**Q1.**

Figure 10 shows two students investigating reaction times.
Student B supports his left hand on a desk.
Student A holds a ruler so that the bottom end of the ruler is between the finger and thumb of student B.
When student A releases the ruler, student B catches the ruler as quickly as he can with his left hand.
The investigation is repeated with the right hand of student B.

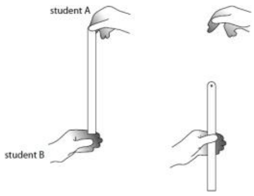



**Figure 10**

(a) Give a reason why it is better to have the 0 cm mark at the bottom of the ruler rather than at the top.
**(1)**

(b) Give a reason why two students are needed for this investigation.
**(1)**

(c) The students took five results for the left hand and five results for the right hand.
Figure 11 shows their results.

| which hand | distance dropped (cm) | | | | | |
|---|---|---|---|---|---|---|
| | trial 1 | trial 2 | trial 3 | trial 4 | trial 5 | average |
| left | 10.1 | 25.5 | 18.4 | 14.6 | 11.7 | 14 |
| right | 17.5 | 16.1 | 19.4 | 18.6 | 20.2 | .................... |

(i) Calculate the average distance dropped for the right hand. Give your answer correct to 2 significant figures.
**(2)**

(ii) Calculate the average time for the left hand.
Use the equation

$$\text{time}^2 = \frac{\text{distance}}{500}$$

**(2)**

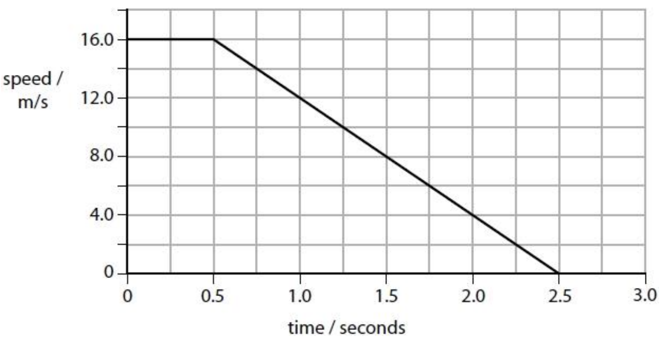
(d) Explain whether any of the readings are anomalous.
**(2)**

(e) Give **two** ways that the students can improve the quality of their data, other than ignoring anomalous results.
**(2)**

(f) Describe how the students could develop their investigation to investigate how reaction time changes with another variable.
**(2)**

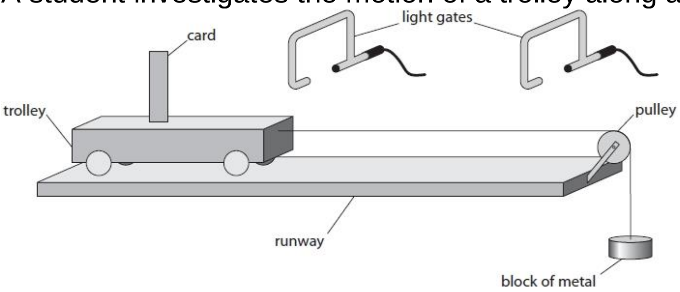
**Q2.**

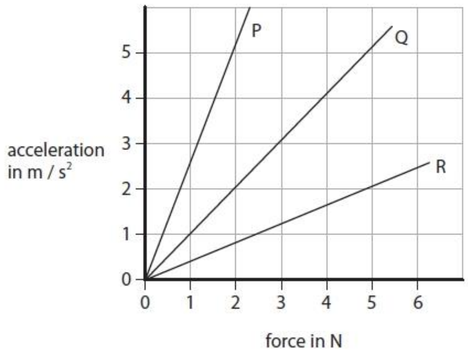
A car driver sees a rabbit on the road.
The driver makes an emergency stop after he sees the rabbit.
Figure 6 shows the speed of the car from the time the driver sees the rabbit until the car stops.




Calculate the distance that the car travels in the first 0.5 seconds. **(3)**

**Q3.**
A student investigates the motion of a trolley along a horizontal runway using the apparatus in Figure 2.




A trolley is attached to a string passing over a pulley.
A block of metal hangs on the end of the string.
Each light gate measures the time it takes for the card to pa
When the trolley is released, it moves along the track.
A computer measures the time it takes for the card to pass between each light gate.
Figure 3 shows a graph of acceleration against force for three trollies of different mass that are pulled along the runway.
The graphs for the trollies are labelled P, Q and R.

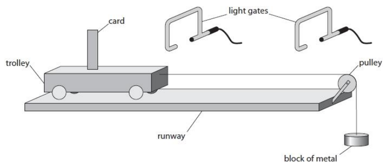
Use the information from the graph.
(i) Calculate the mass of trolley Q

(2)

(ii) Describe how the graph shows that trolley R has the greatest mass.

(2)

**Q4.**
A student investigates the motion of a trolley along a horizontal runway using the apparatus in Figure 2.




A trolley is attached to a string passing over a pulley.
A block of metal hangs on the end of the string.
Each light gate measures the time it takes for the card to pass through the gate.
When the trolley is released, it moves along the track.
A computer measures the time it takes for the card to pass between each light gate.

(i) The card took 0.080 s to pass through the first light gate.
The width of the card is 5 cm.
Calculate the average speed, in m/s, of the trolley through the first light gate.

(2)

Another trolley passes through the first light gate at a velocity of 0.72 m/s.
This trolley passes through the second light gate at a velocity of 1.1 m/s.
The time it takes for the card on the trolley to travel between the two light gates is 0.53 s.

(ii) State the equation relating acceleration, change in velocity and time.

(1)

(iii) Calculate the acceleration of the trolley between the two light gates.

(2)

**Q5.**
A car is travelling down a slope at 2.0 m/s.
The car accelerates for 4.0 s.
The speed of the car increases to 12 m/s.
Calculate the acceleration of the car.
Use the equation

$$a = \frac{(v - u)}{t}$$

(2)

**Q6.**
Another cyclist travels 1200 m in a time of 80 s.
Calculate the average speed of the cyclist.
Use the equation

$$\text{average speed} = \frac{\text{distance}}{\text{time}}$$

(2)

**Q7.**

An aircraft waits at the start of a runway.
The aircraft accelerates from a speed of 0 m/s to a speed of 80 m/s.
The acceleration of the aircraft is 4 m/s$^2$.
Calculate the distance, *x*, travelled by the aircraft while it is accelerating.
Use the equation

$$x = \frac{v^2 - u^2}{2a}$$

**(2)**

**Q8.**

A car with a mass of 1800 kg is accelerating at 1.2 m/s$^2$.
Calculate the force used to accelerate the car.
Use the equation

force = mass × acceleration

**(2)**

**Q9.**

A car accelerates at a constant rate of 1.83 m/s$^2$ along a flat straight road.
The force acting on the car is 1.870 kN.
Calculate the mass of the car.
Give your answer to three significant figures.

**(3)**

**Q10.**

A car accelerates at a constant rate of 1.83 m/s$^2$ along a flat straight road.
The force acting on the car is 1.870 kN.
The car accelerates from rest for 16 s.
Calculate the speed of the car after 16 s.

**(3)**

**Q11.**

The ball bearing is now dropped through air.
The initial velocity of the ball bearing is zero.
The acceleration of the ball bearing is 10 m/s$^2$.
The ball bearing falls 1.5 m.
Calculate the velocity of the ball bearing when it has fallen 1.5 m.
Use the equation

$$v^2 - u^2 = 2 \times a \times x$$

**(2)**

**Q12.**

(i) A car is moving at 90 km/h when the driver has to stop.
Calculate the thinking time of the driver.
Using the equation:
time = distance ÷ average speed

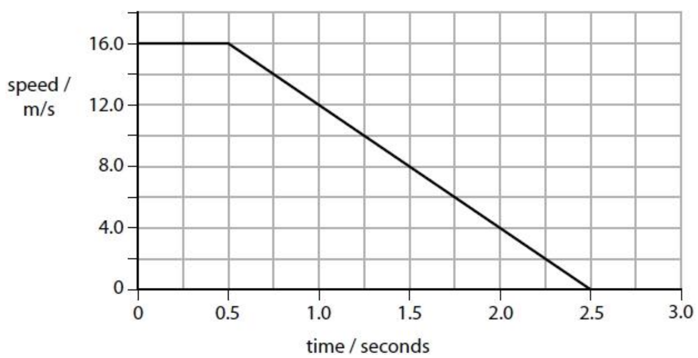
**(2)**

(ii) A car has a mass of 1300 kg.
Calculate the kinetic energy of the car when it is travelling at 20 m/s.

**(2)**

**Q13.**

A car driver sees a rabbit on the road.
The driver makes an emergency stop after he sees the rabbit.
Figure 6 shows the speed of the car from the time the driver sees the rabbit until the car stops.



(i) Which equation relates acceleration to change in velocity and time?

- ☐ **A** $a = \frac{(v-u)}{t}$
- ☐ **B** $a = \frac{t}{(v-u)}$
- ☐ **C** $a = t(v-u)$
- ☐ **D** $a = v - \frac{u}{t}$

(1)

(ii) Calculate the deceleration of the car.

(3)

**Q14.**

A car is travelling along a level road.

(i) Complete the sentence by putting a cross ( ☒ ) in the box next to your answer.
When the velocity of the car is constant, the force of friction on it is

(1)

- ☐ **A** zero
- ☐ **B** greater than the driving force
- ☐ **C** smaller than the driving force
- ☐ **D** the same size as the driving force

(ii) The car now accelerates in a straight line.
Its average acceleration is 12 $m/s^2$.
Calculate the increase in velocity of the car in 4.0 s.

(3)

**Q15.**

Figure 1 shows how the thinking distance and braking distance change depending on the speed of a car.

| speed in km / h | speed in m / s | thinking distance in m | braking distance in m | stopping distance in m |
|---|---|---|---|---|
| 50 | 14 | 21 | 21 | 42 |
| 60 | 17 | 25 | 31 | 56 |
| 70 | | 29 | 42 | 71 |
| 80 | 22 | 33 | 55 | 88 |
| 90 | 25 | 37 | 85 | 107 |
| 100 | 28 | 42 | 85 | 127 |

(i) Fill in the gap in the table.

(1)

(ii) A student studies these results and writes the conclusion:
*'The thinking distance is proportional to the speed of the car'*.
Comment on the student's conclusion.

(3)

**Q16.**

Figure 5 shows the apparatus a student uses to investigate how the stopping distance of a toy car depends on the type of surface that it is stopping on.

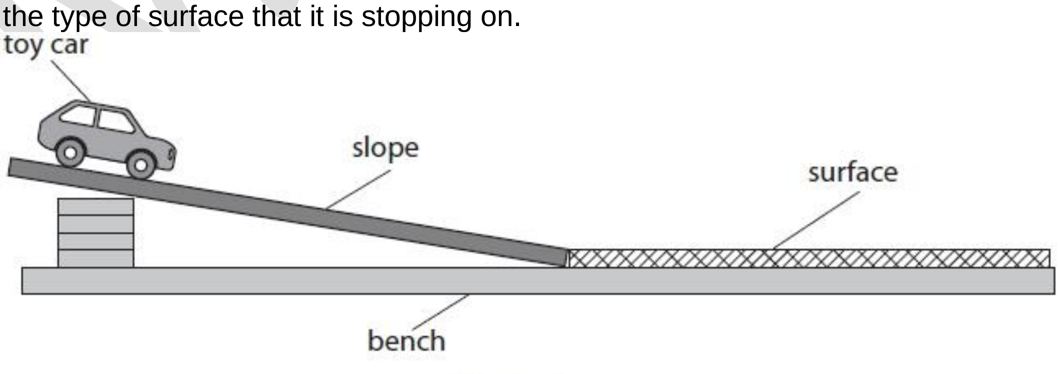



**Figure 5**

Describe an experiment to find out how the stopping distance depends on the surface that stops the toy car.

(2)

**Q17.**
A student lifts a toy car from a bench and places the toy car at the top of a slope as shown in Figure 9.

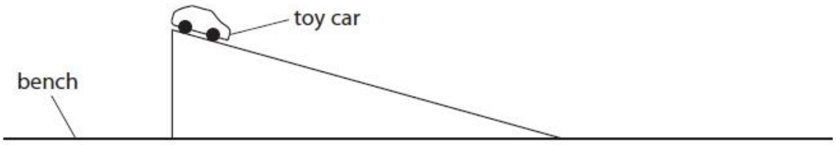



Figure 9

The student lets the toy car roll down the slope.
Describe how the student could find, by experiment, the speed of the toy car at the bottom of the slope.

**(4)**

**Q18.**
* Figure 13 is a velocity/time graph for a toy train on a straight track for 7 seconds.

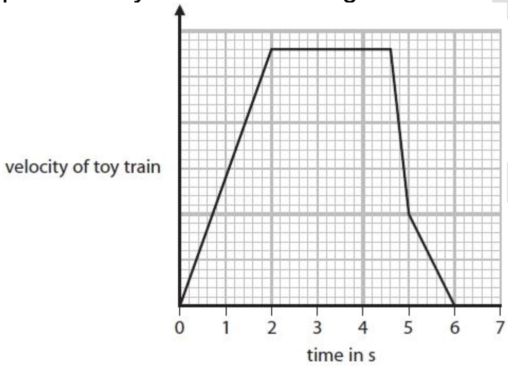
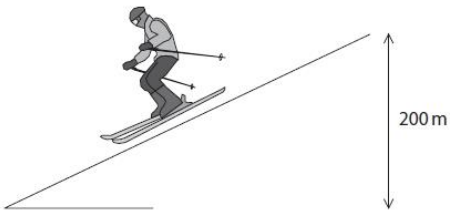



Figure 13

Using information from the graph, describe when and how the velocity and acceleration of the toy train change at different times during the 7 seconds shown on the graph.

**(6)**

**Q19.**
Figure 7 shows a skier going down a hill.




Describe how her speed at the bottom of the slope could be determined.

**(3)**

**Q20.**
Figure 7 shows a ball bearing as it falls slowly through a clear, dense liquid.

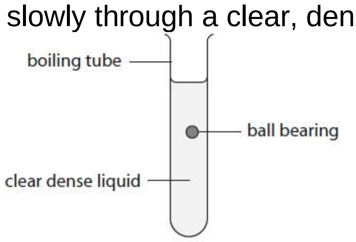



Figure 7

The apparatus in Figure 7 is used to find the average speed of the ball bearing as it falls.
(i) Devise an experiment to determine the average speed of the ball bearing as it falls through the liquid.

**(4)**

You should include:

- any extra apparatus you would use to take measurements
- the measurements you would take
- how you would calculate the speed.

(ii) A student thinks that the ball bearing falls through the liquid at a constant speed.
Explain how you could develop this experiment to determine if the ball bearing falls through the liquid at constant speed.
You may draw a diagram to help your answer.

(2)

**Q21.**
The students use a telescope to view the Moon.
Light from the Moon takes 1.3 s to reach the students.
The speed of light is 300 000 km/s.
Calculate the distance to the Moon.

(2)

distance = speed × time

**Q22.**
Shot-put is an Olympic event.
The shot is a heavy ball.
An athlete throws the shot as far as possible.
A sports scientist analyses an athlete's throw to help improve performance.
The scientist takes pictures of the athlete every 0.1 s during one throw.
Figure 7 shows the pictures of one throw.

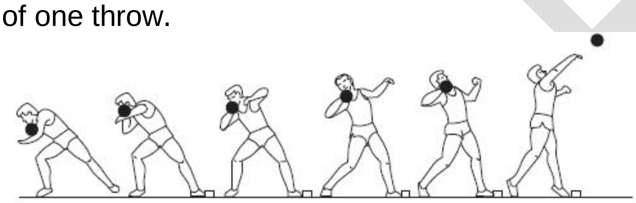



**Figure 7**

(i) Estimate the amount of time during the throw when the shot is in the athlete's hand.

(1)

(ii) Explain how the scientist could improve this method of analysing the throw.

(2)

(iii) The average acceleration of the shot while in the athlete's hand is 20.6 $m/s^2$.
The mass of the shot is 7.26 kg.
Calculate the average force that the athlete applies to the shot during the throw.

(2)

(iv) In another throw, the shot is in the athlete's hand for 0.48 s.
The average acceleration during this time is 23 $m/s^2$.
Calculate the velocity of the shot as it leaves the athlete's hand.

(3)

**Q23.**
Many factors can affect the stopping distance of a car.
Some of these factors involve the driver and some of these factors involve the car or the road.
Explain how the stopping distance of a car is affected by

- factors involving the driver
- factors involving the car or the road.

You should include examples in your explanations.

(6)

**Q24.**
Figure 12 is a speed limit sign from a European motorway.
The speeds shown are in km/h (kilometres per hour).

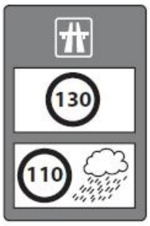



**Figure 12**

(i) The sign tells drivers to drive at a slower speed in wet weather.
Explain why it is safer for drivers to drive at a slower speed in wet weather.

(2)

(ii) Show that a speed of 31 m/s is less than a speed of 130 km/h.

(2)

The driver's reaction time is the time between the driver seeing an emergency and starting to brake.

(iii)

A car is travelling at a speed of 31 m/s.
The car travels 46 m between the driver seeing an emergency and starting to brake.
Calculate the driver's reaction time.
Give your answer to 2 significant figures.

**(3)**

**Q25.**

This table shows data about two other cars.

| car | mass | time taken to reach 30 m/s from rest |
|---|---|---|
| family car | 1400 kg | 10 s |
| sports car | 600 kg | 5 s |

The owner of the family car claims that although the sports car has greater acceleration, it produces a smaller accelerating force than his family car.
Explain how these figures support his claim.

**(2)**

**Q26.**

Figure 5 shows a trolley at the top of a slope.

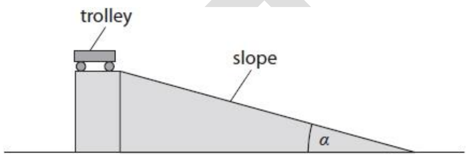



**Figure 5**

A student gently pushes the trolley until it just starts to roll down the slope.
The student measures the time it takes for the trolley to roll down the slope.
The student repeats this for different values of the angle *α*.
Figure 6 is a graph of the student's results.

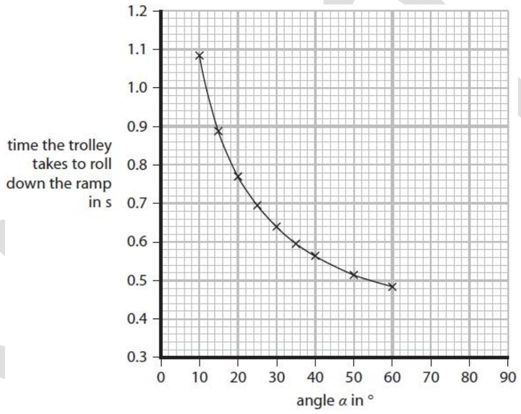



**Figure 6**

(i) Use the graph in Figure 6 to find the time the trolley takes to roll down the ramp when the angle *α* = 45°.

**(1)**

(ii) Use the graph in Figure 6 to estimate the time the trolley takes to roll down the ramp when the angle *α* = 80°.

Show your working on the graph.

**(2)**

(iii) The student had a choice of how to measure the time the trolley takes to roll down the ramp.

1. Use a hand-held stopwatch.
2. Use light gates at the top and bottom of the slope.

The student chose to use the light gates.
Explain why this was the correct choice.
You should refer to the data on the time axis of Figure 6 in your answer.

**(2)**

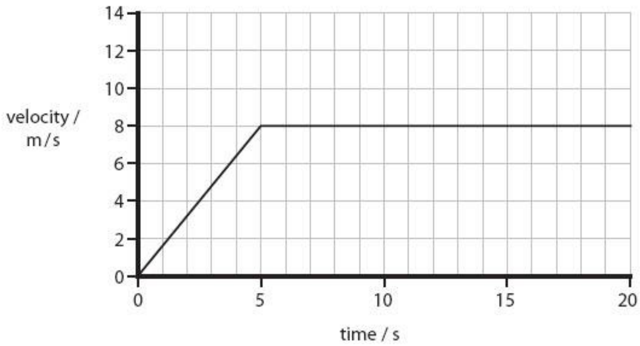
**Q27.**

A toy car has a mass of 0.10 kg.
The toy car accelerates at 2.0 $m/s^2$.
Calculate the force producing this acceleration.
State the unit.
Use the equation
$F = m \times a$

**(3)**

**Q28.**

(a) Here is the velocity-time graph for a car for the first 20 s of a journey.




(i) Calculate the change in velocity of the car during the first 5 s.

(1)

(ii) Calculate the acceleration of the car during the first 5 s.

(2)

(iii) State the size of the resultant force between 10 s and 15 s

(1)

(b) The mass of a car is 1200 kg.
Calculate the resultant force on the car required to produce an acceleration of 0.8 $m/s^2$.

(2)

*(c) A car, travelling at 20 m/s, with just the driver inside takes 70 m to stop in an emergency.
The same car is then fully loaded with luggage and passengers as well as the driver.
Explain why it will take a different distance to stop in an emergency from the same speed.

(6)

**Q29.**

* A car, travelling at 20 m/s, with just the driver inside takes 70 m to stop in an emergency.
The same car is then fully loaded with luggage and passengers as well as the driver.
Explain why it will take a different distance to stop in an emergency from the same speed.

(6)

**Q30.**

(a) Which of these situations can increase the reaction time of a driver?

(1)

☐ **A** an icy road
☐ **B** worn tyres on his car
☐ **C** stopping for a cup of coffee
☐ **D** driving for a long time without taking a break

(b) (i) A car engine produces an average driving force of 1200 N.
The car travels 8.0 m.
Calculate the work done by the force over this distance.

(2)

(ii) The car has a mass of 1400 kg and travels at a velocity of 25 m/s.
Calculate the kinetic energy of the car.

(3)

**Q31.**

A car is travelling at 10 m/s.
The driver sees a danger and stops the car.
(i) The stopping distance for the car would be smaller if the car

(1)

☐ **A** had more passengers
☐ **B** had worn tyres
☐ **C** needed new brakes
☐ **D** was travelling more slowly

Figure 4 shows a speed-time graph for the driver stopping the car.

(ii) Use the graph to find the driver's reaction time.

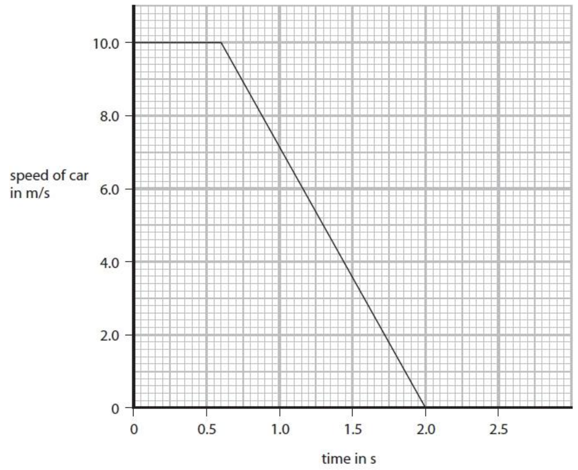


Figure 4

**Q32.**
Shot-put is an Olympic event.
The shot is a heavy ball.
An athlete throws the shot as far as possible.
A sports scientist analyses an athlete's throw to help improve performance.
The scientist can measure several quantities in the analysis.
Which one of the following is a scalar quantity?

(1)

- ☒ **A** acceleration
- ☒ **B** force
- ☒ **C** mass
- ☒ **D** velocity

| test number | stopping distance in m |
|---|---|
| 1 | 0.35 |
| 2 | 0.32 |
| 3 | 0.52 |
| 4 | 0.38 |
| 5 | 0.33 |

Figure 6

**Q33.**
Figure 6 shows a set of results used to find the average stopping distance of the toy car on a surface.

(i) State the anomalous value of stopping distance given in the table in Figure 6.

(1)

(ii) Use the results in Figure 6 to calculate the average stopping distance.

(2)

(iii) State **one** way the student could increase the speed of the car as it reaches the flat surface.

(1)

**Q34.**
(i) Which of these is the correct equation that relates force, mass and acceleration?

(1)

- ☒ **A** F = *m* + *a*
- ☒ **B** F = *m* − *a*
- ☒ **C** F = *m* × *a*
- ☒ **D** F = *m* ÷ *a*

(ii) A cyclist has a mass of 70 kg.
Calculate the force needed to accelerate the cyclist at 2.0 m / s$^2$.
State the unit.

(2)

**Q35.**
(i) Which of these would be a typical speed for a racing cyclist travelling down a steep straight slope?

(1)

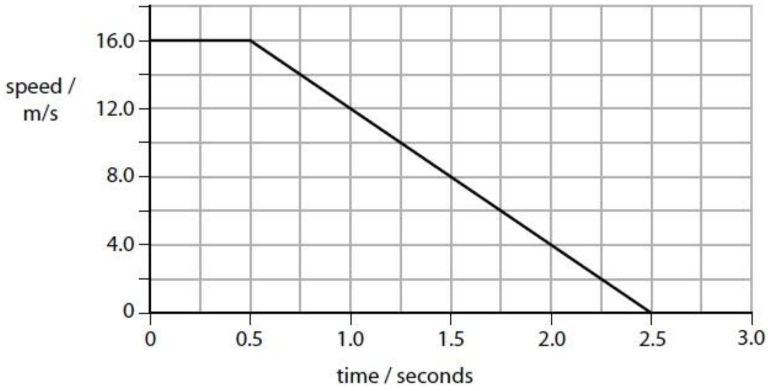
- ☒ **A** 0.2 m/s
- ☒ **B** 2 m/s
- ☒ **C** 20 m/s
- ☒ **D** 200 m/s

(ii) A cyclist travels down a slope.
The top of the slope is 20 m vertically above the bottom of the slope.
The cyclist has a mass of 75 kg.
Calculate the change in gravitational potential energy of the cyclist between the top and the bottom of the slope.
The gravitational field strength, g, is 10 N/kg.

(3)

**Q36.**
Quantities can be either scalar or vector.
Which of these is a vector quantity?

- ☐ **A** mass
- ☐ **B** force
- ☐ **C** energy
- ☐ **D** distance




**Q37.**
A car driver sees a rabbit on the road.
The driver makes an emergency stop after he sees the rabbit.
Figure 6 shows the speed of the car from the time the driver sees the rabbit until the car stops.
The distance travelled by the car from the time the driver first sees the rabbit to when car starts to slow down is the

**(1)**

- ☐ **A** average distance
- ☐ **B** braking distance
- ☐ **C** stopping distance
- ☐ **D** thinking distance

**Q38.**
A car approaches traffic lights.
The traffic lights turn to red so the car has to stop.
Which of the following factors affects the thinking distance when the car has to stop?

**(1)**

- ☐ **A** condition of the road
- ☐ **B** mass of the car
- ☐ **C** reaction time
- ☐ **D** worn brakes

**Q39.**
(a) Which of these is a vector?

**(1)**

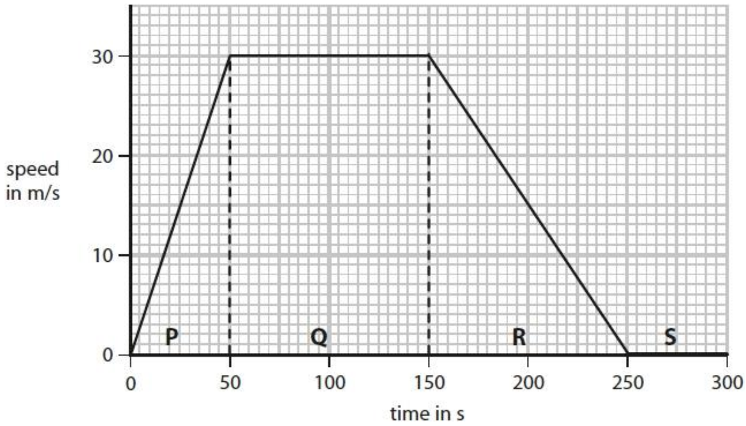
- ☐ **A** energy
- ☐ **B** force
- ☐ **C** mass
- ☐ **D** work

**Q40.**
Two students, Alice and Bob, carry out an experiment to measure the speed of cars.
Alice paces out the distance between two lamp posts.
She records:
'*Distance between lamp posts = 20 paces*'
Bob starts to count when a car passes the first lamp post. He stops counting when he thinks it has passed the second lamp post.
He records:
'*My estimate for the time taken for the car to pass between the two lamp posts = 3*'
Give **three** ways the students could improve their experimental procedure.

**(3)**

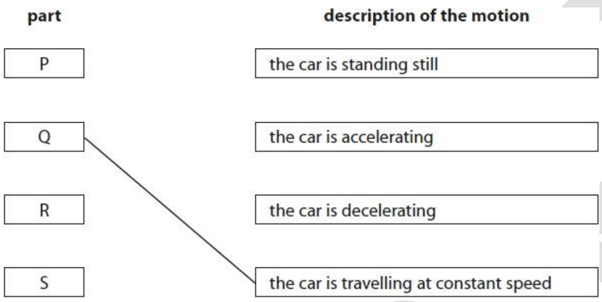
**Q41.**

Figure 1 shows a speed/time graph for a car.




(i) The graph in Figure 1 is divided into four parts, **P**, **Q**, **R** and **S**.
Draw a line from the letter for each **part** to the correct **description of the motion** during that part.
One line has been drawn for you.

**(2)**




(ii) In two parts of the graph in Figure 1 the forces are balanced.
State the letters of the two parts of the graph where the horizontal forces acting on the car are balanced.

**(2)**

(iii) Calculate the distance travelled by the car in part Q.
Use the equation

distance travelled = average speed × time

**(2)**

**Q42.**
Figure 1 shows a block hanging from a spring balance.

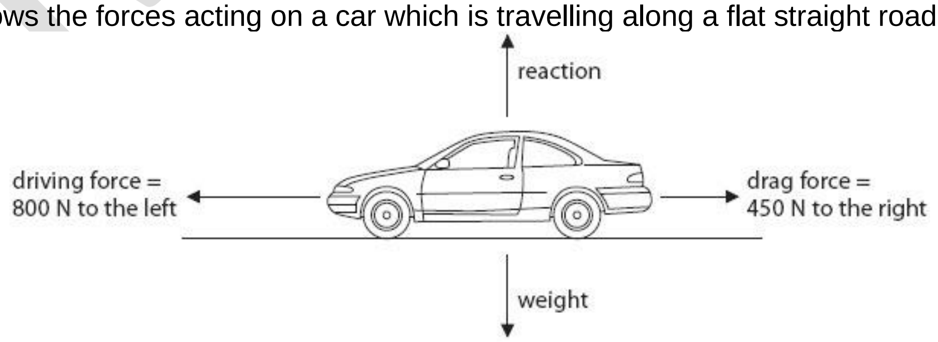

Use a word from the box to complete the sentence below.

| | | | |
|---|---|---|---|
| density | mass | volume | weight |

The quantity measured by the spring balance in Figure 1 is

**(1)**

**Q43.**
The diagram shows the forces acting on a car which is travelling along a flat straight road.




(i) The size of the resultant force on the car is 350 N.
In which direction is the resultant force acting?

**(1)**

☐ **A** down ↓
☐ **B** to the left ←
☐ **C** to the right →
☐ **D** up ↑

(ii) Complete the sentence by putting a cross ( ■ ) in the box next to your answer.
The car is

**(1)**

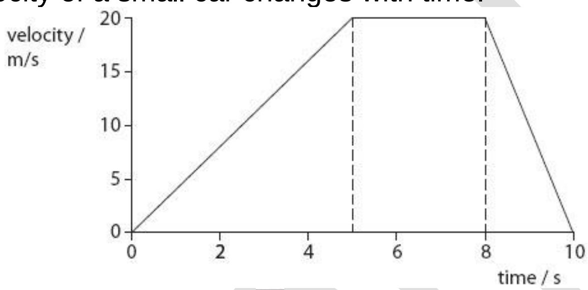
☐ **A** accelerating
☐ **B** decelerating
☐ **C** moving at a constant speed
☐ **D** not moving

**(2)**

(iii) The mass of the car is 625 kg.
Calculate the weight of the car.
gravitational field strength = 10N/kg

**(2)**

**Q44.**
The graph shows how the velocity of a small car changes with time.




(a) Complete the sentence by putting a cross ( ☒ ) in the box next to your answer.
The resultant force on the car will be zero when the car is

**(1)**

☐ **A** accelerating
☐ **B** decelerating
☐ **C** changing velocity
☐ **D** moving at a constant velocity

(b) (i) Use the graph to estimate the velocity of the car at three seconds.

**(1)**

(ii) Calculate the acceleration of the car when it is speeding up.

**(2)**

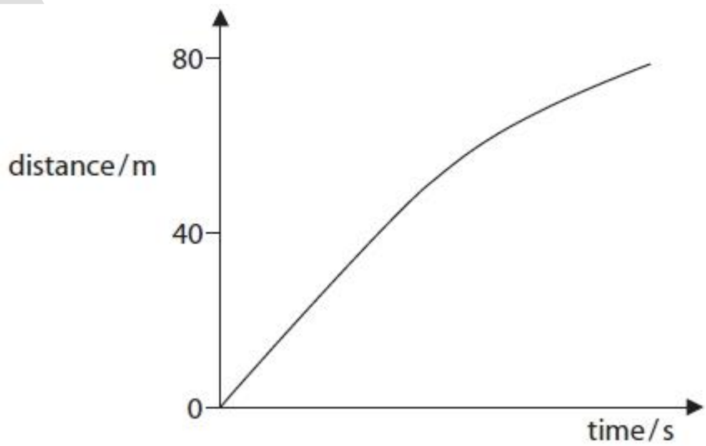
(iii) Explain why the units of acceleration are $m/s^2$.

**(2)**

(iv) Show that the car travels further at a constant velocity than it does when it is slowing down.

**(3)**

**Q45.**
The distance-time graph for a car is shown below.




Describe what the graph shows about the speed of the car as it travels the 80 m. **(2)**

**Q46.**
Some students investigate the speed of cars.
They measure the time it takes each car to travel a distance of 80 m.
(a) State **two** measuring instruments the students should use.

(2)

(b) The table shows some of their results.

| colour of car | distance travelled / m | time / s |
|---|---|---|
| green | 80 | 5.0 |
| red | 80 | 4.0 |
| blue | 80 | 5.5 |
| black | 80 | 4.3 |
| white | 80 | 5.6 |

(i) State the colour of the slowest car.

(1)

(ii) Calculate the speed of the black car.

(2)

(iii) 20 miles per hour is approximately 9 m/s.
Estimate the speed, in miles per hour, of the black car.

(1)

**Q47.**
Which of these speeds would be normal for a person walking?

(1)

- ☐ **A** 0.1 m/s
- ☐ **B** 1.0 m/s
- ☐ **C** 10 m/s
- ☐ **D** 100 m/s

**Q48.**
The mass of a car is 1200 kg.
Calculate the resultant force on the car required to produce an acceleration of 0.8 $m/s^2$.

(2)

**Q49.**
(i) State the equation that relates acceleration to change in velocity and time taken.

(1)

(ii) A van accelerates from a velocity of 2 m / s to a velocity of 20 m / s in 12 s.
Calculate the acceleration of the van.

(2)

**Q50.**
A student wants to measure the average speed of a cyclist.
The student estimates that one of his own steps is 1 m.
He counts 100 steps between two posts on a track.
He uses a stopwatch to measure the time the cyclist takes to travel between the two posts.
Figure 2 shows the set-up used to measure the average speed.

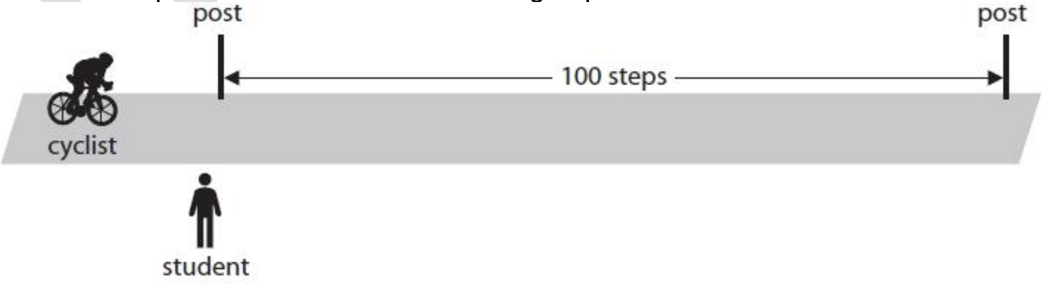


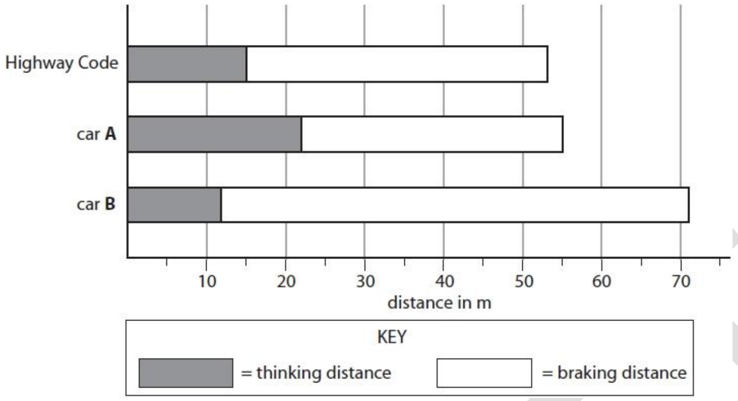

**Figure 2**

State **two** improvements the student could make to this method.

(2)

**Q51.**

* The chart shows the thinking, braking and stopping distances for an average car and driver stopping from 50 miles per hour as shown in the Highway Code.
It also shows the thinking, braking and stopping distances for drivers of cars **A** and **B**, both stopping from 50 miles per hour.




**A** and **B** are different cars on different roads.
Use the factors that can affect thinking and braking distances to explain the differences in stopping distances for cars **A** and **B**.

(6)

**Q52.**

A student needs to measure the average speed of an accelerating trolley between two marks on a bench.
Figure 3 shows the arrangement of some apparatus that the student can use.

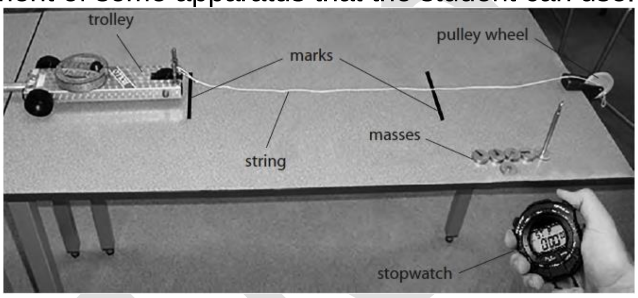



**Figure 3**

(i) One piece of apparatus is missing from the diagram.
This piece of apparatus is needed to determine the average speed.
State the extra piece of apparatus needed to determine the average speed.

(1)

(ii) Describe how the student can make the trolley accelerate along the bench.

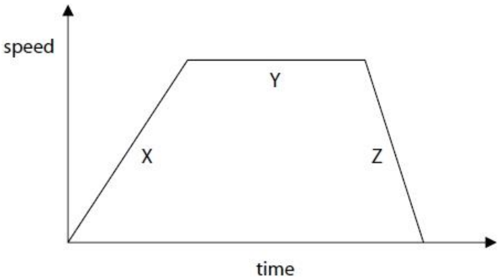
(2)

(iii) The student wishes to develop the experiment to determine the acceleration of the trolley.
State **one other** measurement that the student must make to determine the acceleration of the trolley.

(1)

**Q53.**

* Figure 12 is a speed-time graph for a car moving on a horizontal road.




Describe the energy transfers taking place during the movement of the car.
You should refer to energy stores as well as transfers between energy stores for all three sections of the graph.

(6)

**Q54.**

Figure 10 is a velocity / time graph for 15 s of a cyclist's journey.

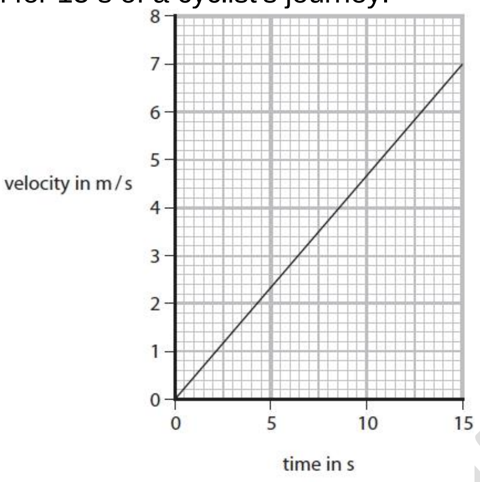



**Figure 10**

Calculate the distance the cyclist travels in the 15 s.

**(3)**

**Q55.**

Use words from the box to complete the sentences below.

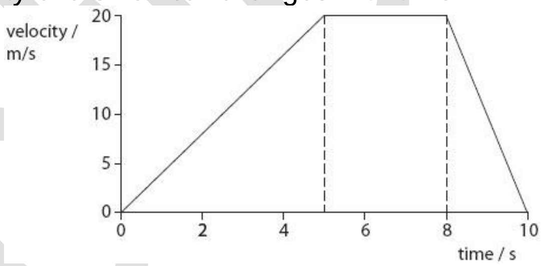
| | | | |
|---|---|---|---|
| direction | energy | mass | size |

**(2)**

Vectors have size and ............................................................ .
Scalars have only ............................................................ .

**Q56.**

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




(i) Use the graph to estimate the velocity of the car at three seconds.

**(1)**

(ii) Calculate the acceleration of the car when it is speeding up.

**(2)**

(iii) Explain why the units of acceleration are $m/s^2$.

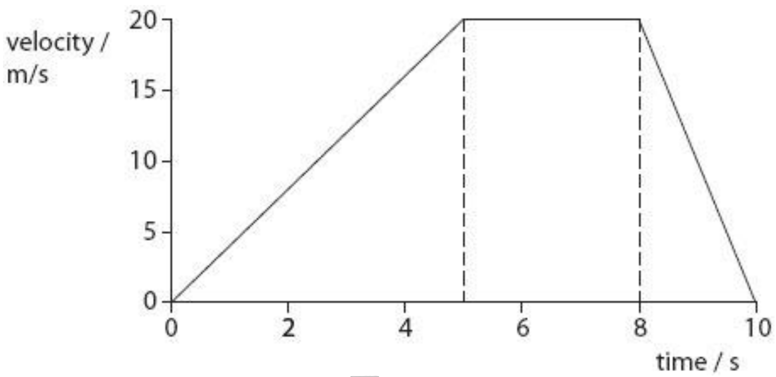
**(2)**

(iv) Show that the car travels further at a constant velocity than it does when it is slowing down.

**(3)**

**Q57.**

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



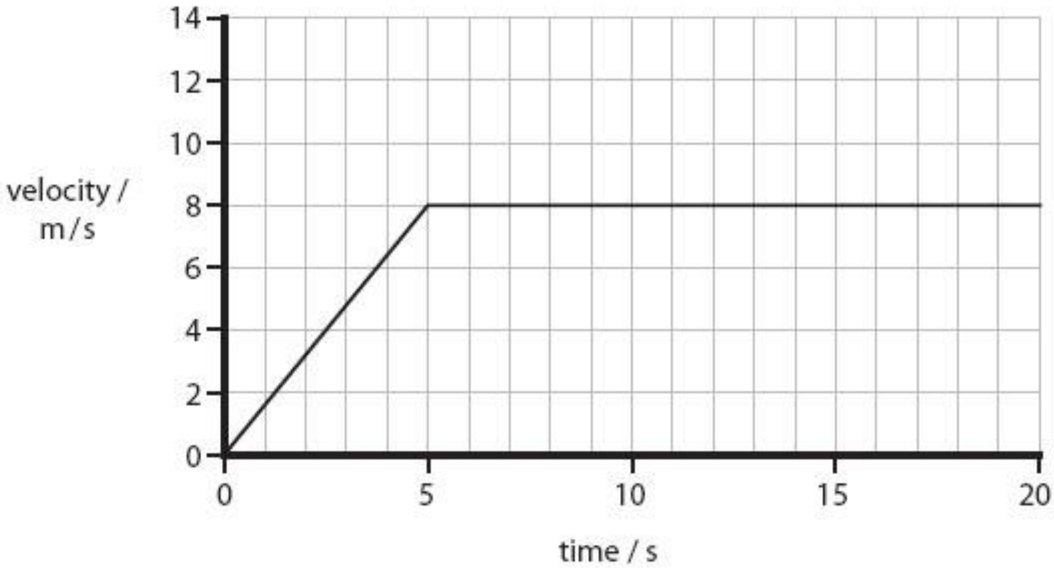

Complete the sentence by putting a cross ( ☒ ) in the box next to your answer.
The resultant force on the car will be zero when the car is

**(1)**

☐ **A** accelerating
☐ **B** decelerating
☐ **C** changing velocity
☐ **D** moving at a constant velocity

**Q58.**

Here is the velocity-time graph for a car for the first 20 s of a journey.




(i) Calculate the change in velocity of the car during the first 5 s.

**(1)**

(ii) Calculate the acceleration of the car during the first 5 s.

**(2)**

(iii) State the size of the resultant force between 10 s and 15 s

**(1)**