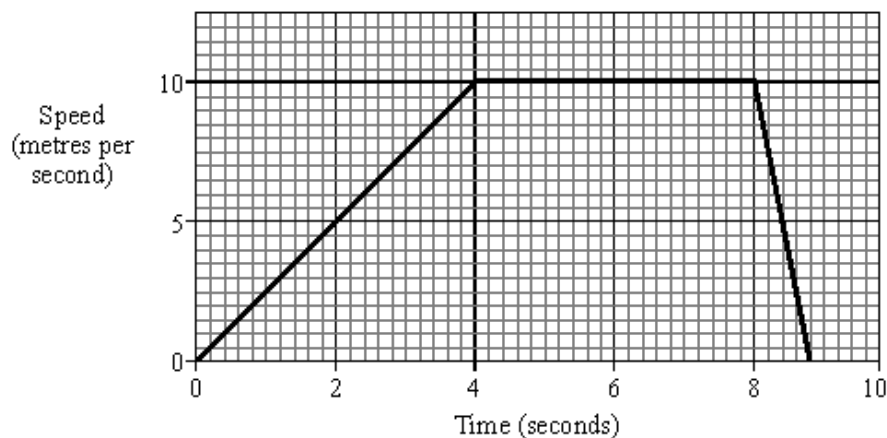


Q1. The graph shows the speed of a runner during an indoor 60 metres race.



- (a) Calculate the acceleration of the runner during the first four seconds.
(Show your working.)

.....

.....

.....

(3)

- (b) How far does the runner travel during the first four seconds?
(Show your working.)

.....

.....

.....

(3)

- (c) At the finish, a thick wall of rubber foam slows the runner down at a rate of 25 m/s^2 .
The runner has a mass of 75kg.
Calculate the average force of the rubber foam on the runner.
(Show your working.)

.....

.....

.....

Answer newtons (N)

(2)

(Total 8 marks)

Q2. When a gun is fired, a very large force acts on the bullet for a very short time.

The change in momentum of the bullet is given by the following relationship:

$$\text{force (N)} \times \text{time(s)} = \text{change in momentum (kg m/s)}$$

- (a) An average force of 4000 newton acts for 0.01 seconds on a bullet of mass 50g.

Calculate the speed of the bullet. (*Show your working.*)

.....
.....
.....

Answer m/s

(4)

- (b) The bullet is fired horizontally. In the short time it takes for the bullet to reach its target, its horizontal speed has fallen to 80% of its initial speed.

- (i) Explain why the speed of the bullet decreases so quickly.

.....
.....

(2)

- (ii) Calculate the percentage of its original kinetic energy the bullet still has when it reaches its target.

(*Show your working.*)

.....
.....
.....
.....

(4)

(Total 10 marks)

- Q3.** Mira and Susan are rock climbing. They are using a nylon climbing rope. Mira has fastened herself to the rock face and to one end of the rope. The other end of the rope is fastened to Susan. This means that, if Susan falls, the rope will hold her. Susan weighs 540 N.



- (a) (i) Use the words *distance*, *force* and *work* to write an equation which shows the relationship between them

.....

(1)

- (ii) What vertical distance up the rock face does Susan climb when she does 2000 J of work against gravity? Show your working and give your answer to the nearest 0.1 m.

.....

.....

Distance = metres

(2)

- (iii) How much gravitational energy will Susan gain when she does 2000 J of work against gravity?

.....

(1)

- (b) The climbers dislodge a 3 kg stone which falls down the rock face.

What is the speed of the stone when its kinetic energy is 600 J?

$$\text{kinetic energy} = \frac{1}{2} \text{ mass} \times \text{speed}^2$$

Show clearly how you get to your answer and give the unit.

.....

.....

.....

Speed =

(3)

- (c) The climbing rope is made of nylon. Nylon is very strong. Another advantage is that it stretches. This means that, if Susan falls, it transfers some of her kinetic energy to elastic (or strain) energy at the end of the fall.

Explain, in terms of *force* and *deceleration*, what would happen if Susan fell and the climbing rope did **not** transfer any of her kinetic energy to elastic energy.

.....

.....

.....

.....

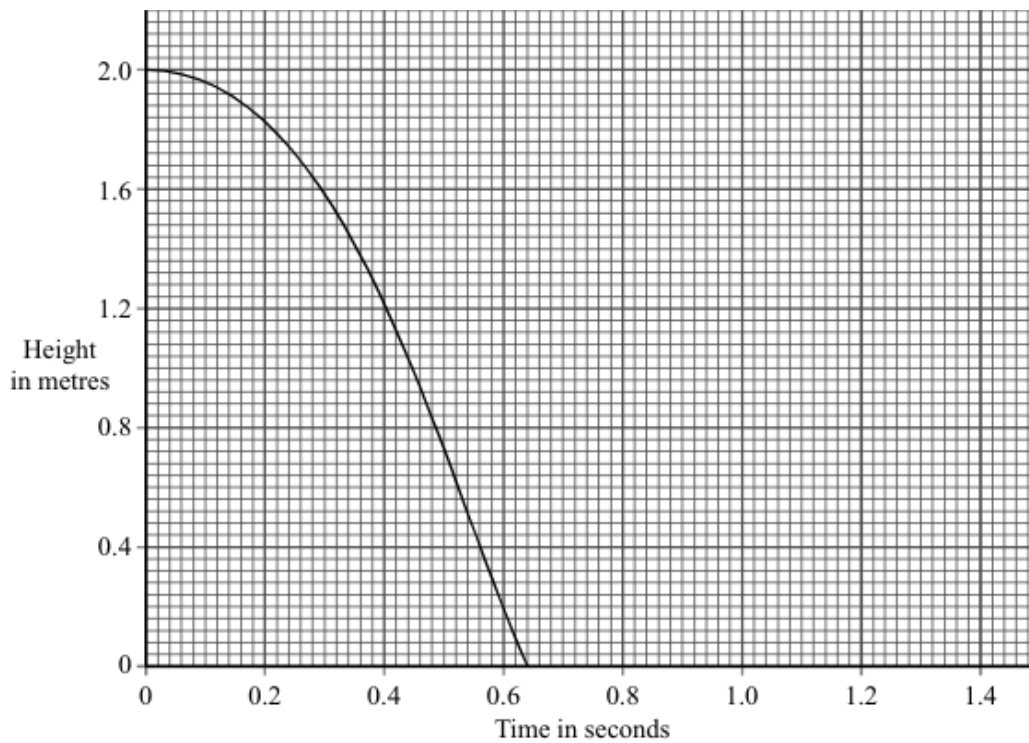
.....

.....

(3)

(Total 10 marks)

- Q4.** A bouncy ball is dropped vertically from a height of 2.00 m onto the floor. The graph shows the height of the ball above the floor at different times during its fall until it hits the floor after 0.64 s.



- (a) What is the average speed of the ball over the first 0.64 s? Show clearly how you work out your answer.

.....

Average speed = m/s

(1)

- (b) After it hits the floor the ball bounces back to a height of 1.25 m. It reaches this height 1.16 s after it was dropped. Plot this point on the grid above and sketch a graph to show the height of the ball above the floor between 0.64 s and 1.16 s.

(3)

- (c) (i) The ball bounces on the floor 0.64 s after being dropped. How long after being dropped will it be before it bounces a second time?

.....

(1)

- (ii) What distance will the ball travel between its first and second bounce?

.....

(1)

- (d) The ball was held stationary before being dropped. On the graph and your sketch mark **two** other points X_1 and X_2 , where the ball is stationary, and in each case explain why the ball is not moving.

X_1

.....

X_2

.....

(2)
(Total 8 marks)

- Q5.** A rollercoaster car stops above a vertical drop. Suddenly it falls under gravity.



The drop is 60 metres high and at the bottom of the drop the car travels at 125 km/h.
The acceleration experienced by the people in the car is 10 m/s^2 . The mass of the car and its passengers is 1210 kg.

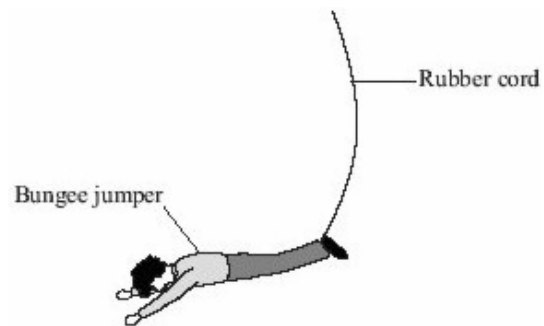
Calculate the force exerted on the car and its passengers. Show your working.

.....
.....
.....
.....
.....

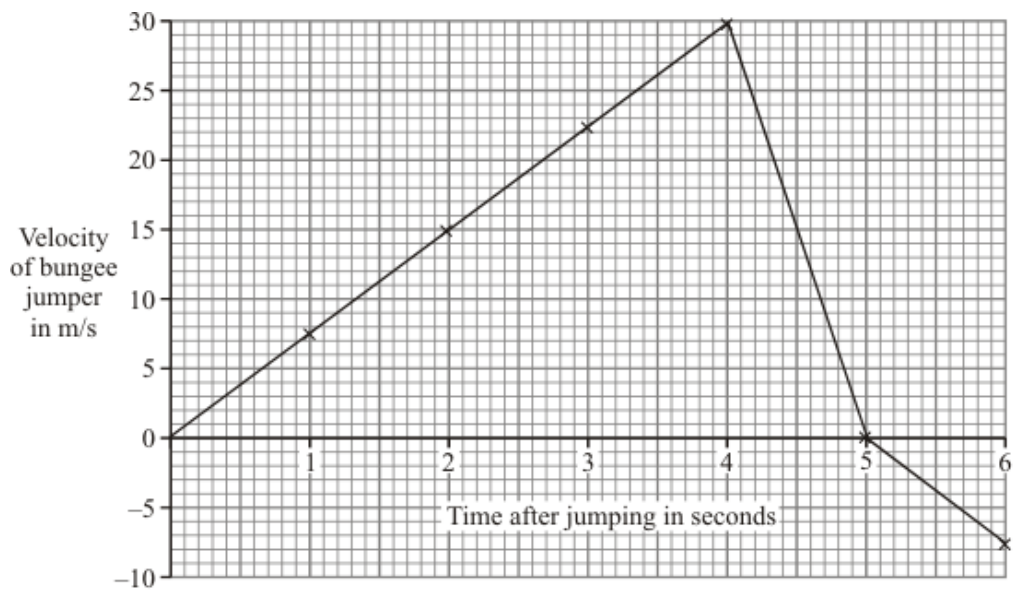
Force = N

(Total 3 marks)

Q6. In bungee jumping, a fixed rubber cord is fastened to the jumper's ankles.



The graph shows how the bungee jumper's velocity changes during part of the jump.



- (a) Calculate the acceleration of the bungee jumper between 2 and 4 seconds. Show your working.

.....

.....

.....

.....

Acceleration = m/s^2

(3)

- (b) Describe, in as much detail as you can, what happens to the bungee jumper after 4 seconds.

.....

.....

.....

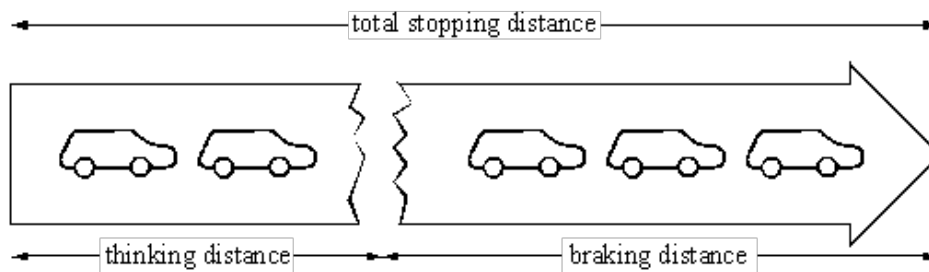
.....

.....

.....

(3)
(Total 6 marks)

- Q7.** 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.



$$\text{thinking distance} + \text{braking distance} = \text{total stopping distance}$$

$$\text{thinking distance} + \text{braking distance} = \text{total stopping distance}$$

- (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.

.....

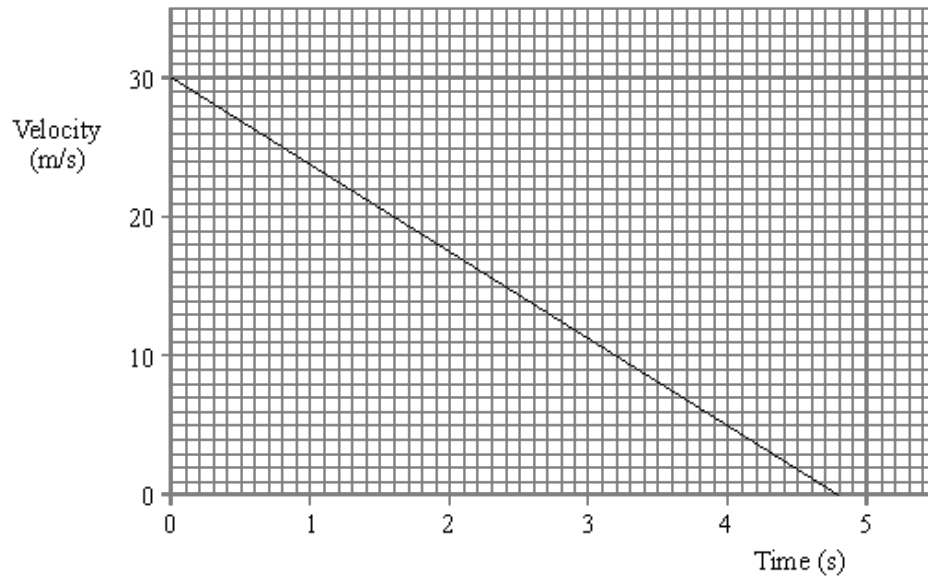
.....

.....

.....

(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.



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;

.....

.....

Braking force N

(2)

(iii) the braking distance.

.....

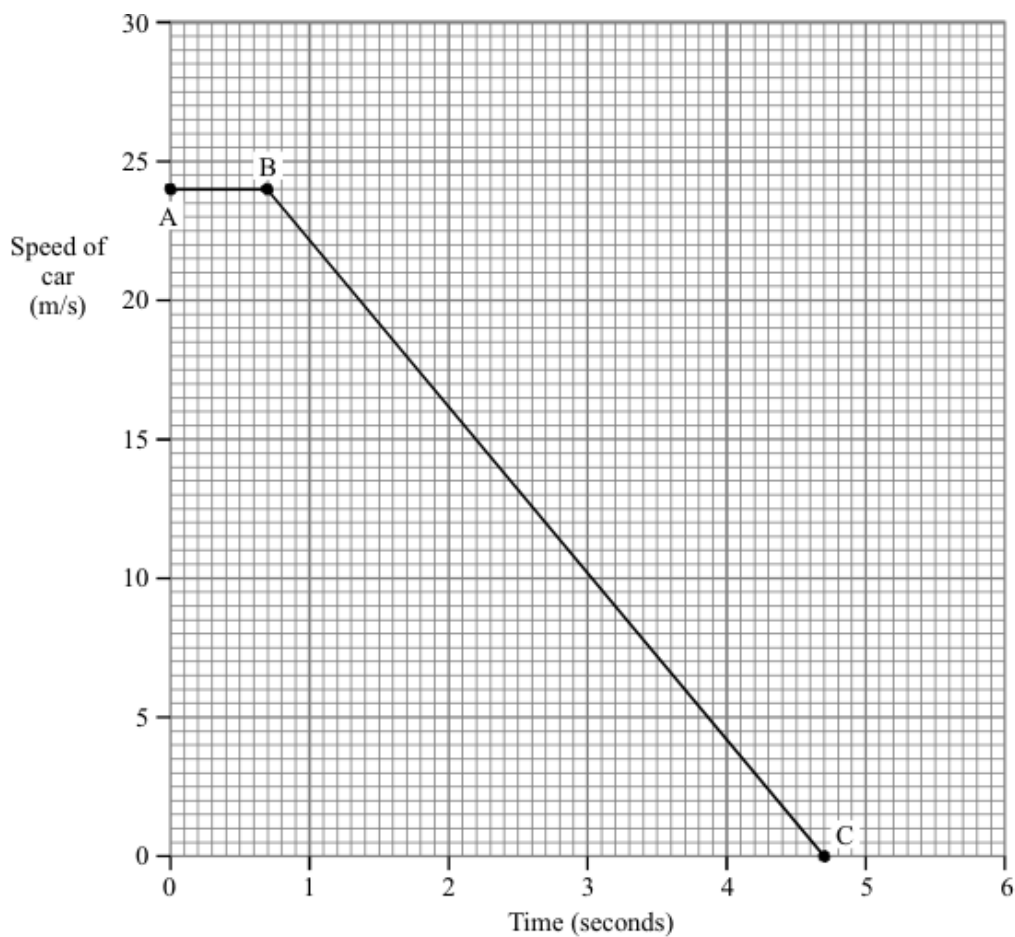
Braking distance m

(2)

(Total 13 marks)

Q8. 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.

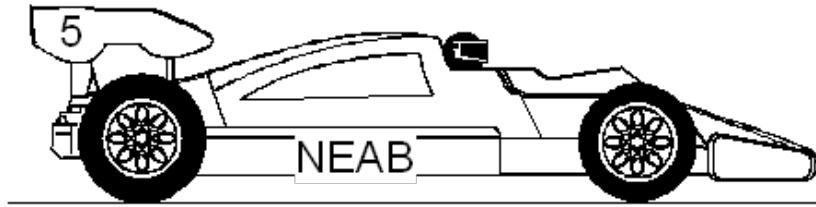
.....
.....
.....
.....
.....

Braking force N

(3)

(Total 15 marks)

- Q9.** 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.

.....

.....

.....

.....

.....

.....

(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.

.....

.....

.....

.....

.....

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

.....

.....

.....

.....

- (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.

.....

.....

.....

.....

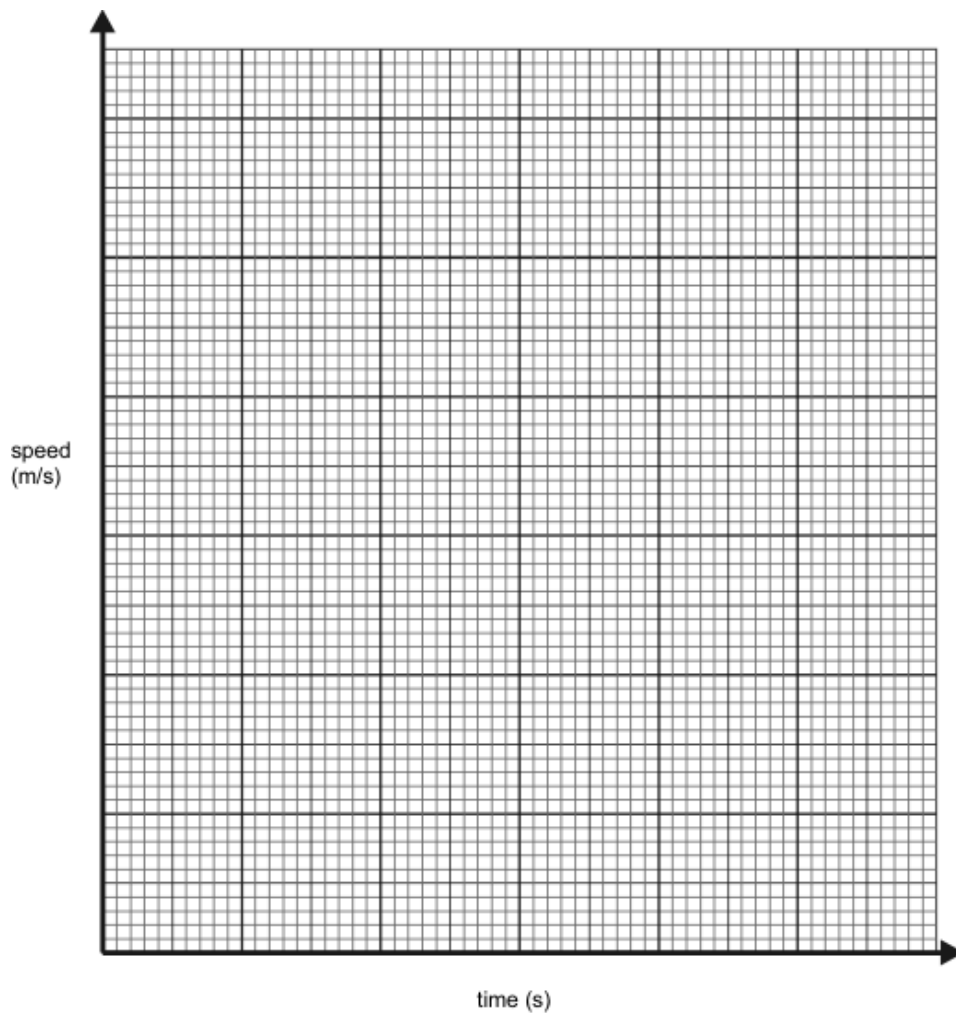
.....

.....

(12)
(Total 16 marks)

Q10. 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) 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”.

.....
.....

- (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.

.....

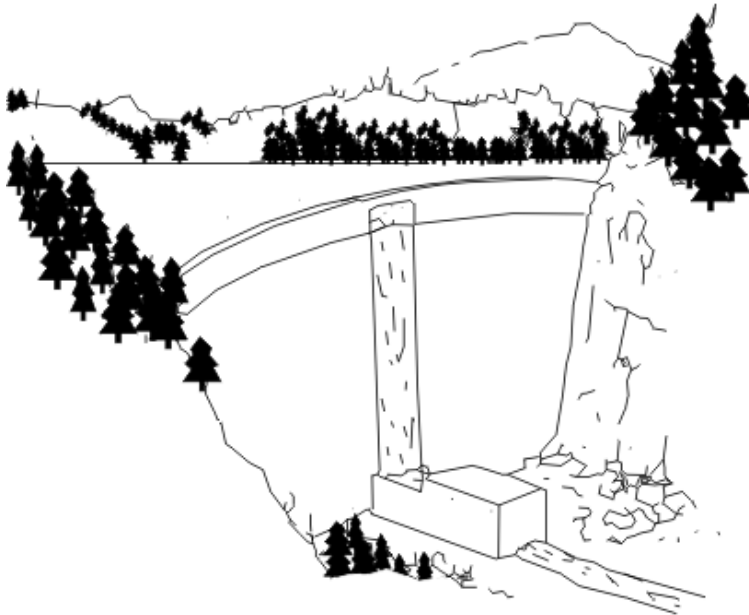
.....

.....

.....

(8)
(Total 19 marks)

- Q11.** The diagram below shows water falling from a dam. Each minute 12 000 kg of water falls vertically into the pool at the bottom.



The time taken for the water to fall is 2 s and the acceleration of the water is 10 m/s^2 .

- (a) Assume the speed of the water at the bottom of the dam is zero. Calculate the speed of the water just before it hits the pool at the bottom.

.....

.....

(2)

- (b) Use your answer to part (a) to calculate the average speed of the falling water.

.....

(1)

(c) Calculate the height that the water falls.

.....
.....

(2)

(d) What weight of water falls into the pool each minute?

.....
.....

(2)

(e) How much work is done by gravity each minute as the water falls?

.....
.....

(2)

(f) A small electrical generator has been built at the foot of the waterfall. It uses the falling water to produce electrical power.

(i) How much energy is available from the falling water each minute?

.....

(ii) How much power is available from the falling water?

.....
.....

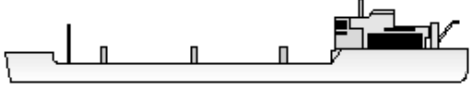
(iii) If the generator is 20% efficient, calculate the electrical power output of the generator.

.....
.....

(4)

(Total 13 marks)

Q12. The table contains typical data for an oil tanker.

| | | |
|---|--------------------|---------------|
|  | Mass | 56 000 000 kg |
| | Cruising speed | 12 m/s |
| | Deceleration force | 392 000 N |
| | Stopping distance | 10 000 m |

- (i) Write down the equation which links acceleration, force and mass.

.....

(1)

- (ii) Calculate the deceleration of the oil tanker. Show clearly how you work out your answer.

.....

.....

.....

Deceleration = m/s^2

(2)

(Total 3 marks)

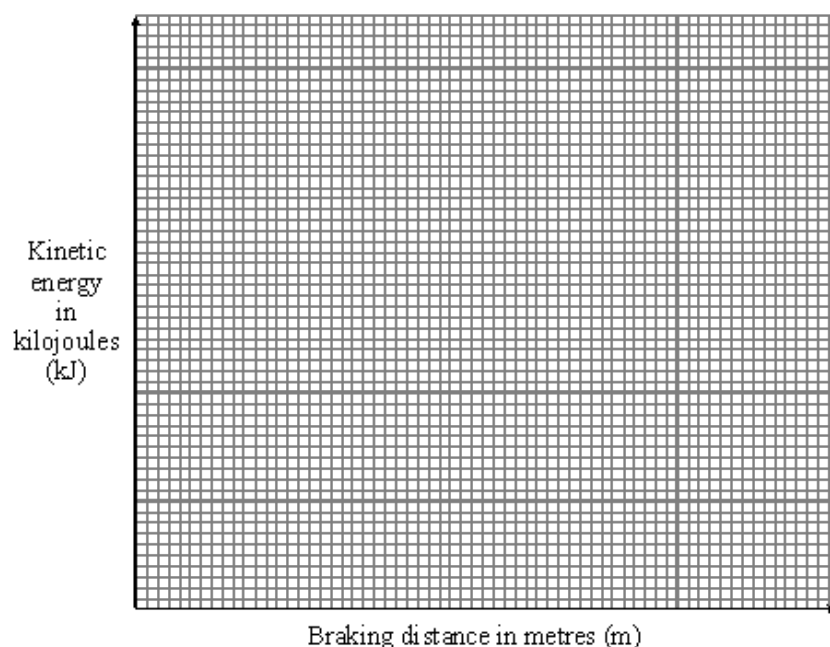
##

The table shows the braking distances for a car at different speeds and kinetic energy. The braking distance is how far the car travels once the brakes have been applied.

| Braking distance in m | Speed of car in m/s | Kinetic energy of car in kJ |
|--------------------------|------------------------|--------------------------------|
| 5 | 10 | 40 |
| 12 | 15 | 90 |
| 20 | 20 | 160 |
| 33 | 25 | 250 |
| 45 | 30 | 360 |

(a) A student suggests, “the braking distance is directly proportional to the kinetic energy.”

(i) Draw a line graph to test this suggestion.



(3)

(ii) Does the graph show that the student's suggestion was correct or incorrect? Give a reason for your answer.

.....

(1)

(iii) Use your graph and the following equation to predict a braking distance for a speed of 35 metres per second (m/s). The mass of the car is 800 kilograms (kg). Show clearly how you obtain your answer.

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

.....

Braking distance = m

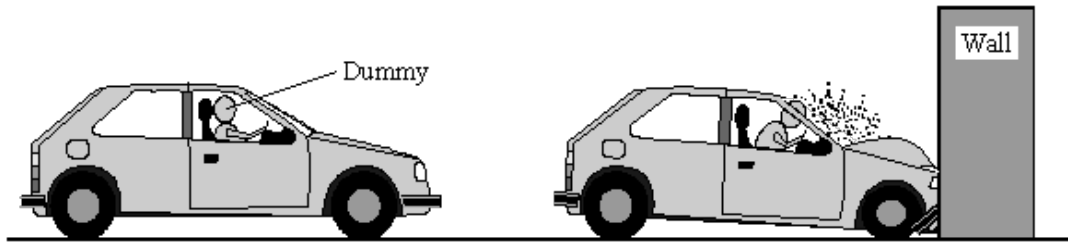
(2)

(iv) State **one** factor, apart from speed, which would increase the car's braking distance.

.....

(1)

- (b) The diagram shows a car before and during a crash test. The car hits the wall at 14 metres per second (m/s) and takes 0.25 seconds (s) to stop.



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

.....

(1)

- (ii) Calculate the deceleration of the car.

.....

Deceleration = m/s²

(1)

- (iii) In an accident the crumple zone at the front of a car collapses progressively. This increases the time it takes the car to stop. In a front end collision the injury to the car passengers should be reduced. Explain why. The answer has been started for you.

By increasing the time it takes for the car to stop, the

.....

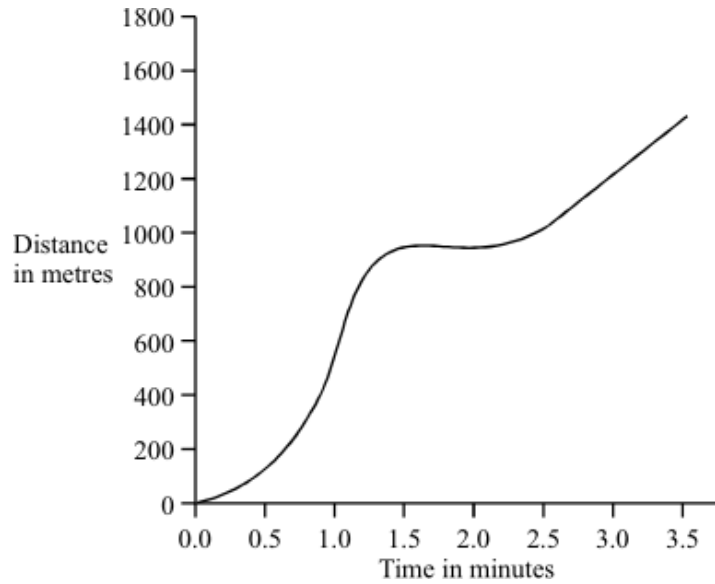
.....

.....

(2)

(Total 11 marks)

- Q14.** The graph shows how the distance travelled by a car changes with time during a short journey.



- (i) Describe fully the motion of the car during the first **two** minutes of the journey.

.....

.....

.....

.....

.....

(3)

- (ii) During the last minute of the journey the velocity of the car changes although the speed remains constant. How is this possible?

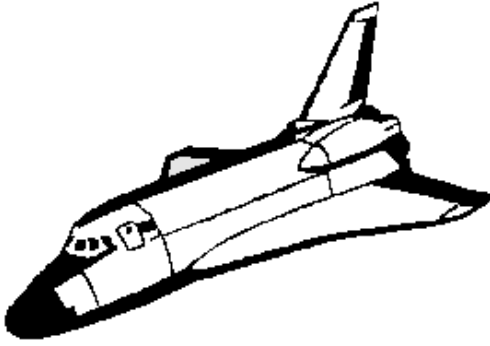
.....

.....

(1)

(Total 4 marks)

- Q15.** 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.

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

.....

.....

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.

.....

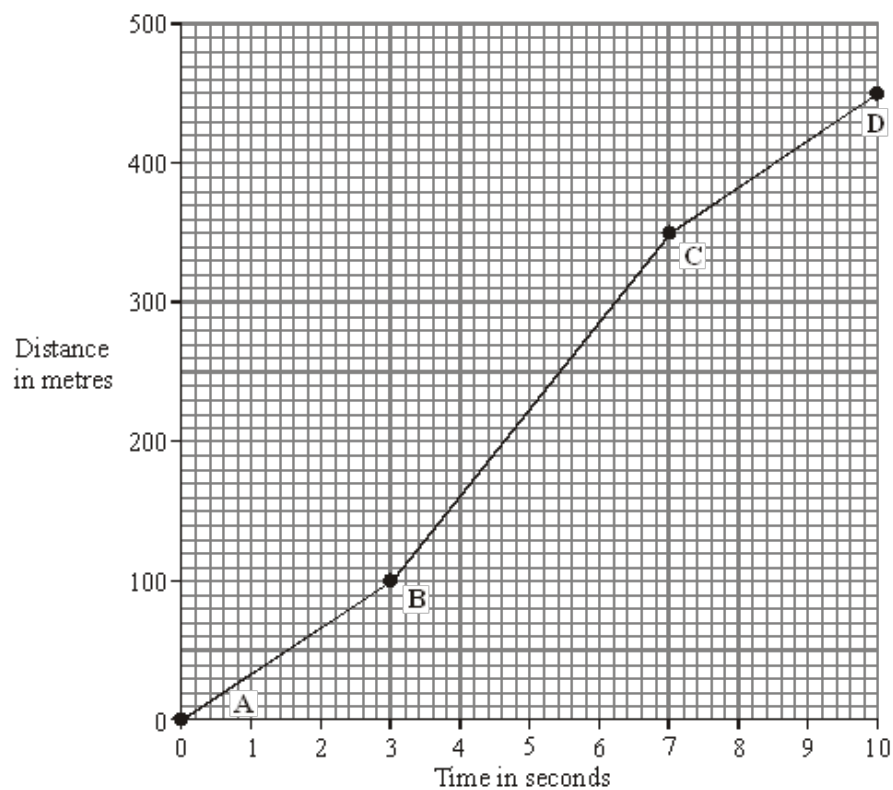
.....

Force = newtons

(1)

(Total 9 marks)

- Q16.** The distance-time graph represents the motion of a car during a race.



- (a) Describe the motion of the car between point **A** and point **D**. You should not carry out any calculations.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

.....

.....

.....

.....

.....

(3)

- (b) Calculate the gradient of the graph between point **B** and point **C**. Show clearly how you get your answer.

.....

.....

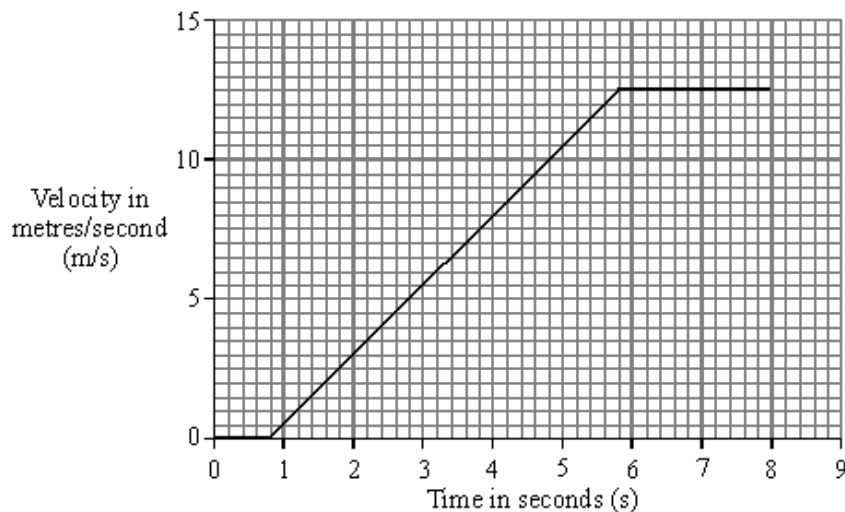
.....

gradient =

(3)

(Total 6 marks)

- Q17.** A car travelling along a straight road has to stop and wait at red traffic lights. The graph shows how the velocity of the car changes after the traffic lights turn green.



- (a) Between the traffic lights changing to green and the car starting to move there is a time delay. This is called the reaction time. Write down **one** factor that could affect the driver's reaction time.

.....

(1)

- (b) Calculate the distance the car travels while accelerating. Show clearly how you work out your answer.

.....
.....

Distance =metres

(3)

- (c) Calculate the acceleration of the car. Show clearly how you work out your final answer and give the units.

.....
.....
.....

Acceleration =

(4)

- (d) The mass of the car is 900 kg.

- (i) Write down the equation that links acceleration, force and mass.

.....

(1)

- (ii) Calculate the force used to accelerate the car. Show clearly how you work out your final answer.

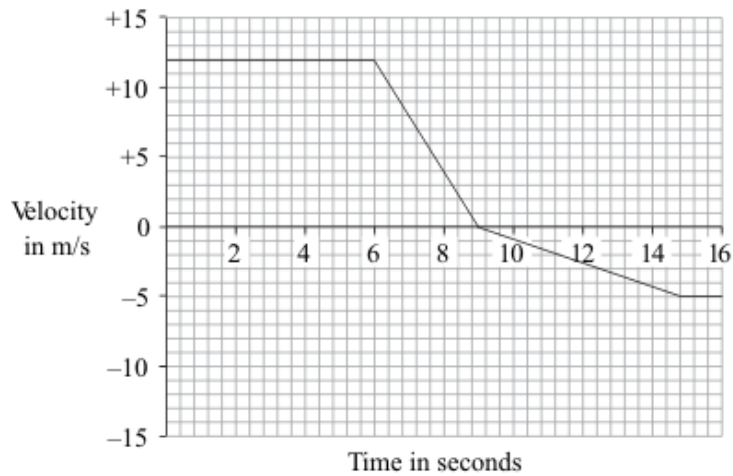
.....
.....

Force = newtons

(2)

(Total 11 marks)

- Q18.** A car is driven along a straight road. The graph shows how the velocity of the car changes during part of the journey.



- (a) Use the graph to calculate the deceleration of the car between 6 and 9 seconds.

Show clearly how you work out your answer and give the unit.

.....

.....

.....

Deceleration =

(3)

- (b) At what time did the car change direction?

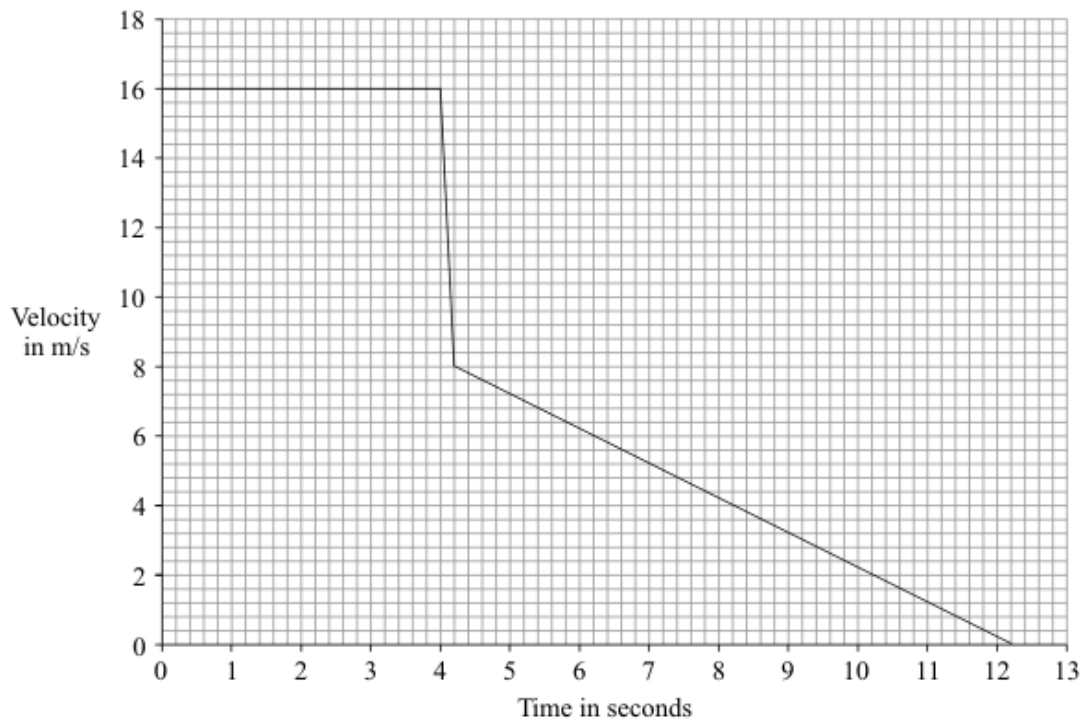
..... seconds

(1)

(Total 4 marks)

Q19. In an experiment at an accident research laboratory, a car driven by remote control was crashed into the back of an identical stationary car. On impact the two cars joined together and moved in a straight line.

- (a) The graph shows how the velocity of the remote-controlled car changed during the experiment.



- (i) How is the *velocity* of a car different from the speed of a car?

.....

(1)

- (ii) Use the graph to calculate the distance travelled by the remote-controlled car before the collision.

Show clearly how you work out your answer.

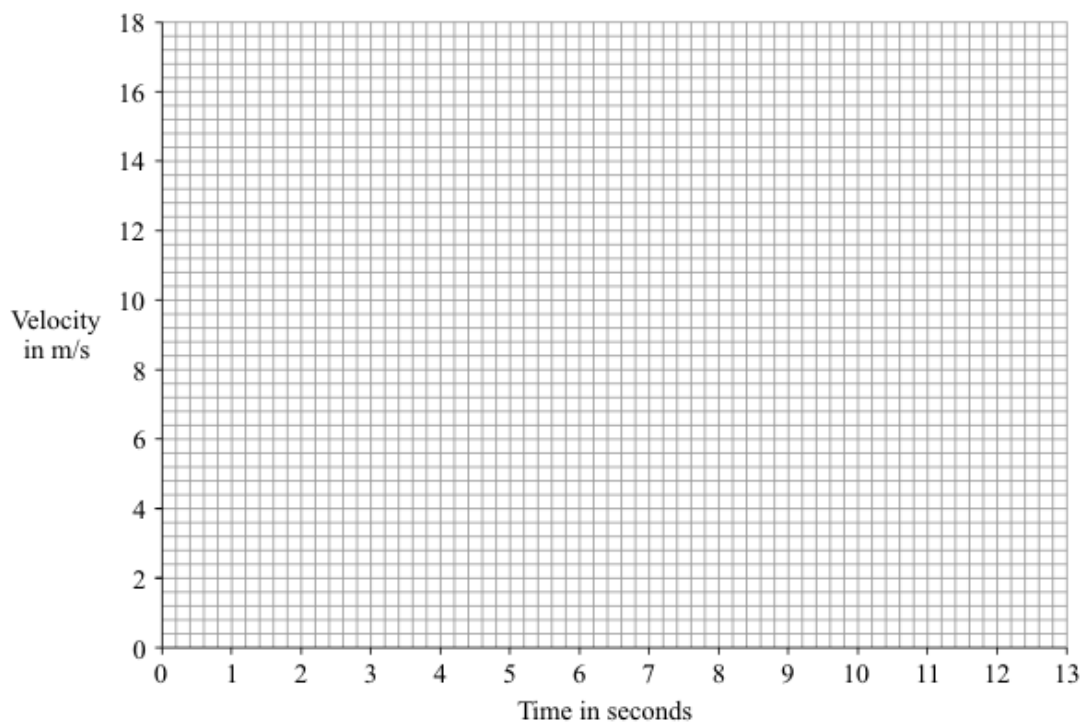
.....

.....

Distance = m

(2)

- (iii) Draw, on the grid below, a graph to show how the velocity of the second car changed during the experiment.



(2)

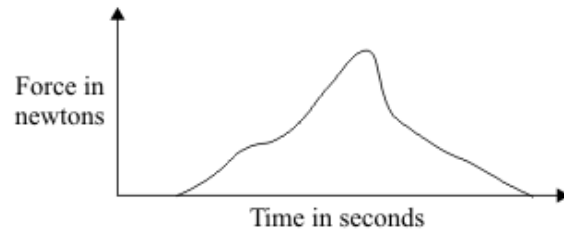
- (iv) The total momentum of the two cars was not conserved.

What does this statement mean?

.....
.....

(1)

- (b) The graph line shows how the force from a seat belt on a car driver changes during a collision.



Scientists at the accident research laboratory want to develop a seat belt that produces a constant force throughout a collision.

Use the idea of momentum to explain why this type of seat belt would be better for a car driver.

.....

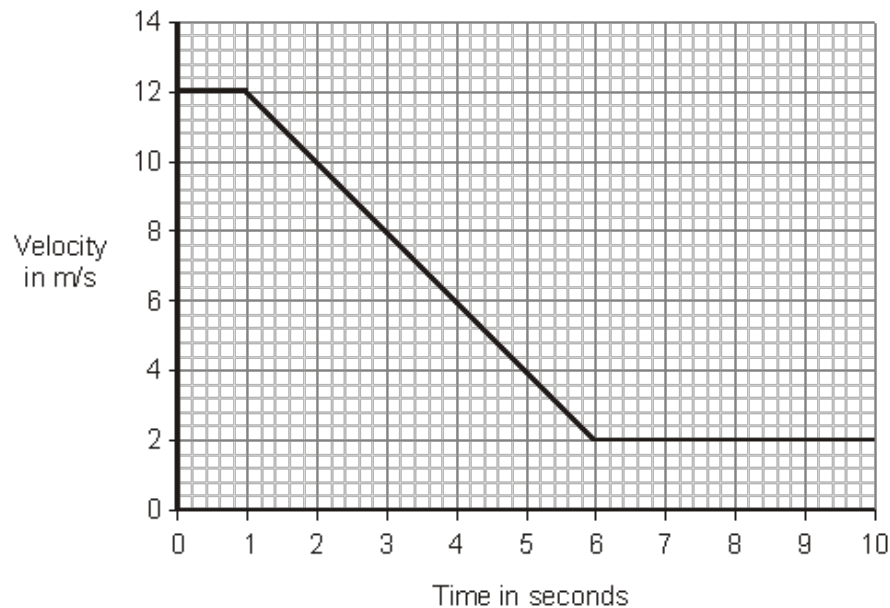
.....

.....

.....

(2)
(Total 8 marks)

- Q20.** A car is driven along a straight, snow covered, road. The graph shows how the velocity of the car changes from the moment the driver sees a very slow moving queue of traffic ahead.



- (a) Use the graph to calculate the distance the car travels while it is slowing down.

Show clearly how you work out your answer.

.....
.....
.....

Distance = m

(3)

- (b) The car has a mass of 1200 kg.

Calculate the kinetic of the car when it travels at a speed of 12 m/s.

Write down the equation you use, and then show clearly how you work out your answer.

.....
.....
.....
.....
.....
.....

Kinetic energy = J

(2)

(Total 5 marks)

- Q21.** The diagram shows the horizontal forces acting on a car of mass 1200 kg.



- (a) Calculate the acceleration of the car at the instant shown in the diagram.

Write down the equation you use, and then show clearly how you work out your answer and give the unit.

.....

.....

.....

.....

.....

.....

.....

.....

Acceleration =

(4)

- (b) Explain why the car reaches a top speed even though the thrust force remains constant at 3500 N.

.....

.....

.....

.....

.....

.....

(3)

- (c) The diagram shows a car and a van.



The two vehicles have the same mass and identical engines.

Explain why the top speed of the car is higher than the top speed of the van.

.....

.....

.....

.....

.....

.....

.....

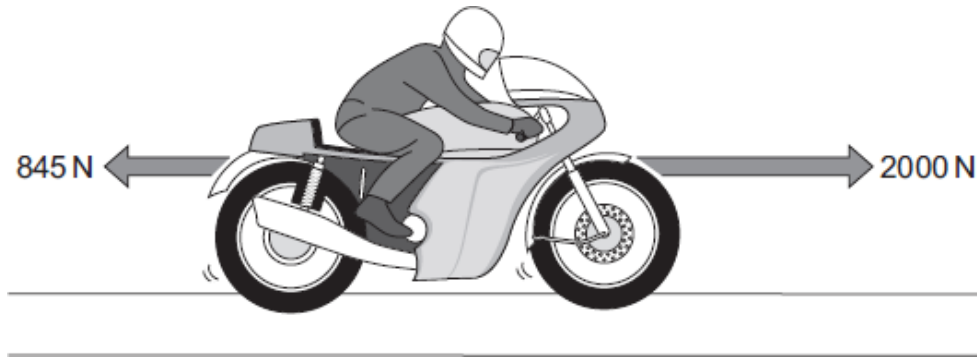
.....

.....

.....

(4)
(Total 11 marks)

- Q22.** 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.

| |
|---|
| $\text{resultant force} = \text{mass} \times \text{acceleration}$ |
|---|

Show clearly how you work out your answer.

.....

.....

.....

.....

.....

Acceleration = m/s^2

(3)

- (b) A road safety organisation has investigated the causes of motorbike accidents.

The main aim of the investigation was to find out whether there was any evidence that young, inexperienced riders were more likely to be involved in an accident than older, experienced riders.

Data obtained by the organisation from a sample of 1800 police files involving motorbike accidents, is summarised in the table.

| Size of motorbike engine | Percentage of all motorbikes sold | Total number in the sample of 1800 accident files |
|--------------------------|-----------------------------------|---|
| up to 125 cc | 36 | 774 |
| 126 to 350 cc | 7 | 126 |
| 351 to 500 cc | 7 | 162 |
| over 500 cc | 50 | 738 |

Most of the motorbikes with engines up to 125 cc were ridden by young people.
The motorbikes with engines over 500 cc were ridden by older, more experienced riders.

- (i) In terms of the main aim of the investigation, is this data valid?

Draw a ring around your answer. **NO** **YES**

Explain the reason for your answer.

.....

.....

.....

.....

(2)

- (ii) The organisation concluded that:

“Young, inexperienced riders are more likely to be involved in a motorbike accident than older, experienced riders”.

Explain how the data supports this conclusion.

.....

.....

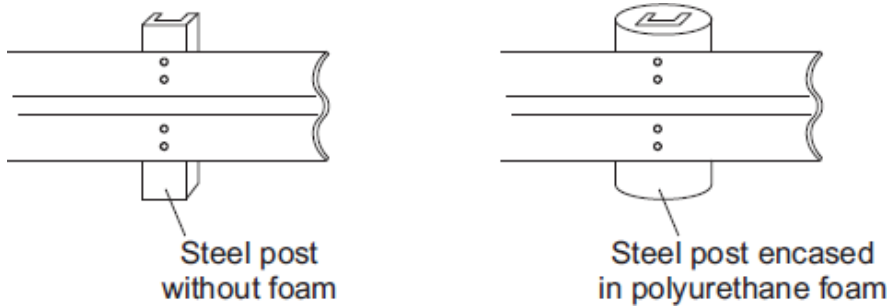
.....

.....

(2)

- (c) Of particular concern to motorbike riders is the design of steel crash barriers. Riders falling off and sliding at high speed into a steel support post are often seriously injured.

One way to reduce the risk of serious injury is to cover the post in a thick layer of high impact polyurethane foam.



- (i) Use the ideas of momentum to explain how the layer of foam reduces the risk of serious injury to a motorbike rider sliding at high speed into the support post.

.....

.....

.....

.....

.....

(3)

- (ii) Crash barrier tests use dummies that collide at 17 m/s with the barrier. Each test costs about £12 000. New safety devices for crash barriers are tested many times to make sure that they will improve safety.

Do you think that the cost of developing the new safety devices is justified?

Draw a ring around your answer. **NO YES**

Give a reason for your answer.

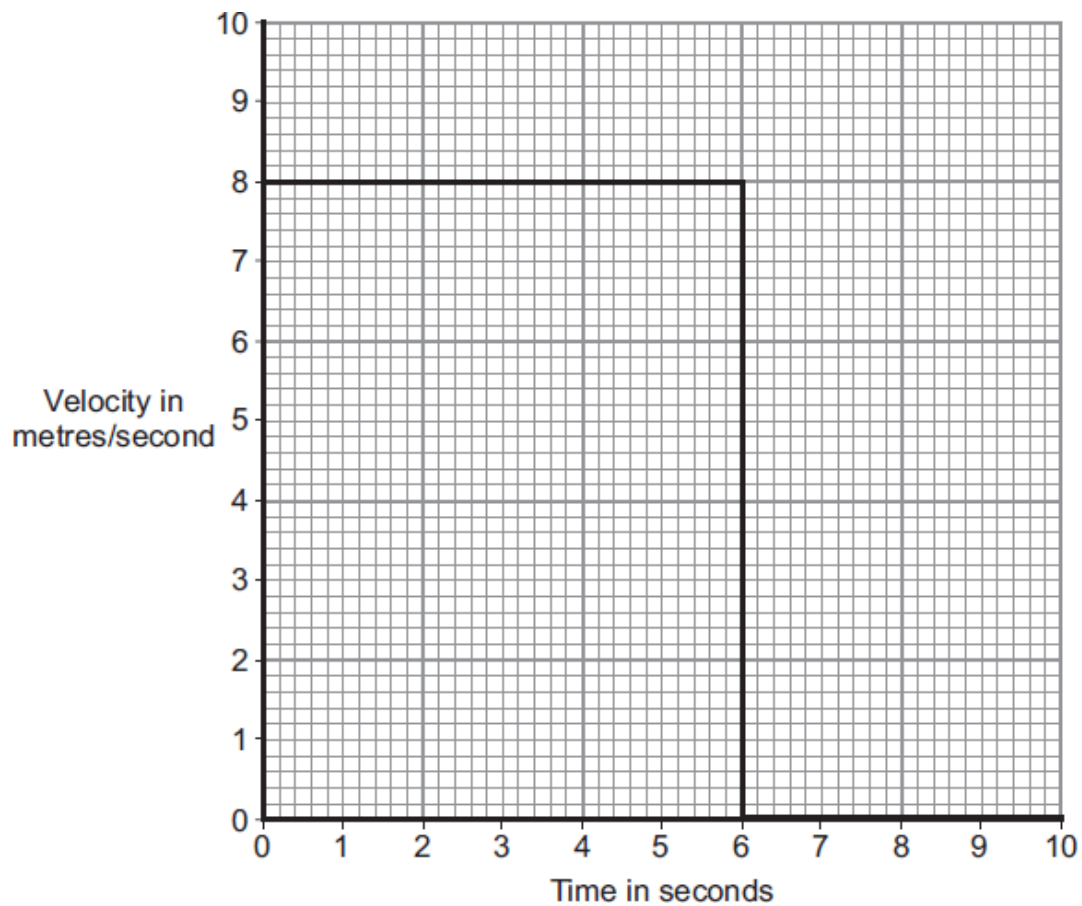
.....

.....

(1)

(Total 11 marks)

Q23. The diagram shows the velocity-time graph for an object over a 10 second period.



- (a) Use the graph to calculate the distance travelled by the object in 10 seconds.

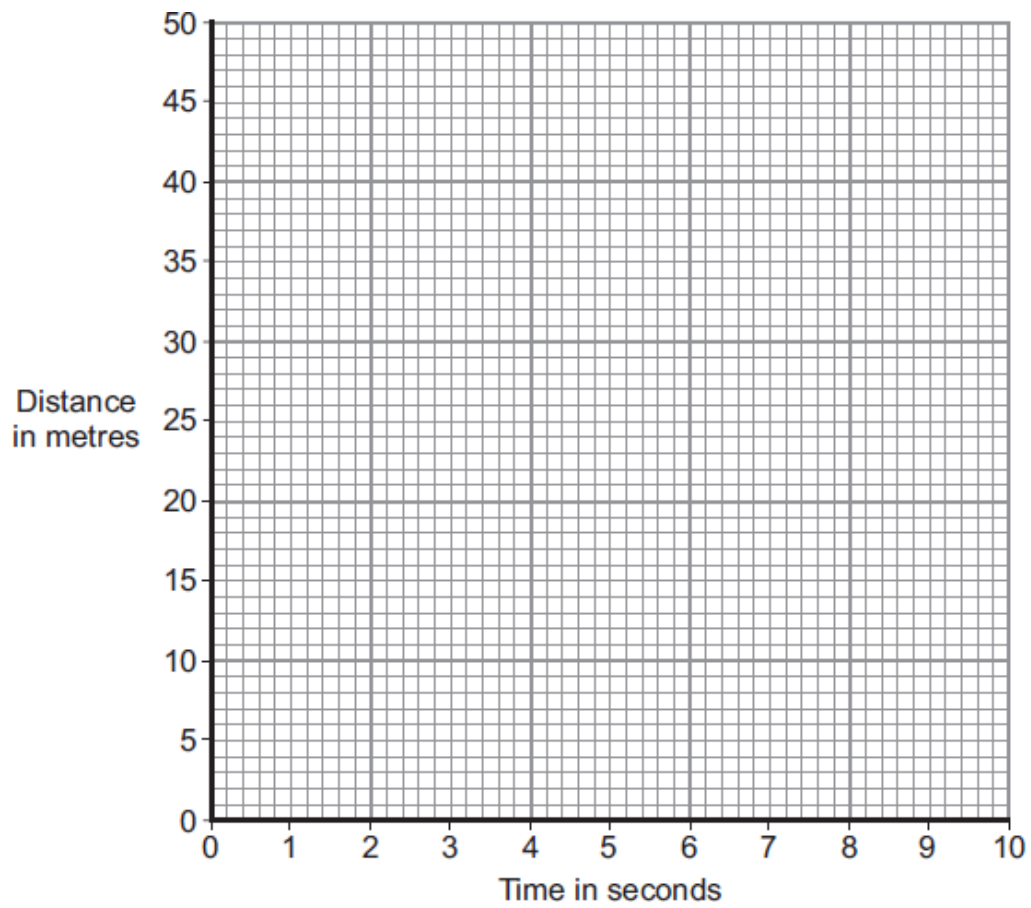
Show clearly how you work out your answer.

.....
.....

Distance = m

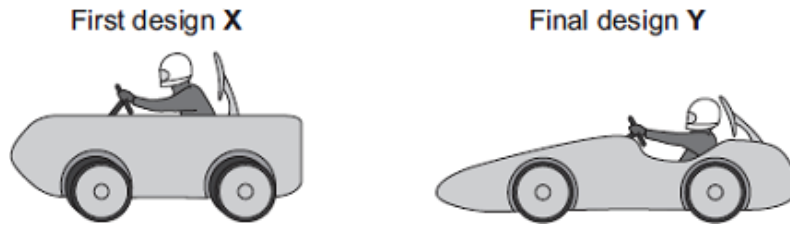
(2)

(b) Complete the distance-time graph for the object over the same 10 seconds.



(2)
(Total 4 marks)

- Q24.** (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.

.....

.....

.....

.....

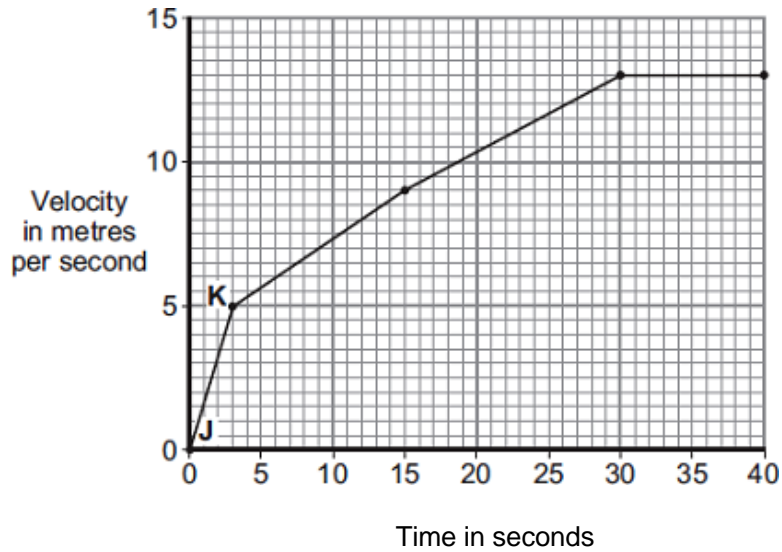
.....

.....

(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.



- (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**.

.....

Distance = m

(2)

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

.....

(1)

(Total 8 marks)

