1 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.

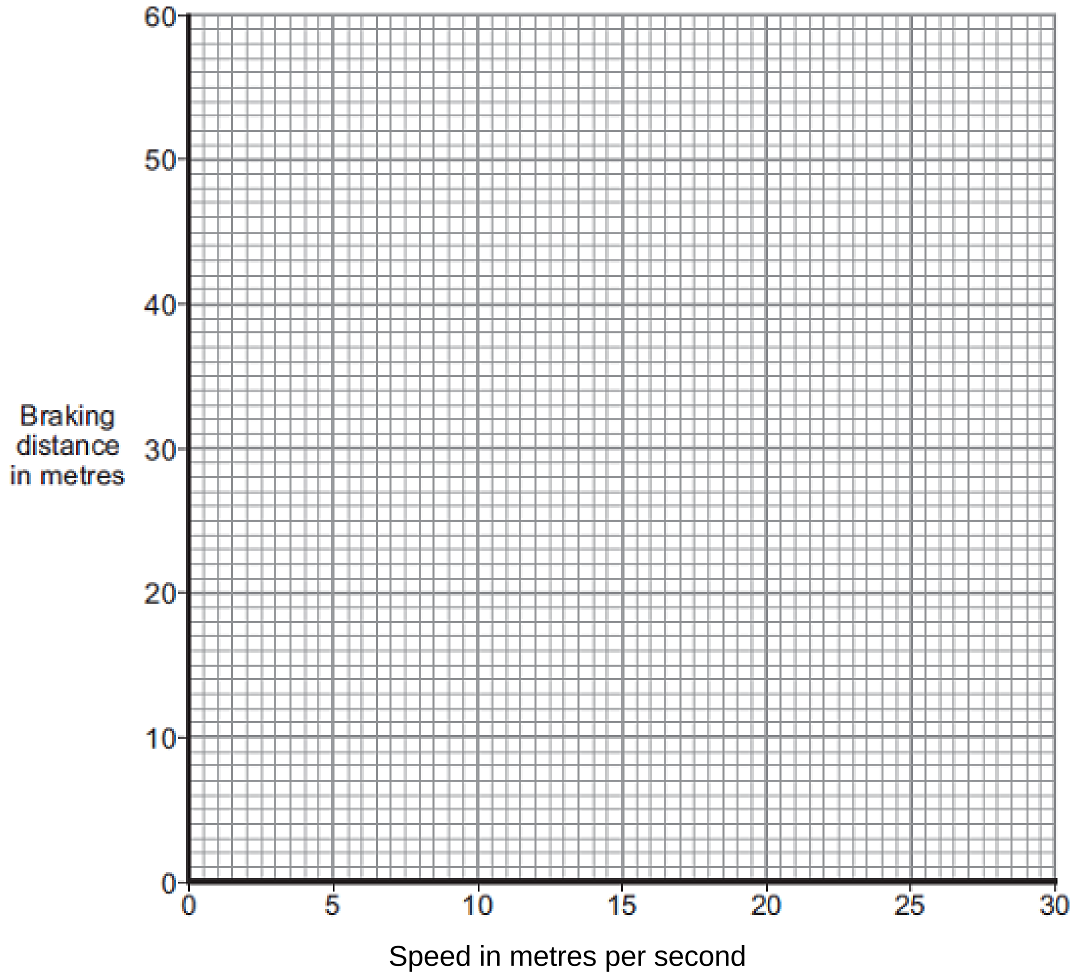
....

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)

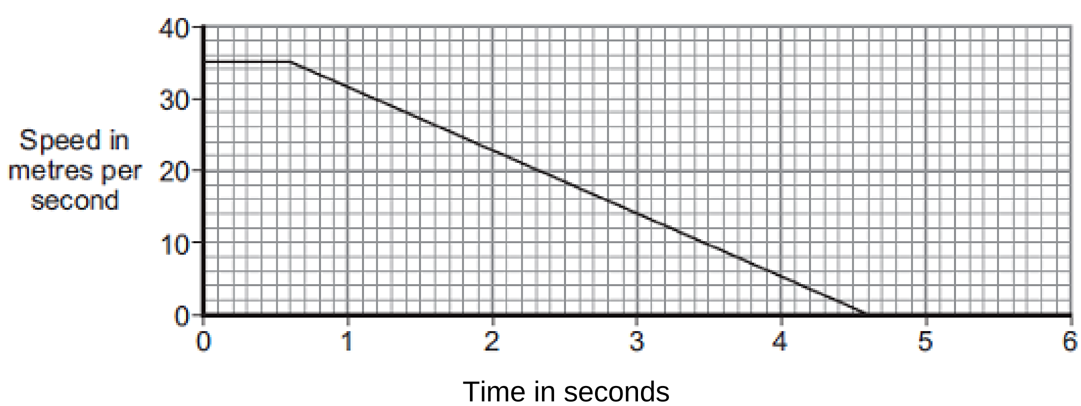
(ii) Use your graph to determine the braking distance, in metres, at a speed of 22 m / s.

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.



(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)

2 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)

3 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.

....

....

....

....

....

....

....

....

(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.

....

....

....

....

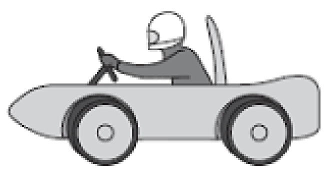
....

....

Velocity of skateboard = ... m / s

(3)
(Total 6 marks)

4 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 ....

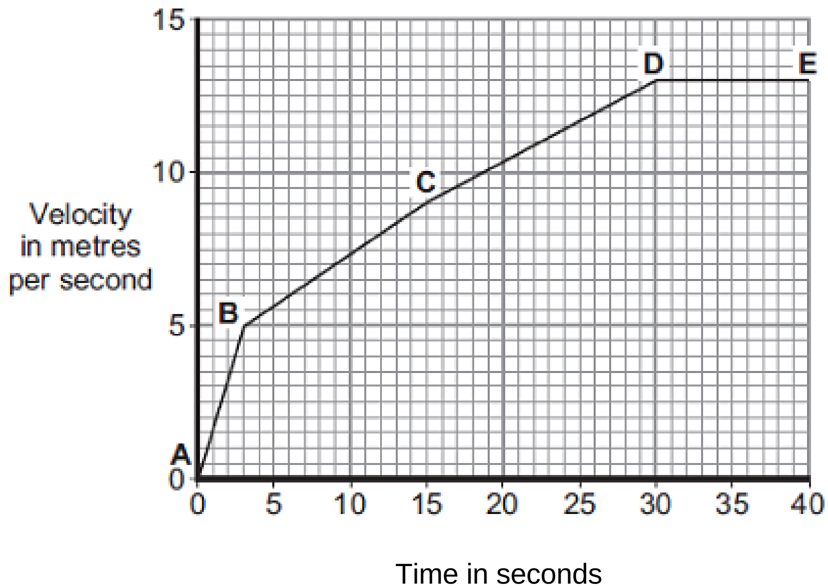
....

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**.

....

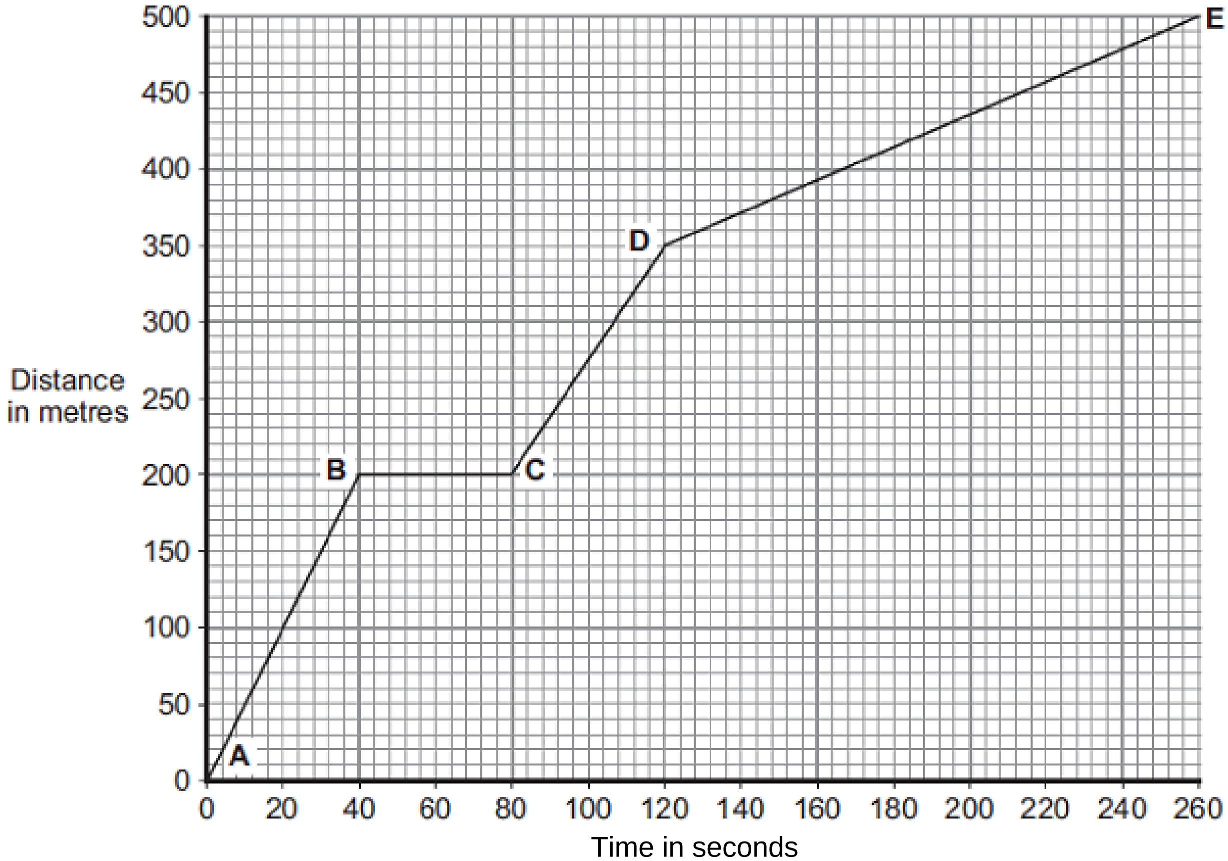
....

Momentum = ... kg m/s

(2)
(Total 6 marks)

5

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)

6 (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.

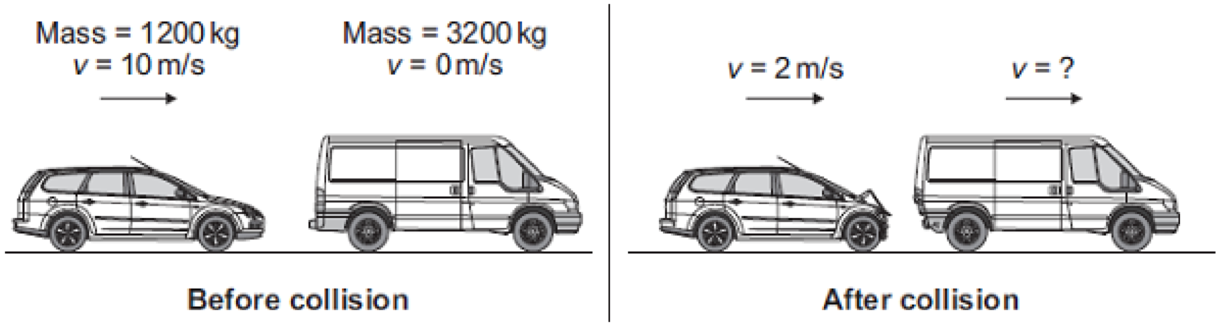
Why?

....

....

(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.

....

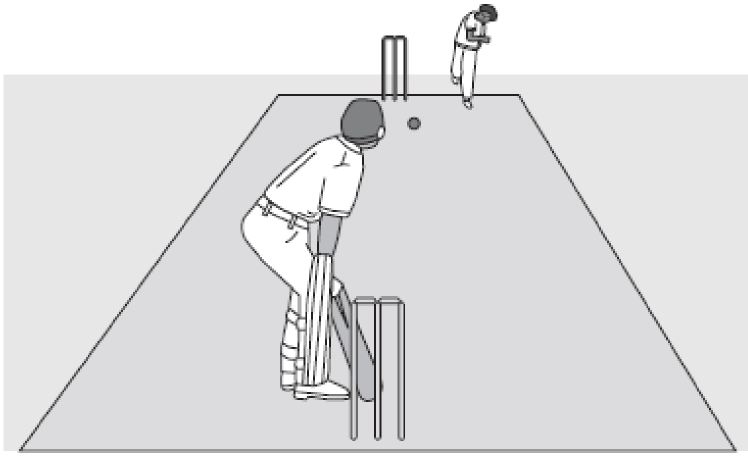
....

....

Velocity = ... m/s forward

(2)
(Total 7 marks)

7 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.

....

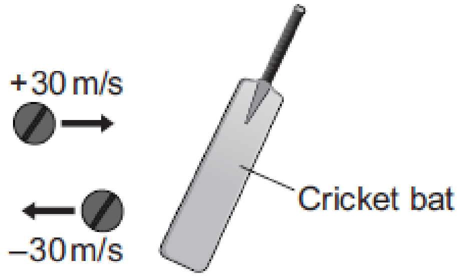
....

....

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.

momentum = mass × 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.

....

....

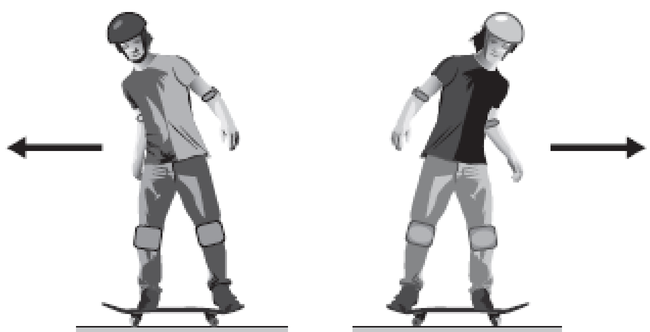
....

....

....

(2)
(Total 7 marks)

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



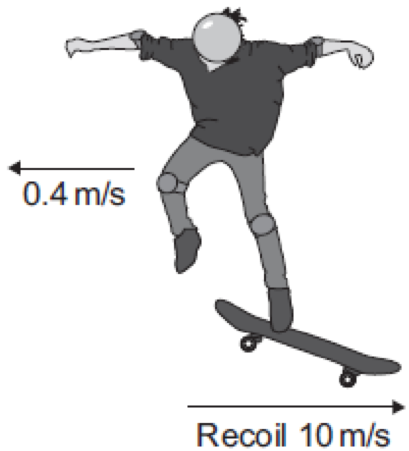
Why do the teenagers **not** have the same momentum?

....

....

(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.

....

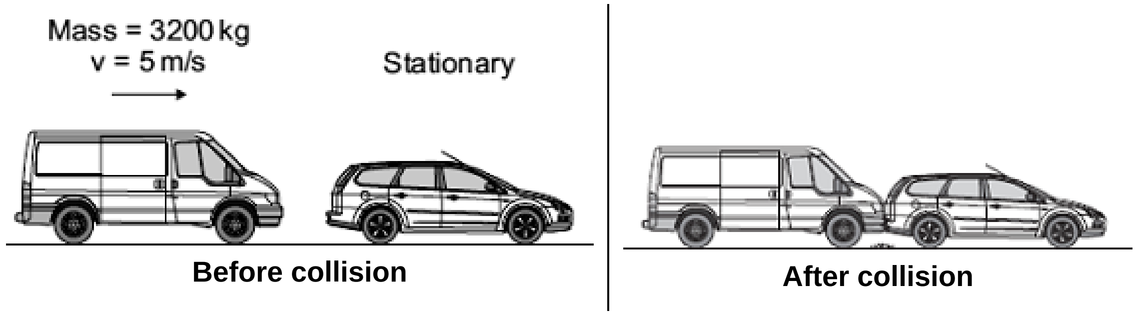
....

....

....

(2)
(Total 7 marks)

9 (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)

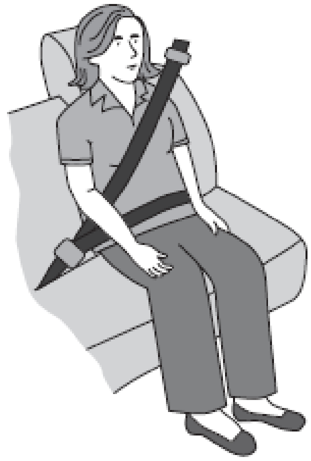
(iii) Complete the following sentence by drawing a ring around the correct line in the box.

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

momentum of the car after the collision.

(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)

10 (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.

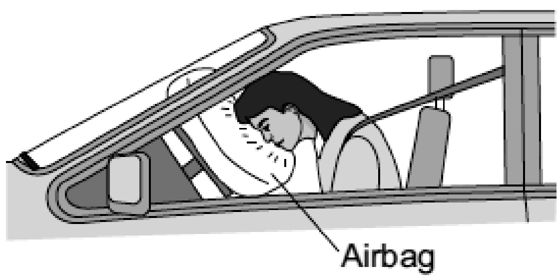
....

....

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.

....

....

....

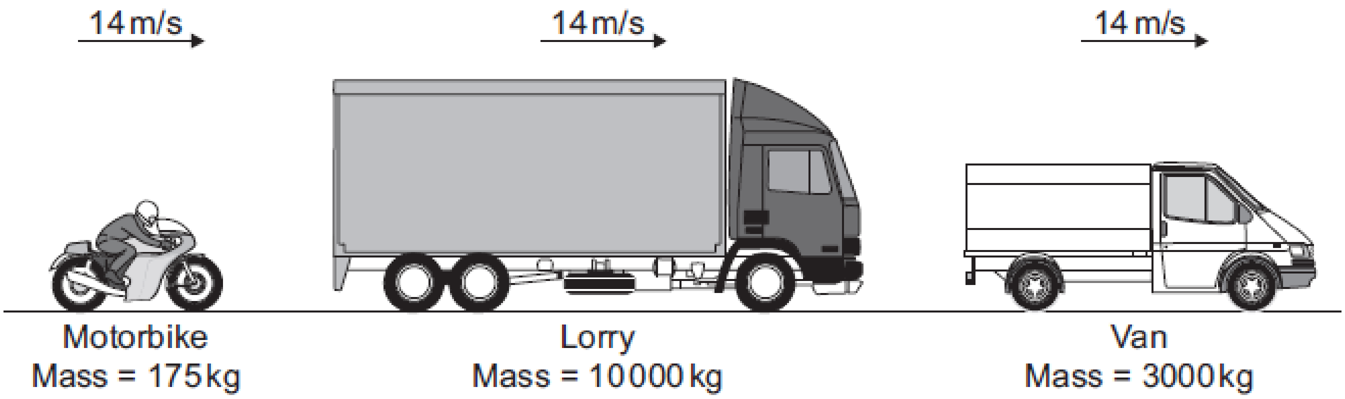
....

....

....

(3)
(Total 6 marks)

11 (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).

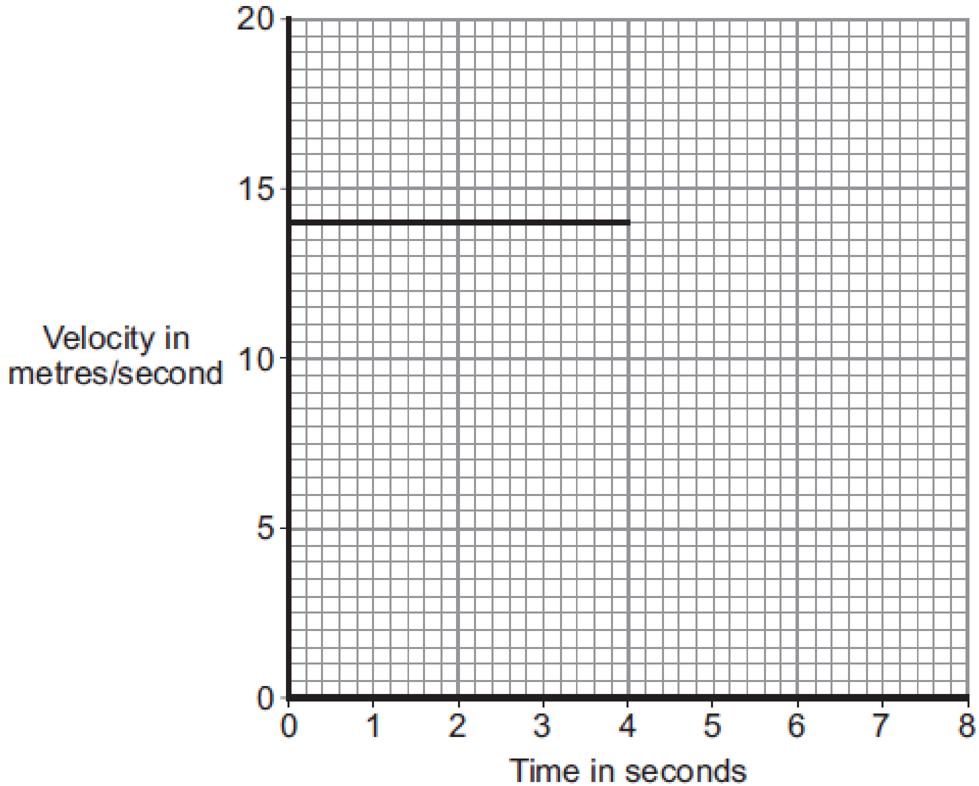
....

....

(1)

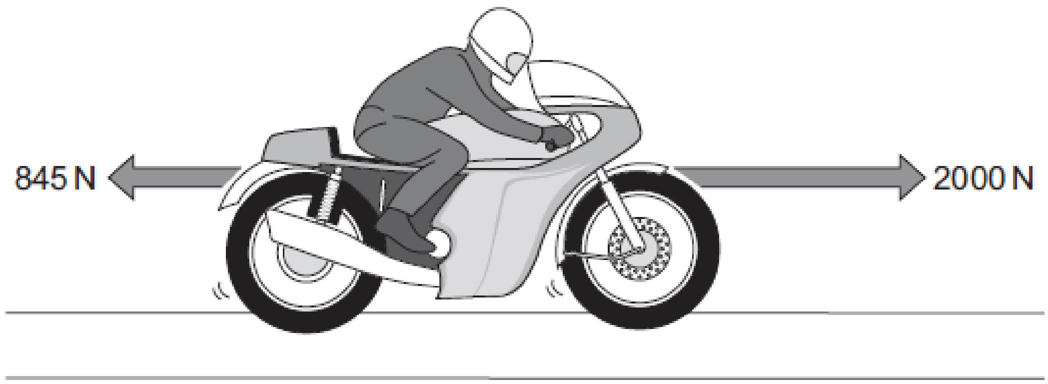
(iii) The graph shows the velocity of the motorbike up to the time when it starts to accelerate. The motorbike accelerates constantly, going from a speed of 14 m/s to a speed of 20 m/s in a time of 2 seconds. The motorbike then stays at 20 m/s.

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



(3)
(Total 9 marks)

12 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.

....

....

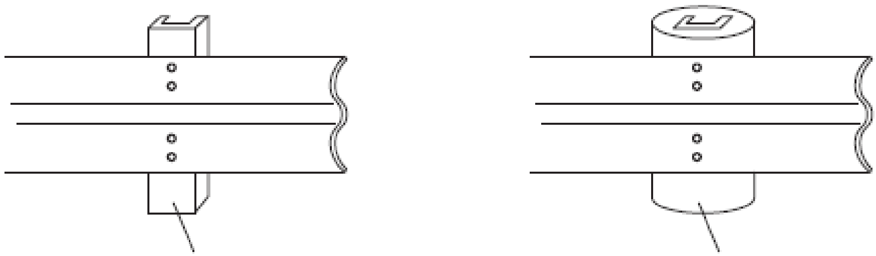
....

....

(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)

13

(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.

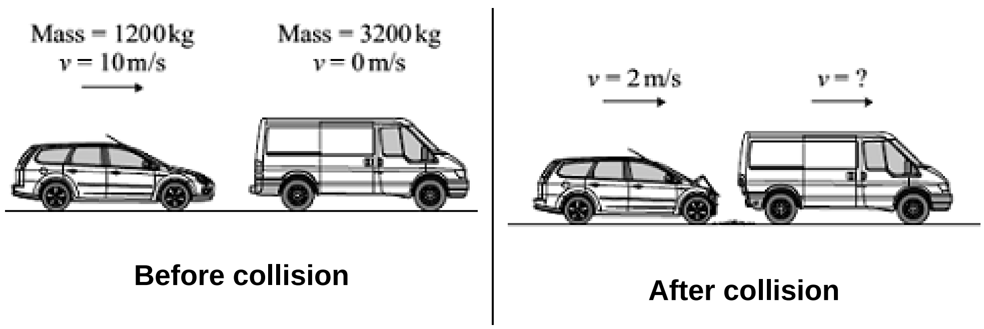
Why?

....

....

(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.

....

....

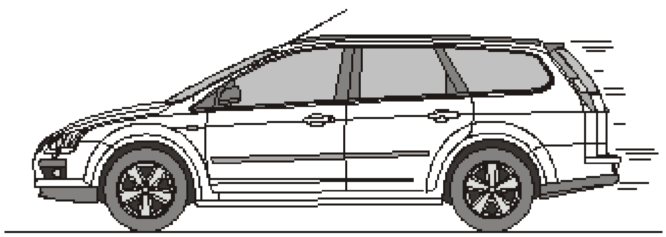
....

Velocity =.. m/s forward

(2)

(Total 7 marks)

14 (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.

....

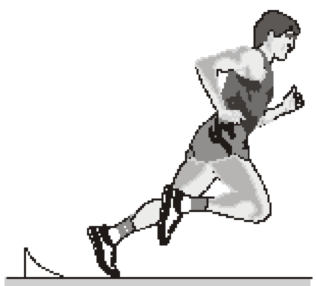
....

....

....

(2)
(Total 5 marks)

15 (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)

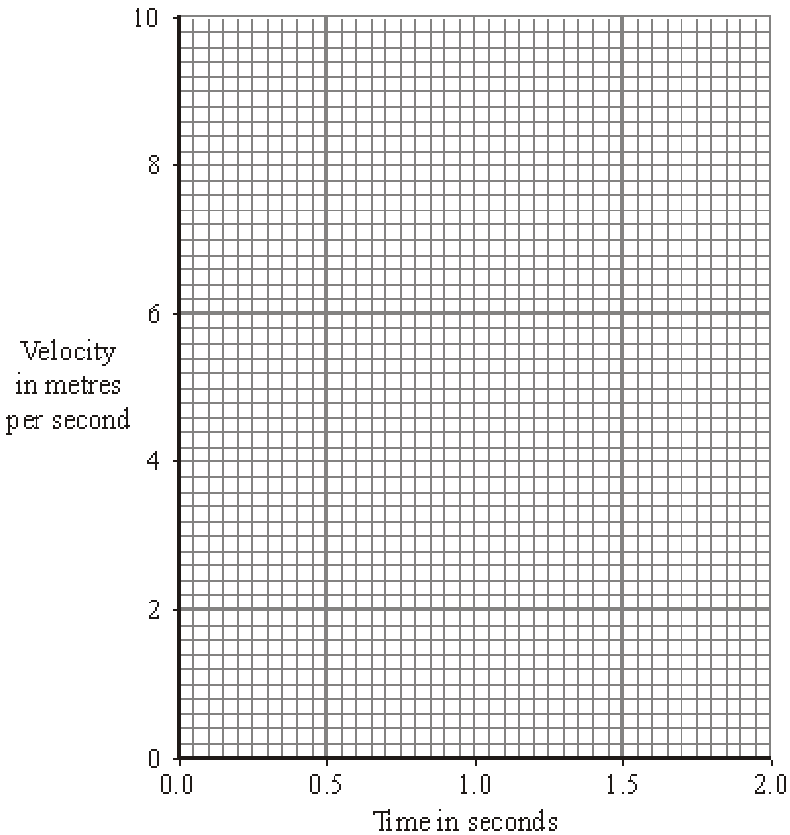
(iii) Complete the following sentence.

The velocity of the athlete is the .... of the

athlete in a given direction.

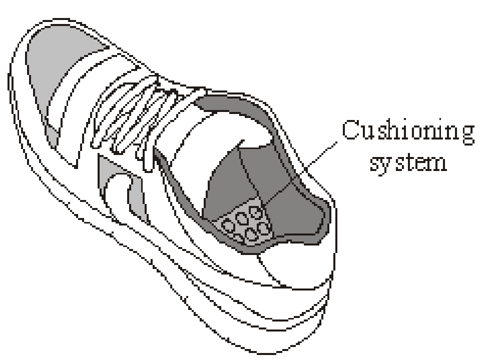
(1)

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

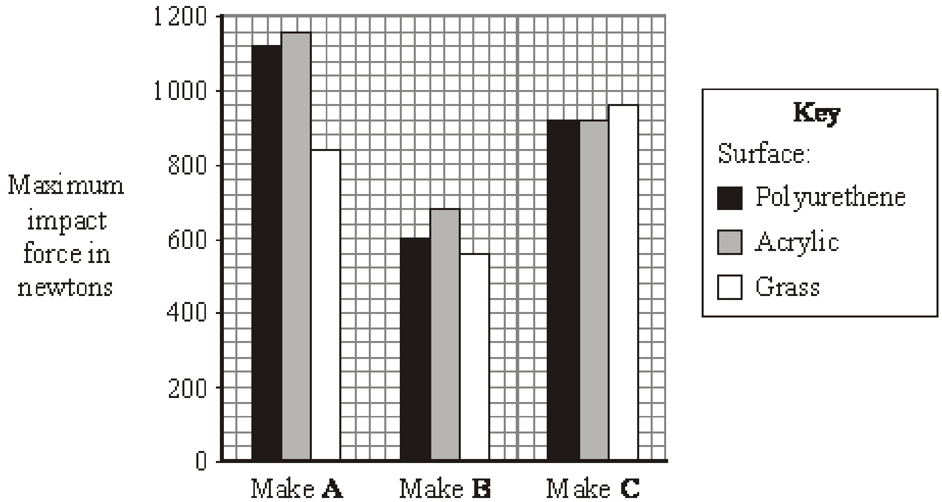


(2)

(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.

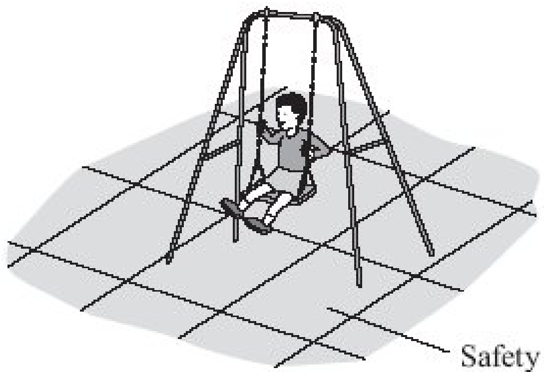
Why is this data likely to be more reliable than data obtained using human athletes?

....

....

(1)
(Total 10 marks)

16 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.

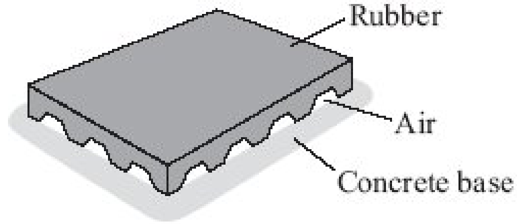
....

....

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.

....

....

....

....

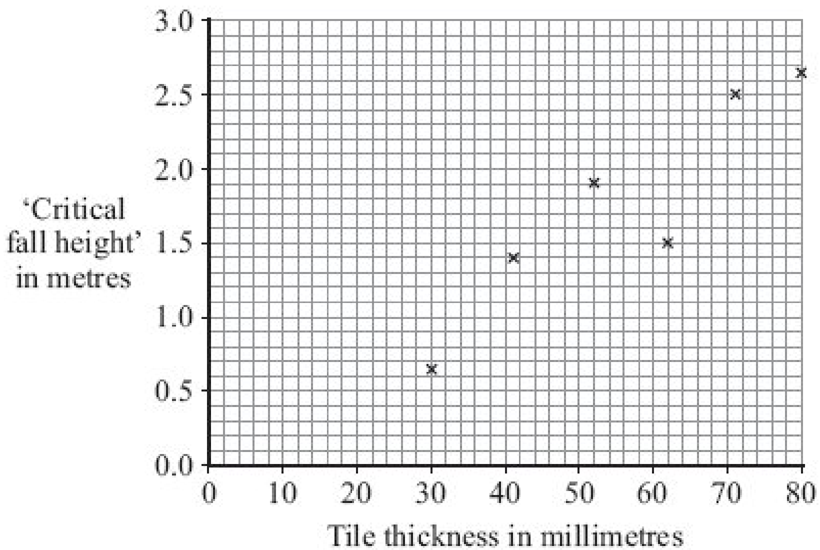
....

....

(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.

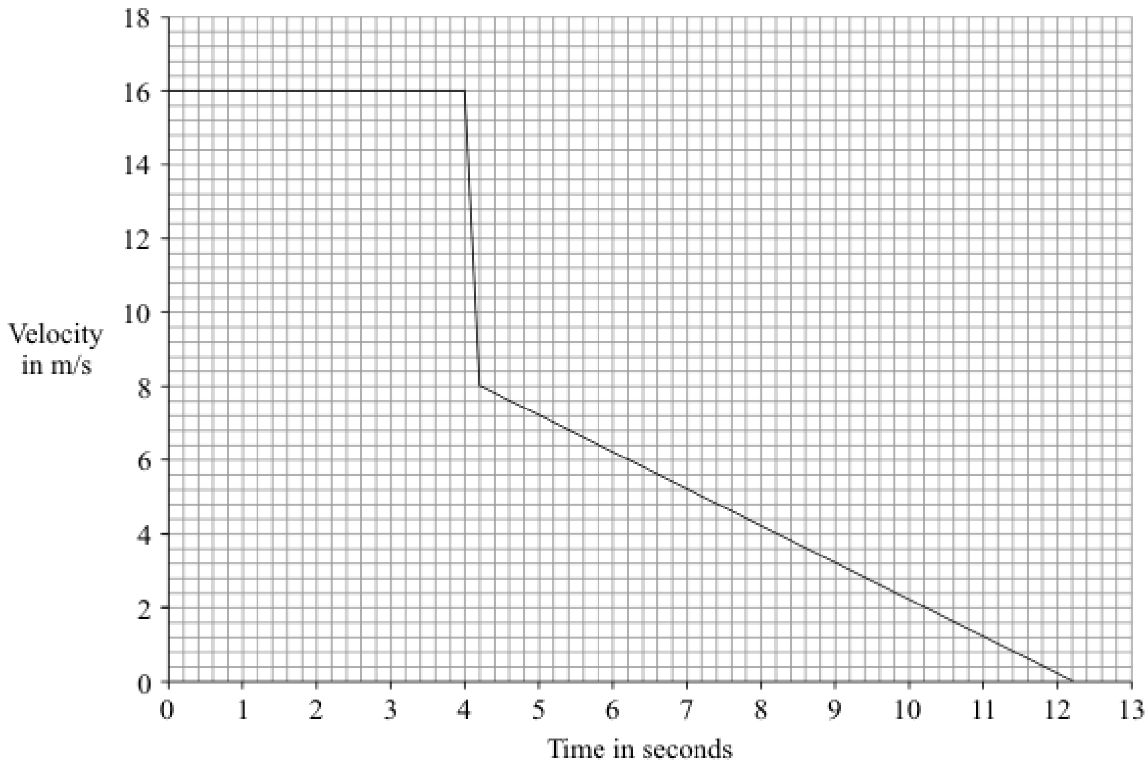
....

....

(1)
(Total 11 marks)

17 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.

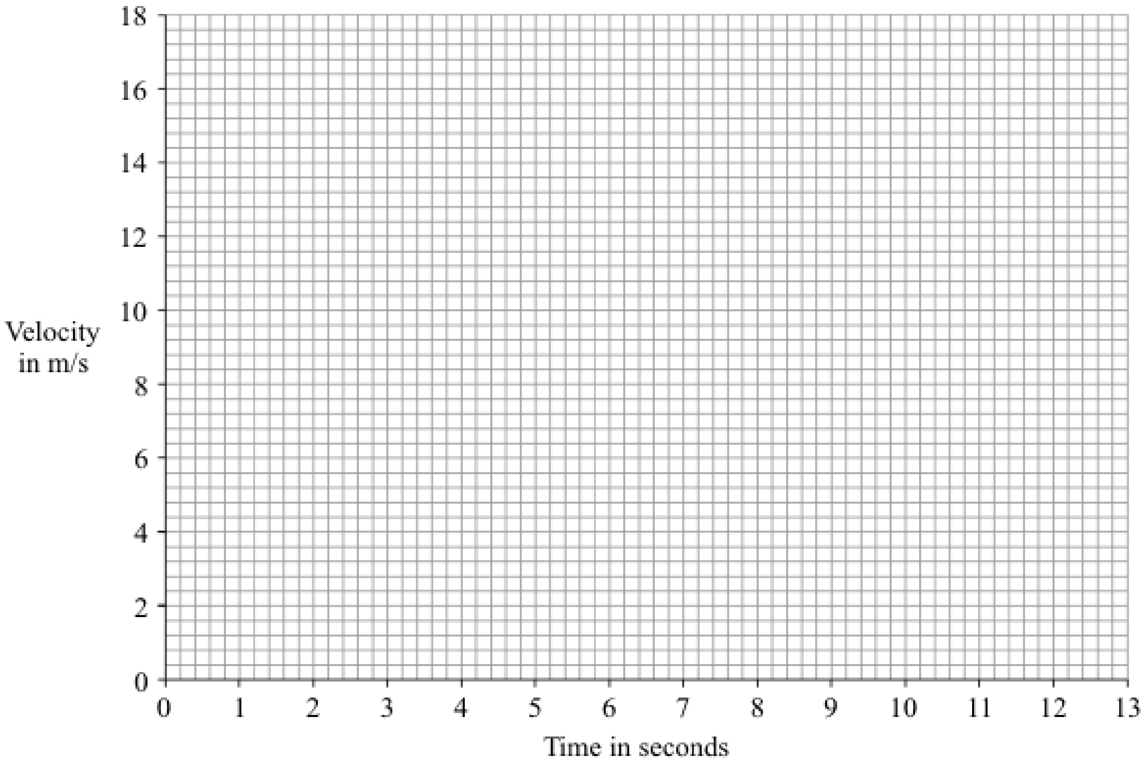
....

....

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.

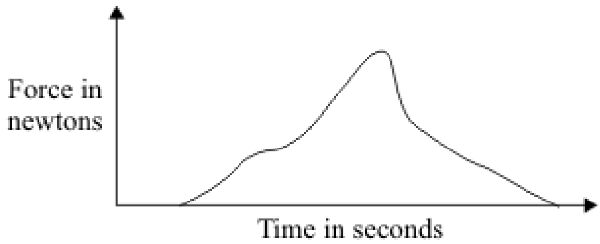
What does this statement mean?

....

....

(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.

....

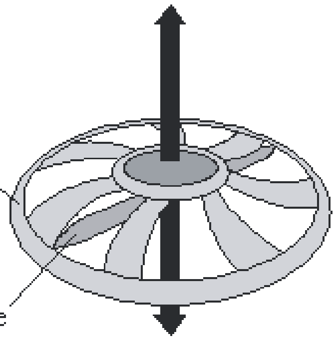
....

....

....

(2)
(Total 8 marks)

18 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.

....

....

....

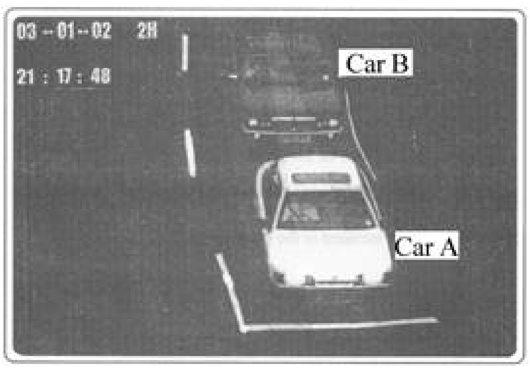
....

....

....

(3)
(Total 8 marks)

19 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.

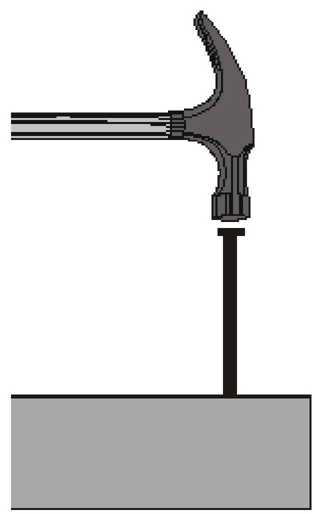
....

....

Speed = ... m/s

(3)
(Total 7 marks)

20 (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)

21 (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.

....

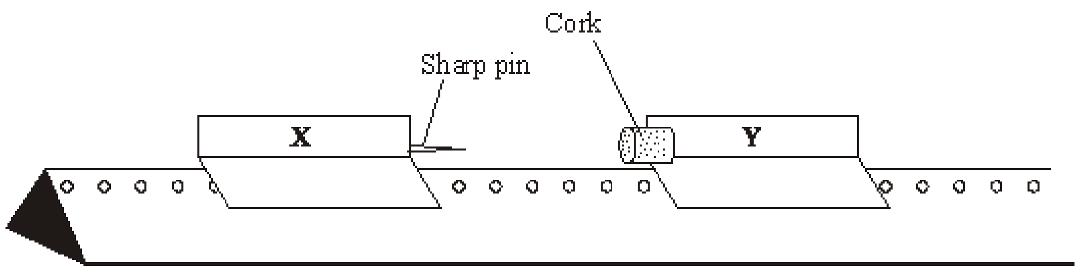
(1)

(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)

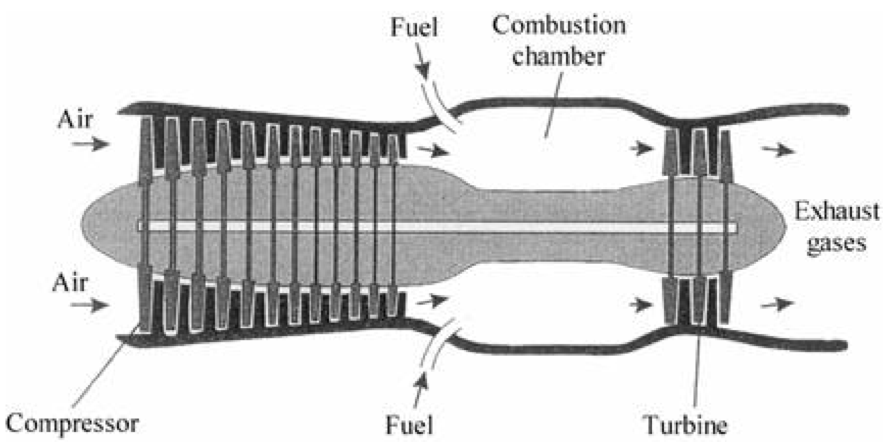
22 (a) What is the principle of conservation of momentum?

....

....

(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.)

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

....

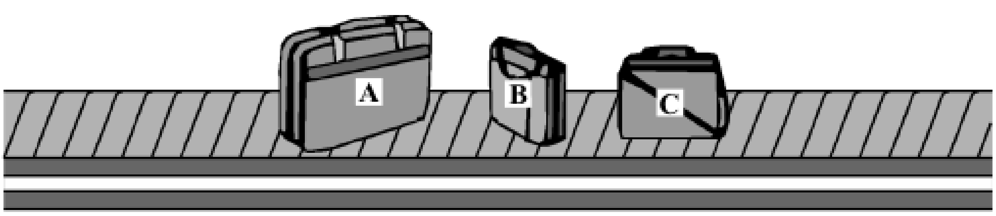
....

....

Mass of air = ... kg

(2)
(Total 9 marks)

23 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?

....

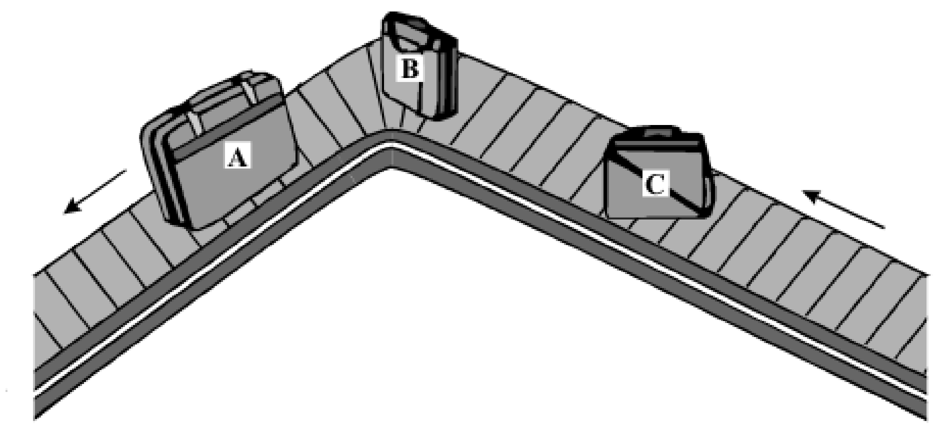
Give a reason for your answer.

....

....

(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.

....

....

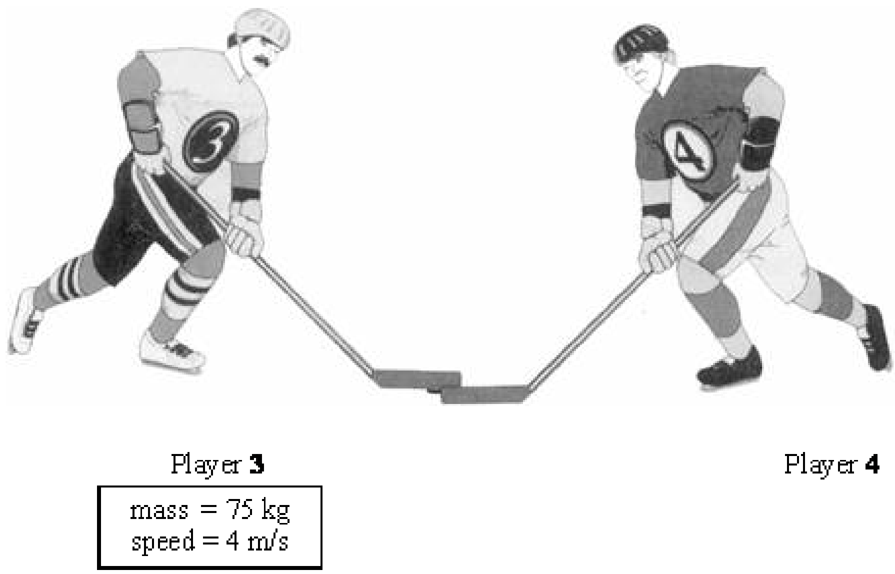
(2)

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

J/s kg m/s Nm

(1)
(Total 7 marks)

24 (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** = ...

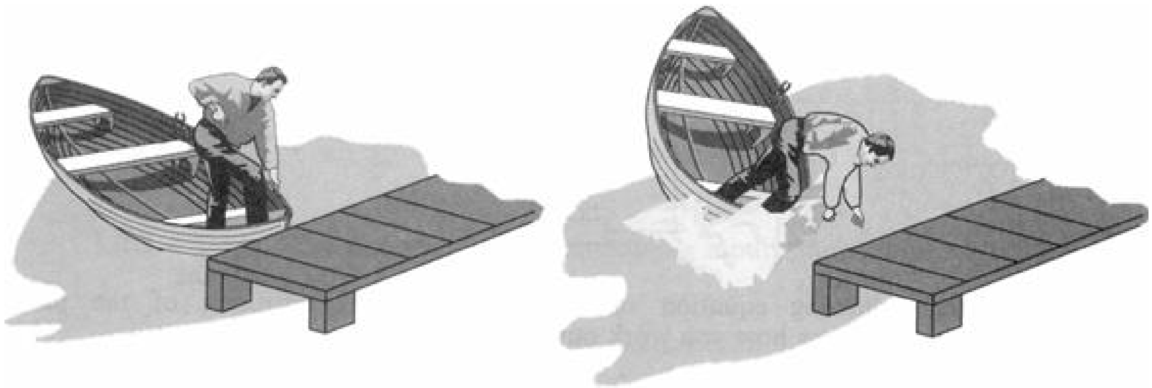
(3)

(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.

....

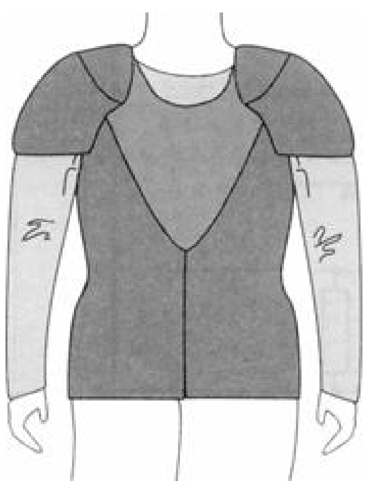
....

....

....

(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.

....

....

....

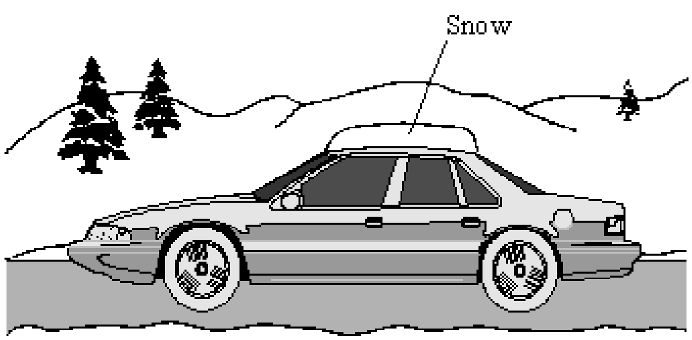
....

....

....

(3)
(Total 9 marks)

25 (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.

....

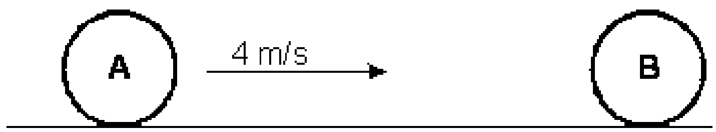
(2)

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

Nm J/s Ns

(1)
(Total 7 marks)

26 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.

....

....

....

....

....

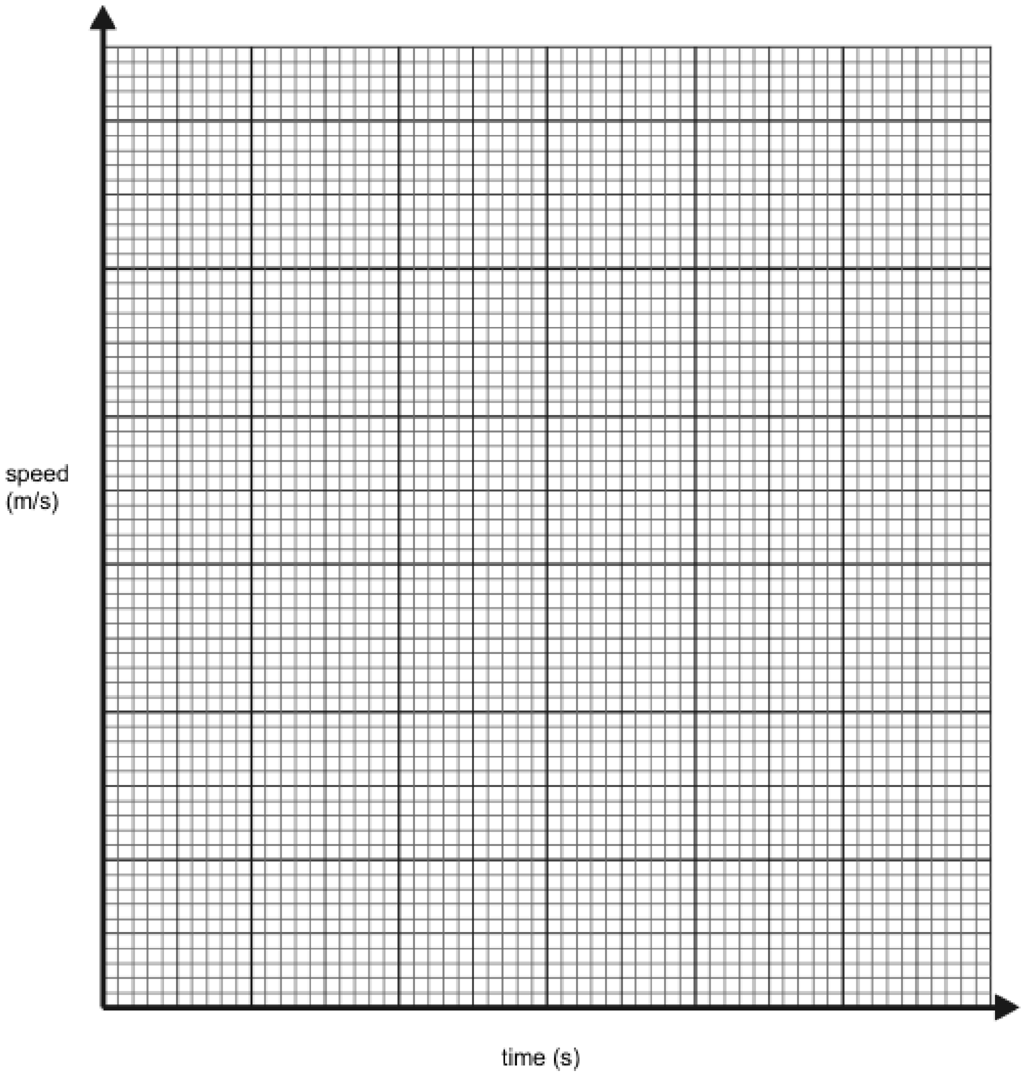
Answer .... J

(3)

(Total 8 marks)

27 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.

....

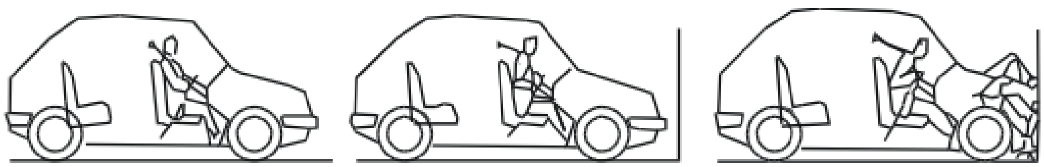
....

....

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)

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

....

....

(2)

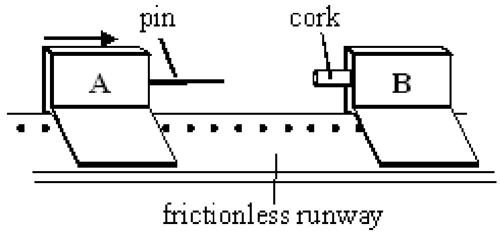
(b) In a collision momentum is always conserved. What does this mean?

....

....

(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.

....

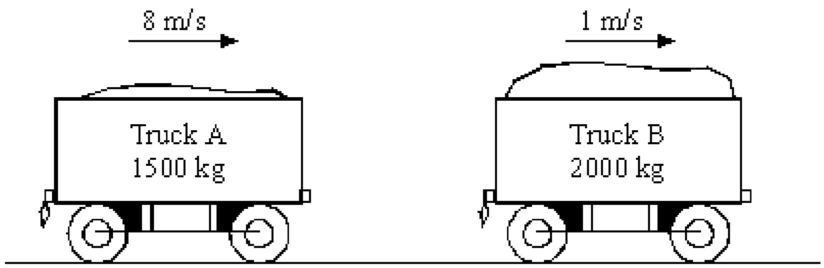
....

....

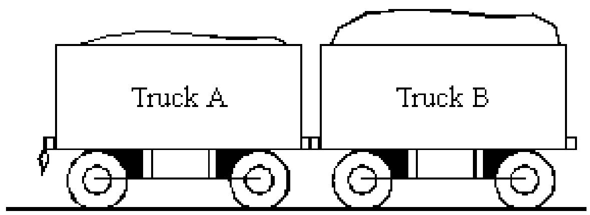
....

(4)
(Total 12 marks)

29 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)

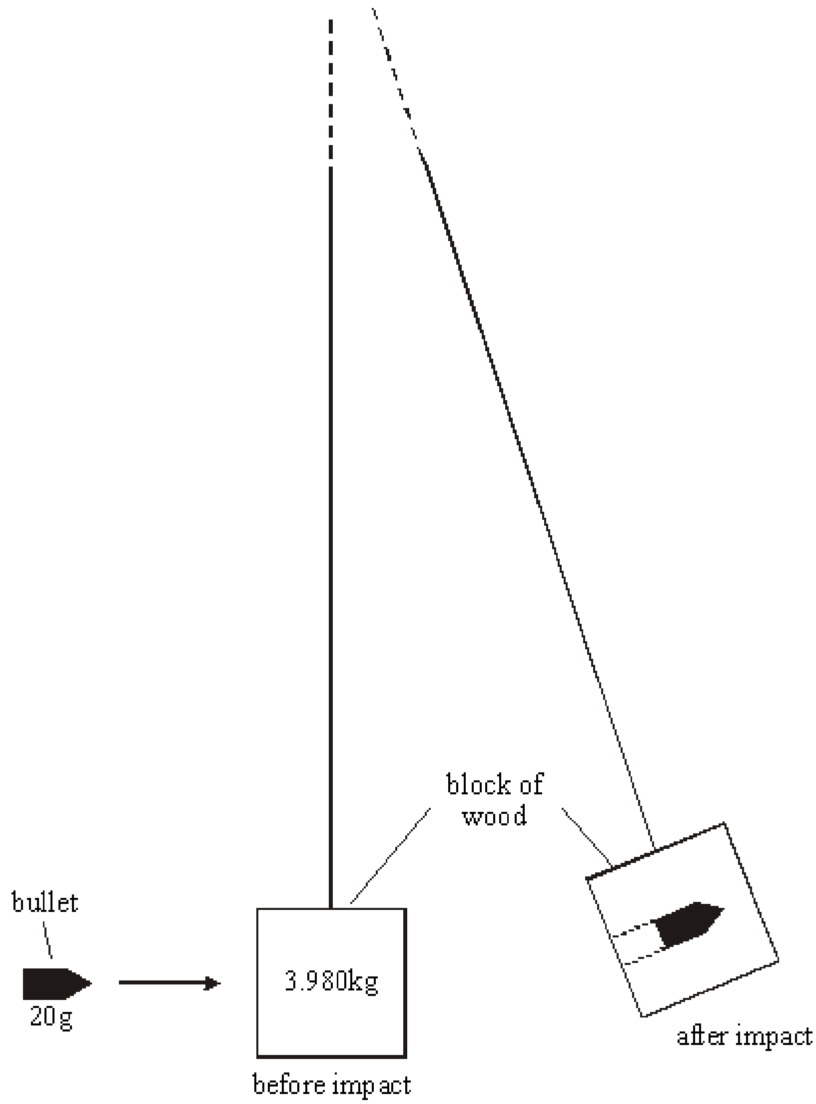
30 (a) When an object is moving it is said to have momentum.
Define momentum.

....

....

(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?

....

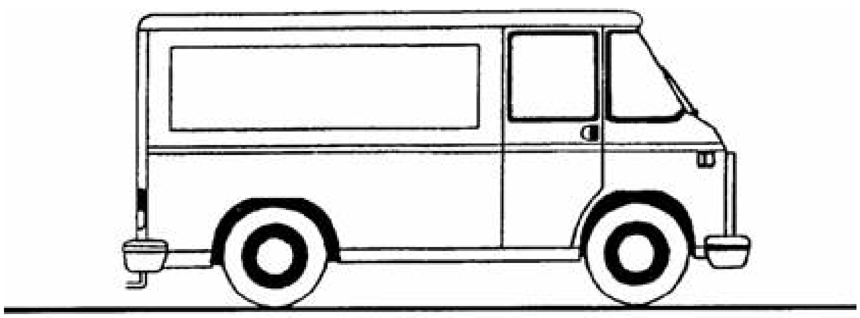
....

....

....

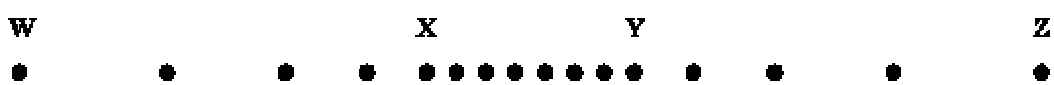
(1)
(Total 13 marks)

31



(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)

32 (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.

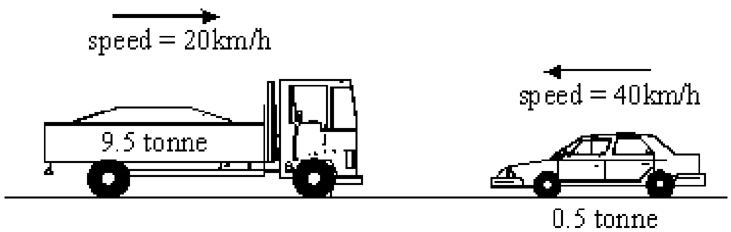
....

....

....

(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)

Mark schemes

1 (a) increases

1

increases

1

(b) 23 (m)

*accept 43 circled for **1** mark*

*accept 9 + 14 for **1** mark*

2

(c) (i) all points correctly plotted

all to ± ½ small square

*one error = **1** mark*

*two or more errors = **0** marks*

2

line of best fit

1

(ii) correct value from their graph (± ½ small square)

1

(d) (i) 70

*½ × 35 × 4 gains **2** marks*

*attempt to estimate area under the graph for **1** mark*

3

(ii) line from (0.6,35)

1

sloping downwards with a less steep line than the first line

1

cutting time axis at time > 4.6 s

accept cutting x-axis at 6

1

(e) (i) 42 000

*1200 × 35 gains **1** mark*

2

kgm / s

Ns

1

(ii) 10 500 (N)

*42 000 / 4 gains **1** mark*

alternatively:

$a = 35 / 4 = 8.75$ m / s^2

$F = 1200 \times 8.75$

2

[19]

2 (a) Zero / 0

Accept none

Nothing is insufficent

1

velocity / speed = 0

accept it is not moving

paintball has not been fired is insufficient

1

(b) 0.27

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

2

(c) equal to

1

[5]

3 (a) momentum before (jumping) = momentum after (jumping)

accept momentum (of the skateboard and skateboarder) is conserved

1

before (jumping) momentum of skateboard and skateboarder is zero

accept before (jumping) momentum of skateboard is zero

accept before (jumping) total momentum is zero

1

after (jumping) skateboarder has momentum (forwards) so skateboard must have (equal) momentum (backwards)

answers only in terms of equal and opposite forces are insufficient

1

(b) 7

*accept –7 for **3** marks*

*allow **2** marks for momentum of skateboarder equals 12.6*

or

$0 = 42 \times 0.3 + (1.8 \times -v)$

or

*allow **1** mark for stating use of conservation of momentum*

3

[6]

4 (a) any **two** from:

- (make shape / body) more streamlined

  accept a correct description
  accept lower the seating position of the driver

- increase power of engine

  faster engine is insufficient

- reduce mass / weight (of go-kart)

  change wheel size is insufficient

2

(b) (i) A–B

reason only scores if A–B is chosen

1

steepest / steeper gradient / slope

1

(iii) 1820

*allow **1** mark for correct substitution, ie 140 × 13 provided no subsequent step shown*

2

[6]

5 (a) **D** – **E**

reason only scores if D – E chosen

1

shallowest slope / gradient

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

1

(b) 80 000

*allow **1** mark for correct substitution, ie 16 000 × 5 provided no subsequent step shown*

2

(c) (i) <u>straight</u> line starting at origin

accept within one small square of the origin

1

passing through t = 220 and d = 500

1

(i) 186

accept any value between 180 and 188
accept where their line intersects given graph line correctly read ±4 s

1

[7]

6 (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

[7]

7 (a) 98

*allow **1** mark for correct substitution*

ie ½ × 0.16 × 35 × 35 provided no subsequent step shown

an answer of 98 000 scores 0

2

(b) (i) 9.6

*allow **1** mark for (change in velocity =) 60*

ignore negative sign

2

(ii) 9600

ignore negative sign

or

their (b)(i) ÷ 0.001 correctly calculated, unless (b) (i) equals 0

1

(c) increases the time

1

to reduce/change <u>momentum</u> (to zero)

only scores if 1st mark scored

decreases rate of change of momentum scores both marks provided there are no contradictions

accept decreased acceleration/deceleration

equations on their own are insufficient

1

[7]

8 (a) (moving in) different / opposite directions

accept one has positive momentum the other negative momentum

accept they have different velocities

1

(b) (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

(c) any **two** from:

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

2

[7]

9 (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

[6]

10 (a) direction

1

(b) 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

(c) 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

[6]

11 (a) (i) lorry

reason only scores if lorry chosen

1

greatest mass

accept weight for mass

accept heaviest

accept correct calculations for all 3 vehicles

the biggest is insufficient

1

(ii) 2450

*allow **1** mark for correct substitution*

ie 175 × 14

2

(b) (i) increases

accept any clear indication of the correct answer

1

(ii) speed increases

accept velocity for speed

accept gets faster

*do **not** accept it accelerates on its own*

moves more is insufficient

1

(iii) straight line going to 6, 20

*allow **1** mark for a curve going to 6,20*

***or** a straight line diagonally upwards but missing 6,20*

2

horizontal line from 6,20 to 8,20

*allow a horizontal line from where their **diagonal** meets 20m/s to 8,20*

1

[9]

12 (a) 4.2

*2 marks for correct substitution **and** transformation, ie 1155/275*

*allow **1** mark for correct resultant force with a subsequent incorrect method, ie 1155*

*allow **1** mark for an incorrect resultant force with a subsequent correct method,*

*eg answers of 7.27 or 10.34 gain **1** mark*

3

(b) (i) YES

marks are for the explanation

any **two** from:

- data (from police files) can be trusted
- data answers the question asked

  allow a conclusion can be made from the data
- large sample used

NO

any **two** from:

- the sample is not representative
- the sample size is too small
- accident files do not indicate age / experience of riders

  *an answer YES and NO can score **1** mark from each set of mark points*

2

(ii) more accidents with motorbikes up to 125 cc

*accept for **2** marks an answer in terms of number of under 125 cc to accidents ratio compared correctly with number of over 500 cc to accidents ratio*

1

even though there are fewer of these bikes than bikes over 500 cc

1

(c) (i) increases the time taken to stop

accept increases collision time

1

decreases rate of change in momentum

accept reduces acceleration / deceleration

accept $F = \frac{\Delta mv}{\Delta t}$

reduces momentum is insufficient

1

reduces the force (on the rider)

1

(ii) YES

any sensible reason, eg:

the mark is for the reason

- cannot put a price on life / injury

  accept may save lives

- fewer (serious) injuries

  accept reduces risk of injury

- reduces cost of health care / compensation

NO

any sensible suggestion, eg:

- money better spent on …

  needs to be specific

- total number of riders involved is small

1

[11]

13 (a) (i) momentum before = momentum after

or

(total) momentum stays the same

accept no momentum is lost

accept no momentum is gained

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

this may be given in words rather than symbols

or

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

[7]

14 (a) (i) 10800

allow 1 mark for correct substitution i.e. 900 × 12

2

(ii) arrow pointing towards the left

allow anywhere on the diagram or at bottom of the page

1

(b) zero

accept 0 / none / nothing

1

velocity is zero

accept speed for velocity

accept stopped / not moving

accept a calculation i.e. 900 × 0 = 0

1

[5]

15 (a) (i) 4.5

*allow **1** mark for correct substitution i.e. 9 ÷ 2*

2

(ii) m/s^2

accept answer given in (a)(i) if not contradicted here

1

(iii) speed

1

(iv) <u>straight</u> line from the <u>origin</u> passing through (2s, 9m/s)

*allow **1** mark for <u>straight</u> line from the origin passing through to t = 2 seconds*

*allow **1** mark for an attempt to draw a straight line from the origin passing through (2,9)*

*allow **1** mark for a minimum of 3 points plotted with no line provided if joined up would give correct answer. Points must include(0,0) and (2,9)*

2

(b) (i) **B**

*if **A** or **C** given scores **0** marks in total*

1

small<u>est</u> (impact) force

1

on <u>all/ every/ any</u> surfaces

these marks are awarded for comparative answers

1

(ii) (conditions) can be repeated

or

difficult to measure forces with human athletes

accept answers in terms of variations in human athletes e.g.

athletes may have different weights area / size of feet may be different difficult to measure forces athletes run at different speeds

accept any answer that states or implies that with humans the conditions needed to repeat tests may not be constant

e.g.
athletes unable to maintain constant speed during tests (or during repeat tests)

*do **not** accept the robots are more accurate*

removes human error is insufficient

fair test is insufficient

1

[10]

16 (a) (i) 210

*allow **1** mark for correct substitution i.e. 35 × 6*

2

kg m/s **or** Ns

*do **not** accept n for N*
*accept 210 000g m/s for **3** marks*

1

(ii) 840

if answer given is not 840 accept their (a)(i) in kg m/s ÷ 0.25 correctly calculated for both marks

*allow **1** mark for correct substitution i.e. 210 ÷ 0.25 or their (a)(i) ÷ 0.25*

2

(b) increases the time to stop

accept increases impact time
*do **not** accept any references to slowing down time*

1

decreases rate of change in momentum

accept reduces acceleration/deceleration
reduces momentum is insufficient

1

reduces the force (on the child)

1

(c) any **two** from:

- insufficient range of tests/thicknesses for required cfh

  accept need data for thicknesses above 80 mm/ cfh 2.7 m
  not enough tests is insufficient

- (seems to be) some anomalous data

- (repeats) needed to improve reliability (of data)

  accept data/ results are unreliable
  *do **not** accept maybe systematic/random error*
  *do **not** accept reference to precision*

- need to test greater range/variety of dummies

  accept children for dummies
  accept specific factor such as weight/height/size

2

(d) Tyres do not need to be dumped/burned/ less land-fill/ saves on raw materials

accept less waste
*do **not** accept recycling on its own*

1

[11]

17 (a) (i) velocity includes direction

accept velocity is a vector

1

(ii) 64

*allow **1** mark for obtaining values of 16 and 4 from the graph*
***or** marking correct area or correct attempt to calculate an area*

2

(iii) any **two** from:

- velocity zero from 0 to 4 seconds
- increasing in 0.2 s (or very rapidly) to 8 m/s
- decreasing to zero over the next 8 seconds

2

(iv) momentum before does not equal momentum after

ignore reference to energy

or total momentum changes

or an external force was applied

1

(b) to reduce the momentum of the driver

1

a smaller (constant) force would be needed

*do **not** accept reduces the impact / impulse on the driver*

1

[8]

18 (a) 4 (m/s)

***1** mark for correct transformation of either equation*
***1** mark for correct substitution with or without transformation*
***1** mark for correct use of 0.6N*
*max score of **2** if answer is incorrect*

3

(b) **greater** change in momentum

or greater mass of air (each second)

or increase in velocity of air

accept speed for velocity

force upwards increased

lift force is increased

*do **not** accept upthrust*

1

or force up greater than force down

accept weight for force down

1

(c)
- increase the time **to stop**

1

- decrease rate of change in momentum or same momentum change

accept reduced deceleration/ acceleration

1

- reducing the force on the toy

*do **not** accept answers in terms of the impact/ force being absorbed*

*do **not** accept answers in terms of energy transfer*

*do **not** credit impact is reduced*

1

[8]

19 (i) momentum (change in) = mass × velocity (change in)

accept ... speed

1

(ii) 9000

*1500 × 6 for 1 mark but **not** from incorrect equation*

2

kilogram metre(s) per second **or** kg m/s

1

(iii) **either** 7.5 (m/s)

or change in momentum of car B change in momentum of car A (1)
9000 = 1200 × v (1)

or v = 9000 ÷ 1200 (1)

or error carried forward from part (ii)

__examples__

5 (m/s) if 6000 offered in (ii) (3)

12.5(m/s) if 15000 offered in (ii)

(3)

3

[7]

20 (a) (i) momentum = mass × velocity

accept … × speed ***or*** *any transposed version*

1

(ii) 11.2 to 11.3

0.75 × 15 for ***1*** *mark*

2

kg m/s down(wards) **or** Ns down(ward)

n.b. both unit ***and*** *direction required for this mark*

1

(iii) 11.2 to 11.3

accept same numerical answer as part (a)(ii)

accept answer without any unit ***or*** *with the same unit as in part (a)(ii), even if incorrect, but any other unit cancels the mark*

1

(iv) $\text{force} = \dfrac{\text{change in momentum}}{\text{time}}$

accept transposed version

1

(v) 112 to 113 **or** numerical value from (a)(ii) × 10

11.25 ÷ 0.1 ***or*** *(a)(ii) ÷ 0.1 for* ***1*** *mark*

2

newton(s)

or *N*

accept Newton(s)

do ***not*** *credit 'Ns'* ***or*** *n*

1

(b) (the user will experience a) large change in momentum

*do **not** credit just '… momentum changes'*

1

(but) seat belt increases the time for this to occur **or**
seat belt stops you hitting something which would stop you quickly

*do **not** credit just '… stops you hitting the windscreen etc.'*

1

(so) the force on the user is less(*)

1

(so) less chance of (serious / fatal) injury(*)

(*) depends on previous response re momentum or continued movement

1

[13]

21 (a) (i) **either**
the momentum in a particular direction after (the collision) is the same as the momentum in that direction before (the collision)

*accept 'momentum before equals momentum after' for **1** mark*

or total momentum after (the collision) equals the total momentum before (the collision) (2)

*accept 'momentum before equals momentum after' for **1** mark*

2

(ii) explosion(s)
or (action of a) rocket (motor(s))
or (action of a) jet (engine)
or firing a gun

accept any other activity in which things move apart as a result of the release of internal energy eg throwing a ball

1

(iii) momentum = mass × velocity **or** any correctly transposed version

accept momentum = mass × speed
accept p = mv
*do **not** accept momentum = ms*
or M = mv

1

(iv) 0.8

*if answer 0.8 not given, any **two** for (1) each:*
*momentum of **X** = 0.2 × 1.2*
*= momentum of **X and Y** after impact*
*= 0.3 × v **or** = (0.1 + 0.2) × v*

3

m/s

1

to the right

1

(v) any **one** from:

conservation of momentum (applies)

no external forces

*do **not** accept just 'no (other) forces act'*

friction is negligible / insignificant

no friction

no air resistance

1

(b) force = (change in) momentum ÷ time

or any correctly transposed version

1

4000 **or** 4 kilonewtons

dependent on correct or no equation
*force = 5 ÷ 0.00125 gains **1** mark*

2

[13]

22 (a) Total momentum (of a system of bodies) remains constant

accept momentum before (a collision) = momentum after (a collision)

1

Provided no external force acts

1

(b) (i) rotate the compressor

1

(ii) • fuel is mixed with the air and ignited

• causing an increase in the pressure **or** temperature **or** speed of the gases

accept air out faster than air in
accept gases have momentum ***or***

• force backwards

• exhaust gases have momentum (backwards) **or** force (backwards)

if the answer is in terms of force then this third point must be scored before the fourth can be credited

• engine **or** aircraft has (equal) momentum forwards **or** force forwards

4

(c) m = 350

answer 0.35 one mark only

allow one mark if 105 000 ***or*** *475-175* ***or*** *300 have been used*

2

[9]

23 (a) (i) zero

accept nothing

1

speed is zero

accept not moving

1

(ii) A

1

largest mass **or** weight

accept heaviest luggage

do ***not*** *accept largest luggage*

1

(iii) momentum does change

accept yes

1

direction is changing

accept velocity is changing
do ***not*** *accept answers in terms of speed changing*

1

(iv) kg m/s

1

[7]

24 (a) (i) direction indicated

*accept to right **or** **+** or – **or** arrow drawn on diagram*

1

300

1

kg m/s **or** Ns

1

(ii) 300 (kg m/s)

1

(b) momentum of person towards jetty = momentum of boat away from jetty
or total momentum is constant so as person goes one way boat goes the other

***1** mark is for the idea of momentum conservation*
***1** is for direction*

2

(c) time of collision increases

*do **not** accept momentum is conserved*

1

so a smaller force is exerted

*do **not** accept designed to absorb energy **or** momentum*

1

to produce the same change of momentum **or** impulse force

*do **not** accept cushions fall*

1

[9]

25 (a) the snow

1

smallest mass

*do **not** accept it is not moving*
accept weight for mass
accept it's the lightest

1

(b) (i) decrease

1

velocity reducing

accept speed for velocity

accept it is stopping

*do **not** accept the brakes are on*

accept car is decelerating

1

(ii) forwards

1

direction of momentum does not change
or the car stops and snow does not

dependent on forwards given

accept answers given in terms of Newton's second or first law of motion

accept momentum of snow

*do **not** accept the snow still has momentum*

1

(c) Ns

1

[7]

26 (a) (i) 6

for 1 mark

1

(ii) 6

for 1 mark

1

(iii) 1.5

for 1 mark

1

(iv) 4.5

for 1 mark

1

(v) 3

for 1 mark

1

(b) initial ke = 12J;

final ke = 0.75J + 6.75J;

energy loss = 4.5J

for 1 mark each

(If wrong; any correct ke value gains 1 mark; maximum of 2
path through calculation clear and correct gains 1 mark)
(ignore either ball – max 1 mark)

3

[8]

27 (a) Each scale optimum
Else both half size
Straight line joining 30,0 to 30,0.67 to 0, 5.67

any 5 for 1 mark each

5

(b) 6
Else a = 30/5

gets 2 marks

Else a = v/t

gets 1 mark

3

(c) 9000
Else F = 6 × 1500

gets 2 marks

Else F = ma

gets 1 mark

3

(d) (i) Driver has forward momentum
Which is conserved
Giving drive relative forward speed to car

for one mark each

3

(ii) Car stops in 75m

gets 1 mark

W = F.d or 9000 × 75

gets 1 mark

W = 675 000 J

OR ke = 1/2 mv^2

gets 1 mark

ke = 1/2.1500.302

ke = 675 000 J

3

[17]

28 (a) mass and velocity/speed multiplied

for 1 mark each

2

(b) total momentum before and after collision are the same

for 1 mark each

2

(c) (i) $M_AU_A + M_BU_B = (M_A + M_B)v$

2 × 6 = (2 + 1)v

v = 4

m/s

for 1 mark each

4

(ii) 1/2 mv^2 (before) – 1/2 mv^2 (after) 1/2 2.36 – 1/2 3.16 = 12
J

for 1 mark each

4

[12]

29 (a) Throughout the question the equation M = mv is credited once only. This is the first time it appears. The mark scheme below assumes it will appear in (i).

(i) M = mv m × v sufficient **not** m × s, mass × speed

= 1500 × 8

= 12 000

(see marking of calculations)

3

(ii) M = mv
M = 2000 × 1 = 2000
(see marking of calculations)

2

(iii) must be sum of (i) and (ii) 14 000
for 1 mark

1

(b) total mass = 3500
momentum = 14 000 (conserved)
M = mv **or** v = 14 000/3500
v = 4
m/s

5

(c) (i) it reduces
for 1 mark

1

(ii) ke to sound/heat
for 1 mark

1

[12]

30 (a) product of mass and velocity

1

(b) (i) 4kg or 4000g

1

(ii) M = 8kgm/s or Ns
for 3 marks

else M = 8
for 2 marks

else M – mv or 4 × 2
for 1 mark

3

(iii) 8 kgm/s (watch e.c.f.)

1

(iv) v = 400

for 3 marks

else v = 8/0.02

for 2 marks

else M – mv, v – M/m or 8 = 0.02v

for 1 mark

3

(v) ke = 8

for 3 marks

else ke = 1/2 (4 × 2^2)

for 2 marks

else ke = 1/2 (mv^2)

for 1 mark

3

(vi) transferred to heat and sound
or does work against wood/pushing wood aside/deforming bullet

1

[13]

31 (a) WX deceleration / speed decreasing / slowing down / negative acceleration

XY constant speed / steady speed *not* constant motion / slow speed

YZ acceleration / speed increasing / speeding up

for 1 mark each

3

(b) distance = v × t **or** distance = 30 × 20

gains 1 mark

but
distance = 600(m)

gains 2 marks

2

(c) acceleration = v / t **or** acceleration = 30 / 12

gains 1 mark

(if –30 / 12, allow negative sign here if not in the answer)

3

but

acceleration = 2.5 (m/s²)

gains 2 marks

but

acceleration = -2.5 (m/s²)

gains 3 marks

(d) in a crash / during hard braking car body stops / slows rapidly driver / passengers continue to move forward *not* thrown forward seatbelts provide backward force / keep them in their seats / restrain them to stop them hitting the windscreen / dashboard

(an alternative argument involving momentum is acceptable)

for 1 mark each

4

[12]

32 (a) *ideas that* greater speed means more kinetic energy

gains 1 mark

but *any evidence of the formula* ½ mv^2

but making the case that kinetic energy depends on the speed squared

gains 3 marks

or that $2^2 = 4$

3

(b) (i) any evidence of concept of momentum or mass × speed (or velocity) in words or figures e.g. 9.5 × 20 **or** 0.5 × 40

gains 1 mark

but correct values for momentum of lorry and car i.e. 190 and 20 [ignore units]

gains 2 marks

but initial momentum correctly calculated 170 or 190 – 20

gains 3 marks

THEN
evidence when calculating final speed of
idea that momentum is conserved
use of combined mass

each gain 1 mark

but
17 [or 0.1 × figure for initial momentum]
(NB direction not required)

gains 3 marks

6

(ii) kinetic energy is lost

for 1 mark

[*credit* (some kinetic) energy transferred as heat/sound]
[NB Accept only answers in terms of energy as required by the question]

1

[10]