## FORCES AND BRAKING

### Q1.

The stopping distance of a car is the sum of the thinking distance and the braking distance.

The table below shows how the thinking distance and braking distance vary with speed.

| **Speed in m / s** | **Thinking distance in m** | **Braking distance in m** |
|---|---|---|
| 10 | 6 | 6.0 |
| 15 | 9 | 13.5 |
| 20 | 12 | 24.0 |
| 25 | 15 | 37.5 |
| 30 | 18 | 54.0 |

(a) What is meant by the braking distance of a vehicle?

______________________________________________________

______________________________________________________

**(1)**

(b) The data in the table above refers to a car in good mechanical condition driven by an alert driver.

Explain why the stopping distance of the car increases if the driver is very tired.

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

**(2)**

(c) A student looks at the data in the table above and writes the following:

thinking distance $\propto$ speed

thinking distance $\propto$ speed

Explain whether the student is correct.

**(2)**

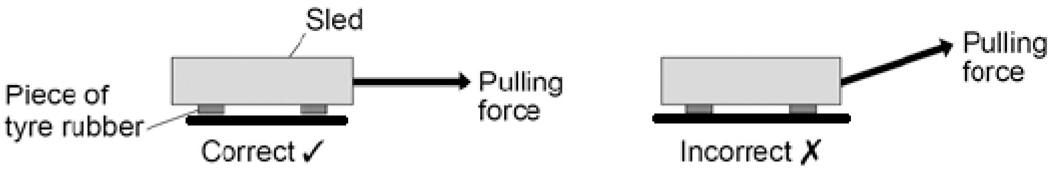
(d) Applying the brakes with too much force can cause a car to skid.

The distance a car skids before stopping depends on the friction between the road surface and the car tyres and also the speed of the car.

Friction can be investigated by pulling a device called a 'sled' across a surface at constant speed.

The figure below shows a sled being pulled correctly and incorrectly across a surface.

The constant of friction for the surface is calculated from the value of the force pulling the sled and the weight of the sled.




Why is it important that the sled is pulled at a constant speed?

Tick **one** box.

| | |
|---|---|
| If the sled accelerates it will be difficult to control. | ☐ |
| If the sled accelerates the value for the constant of friction will be wrong. | ☐ |
| If the sled accelerates the normal contact force will change. | ☐ |

**(1)**

(e) If the sled is pulled at an angle to the surface the value calculated for the constant of friction would not be appropriate.

Explain why.

**(2)**

(f) By measuring the length of the skid marks, an accident investigator determines that the distance a car travelled between the brakes being applied and stopping was 22 m.

The investigator used a sled to determine the friction. The investigator then calculated that the car decelerated at 7.2 m / $s^2$.

Calculate the speed of the car just before the brakes were applied.

Give your answer to two significant figures.

Use the correct equation from the Physics Equation Sheet.

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Speed = ____________________________ m / s

**(3)**

**(Total 11 marks)**

## Q2.

A number of different forces act on a moving vehicle.

(a) A car moving at a steady speed has a driving force of 3000 N.

(i) What is the value of the resistive force acting on the car?

Tick (✓) **one** box.

| | **Tick (✓)** |
|---|---|
| 2000 N | |
| 3000 N | |
| 4000 N | |

**(1)**

(ii) What causes most of the resistive force?

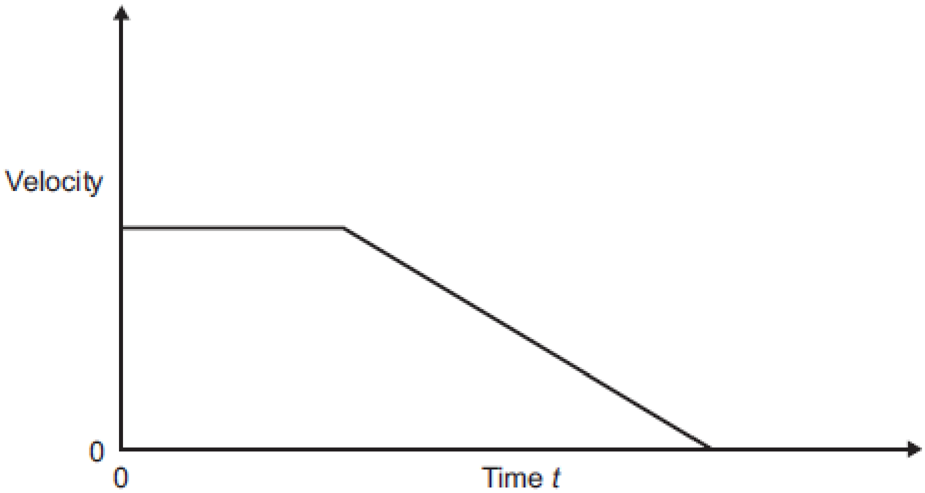
Tick (✓) **one** box.

| | **Tick (✓)** |
|---|---|
| Air resistance | |
| Faulty brakes | |
| Poor condition of tyres | |

**(1)**

(b) A car is moving along a road. The driver sees an obstacle in the road at time $t = 0$ and applies the brakes until the car stops.

The graph shows how the velocity of the car changes with time.




(i) Which feature of the graph represents the negative acceleration of the car?

Tick (✓) **one** box.

| | **Tick (✓)** |
|---|---|
| The area under the graph | |
| The gradient of the sloping line | |
| The intercept on the y-axis | |

**(1)**

(ii) Which feature of the graph represents the distance travelled by the car?

Tick (✓) **one** box.

| | **Tick (✓)** |
|---|---|
| The area under the graph | |
| The gradient of the sloping line | |
| The intercept on the y-axis | |

**(1)**

(iii) On a different journey, the car is moving at a **greater** steady speed.

The driver sees an obstacle in the road at time $t = 0$ and applies the brakes until the car stops.

The driver's reaction time and the braking distance are the same as shown the graph above.

On the graph above draw another graph to show the motion of the car.

**(3)**

(c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Thinking distance and braking distance affect stopping distance.

Explain how the factors that affect thinking distance and braking distance affect stopping distance.

____________________________________________________________

**(6)**
**(Total 13 marks)**

## Q3.

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

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

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

**(1)**

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

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

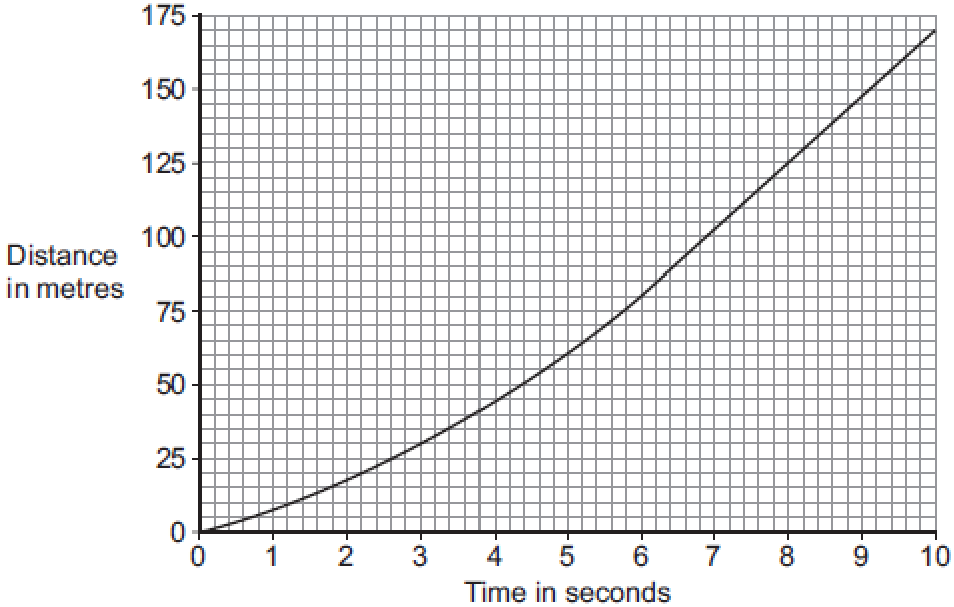
**(1)**

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

**(1)**

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

**Figure 1**




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

___

___

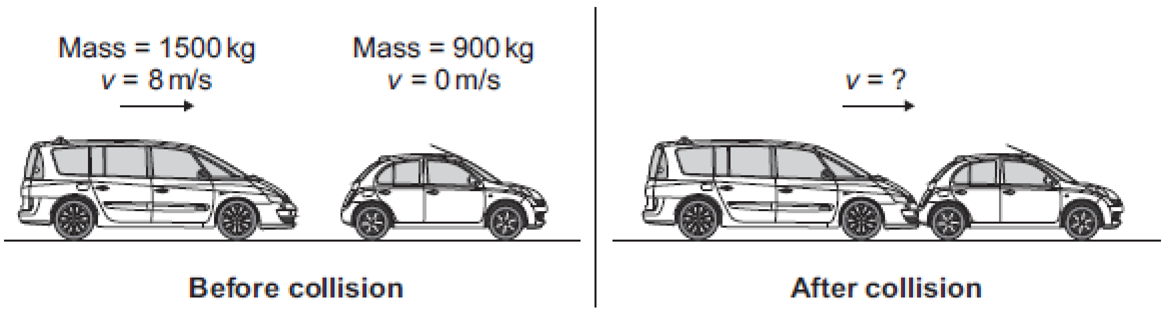
Maximum speed = ________________ m / s

**(2)**

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

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

**Figure 2**




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

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

___

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**(1)**

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

___

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Velocity = ____________________ m / s

**(3)**

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

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

Explain why.

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**(4)**

**(Total 13 marks)**

## Q4.

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

The results are shown in the table.

| **Speed in metres per second** | **Thinking distance in metres** | **Braking distance in metres** | **Stopping distance in metres** |
|---|---|---|---|
| 10 | 6 | 6 | 12 |
| 15 | 9 | 14 | 43 |
| 20 | 12 | 24 | 36 |
| 25 | 15 | 38 | 53 |

| | | | |
|---|---|---|---|
| 30 | 18 | 55 | 73 |

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

As speed increases, thinking distance

| |
|---|
| decreases. |
| increases. |
| stays the same. |

As speed increases, braking distance

| |
|---|
| decreases. |
| increases. |
| stays the same. |

**(2)**

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

Draw a ring around the incorrect value in the table.

Calculate the correct value of this stopping distance.

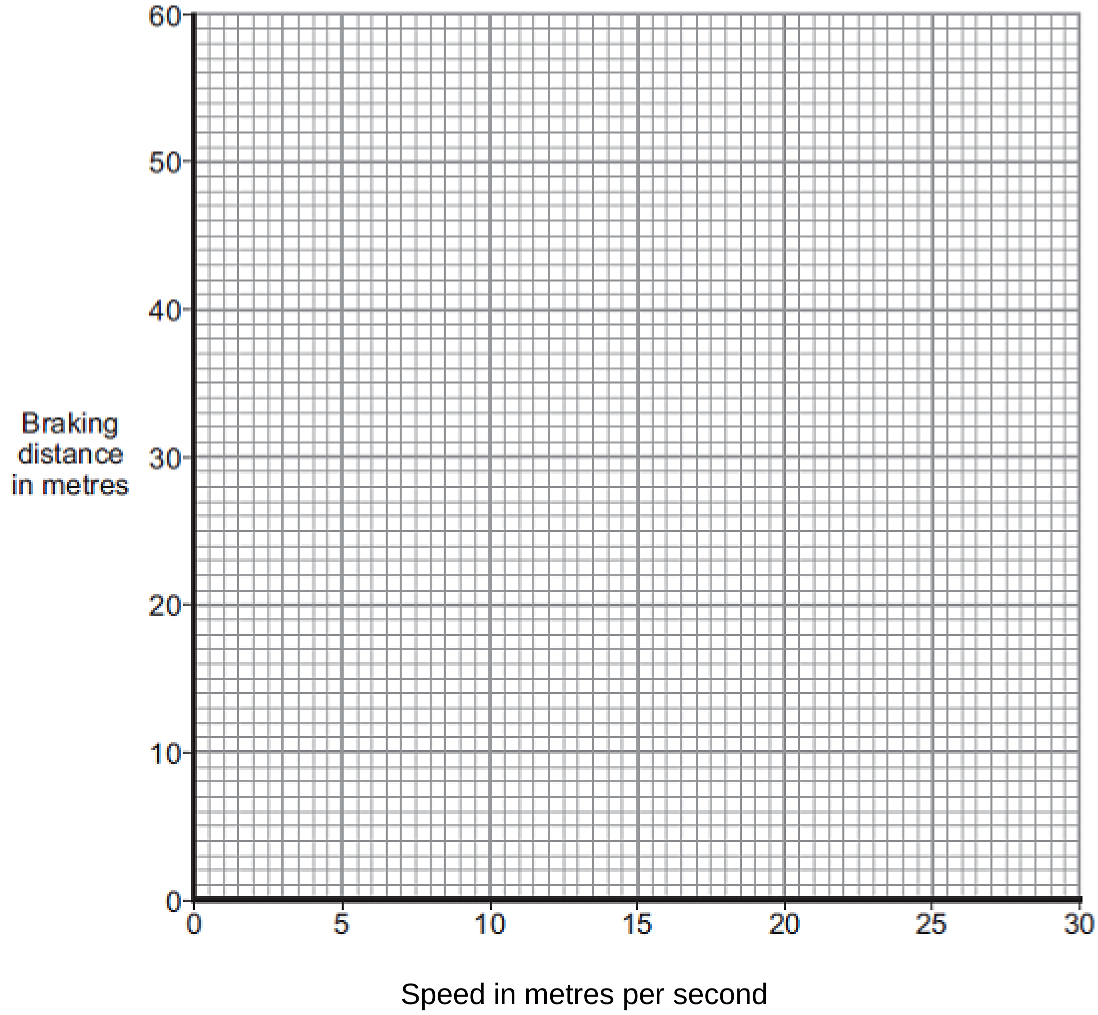
___________________________________________________________________

Stopping distance = ________________ m

**(2)**

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

Draw a line of best fit through your points.




**(3)**

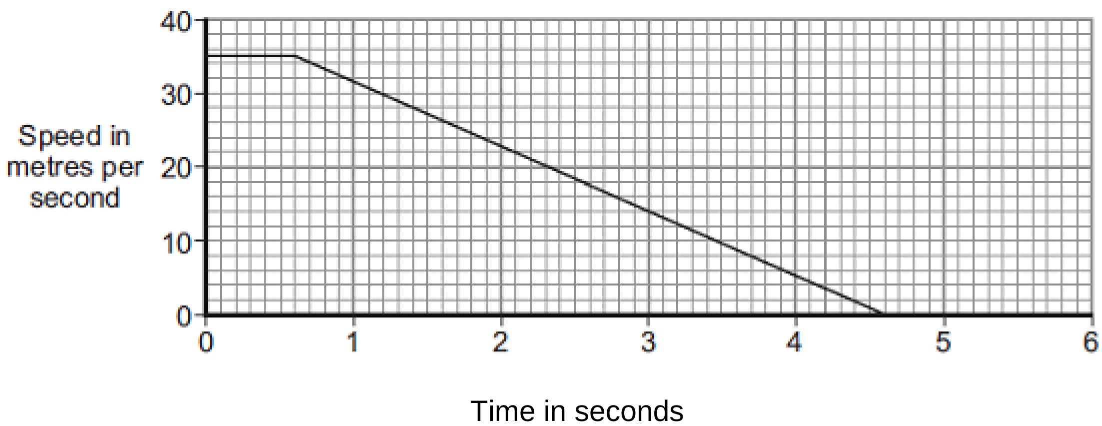
(ii) Use your graph to determine the braking distance, in metres, at a speed of 22 m / s.

Braking distance = ________________ m

**(1)**

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

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




(i) Determine the braking distance.

___________________________________________________________

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______________________________________________________________

______________________________________________________________

Braking distance = ________________ m

**(3)**

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

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

**(3)**

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

(i) Calculate the momentum of the car.

Give the unit.

______________________________________________________________

______________________________________________________________

______________________________________________________________

Momentum = ______________________

**(3)**

(ii) The car stops in 4 seconds.

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

______________________________________________________________

______________________________________________________________

Force = ________________ N

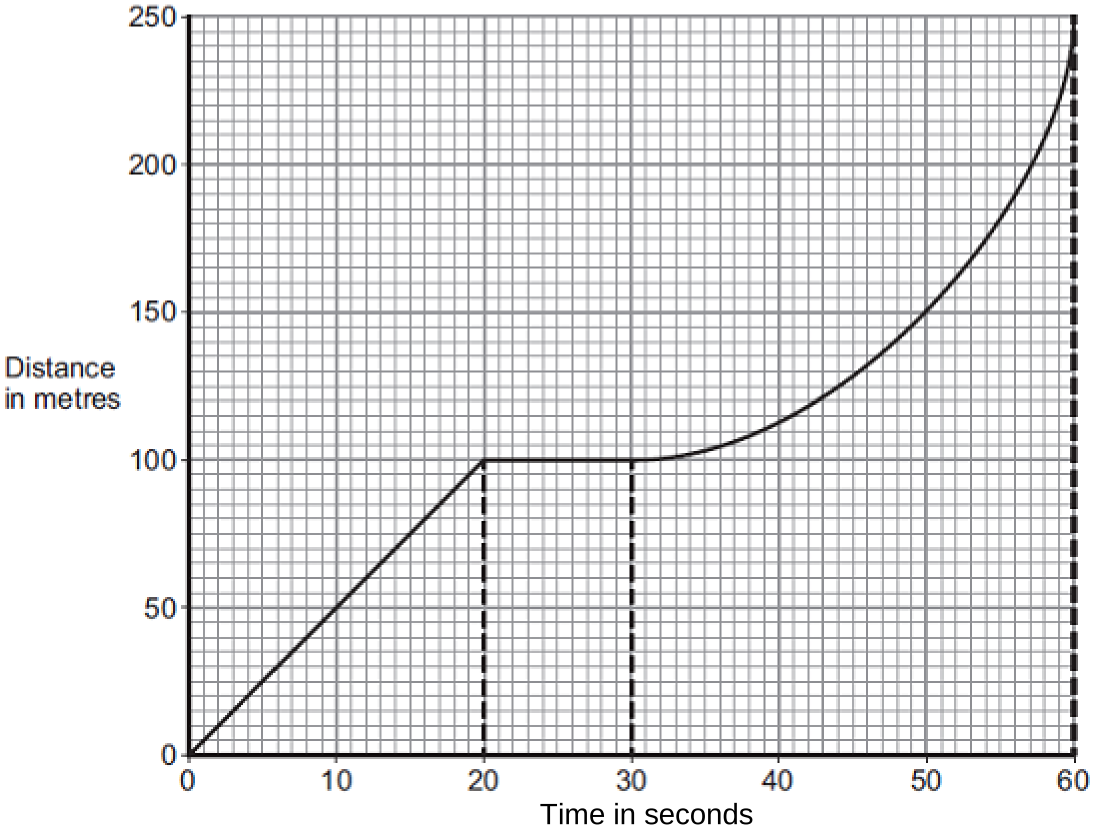
**(2)**

**(Total 19 marks)**

## Q5.

A bus is taking some children to school.

(a) The bus has to stop a few times. The figure below shows the distance–time graph for part of the journey.




(i) How far has the bus travelled in the first 20 seconds?

Distance travelled = ______________________ m

**(1)**

(ii) Describe the motion of the bus between 20 seconds and 30 seconds.

___________________________________________________________________

___________________________________________________________________

**(1)**

(iii) Describe the motion of the bus between 30 seconds and 60 seconds.

Tick (✓) **one** box.

| | **Tick (✓)** |
|---|---|
| Accelerating | |
| Reversing | |
| Travelling at constant speed | |

**(1)**

(iv) What is the speed of the bus at 45 seconds?

Show clearly on the figure above how you obtained your answer.

___________________________________________________________________

___________________________________________________________________

Speed = ______________________ m / s

**(3)**

(b) Later in the journey, the bus is moving and has 500 000 J of kinetic energy.

The brakes are applied and the bus stops.

(i) How much work is needed to stop the bus?

Work = ______________________ J

**(1)**

(ii) The bus stopped in a distance of 25 m.

Calculate the force that was needed to stop the bus.

Force = ______________________ N

**(2)**

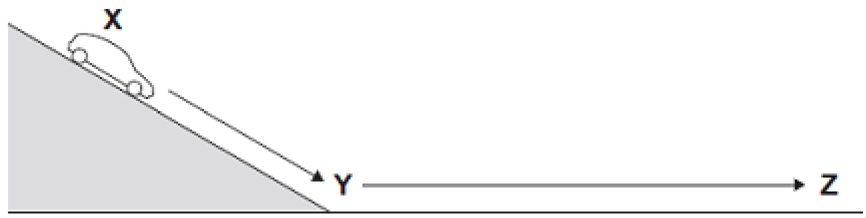
(iii) What happens to the kinetic energy of the bus as it is braking?

**(2)**

**(Total 11 marks)**

## Q6.

(a) The diagram shows a car at position **X**.




The handbrake is released and the car rolls down the slope to **Y**.
The car continues to roll along a horizontal surface before stopping at **Z**.
The brakes have **not** been used during this time.

(i) What type of energy does the car have at **X**?

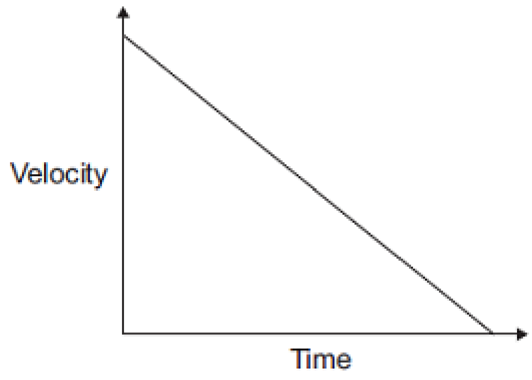
**(1)**

(ii) What type of energy does the car have at **Y**?

___________________________________

**(1)**

(b) The graph shows how the velocity of the car changes with time between **Y** and **Z**.




(i) Which feature of the graph represents the negative acceleration between **Y** and **Z**?

___________________________________

**(1)**

(ii) Which feature of the graph represents the distance travelled between **Y** and **Z**?

___________________________________

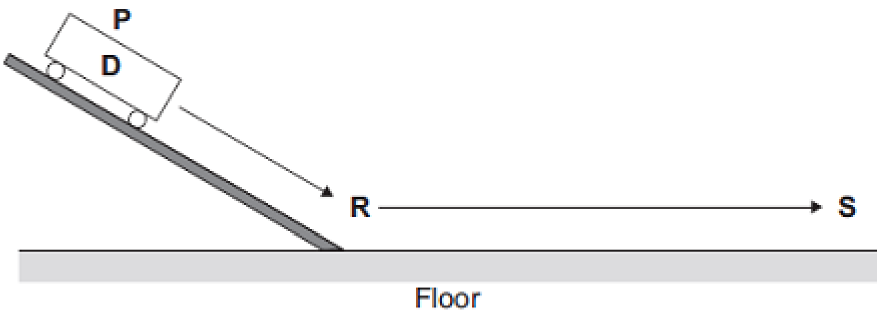
**(1)**

(iii) The car starts again at position **X** and rolls down the slope as before. This time the brakes are applied lightly at **Y** until the car stops.

Draw on the graph another straight line to show the motion of the car between **Y** and **Z**.

**(2)**

(c) Three students carry out an investigation. The students put trolley **D** at position **P** on a slope. They release the trolley. The trolley rolls down the slope and along the floor as shown in the diagram.




The students measure the distance from **R** at the bottom of the slope to **S** where the trolley stops. They also measure the time taken for the trolley to travel the distance

**RS**.
They repeat the investigation with another trolley, **E**.

Their results are shown in the table.

| **Trolley** | **Distance RS in centimetres** | **Time taken in seconds** | **Average velocity in centimetres per second** |
|---|---|---|---|
| **D** | 65 | 2.1 | |
| **E** | 80 | 2.6 | |

(i) Calculate the average velocity, in centimetres per second, between **R** and **S** for trolleys **D** and **E**. Write your answers in the table.

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**(3)**

(ii) Before the investigation, each student made a prediction.

- Student **1** predicted that the two trolleys would travel the same distance.
- Student **2** predicted that the average velocity of the two trolleys would be the same.
- Student **3** predicted that the negative acceleration of the two trolleys would be the same.

Is each prediction correct?

Justify your answers.

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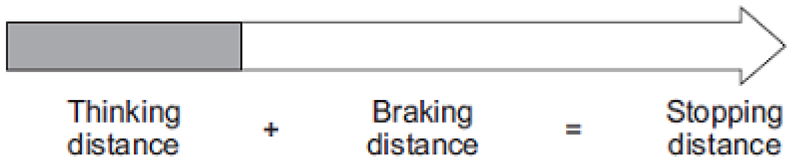
**(3)**
**(Total 12 marks)**

## Q7.

The diagram shows how the thinking distance and braking distance of a car add together to give the stopping distance of the car.




(a) Use words from the box to complete the sentence.

| | | | |
|---|---|---|---|
| **distance** | **energy** | **force** | **time** |

The stopping distance is found by adding the distance the car travels during the driver's reaction ____________________ and the distance the car travels under the braking ____________________ .

**(2)**

(b) Which **one** of the following would **not** increase the thinking distance?

Tick (✓) **one** box.

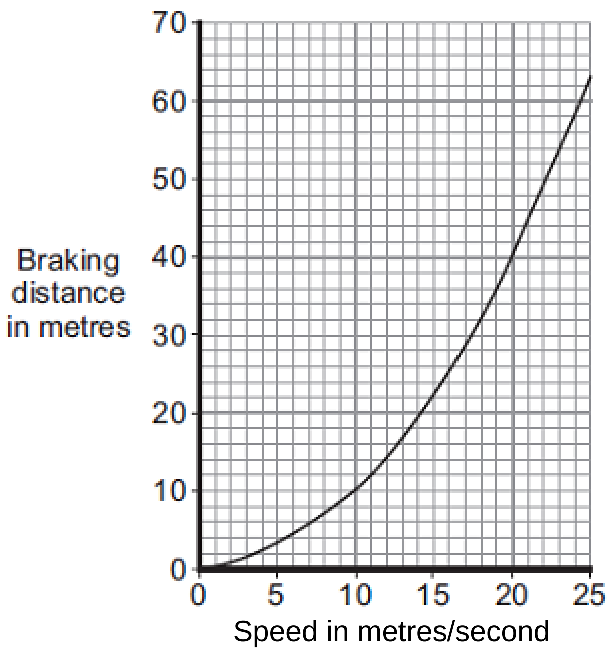
The car driver being tired. ☐

The car tyres being badly worn. ☐

The car being driven faster. ☐

**(1)**

(c) The graph shows how the braking distance of a car changes with the speed of the car.
The force applied to the car brakes does not change.



(i) What conclusion about braking distance can be made from the graph?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

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**(2)**

(ii) The graph is for a car driven on a dry road.

Draw a line on the graph to show what is likely to happen to the braking distance at different speeds if the same car was driven on an icy road.

**(1)**

(d) A local council has reduced the speed limit from 30 miles per hour to 20 miles per hour on a few roads. The reason for reducing the speed limit was to reduce the number of accidents.

(i) A local newspaper reported that a councillor said:

"It will be much safer because drivers can react much faster when driving at 20 miles per hour than when driving at 30 miles per hour."

This statement is wrong. Why?

______________________________________________________________________

______________________________________________________________________

**(1)**

(ii) The local council must decide whether to introduce the lower speed limit on a lot more roads.

What evidence should the local council collect to help make this decision?

______________________________________________________________________

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______________________________________________________________________

______________________________________________________________________

**(2)**

**(Total 9 marks)**

## Q8.

(a) The stopping distance of a vehicle is made up of two parts, the thinking distance and the braking distance.

(i) What is meant by *thinking distance*?

______________________________________________________________________

______________________________________________________________________

**(1)**

(ii) State **two** factors that affect thinking distance.

1. ___________________________________________

___________________________________________

2. ___________________________________________

___________________________________________

**(2)**

(b) A car is travelling at a speed of 20 m/s when the driver applies the brakes. The car decelerates at a constant rate and stops.

(i) The mass of the car and driver is 1600 kg.

Calculate the kinetic energy of the car and driver before the brakes are applied.

___________________________________________

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___________________________________________

Kinetic energy = ________________________ J

**(2)**

(ii) How much work is done by the braking force to stop the car and driver?

Work done = ________________________ J

**(1)**

(iii) The braking force used to stop the car and driver was 8000 N.

Calculate the braking distance of the car.

___________________________________________

___________________________________________

___________________________________________

___________________________________________

Braking distance = ________________________ m

**(2)**

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

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

___________________________________________

___________________________________________

**(1)**

(v) Applying the brakes of the car causes the temperature of the brakes to increase.

Explain why.

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**(2)**

(c) Hybrid cars have an electric engine and a petrol engine. This type of car is often fitted with a regenerative braking system. A regenerative braking system not only slows a car down but at the same time causes a generator to charge the car's battery.

State and explain the benefit of a hybrid car being fitted with a regenerative braking system.

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**(3)**

**(Total 14 marks)**

## Q9.

A car has an oil leak. Every 5 seconds an oil drop falls from the bottom of the car onto the road.

(a) What force causes the oil drop to fall towards the road?

___

**(1)**

(b) The diagram shows the spacing of the oil drops left on the road during part of a journey


Describe the motion of the car as it moves from **A** to **B**.

___

Explain the reason for your answer.

___

___

___

**(3)**

(c) When the brakes are applied, a braking force slows down and stops the car.

(i) The size of the braking force affects the braking distance of the car.

State **one** other factor that affects the braking distance of the car.

**(1)**

(ii) A braking force of 3 kN is used to slow down and stop the car in a distance of 25 m.

Calculate the work done by the brakes to stop the car and give the unit.

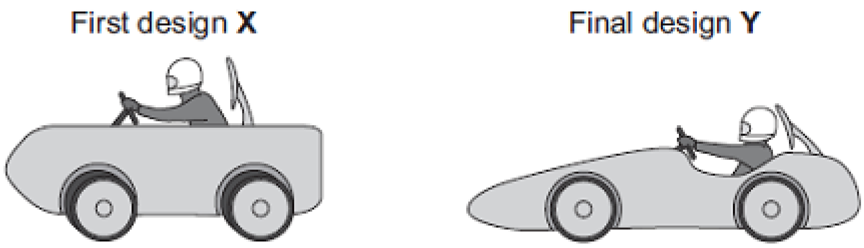
Work done = ____________________

**(3)**

**(Total 8 marks)**

## Q10.

(a) Some students have designed and built an electric-powered go-kart. After testing, the students decided to make changes to the design of their go-kart.




The go-kart always had the same mass and used the same motor.

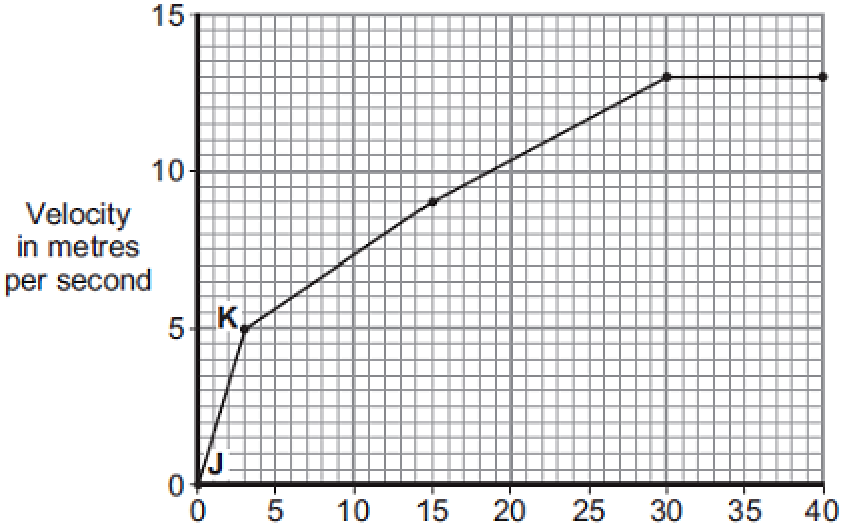
The change in shape from the first design (**X**) to the final design (**Y**) will affect the top speed of the go-kart.

Explain why.

**(3)**

(b) The final design go-kart, **Y**, is entered into a race.

The graph shows how the velocity of the go-kart changes during the first 40 seconds of the race.




Time in seconds

(i) Use the graph to calculate the acceleration of the go-kart between points **J** and **K**.

Give your answer to **two** significant figures.

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Acceleration = ____________________ $m/s^2$

**(2)**

(ii) Use the graph to calculate the distance the go-kart travels between points **J** and **K**.

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Distance = ____________________ m

**(2)**

(iii) What causes most of the resistive forces acting on the go-kart?

___

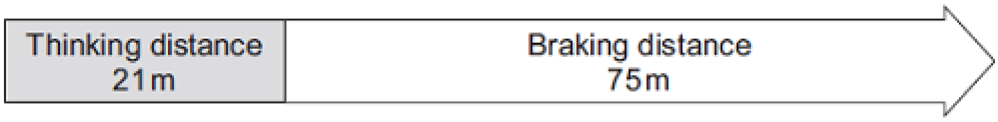
**(1)**

**(Total 8 marks)**

## Q11.

(a) A car driver makes an emergency stop.

The chart shows the ‘thinking distance’ and the ‘braking distance’ needed to stop the car.



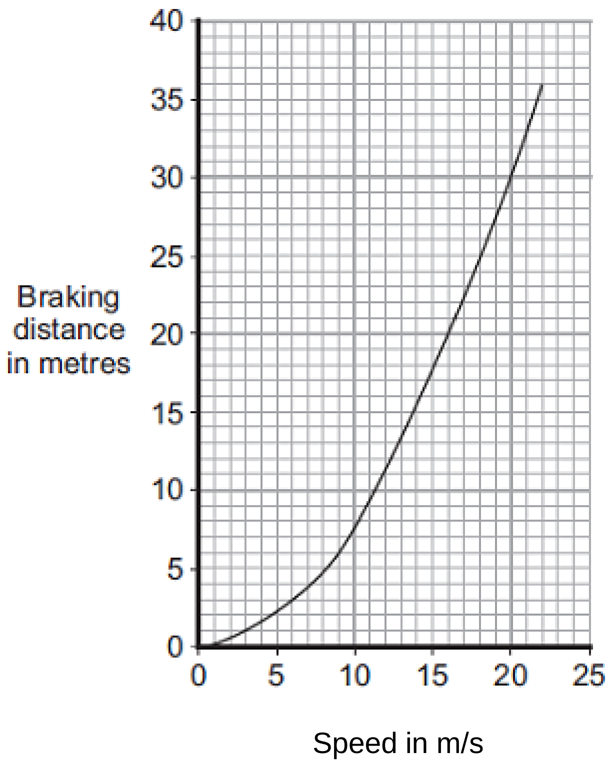

Calculate the total stopping distance of the car.

___________________________________________________________________________

Stopping distance = ______________________________ m

**(1)**

(b) The graph shows how the braking distance of a car driven on a dry road changes with the car’s speed.




The braking distance of the car on an icy road is longer than the braking distance of the car on a dry road.

(i) Draw a new line on the graph to show how the braking distance of the car on an icy road changes with speed.

**(2)**

(ii) Which **one** of the following would also increase the braking distance of the car?

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

Rain on the road ☐

The driver having drunk alcohol ☐

The driver having taken drugs ☐

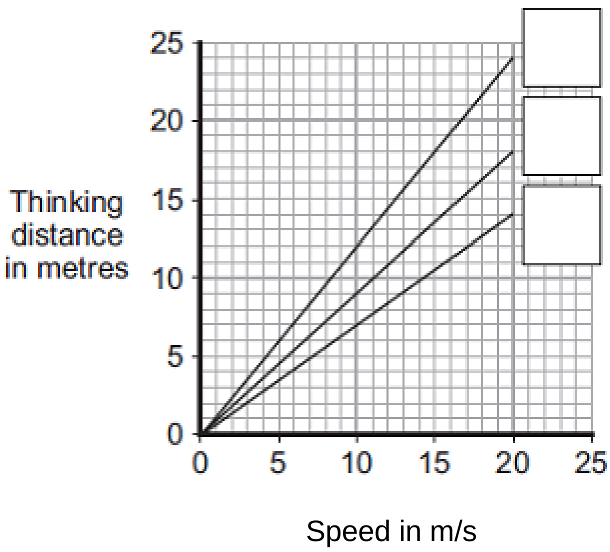
**(1)**

(c) The thinking distance depends on the driver's reaction time.

The table shows the reaction times of three people driving under different conditions.

| Car driver | Condition | Reaction time in second |
|---|---|---|
| **A** | Wide awake with no distractions | 0.7 |
| **B** | Using a hands-free mobile phone | 0.9 |
| **C** | Very tired and listening to music | 1.2 |

The graph lines show how the thinking distance for the three drivers, **A**, **B**, and **C**, depends on how fast they are driving the car.




(i) Match each graph line to the correct driver by writing **A**, **B**, or **C** in the box next to the correct line.

**(2)**

(ii) The information in the table cannot be used to tell if driver **C**'s reaction time is increased by being tired **or** by listening to music.
Explain why.

______________________________________________

______________________________________________

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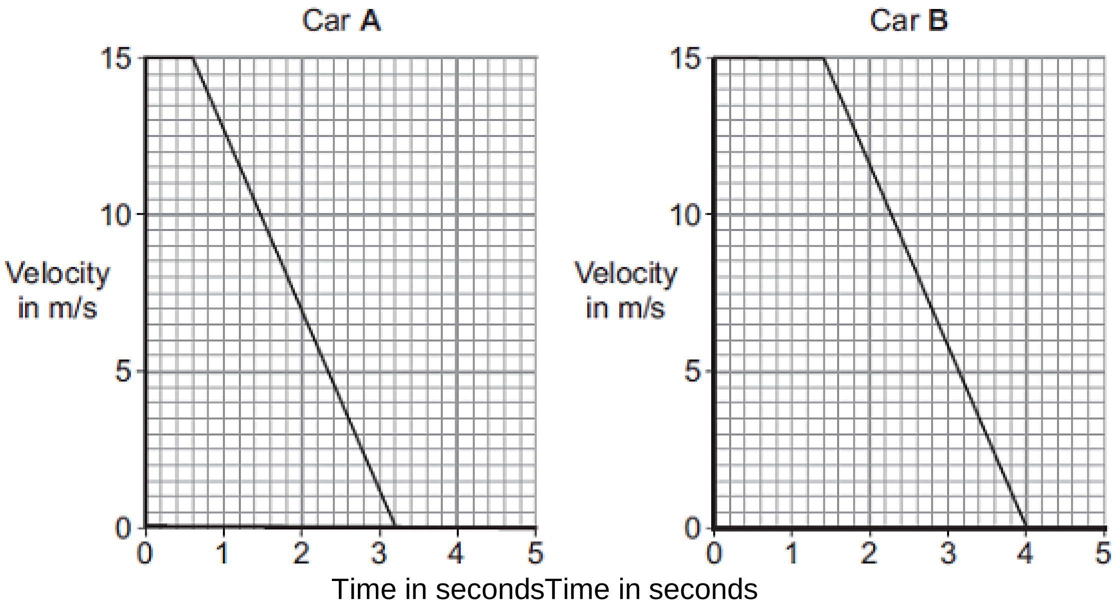
**(2)**
**(Total 8 marks)**

## Q12.

(a) The graphs show how the velocity of two cars, **A** and **B**, change from the moment the car drivers see an obstacle blocking the road.




One of the car drivers has been drinking alcohol. The other driver is wide awake and alert.

(i) How does a comparison of the two graphs suggest that the driver of car **B** is the one who has been drinking alcohol?

______________________________________________________________

______________________________________________________________

**(1)**

(ii) How do the graphs show that the two cars have the same deceleration?

______________________________________________________________

______________________________________________________________

**(1)**

(iii) Use the graphs to calculate how much further car **B** travels before stopping compared to car **A**.

Show clearly how you work out your answer.

______________________________________________________________

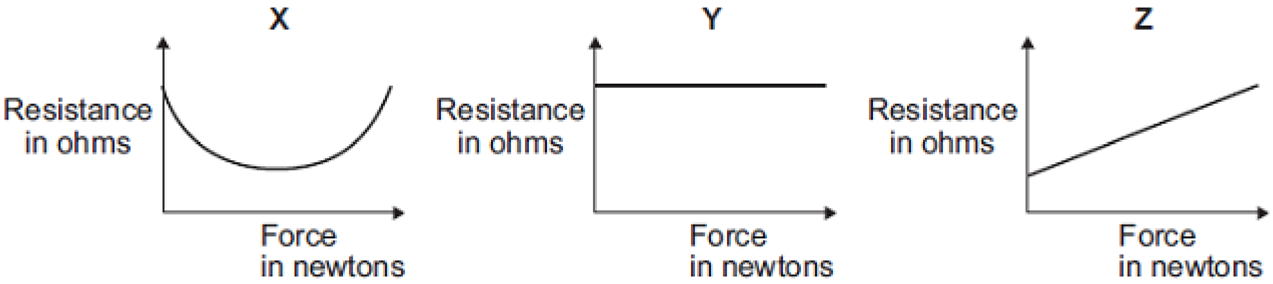
______________________________________________________________

______________________________________________________________

Additional stopping distance = ____________________ m

**(3)**

(b) In a crash-test laboratory, scientists use sensors to measure the forces exerted in collisions. The graphs show how the electrical resistance of 3 experimental types of sensor, **X**, **Y**, and **Z**, change with the force applied to the sensor.




Which of the sensors, **X**, **Y** or **Z**, would be the best one to use as a force sensor?

____________________

Give a reason for your answer.

______________________________________________________________

______________________________________________________________

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______________________________________________________________

**(2)**
**(Total 7 marks)**

## Q13.

The London Eye is one of the largest observation wheels in the world.

© Angelo Ferraris/Shutterstock

The passengers ride in capsules. Each capsule moves in a circular path and accelerates.

(a) Explain how the wheel can move at a steady speed and the capsules accelerate at the same time.

______________________________________________________________

(2)

(b) In which direction is the resultant force on each capsule?

(1)

(c) The designers of the London Eye had to consider **three** factors which affect the resultant force described in part (b).

Two factors that increase the resultant force are:

- an increase in the speed of rotation
- an increase in the total mass of the wheel, the capsules and the passengers.

Name the other factor that affects the resultant force and state what effect it has on the resultant force.

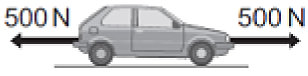
(1)

**(Total 4 marks)**

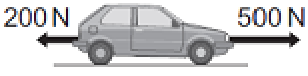
## Q14.

(a) A car is being driven along a straight road. The diagrams, **A**, **B** and **C**, show the horizontal forces acting on the moving car at three different points along the road.

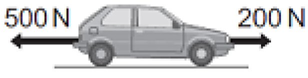
Describe the motion of the car at each of the points, **A**, **B** and **C**.




**A**




**B**

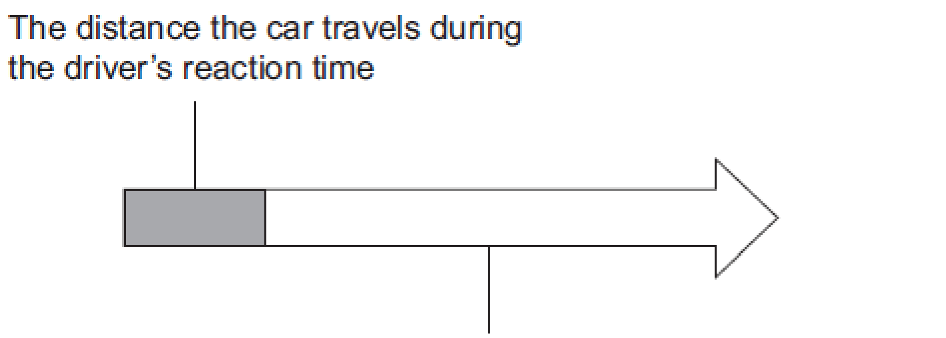



**C**

(3)

(b) The diagram below shows the stopping distance for a family car, in good condition, driven at 22 m/s on a dry road. The stopping distance has two parts.

(i) Complete the diagram below by adding an appropriate label to the second part of the stopping distance.

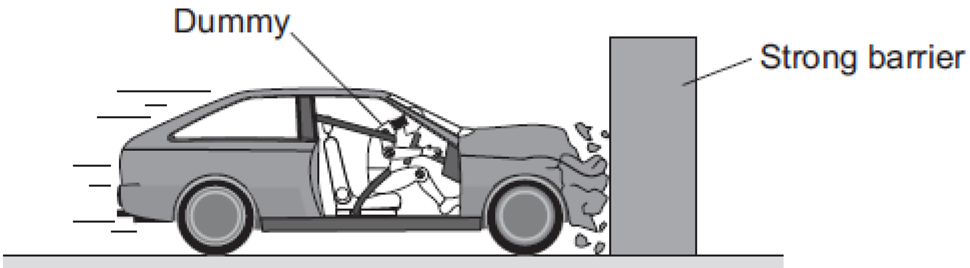



**(1)**

(ii) State **one** factor that changes both the first part **and** the second part of the stopping distance.

**(1)**

(c) The front crumple zone of a car is tested at a road traffic laboratory. This is done by using a remote control device to drive the car into a strong barrier. Electronic sensors are attached to the dummy inside the car.




(i) At the point of collision, the car exerts a force of 5000 N on the barrier.

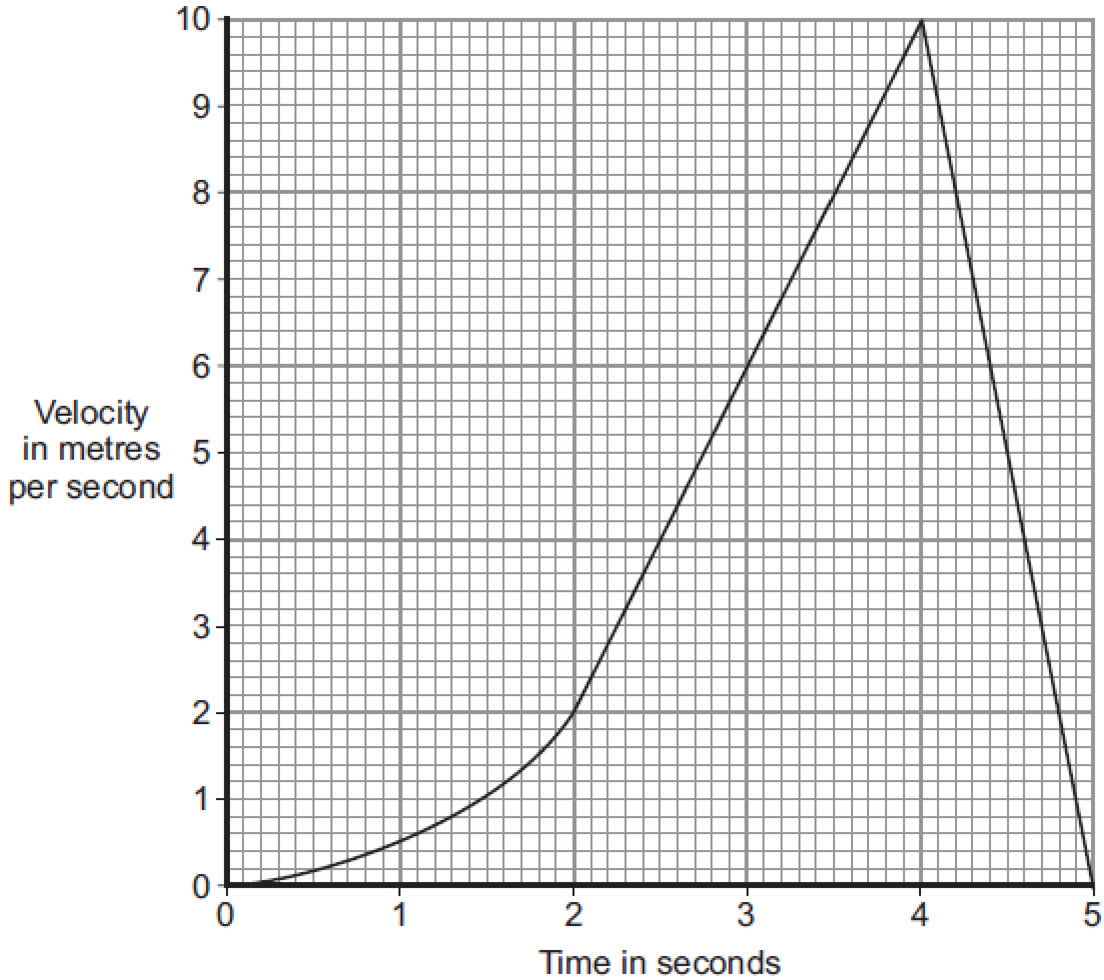
State the size and direction of the force exerted by the barrier on the car.

**(1)**

(ii) Suggest why the dummy is fitted with electronic sensors.

**(1)**

(iii) The graph shows how the velocity of the car changes during the test.




Use the graph to calculate the acceleration of the car just before the collision with the barrier.

Show clearly how you work out your answer, including how you use the graph, and give the unit.

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Acceleration = ______________________________

**(3)**

**(Total 10 marks)**

## Q15.

Motorway accidents have many causes.

(a) Which **one** of the following is most likely to increase the chance of a car being in an accident?

Tick (✓) the box next to your answer.

The car has just had new tyres fitted. ☐

The driver has been drinking alcohol. ☐

A road surface in dry conditions ☐

Give a reason for your answer.

______________________________________________________________

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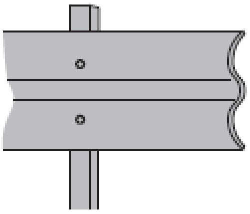
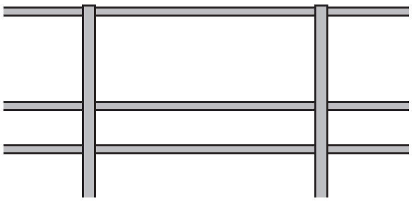
**(2)**

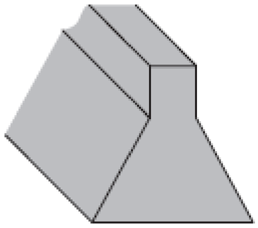
(b) The diagram shows three designs of motorway crash barriers.



Steel sheets



Steel 'ropes'



Solid concrete

Before a new design of barrier is used, it must be tested.
A car of mass 1500 kg is driven at 30 m/s to hit the barrier at an angle of 20 degrees.
This barrier must slow the car down and must not break.

Explain why the mass of the car, the speed of the car and the angle at which the car hits the barrier must be the same in every test.

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**(2)**

(c) A group of scientists has suggested that new designs of crash barriers should be first tested using computer simulations.

Which **two** statements give sensible reasons for testing new barrier designs using a computer simulation?

Put a tick (✓) in the box next to each of your answers.

The design of the barrier can be changed easily. ☐

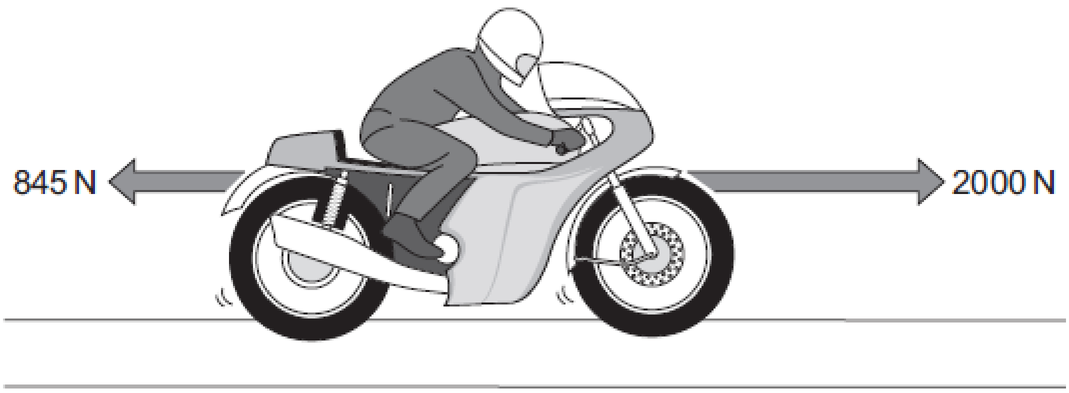
Data for different conditions can be obtained quickly. ☐

Simulations are more realistic than using cars and barriers. ☐

**(1)**
**(Total 5 marks)**

## Q16.

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.

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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.

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**(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.

______________________________________________________________

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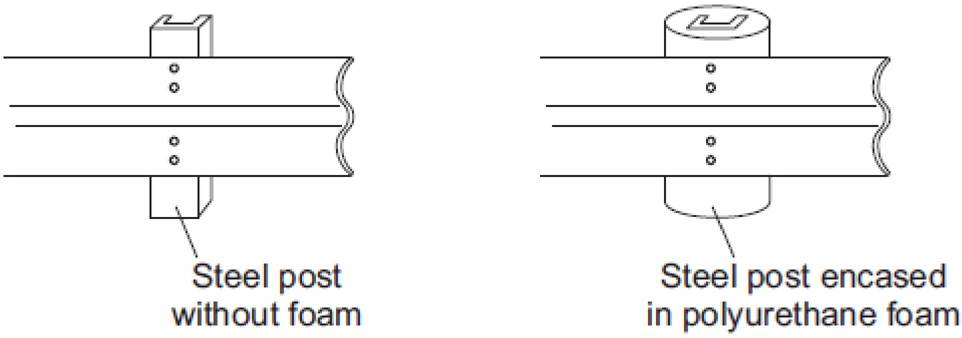
**(2)**

(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.

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**(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.

______________________________________________________________________

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**(1)**
**(Total 11 marks)**

## Q17.

(a) The total stopping distance of a car has two parts. One part is the distance the car travels during the driver's reaction time. This distance is often called the 'thinking distance'.

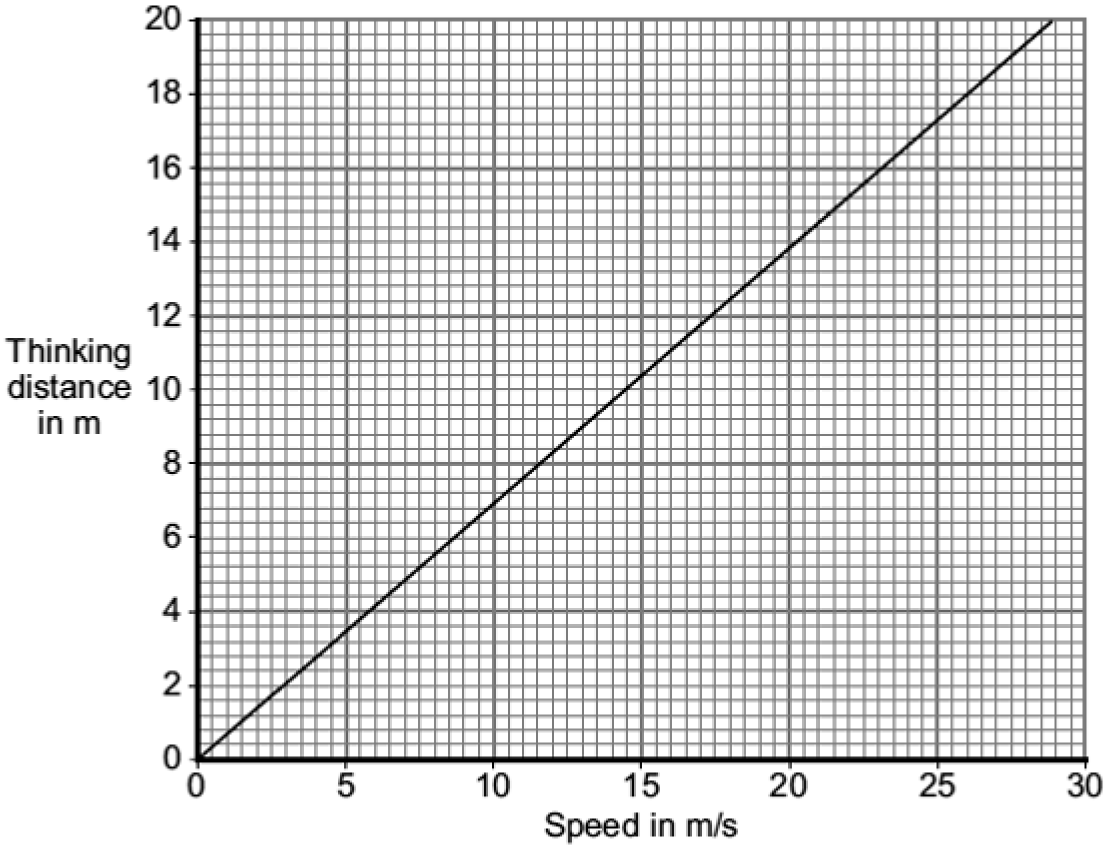
What distance is added to the 'thinking distance' to give the total stopping distance?

______________________________________________________________________

______________________________________________________________________

**(1)**

(b) The graph shows the relationship between the speed of a car and the thinking distance.



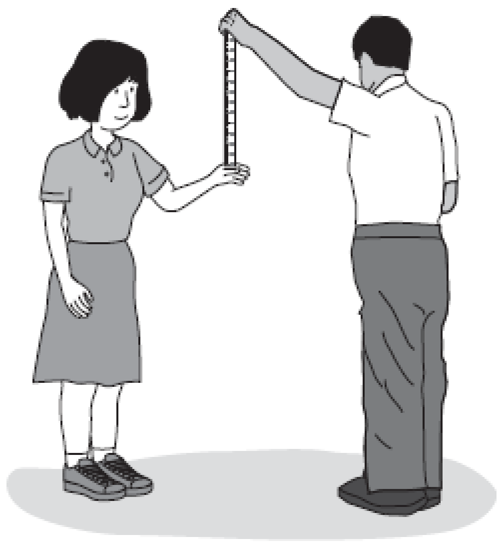

Describe the relationship between speed and thinking distance.

___________________________________________________________________

___________________________________________________________________

**(2)**

(c) The diagram shows two students investigating reaction time.



One student holds a 30 cm ruler, then lets go. As soon as the second student sees the ruler fall, she closes her hand, stopping the ruler. The further the ruler falls before being stopped, the slower her reaction time.

(i) One student always holds the ruler the same distance above the other student's hand.
In this experiment, what type of variable is this?

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

independent variable ☐

dependent variable ☐

control variable ☐

**(1)**

(ii) Describe how this experiment could be used to find out whether listening to music affects reaction time.

______________________________________________________________

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**(2)**

(d) The following information is written on the label of some cough medicine.

| |
|---|
| **WARNING**: Causes drowsiness.<br>Do not drive or operate machinery. |

How is feeling drowsy (sleepy) likely to affect a driver's reaction time?

______________________________________________________________

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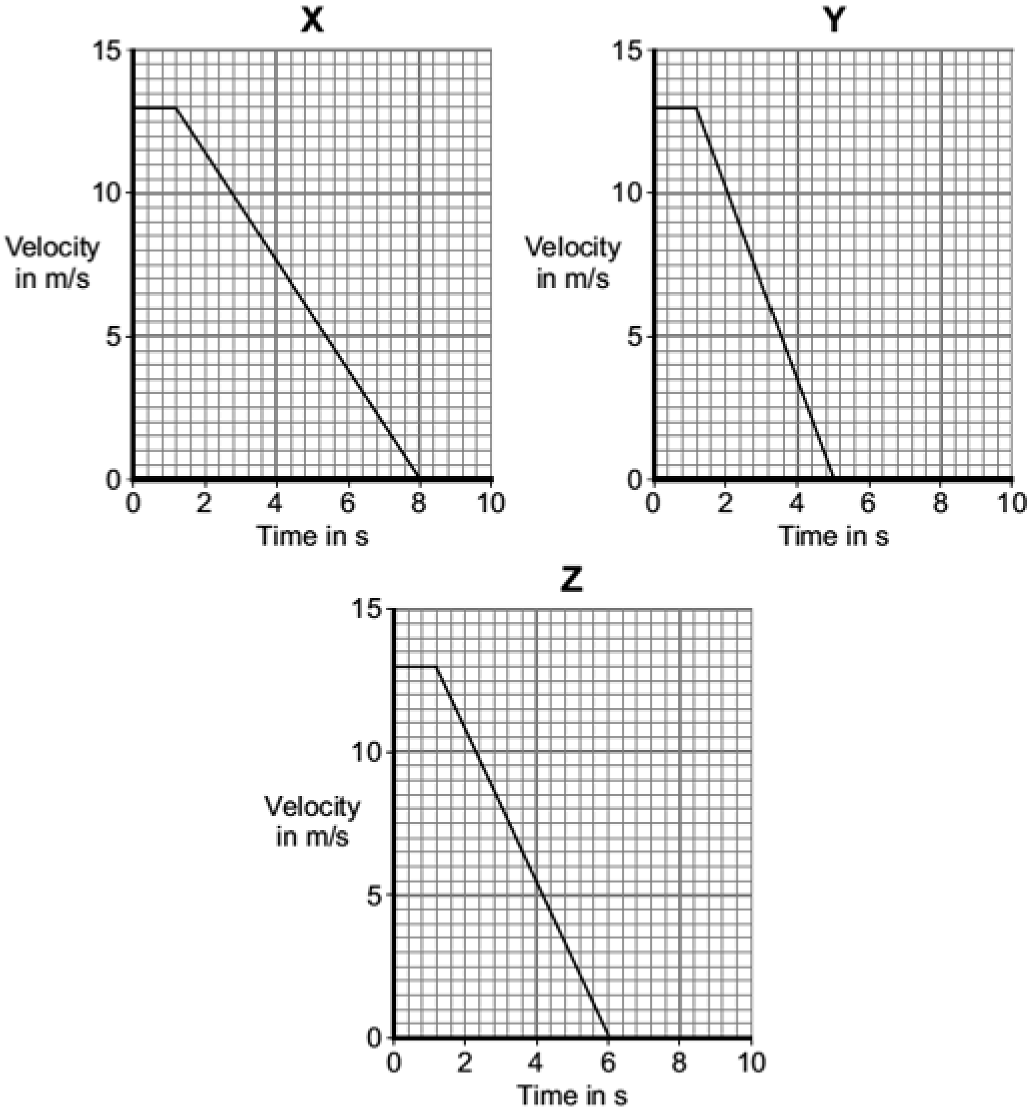
**(1)**

(e) Three cars, **X**, **Y** and **Z** , are being driven along a straight road towards a set of traffic lights.
The graphs show how the velocity of each car changes once the driver sees that the traffic light has turned to red.




Which one of the cars, **X**, **Y** or **Z** , stops in the shortest distance?

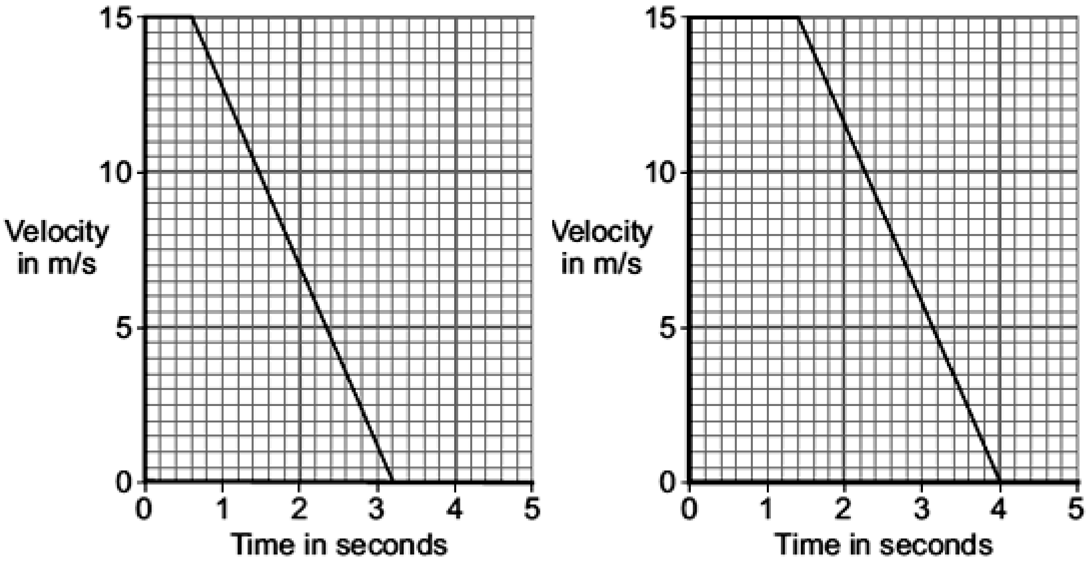
________________________

**(1)**
**(Total 8 marks)**

## Q18.

(a) The graphs show how the velocity of two cars, **A** and **B**, change from the moment the car drivers see an obstacle blocking the road.

**Car A** **Car B**




One of the car drivers has been drinking alcohol. The other driver is wide awake and alert.

(i) How does a comparison of the two graphs suggest that the driver of car **B** is the one who has been drinking alcohol?

___________________________________________________________________

___________________________________________________________________

**(1)**

(ii) How do the graphs show that the two cars have the same deceleration?

___________________________________________________________________

___________________________________________________________________

**(1)**

(iii) Use the graphs to calculate how much further car **B** travels before stopping compared to car **A**.

Show clearly how you work out your answer.

___________________________________________________________________

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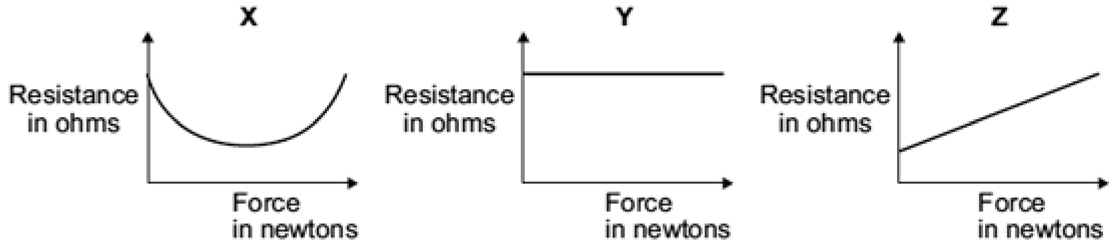
Additional stopping distance = ______________________ m

**(3)**

(b) In a crash test laboratory, scientists use sensors to measure the forces exerted in collisions. The graphs show how the electrical resistance of 3 experimental types of sensor, **X**, **Y** and **Z**, change with the force applied to the sensor.




Which of the sensors, **X**, **Y** or **Z**, would be the best one to use as a force sensor?

______________________________

Give a reason for your answer.

________________________________________________________________

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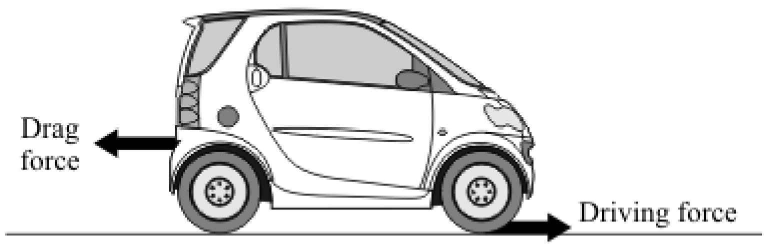
**(2)**
**(Total 7 marks)**

## Q19.

The diagram shows the horizontal forces acting on a car travelling along a straight road.




(a) Complete the following sentences by drawing a ring around the correct word in each box.

(i) When the driving force equals the drag force, the speed ofthe car is

| |
|---|
| decreasing |
| constant |
| increasing |

**(1)**

(ii) Putting the brakes on transforms the car's kinetic energy mainly into

| |
|---|
| heat |
| light |
| sound |

**(1)**

(b) The charts, **A**, **B** and **C** give the thinking distance and the braking distance for a car driven under different conditions.

(i) Draw straight lines to match each chart to the correct conditions.

Draw only **three** lines.

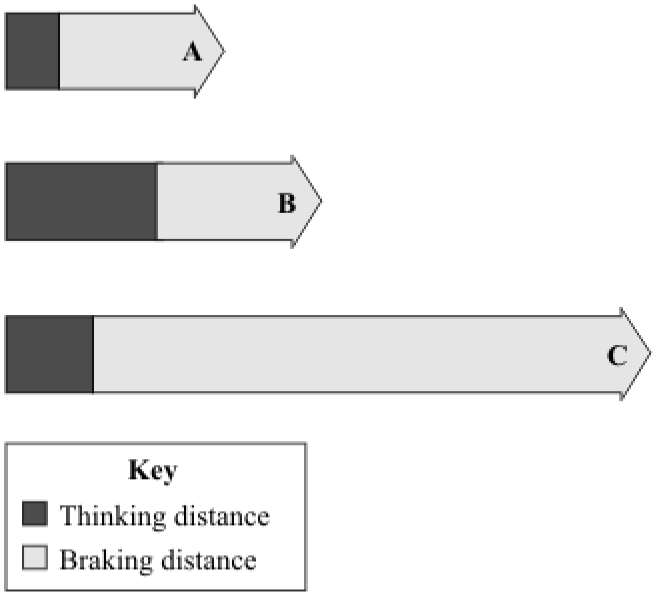
**Conditions**

Speed = 22 m/s
driver wide awake

Speed = 13 m/s
driver wide awake

Speed = 13 m/s
driver very tired

**Charts**




**(2)**

(ii) The three charts above all apply to dry road conditions.

How would the braking distances be different if the road were wet?

______________________________________________________________

______________________________________________________________

**(1)**

**(Total 5 marks)**

## Q20.

(a) A car driver makes an emergency stop.

The chart shows the 'thinking distance' and the 'braking distance' needed to stop the car.

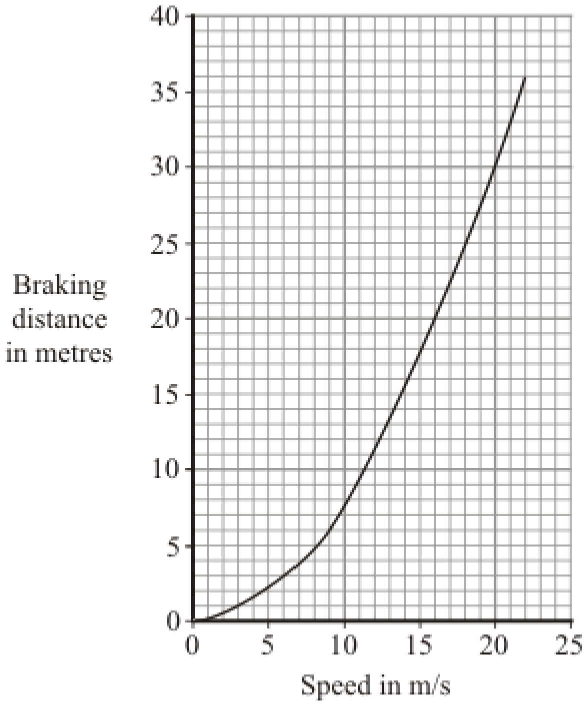

Calculate the total stopping distance of the car.

______________________________________________________________

Stopping distance = ____________________ m

**(1)**

(b) The graph shows how the braking distance of a car driven on a dry road changes with the car's speed.




The braking distance of the car on an icy road is longer than the braking distance of the car on a dry road.

(i) Draw a new line on the graph to show how the braking distance of the car on an icy road changes with speed.

**(2)**

(ii) Which **two** of the following would also increase the braking distance of the car?

Put a tick (✓) next to each of your answers.

rain on the road ☐

the driver having drunk alcohol ☐

car brakes in bad condition ☐

the driver having taken drugs ☐

**(2)**

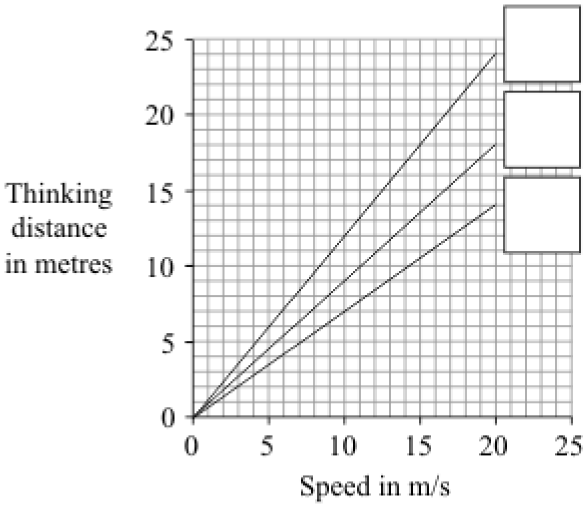
(c) The thinking distance depends on the driver's reaction time.

The table shows the reaction times of three people driving under different conditions.

| **Car driver** | **Condition** | **Reaction time in seconds** |
|---|---|---|
| **A** | Wide awake with no distractions | 0.7 |
| **B** | Using a hands-free mobile | 0.9 |

| | | |
|---|---|---|
| | phone | |
| **C** | Very tired and listening to music | 1.2 |

The graph lines show how the thinking distance for the three drivers, **A**, **B** and **C**, depends on how fast they are driving the car.




(i) Match each graph line to the correct driver by writing **A**, **B** or **C** in the box next to the correct line.

**(2)**

(ii) The information in the table cannot be used to tell if driver **C**'s reaction time is increased by being tired or by listening to music.

Explain why.

___________________________________________________________________

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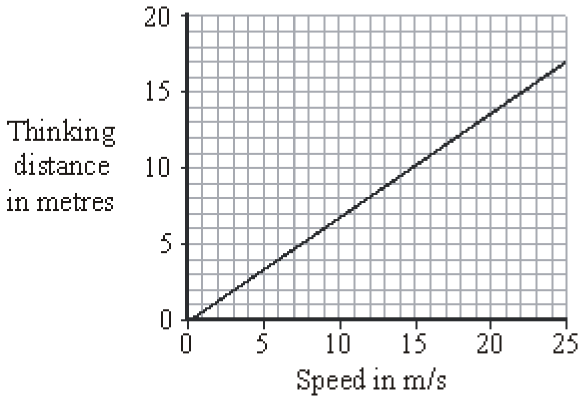
**(2)**
**(Total 9 marks)**

## Q21.

(a) A car driver takes a short time to react to an emergency before applying the brakes. The distance the car will travel during this time is called the 'thinking distance'.

The graph shows how the thinking distance of a driver depends on the speed of the car.




(i) What is the connection between thinking distance and speed?

___________________________________________________________

**(1)**

(ii) Many people drive while they are tired.

Draw a new line on the graph to show how thinking distance changes with speed for a tired driver.

**(1)**

(iii) The graph was drawn using data given in the Highway Code.

Do you think that the data given in the Highway Code is likely to be reliable?

Draw a ring around your answer.

**Yes** **No** **Maybe**

Give a reason for your answer.

___________________________________________________________

___________________________________________________________

**(1)**

(b) The distance a car travels once the brakes are applied is called the 'braking distance'.

(i) What is the relationship between thinking distance, braking distance and stopping distance?

___________________________________________________________

**(1)**

(ii) State **two** factors that could increase the braking distance of a car at a speed of 15 m/s.

1. ___________________________________________________________

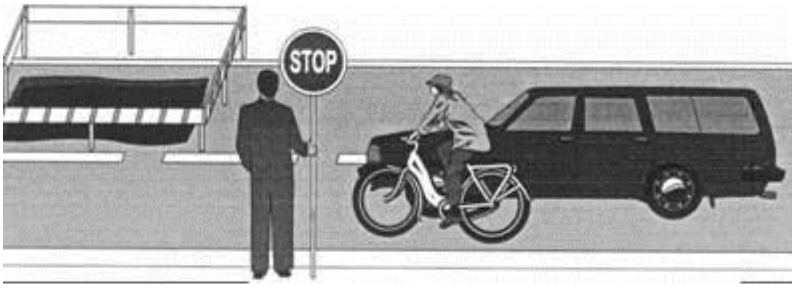
2. ___________________________________________________________

**(2)**

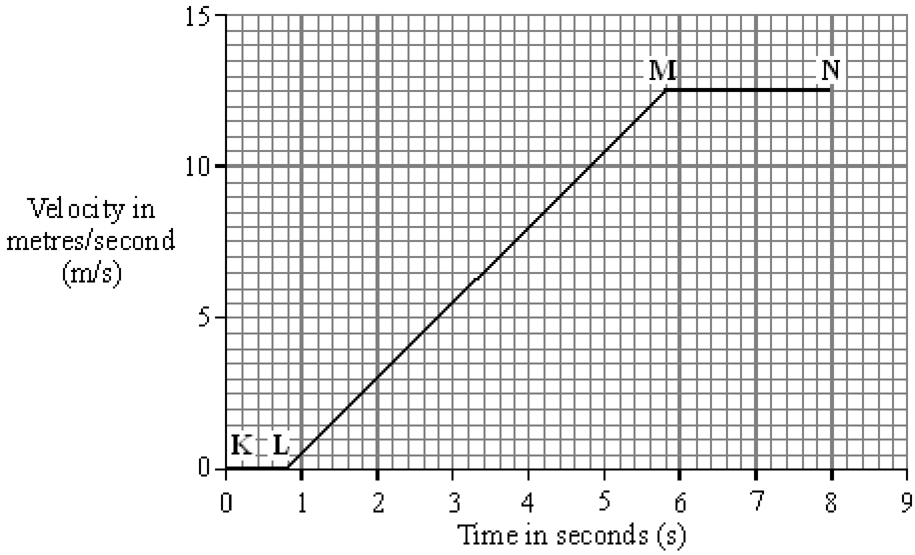
**(Total 6 marks)**

## Q22.

A car and a bicycle are travelling along a straight road. They have stopped at road works.




The graph shows how the velocity of the car changes after the sign is changed to GO.




(a) Between which two points on the graph is the car moving at constant velocity?

______________________________________________________________________

**(1)**

(b) Between which two points on the graph is the car accelerating?

______________________________________________________________________

**(1)**

(c) Between the sign changing to GO and the car starting to move, there is a time delay. This is called the reaction time.

(i) What is the reaction time of the car driver?

Reaction time = __________________ seconds

**(1)**

(ii) Which **one** of the following could increase the reaction time of a car driver? Tick the box next to your choice.

Drinking alcohol ☐

Wet roads ☐

Worn car brakes ☐

**(1)**

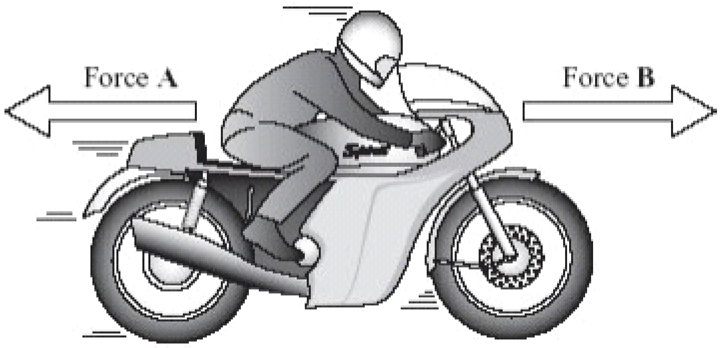
(d) The cyclist starts to move at the same time as the car. For the first 2 seconds the cyclist's acceleration is constant and is greater than that of the car.

Draw a line on the graph to show how the velocity of the cyclist might change during the first 2 seconds of its motion.

**(2)**
**(Total 6 marks)**

## Q23.

(a) The diagram shows the horizontal forces that act on a **moving** motorbike.




(i) Describe the movement of the motorbike when force **A** equals force **B**.

___

___

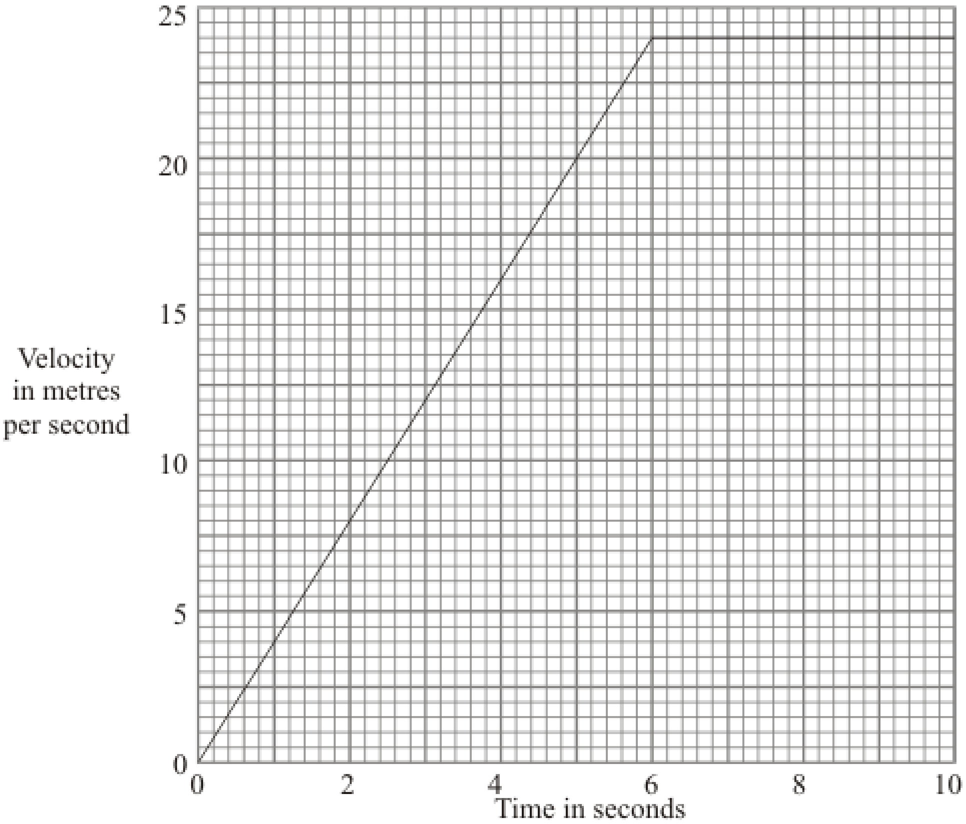
**(2)**

(ii) What happens to the speed of the motorbike if force **B** becomes smaller than force **A**?

___

**(1)**

(b) The graph shows how the velocity of a motorbike changes when it is travelling along a straight road.




(i) What was the change in velocity of the motorbike in the first 5 seconds?

___________________________________________________________________

**(1)**

(ii) Write down the equation which links acceleration, change in velocity and time taken.

___________________________________________________________________

**(1)**

(iii) Calculate the acceleration of the motorbike during the first 5 seconds. Show clearly how you work out your answer and give the unit.

___________________________________________________________________

___________________________________________________________________

Acceleration = ______________________________

**(3)**

(c) A car is travelling on an icy road.

Describe and explain what might happen to the car when the brakes are applied.

___________________________________________________________________

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___________________________________________________________________

**(2)**

(d) Name **three** factors, other than weather conditions, which would increase the overall stopping distance of a vehicle.

1. ______________________________________________

______________________________________________

2. ______________________________________________

______________________________________________

3. ______________________________________________

______________________________________________

**(3)**

**(Total 13 marks)**

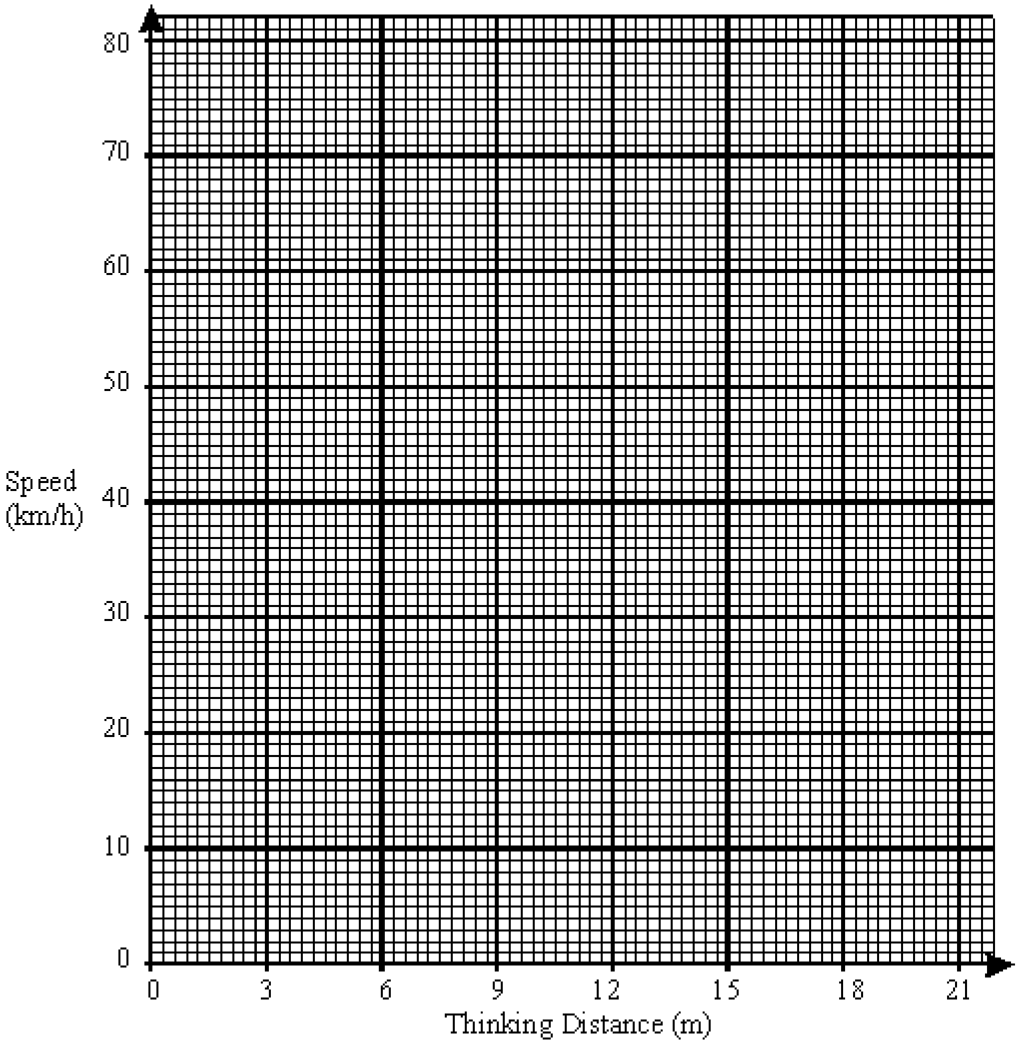
## Q24.

When a car driver has to react and apply the brakes quickly, the car travels some distance before stopping. Part of this distance is called the “thinking distance”. This is how far the car travels while the driver reacts to a dangerous situation.

The table below shows the thinking distance (m) for various speeds (km/h).

| | | | | |
|---|---|---|---|---|
| Thinking distance (m) | 0 | 9 | 12 | 15 |
| Speed (km/h) | 0 | 48 | 64 | 80 |

(a) On the graph paper below, draw a graph of the thinking distance against speed.




**(2)**

(b) Describe how thinking distance changes with speed.

______________________________________________________________________

______________________________________________________________________

**(1)**

(c) The time the driver spends thinking before applying the brakes is called the "thinking time".

A driver drank two pints of lager. Some time later the thinking time of the driver was measured as 1.0 seconds.

(i) Calculate the thinking distance for this driver when driving at 9 m/s.

______________________________________________________________________

______________________________________________________________________

Answer ______________________ m

**(1)**

(ii) A speed of 9 m/s is the same as 32 km/h. Use your graph to find the thinking distance at 32 km/h for a driver who has not had a drink.

______________________________________________________________________

Answer ______________________ m

**(1)**

(iii) What has been the effect of the drink on the thinking distance of the driver?

___________________________________________________________________

___________________________________________________________________

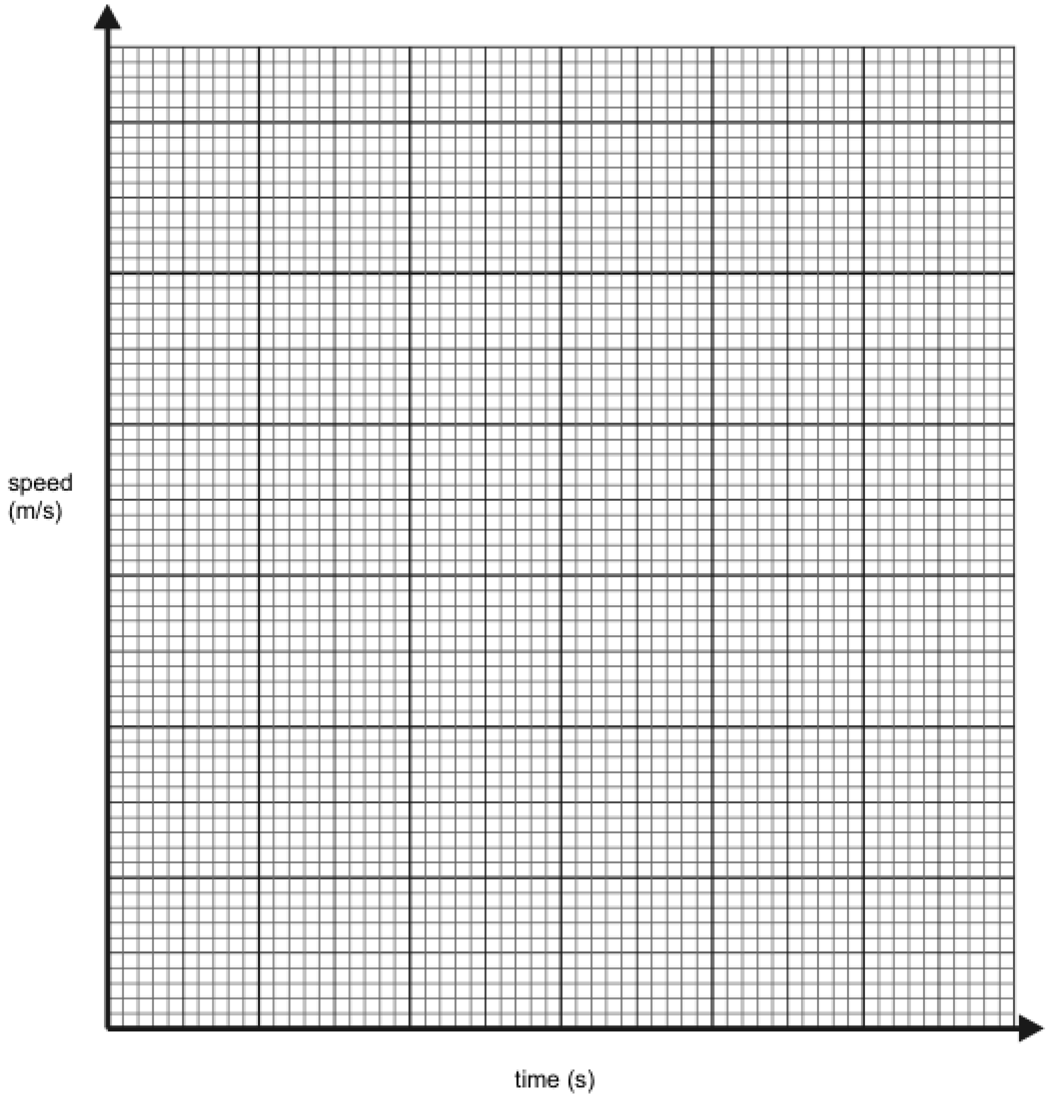
**(1)**

**(Total 6 marks)**

## Q25.

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$^2$

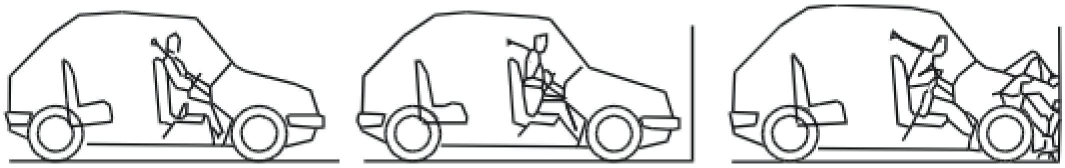
**(3)**

(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.

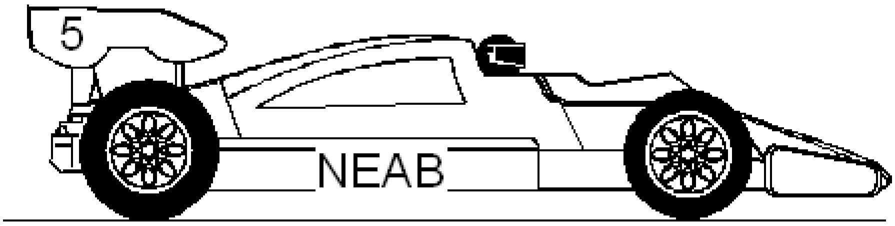
(ii) The car was travelling at 30 m/s immediately before the crash. Calculate the energy which has to be dissipated as the front of the car crumples.

**(8)**

**(Total 17 marks)**

## Q26.

A racing driver is driving his car along a **straight** and **level** road as shown in the diagram below.




(a) The driver pushes the accelerator pedal as far down as possible. The car does not accelerate above a certain maximum speed. Explain the reasons for this in terms of the forces acting on the car.

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**(4)**

(b) The racing car has a mass of 1250 kg. When the brake pedal is pushed down a constant braking force of 10 000 N is exerted on the car.

(i) Calculate the acceleration of the car.

______________________________________________________________

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(ii) Calculate the kinetic energy of the car when it is travelling at a speed of 48 m/s.

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______________________________________________________________

______________________________________________________________

(iii) When the brakes are applied with a constant force of 10 000 N the car travels a distance of 144 m before it stops. Calculate the work done in stopping the car.

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________________

______________________________________________________________________

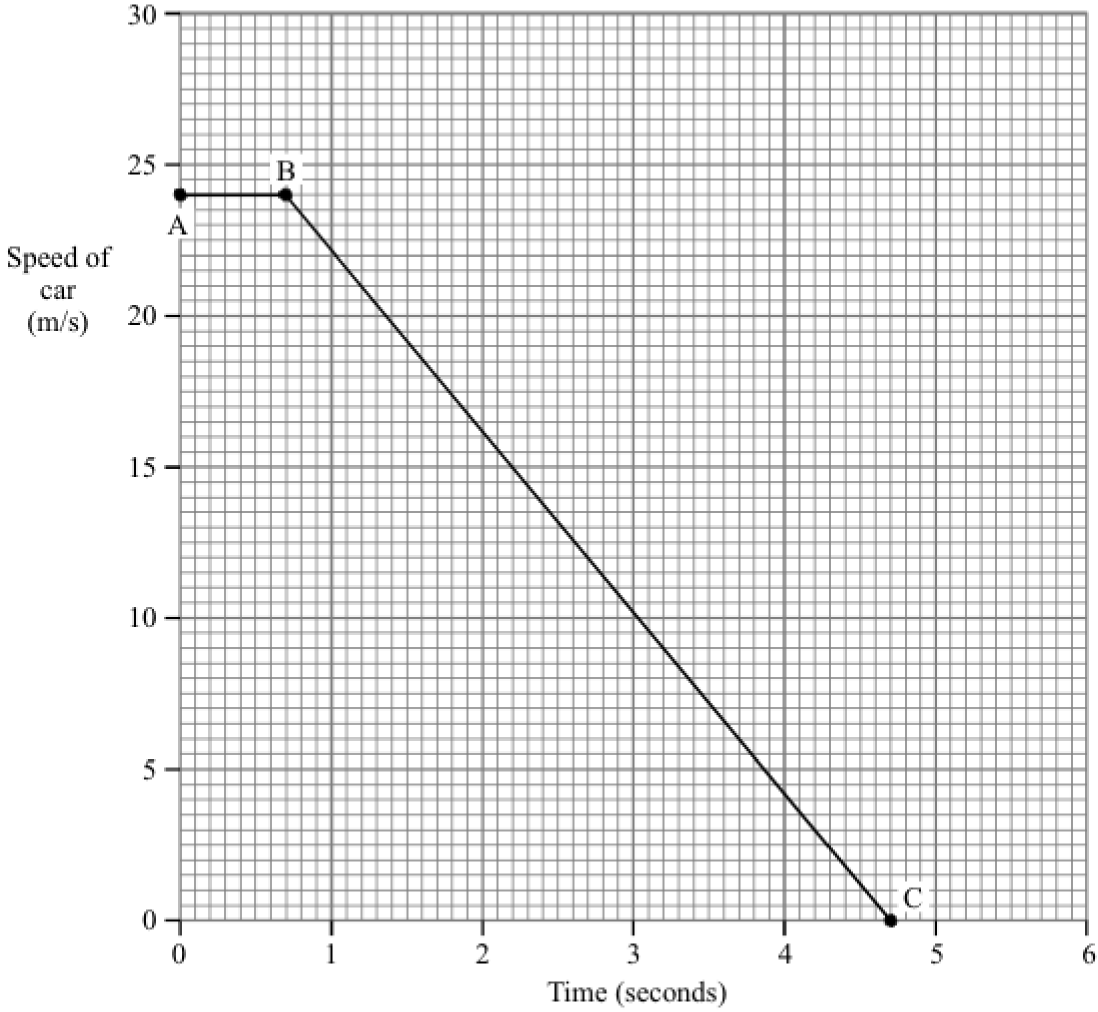
______________________________________________________________________

**(12)**
**(Total 16 marks)**

## Q27.

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

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




(a) Which part of the graph represents the "reaction time" or "thinking time" of the driver?

______________________________________________________________________

**(1)**

(b) (i) What is the thinking time of the driver?

Time _____________ seconds

**(1)**

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

Distance ____________________ m

**(3)**

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

Acceleration ________________________

**(4)**

(d) Calculate the distance travelled by the car during braking.

Distance _________________________ m

**(3)**

(e) The mass of the car is 800 kg. Calculate the braking force.

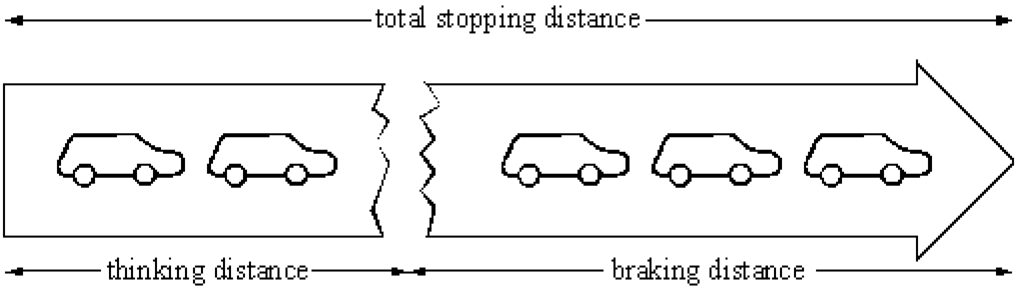
Braking force _____________________ N

**(3)**

**(Total 15 marks)**

## Q28.

The Highway Code gives tables of the shortest stopping distances for cars travelling at various speeds. An extract from the Highway Code is given below.




thinking distance + braking distance = total stopping distance

(a) A driver's reaction time is 0.7 s.

(i) Write down **two** factors which could increase a driver's reaction time.

1. ______________________________________________

2. ______________________________________________

**(2)**

(ii) What effect does an increase in reaction time have on:

A thinking distance; ______________________________

B braking distance; ______________________________

C total stopping distance? __________________________

**(3)**

(b) Explain why the braking distance would change on a wet road.

______________________________________________

______________________________________________

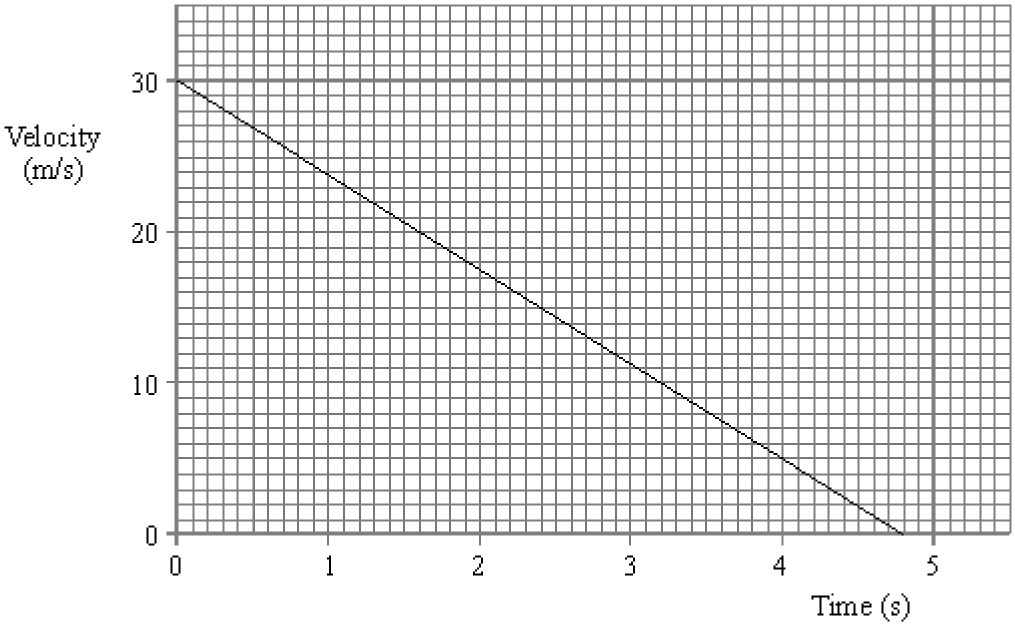
______________________________________________

______________________________________________

**(2)**

(c) A car was travelling at 30 m/s. The driver braked. The graph below is a velocity-time graph showing the velocity of the car during braking.

**Q29.**




Calculate:

(i) the rate at which the velocity decreases (deceleration);

________________________________________________________________

________________________________________________________________

Rate ______________ $m/s^2$

**(2)**

(ii) the braking force, if the mass of the car is 900 kg;

________________________________________________________________

________________________________________________________________

Braking force _________________ N

**(2)**

(iii) the braking distance.

________________________________________________________________

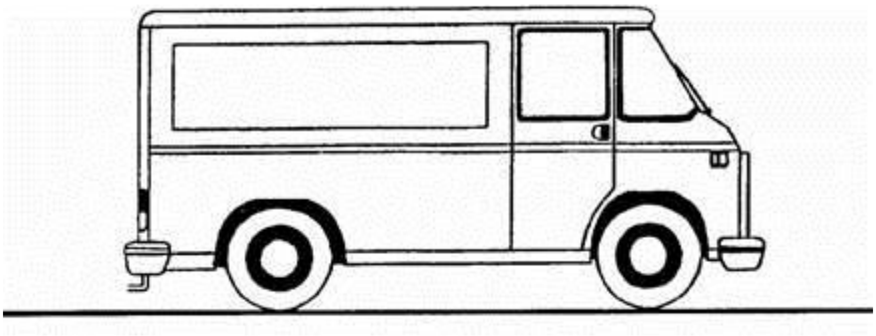
________________________________________________________________

Braking distance ________________ m

**(2)**

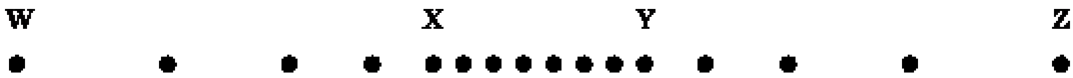
**(Total 13 marks)**

**Q29.**



(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.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

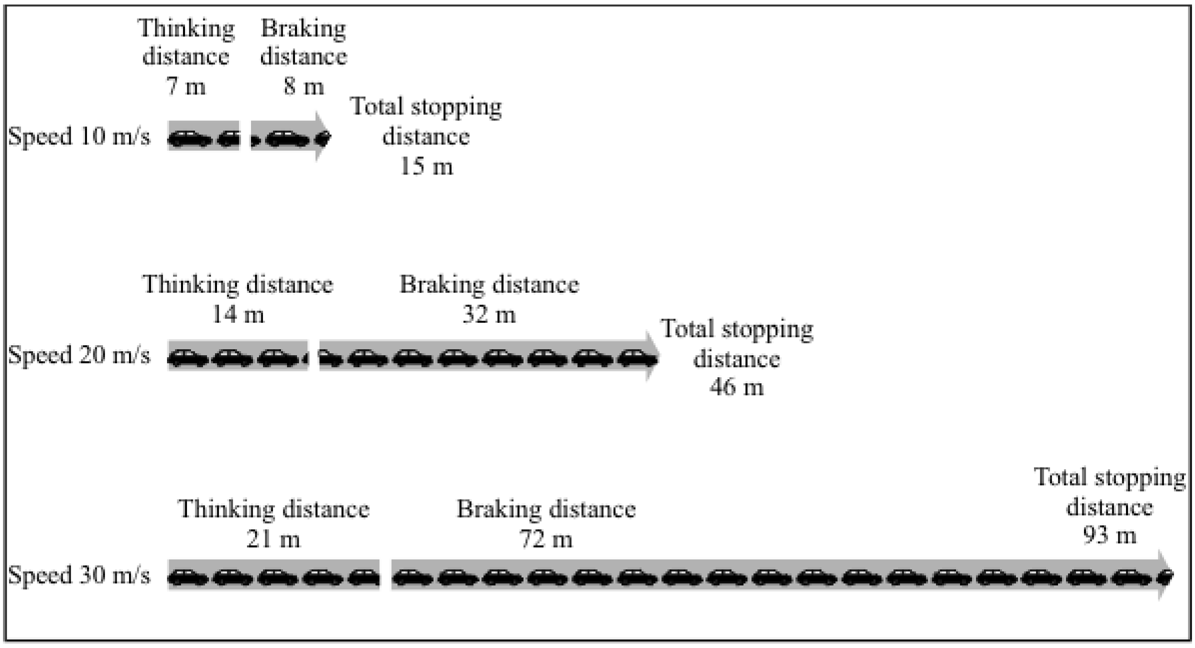
___________________________________________________________________

**(4)**

**(Total 12 marks)**

## Q30.

The diagram below shows the thinking distances, braking distances and total stopping distances at different speeds.




(a) Look at the total stopping distances at each speed.

Complete the sentence by choosing the correct words from the box.

| | | | |
|---|---|---|---|
| **distance** | **force** | **mass** | **time** |

The total stopping distance depends on the distance the car travels during the driver's reaction _______________ and under the braking ________________ .

**(2)**

(b) Give **three** other factors that could cause the total stopping distance of a car to be greater. Do **not** give the factors in **Figure 1.**

1. ______________________________________________

______________________________________________

2. ______________________________________________

______________________________________________

3. ______________________________________________

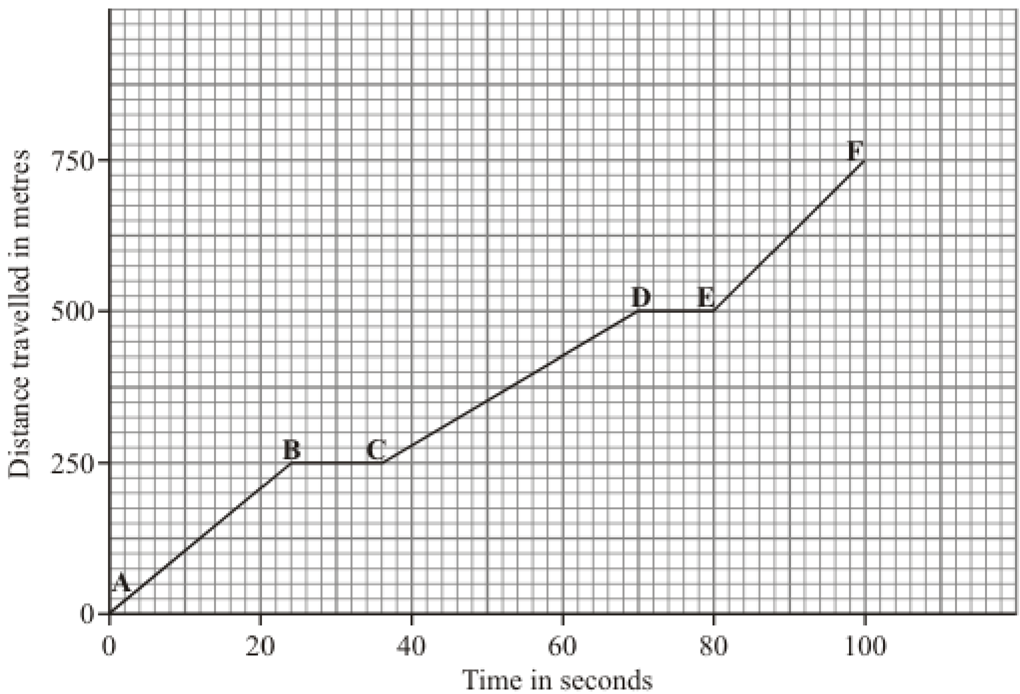
______________________________________________

**(3)**
**(Total 5 marks)**

## Q31.

This question is about a car travelling through a town.

(a) The graph shows how far the car travelled and how long it took.




(i) Between which points was the car travelling fastest? Tick (✓) your answer.

| Points | Tick (✓) |
|---|---|
| A – B | |
| B – C | |
| C – D | |
| D – E | |

| E – F | |
|---|---|

**(1)**

(ii) Between which points was the car stationary?

______________________________________________

______________________________________________

**(1)**

(b) Complete the sentences by writing the correct words in the spaces.

When a car has to stop, the **overall** stopping distance is greater if:

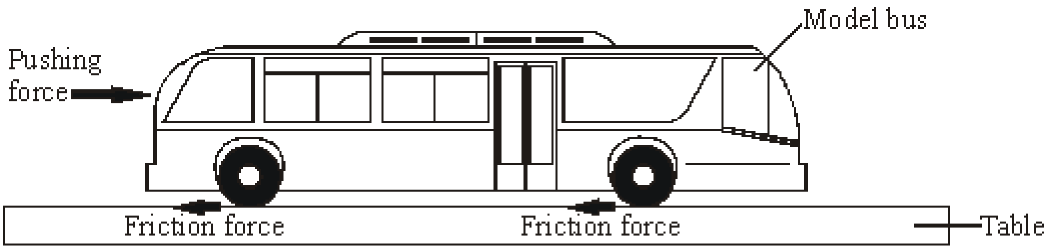
- the car is poorly maintained;
- there are adverse weather conditions;
- the car is travelling _________________ ;
- the driver's reactions are _________________ .

Also, the greater the speed of the car, then the greater the braking ______________ needed to stop in a certain time.

**(3)**
**(Total 5 marks)**

## Q32.

(a) The model bus is being pushed on a table.




(i) At first the pushing force does **not** make the model bus move. Explain why.

______________________________________________

______________________________________________

**(1)**

(ii) Write down **two** things that happen as the pushing force increases.

1. ______________________________________________

______________________________________________

2. ______________________________________________

______________________________________________

**(2)**

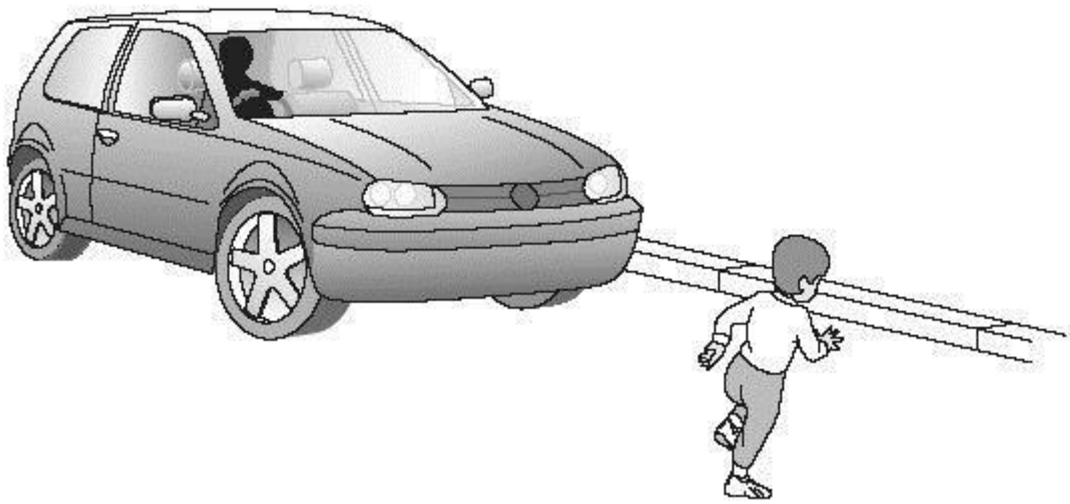
(iii) Complete the formula by choosing the correct words from the box.

| | | |
|---|---|---|
| **acceleration** | **distance moved** | **force applied** |
| **speed** | **time taken** | |

Work done on the model bus = ________________ × ________________

**(2)**

(b) In this situation, the car driver needs to stop the car in the shortest possible distance.



(i) Complete the table by putting ticks (✓) to show which factors would make the stopping distance greater. The first one has been done for you.

| **Factor** | **Tick ( ✓ ) makes stopping distance greater** |
|---|---|
| brakes are old and worn | ✓ |
| car is travelling fast | |
| driver has been drinking alcohol | |
| four new tyres are fitted | |
| hot, dry, sunny weather | |
| ice on the road | |

**(3)**

(ii) Complete the sentence by writing the correct words in the spaces.

The car will skid if the braking force is too big compared with the friction

between the car's __________________ and the __________________ .

**(1)**

**(Total 9 marks)**

## Q33.

(a) A driver may have to make an emergency stop.

Stopping distance = thinking distance + braking distance.

Give **three** different factors which affect the thinking distance or the braking distance. In your answer you should explain what effect **each** factor has on the stopping distance.

1. ______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

2. ______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

3. ______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

**(6)**

(b) Complete the following sentences by writing in the **two** missing words.

Acceleration is the rate of change of ______________________________ .

The acceleration of a car depends on the force applied by the engine and the

______________________ of the car.

**(2)**

(c) A car moves because of the force applied by the engine.

Name **two** other forces which act on the car when it is moving. Give the direction in which **each** of these factors acts.

1. ______________________________________________________________

Direction of this force ______________________________________________

2. ______________________________________________________________

Direction of this force ______________________________________________

**(4)**

(d) Complete the following sentence by writing in the missing word.

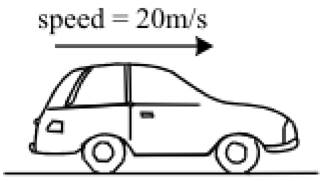
The velocity of a car is its speed in a particular ______________________

**(1)**

**(Total 13 marks)**

## Q34.

A car travels along a level road at 20 metres per second.




(a) Calculate the distance travelled by the car in 4 seconds.

(Show your working.)

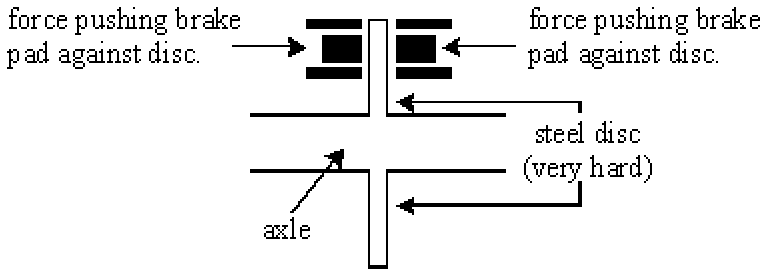
______________________________________________________________

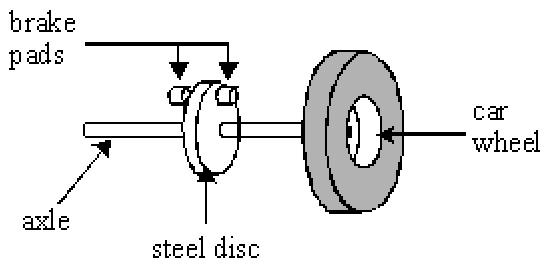
______________________________________________________________

______________________________________________________________

**(3)**

(b) When the brake pedal of the car is pushed, brake pads press against very hard steel discs.




The force of friction between the brake pads and the steel discs gradually stops the car.

What **two** effects does using the brakes have on the **brake pads** and **wheel discs**?

1. ______________________________________________________________________

2. ______________________________________________________________________

**(3)**

**(Total 6 marks)**