

Forces part 1 AQA Triple Physics

Name: _____

Class: _____

Date: _____

Time: **105 minutes**

Marks: **99 marks**

Comments:

1.

Speed limits on roads increase safety.

(a) The braking distance of a car increases as the speed of the car increases.

Give two **other** factors that **increase** the braking distance of a car.

1. _____

2. _____

(2)

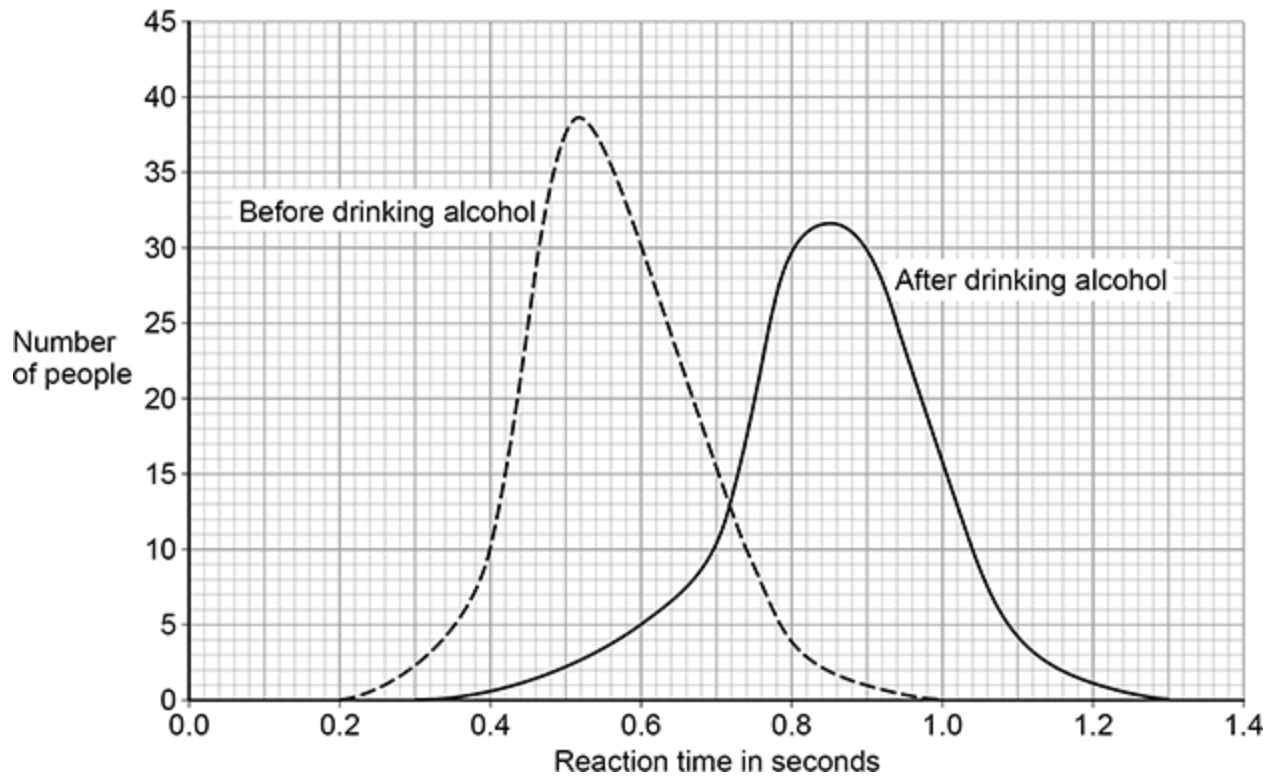
(b) Explain why the driver's reaction time affects the thinking distance of a car.

(2)

(c) Scientists have investigated how drinking alcohol affects a person's reaction time.

Figure 1 shows the results of the investigation.

Figure 1



Which of the following conclusions can be made using Figure 1?

Tick (✓) **two** boxes.

Every person's reaction time increases after drinking alcohol.

Mean reaction time increases after drinking alcohol.

Some people's reaction time is not affected by drinking alcohol.

The change in reaction time is not the same for all people after drinking alcohol.

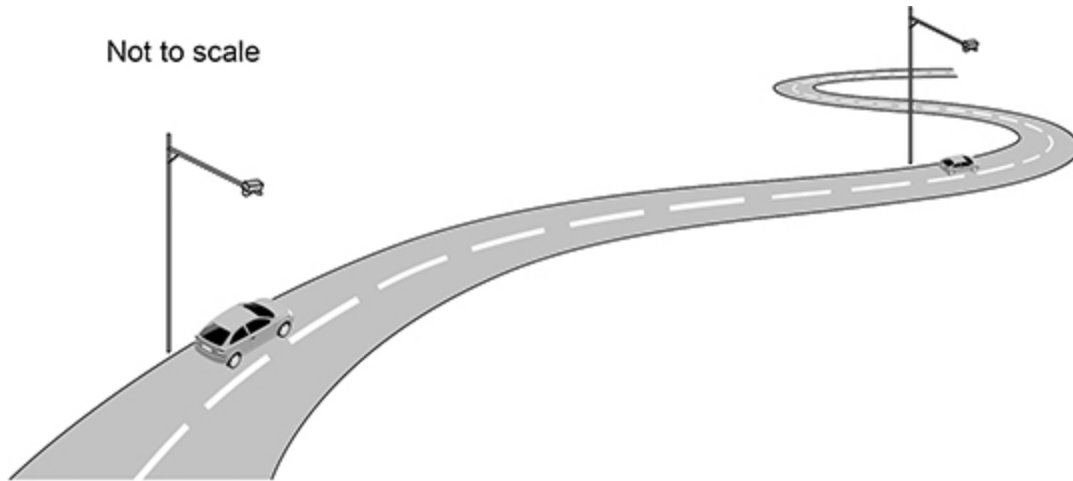
There is a smaller range of reaction times after drinking alcohol.

(2)

Figure 2 shows some speed cameras on a road.

The speed cameras determine the average speed of cars on the road.

Figure 2



(d) The speed limit on the road in **Figure 2** is 20 m/s.

The cameras in **Figure 2** are 1.5 km apart.

Calculate the minimum time it takes to travel 1.5 km without breaking the speed limit.

Use the Physics Equations Sheet.

Minimum time = _____ s

(4)

- (e) The average speed of a car between the cameras and the average velocity of the car between the cameras are different.

Explain why.

(3)
(Total 13 marks)

2.

Hailstones are small balls of ice. Hailstones form in clouds and fall to the ground.

Figure 1 shows different-sized hailstones.

Figure 1



A hailstone falls from a cloud and accelerates.

- (a) Why does the hailstone accelerate?

(1)

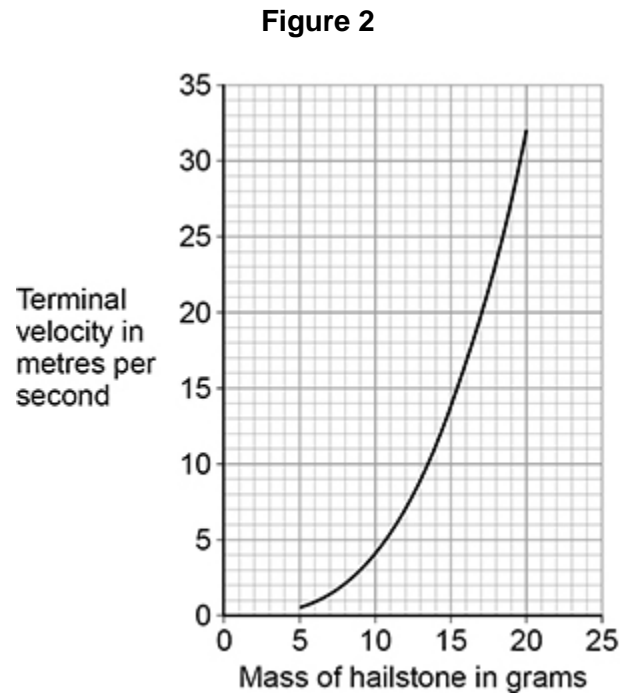
(b) The hailstone stops accelerating and reaches terminal velocity.

Explain why the hailstone reaches terminal velocity.

(3)

A scientist investigated how the mass of hailstones affects their terminal velocity.

Figure 2 shows the results.



(c) Why does terminal velocity increase with mass?

Tick (✓) **one** box.

As mass increases the cross-sectional surface area of a hailstone increases.

As mass increases the volume of a hailstone increases.

As mass increases the weight of a hailstone increases.

(1)

(d) Explain the difference in the maximum kinetic energy of a hailstone with a mass of 10 g and a hailstone with a mass of 20 g.

(3)

(e) The kinetic energy of a hailstone is measured in joules.

Which of the following is the same as 1 joule?

Tick (✓) **one** box.

1 N m

1 N/m

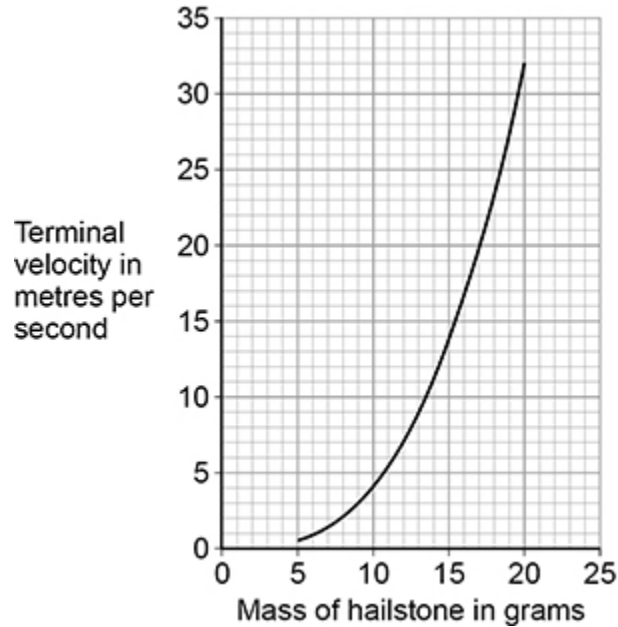
1 N/m²

1 N m²

(1)

Figure 2 is repeated below.

Figure 2



(f) A hailstone hit the ground at its terminal velocity of 25 m/s.

The hailstone took 0.060 s to stop moving.

Determine the average force on the hailstone as it hit the ground.

Use information from **Figure 2**.

Use the Physics Equations Sheet.

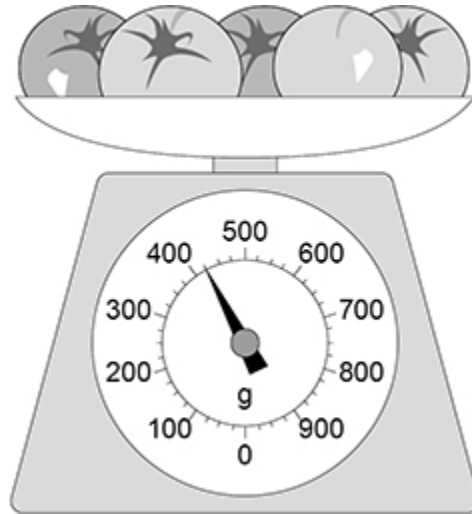
Average force = _____ N

(3)

(Total 12 marks)

3. **Figure 1** shows a balance used to measure the mass of five tomatoes.

Figure 1



(a) What is meant by 'centre of mass'?

(1)

(b) Calculate the mean weight of a tomato in **Figure 1**.

Use the Physics Equations Sheet.

gravitational field strength = 9.8 N/kg

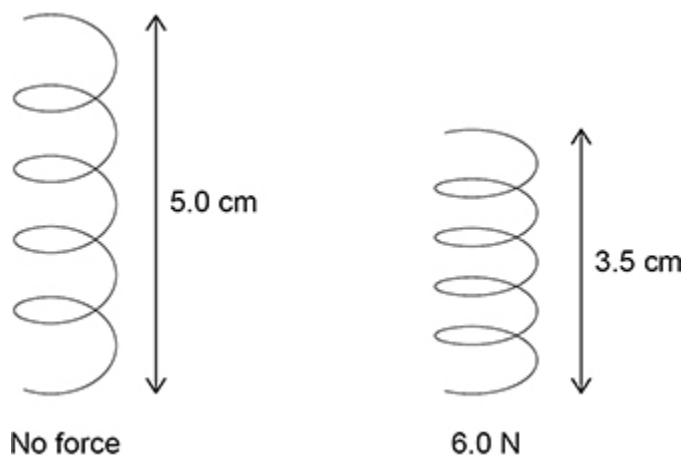
Weight = _____ N

(3)

- (c) The balance in **Figure 1** contains a spring that compresses when the tomatoes are placed on the balance.

Figure 2 shows the spring with no force acting and with a 6.0 N force acting.

Figure 2



Determine the spring constant of the spring.

Use the Physics Equations Sheet.

Spring constant = _____ N/m

(3)

- (d) Explain **one** property of the spring that makes it suitable for use in the balance.

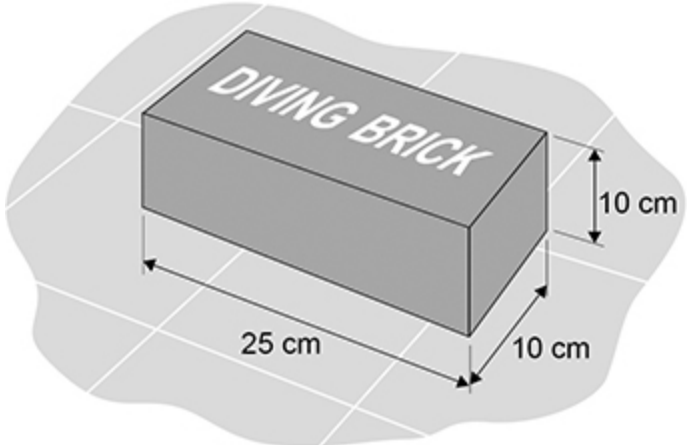
(2)

(Total 9 marks)

4. Diving bricks sink to the bottom of a swimming pool.

Figure 1 shows a diving brick.

Figure 1

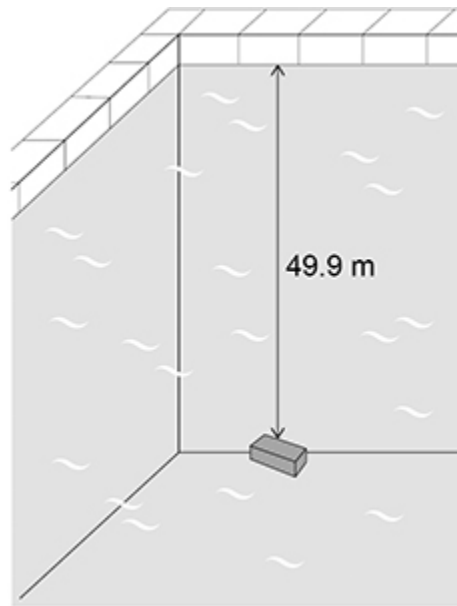


Swimmers practise diving to the bottom of the swimming pool to pick up the diving brick.

(a) Explain why the forces on the brick at the bottom of the pool cause the brick to be stationary.

(3)

Figure 2



Determine the force due to the weight of the water on the top surface of the brick in **Figure 2**.

Use the Physics Equations Sheet.

Give your answer to 3 significant figures.

Force (3 significant figures) = _____ N

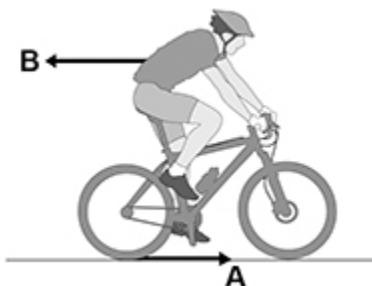
(3)
(Total 12 marks)

5. **Figure 1** shows a cyclist on a bicycle.

The cyclist is moving at a constant velocity.

Arrows **A** and **B** represent the horizontal forces acting on the bicycle and cyclist.

Figure 1



(a) What is force **A**?

Tick (✓) **one** box.

Air resistance

Friction

Tension

Upthrust

(1)

(b) What is force **B**?

Tick (✓) **one** box.

Air resistance

Magnetic

Tension

Upthrust

(1)

(c) What is the relationship between force **A** and force **B** when the cyclist travels at a constant velocity?

Tick (✓) **one** box.

A = B

A > B

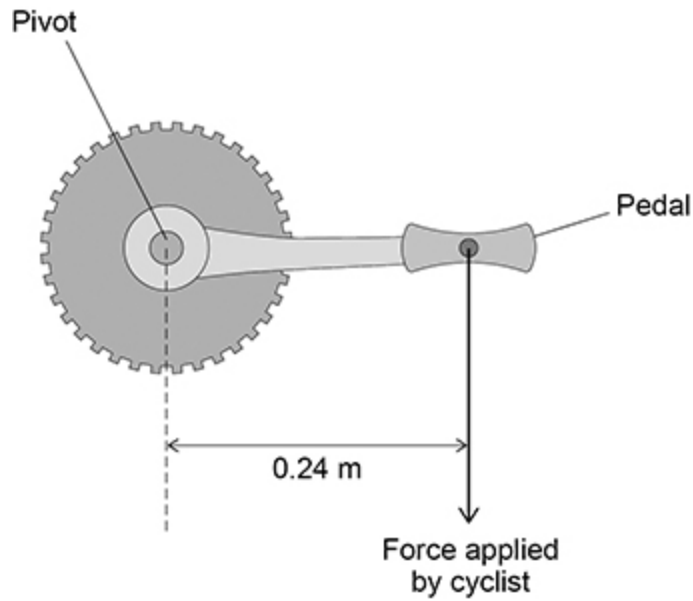
A < B

(1)

(d) The cyclist applies a force of 150 N to one of the bicycle pedals.

Figure 2 shows the distance between the force applied and the pivot.

Figure 2



Calculate the moment about the pivot caused by the force applied to the pedal in **Figure 2**.

Use the equation:

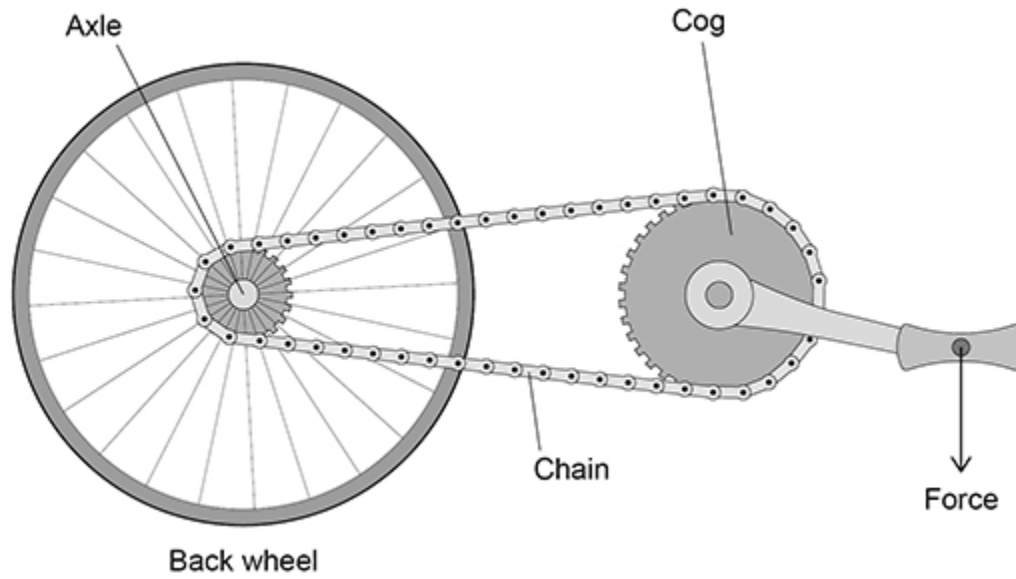
$$\text{moment of a force} = \text{force} \times \text{distance}$$

Moment = _____ N m

(2)

(e) **Figure 3** shows how the pedal is connected to the back wheel of the bicycle.

Figure 3



Complete the sentence.

Choose the answer from the box.

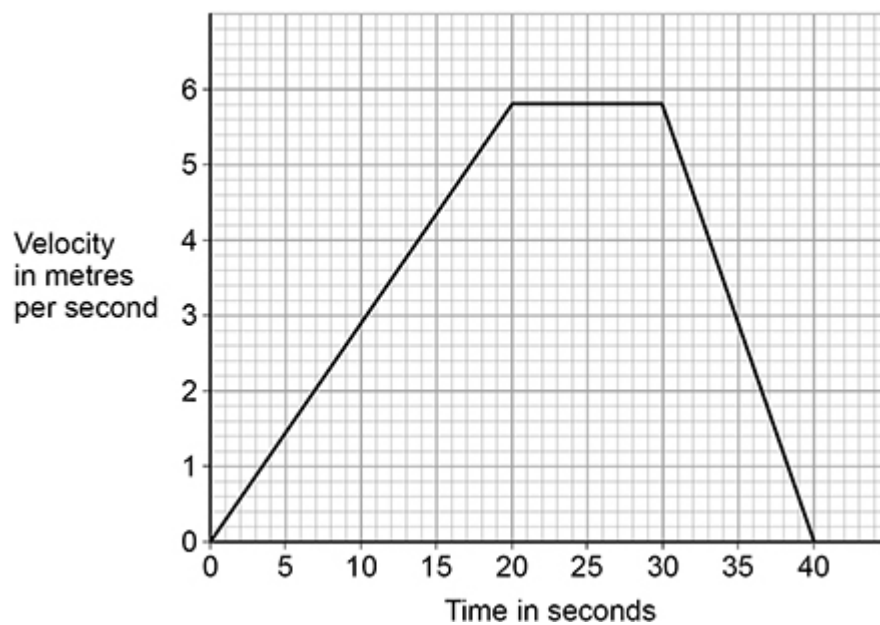
axle	chain	cog
-------------	--------------	------------

The force from the cyclist pushing down on the pedal is transmitted to the back wheel by the _____.

(1)

Figure 4 shows how the velocity of the cyclist changes during a journey.

Figure 4



(f) What is the change in velocity of the cyclist in the first 20 seconds of the journey?

Tick (✓) **one** box.

5.2 m/s

5.4 m/s

5.6 m/s

5.8 m/s

(1)

(g) Determine the acceleration of the cyclist during the first 20 seconds of the journey.

Use your answer from part (f)

Use the equation:

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

Acceleration of the cyclist = _____ m/s²

(2)

(h) Complete the sentence.

Choose the answer from the box.

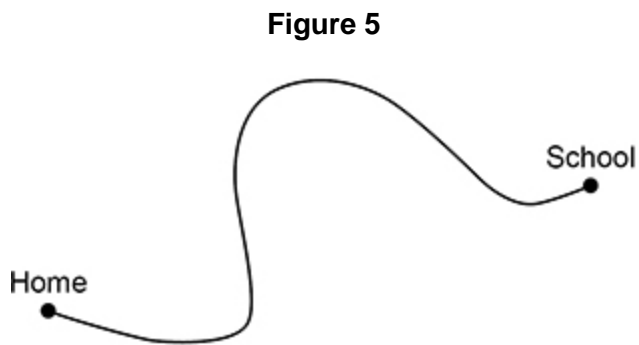
deceleration	speed	velocity
---------------------	--------------	-----------------

Between 30 and 40 seconds the cyclist moves with a constant _____.

(1)

- (i) The cyclist travels from home to school.

Figure 5 shows the route the cyclist followed.

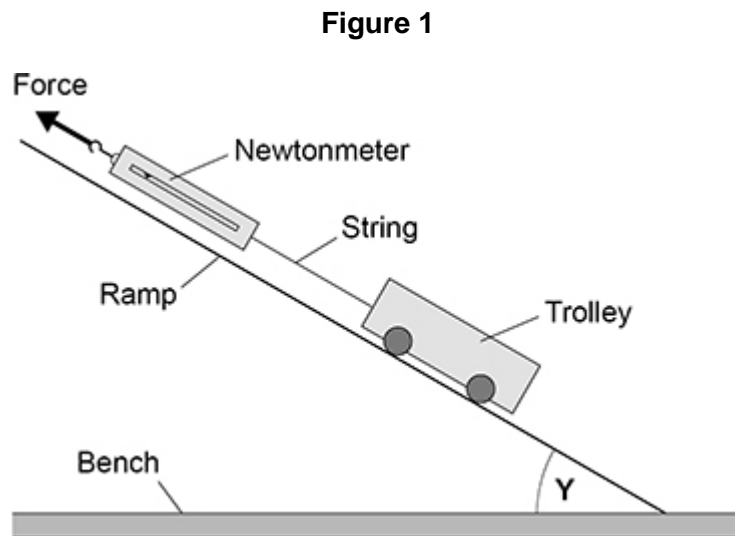


Draw an arrow on **Figure 5** to show the displacement of the cyclist.

(1)
(Total 11 marks)

- 6.** A student investigated how the angle of a ramp affects the force required to hold a trolley stationary on the ramp.

Figure 1 shows the equipment used.



- (a) Measure the angle **Y** in **Figure 1**

Angle **Y** = _____ degrees

(1)

Figure 2 shows the newtonmeter before the investigation started.

Figure 2



(b) What type of error is shown on the newtonmeter in Figure 2?

Tick (✓) **one** box.

Human error

Random error

Zero error

(1)

(c) How can this error be corrected after the measurements have been taken?

Tick (✓) **one** box.

Add 0.5 N to each measurement

Multiply each measurement by 0.5 N

Subtract 0.5 N from each measurement

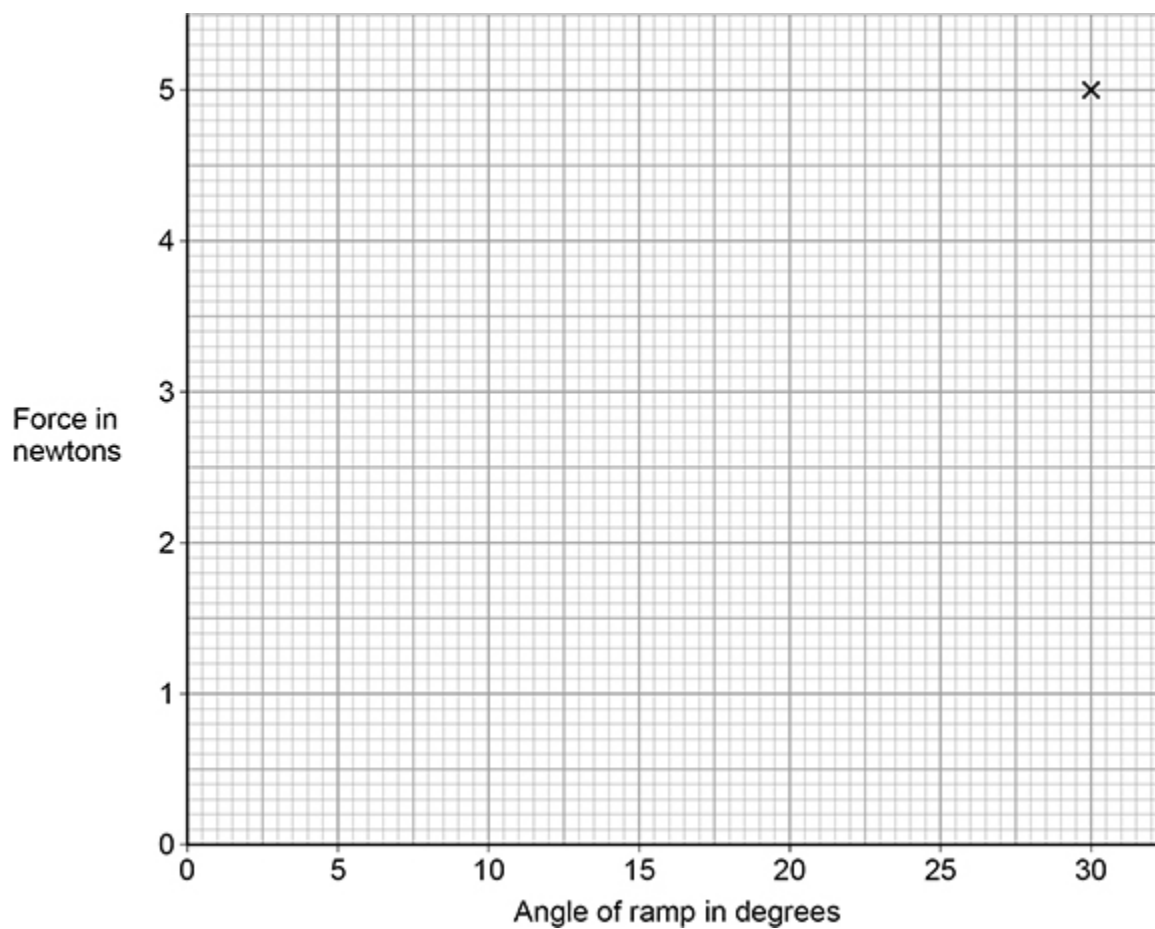
(1)

The table below shows the corrected results.

Angle of ramp in degrees	Force in newtons
5	0.9
10	1.7
15	2.6
20	3.4
25	4.2
30	5.0

Figure 3 is an incomplete graph of the results

Figure 3



(d) Plot the missing results from the table above on **Figure 3**.

(2)

(e) **Figure 4** shows a person in a wheelchair using two different ramps to enter a van.

Figure 4



The ramps are at different angles to the ground.

Explain **one** advantage of using the long ramp compared with using the short ramp.

(2)

(f) A force of 160 N is used to move the wheelchair up the long ramp.

The ramp is 2.5 m long.

Calculate the work done to move the wheelchair up the ramp.

Use the equation:

$$\text{work done} = \text{force} \times \text{distance}$$

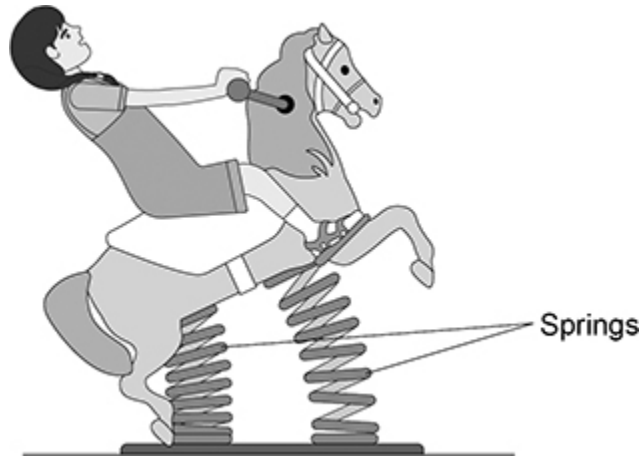
Work done = _____ J

(2)

(Total 9 marks)

7. **Figure 1** below shows a child on a playground toy.

Figure 1



(a) The springs have been elastically deformed.

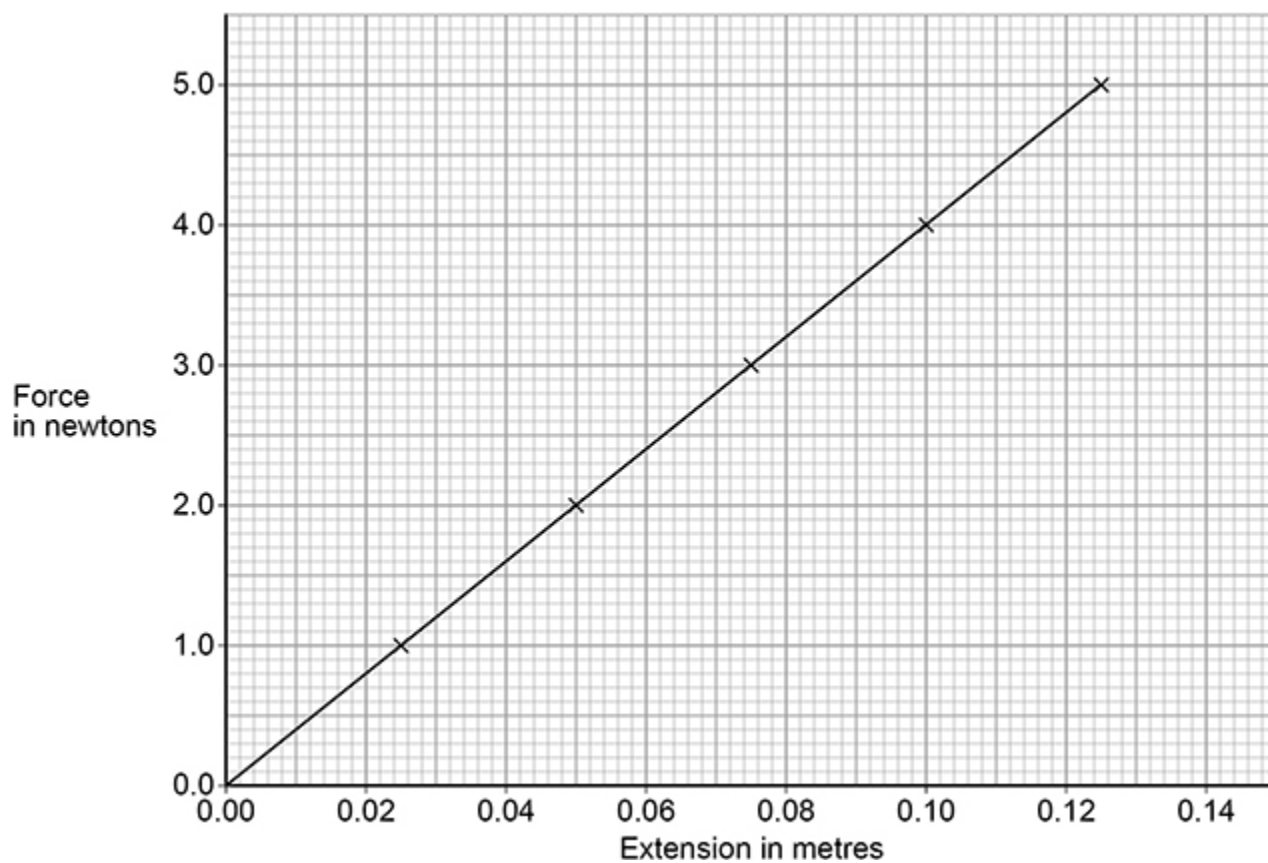
Explain what is meant by 'elastically deformed'.

(2)

A student investigated the relationship between the force applied to a spring and the extension of the spring.

Figure 2 below shows the results.

Figure 2



(c) Which equation links extension (e), force (F) and spring constant (k).

Tick (✓) **one** box.

force = spring constant \times (extension)²

force = spring constant \times extension

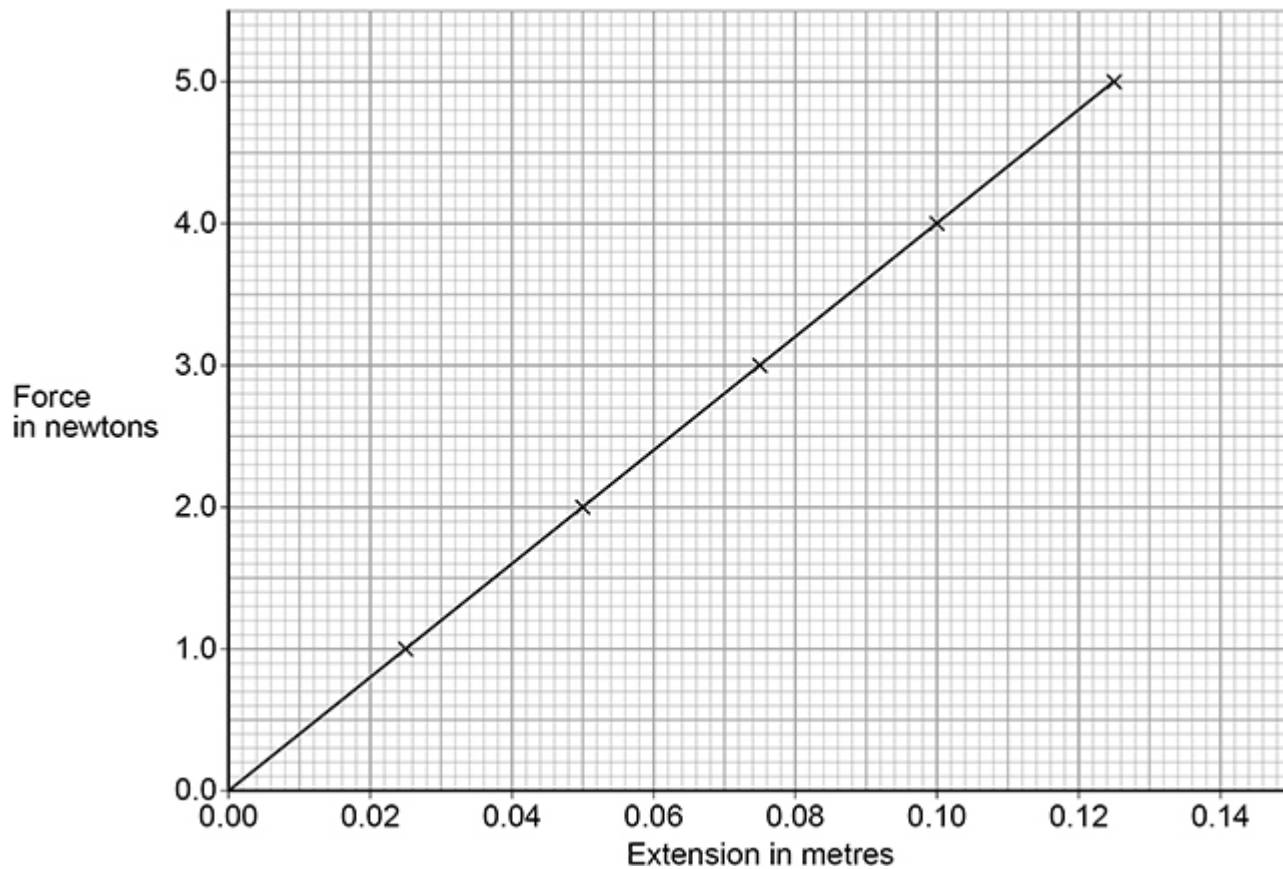
force = $\frac{\text{extension}}{\text{spring constant}}$

force = $\frac{\text{spring constant}}{\text{extension}}$

(1)

Figure 2 is repeated below.

Figure 2



(d) Determine the spring constant of the spring.

Use **Figure 2**.

Spring constant = _____ N/m

(3)

(e) The student concluded:

'The extension of the spring is directly proportional to the force applied to the spring.'

Describe how **Figure 2** supports the student's conclusion.

(2)

(f) The student repeated the investigation using a different spring with a spring constant of 13 N/m.

Calculate the elastic potential energy of the spring when the extension of the spring was 20 cm.

Use the Physics Equations Sheet.

Elastic potential energy = _____ J

(3)

(Total 17 marks)

8.

The thinking distance and braking distance for a car vary with the speed of the car.

(a) Explain the effect of **two** other factors on the **braking** distance of a car.

Do **not** refer to speed in your answer.

(4)

(b) Which equation links acceleration (*a*), mass (*m*) and resultant force (*F*).

Tick (✓) **one** box.

- resultant force = mass × acceleration
- resultant force = mass × acceleration²
- resultant force = $\frac{\text{mass}}{\text{acceleration}^2}$
- resultant force = $\frac{\text{mass}}{\text{acceleration}}$

(1)

(c) The mean braking force on a car is 7200 N.

The car has a mass of 1600 kg.

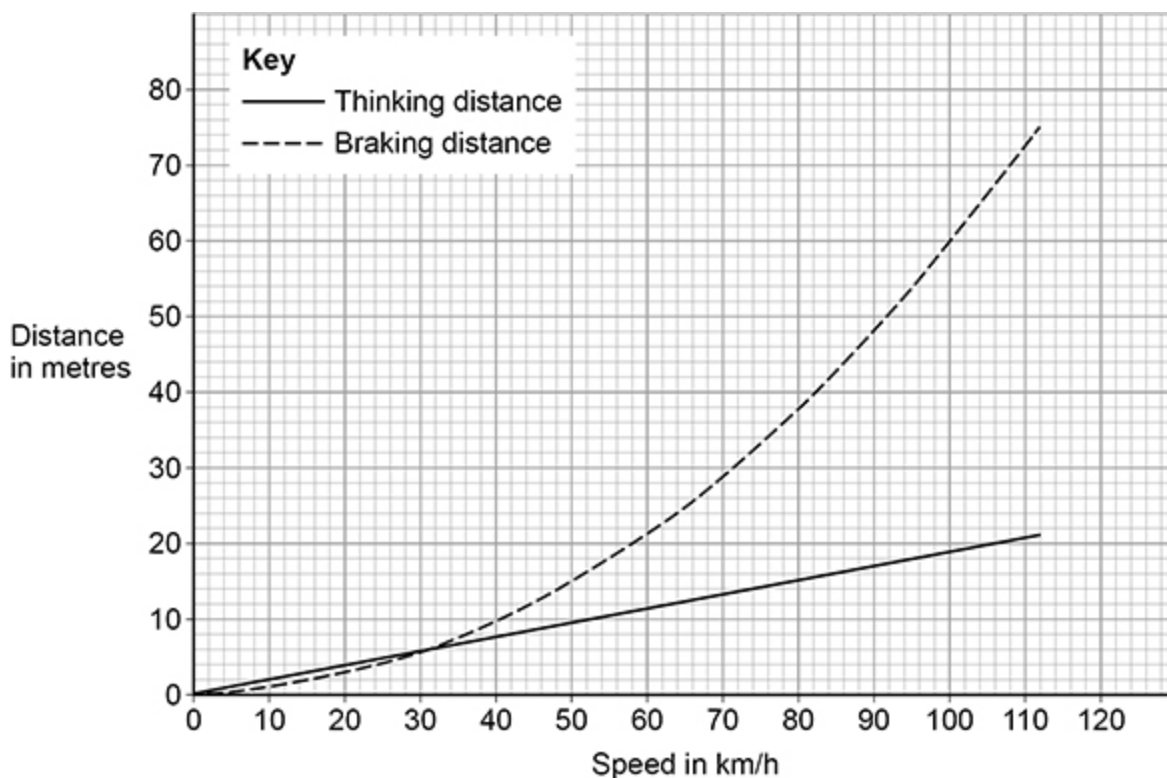
Calculate the deceleration of the car.

Deceleration = _____ m/s²

(3)

- (d) **Figure 1** below shows how the thinking distance and braking distance for a car vary with the speed of the car.

Figure 1



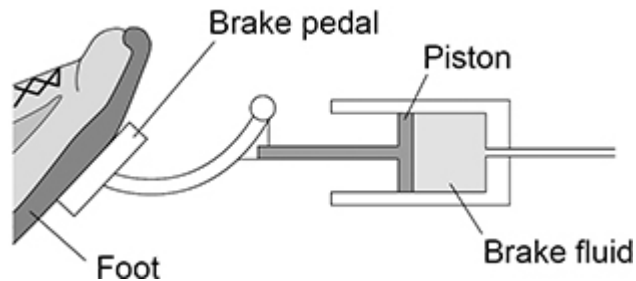
Determine the stopping distance when the car is travelling at 80 km/h.

Stopping distance = _____ m

(2)

Figure 2 below shows part of the braking system for a car.

Figure 2



Mark schemes

- 1.** (a) any **two** from:
- wet / icy road conditions
ignore weather
 - poor condition of brakes
 - poor condition of tyres
 - increased mass of car
allow weight for mass
 - negative gradient of the road
allow going downhill
- 2
- (b) distance = speed × time
- 1
- (so) longer reaction time = longer distance
- 1
- (c) mean reaction time increases after drinking alcohol
- 1
- the change in reaction time is not the same for all people after drinking alcohol
- 1
- (d) distance = 1500 (m)
- 1
- $1500 = 20 \times t$
- allow a correct substitution using an incorrectly / not converted value of distance*
- 1
- $t = \frac{1500}{20}$
- allow a correct rearrangement using an incorrectly / not converted value of distance*
- 1
- 75 (s)
- allow a correctly calculated value using an incorrectly / not converted value of distance*
- 1

- (e) velocity is a vector and speed is a scalar
allow velocity includes direction (speed does not)

1

road is not straight
allow driver may change lanes

1

therefore direction changes so the velocity changes

1

[13]

2.

- (a) there is a resultant force acting
allow weight/gravity is greater than air resistance
allow (initially) weight/gravity is the only force acting

1

- (b) as the velocity of the hailstone increases air resistance increases
allow speed for velocity

1

until air resistance becomes equal to the weight of the hailstone

1

so the resultant force is (equal to) zero

1

- (c) as mass increases the weight of a hailstone increases

1

- (d) kinetic energy depends on both mass and velocity
allow $E_k = \frac{1}{2} mv^2$

1

as mass increases so does terminal / maximum velocity
a statement is required

1

kinetic energy $\propto m$ and kinetic energy $\propto v^2$ so as mass doubles
kinetic energy more than doubles
this mark can be scored by relevant calculations

1

- (e) 1 N m

1

(f) mass = 0.0185 (kg)

allow 0.018 to 0.019 inclusive

1

$$F = \frac{0.0185 \times 25}{0.060}$$

allow a correct substitution using an incorrectly / not converted value of m

1

$$F = 7.708 \text{ (N)}$$

allow 7.7 (N)

allow correct calculation using an incorrectly / not converted value of m

1

if no other marks are awarded

a misreading of the scale giving a value between 15.6 and 15.7 inclusive that is then correctly converted giving an answer between 6.50 and 6.54 scores 2 marks

a misreading of the scale giving a value between 15.6 and 15.7 inclusive that is then not converted giving an answer between 6500 and 6542 scores 1 mark

[12]

3.

(a) the point at which weight may be considered to act

allow the point through which the line of action of the weight acts

or

the point where the mass appears to be concentrated

allow the point at which the mass is concentrated

1

(b) mass of 5 tomatoes = 0.425 (kg)

1

mass of 1 tomato = 0.085 (kg)

allow an incorrect and / or not converted reading correctly divided by 5

1

$$W = (0.085 \times 9.8) = 0.833 \text{ (N)}$$

allow a correct calculation using their value of mass

1

(c) $6.0 = k \times 0.015$

1

$$k = \frac{6.0}{0.015}$$

allow correct rearrangement using an incorrectly calculated value of e

1

$$k = 400 \text{ (N/m)}$$

allow a correct calculation using an incorrectly calculated value of e

1

(d) deforms elastically

1

(so) will return to its original length / shape (after force is removed)

OR

compression is directly proportional to the force (applied) (1)

(so) gives a linear scale (1)

allow easy to calibrate

1

[9]

4.

(a) upthrust acts (upwards on the brick)

1

normal contact force acts upwards (on the brick)

1

weight is equal to upthrust plus normal contact force

allow resultant force is equal to zero only if all three forces are given

1

(b) $A = 0.25 \times 0.10 = 0.025 \text{ m}^2$

1

$$P = \frac{637}{0.025}$$

allow correct substitution of incorrectly calculated value of A

1

$$P = 25\,480 \text{ (Pa)}$$

allow correct calculation using an incorrectly calculated value of A to gain further marks, $P = F/A$ or an incorrect rearrangement of $P = F/A$ must have been used with the given data

1

$$25\,480 = \underline{2.5} \times \rho \times 9.8$$

allow correct substitution of incorrectly calculated value of P

1

$$\rho = \frac{25\,480}{9.8 \times 2.5}$$

allow correct rearrangement using an incorrectly calculated value of P

allow use of $h = 2.6 \text{ (m)}$

1

$$\rho = 1040 \text{ kg/m}^3$$

allow correct calculation using an incorrectly calculated value of P

allow use of $h = 2.6 \text{ (m)}$

1

Alternative method

$$A = 0.25 \times 0.10 = 0.025 \text{ (m}^2\text{)}$$

1

volume of water column

$$(V) = 0.025 \times 2.5$$

allow use of an incorrectly calculated value of A

1

$$V = 0.0625 \text{ (m}^3\text{)}$$

allow use of an incorrectly calculated value of A

1

$$m \left(= \frac{637}{9.8} \right) = 65 \text{ (kg)}$$

1

$$\rho = \frac{65}{0.0625}$$

allow use of an incorrectly calculated value of V

1

$$\rho = 1040 \text{ (kg/m}^3\text{)}$$

1

(c) $F = 618 \times \frac{49.9}{2.5}$

allow calculation of density = 1008.979 (kg/m³)

1

$$F = 12\,335.28$$

1

$$F = 12\,300 \text{ (N)}$$

allow correct rounding of an incorrectly calculated value of F

1

allow max of 2 marks if 50 m is used

[12]

5.

(a) friction

1

(b) air resistance

1

(c) **A = B**

1

- (d) $M = 150 \times 0.24$ 1
- $M = 36 \text{ (Nm)}$ 1
- (e) chain 1
- (f) 5.8 m/s 1
- (g) $a = \frac{5.8}{20}$
allow their v from part (f) 1
- $a = 0.29 \text{ (m/s}^2\text{)}$
allow a correctly calculated value using their v from part (f) 1
- (h) Deceleration 1
- (i) straight arrow drawn between home and school pointing towards school. 1

[11]

- 6.** (a) 30° 1
- (b) zero error 1
- (c) subtract 0.5 N from each measurement 1
- (d) points plotted correctly
allow 5 correctly plotted for 2 marks, 2–4 correctly plotted for 1 mark
allow \pm half a square
ignore any attempt at a line of best fit 2
- (e) the long ramp has a smaller angle
allow description (eg shallower gradient / less steep) 1
- (so) less force is needed (to hold the wheelchair stationary on the ramp)
allow (so) less force is needed to move the wheelchair up the ramp 1

(f) $W = 160 \times 2.5$

1

$W = 400 \text{ (J)}$

1

[9]

7.

(a) will return to its original shape/length

1

when the force is removed

allow (when) the child gets off

the second mark is dependent on scoring the first mark

1

(b) **Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.

5-6

Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.

3-4

Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1-2

No relevant content

0

Indicative content

- set up a clamp stand with a clamp
- hang the spring from the clamp
- use a second clamp and boss to fix a (half) metre rule alongside the spring
- record the ruler reading that is level with the bottom of the spring
- hang a 1 N / a known weight from the bottom of the spring
- record the new position of the bottom of the spring
- calculate the extension of the spring
- measure the extension of the spring
- add further weights to the spring so the force increases 1 N at a time up to 5 N
- for each new force record the position of the bottom of the spring and calculate / measure the extension

Risk Assessment

Hazard: Clamp (stand, boss and masses) might fall off desk

Risk: injury to feet

Precaution: Use clamp to fix apparatus to the bench **or**

Ensure that the slotted masses hang over the base/foot of the stand **or**

Ensure that the boss is screwed tightly into the stand and clamp **or**

Put (heavy) masses on the base/foot of the stand **or** Stand up so that you can move out of the way

Hazard: Spring could break / come loose

Risk: damage eye

Precaution: Wear safety goggles

If a risk assessment / hazard is not given, the answer can still reach level 3, but not full marks.

Full marks may be awarded for alternative feasible methods.

- (c) force = spring constant \times extension 1
- (d) 5.00 0.125 1
allow any correct pair of values from the graph
- $k = \frac{5.00}{0.125}$ 1
allow a misread value(s) from the graph
- $k = 40$ (N/m) 1
allow a correct calculation using their incorrect value(s)

(e) the line is straight
allow the line does not curve
allow a constant gradient 1

and passes through the origin 1

(f) $e = 0.20 \text{ m}$ 1

$E_e = 0.5 \times 13 \times 0.20^2$
allow an incorrectly / not converted value of e 1

$E_e = 0.26 \text{ (J)}$
use of two incorrectly/not converted values scores a maximum of 1 mark 1

[17]

8.

(a) **Level 2:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account. 3-4

Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking. 1-2

No relevant content 0

Indicative content

Factors

- poor condition of tyres
- poor road surface
- wet or icy road
- poor/worn brakes

Explanation

- because of decreased friction

Factors

- increased mass of car/passengers

Explanation

- increases kinetic energy of car
- more work needs to be done to stop car
- increases momentum of the car

Factor

- road slopes downhill

Explanation

- (a component of) gravity opposes the braking force
- resultant (braking) force is reduced

allow answers in terms of reducing braking distance throughout

A single factor with no related explanation is insufficient to score a mark

(b) resultant force = mass \times acceleration

1

(c) $7200 = 1600 \times a$

ignore negatives throughout

1

$$a = \frac{7200}{1600}$$

1

$$a = 4.5 \text{ (m/s}^2\text{)}$$

1

(d) 15 (m) 38 (m)

two correct values identified

1

$$= 53 \text{ (m)}$$

*allow the correct addition of a misread braking distance
and /or a misread thinking distance taken from the
graph*

1

(e) $p = \frac{F}{A}$

1

(f) $120\,000 = \frac{60}{A}$

1

$$A = \frac{60}{120\,000}$$

1

$$A = 0.0005$$

1

$$A = 5 (.0) \times 10^{-4}$$

allow an answer given to 2 sig figs from an incorrect calculation using the given data

1

m²

1

[16]