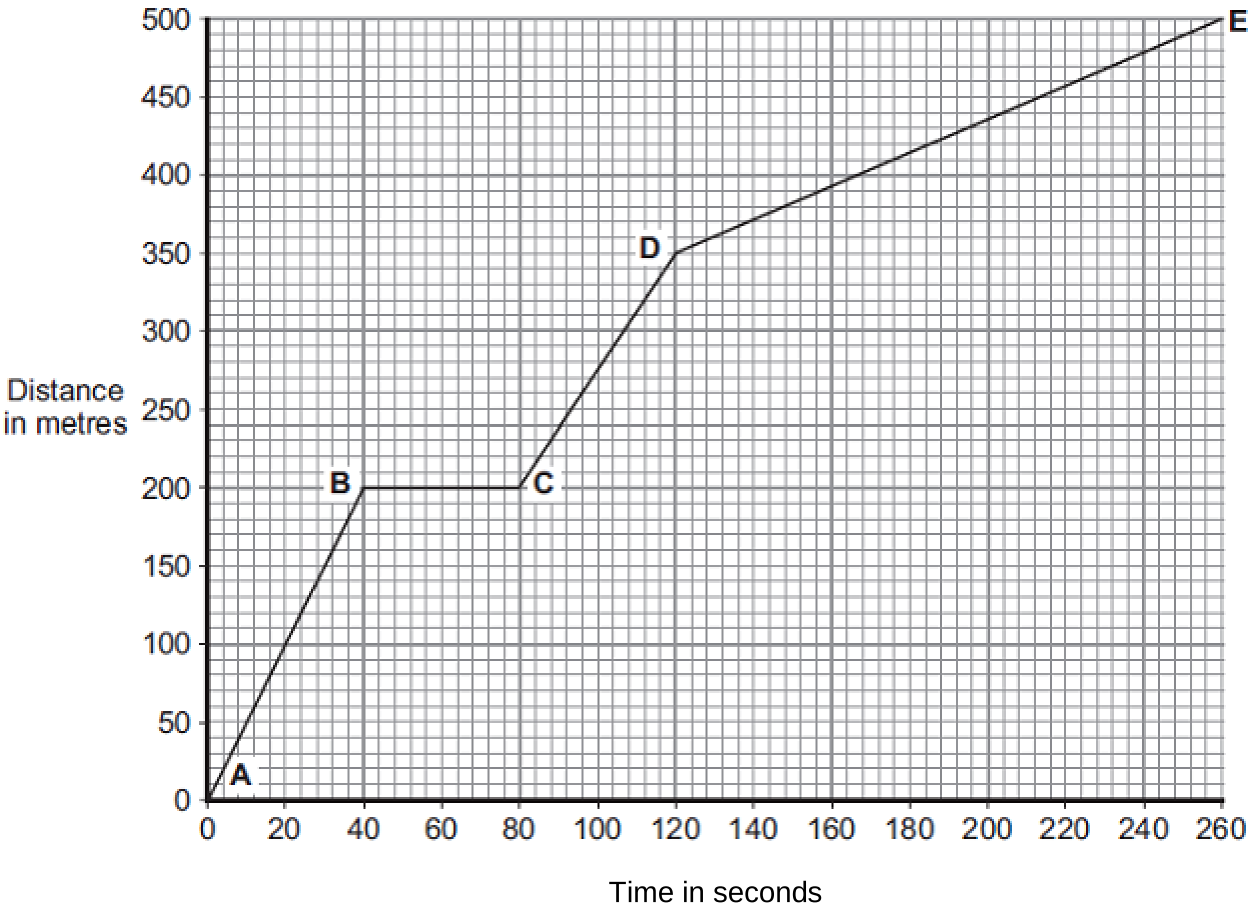
Momentum = ____________________ kg m/s

(2)

(Total 6 marks)

Q8.

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.



(a) Between which two points was the bus travelling the slowest?

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

Points	**Tick (✓)**
A – B	

C – D	
D – E	

Give a reason for your answer.

____

____

(2)

(b) The bus travels at 5 m/s between points **A** and **B**.
The bus and passengers have a total mass of 16 000 kg.

Use the equation in the box to calculate the momentum of the bus and passengers between points **A** and **B**.

momentum = mass x velocity

Show clearly how you work out your answer.

____

____

Momentum = ___________________________ kg m/s

(2)

(c) 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 220 seconds. The cyclist travelled the whole distance at a constant speed.

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

(2)

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

The cyclist overtook the bus after ________________________ seconds.

(1)

(Total 7 marks)

Q9.

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

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

____

____

(1)

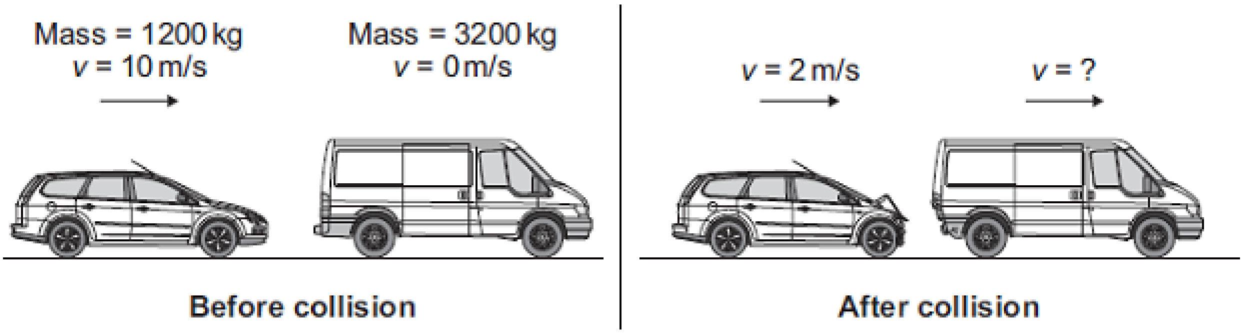
(ii) In a collision, momentum is **not always** conserved.

Why?

____

(1)

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



(i) 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)

(ii) 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.

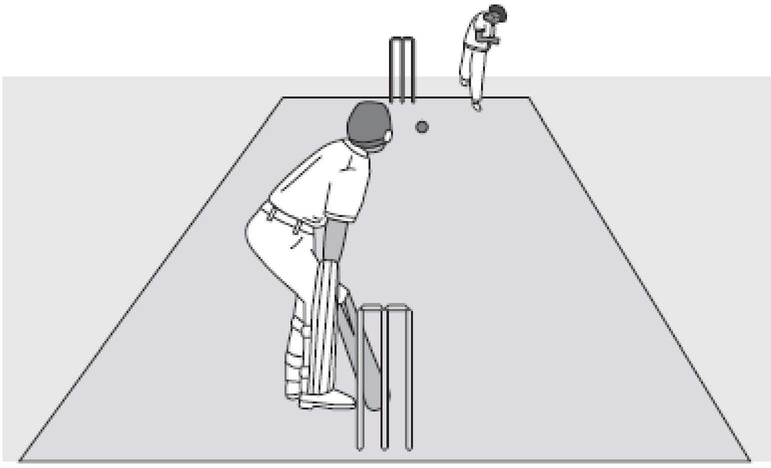
Velocity = ___________________________ m/s forward

(2)

(Total 7 marks)

Q10.

The picture shows players in a cricket match.



(a) A fast bowler bowls the ball at 35 m/s. The ball has a mass of 0.16 kg.

Use the equation in the box to calculate the kinetic energy of the cricket ball as it leaves the bowler's hand.

$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times \text{speed}^2$$

Show clearly how you work out your answer.

____

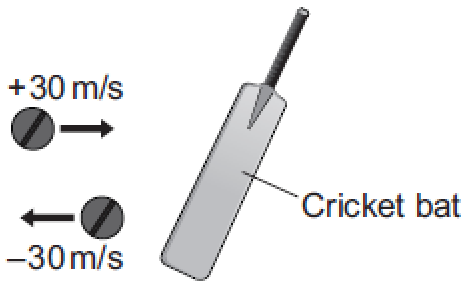
____

____

Kinetic energy = ______________________ J

(2)

(b) When the ball reaches the batsman it is travelling at 30 m/s. The batsman strikes the ball which moves off at 30 m/s in the opposite direction.



(i) Use the equation in the box to calculate the change in momentum of the ball.

$$\text{momentum} = \text{mass} \times \text{velocity}$$

Show clearly how you work out your answer.

____

____

Change in momentum = ______________________________ kg m/s

(2)

(ii) The ball is in contact with the bat for 0.001 s.

Use the equation in the box to calculate the force exerted by the bat on the ball.

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

Show clearly how you work out your answer.

____

____

Force = ______________________________ N

(1)

(c) A fielder, as he catches a cricket ball, pulls his hands backwards.

Explain why this action reduces the force on his hands.

____

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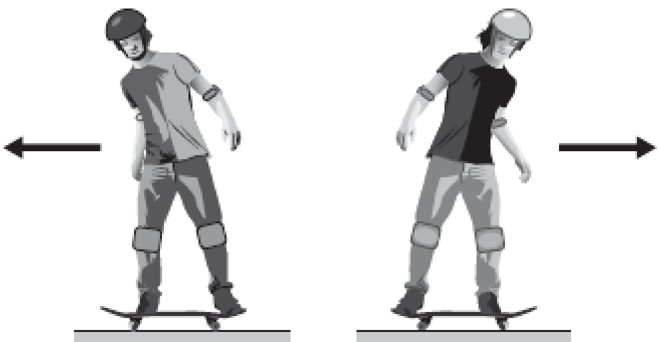
____

(2)

(Total 7 marks)

Q11.

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



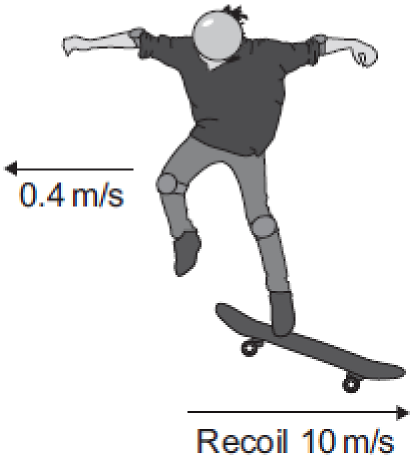
Why do the teenagers **not** have the same momentum?

____

____

(1)

(b) 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.

(i) What is meant by 'momentum being conserved'?

____

____

(1)

(ii) 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)

(c) Once the skateboard starts to recoil, it soon slows down and its kinetic energy decreases.

Explain why.

____

____

____

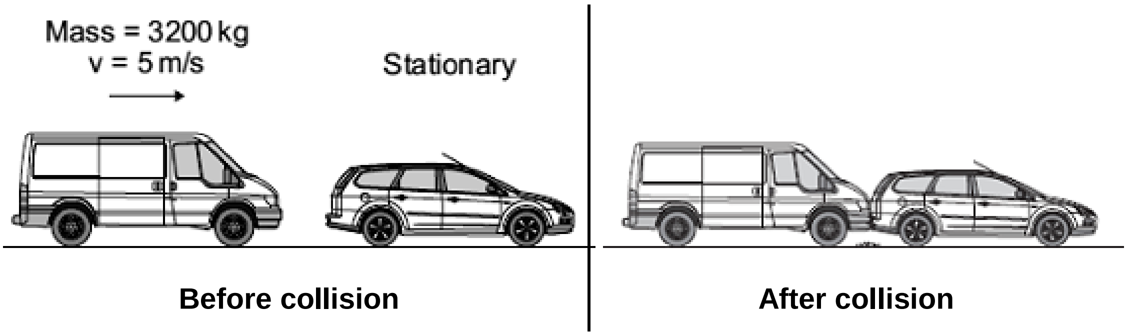
____

(2)

(Total 7 marks)

Q12.

(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.

(i) Calculate the momentum of the van just before the collision.

Show clearly how you work out your answer.

____

____

Momentum = _______________ kg m/s

(2)

(ii) 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)

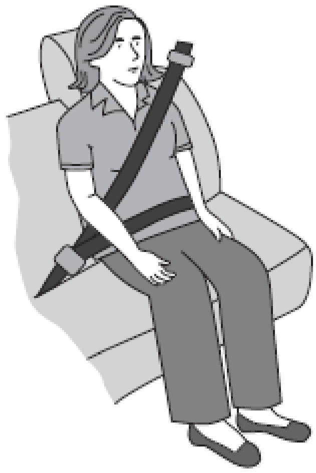
(iii) Complete the following sentence by drawing a ring around the correct line in the box.

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

more than
the same as
less than

(1)

(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)

(Total 6 marks)

Q13.

(a) Complete the following sentence.

The momentum of a moving object has a magnitude, in kg m/s,

and a ________________________ .

(1)

(b) 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.

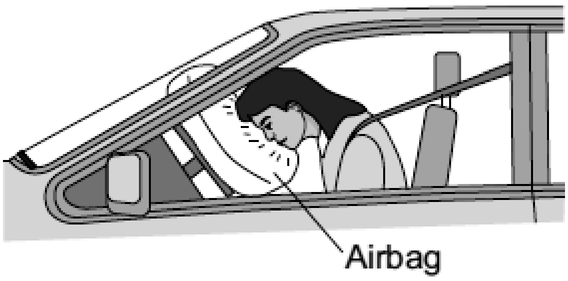
____

____

Force = ________________________ N

(2)

(c) 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.

___

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___

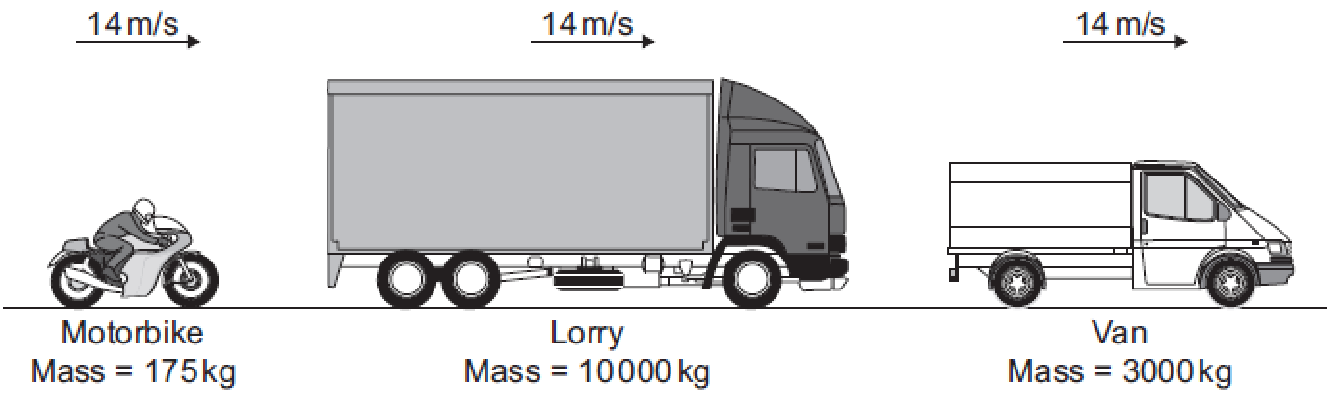
___

(3)

(Total 6 marks)

Q14.

(a) (i) The diagram shows three vehicles travelling along a straight road at 14 m/s.



Which vehicle has the greatest momentum?

___

Give the reason for your answer.

___

___

___

(2)

(ii) Use the equation in the box to calculate the momentum of the motorbike when it travels at 14 m/s.

momentum	=	mass	×	velocity

Show clearly how you work out your answer.

____

____

Momentum = ____________________________ kg m/s

(2)

(b) The motorbike follows the lorry for a short time, and then accelerates to overtake both the lorry and van.

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

When the motorbike starts to overtake, the kinetic energy

	decreases.
of the motorbike	stays the same.
	increases.

(1)

(ii) Give a reason for your answer to part (b)(i).

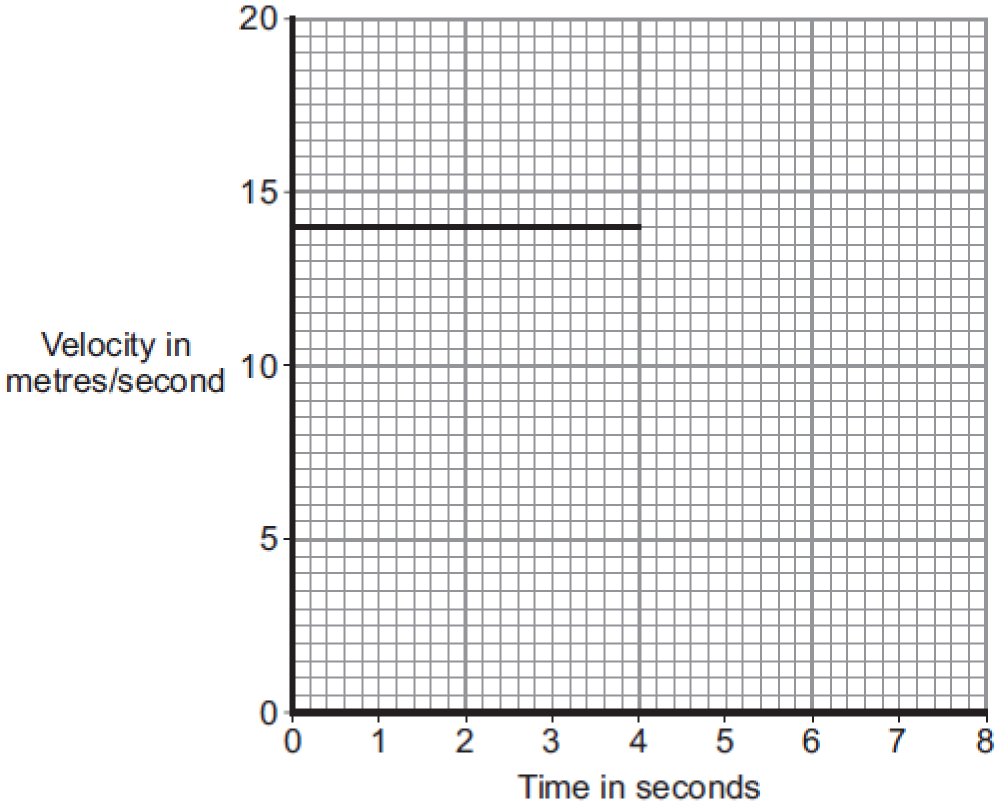
____

____

(1)

(iii) The graph shows the velocity of the motorbike up to the time when it starts to accelerate. The motorbike accelerates constantly, going from a speed of 14 m/s to a speed of 20 m/s in a time of 2 seconds. The motorbike then stays at 20 m/s.

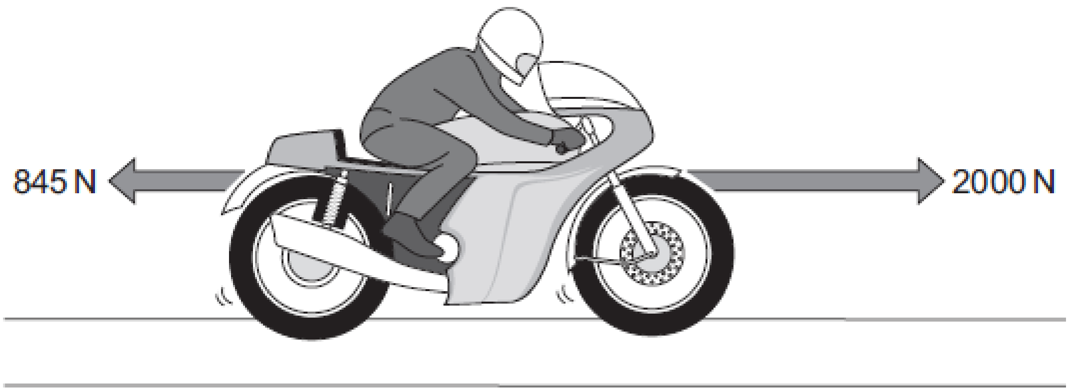
Complete the graph to show the motion of the motorbike over the next 4 seconds.



(3)
(Total 9 marks)

Q15.

The arrows in the diagram represent the horizontal forces acting on a motorbike at one moment in time.



(a) The mass of the motorbike and rider is 275 kg.

Calculate the acceleration of the motorbike at this moment in time.

Show clearly how you work out your answer.

___

___

___

___

___

Acceleration = ______________________________ m/s^2

(3)

(b) A road safety organisation has investigated the causes of motorbike accidents.

The main aim of the investigation was to find out whether there was any evidence that young, inexperienced riders were more likely to be involved in an accident than older, experienced riders.

Data obtained by the organisation from a sample of 1800 police files involving motorbike accidents, is summarised in the table.

Size of motorbike engine	**Percentage of all motorbikes sold**	**Total number in the sample of 1800 accident files**
up to 125 cc	36	774
126 to 350 cc	7	126
351 to 500 cc	7	162
over 500 cc	50	738

Most of the motorbikes with engines up to 125 cc were ridden by young people. The motorbikes with engines over 500 cc were ridden by older, more experienced riders.

(i) In terms of the main aim of the investigation, is this data valid?

Draw a ring around your answer. **NO** **YES**

Explain the reason for your answer.

____

____

____

____

(2)

(ii) The organisation concluded that:

“Young, inexperienced riders are more likely to be involved in a motorbike accident than older, experienced riders”.

Explain how the data supports this conclusion.

____

____

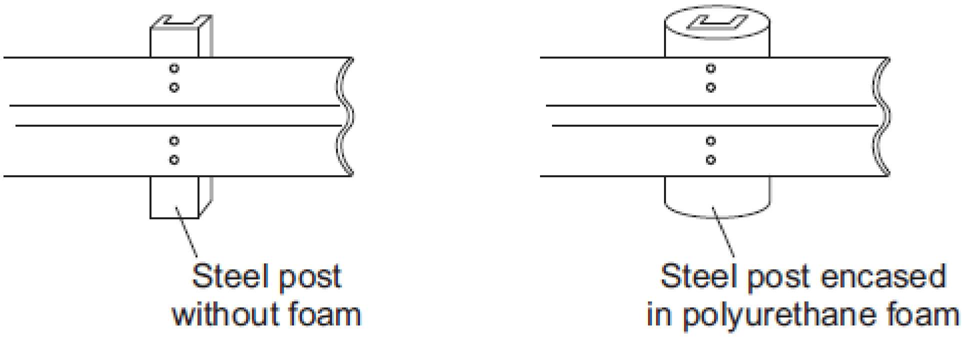
____

____

(2)

(c) Of particular concern to motorbike riders is the design of steel crash barriers. Riders falling off and sliding at high speed into a steel support post are often seriously injured.

One way to reduce the risk of serious injury is to cover the post in a thick layer of high impact polyurethane foam.



(i) Use the ideas of momentum to explain how the layer of foam reduces the risk of serious injury to a motorbike rider sliding at high speed into the support post.

___

___

___

___

___

(3)

(ii) Crash barrier tests use dummies that collide at 17 m/s with the barrier. Each test costs about £12 000. New safety devices for crash barriers are tested many times to make sure that they will improve safety.

Do you think that the cost of developing the new safety devices is justified?

Draw a ring around your answer. **NO** **YES**

Give a reason for your answer.

___

___

(1)

(Total 11 marks)

Q16.

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

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

___

___

(1)

(ii) In a collision, momentum is **not** always conserved.

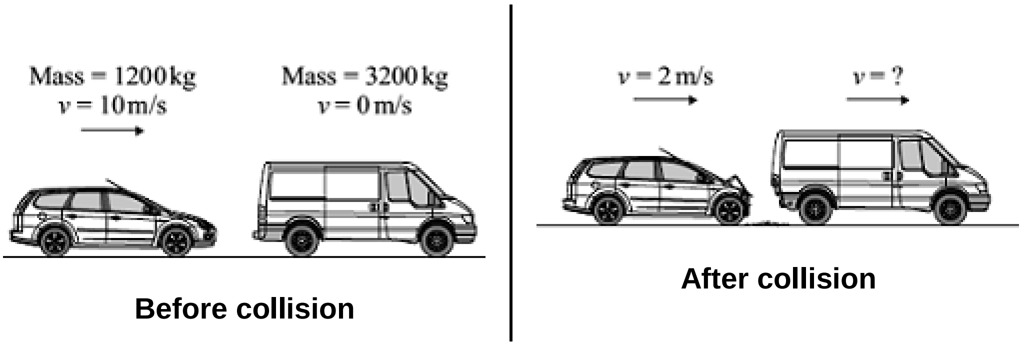
Why?

____

____

(1)

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



Before collision **After collision**

(i) 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)

(ii) 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.

____

____

____

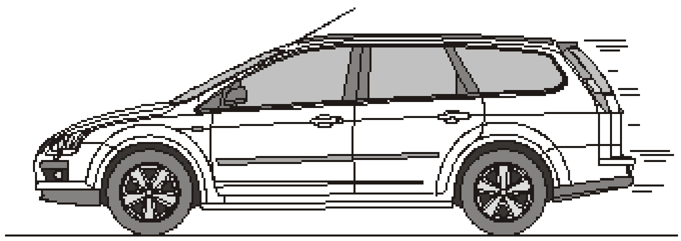
Velocity = ___________________________ m/s forward

(2)

(Total 7 marks)

Q17.

(a) The diagram shows a car travelling at a speed of 12 m/s along a straight road.



(i) Calculate the momentum of the car.

Mass of the car = 900 kg

Show clearly how you work out your answer.

____

____

____

____

Momentum = _______________ kg m/s

(2)

(ii) Momentum has direction.

Draw an arrow on the diagram to show the direction of the car's momentum.

(1)

(b) The car stops at a set of traffic lights.

How much momentum does the car have when it is stopped at the traffic lights?

____

Give a reason for your answer.

____

____

____

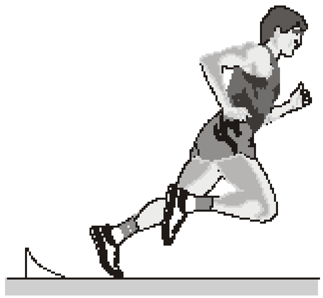
____

(2)

(Total 5 marks)

Q18.

(a) The diagram shows an athlete at the start of a race. The race is along a straight track.



In the first 2 seconds, the athlete accelerates constantly and reaches a speed of 9 m/s.

(i) Calculate the acceleration of the athlete.

Show clearly how you work out your answer.

____

____

____

Acceleration = _______________

(2)

(ii) Which **one** of the following is the unit for acceleration?

Draw a ring around your answer.

J/s **m/s** **m/s^2** **Nm**

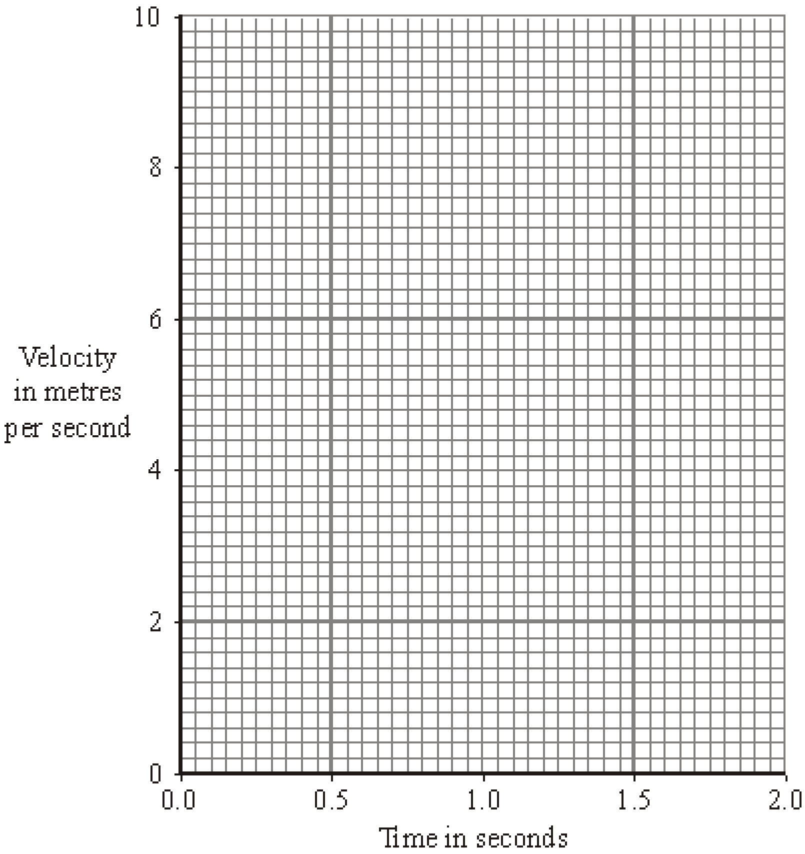
(1)

(iii) Complete the following sentence.

The velocity of the athlete is the __________________________________ of the athlete in a given direction.

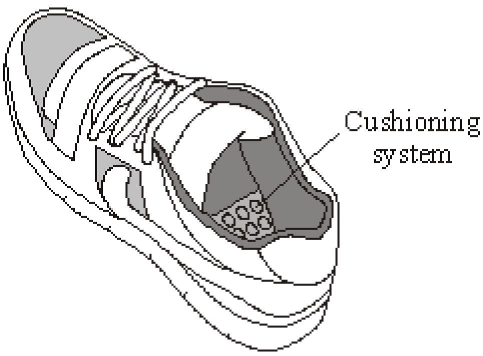
(1)

(iv) Complete the graph to show how the velocity of the athlete changes during the first 2 seconds of the race.

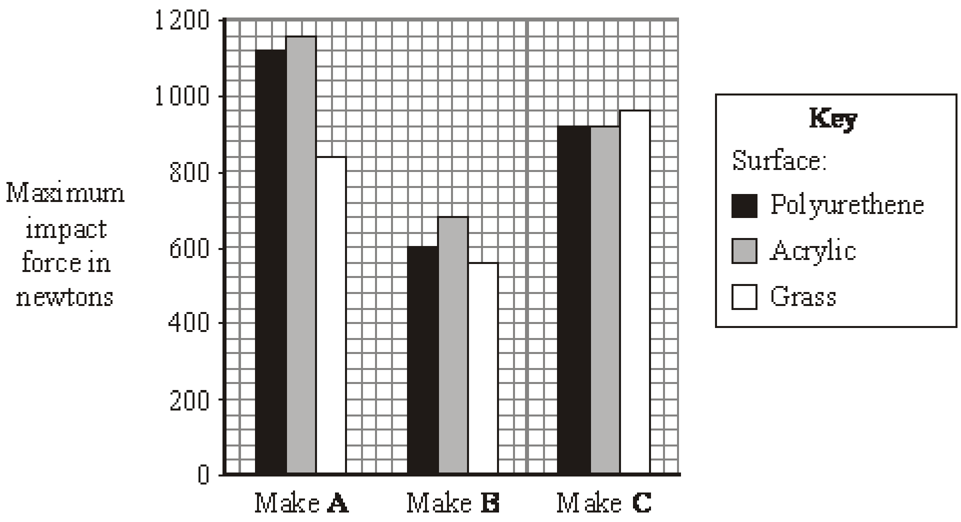


(2)

(b) Many running shoes have a cushioning system. This reduces the impact force on the athlete as the heel of the running shoe hits the ground.



The bar chart shows the maximum impact force for three different makes of running shoe used on three different types of surface.



(i) Which **one** of the three makes of running shoe, **A**, **B** or **C**, has the best cushioning system?

____

Explain the reason for your answer.

____

____

____

____

(3)

(ii) The data needed to draw the bar chart was obtained using a robotic athlete fitted with electronic sensors.

Why is this data likely to be more reliable than data obtained using human athletes?

____

____

(1)

(Total 10 marks)

Q19.

The diagram shows a child on a playground swing.
The playground has a rubber safety surface.

(a) The child, with a mass of 35 kg, falls off the swing and hits the ground at a speed of 6 m/s.

(i) Calculate the momentum of the child as it hits the ground.

Show clearly how you work out your answer and give the unit.

____

____

____

Momentum = ______________________________

(3)

(ii) After hitting the ground, the child slows down and stops in 0.25 s.
Use the equation in the box to calculate the force exerted by the ground on the child.

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

Show clearly how you work out your answer.

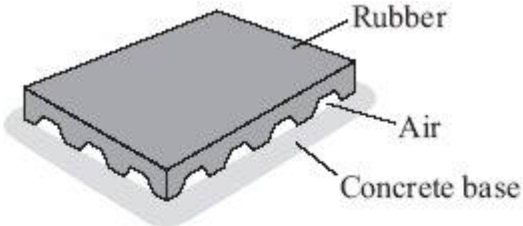
____

____

Force = ______________________________ N

(2)

(b) The diagram shows the type of rubber tile used to cover the playground surface.

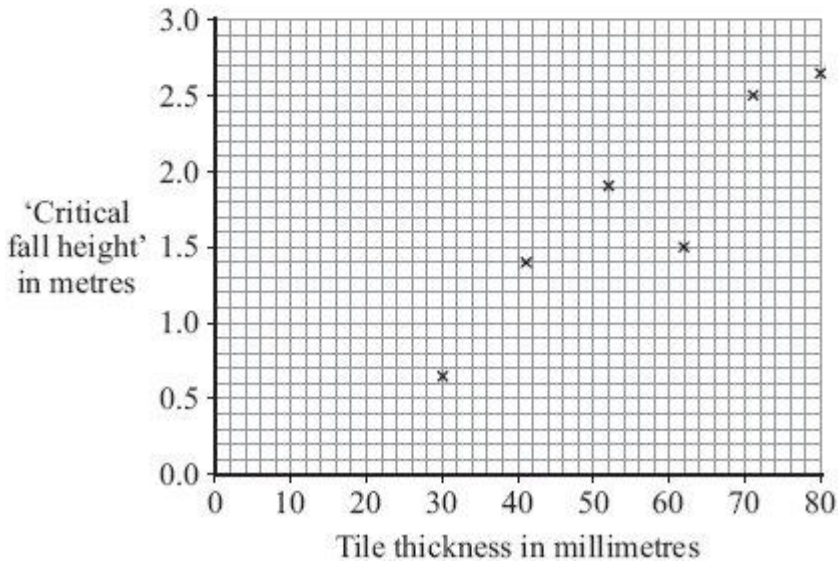


Explain how the rubber tiles reduce the risk of children being seriously injured when they fall off the playground equipment.

(3)

(c) The ‘critical fall height’ is the height that a child can fall and **not** be expected to sustain a life-threatening head injury.
A new type of tile, made in a range of different thicknesses, was tested in a laboratory using test dummies and the ‘critical fall height’ measured. Only one test was completed on each tile.

The results are shown in the graph.



The ‘critical fall height’ for playground equipment varies from 0.5 m to 3.0 m.

Suggest **two** reasons why more tests are needed before this new type of tile can be used in a playground.

1. ______________________________

2. ______________________________

(2)

(d) Developments in technology allow manufacturers to make rubber tiles from scrap car tyres.

Suggest why this process may benefit the environment.

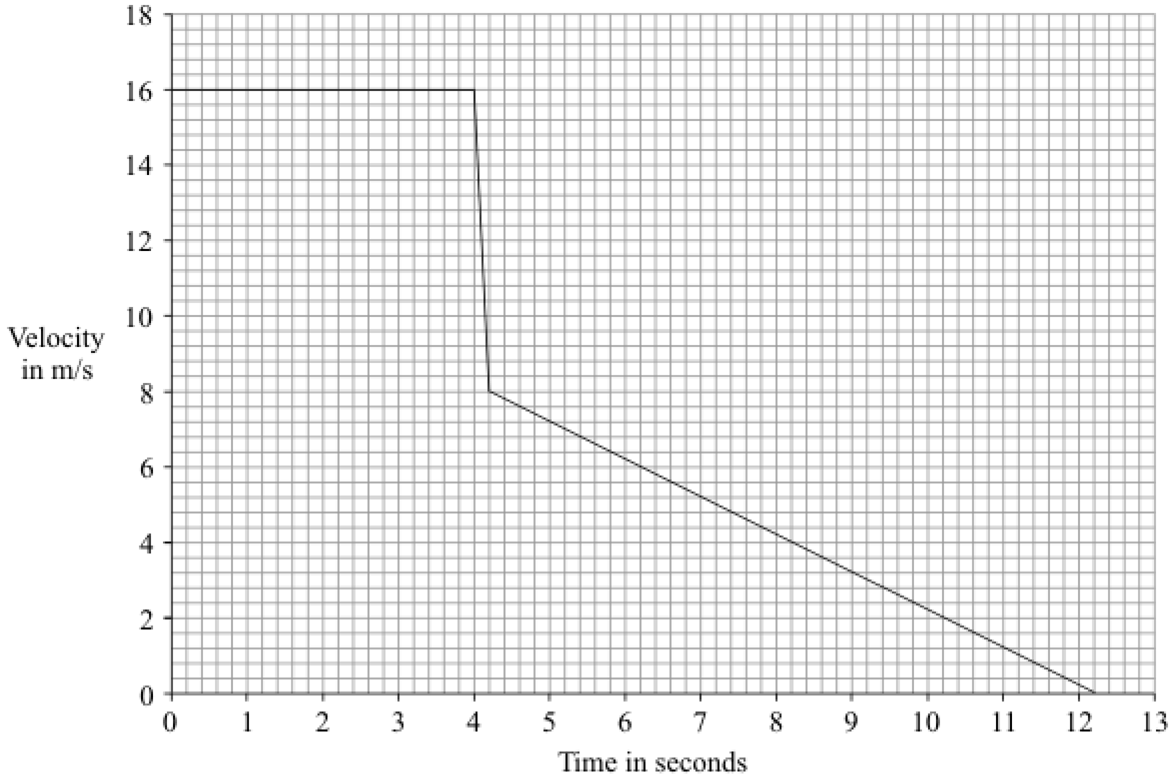
____

(1)
(Total 11 marks)

Q20.

In an experiment at an accident research laboratory, a car driven by remote control was crashed into the back of an identical stationary car. On impact the two cars joined together and moved in a straight line.

(a) The graph shows how the velocity of the remote-controlled car changed during the experiment.



(i) How is the *velocity* of a car different from the speed of a car?

____

(1)

(ii) Use the graph to calculate the distance travelled by the remote-controlled car before the collision.

Show clearly how you work out your answer.

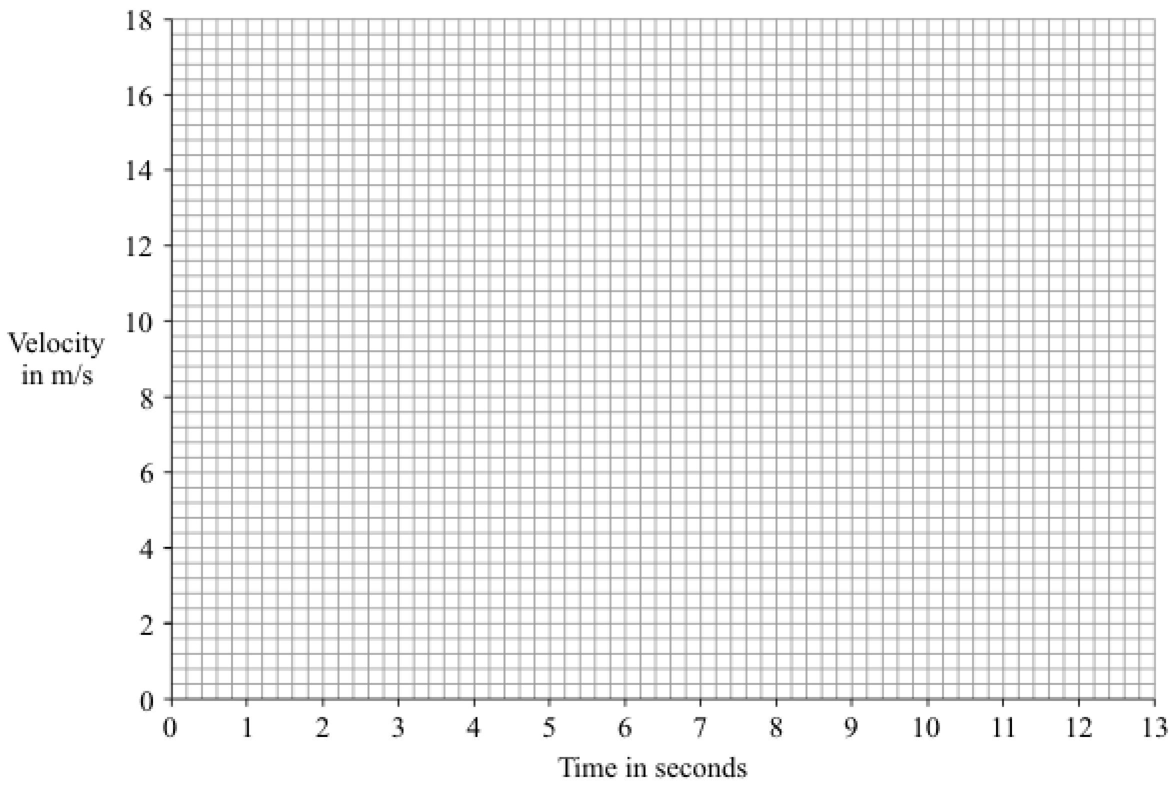
____

____

Distance = ______________________ m

(2)

(iii) Draw, on the grid below, a graph to show how the velocity of the second car changed during the experiment.



(2)

(iv) The total momentum of the two cars was not conserved.

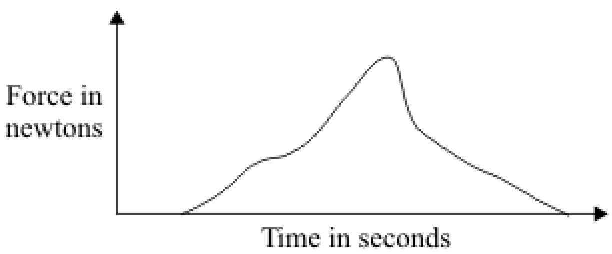
What does this statement mean?

____

____

(1)

(b) The graph line shows how the force from a seat belt on a car driver changes during a collision.



Scientists at the accident research laboratory want to develop a seat belt that produces a constant force throughout a collision.

Use the idea of momentum to explain why this type of seat belt would be better for a car driver.

____

____

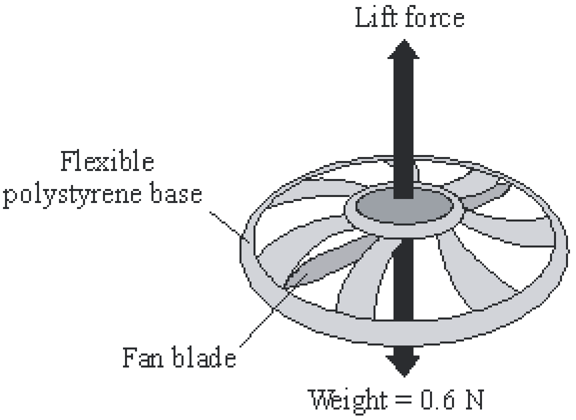
____

____

(2)
(Total 8 marks)

Q21.

The diagram shows a small, radio-controlled, flying toy. A fan inside the toy pushes air downwards creating the lift force on the toy.



When the toy is hovering in mid-air, the fan is pushing 1.5 kg of air downwards every 10 seconds. Before the toy is switched on, the air is stationary.

(a) Use the equation in the box to calculate the velocity of the air when the toy is hovering.

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

Show clearly how you work out your answer.

____

____

____

Velocity = ______________________ m/s

(3)

(b) Explain why the toy accelerates upwards when the fan rotates faster.

____

____

____

____

(2)

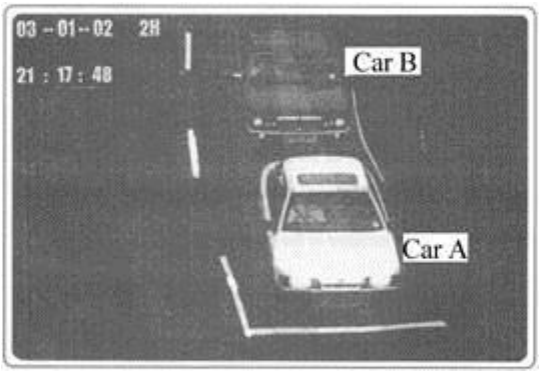
(c) The toy is not easy to control so it often falls to the ground.

Explain how the flexible polystyrene base helps to protect the toy from being damaged when it crashes into the ground.

(3)
(Total 8 marks)

Q22.

The roads were very icy. An accident was recorded by a security camera.



Car **A** was waiting at a road junction. Car **B**, travelling at 10 m/s, went into the back of car **A**. This reduced car **B**'s speed to 4 m/s and caused car **A** to move forward.

The total mass of car **A** was 1200 kg and the total mass of car **B** was 1500 kg.

(i) Write down the equation, in words, which you need to use to calculate momentum.

(1)

(ii) Calculate the change in momentum of car **B** in this accident.

Show clearly how you work out your final answer and give the unit.

Change in momentum = ______________________

(3)

(iii) Use your knowledge of the conservation of momentum to calculate the speed, in m/s, of car **A** when it was moved forward in this accident.

Show clearly how you work out your final answer.

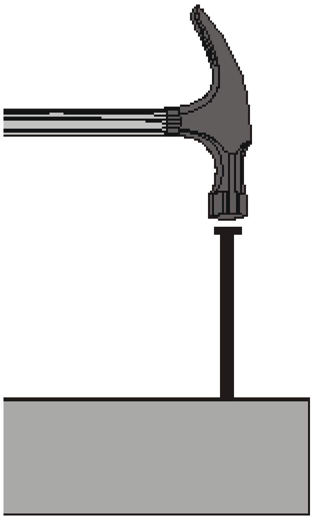
Speed = ________________________________ m/s

(3)

(Total 7 marks)

Q23.

(a) The diagram shows a hammer which is just about to drive a nail into a block of wood.



The mass of the hammer is 0.75 kg and its velocity, just before it hits the nail, is 15.0 m/s downward. After hitting the nail, the hammer remains in contact with it for 0.1 s. After this time both the hammer and the nail have stopped moving.

(i) Write down the equation, in words, which you need to use to calculate momentum.

____

(1)

(ii) What is the momentum of the hammer just before it hits the nail?

Show how you work out your answer and give the units and direction.

____

____

____

Momentum = ____________________________________

(3)

(iii) What is the change in momentum of the hammer during the time it is in contact with the nail?

____

(1)

(iv) Write down an equation which connects *change in momentum*, *force* and *time*.

____

(1)

(v) Calculate the force applied by the hammer to the nail.

Show how you work out your answer and give the unit.

___

___

___

Force = ___

(3)

(b) A magazine article states that:

"Wearing a seat belt can save your life in a car crash."

Use your understanding of momentum to explain how this is correct.

___

___

___

___

___

___

___

___

(4)
(Total 13 marks)

Q24.

(a) When two objects collide, and no other forces act, then *conservation of momentum* applies.

(i) What does the term conservation of momentum mean?

___

___

___

(2)

(ii) Apart from collisions and similar events, give another type of event in which *conservation of momentum* applies.

___

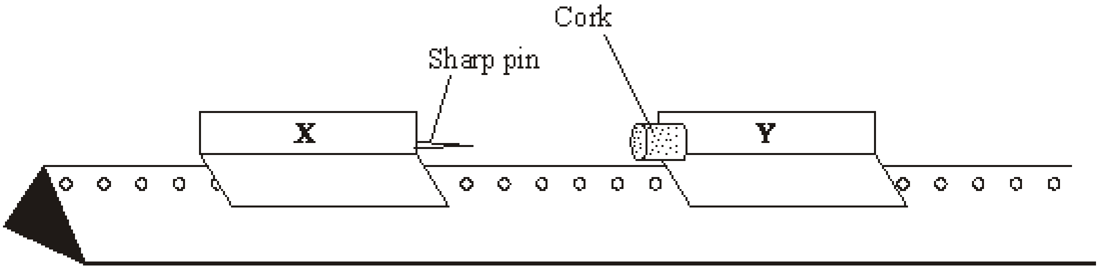
(1)

(iii) Write, in words, the equation which you need to use to calculate momentum.

___

(1)

(iv) The diagram shows a straight and horizontal runway and two trolleys, **X** and **Y**, which can move on the runway.



X has a mass of 0.2 kg and its velocity is 1.2 m/s to the right. **Y** has a mass of 0.1 kg and is stationary. When **X** collides with **Y** they stick together.

Calculate the velocity of the trolleys after the collision.

Show clearly how you work out your answer and give the unit and direction.

____

____

____

____

Velocity of the trolleys = ______________________________

(5)

(v) What assumption did you make in order to calculate your answer to part (a)(iv)?

____

____

(1)

(b) Just before it hits a target, a bullet has a momentum of 5 kg m/s. It takes 0.00125 s for the target to stop the bullet.

Calculate the force, in newtons, needed to do this.

Write, in words, the equation that you will need to use and show clearly how you work out your answer.

Force = ____________________ newtons

(3)

(Total 13 marks)

Q25.

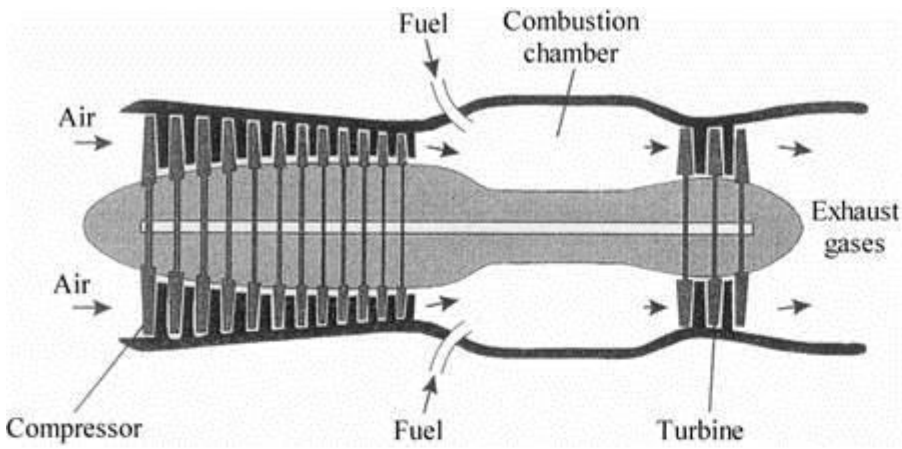
(a) What is the principle of conservation of momentum?

____

____

(2)

(b) The diagram shows a simplified aircraft jet engine.



Adapted from GCSE Physics by Tom Duncan. John Murray (Publishers) Ltd.

(i) What is the function of the turbine?

____

____

(1)

(ii) Explain how the engine produces a forward thrust.

____

____

____

____

____

____

____

(4)

(c) During flight, air enters the engine at 175 m/s and leaves at 475 m/s. A forward thrust of 105 kN is produced.

Use the following equation to calculate the mass of air passing through the engine every second. (Ignore the mass of the burned fuel.)

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

____

____

____

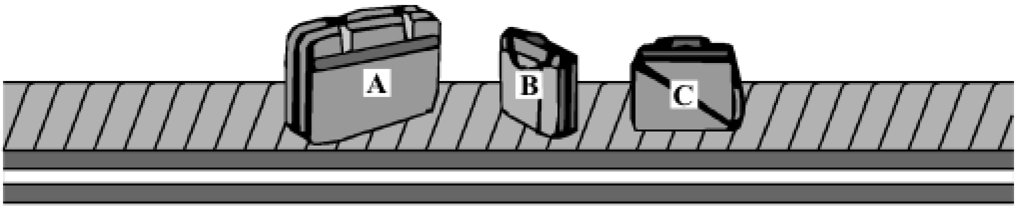
Mass of air = ________________________ kg

(2)

(Total 9 marks)

Q26.

The picture shows luggage which has been loaded onto a conveyor belt.



Each piece of luggage has a different mass.

Mass of **A** = 22 kg mass of **B** = l2 kg mass of **C** = 15 kg

(a) (i) What is the momentum of the luggage before the conveyor belt starts to move?

____

Give a reason for your answer.

____

____

(2)

(ii) When the conveyor belt is switched on the luggage moves with a constant speed. Which piece of luggage **A**, **B** or **C** has the most momentum?

____

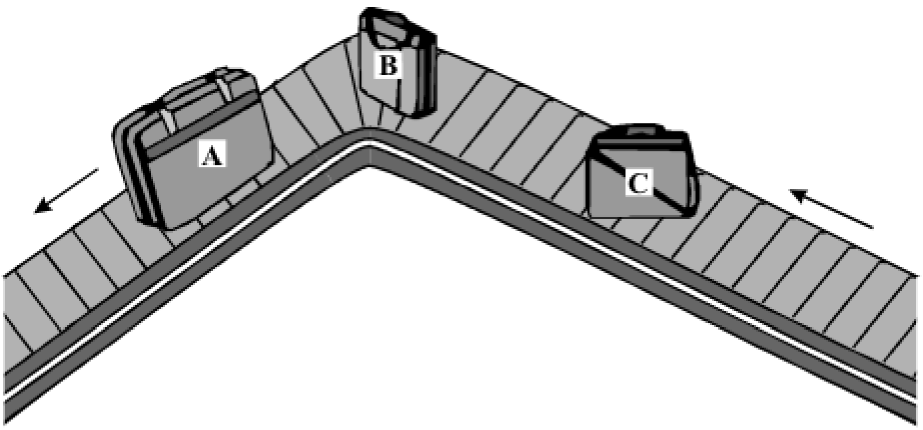
Give a reason for your answer.

____

____

(2)

(iii) At one point the conveyor belt turns left. The luggage on the belt continues to move at a constant speed.



Does the momentum of the luggage change as it turns left with the conveyor belt?

____

Give a reason for your answer.

____

____

(2)

(b) Draw a circle around the unit which can be used to measure momentum.

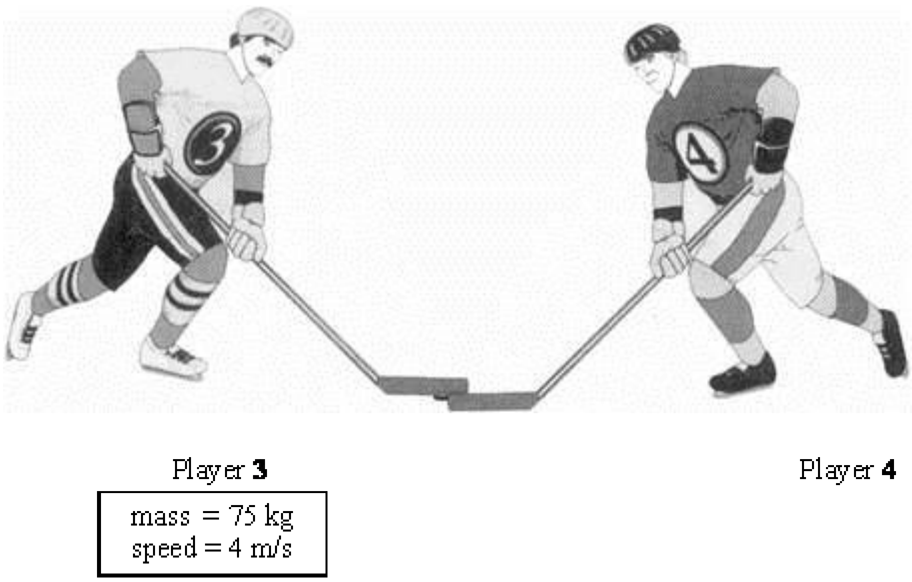
J/s kg m/s Nm

(1)

(Total 7 marks)

Q27.

(a) The picture shows two ice hockey players skating towards the puck. The players, travelling in opposite directions, collide, fall over and stop.



(i) Use the data given in the box to calculate the momentum of player number **3** before the collision. Show clearly how you work out your answer and give the unit.

____

____

Momentum of player **3** = ____________________

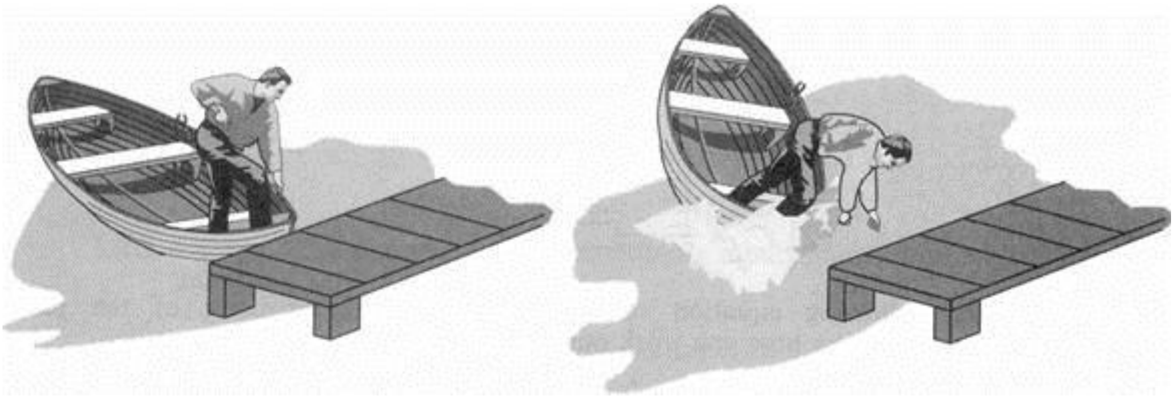
(3)

(ii) What is the momentum of player **4** just before the collision?

____

(1)

(b) The pictures show what happened when someone tried to jump from a stationary rowing boat to a jetty.



Use the idea of momentum to explain why this happened.

____

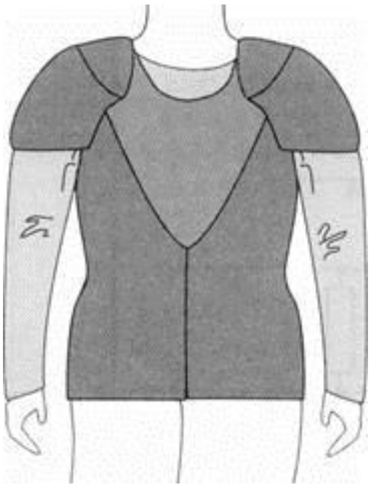
____

____

____

(2)

(c) The diagram shows one type of padded body protector which may be worn by a horse rider.



If the rider falls off the horse, the body protector reduces the chance of the rider being injured. Use the idea of momentum to explain why.

____

____

____

____

____

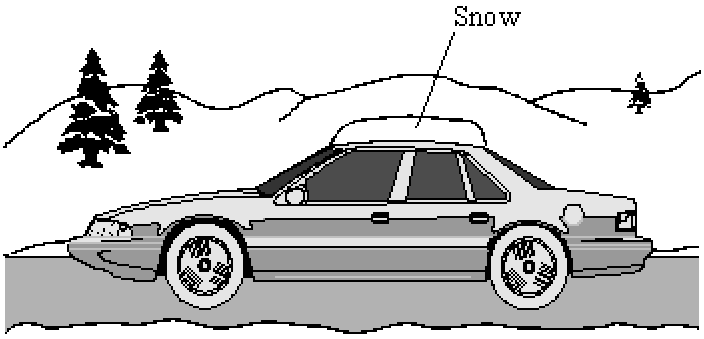
____

(3)

(Total 9 marks)

Q28.

(a) The diagram shows a car being driven at 14 rn/s. The driver has forgotten to clear a thick layer of snow from the roof.



Mass of car	= 750 kg
Mass of driver	= 80 kg
Mass of snow	= 35 kg

Which of the following has the smallest momentum? Draw a circle around your answer.

the car   the driver   the snow

Give a reason for your answer.

____

____

(2)

(b) Seeing an obstacle in the road, the driver applies the car brakes. The car slows down in a straight line.

(i) Does the momentum of the car increase, decrease or stay the same?

____

Give a reason for your answer.

____

(2)

(ii) As the car slows down the snow starts to slide. In which direction will the snow start to slide, backwards, forwards or sideways?

____

Give a reason for your choice of direction.

____

(2)

(c) Draw a circle around the unit which can be used to measure momentum.

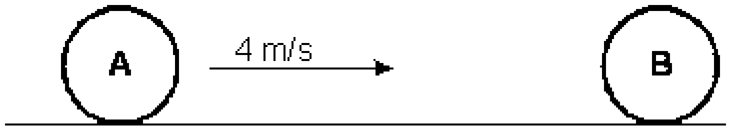
Nm   J/s   Ns

(1)

(Total 7 marks)

Q29.

The diagram below shows two balls on the bowling green. Ball A is moving with a velocity of 4 m/s, and is about to collide with ball B which is stationary. Both balls have a mass of 1.5 kg.



After the collision both balls move to the right but the velocity of A is now 1 m/s.

(a) (i) Calculate the momentum of ball A just before the collision.

____

Answer ____________ kg m/s

(1)

(ii) What is the total momentum of balls A and B after the collision?

____

____

Answer _____________ kg m/s

(1)

(iii) Calculate the momentum of ball A just after the collision.

____

Answer _____________ kg m/s

(1)

(iv) Calculate the momentum of ball B just after the collision.

____

Answer _____________ kg m/s

(1)

(v) Calculate the velocity of ball B just after the collision.

____

Answer _______________ m/s

(1)

(b) Calculate the loss of kinetic energy in the collision.

____

____

____

____

____

Answer ________________ J

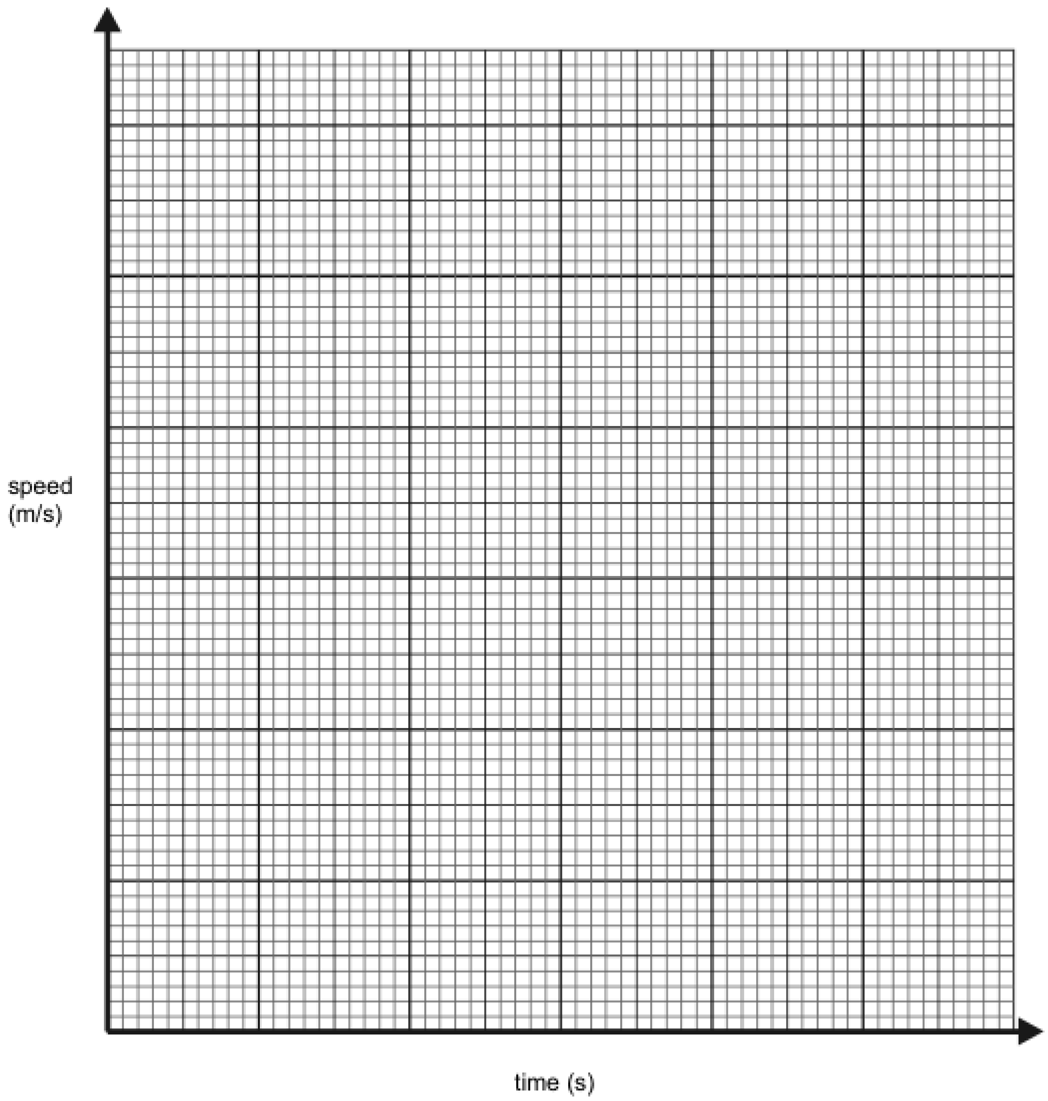
(3)

(Total 8 marks)

Q30.

A driver is driving along a road at 30 m/s. The driver suddenly sees a large truck parked across the road and reacts to the situation by applying the brakes so that a constant braking force stops the car. The reaction time of the driver is 0.67 seconds, it then takes another 5 seconds for the brakes to bring the car to rest.

(a) Using the data above, draw a speed-time graph to show the speed of the car from the instant the truck was seen by the driver until the car stopped.



(5)

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

____

____

____

Answer = __________________ m/s^2

(3)

(c) The mass of the car is 1500 kg. Calculate the braking force applied to the car.

____

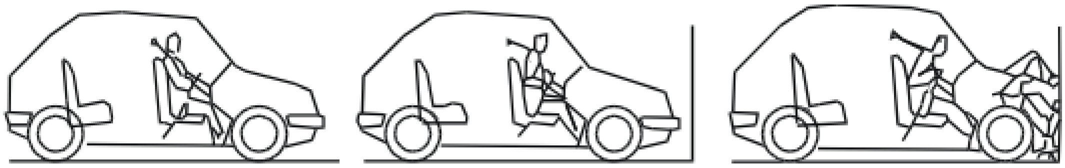
____

____

Answer = ____________________ N

(3)

(d) The diagrams below show what would happen to a driver in a car crash.



(i) Explain why the driver tends to be thrown towards the windscreen.

____

____

____

____

____

____

(ii) The car was travelling at 30 m/s immediately before the crash. Calculate the energy which has to be dissipated as the front of the car crumples.

____

____

____

____

(8)

(Total 17 marks)

Q31.

(a) How can the momentum of an object be calculated?

____

____

(2)

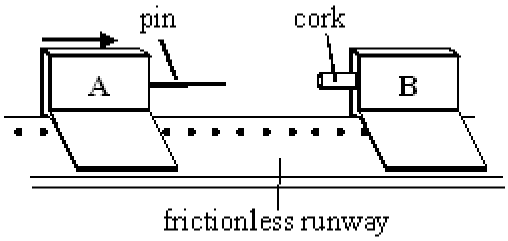
(b) In a collision momentum is always conserved. What does this mean?

____

____

(2)

(c) Two trolleys are placed on a frictionless runway as shown in the diagram below. Trolley A has a protruding pin, and trolley B is fitted with a piece of soft cork so that the trolleys will stick together after colliding.



Trolley A has a mass of 2 kg, and trolley B has a mass of 1 kg. Trolley B is stationary. Trolley A strikes trolley B at a speed of 6 m/s. Both trolleys then move to the right together.

(i) Calculate the speed at which trolleys A and B jointly move after the collision.

____

____

____

____

(4)

(ii) Calculate the change in kinetic energy which occurs during the collision.

____

____

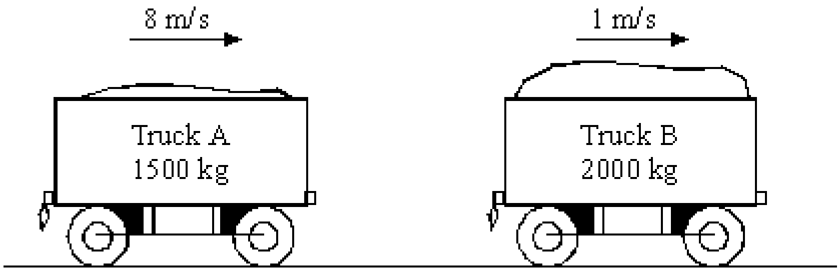
____

____

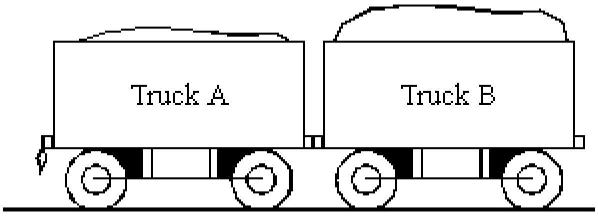
(4)
(Total 12 marks)

Q32.

The drawing below shows two railway trucks A and B, moving in the same direction. Truck **A**, of mass 1500 kg, is initially moving at a speed of 8 m/s. Truck **B**, of mass 2000 kg, is initially moving at a speed of 1 m/s.



Truck A catches up and collides with truck B. The two trucks become coupled together as shown in the diagram.



(a) Calculate:

(i) the initial momentum of truck A.

____

______________________________ momentum _____________________ kg m/s

(ii) the initial momentum of truck B.

____

______________________________ momentum _____________________ kg m/s

(iii) the total momentum of the trucks before the collision.

____

_________________________ total momentum _____________________ kg m/s

(6)

(b) Calculate the speed of the coupled trucks after the collision.

____

____

____

____

(5)

(c) (i) How is the total kinetic energy of the trucks changed as a result of the collision?
A calculated answer is not needed for full marks.

____

(ii) State an energy transfer which accounts for part of the change in the total kinetic energy of the trucks during the collision.

____

(2)

(Total 12 marks)

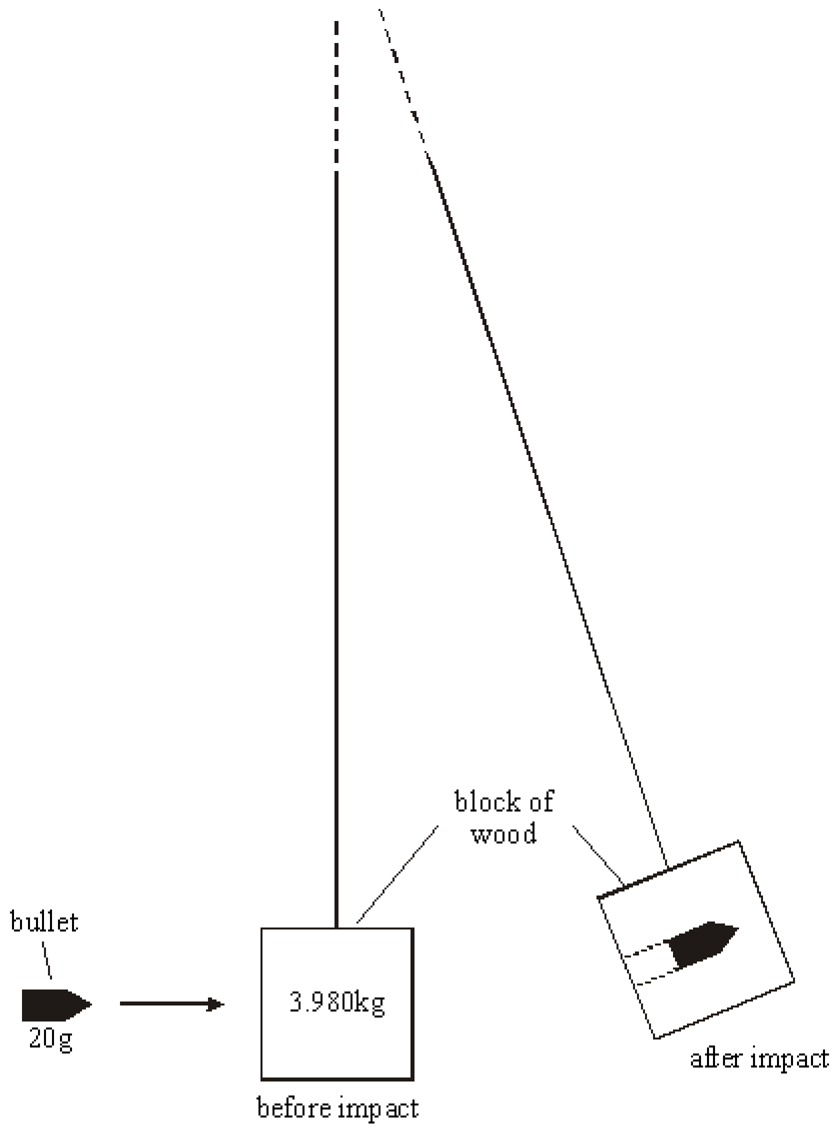
Q33.

(a) When an object is moving it is said to have momentum.
Define momentum.

____

(1)

(b) The diagram below shows one way of measuring the velocity of a bullet.



A bullet is fired into a block of wood suspended by a long thread.
The bullet stops in the wooden block.
The impact of the bullet makes the block swing.
The velocity of the wooden block can be calculated from the distance it swings.

In one such experiment the block of wood and bullet had a velocity of 2 m/s **immediately after** impact. The mass of the bullet was 20 g and the mass of the wooden block 3.980 kg.

(i) Calculate the combined mass of the block of wood and bullet.

______________________________________ Mass _____________________

(1)

(ii) Calculate the momentum of the block of wood and bullet **immediately after** impact.

____

____

____

____

______________________________________ Momentum _______________

(3)

(iii) State the momentum of the bullet **immediately before** impact.

____

(1)

(iv) Calculate the velocity of the bullet **before** impact.

____

____

____

______________________________________ Velocity ______________ m/s

(3)

(v) Calculate the kinetic energy of the block of wood and bullet **immediately after** impact.

____

____

____

_____________________________________ Kinetic energy ____________ J

(3)

(vi) The kinetic energy of the bullet before the impact was 1600 joules. This is much greater than the kinetic energy of the bullet and block just after the impact.
What has happened to the rest of the energy?

____

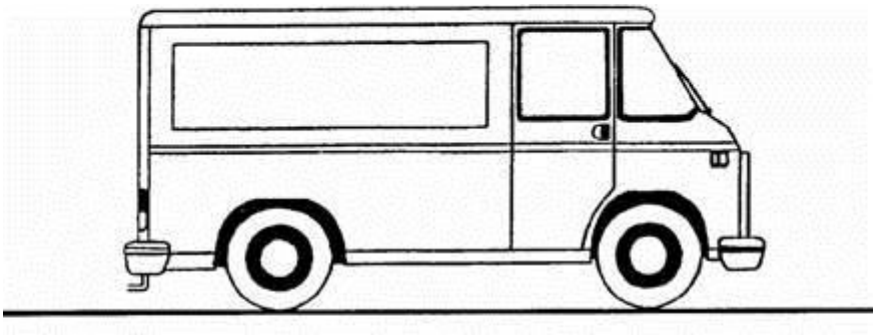
____

____

____

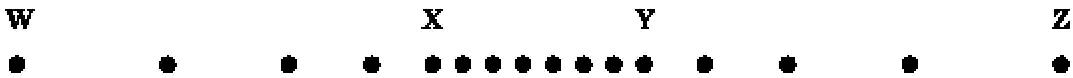
(1)
(Total 13 marks)

Q34.



(a) The van shown above has a fault and leaks one drop of oil every second.

The diagram below shows the oil drops left on the road as the van moves from **W** to **Z**.



Describe the motion of the van as it moves from:

W to **X** ____

____

X to **Y** ____

____

Y to **Z** ____

____

(3)

(b) The van was driven for 20 seconds at a speed of 30m/s.

Calculate the distance travelled.

____

____

____

Distance ___________ m

(2)

(c) The van was travelling at 30m/s. It slowed to a stop in 12 seconds.

Calculate the van's acceleration.

____

____

____

Acceleration ___________ m/s^2

(3)

(d) The driver and passenger wear seatbelts. Seatbelts reduce the risk of injury.

Explain how seatbelts reduce the risk of injury.

____

____

____

____

____

____

____

____

(4)

(Total 12 marks)

Q35.

(a) The amount of damage caused when a car collides with a wall depends on the amount of energy transferred.

If the speed of a car **doubles**, the amount of energy transferred in a collision increases **four** times.

Explain, as fully as you can, why this is so.

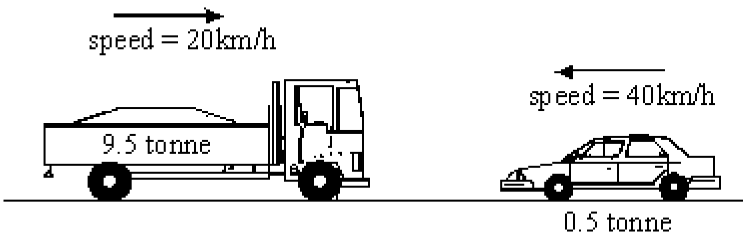
____

____

____

(3)

(b) The diagram shows a car and a lorry about to collide.



When they collide, the two vehicles become tightly locked together.

(i) Calculate the speed of the vehicles immediately after the collision.

(Show your working. There is no need to change to standard units.)

____

____

Answer ____________________ km/h

(6)

(ii) The collision between the car and the lorry is inelastic.

Explain, in terms of energy, what this means.

____

(1)

(Total 10 marks)