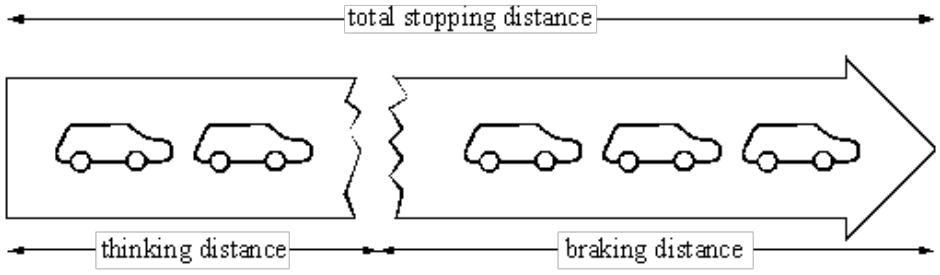
Q1. The Highway Code gives tables of the shortest stopping distances for cars travelling at various speeds. An extract from the Highway Code is given below.



thinking distance + braking distance = total stopping distance

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.

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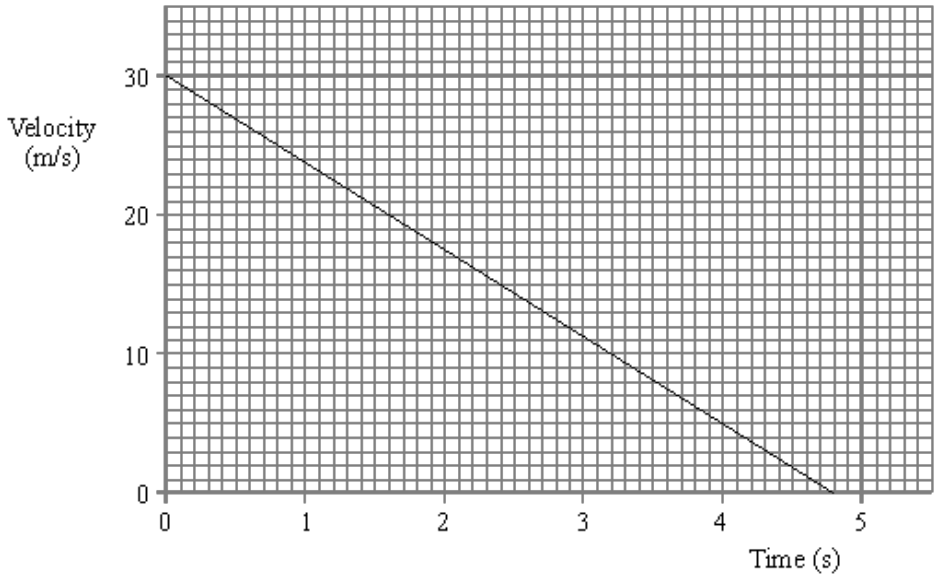
(2)

(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.



Calculate:

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

.....

.....

Rate ..... m/s²

(2)

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

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Braking force ..... N

(2)

(iii) the braking distance.

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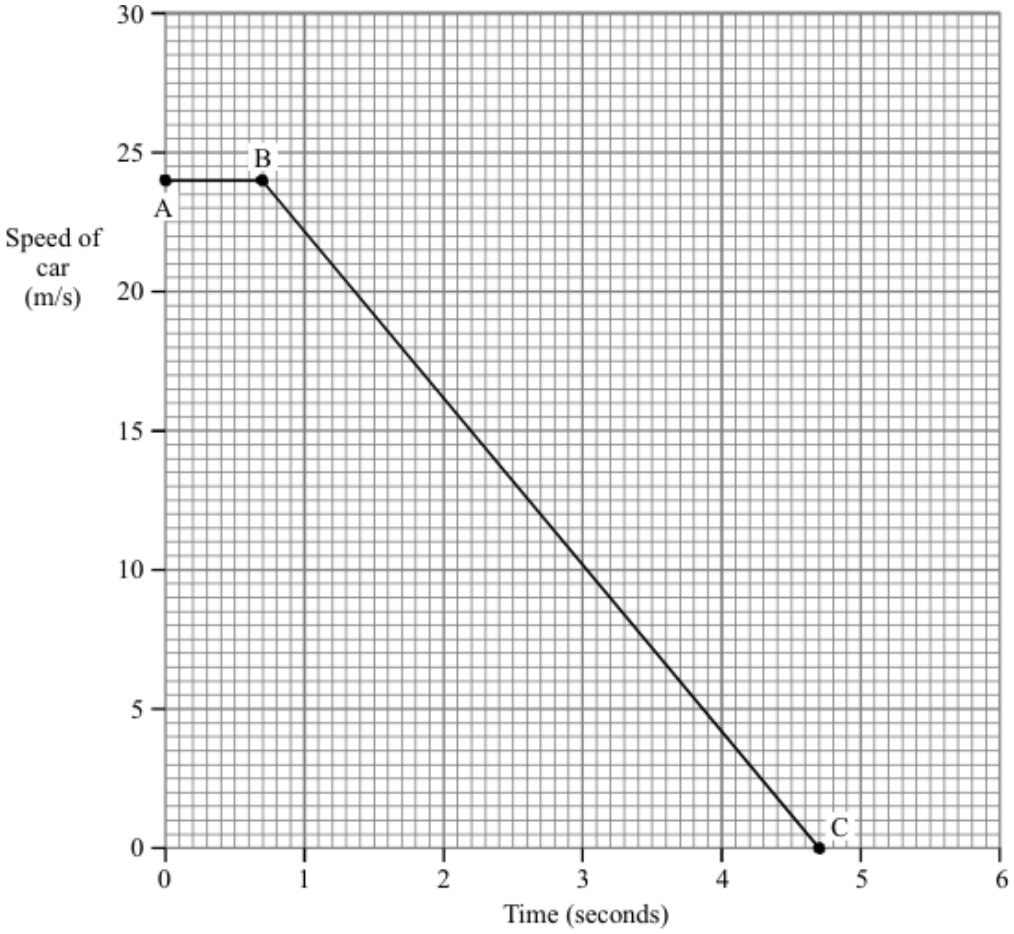
Braking distance ..... m

(2)

(Total 13 marks)

Q2. 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?

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(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.

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Distance ..... m

(3)

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

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Acceleration .....

(4)

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

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Distance ..... m

(3)

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

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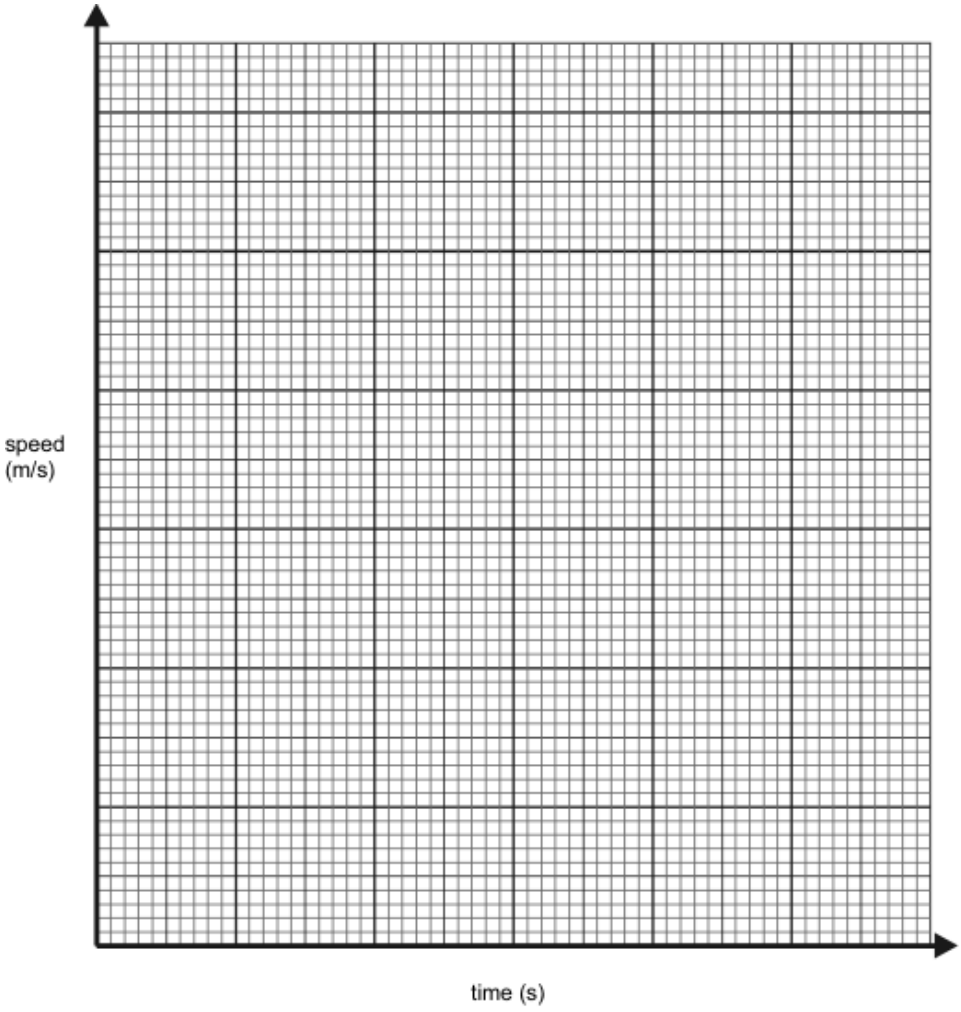
Braking force ..... N

(3)

(Total 15 marks)

Q3. 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.

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Answer = ... m/s^2

(3)

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

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.....

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.

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(ii) During the collision the front end of the car becomes crumpled and buckled. Use this information to explain why such a collision is described as “inelastic”.

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(iii) 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.

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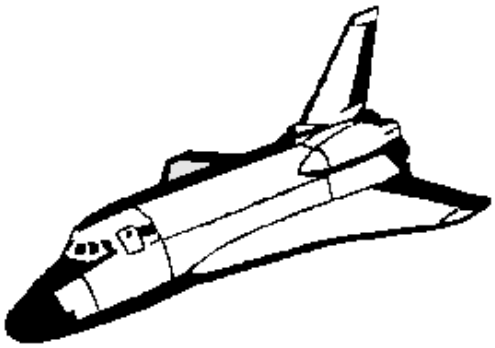
(8)

(Total 19 marks)

Q4. The diagram shows an orbiter, the reusable part of a space shuttle. The data refers to a typical flight.



Orbiter data	
Mass	78 000 kg
Orbital speed	7.5 km/s
Orbital altitude	200 km
Landing speed	100 m/s
Flight time	7 days

(a) (i) What name is given to the force which keeps the orbiter in orbit around the Earth?

.....

(1)

(ii) Use the following equation to calculate the kinetic energy, in joules, of the orbiter while it is in orbit.

$$\text{kinetic energy} = \tfrac{1}{2}\, mv^2$$

.....

.....

Kinetic energy = ... joules

(2)

(iii) What happens to most of this kinetic energy as the orbiter re-enters the Earth's atmosphere?

.....

.....

(1)

(b) After touchdown the orbiter decelerates uniformly coming to a halt in 50 s.

(i) Give the equation that links acceleration, time and velocity.

.....

(1)

(ii) Calculate the deceleration of the orbiter. Show clearly how you work out your answer and give the unit.

.....

.....

Deceleration = ...

(2)

(c) (i) Give the equation that links acceleration, force and mass.

.....

(1)

(ii) Calculate, in newtons, the force needed to bring the orbiter to a halt. Show clearly how you work out your answer.

.....

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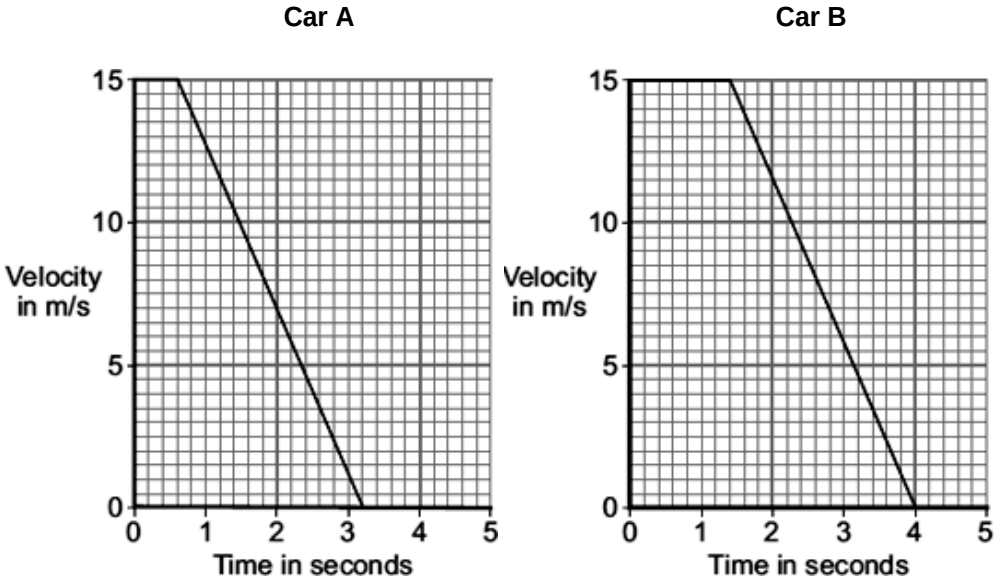
Force = ... newtons

(1)

(Total 9 marks)

Q5. (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.

.....

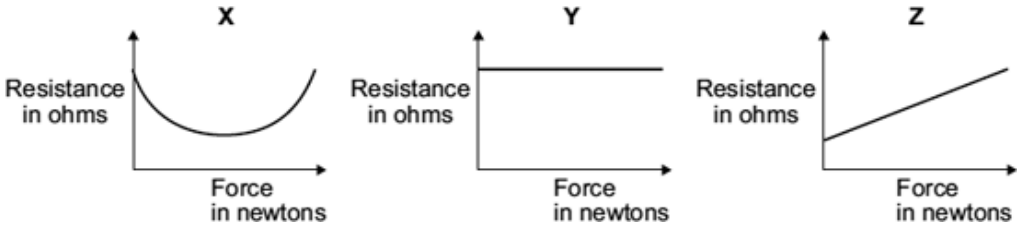
.....

.....

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?

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Give a reason for your answer.

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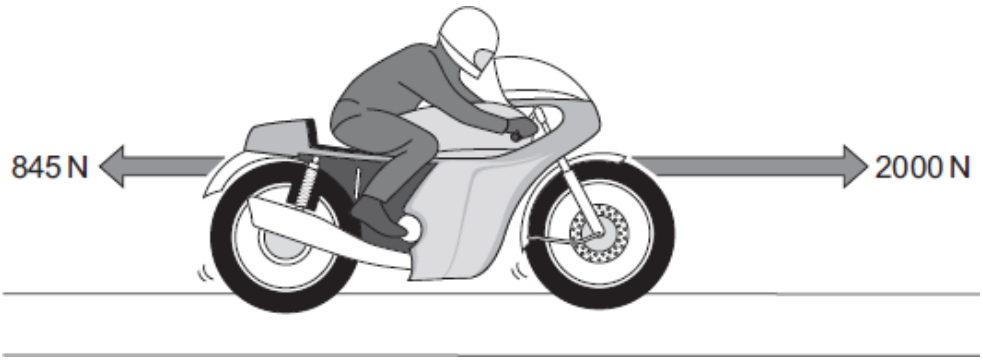
(2)

(Total 7 marks)

Q6. 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.

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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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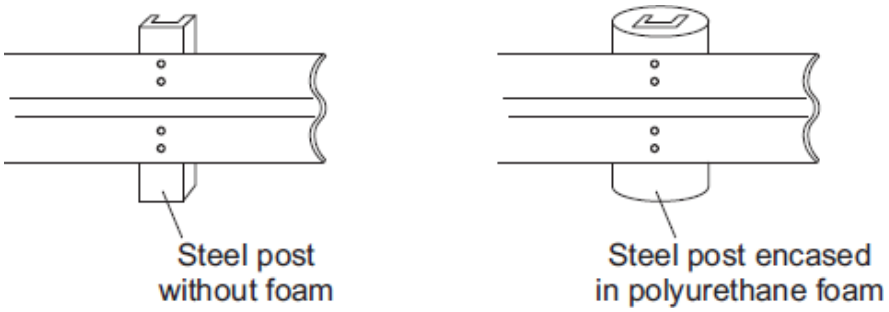
(2)

(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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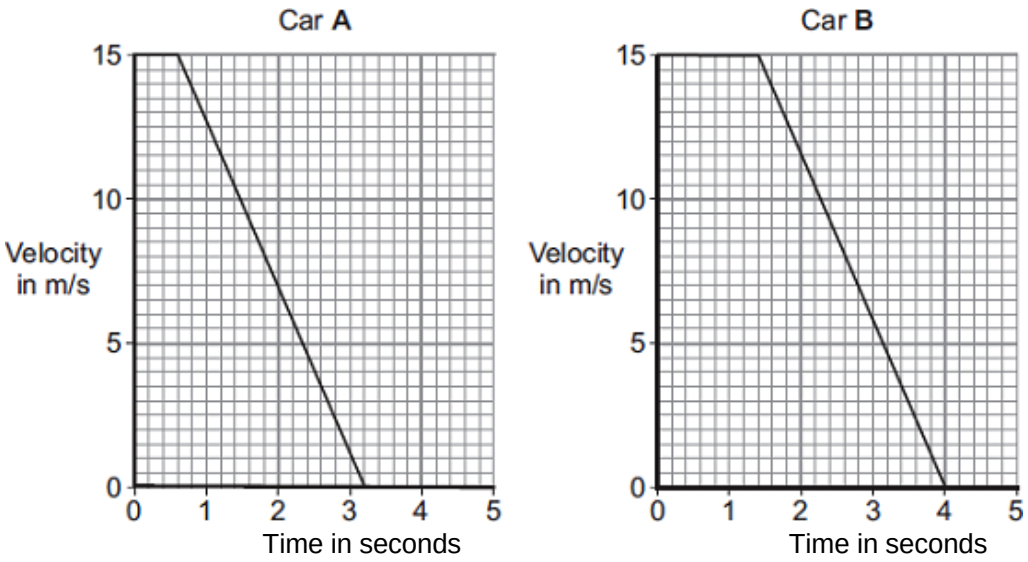
(1)

(Total 11 marks)

Q7. (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.

.....

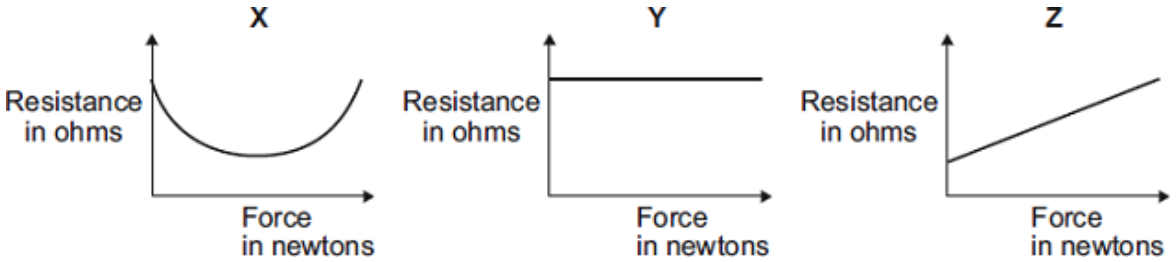
.....

.....

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?

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Give a reason for your answer.

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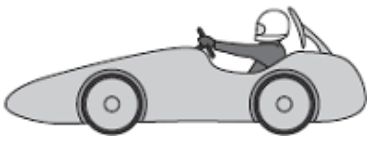
(2)
(Total 7 marks)

Q8. (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.

First design **X**

Final design **Y**



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.

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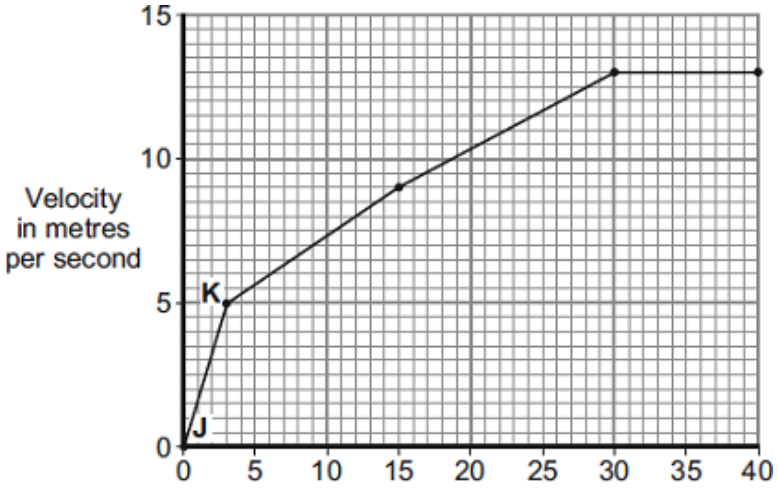
(3)

(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.



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

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

.....

.....

.....

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?

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(1)

(Total 8 marks)

Q9. (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.

Use the correct equation from the Physics Equations Sheet.

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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.

Use the correct equation from the Physics Equations Sheet.

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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.

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(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)