

AQA GCSE PHYSICS (HIGHER) • 8463

PHYSICS



EXAM QUESTION PACK

4.5.6.1.1 DISTANCE AND DISPLACEMENT (PACK 1)

SCORE

/230

PERCENTAGE

%

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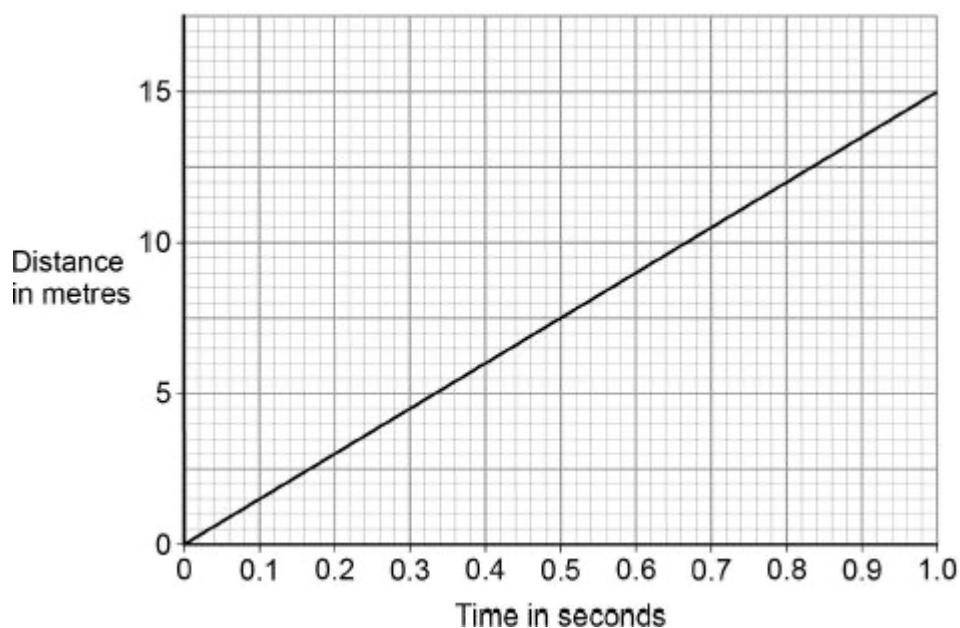
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Q1.

- (a) **Figure 1** shows the distance-time graph for a car travelling at 15 m/s

Figure 1



When the driver is tired, his reaction time increases from 0.50 seconds to 0.82 seconds.

Determine the **extra** distance the car would travel before the driver starts braking.

Distance = _____ m

(2)

- (b) When the brakes are used, the temperature of the brakes increases.

Explain why. Use ideas about energy in your explanation.

(2)

- (c) A lorry travels 84 m with a constant acceleration of 2.0 m/s^2 to reach a velocity of 19 m/s

Calculate the initial velocity of the lorry.

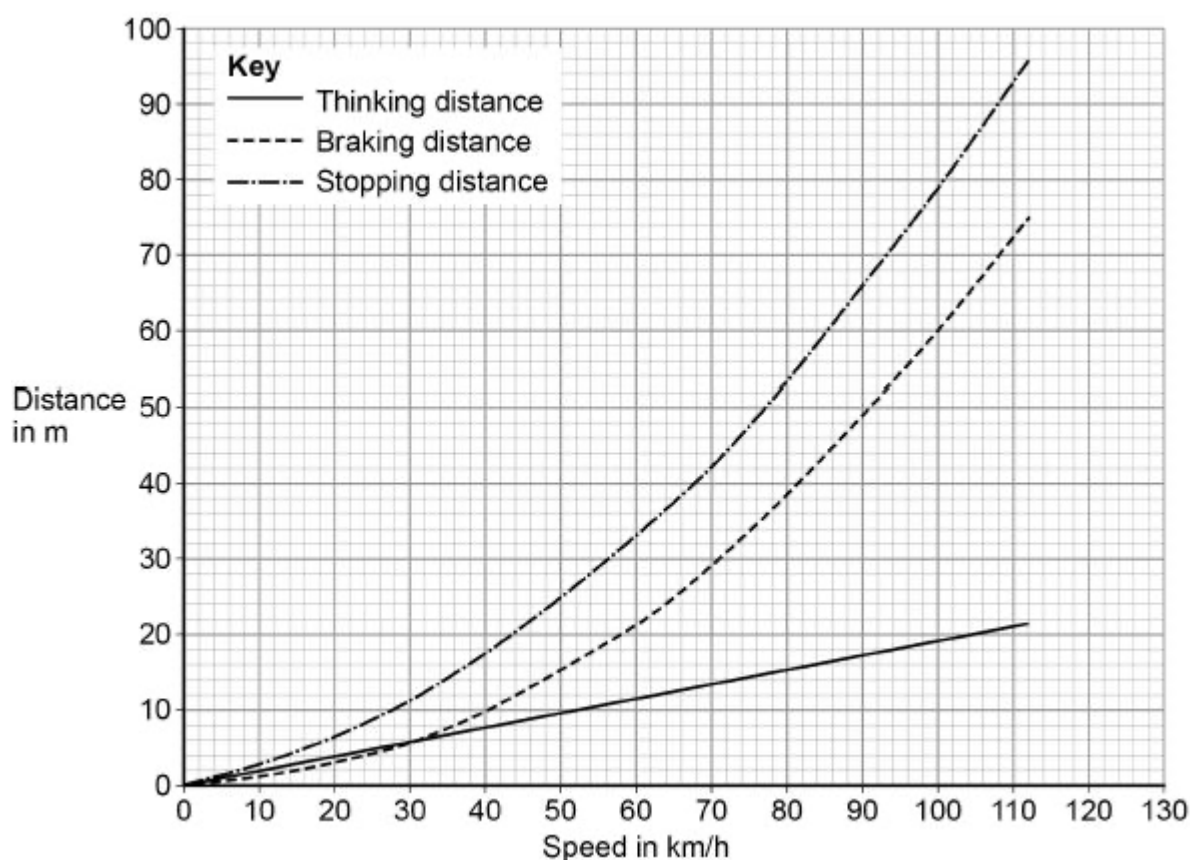
Use the Physics Equations Sheet.

Initial velocity = _____ m/s

(3)

- (d) **Figure 2** shows how the thinking distance, braking distance and stopping distance for a car vary with the speed of the car.

Figure 2



Describe the relationships shown in **Figure 2**

You should include factors that would affect the gradient of the lines.

(6)
(Total 13 marks)

Q2.

The stopping distance of a car depends on the thinking distance and the braking distance.

- (a) Thinking distance depends on the driver's reaction time.

Give **two** factors that can affect reaction time.

1. _____

2. _____

(2)

- (b) Give **one** factor that can affect the braking distance.

(1)

- (c) The thinking distance is the distance travelled during the driver's reaction time.

A car was travelling at 13 m/s

The driver's reaction time was 0.6 s

Calculate the thinking distance.

Use the equation:

$$\text{distance travelled} = \text{speed} \times \text{time}$$

Thinking distance = _____ m

(2)

- (d) The braking distance of the car was 14.0 m

What was the stopping distance of the car?

Stopping distance = _____ m

(1)

- (e) What is the link between speed and braking distance?

Complete the sentence.

The greater the speed, the _____

(1)

- (f) If a large braking force is applied, the car decelerates and stops in a very short distance.

Give **two** disadvantages of applying a large braking force.

1. _____

2. _____

(2)

(Total 9 marks)

Q3.

An athlete trains to improve his fitness by walking, cycling and running.

- (a) What is a typical mean speed for a person walking?

Tick **one** box.

1.5 m/s

☐

3.0 m/s

☐

4.5 m/s

☐

6.0 m/s

☐

(1)

- (b) What is a typical mean speed for a person cycling?

Tick **one** box.

1.5 m/s

☐

3.0 m/s

☐

4.5 m/s

☐

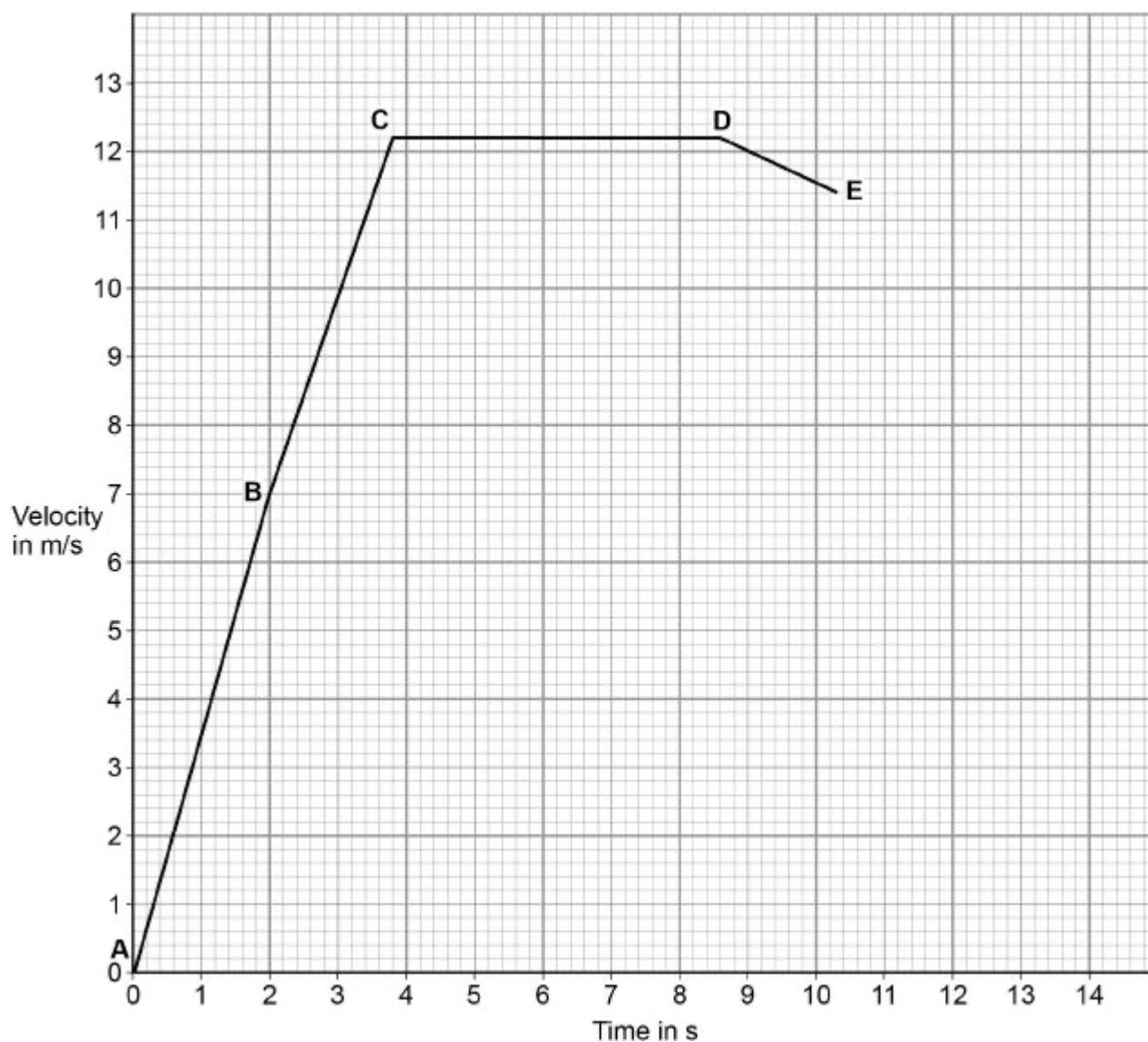
6.0 m/s

☐

(1)

The athlete takes part in a race on a straight, horizontal running track.

The graph below shows the velocity–time graph for the athlete. **A**, **B**, **C**, **D** and **E** represent points in the race.



(c) Determine the time taken for the athlete to move between points **C** and **D**.

Time at **C** = _____ s

Time at **D** = _____ s

Time taken between points **C** and **D** = _____ s

(2)

- (d) Point **E** represents the end of the race.

After point **E**, the athlete has a constant deceleration.

The athlete stops 14 seconds after the start of the race.

Complete the graph above to show the motion of the athlete after point **E**.

(2)

- (e) Which section of the graph above shows the athlete moving at constant velocity?

Tick **one** box.

A-B

☐

B-C

☐

C-D

☐

D-E

☐

(1)

- (f) Which section of the graph above represents a part of the race where the resultant force on the athlete is zero?

Tick **one** box.

A-B

☐

B-C

☐

C-D

☐

D-E

☐

(1)

- (g) What does the area under a velocity-time graph represent?

Tick **one** box.

Acceleration

☐

Distance travelled

☐

Energy

☐

Speed

☐

(1)

- (h) Write the equation which links acceleration, mass and resultant force.

(1)

- (i) In another race, the athlete had a constant acceleration during the first 3.2 seconds. His velocity increased from 0 m/s to 11.6 m/s

Calculate the acceleration of the athlete.

Use the equation:

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

Acceleration = _____ m/s²

(2)

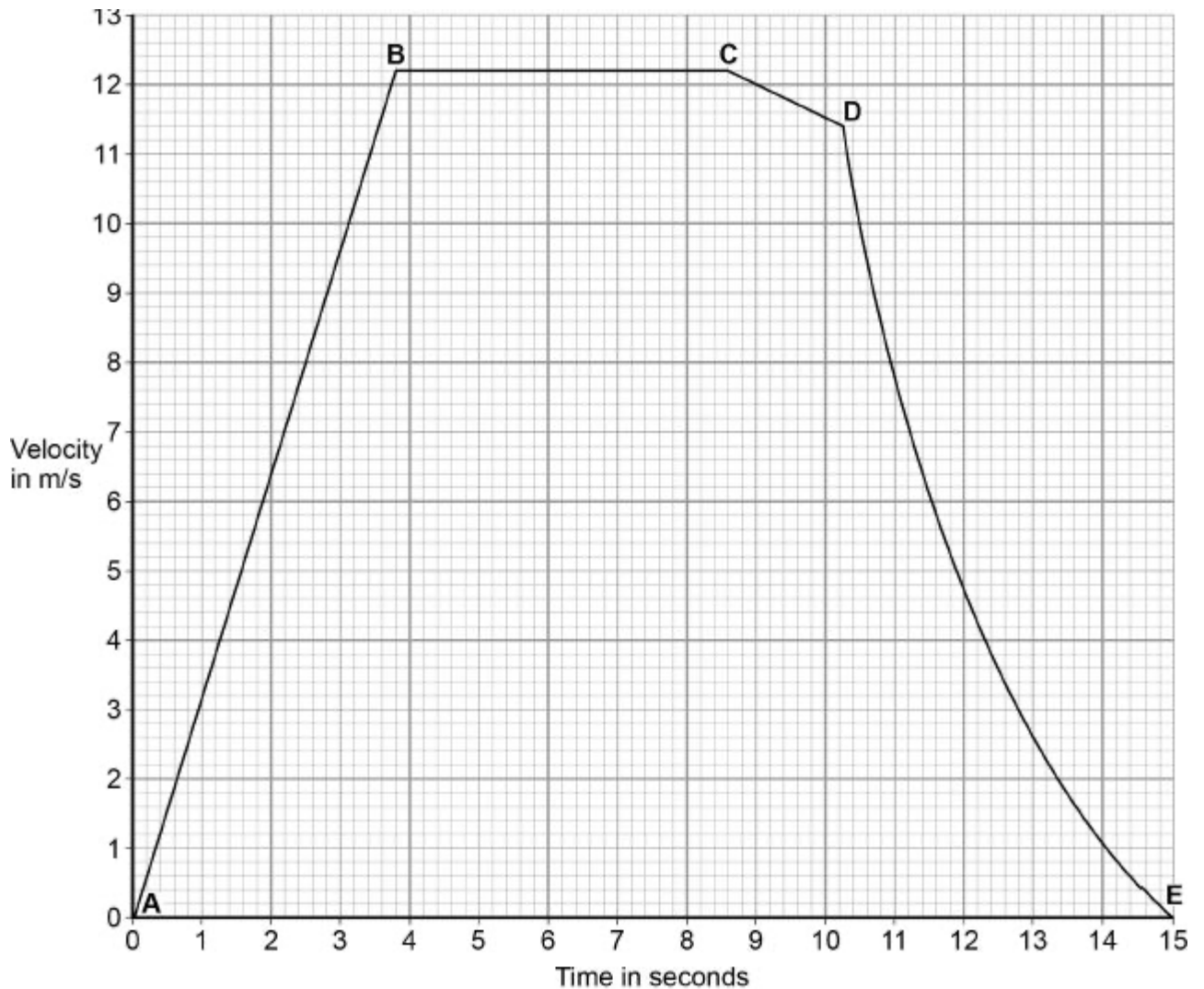
(Total 12 marks)

Q4.

An athlete takes part in a race on a straight, horizontal running track.

Figure 1 shows the velocity-time graph for the athlete during the race.

Figure 1



- (a) What is the main force that opposes the athlete's forward motion?

(1)

- (b) Which section of the graph represents a part of the race where the resultant force on the athlete is zero?

Tick **one** box.

A-B	B-C	C-D	D-E
☐	☐	☐	☐

(1)

- (c) The athlete has a mass of 94.8 kg

Calculate the momentum of the athlete at a time of 6.0 s

Use **Figure 1**.

Momentum = _____ kg m/s

(3)

- (d) The acceleration is **not** constant from **D** to **E**.

Determine the acceleration at a time of 12.0 s

Use **Figure 1**.

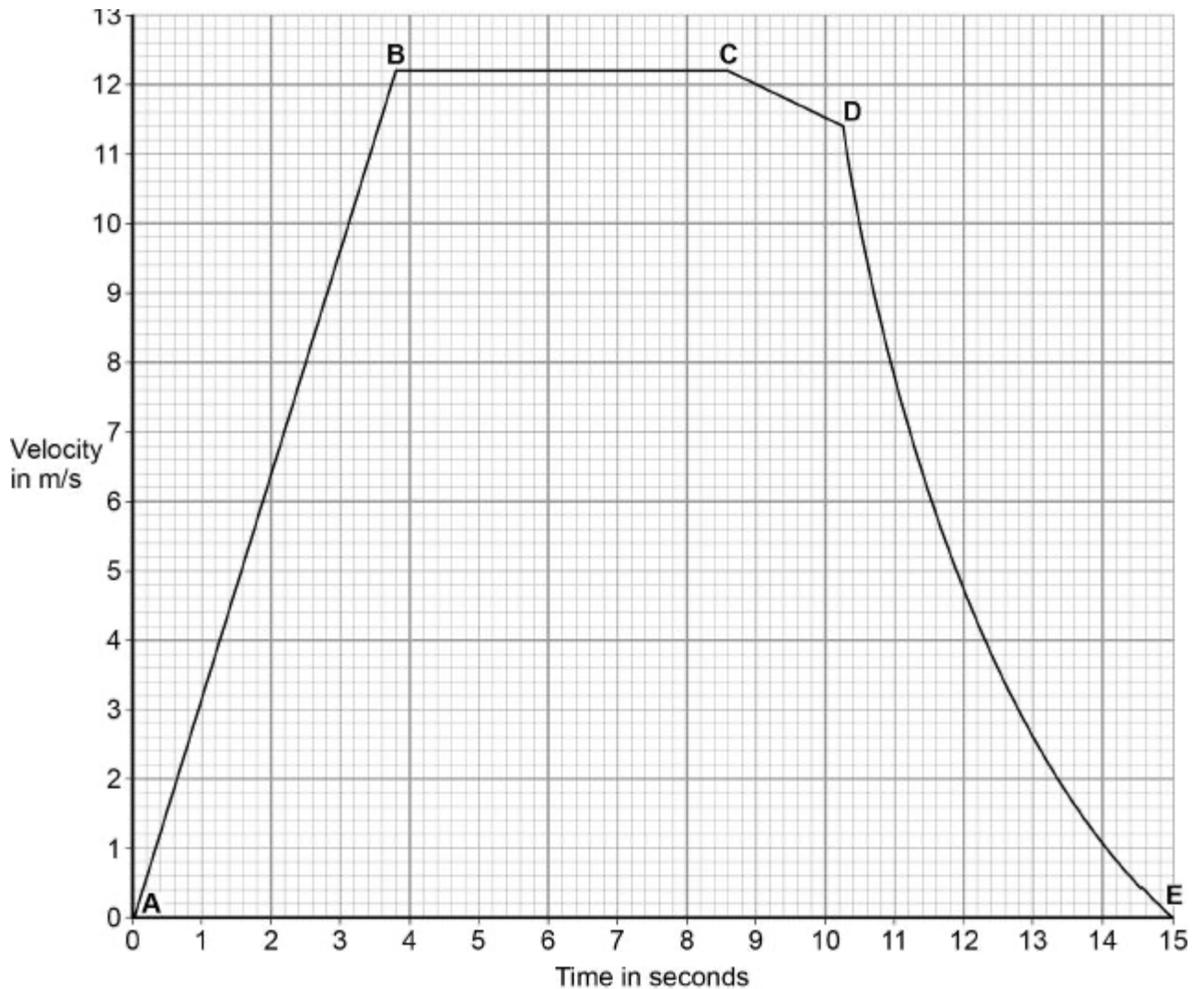
Give the unit.

Acceleration = _____ Unit _____

(5)

Figure 2 is a copy of **Figure 1** to help you answer the following questions.

Figure 2



A second athlete starts the race at the same time as the first athlete.

The second athlete moves with a constant acceleration of 1.6 m/s^2 for the first 6.0 seconds of the race.

The first athlete travels further than the second athlete during the first 6.0 seconds.

- (e) Draw a line on **Figure 2** to represent the motion of the second athlete for the first 6.0 seconds of the race.

(2)

- (f) Determine the extra distance travelled by the first athlete over the first 6.0 seconds of the race.

Use **Figure 2**.

Extra distance travelled by first athlete = _____ m

(4)

(Total 16 marks)

Q5.

Astronauts have landed on the Moon on six separate occasions.

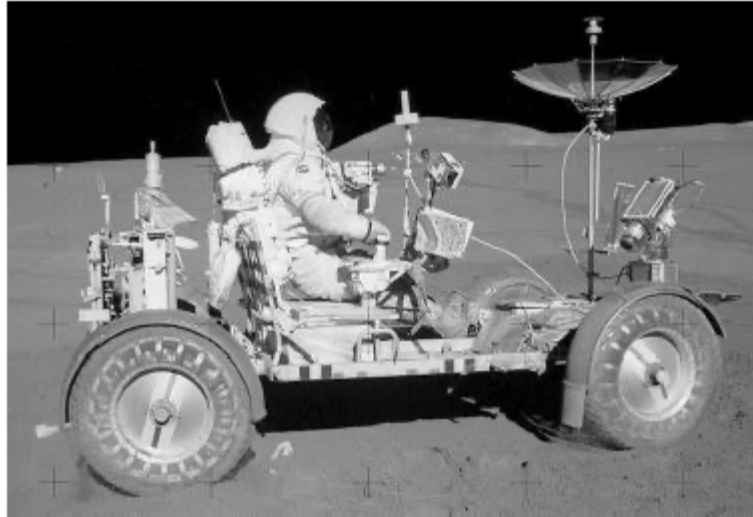
- (a) The Moon is in a circular orbit around the Earth. The speed of the Moon is constant.

Explain why the Moon is accelerating.

(3)

The astronauts moved around the surface of the Moon in a lunar rover.

The photograph below shows a lunar rover.



- (b) At one point, the lunar rover accelerated from 1.4 m/s to 2.6 m/s

The acceleration of the lunar rover was 0.31 m/s²

Which calculation could be used to calculate the distance travelled s during this acceleration?

Tick **one** box.

$$s = \sqrt{2.6^2 - 1.4^2 - 2 \times 0.31}$$

☐

$$s = \frac{1.4^2 - 2.6^2}{2 \times 0.31}$$

☐

$$s = \frac{2.6^2 - 1.4^2}{2 \times 0.31}$$

☐

$$s = \frac{2 \times (2.6^2 - 1.4^2)}{0.31}$$

☐

(1)

- (c) The lunar rover used four electric motors connected in parallel to a 36 V battery.

The maximum output power of one motor was 190 W

The efficiency of each motor was 72%

Calculate the current drawn from the battery when all four motors were operating at maximum power.

Current = _____ A

(6)

- (d) Scientists once thought that the Moon formed elsewhere in the solar system and later came to orbit the Earth.

Studies of Moon rocks brought back by the astronauts showed that the rocks were extremely similar to those found on Earth.

This led to a new theory about how the Moon formed called the 'Giant Impact Hypothesis'.

According to the Giant Impact Hypothesis, a small planet collided with the Earth. Molten rock thrown up by the collision then formed the Moon.

Suggest why a new theory was developed.

(2)

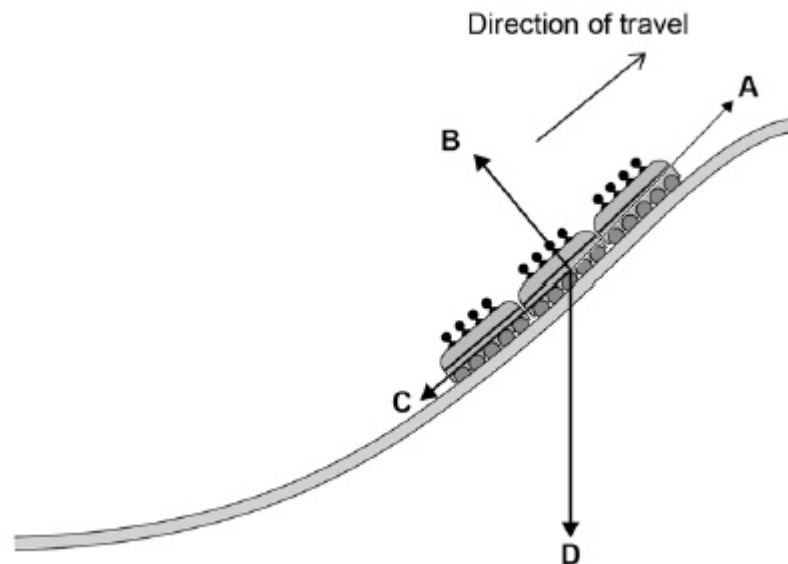
(Total 12 marks)

Q6.

Figure 1 shows a rollercoaster train as it is pulled up a slope on the track.

The arrows, **A**, **B**, **C** and **D**, represent the forces acting on the rollercoaster train.

Figure 1



(a) Give **two** ways that the force arrows show that forces are vector quantities.

1. _____

2. _____

(2)

(b) Which arrow shows the weight of the rollercoaster train?

Tick **one** box.

A ☐ B ☐ C ☐ D ☐

(1)

(c) Which arrow shows the normal contact force?

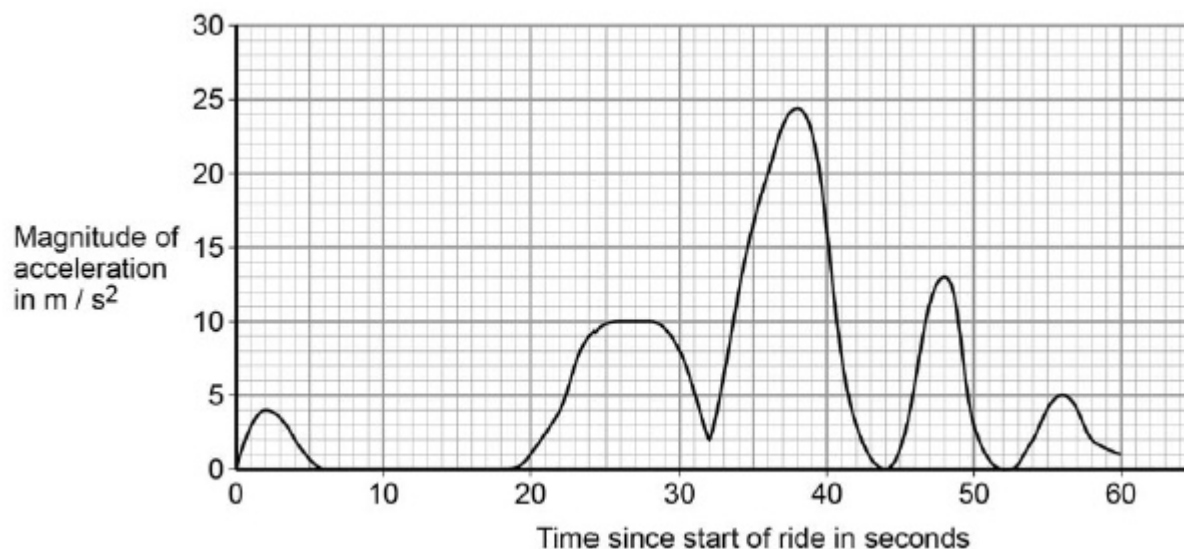
Tick **one** box.

A ☐ B ☐ C ☐ D ☐

(1)

Figure 2 shows the magnitude of the acceleration of the rollercoaster train during the ride.

Figure 2



(d) Why has a line graph been drawn instead of a bar chart?

Tick **one** box.

Acceleration is a control variable.

☐

Both variables are continuous.

☐

Line graphs are easier to read.

☐

Time is a categoric variable.

☐

(1)

(e) What conclusion can be made from **Figure 2** about the motion of the rollercoaster train between 10 and 15 seconds?

Tick **one** box.

It is moving at a constant velocity.

☐

Its velocity is decreasing.

☐

Its velocity is increasing.

☐

(1)

(f) What is the maximum acceleration of the rollercoaster train?

Use **Figure 2**.

Acceleration = _____ m/s²

(1)

(g) The maximum safe acceleration for most people is 5 times the acceleration due to gravity.

Acceleration due to gravity = 9.8 m/s^2

Explain whether the acceleration of this rollercoaster train is safe for most people

(3)

- (h) One of the passengers on the rollercoaster train has a mass of 58 kg

Calculate the maximum force experienced by the passenger during the ride.

Use the equation:

$$\text{force} = \text{mass} \times \text{acceleration}$$

Give the unit.

Maximum force = _____ Unit _____

(3)

(Total 13 marks)

Q7.

Figure 1 shows an electric wheelchair.

Figure 1



- (a) The wheelchair moves at a constant speed of 2.4 m/s for 4.5 seconds.

Calculate the distance moved by the wheelchair.

Use the equation:

$$\text{distance} = \text{speed} \times \text{time}$$

Distance = _____ m

(2)

- (b) What could be a reason for the speed of the wheelchair decreasing?

Tick **one** box.

It started going downhill.

☐

It started going uphill.

☐

Its store of kinetic energy increased.

☐

It used more power from its battery.

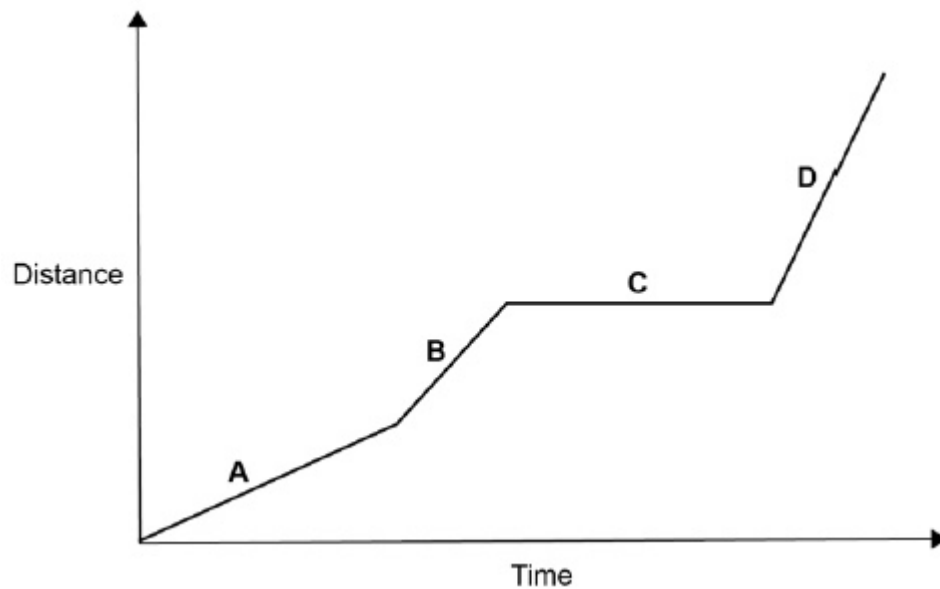
☐

(1)

A student measured how the distance travelled by the wheelchair changed over time.

Figure 2 shows a sketch-graph of the results.

Figure 2



- (c) In which section of the graph, **A**, **B**, **C**, or **D**, did the wheelchair travel fastest?

Give the reason for your answer.

Section _____

Reason _____

(2)

- (d) The student used a data logger with a distance sensor to record the data.

Give **two** advantages of using a data logger rather than using a stopclock and tape measure.

1. _____

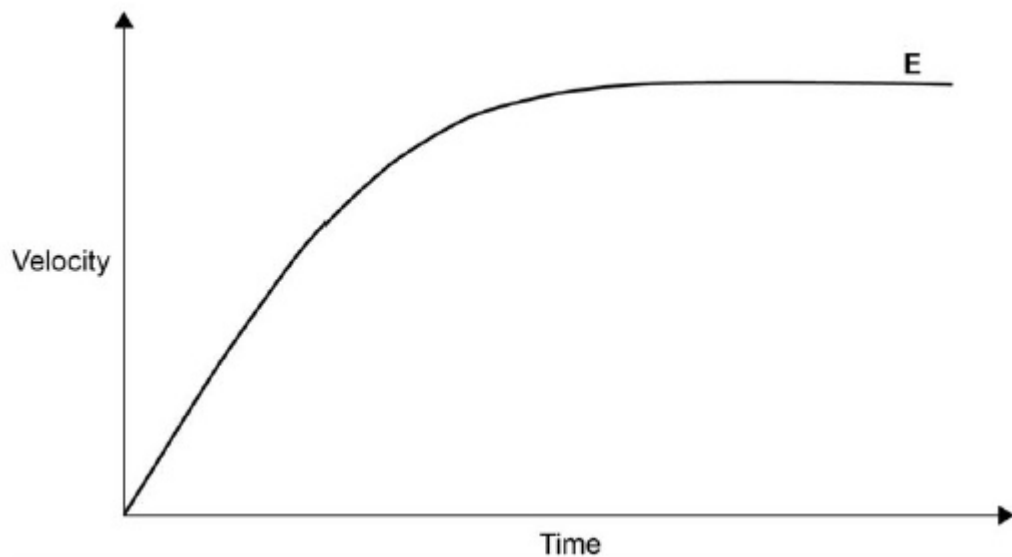
2. _____

(2)

The velocity of the wheelchair changes as it accelerates to its top speed.

Figure 3 shows a sketch-graph of the changes.

Figure 3



- (e) The forward force on the wheelchair is constant as it accelerates on flat ground.
Which force reduces the acceleration?

Tick **one** box.

Air resistance

☐

Magnetism

☐

Tension

☐

Weight

☐

(1)

- (f) Explain the acceleration of the wheelchair at point **E** on **Figure 3**.

(2)

- (g) The wheelchair starts from rest.

It accelerates at a constant rate until it has a speed of 1.5 m/s

The wheelchair travels a distance of 2.0 m while it is accelerating.

Calculate the acceleration of the wheelchair.

Using the Physics Equations Sheet.

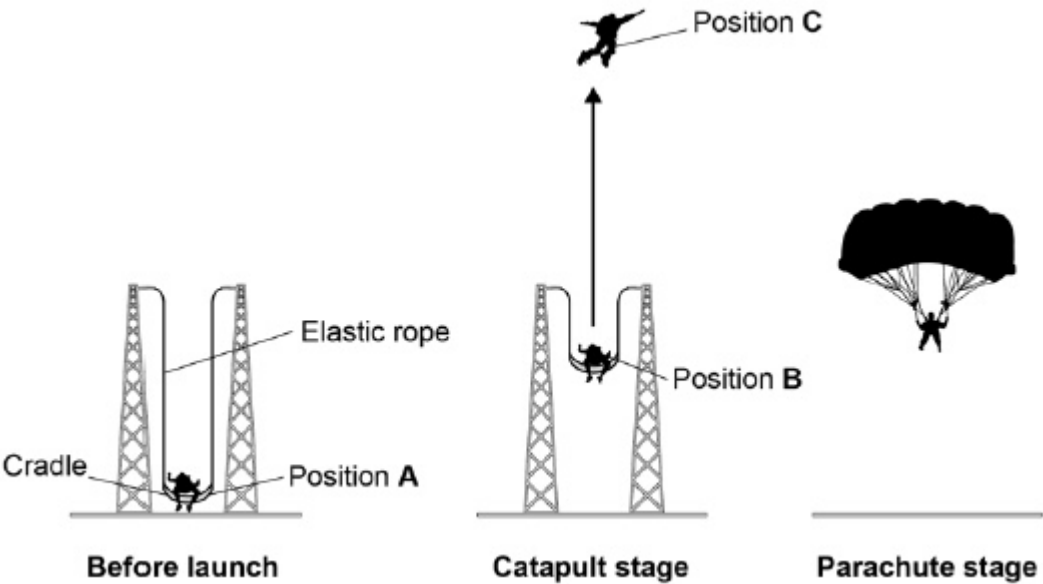
Acceleration = _____ m/s²

(3)
(Total 13 marks)

Q8.

The diagram shows the stages of an extreme sport called ‘human catapult’.

- A person lies in a cradle which is held to the ground.
- The cradle is released.
- The person is launched vertically into the air by an elastic rope.
- The person then parachutes back to the ground.



- (a) In position **A** there is a store of elastic energy.

Position **C** is the person’s maximum height.

Describe the energy transfers from position **A**, through position **B**, to position **C**.

(3)

- (b) In the last few metres of his descent during the parachute stage, the person travels at a terminal velocity.

Explain why.

(2)

- (c) When stretched in position **A**, the elastic rope stores 25 000 joules.

The elastic rope behaves like a spring, with a spring constant of 125 N/m

Calculate the extension of the elastic rope.

Use the Physics Equations Sheet.

Extension of elastic rope = _____ m

(4)

- (d) The vertical velocity of the person at position **B** in the diagram is 26 m/s

The vertical velocity at position **C** is 0 m/s

Calculate the distance between position **B** and position **C**. Ignore the effect of air resistance.

Use the Physics Equations Sheet.

Distance = _____ m

(4)

(Total 13 marks)

Q9.

Speed and velocity are different quantities.

- (a) Complete the sentence.

Choose the answers from the box.

distance	direction	scalar	time	vector
-----------------	------------------	---------------	-------------	---------------

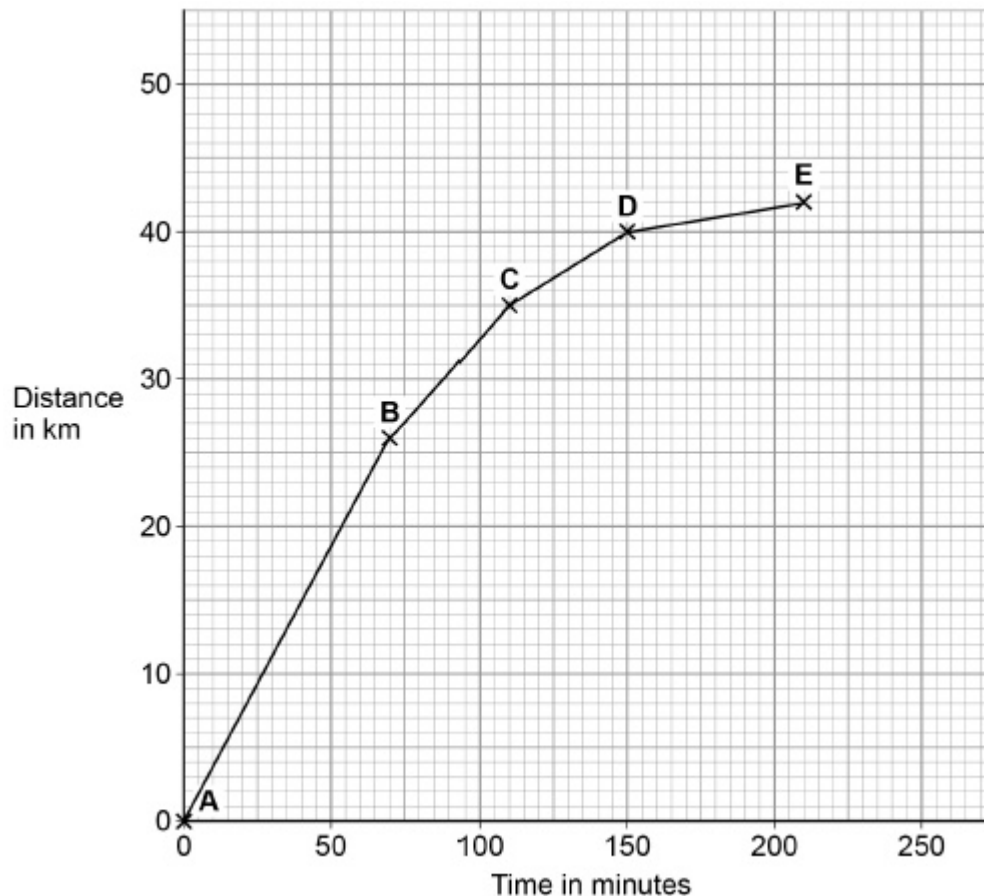
Velocity is a _____ quantity.

The velocity of an object is its speed in a given _____ .

(2)

Figure 1 shows the distance-time graph for an athlete in a running race.

Figure 1



(b) Determine the:

- distance of the race
- time taken for the athlete to complete the race.

Use **Figure 1**.

Distance = _____ km

Time taken = _____ minutes

(2)

(c) What is the motion of the athlete between points **B** and **C** on **Figure 1**?

Tick **one** box.

Moving at constant speed

☐

Moving with decreasing speed

☐

Moving with increasing speed

☐

Not moving

☐

(1)

(d) Which section on **Figure 1** shows the athlete moving at the highest speed?

Tick **one** box.

A to B	☐
B to C	☐
C to D	☐
D to E	☐

(1)

(e) How does the section you gave as your answer in part (d) show the highest speed?

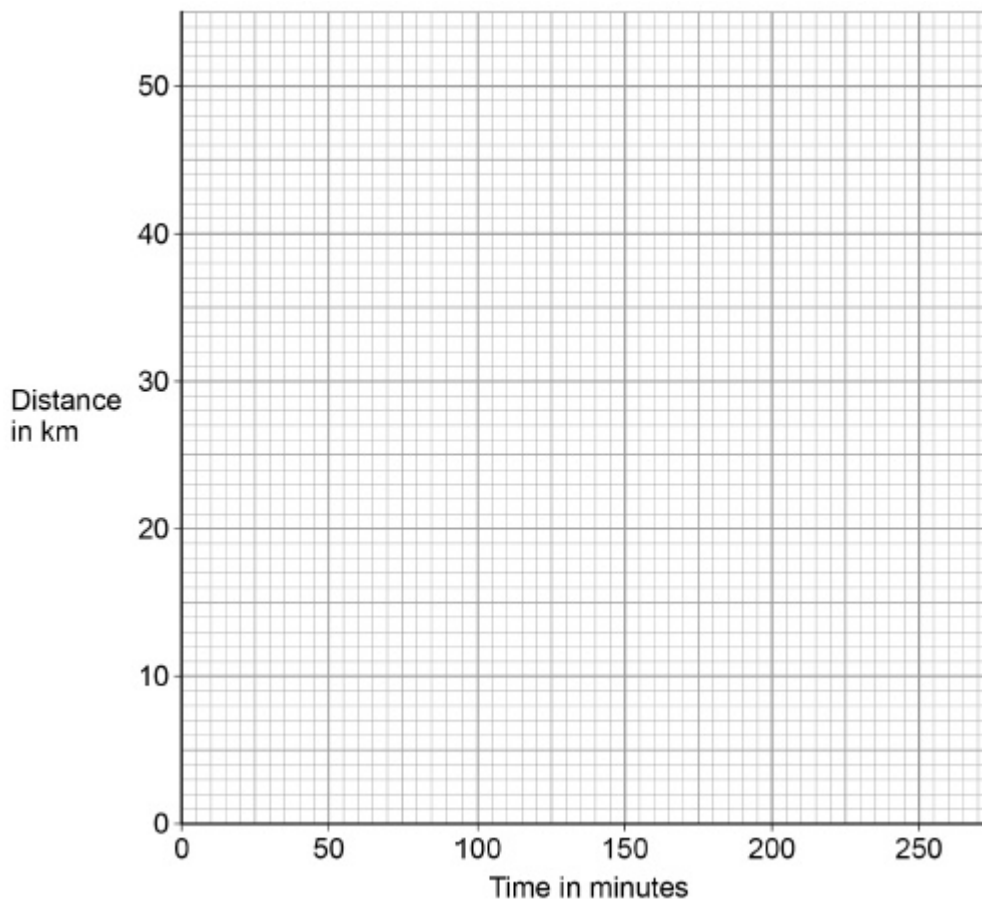
(1)

(f) A cyclist travelled the same distance as the athlete.

The cyclist travelled at a constant speed for 120 minutes.

Complete **Figure 2** to show a distance-time graph for the cyclist.

Figure 2



(2)

A car following the race accelerates at a constant rate in a straight line.

The velocity of the car increases from 1.9 m/s to 3.4 m/s in 60 seconds.

(g) Calculate the change in velocity of the car.

Change in velocity = _____ m/s

(1)

(h) Calculate the acceleration of the car.

Use your answer to part (g).

Use the equation:

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

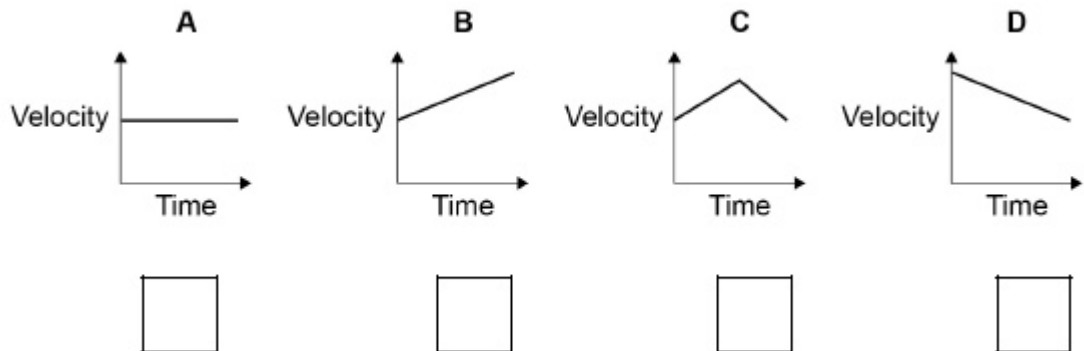
Give the unit.

Acceleration = _____ unit _____

(3)

- (i) Which graph shows how the velocity of the car changes as the car accelerates?

Tick **one** box.



(1)

(Total 14 marks)

Q10.

Speed and velocity are different quantities.

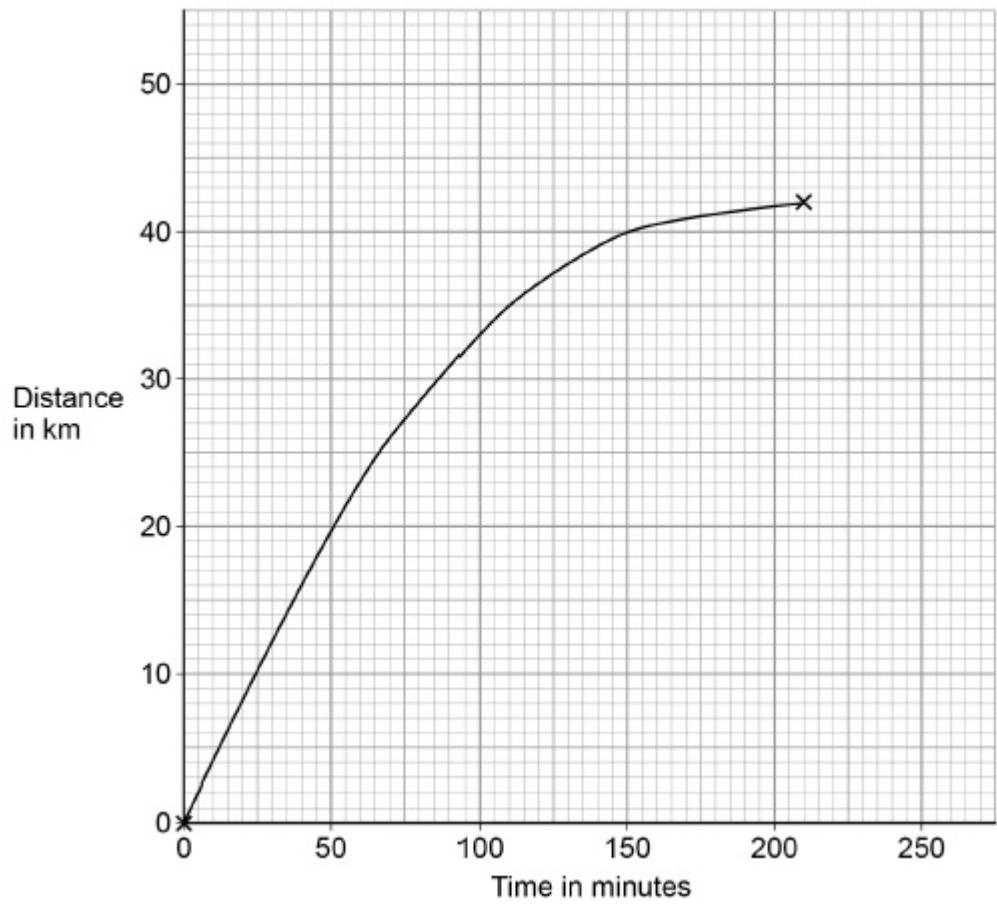
- (a) Complete the sentences.

Velocity is a _____ quantity.

The velocity of an object is its speed in a given _____.

(2)

The graph shows a distance-time graph for an athlete in a race.



- (b) Determine the distance of the race and the time taken for the athlete to complete the race.

Use the graph.

Distance = _____

Time = _____

(1)

- (c) Describe how you can use the graph to determine the velocity of the athlete 20 minutes after the start of the race.

(3)

A car following the race accelerates at a constant rate in a straight line.

The velocity of the car increases from 4.9 m/s to 6.4 m/s in 3.00 minutes.

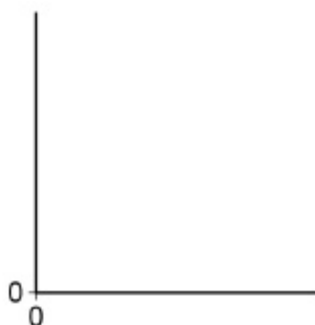
- (d) Calculate the acceleration of the car.

Give your answer to 3 significant figures.

Acceleration = _____ m/s²

(4)

- (e) Sketch a velocity-time graph to represent the acceleration of the car in part (d).



(2)

- (f) At the end of the race the car is travelling at 5.2 m/s

The brakes are applied causing the car to slow down and stop.

The brakes apply a constant force of 855 N in the opposite direction to the car's motion.

The mass of the car is 950 kg

Calculate the braking distance travelled by the car.

Braking distance = _____ m

(6)

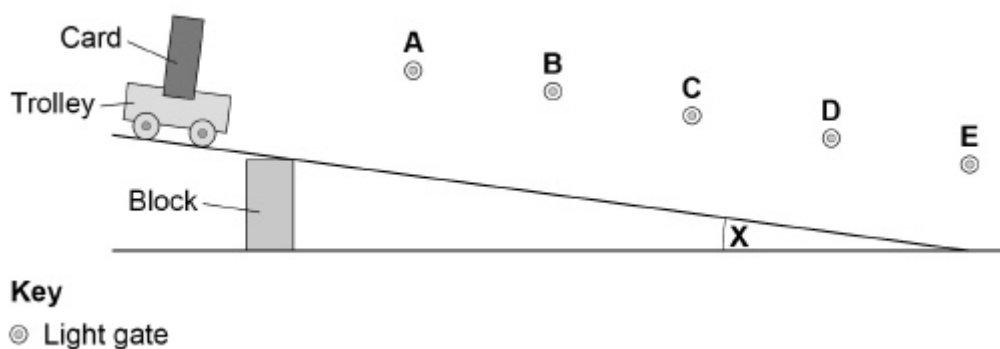
(Total 18 marks)

Q11.

A group of students investigated how the acceleration of a trolley depends on the angle of a ramp.

Figure 1 shows the apparatus.

Figure 1



The students released the trolley from the top of the ramp.

The light gates were attached to a data logger.

The data logger calculated the velocity of the trolley at each light gate.

- (a) When the students released the trolley they did not push it.

Suggest why this is important.

(1)

- (b) Measure angle **X** shown in **Figure 1**.

X = _____ degrees

(1)

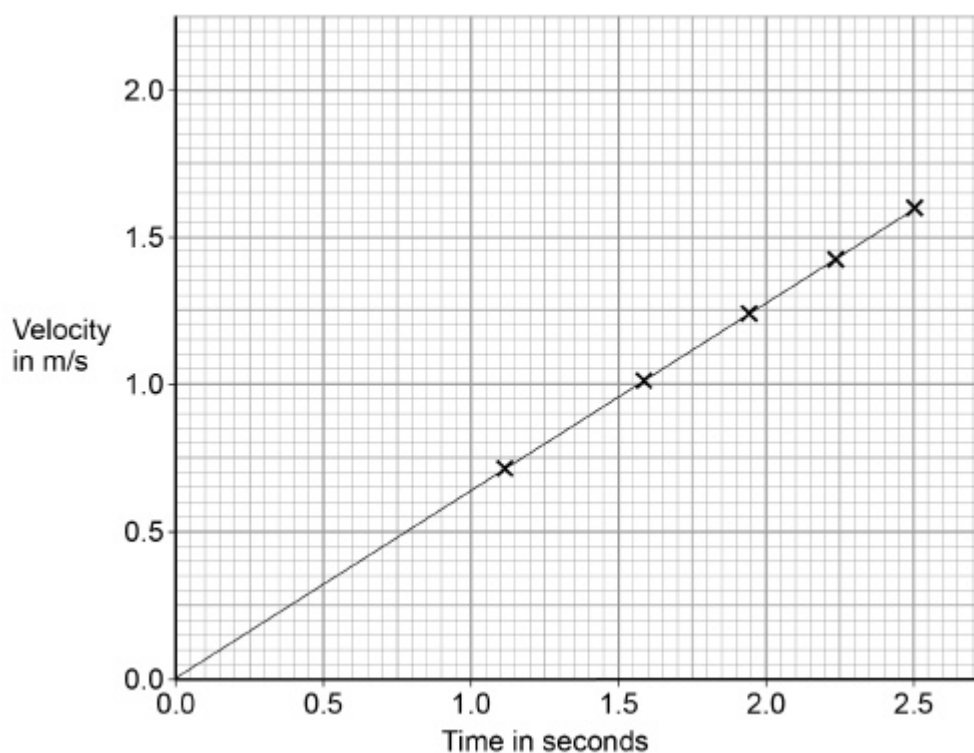
The students repeated the experiment with different angles of the ramp.

- (c) Suggest how the students could increase the angle of the ramp.

(1)

Figure 2 shows the velocity-time graph for the trolley when the angle of the ramp was **X**.

Figure 2



- (d) The gradient of the line represents the acceleration of the trolley.

Determine the acceleration of the trolley in **Figure 2**.

Acceleration = _____ m/s²

(3)

- (e) What does the area under the graph in **Figure 2** represent?

Tick **one** box.

Average velocity	
Maximum velocity	
Time taken	
Total distance travelled	

(1)

- (f) The students repeated the measurements for each angle several times.

Suggest how the students could check the repeatability of the data.

(2)

- (g) The trolley was released from a point 0.34 m above the surface the ramp was resting on.

The mass of the trolley was 0.75 kg

Gravitational field strength = 9.8 N/kg

Calculate the gravitational potential energy of the trolley before it was released.

Use the equation:

gravitational potential energy = mass $\times$ gravitational field strength $\times$ height

Gravitational potential energy = _____ J

(2)

(Total 11 marks)

Q12.

Figure 1 shows the forces acting on a car while it is moving.

Figure 1



- (a) What is the resultant force acting on the car when it is travelling at constant velocity?

Resultant force = _____ N

(1)

- (b) The car accelerates at 0.8 m/s^2

The mass of the car is 850 kg

Calculate the resultant force acting on the car while it is accelerating.

Use the equation:

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

Resultant force = _____ N

(2)

- (c) The driver notices a hazard and applies the brakes.

The car is travelling at 12 m/s

The driver's reaction time is 0.180 s

Calculate the distance travelled during the driver's reaction time.

Use the equation:

$$\text{distance travelled} = \text{speed} \times \text{time}$$

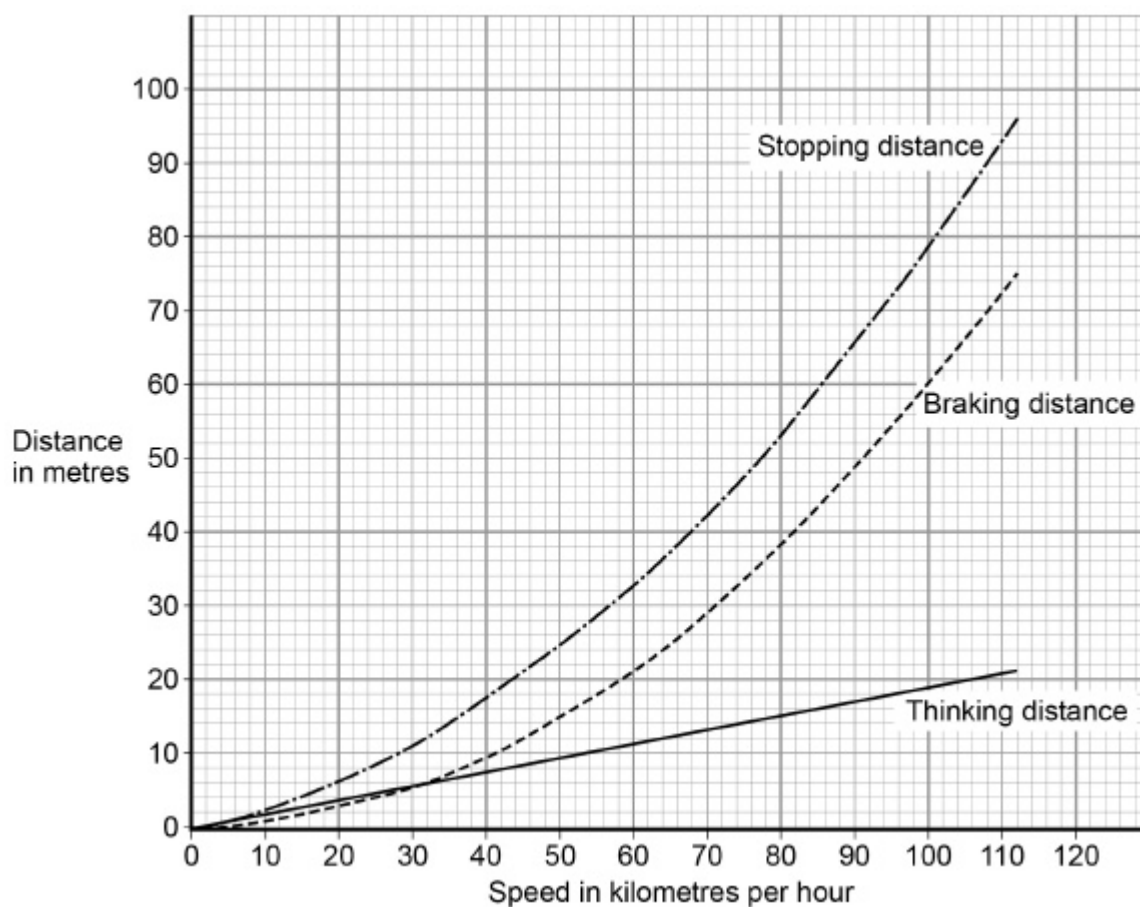
Distance travelled = _____ m

(2)

- (d) **Figure 2** shows how the thinking distance, braking distance and stopping distance

of a car change with speed.

Figure 2



Describe the trends in the data in **Figure 2**.

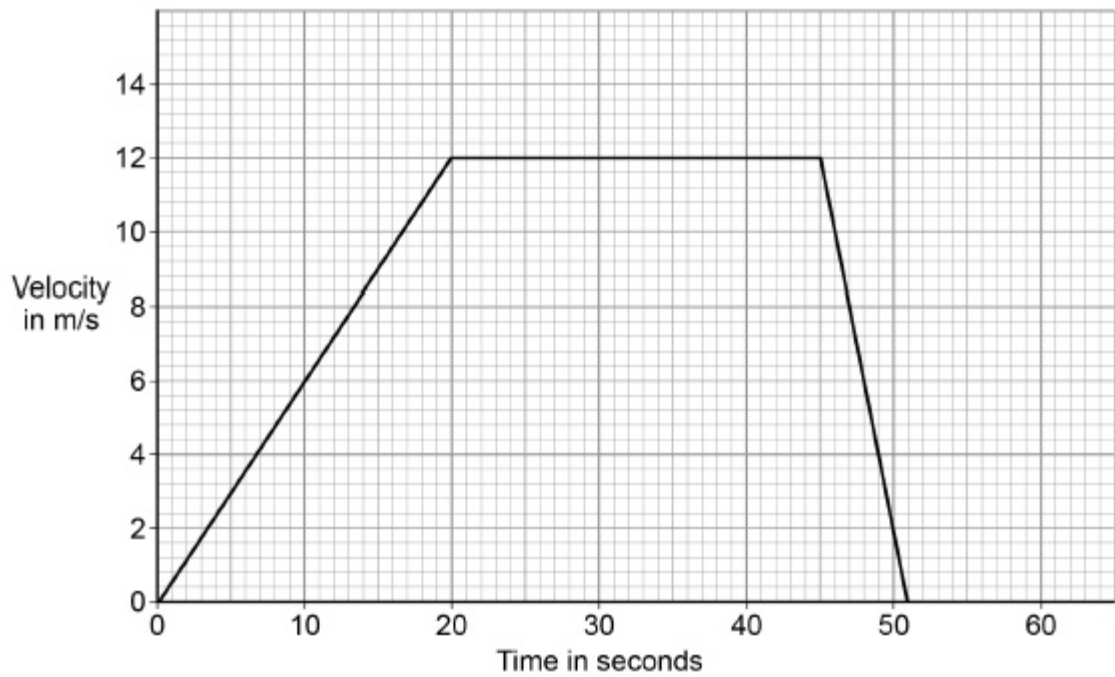
(3)

(Total 8 marks)

Q13.

Figure 1 shows a velocity–time graph for a short car journey.

Figure 1



- (a) Determine the acceleration of the car in the first 20 seconds of the journey.

Give the unit.

Acceleration = _____ Unit _____

(3)

- (b) Determine the total distance travelled by the car during the journey shown in **Figure 1**.

Total distance travelled = _____ m

(4)

- (c) The driver had to stop suddenly.

The car's shock absorbers are springs.

At one point while the car was braking, one shock absorber had an elastic potential energy of 258 J

The spring constant of the shock absorber is 45 300 N/m

Calculate the extension of the shock absorber.

Use the Physics Equations Sheet.

Extension = _____ m

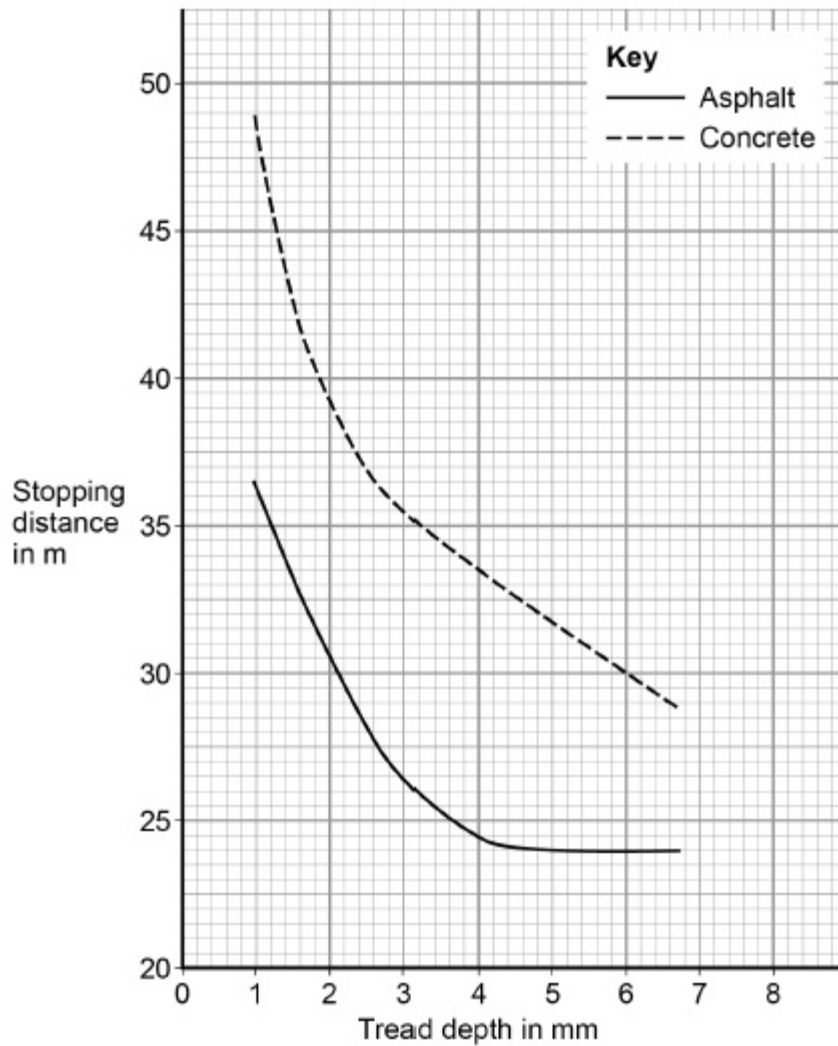
(3)

The stopping distance of a car can be affected by the condition of both the tyres and the road.

- The 'tread depth' of a tyre is the depth of the grooves in the tyre.
- Most roads have surfaces made of asphalt.
- Some roads have surfaces made of concrete.

Figure 2 shows how these factors affect the stopping distance for a car travelling at a certain speed.

Figure 2



- (d) Give **three** conclusions about the factors affecting stopping distance that can be made from **Figure 2**.

1. _____
2. _____
3. _____

(3)

- (e) The lowest stopping distance shown on **Figure 2** is 24 m

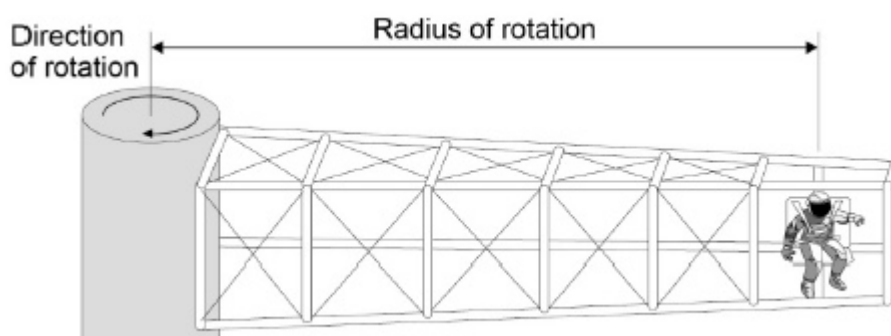
Explain why the stopping distance does not go below 24 m

Q14.

Figure 1 shows a 'G-machine'.

The G-machine is used in astronaut training.

Figure 1



- (a) The astronaut travels at constant speed in a circle.

Explain why the astronaut is accelerating.

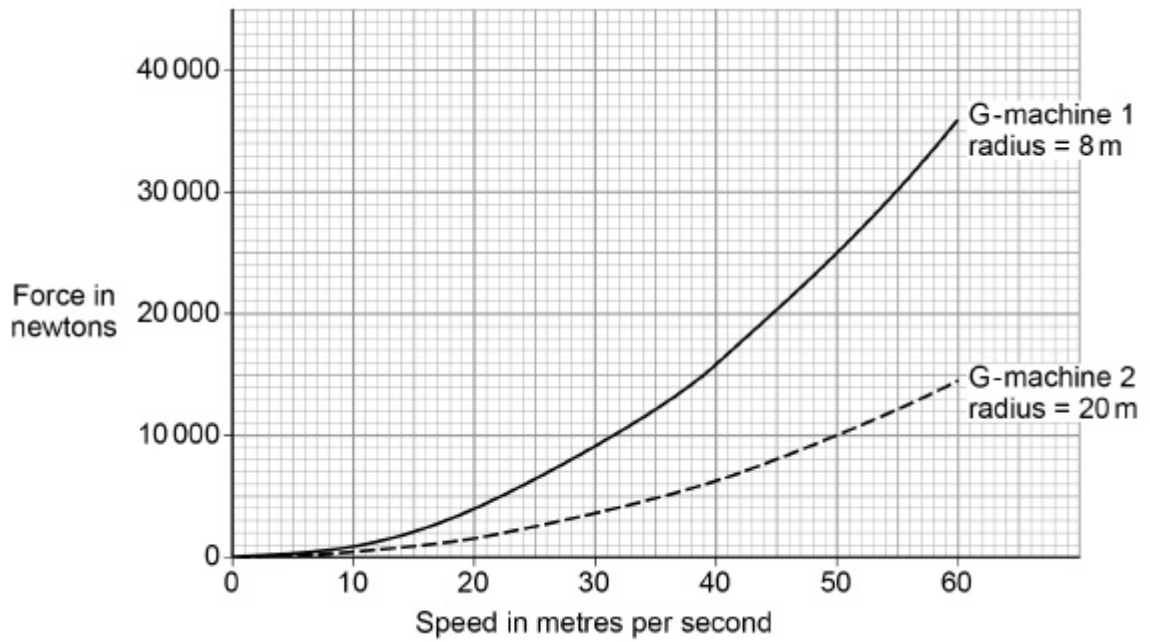
(3)

- (b) The force causing the astronaut to move in a circle is measured.

Figure 2 shows how the speed of the astronaut affects the force causing the astronaut to move in a circle.

The radius of rotation of the astronaut is different for each G-machine.

Figure 2



Give **three** conclusions about the factors affecting the size of the force required to move the astronaut in a circle.

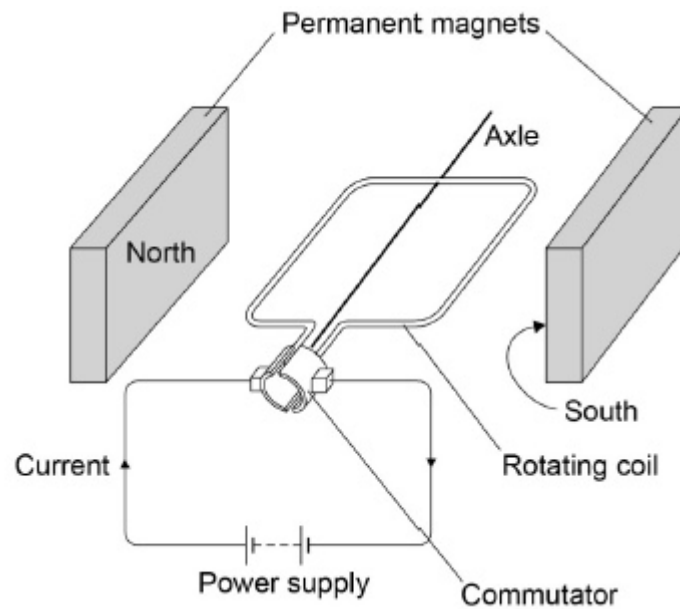
1. _____
- _____
2. _____
- _____
3. _____
- _____

(3)

- (c) Each G-machine is rotated by an electric motor.

Figure 3 shows a simple electric motor.

Figure 3



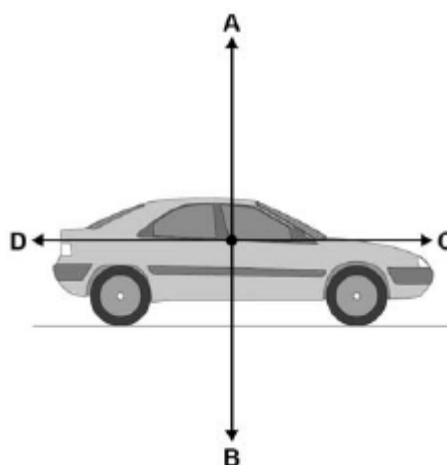
Explain why the coil rotates when there is a current in the circuit.

(3)
(Total 9 marks)

Q15.

Figure 1 shows the forces acting on a car moving at a constant speed.

Figure 1



- (a) Which force would have to increase to make the car accelerate?

Tick **one** box.

A

☐

B

☐

C

☐

D

☐

(1)

- (b) The car travels a distance of 2040 metres in 2 minutes.

Use the following equation to calculate the mean speed of the car.

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

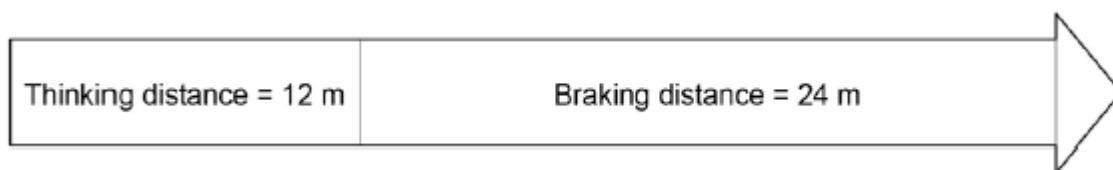
Mean speed = _____ m / s

(2)

- (c) The car makes an emergency stop.

Figure 2 shows the thinking distance and braking distance of the car.

Figure 2



What is the stopping distance?

(1)

- (d) The person driving the car is tired.

What effect will this have on the thinking distance and braking distance?

Tick **one** box for thinking distance.

Tick **one** box for braking distance.

decreases

increases

stays the

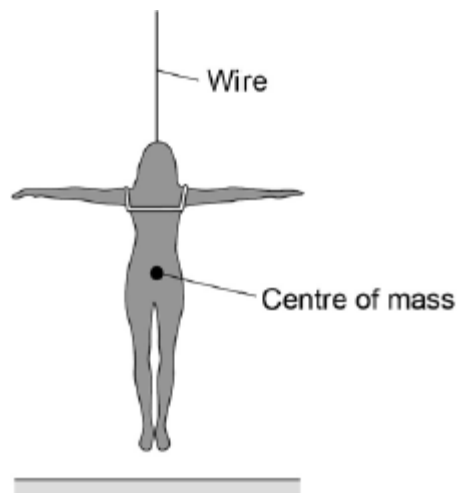
			same
thinking distance	☐	☐	☐
braking distance	☐	☐	☐

(2)
(Total 6 marks)

Q16.

An actor is attached to a wire so that she can hang above the stage.

Look at the figure below.



- (a) On The figure above draw two arrows to show the forces acting on the actor.

(2)

- (b) Which **two** forces are acting on the actor?

Tick **two** boxes.

Air resistance force	☐
Electrostatic force	☐
Gravitational force	☐
Magnetic force	☐
Tension force	☐

(2)

- (c) The actor hangs above the stage in a stationary position.

What is the resultant force on the actor?

Resultant force = _____ N

(1)

- (d) The actor has a mass of 70 kg.

Gravitational field strength = 9.8 N / kg

Use the following equation to calculate the weight of the actor.

Weight = mass $\times$ gravitational field strength

Give your answer to 2 significant figures.

Weight of actor = _____ N

(2)

- (e) A motor pulls vertically upwards on the wire with a force of 720 N.

Calculate the resultant force on the actor.

Resultant force = _____ N

(1)

- (f) Another actor has a mass of 65 kg.

This actor is attached to the wire and the motor pulls her vertically upwards.

The resultant force on the actor is 25 N.

Write down the equation that links acceleration, mass and resultant force.

Equation _____

(1)

- (g) Calculate the acceleration of the actor.

Acceleration of actor = _____ m / s²

(3)

(Total 12 marks)

Q17.

Four students tested their reaction times using a computer program.

When a green light appeared on the screen the students had to press a key.

Table 1 shows their results.

Table 1

Student	Reaction time in s			Mean reaction time in s
	Test 1	Test 2	Test 3	
Boy 1	0.28	0.27	0.26	0.27
Boy 2	0.28	0.47	0.22	0.29
Girl 1	0.31	0.29	0.27	0.29
Girl 2	0.32	0.30	0.29	0.30

- (a) What is meant by 'reaction time' in this experiment?

(1)

- (b) Boy 2 had an anomalous result in **Test 2**.

Suggest a reason why.

(1)

- (c) Give **one** conclusion that can be made from the results in **Table 1**.

(1)

- (d) Suggest further evidence that you could collect to support your conclusion.

(1)

- (e) Reaction time is important at the start of a race.

Table 2 shows the time taken by a boy to run different distances.

Table 2

Distance in m	Time in s
100	12.74
200	25.63
800	139.46

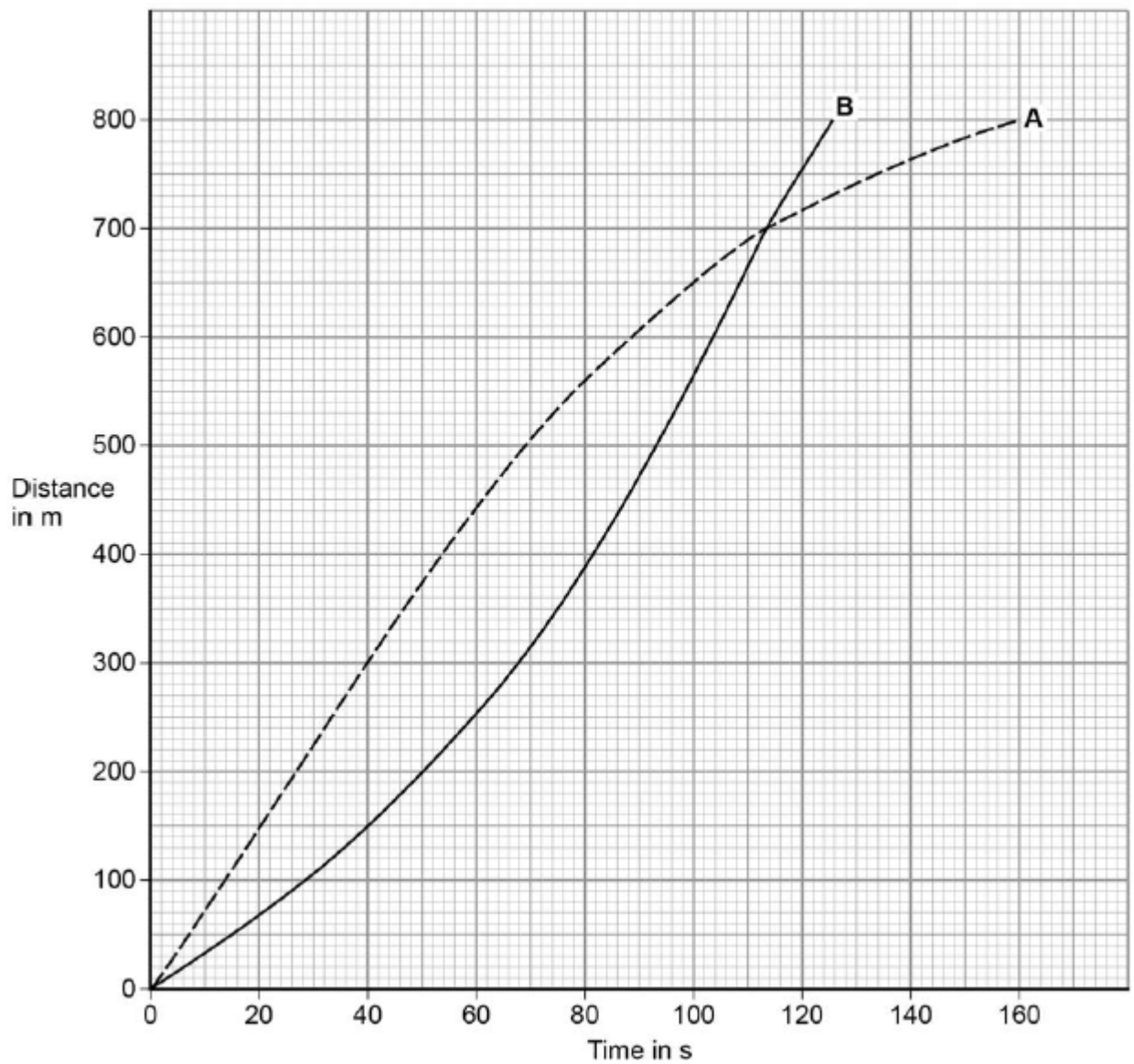
Reaction time is more important in a 100 m race than in an 800 m race.

Explain why.

(2)

- (f) Two girls, **A** and **B**, ran an 800 m race.

The figure below shows how the distance changed with time.



Compare the motion of runners **A** and **B**.

Include data from the figure above.

Q18.

This question is about speed.

- (a) What is a typical value for the speed of sound?

Tick **one** box.

3.3 m / s

☐

3.3×10^2 m / s

☐

3.3×10^3 m / s

☐

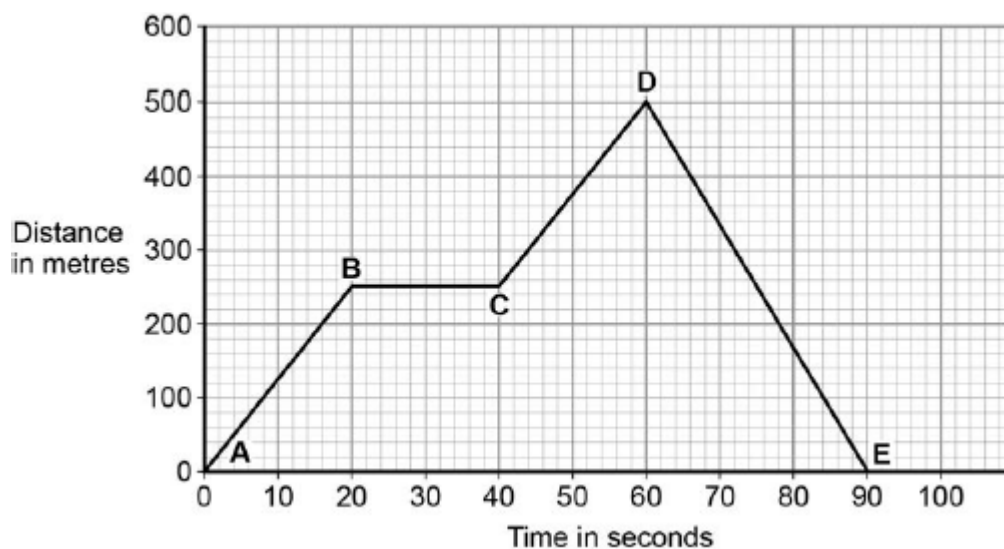
3.3×10^6 m / s

☐

(1)

- (b) **Figure 1** shows a distance–time graph of a car.

Figure 1



Explain what **Figure 1** shows about the motion of the car between point **A** and point **E**.

You should use values from **Figure 1** in your answer.

(4)

- (c) The kinetic energy of a moving car depends on the car's mass and speed.
Write down the equation that links kinetic energy, mass and speed.

(1)

- (d) A car has a mass of 1 650 kg.
The table below shows the kinetic energy of the car moving at 11 m / s.

Mass of car in kg	Speed in m / s	Kinetic energy in J
1 650	11	99 825
1 650	30	

Calculate the missing value in the table above.
Give your answer in kilojoules (kJ).

Kinetic energy = _____ kJ

(2)

- (e) A man is driving his car at a constant speed on a wet road.
He sees a fallen tree on the wet road and tries to stop quickly to prevent an accident.

Figure 2



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Explain why the man may not be able to stop in time.

(6)

(Total 14 marks)

Q19.

The figure below shows an ice skater standing on the ice.



Mass
70 kg

- (a) Write down the equation that links acceleration, change in velocity and time.

_____ (1)

- (b) As the skater pushes away across the ice there is a small frictional force.

After pushing, the skater starts to move with a velocity of 5 m / s.

He slows to 3 m / s in 6 seconds.

Calculate the acceleration of the skater.

Acceleration = _____ m / s² (2)

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

_____ (1)

- (d) Friction reduces the speed of the skater.

Calculate the frictional force acting on the skater to slow him down.

Frictional force = _____ N (2)

- (e) The skater stands still on the ice.

He throws his bag to a friend.

As he throws his bag forwards, the skater moves backwards across the ice.

Use the idea of conservation of momentum to explain why he moves backwards.

(4)

(Total 10 marks)

Mark schemes

Q1.

- (a) either:
7.5 (m) **and** 12.3 (m) from the graph
or
15 (m/s) $\times$ 0.32 (s) using speed
allow 7.5 (m) and between 12.2 (m) and 12.4 (m)

1

extra distance = 4.8 (m)

1

an answer between 4.7 (m) and 4.9 (m) scores 2 marks

- (b) there is a decrease in kinetic energy of the car
allow work is done by friction (on the brakes)

1

so this (causes) the internal / thermal energy store of the brakes to increase

1

- (c) $19^2 - u^2 = 2 \times 2 \times 84$

1

$$u^2 = 19^2 - (2 \times 2 \times 84)$$

1

$$u = 5 \text{ (m/s)}$$

$$u = \sqrt{19^2 - (2 \times 2 \times 84)}$$

1

an answer of 5 (m/s) scores 3 marks

- (d) **Level 3:** Scientifically relevant facts, events or processes are identified and given in detail to form an accurate account.

5–6

Level 2: Scientifically relevant facts, events or processes are identified and their relevance is clear. The account is not fully accurate.

3–4

Level 1: Facts, events or processes are identified and simply stated but their relevance is not clear.

1–2

No relevant content

0

Indicative content

- use of drugs, alcohol, tiredness and distractions would increase the thinking distance
- thinking distance increases with speed
- thinking distance is directly proportional to speed
- use of drugs, alcohol, tiredness and distractions would increase the

gradient of thinking distance

- poor brakes, poor tyres, wet / icy roads and mass would increase the braking distance
- braking distance increases with speed
- braking distance increases at an increasing (accept greater) rate (with speed)
- poor brakes, poor tyres, wet / icy roads and mass would increase the gradient of braking distance
- braking distance is directly proportional to speed squared
- stopping distance = thinking distance + braking distance
- factors that increase thinking and / or braking distance would increase the gradient of stopping distance
- stopping distance increases at an increasing (accept greater) rate (with speed)

[13]

Q2.

(a) any **two** from:

- alcohol
- drugs

allow named drugs

- tiredness
- distraction

allow named distractions

allow caffeine

allow age

ignore drinking unqualified

2

(b) any **one** from:

- speed of vehicle
- condition of tyres
- condition of brakes
- condition of road surface
- water / ice / snow on road
- braking force

allow mass of vehicle

1

(c) (s =) 13×0.6

1

= 7.8 (m)

1

an answer of 7.8 (m) scores 2 marks

(d) 21.8 (m)

allow ecf from part (c)

1

(e) the greater the braking distance

1

- (f) brakes overheat
allow damage to brakes 1
- car goes out of control
allow skidding
allow damage to car or occupants 1
- [9]

Q3.

- (a) 1.5 m/s 1
- (b) 6.0 m/s 1
- (c) **C** = 3.8 (s) **and** **D** = 8.6 (s) 1
- (t =) 4.8 (s)
allow correct subtraction of incorrect values given for C and / or D 1
- (d) straight line from **E** to x-axis 1
- finishing at 14 s 1
- (e) C-D 1
- (f) C-D 1
- (g) distance travelled 1
- (h) (resultant) force = mass × acceleration
allow $F = m a$ 1
- (i) $a = \frac{11.6}{3.2}$ 1
- = 3.625 (m/s²)
allow 3.6 (m/s²) or 3.63 (m/s²) 1
- an answer of 3.6 / 3.625 / 3.63 (m/s²) scores 2 marks*
- [12]

Q4.

- (a) air resistance
allow drag
ignore wind resistance 1
- (b) B–C 1
- (c) (velocity =) 12.2 (m/s) 1
- (momentum =) 94.8×12.2 1
- (momentum =) 1160 (kg m/s)
allow an answer that rounds to 1160 (kg m/s)
an answer of 1147 / 1150 scores 2 marks 1
an answer of 1160 (kg m/s) scores 3 marks
- (d) tangent drawn at 12 s 1
- correct readings of Δv and Δt from tangent 1
- (acceleration) = $\frac{\text{their value of } \Delta v}{\text{their value of } \Delta t}$ 1
- 2.4 (m/s²)
allow value in range –2.2 to –2.6 (m/s²)
allow a correctly calculated answer from

$$-\frac{\text{their value of } \Delta v}{\text{their value of } \Delta t}$$
 1
- m/s²
allow m/s/s 1
- (e) straight line (with gradient of 1.6) from origin to 6 s, 9.6 m/s
allow 1 mark for a straight line below A–B with a positive gradient from origin to 6 s 2
- (f) (calculation of distance travelled by first athlete)
- $(2.2 \times 12.2) = 26.84$ (m) 1
- $(0.5 \times 3.8 \times 12.2) = 23.18$ (m) 1
- an answer of 50.02 (m) scores 2 marks*
- (calculation of distance travelled by second athlete)

$$(0.5 \times 9.6 \times 6 =) 28.8 \text{ (m)}$$

allow ecf from part (e)

$$\text{allow } (9.6^2 - 0 = 2 \times 1.6 \times s =) 28.8 \text{ (m)}$$

1

$$(\text{calculate difference}) = 21.22 \text{ (m)}$$

allow their distance for athlete 1 minus their distance for athlete 2

1

an answer of 21.22 (m) scores 4 marks

[16]

Q5.

(a) (in circular motion) the direction is (constantly) changing

1

(so) velocity is (constantly) changing

1

(and) acceleration is rate of change of velocity

allow

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time}}$$

1

$$(b) \quad s = \frac{2.6^2 - 1.4^2}{2 \times 0.31}$$

1

$$(c) \quad 0.72 = \frac{190}{P_{\text{input}}}$$

$$\text{allow } \frac{72}{100} = \frac{190}{P_{\text{input}}}$$

1

$$P_{\text{input}} = \frac{190}{0.72}$$

1

$$P_{\text{input}} = 264 \text{ (W)}$$

allow an answer that rounds to 264 (W)

1

$$264 = 36 \times I$$

allow their calculated

$$P_{\text{input}} = 36 \times I$$

1

$$I = 7.33 \text{ (A)}$$

1

$$I = 29 \text{ (A)}$$

allow an answer that rounds to 29 (A)
allow their value for 1×4 correctly calculated

1

an answer of 29 (A) scores **6** marks

- (d) old theory suggests Moon rocks would be different from Earth rocks

1

(but) new evidence shows they are similar

this mark is dependent on scoring the first mark

1

allow **1** mark for new evidence (from studying
Moon rocks) could not be explained by the old
theory

[12]

Q6.

- (a) the arrows have different lengths

allow forces can have different sizes

1

the arrows point in different directions

allow forces can have different directions

1

- (b) **D**

1

- (c) **B**

1

- (d) both variables are continuous

1

- (e) it is moving at a constant velocity

1

- (f) $24.5 \text{ (m/s}^2\text{)}$

1

- (g) $5g = 49 \text{ (m/s}^2\text{)}$

1

$49 \text{ m/s}^2 > 24.5 \text{ m/s}^2$

1

so the ride is safe

allow ecf from (f) (ie if their answer to (f) was greater than 49,
then the ride is unsafe)

1

- (h) force = 58×24.5

allow ecf from (f)

1

force = 1421

1

Newton's

allow N

1

[13]

Q7.

- (a) distance = $2.4 \text{ m/s} \times 4.5 \text{ s}$

1

distance = 10.8 (m)

an answer of 10.8 m scores 2 marks

1

- (b) It started going uphill.

1

- (c) **D**

1

the line has the largest gradient

allow it is steepest

allow it travels the furthest distance in the shortest amount of time

1

- (d) any **two** from:

- the data logger records time more accurately
- the data logger can take readings more frequently
- there is less chance for human error when using a data logger
- the data logger automatically records data

allow the converse of each argument, eg there is a human reaction time error when using a stopclock

2

- (e) air resistance

1

- (f) acceleration is zero

1

because the resultant force is zero

allow because the forward force equals the air resistance

there is too much air resistance is insufficient

1

- (g) $v^2 - u^2 = 2as$
 $1.5^2 - 0^2 = 2 \times a \times 2$

1

$$a = \frac{1.5^2}{2 \times 2}$$

1

$$a = 0.56(25) \text{ m/s}^2$$

an answer of 0.56(25) (m/s²) scores 3 marks

1

Q8.

- (a) between **A** and **B** (the elastic store decreases and) the kinetic and gravitational stores increase

1

between **B** and **C** the kinetic store decreases and the gravitational store increases

1

the internal energy store of the surroundings increases

*allow **either***

some energy is dissipated to the surroundings

or

some energy is dissipated as heat / sound

1

- (b) the weight and air resistance are equal and opposite

1

so the resultant force is zero

1

- (c) $25\,000 = \frac{1}{2} \times 125 \times e^2$

1

$$e^2 = \frac{2 \times 25000}{125}$$

1

$$e = \sqrt{\frac{2 \times 25000}{125}}$$

1

$$e = 20 \text{ (m)}$$

*an answer of 20 (m) scores **4** marks*

1

- (d) acceleration = (-9.8 m/s^2)

1

$$0^2 - 26^2 = 2 \times (-9.8) \times s$$

1

$$s = \frac{-26^2}{2 \times (-9.8)}$$

1

$$s = 34 \text{ (m)}$$

allow any correct rounding of 34.489...

*an answer of 34 (m) scores **4** marks*

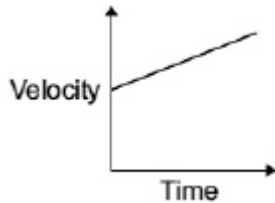
1

Q9.

- (a) vector 1
- direction
must be in this order 1
- (b) 42 (km) 1
- 210 (minutes) 1
- (c) moving at constant speed 1
- (d) **A to B** 1
- (e) the gradient / line is the steepest (in this section) 1
- (f) straight line from origin 1
- finishing at 42 km **and** 120 minutes (2 hours)
allow ecf from part (b) 1
- (g) 1.5 (m/s) 1
- (h) $\frac{1.5}{60}$
allow ecf from part (g) 1
- 0.025
an answer of 0.025 scores 2 marks 1
- m/s² 1
- (i) **B** 1
- [14]**

Q10.

- (a) vector 1
- direction
must be in this order 1

- (b) 42 km **and** 210 minutes 1
- (c) draw a tangent 1
- at 20 minutes 1
- measure the gradient of the tangent 1
- (d) 1.5 m/s 1
- 180 (s) 1
- $\frac{1.5}{180}$ 1
- 0.00833 (m/s²)
- an answer of 0.00833 (m/s²) scores 4 marks*
- an answer of 0.0083333 (m/s²) scores 3 marks*
- an answer of 0.500 (m/s²) scores 3 marks*
- an answer of 0.5 (m/s²) scores 2 marks* 1
- (e) axes labelled and velocity intercept on y-axis 1
- straight line with increasing gradient
- an answer of:*
- 
- scores 2 marks 1
- (f) $-855 = 950 \cdot a$
- ignore sign* 1
- $a = \frac{-855}{950}$ 1
- $a = -0.9 \text{ (m/s}^2\text{)}$ 1
- $0^2 - 5.2^2 = 2 \cdot (-0.9) \cdot s$
- $(v^2 - u^2 = 2as)$
- for this mark, sign of a must be opposite to sign of u, ie*

allow:

$$0^2 - (-5.2)^2 = 2 \times 0.9 \times s$$

1

$$s = \frac{-27.04}{-1.8}$$

ignore signs

1

$$s = 15.0 \text{ (m)}$$

an answer of 15.0 (m) scores **6** marks

allow credit for use of a correct alternative method

1

[18]

Q11.

- (a) so that there wasn't any extra force

1

- (b) 8 (degrees)

allow a range 7–9 (degrees)

1

- (c) increase the height of the block or move the block to the right

or

move the block to the right

allow any other safe suggestion for increasing the angle

1

- (d) two correct pairs of values taken from graph

1

values substituted into:

$$\text{gradient} = \frac{\text{change in } y}{\text{change in } x}$$

1

correctly calculated value

an answer of 0.64 (m/s²) gains **3** marks

allow full credit for correct use of a single pair of values taken anywhere from the straight line

1

- (e) total distance travelled

1

- (f) compare the data from the tests (for the same angle)

1

to see if the results are similar

1

- (g) GPE = 0.75 × 9.8 × 0.34

1

GPE = 2.499 (J)

an answer of 2.499 (J) or rounded to 2.5 (J) scores 2 marks

1

[11]

Q12.

(a) 0 (N)

1

(b) $F = 850 \times 0.8$

1

$F = 680$ (N)

an answer of 680 (N) scores 2 marks

1

(c) 12×0.18

1

$= 2.16$ (m)

an answer of 2.16 (m) scores 2 marks

1

(d) distance increases with speed

1

thinking distance increases linearly

allow thinking distance is directly proportional to speed for first 2 marks

1

braking / stopping distance increases at an increasing rate

allow braking distance is proportional to square of speed

1

[8]

Q13.

(a) $a = 12/20$

1

$= 0.6$

1

m/s²

an answer of 0.6 scores 2 marks

if first 2 marks not awarded, allow 1 mark for an attempt to determine $a = \Delta v/t$ with incorrect values from graph

allow ms⁻²

1

(b) (first calculate area under graph) 20s: $0.5 \times 20 \times 12 = 120$ (m)

1

next 25s: $25 \times 12 = 300$ (m)

1

final 6s: $0.5 \times 6 \times 12 = 36$ (m)

1

total: $120 + 300 + 36 = 456$ (m)

an answer of 456 (m) scores 4 marks

1

(c) $258 = \frac{1}{2} 45\,300 \times e^2$

1

$$e = \sqrt{\frac{2 \times 258}{45\,300}}$$

1

$= 0.107$ (m)

an answer of 0.107 (m) scores 3 marks

allow 0.11, 0.106727...

1

(d) stopping distances lower on asphalt than concrete (for all tread depths)

1

as tread depth increases, stopping distance decreases

1

below a certain tread depth, stopping distance increases much faster

if values quoted, expect to see

4 mm for asphalt and 2.5 mm for concrete

1

(e) stopping distance also includes thinking distance

allow stopping distance = thinking distance + braking distance

1

braking distance can never be zero

1

[15]

Q14.

(a) velocity is a vector (so has both magnitude and direction)

1

direction is changing (and so velocity is changing)

1

if velocity is changing, there is an acceleration

1

(b) as radius increases, force required decreases

allow converse statements for all marking points

1

as speed increases, force required increases

1

at greater speeds, change in force for same change in speed is greater
allow force proportional to square of speed

1

- (c) a conductor carrying a current in magnetic field has a force exerted on it (by the motor effect)

1

(so) force on opposite sides in opposite directions (so the coil turns)

allow current in opposite directions

1

as coil turns, commutator reverses direction of current relative to coil (so rotation can continue)

allow current / force directions in terms of arrows on the diagram (force directions do not have to be correct from Fleming's LHR to illustrate the point)

1

[9]

Q15.

- (a) C

1

- (b) 2040 / 120

1

17 (m / s)

1

allow 17 (m / s) with no working shown for 2 marks

- (c) the thinking distance and the braking distance combined

accept 36 m

1

- (d) thinking distance increases

1

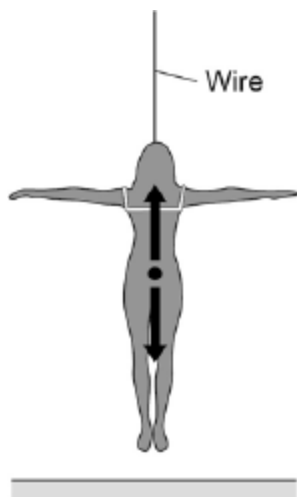
braking distance stays the same

1

[6]

Q16.

- (a)



arrow pointing vertically upwards

1

arrow pointing vertically downwards

1

(b) Gravitational force

*if more than **two** boxes ticked apply list principle*

1

Tension force

1

(c) 0 (N)

1

(d) weight = 70×9.8 (= 686)

1

weight = 690 (N)

1

*allow 690 (N) with no working shown for **2** marks*

*allow 686 (N) with no working shown for **1** mark*

(e) 34 (N) / 30 (N)

allow ecf from 05.4 correctly calculated

1

(f) resultant force = mass $\times$ acceleration

accept $F = ma$

1

accept equation correctly rearranged for a

(g) $25 = 65 \times a$

1

$a = 25 / 65$

1

$a = 0.38(4615...) \text{ (m / s}^2\text{)}$

1

*allow 0.38 (m / s²) with no working for **3** marks*

[12]

Q17.

- (a) the time it took from seeing the green light to pressing a key

1

- (b) he could have been distracted

1

- (c) boys have a shorter reaction time than girls

or

reaction time improves with practice

1

- (d) collect more data / larger sample size
must link to response in 06.3

or

take more repeat readings per person

1

- (e) reaction time will have less effect (as distance increases)

1

because it is a smaller proportion of the total race time

1

- (f) **Level 3 (5–6 marks):**

A coherent description of the race, which uses data from the graph, including discussion of the meanings of the changing gradient of both of the lines.

Level 2 (3–4 marks):

Multiple pieces of data taken from the graphs used to evidence a comparison between the runners. Likely to include discussion of the meaning of the (changing) gradient of one of the lines. Answer not coherently structured.

Level 1 (1–2 marks):

Some data taken from the graph, but may be limited to one aspect or simple readings.
Lack of coherence in answer.

0 marks:

No relevant content.

Indicative content

- A starts at constant speed *for 440 m / 60 s*
- A then slows down *from 60 s*
- the gradient for B is lower at the start so B starts at a slower speed
- the gradient for B increases so B accelerates
- B overtook A *at 700 m / 114 s*
- B has a greater top speed because the maximum gradient is greater
- B won the race *in 126 s / beat A by 34 s*

6

[12]

Q18.

(a) $3.3 \times 10^2 \text{ m / s}$

1

(b) **Level 2 (3–4 marks):**

A detailed and coherent explanation of the shape of the graph and what it says about the motion of the car between each point is given. Values from the graph are clearly referred to in a logical and consistent way.

Level 1 (1–2 marks):

An attempt at an explanation of the motion of the car is given, which may be incomplete or not in a logical sequence. Values from the graph may not be referred to or referred to incorrectly.

0 marks:

No relevant content.

Indicative content

- between **A** and **B** car is moving from origin
- the gradient of the line shows it's moving at a constant speed
- speed between these points is $250 / 20 = 12.5 \text{ m / s}$
- between **B** and **C** car is stationary / not moving
- because between these points the graph is flat
- showing that the car's speed is 0 m / s
- between **C** and **D** car is moving further from origin
- at a constant speed
- speed is $250 / 20 = 12.5 \text{ m / s}$
- movement between these points is the same as at **A–B**
- because the gradient is the same
- between **D** and **E** moves towards origin
- at a constant speed
- speed is $500 / 30 = 16.7 \text{ m / s}$
- gradient between **D** and **E** shows that car moves faster **or** at a greater speed than between any other points

4

(c) kinetic energy = $0.5 \times \text{mass} \times (\text{speed})^2$

allow $E_k = \frac{1}{2} mv^2$

1

(d) $\frac{1}{2} \times 1\,650 \times 30^2$

1

= 742.5 (kJ)

answer must be in kJ for mark

1

allow 742.5 with no working shown for 2 marks

(e) **Level 3 (5–6 marks):**

A detailed and coherent explanation is given of why the man may not be able to stop in time, clearly and logically linking factors that could affect the braking in the situation given

Level 2 (3–4 marks):

An explanation is given, with an attempt at linking factors affecting braking distance

to
the situation given. Links made between factors and explanation may not be complete
and the logic may be unclear.

Level 1 (1–2 marks):

Simple relevant statements made about factors affecting braking, but no attempt to link
to explanations of how they are relevant in the situation given

0 marks:

No relevant content.

Indicative content

- overall stopping distance related to thinking distance and braking distance
- factors affecting thinking distance:
 - driver could be distracted
 - driver could be tired
 - driver could be on medication that affects thinking (eg make drowsy)
 - driver could have drunk alcohol
 - mean that reaction time will be longer so will not brake as quickly
- factors that affect braking distance:
 - condition of car (eg worn brakes means can't stop as quickly, wear on tyres reduces friction with road)
 - speed car is travelling (faster means more kinetic energy)
 - condition of the road (eg the road is wet so friction between tyres and road reduced)

6

[14]

Q19.

- (a) acceleration = change in velocity / time taken

$$\text{allow } a = \Delta v / t$$

1

(b) $= \frac{(3 - 5)}{6}$

1

$$-0.33 \text{ (m / s}^2\text{)}$$

1

allow 0.33 m / s² with no working shown for 2 marks

- (c) force = mass × acceleration

$$\text{allow } F = m a$$

1

- (d) 70×0.33

allow ecf from 4.3

1

$$23.1 \text{ (N)}$$

allow 23.1 with no working shown for 2 marks

(e) before throwing the bag the momentum of the skater and bag is zero

when it is thrown the bag has momentum forwards

because momentum before = momentum after

the skater has equal backwards momentum so will move backwards

1

1

1

1

1

[10]

Examiner reports

Q1.

- (a) About 30% gained both marks, with fewer than 1% gaining just one mark. There was widespread misreading of the graph, in some cases misreading the scale but in a very large proportion there was little attempt to read between the grid lines.

Those who were successful adopted one of three routes: reading the distance off the graph between the given times; finding the time interval from the data given and reading that off the graph from the origin; using the data from the graph along with distance = speed $\times$ time to find the extra distance.

- (b) This was not answered well, with many students simply talking about heat energy, and many of those who referred to kinetic energy talking about kinetic energy in the brakes.

Many students overcomplicated their responses to this question. Over three quarters of students gained no marks.

- (c) This calculation was fairly well done with just over 42% gaining full marks. There were not many able to score compensation marks and so 40% scored zero.

The major problem was the inability to rearrange the equation, and substitution marks were rare as students were trying to substitute into an incorrect equation. A significant minority divided rather than subtracted when moving v^2 from one side of the equation to the other.

- (d) Many students did not grasp that a specific requirement of the question was to include factors that would affect the gradient and only a minority talked about the gradient being altered by factors rather than simply describing the graphs presented.

Lower attaining students described the graphs, often saying that “everyone has stopped by 112 km/h” as this was seen as an end point. Many mentioned factors that would affect each of the distances but the factors were not always attributed to the correct distance. A significant number of students cited factors that affected the stopping distance in their own right.

Fewer than 6% of responses achieved level three.

Q2.

- (a) 77% of students were able to give at least one correct suggestion for factors that might affect the thinking distance; usually the consumption of alcohol or distractions such as the use of a mobile phone. ‘Drinking’ by itself was insufficient for a mark as it needed to be linked to alcohol.
- (b) 56% of students could suggest an appropriate factor that would affect the braking distance. Some were confused between braking distance and overall stopping distance, and were therefore suggesting factors that might affect the thinking distance.
- (c) 83% of students were able to correctly calculate the thinking distance to be 7.8 m.
- (d) 14% of students realised that the overall stopping distance was equal to thinking distance plus braking distance. A very common response was to subtract 7.8 m from

14 m.

- (e) 53% of the students knew that a greater speed would result in a greater braking distance. Common incorrect responses were to say that a greater speed resulted in a slower braking distance or would take longer to brake but without reference to the distance.
- (f) Most students realised that applying a large braking force could cause damage to the car or injury to the occupants. Few students made any reference to the effect on the brakes. 9% of students achieved full marks.

Q3.

- (a) 57% of students were able to recall the typical mean speed for a person walking.
- (b) 33% of students knew this with a greater number of students answering in terms of the typical mean speed for a person cycling being 4.5 m/s.
- (c) 55% of students were able to determine the figures of 3.8 (s) and 8.6 (s) from the graph. Those who did not appreciate the scale used generally answered 3.9 (m).

Most realised that they had to subtract values determined for C and D (though a few did add) to determine the time taken.

- (d) 35% of students did not attempt this question. Of those that did, most students were able to achieve one mark usually for finishing the line at 14 seconds, often just by continuing the line from D to E. 29% of students achieved two marks. A few students drew the lines freehand, which were often not credited due to the number of 'wobbles'.
- (e) 58% of students were able to interpret the graph and determine the region in which the athlete was moving at constant velocity.
- (f) Although the majority of students were able to interpret the graph and determine the region in which the athlete was moving at constant velocity, fewer then realised that the resultant force when travelling at constant velocity would be zero. 35% of students were able to do this.
- (g) The correct answer was the most popular response, with 42% of students selecting 'distance travelled'.
- (h) 25% of students were able to correctly recall the equation. A variety of incorrect answers were seen with arranging the terms incorrectly, or subtracting one term. A significant number of students answered in terms of $v^2 - u^2 = 2as$, despite force and mass being in the question.
- (i) 72% of students answered correctly achieving both marks. However, some students rounded their response to 3.62 rather than 3.63.

Q4.

- (a) Most correct answers gave air resistance, though drag was also credited. Incorrect responses included friction, gravity, wind, wind resistance, resistance, types of energy and acceleration.
- (b) 86% of students were able to interpret the graph correctly.

- (c) 23% of students achieved all three marks. Some students were not able to correctly apply the scale and incorrectly read the value for the velocity for the graph. The only incorrect velocity value which was credited when used in marking points two and three was 12.1 m/s. Many students incorrectly used the time of 6 s given in the question as the velocity.
- (d) To access the first four marking points, students had to draw a tangent. 4% of students who had the necessary mathematical skills were able to achieve full marks. A significant number used the co-ordinates of the point on the graph, whilst others made a triangle out of the deceleration part of the graph and tried to work from the x and y readings despite there being a curve on the third side. The unit mark was scored by the majority of students. Relatively few did not attempt this question.
- (e) 38% of students realised that the acceleration value given led to a velocity of 9.6 m/s after six seconds and then correctly drew the line to obtain two marks. Others who didn't use the acceleration value given drew their line to a velocity of 1.6 m/s or 12.2 m/s.

Some students drew a vertical line upwards from six seconds until it reached the other athlete's 'steady speed' section at 12.2 m/s.

- (f) Those students who knew that the area under the graph represented distance were often then able to go on and achieve four marks. Others who gained some marks found it easier to calculate the area of the triangle for the distance travelled by the second athlete, rather than calculating the area of the trapezium for the first athlete. Few used the equation for the area of a trapezium, more usually splitting the trapezium into a rectangle and triangle.

For the calculation of the distance travelled by the second athlete an error carried forward was allowed from their answer to part (e). Some tried to use the equation $v^2 - u^2 = 2as$ for both athletes, without appreciating that this could only be used for the second athlete.

Many tried to use $d = s \times t$ gaining an overall answer of 15.6 m. They were awarded marking point four if they had clearly indicated they had calculated the distance travelled for both athletes. Others just subtracted the two velocities after six seconds.

Q5.

- (a) Over 11% of students made no attempt to answer this question and more than three quarters scored no marks.

Few students realised that this question was linked to the vector nature of velocity and acceleration. Indeed, several students stated that the question was incorrect because the moon could not be accelerating because it was moving at constant speed.

Students who attempted an incorrect explanation attributed the acceleration to a variety of causes – global warming, astronauts landing on the moon and the earth's changing magnetic field were fairly common answers.

Students who scored marks for this question usually cited the constant change in direction of the moon, linking this to a change in velocity, but omitting the link between velocity and acceleration.

- (b) Around half of students chose the correct response to the calculation. The next most

popular choice was the final box, which was similar to the correct one, but with '2' as a multiplier. The other two responses were equally chosen.

- (c) Around 3% of students performed this complex calculation correctly to gain all six marks. Some students attempted calculations, but it was often difficult to follow the line of reasoning. Strings of figures, apparently randomly multiplied or divided, were often seen, with no attempt to explain what was being worked out. It would benefit students to explain, just with a word or two, what they think they are working out. Some students attempted to deal with all stages of this multi-stage calculation in one equation – such answers seldom scored any marks.

Of those whose working was clear enough to follow, the most frequent mistake was working out the input power as 72% of the output power, ending up with a smaller value for the input power than the output. However, such answers could go on to gain up to three of the marks by using the $P = IV$ equation and/or multiplying by four.

- (d) In order to gain marks, students needed to refer to the old theory and what it would suggest about the composition of Moon rocks compared to Earth rocks. Very few answers made reference to the old theory, so very few students gained marks.

Many answers stated that if the Moon rocks had a similar composition to Earth rocks, it was likely that they originated from the same place – this is what was stated in the question so there was no credit for repeating it.

There was evidence that a number of students had mis-read or failed to understand the question, as they referred to the Giant Impact Hypothesis as being incorrect because the Earth would have been destroyed in a collision.