Momentum

Questions

Name: _____

Class: _____

Date: _____

Time: **111 minutes**

Marks: **111 marks**

Comments:

1 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)

2 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.

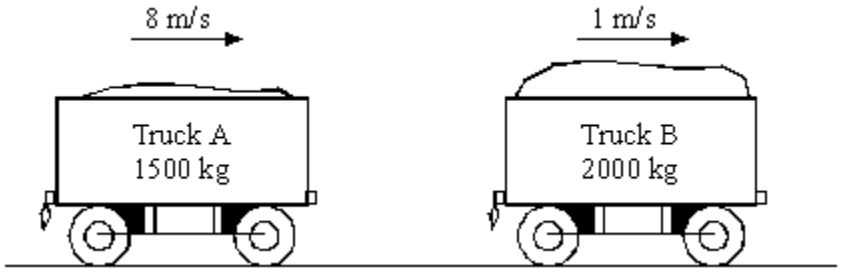
Calculate the velocity at which the skateboard moves backwards if the skateboarder jumps forwards at a velocity of 0.3 m / s.

Velocity of skateboard = _____ m / s

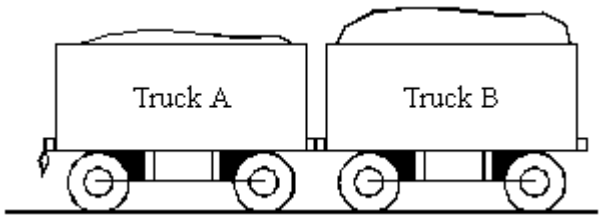
(3)

(Total 6 marks)

3 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)

4 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.

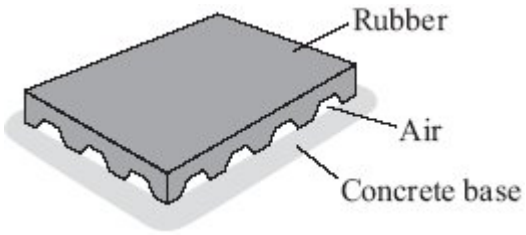
_____

_____

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.

_____

_____

_____

_____

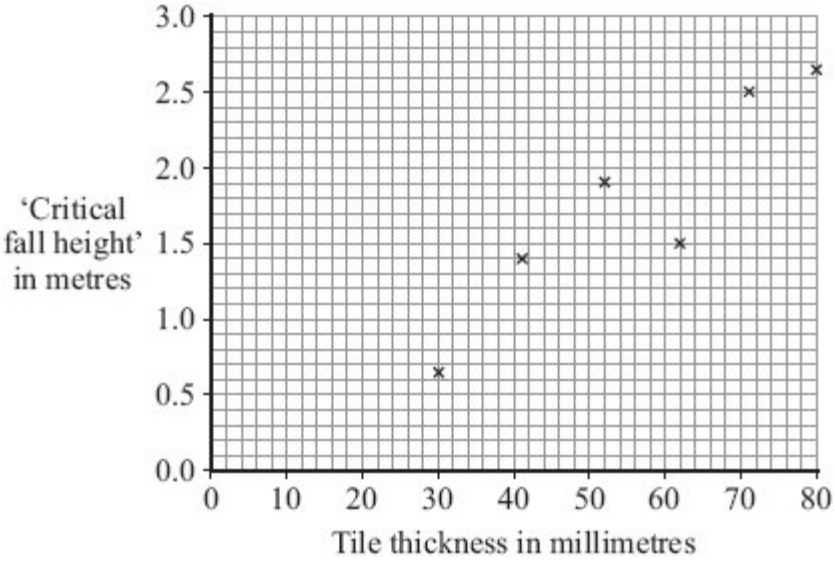
_____

_____

(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)

5 (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.

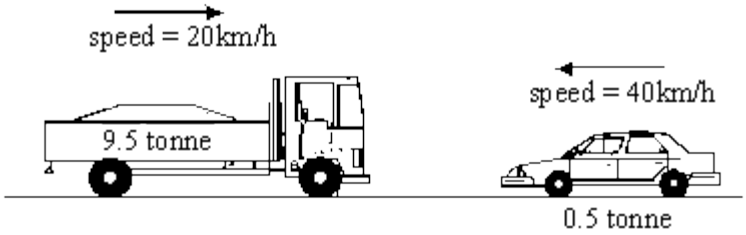
_____

_____

_____

(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.

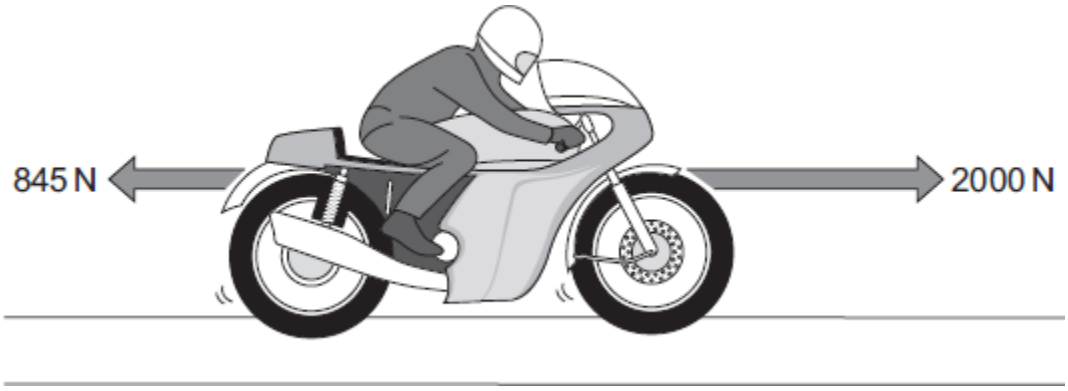
Explain, in terms of energy, what this means.

_____

(1)

(Total 10 marks)

6 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.

_____

_____

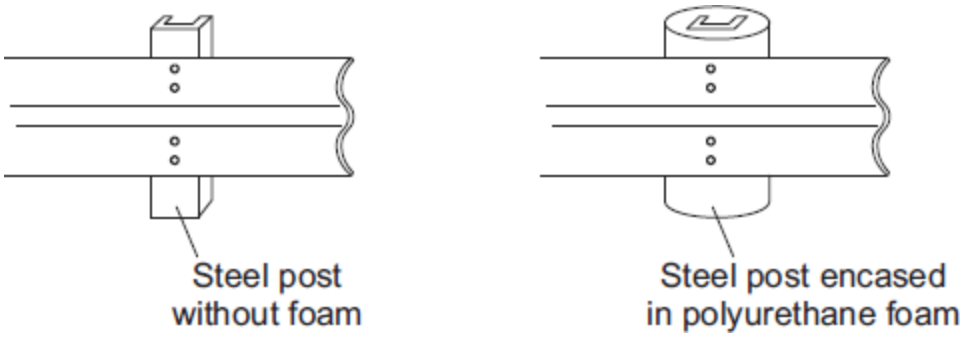
_____

_____

(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)

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

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

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

_____

_____

(1)

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

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

_____

_____

(1)

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

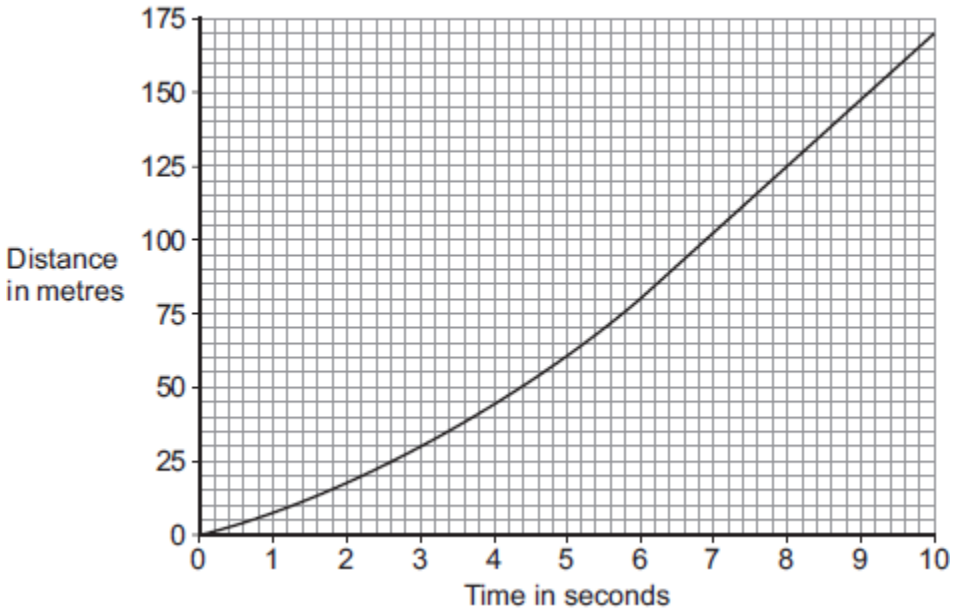
_____

_____

(1)

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

Figure 1



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

_____

_____

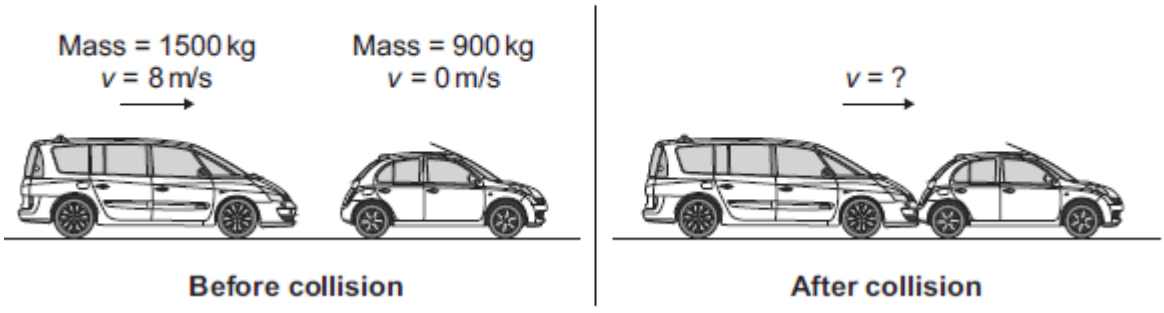
Maximum speed = _____ m / s

(2)

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

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

Figure 2



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

What is meant by the statement ‘momentum is conserved’?

_____

_____

(1)

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

_____

_____

_____

_____

_____

Velocity = _____ m/s

(3)

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

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

Explain why.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 13 marks)

8 (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.

_____

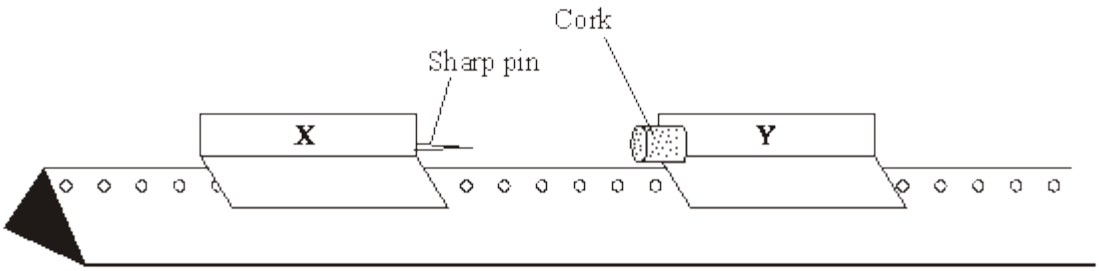
(1)

(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.

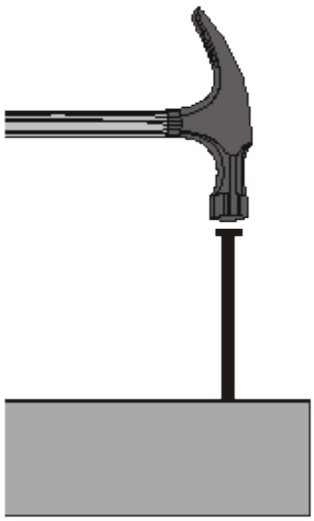
Write, in words, the equation that you will need to use and show clearly how you work out your answer.

Force = _____ newtons

(3)

(Total 13 marks)

9 (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.

_____

_____

_____

_____

_____

_____

_____

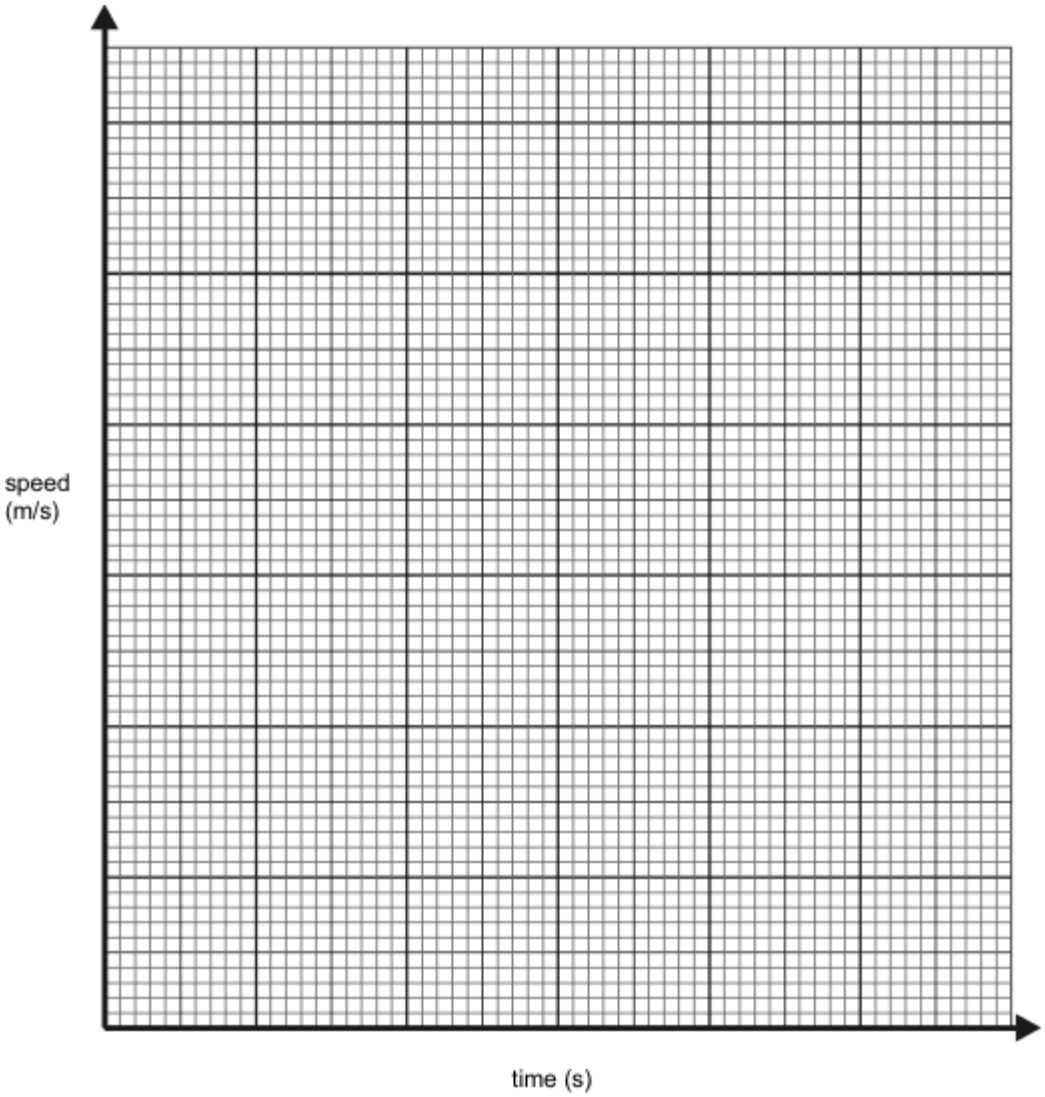
_____

(4)

(Total 13 marks)

10 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

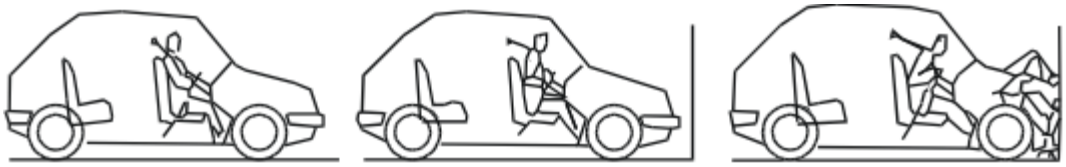
(3)

(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)