Q1. (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.

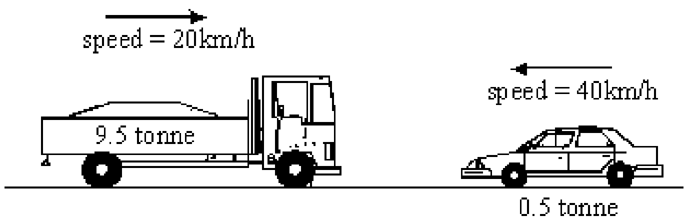
....

....

....

(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)

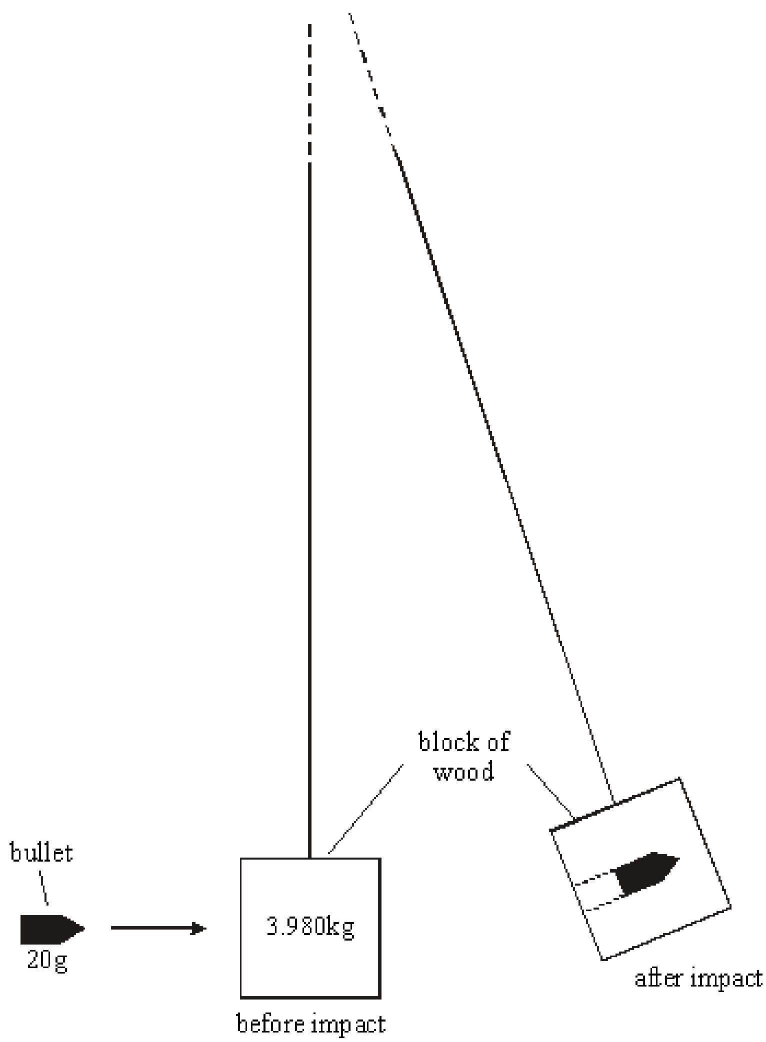
Q2. (a) When an object is moving it is said to have momentum.
Define momentum.

....

....

(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?

....

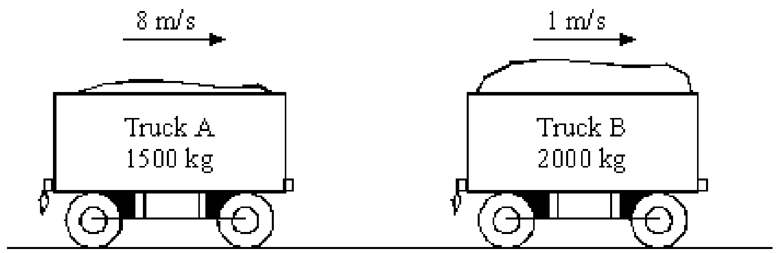
....

....

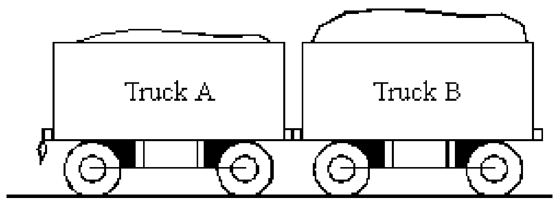
....

(1)
(Total 13 marks)

Q3. 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.

....

(iii) What would have been the effect on the change of total kinetic energy of the trucks if the collision had been more elastic?

....

(3)
(Total 14 marks)

Q4. (a) How can the momentum of an object be calculated?

....

....

(2)

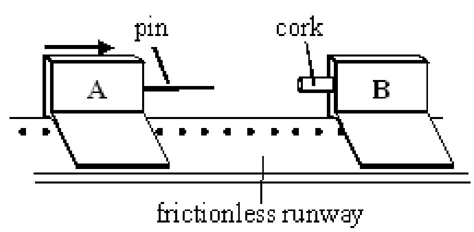
(b) In a collision momentum is always conserved. What does this mean?

....

....

(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.

....

....

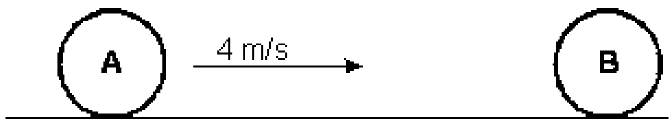
....

....

(4)

(Total 12 marks)

Q5. 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.

....

....

....

....

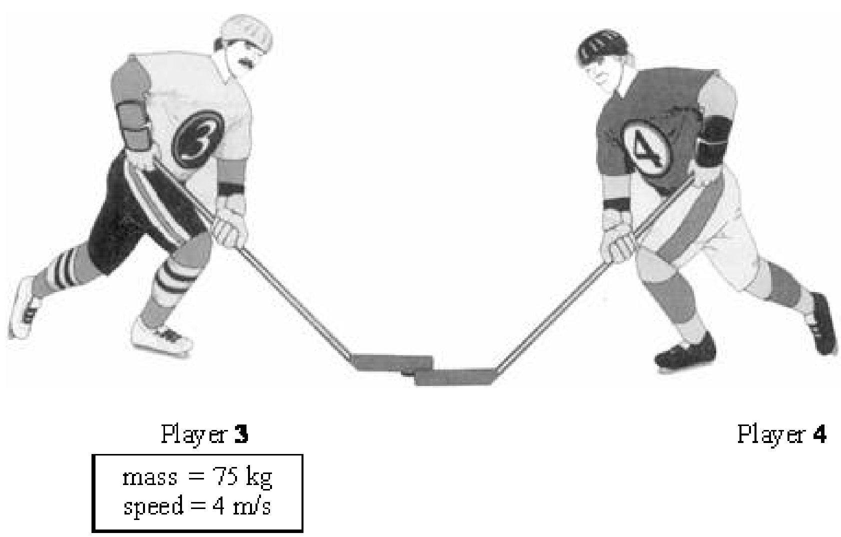
....

Answer .... J

(3)

(Total 8 marks)

Q6. (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 following equation and 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 = mass × velocity

....

....

Momentum of player **3** = ...

(3)

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

....

(1)

(iii) The collision between the two players is **not** *elastic*. What is meant by an *elastic* 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.

....

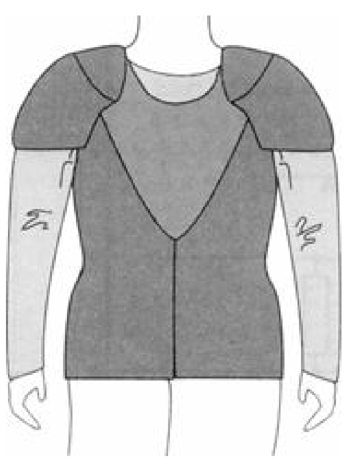
....

....

....

(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 10 marks)

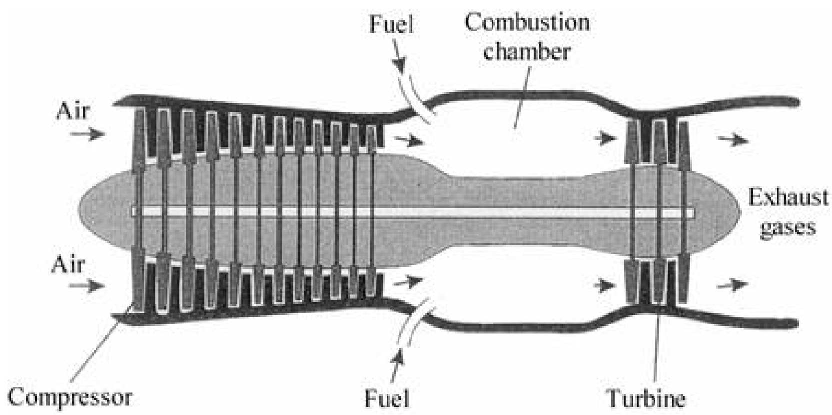
Q7. (a) What is the principle of conservation of momentum?

....

....

(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)

Q8. (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.

....

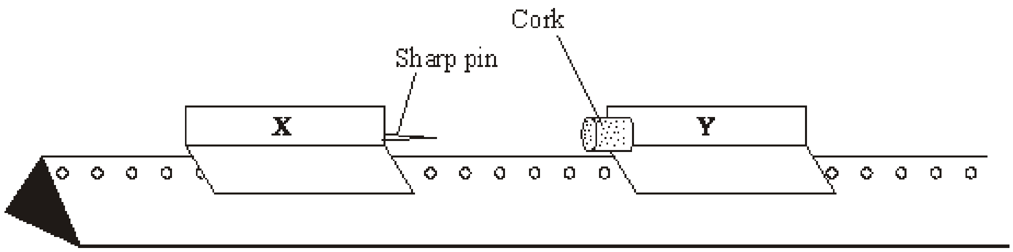
(1)

(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.

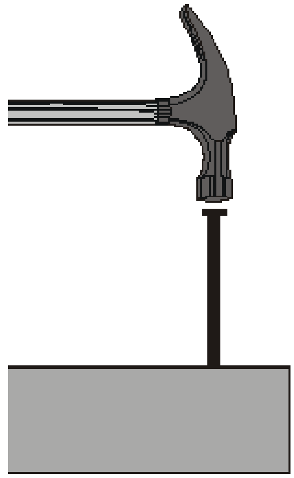
Write, in words, the equation that you will need to use and show clearly how you work out your answer.

Force = ... newtons

(3)

(Total 13 marks)

Q9. (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.

....

....

....

....

....

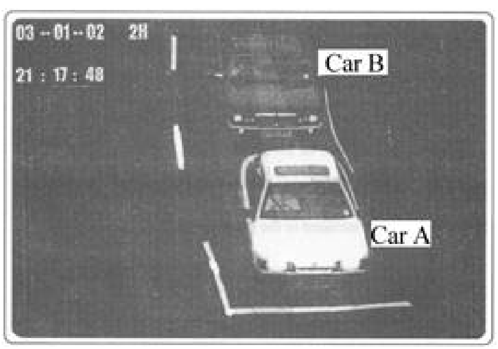
....

....

....

(4)
(Total 13 marks)

Q10. 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.

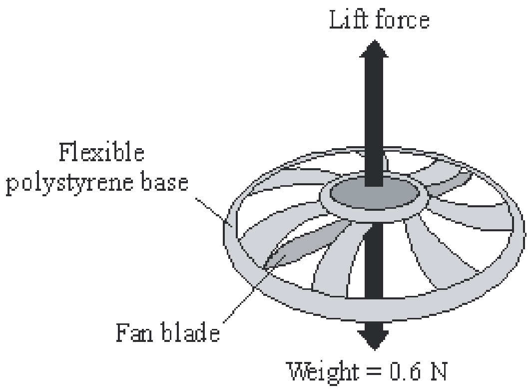
....

....

Speed = ... m/s

(3)
(Total 7 marks)

Q11. 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 equations in the box to calculate the velocity of the air when the toy is hovering.

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

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

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.

....

....

....

....

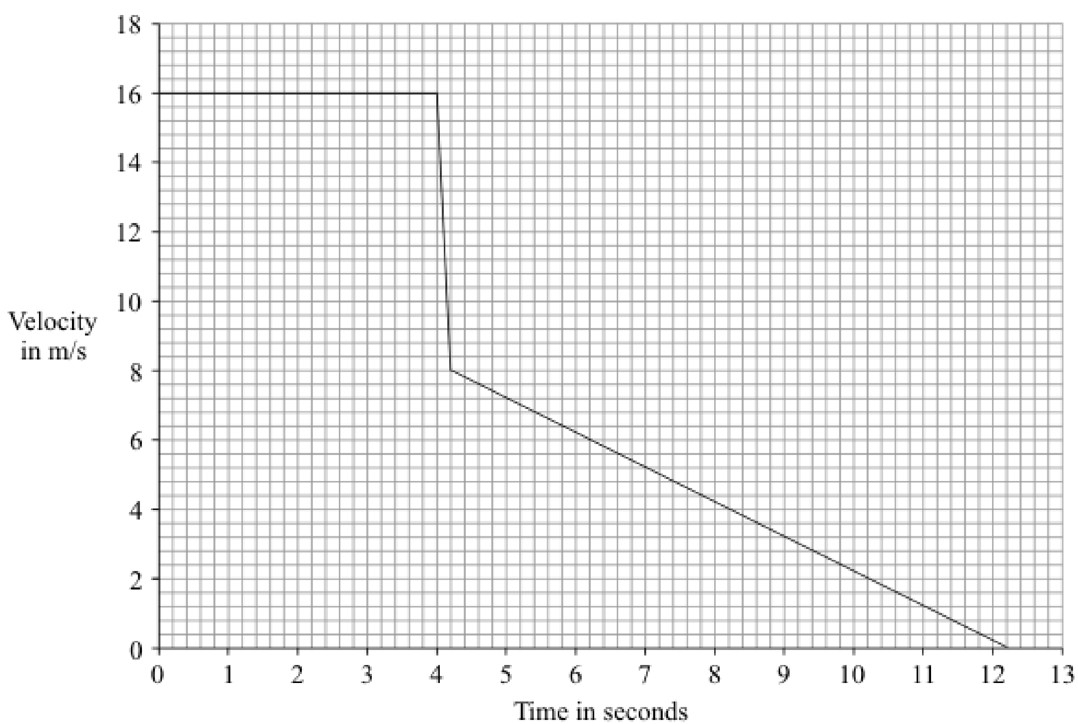
....

....

(3)
(Total 8 marks)

Q12. 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.

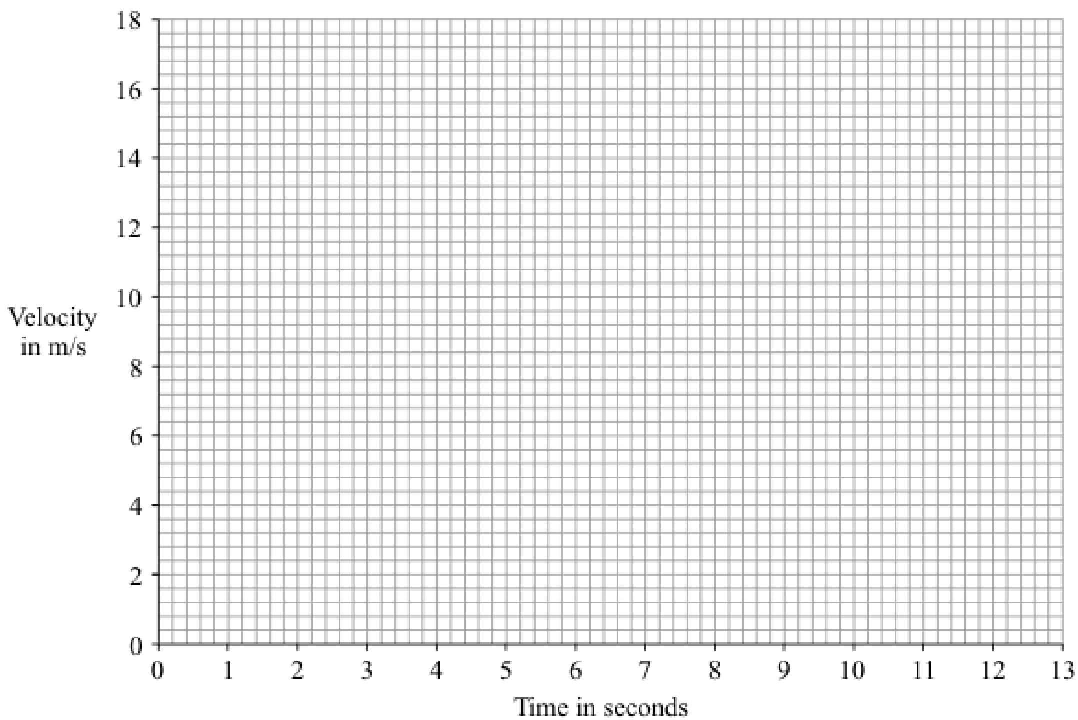
....

....

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.

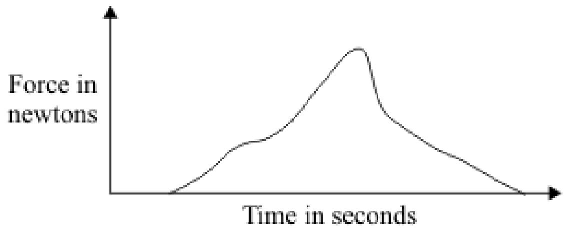
What does this statement mean?

....

....

(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)

Q13. 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) Use the equation in the box to calculate the momentum of the child as it hits the ground.

momentum = mass × velocity

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.

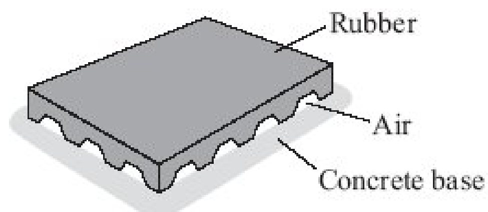
....

....

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.

....

....

....

....

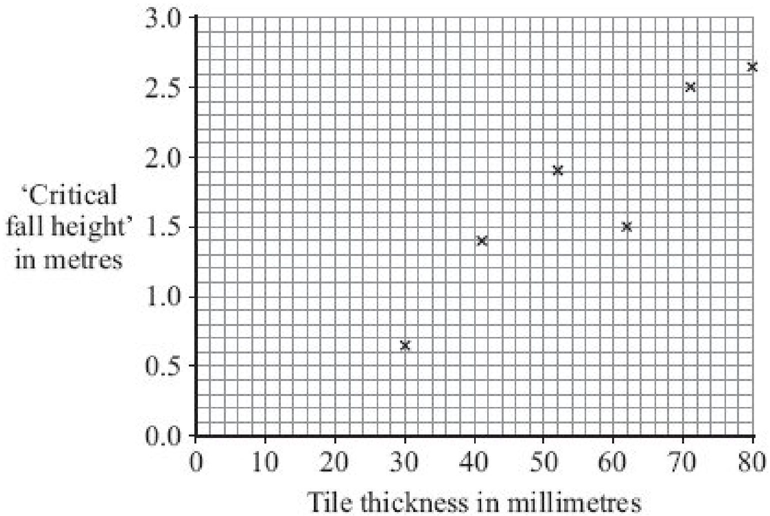
....

....

(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)

Q14. (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.

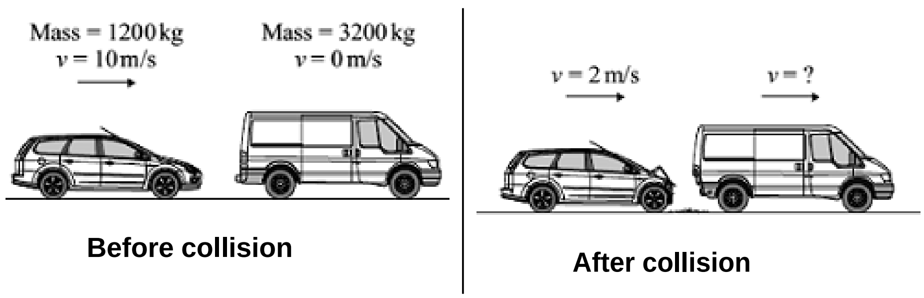
Why?

....

....

(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 and the equation in the box to calculate the **change** in the momentum of the car.

momentum = mass × velocity

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.

....

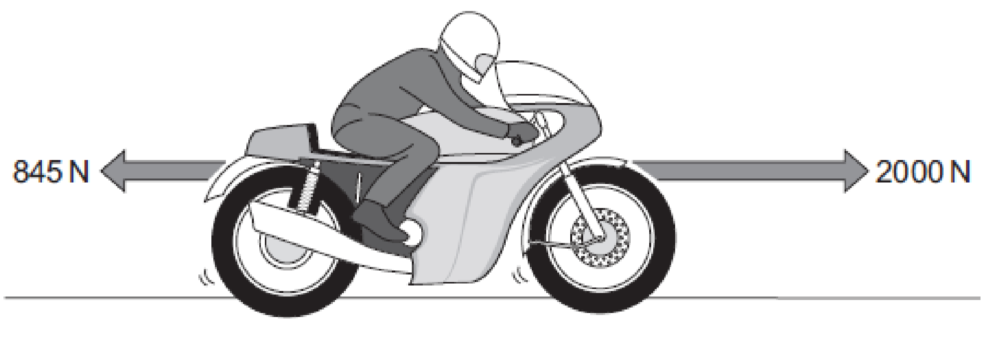
....

....

Velocity =.. m/s forward

(2)
(Total 7 marks)

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.

Use the equation in the box to calculate the acceleration of the motorbike at this moment in time.

resultant force = mass × acceleration

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.

....

....

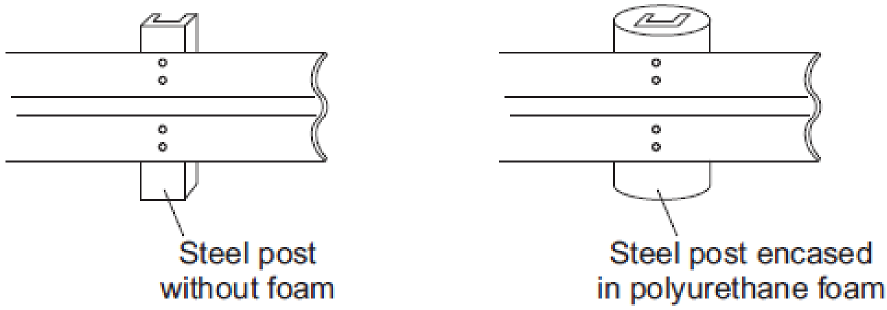
....

....

(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) 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.

Use the equations in the box to calculate the average force exerted by the lorry on the car during the collision.

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

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

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.

....

....

....

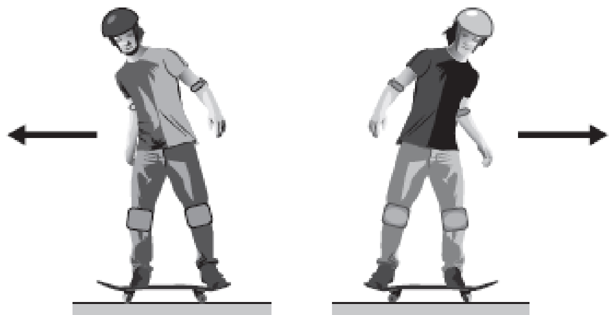
....

....

....

(3)
(Total 6 marks)

Q17. (a) The picture shows two teenagers riding identical skateboards.
The skateboards are moving at the same speed and the teenagers have the same mass.



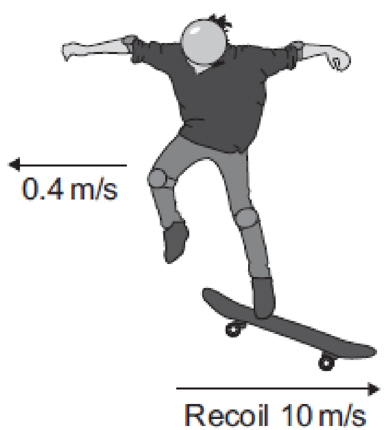
Why do the teenagers **not** have the same momentum?

....

....

(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.

Use the equation in the box to calculate the mass of the skateboard.

momentum = mass × velocity

....

....

....

Mass = ... kg

(3)

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

Explain why.

....

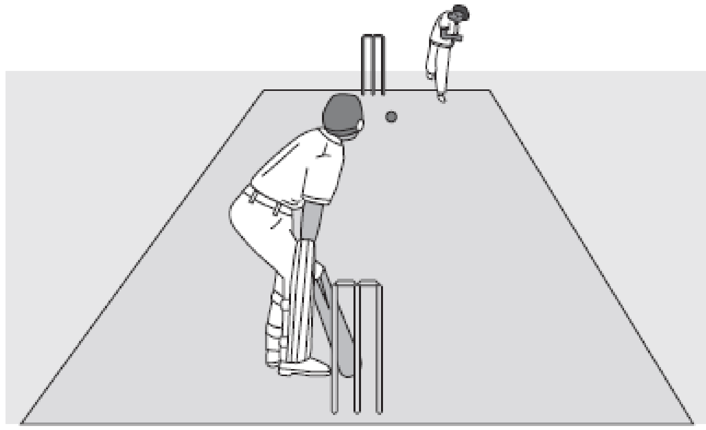
....

....

....

(2)
(Total 7 marks)

Q18. 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.

....

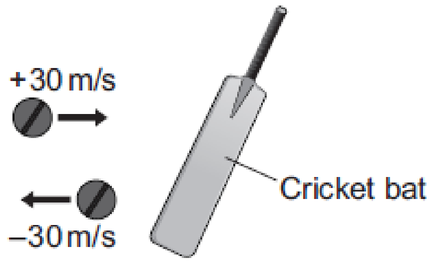
....

....

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.

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(2)
(Total 7 marks)

Q19. (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.

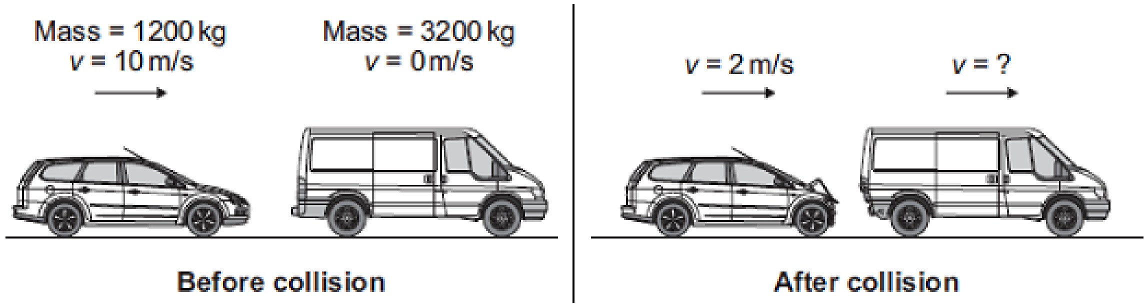
Why?

....

....

(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 and the equation in the box to calculate the **change** in the momentum of the car.

momentum = mass x velocity

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)