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physics aqa | gcse

solutions

forces

0 3 . 1 The driver of a vehicle sees a hazard on the road.

The driver uses the brakes to stop the vehicle.

Explain the factors that affect the distance needed to stop a vehicle in an emergency.

[6 marks]

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- reaction time explained in terms of longer reaction times increase thinking distance (from a given speed)
- taking drugs
- drinking alcohol
- tiredness
- age
- distractions explained in terms of the effect on driver's reaction time
- speed explained in terms of the faster the vehicle the greater the distance travelled in the driver's reaction time (or converse) OR explained in terms of increased speed increases KE so increases work done to stop the vehicle
- condition of the tyres
- condition of road surface
- wet/icy roads explained in terms of condition of tyres and road surface (including weather considerations) affecting friction (between tyres and road)
- condition of brakes explained in terms of effect on braking force (applied to the wheels) or reduced friction

0 3 . 2 Write down the equation which links distance, force and work done.

[1 mark]

W = F x D

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0 3 . 3 The work done by the braking force to stop a vehicle was 900 000 J

The braking force was 60 000 N

Calculate the braking distance of the vehicle.

[3 marks]

W = F x D so $D = \frac{W}{F}$

$D = \frac{900\,000}{60\,000} = 15m$

Braking distance = 15 m

0 3 . 4 The greater the braking force, the greater the deceleration of a vehicle.

Explain the possible dangers caused by a vehicle having a large deceleration when it is braking.

[2 marks]

brakes overheating or brakes locking (causing)

loss of control or (causing) a skid

06.1 An adult of mass 80 kg has more inertia than a child of mass 40 kg

What is inertia?

[1 mark]

the tendency of an object to continue in its state of rest or motion

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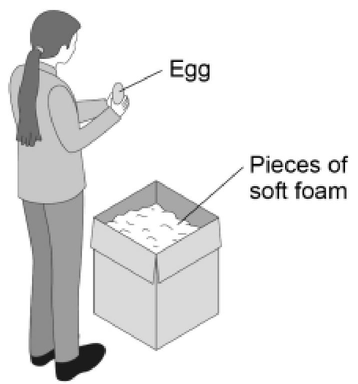
06.2 A teacher demonstrated the idea of a safety surface.

She dropped a raw egg into a box filled with pieces of soft foam.

The egg did not break.

Figure 10 shows the demonstration.

Figure 10



Explain why the egg is less likely to break when dropped onto soft foam rather than onto a concrete floor.

[3 marks]

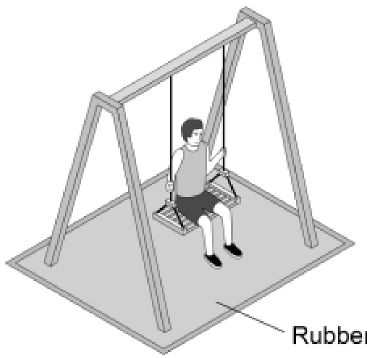
(soft foam) increases the time taken to stop or increases the time taken to decrease momentum

decreases the rate of change in momentum

reducing the force (on the egg)

0 6 . 3 **Figure 11** shows a child on a playground swing. The playground has a rubber safety surface.

Figure 11



A child of mass 32 kg jumped from the swing.

When the child reached the ground she took 180 milliseconds to slow down and stop.

During this time an average force of 800 N was exerted on her by the ground.

Calculate the velocity of the child when she first touched the ground.

Use the Physics Equations Sheet.

[4 marks]

$t = \left(\frac{180}{1000}\right) = 0.18\,s$

$F = \frac{mv}{t}$ $\quad v = \frac{Ft}{m}$

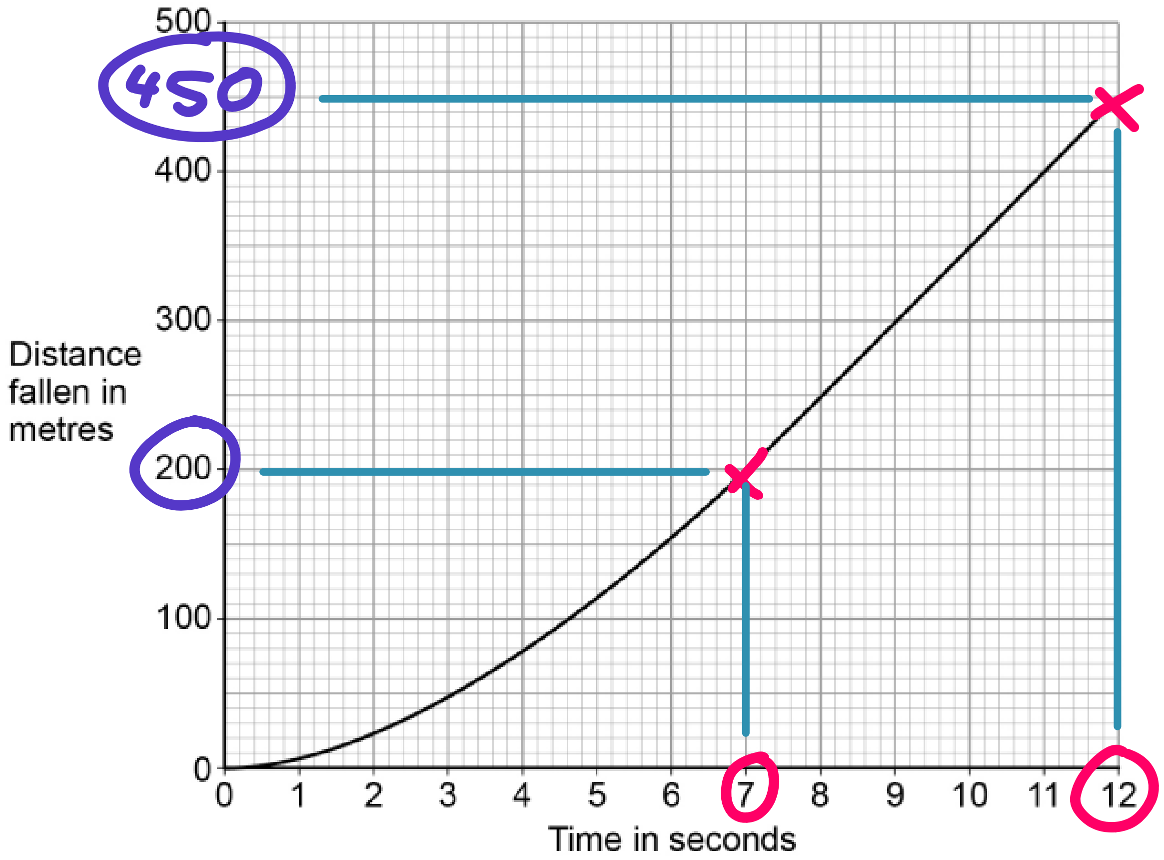
$v = \frac{800 \times 0.18}{32} = 4.5\,\frac{m}{s}$

0 8 An aeroplane is 4000 m above the Earth's surface.

A skydiver jumps from the aeroplane and falls vertically.

Figure 15 shows the distance the skydiver falls during the first 12 seconds after jumping.

Figure 15



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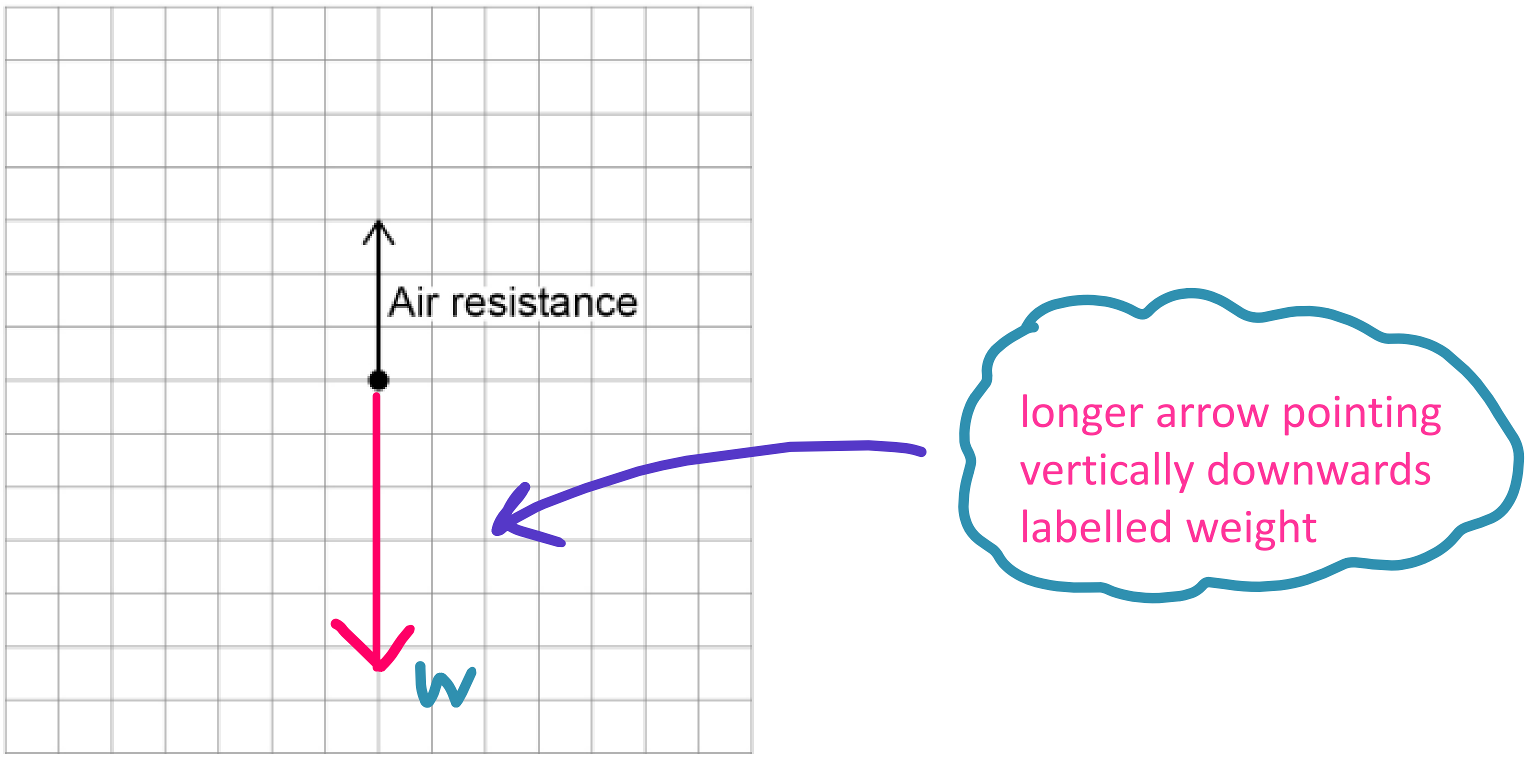
0 8 . 1 **Figure 16** shows part of the free body diagram for the skydiver three seconds after jumping.

Complete the free body diagram for the skydiver.

[2 marks]

Figure 16



0 8 . 2 Explain the changing motion of the skydiver in terms of the forces acting on the skydiver.

[4 marks]

initially air resistance is less than weight / gravity so the skydiver accelerates

acceleration causes the air resistance to increase

~~resultant force decreases to zero~~

so the skydiver falls at terminal velocity

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0 8 . 3 Use **Figure 15** to determine the speed of the skydiver between 7 seconds and 12 seconds.

[3 marks]

(See graph)

7 → 200

12 → 450

$= \frac{450-200}{12-7} \frac{m}{s}$

$= 50 \frac{m}{s}$

0 8 . 4 In 2012 a skydiver jumped from a helium balloon 39 000 metres above the Earth's surface. The skydiver reached a maximum speed of 377 m/s

Jumping from 39 000 metres allowed the skydiver to reach a much higher speed than a skydiver jumping from 4000 metres.

Explain why.

[3 marks]

The higher the altitude the less dense the air so the air resistance on the skydiver (falling from 39000m) was less (at the same speed) so the skydiver was able to accelerate for longer before reaching (a higher) terminal velocity

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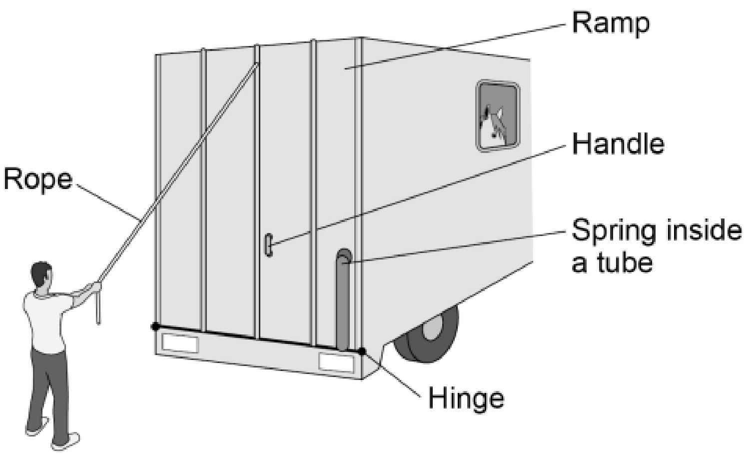
1 0 **Figure 19** shows the back of a lorry. The lorry is used to carry horses.

Figure 19



The ramp is lowered by pulling on the rope or by pulling on the handle.

The hinge acts as a pivot.

1 0 . 1 Explain why it is easier to lower the ramp by pulling on the rope rather than pulling on the handle.

[2 marks]

the (perpendicular) distance from the pivot / hinge to (the line of action of) the force is greater so a smaller force is required

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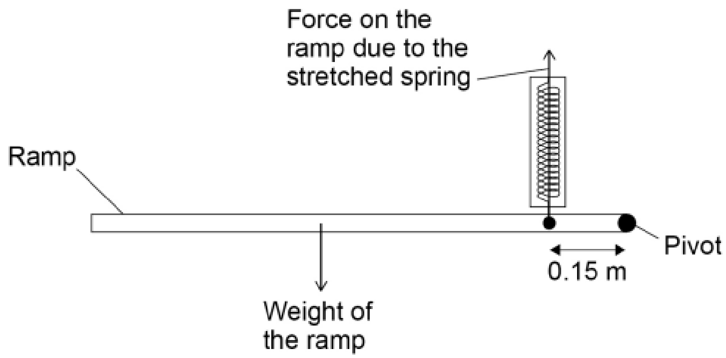
When the ramp is lowered, work is done to stretch a spring on the side of the ramp.
Elastic potential energy is stored in the stretched spring.

Figure 20 shows the ramp part way down in a balanced horizontal position.

Figure 20



1 0 . 2 With the ramp horizontal:

the moment caused by the weight of the ramp = 924 Nm

the spring is stretched by 0.250 m

Calculate the elastic potential energy stored in the stretched spring.

Use data from **Figure 20**.

[6 marks]

ACWM = CWM

$F = K \times e$

$924\,\text{Nm} = F \times 0.15$

$6160 = K \times 0.25$

$\frac{924}{0.15} = F = 6160$

$K = 24640\,\frac{N}{m}$

$E_p = \frac{Ke^2}{2}$

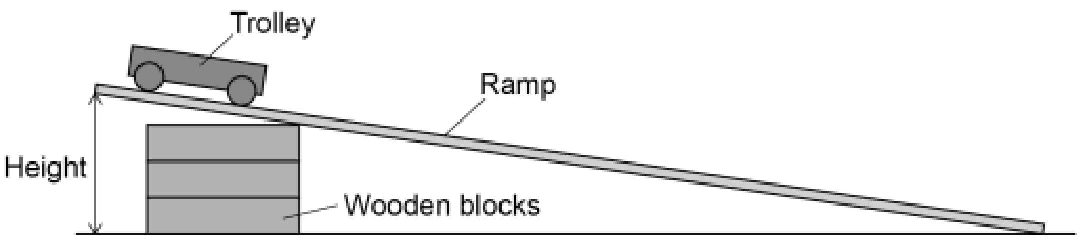
$E_p = \frac{24640 \times (0.25)^2}{2} = 770\,J$

Elastic potential energy = 770 J

0 2 A student investigated how the height of a ramp affects the acceleration of a trolley down the ramp.

Figure 3 shows some of the equipment used.

Figure 3



0 2 . 1 Plan an investigation to determine how the height of the ramp affects the acceleration of the trolley.

[6 marks]

- place one wooden block under the ramp
- vary the height by placing a different number of wooden blocks
- measure the height of the ramp using a metre rule
- measure the distance travelled using a metre rule
- measure time taken using light gates (and computer/datalogger)
- measure time taken using a stopclock or ticker timer
- release trolley from the same position each time
- release the trolley without applying a force results
- repeat at the same height and calculate a mean
- repeat for different heights
- calculate acceleration using

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

OR

$$v^2 = u^2 + 2as$$

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

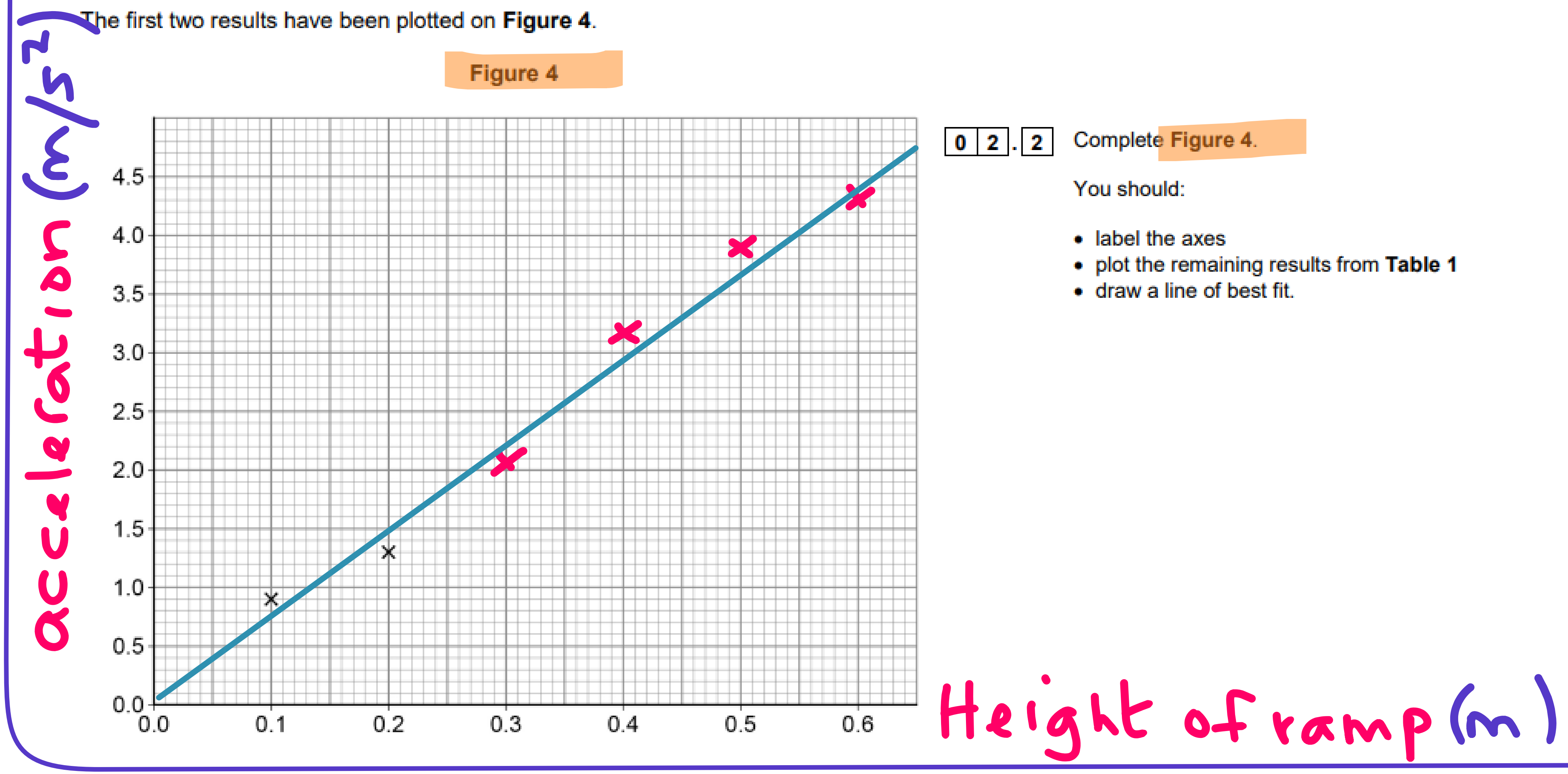
Table 1 shows the results.

Table 1

Height of ramp in metres	0.1	0.2	0.3	0.4	0.5	0.6
Acceleration in m/s^2	0.9	1.3	2.1	3.2	3.9	4.3

The first two results have been plotted on **Figure 4**.

Figure 4



0 2 . 2 Complete **Figure 4**.

You should:

- label the axes
- plot the remaining results from **Table 1**
- draw a line of best fit.

[4 marks]

0 2 . 3 Write down the equation that links acceleration (a), mass (m) and resultant force (F).

[1 mark]

$F = m \times a$

0 2 . 4 When the resultant force on the trolley was 0.63 N the acceleration of the trolley was 2.1 m/s^2

Calculate the mass of the trolley.

[3 marks]

$F = m \times a$ so $m = \frac{F}{a}$

$m = \frac{0.63\,N}{2.1\,m/s^2} = 0.30\,kg$

Mass of trolley = 0.30 kg

0 3 **Figure 5** shows a computer keyboard.

There is a spring under each key.

Figure 5

$F \propto e$

$F = ke$

0 3 . 1 The springs behave elastically when a force is applied.

What is meant by elastic behaviour?

[1 mark]

Tick (✓) **one** box.

The spring will be compressed when the force is applied to it.	
The spring will become deformed when the force is applied to it.	
The spring will become longer when the force is removed.	
The spring will return to its original length when the force is removed.	✓

0 3 . 2 Suggest **two** properties that should be the same for each spring.

[2 marks]

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1 • spring constant

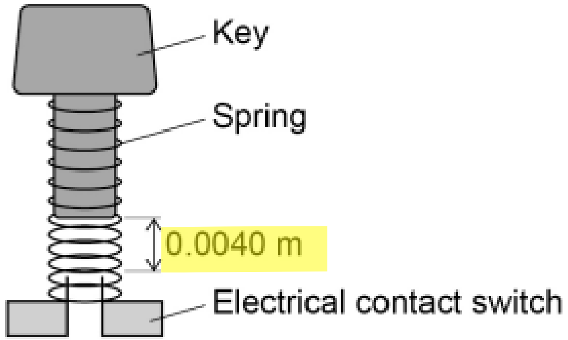
2 • (original) length

• diameter

(any 2)

0 3 . 3 **Figure 6** shows one of the keys and its spring.

Figure 6



The key must be pressed with a minimum force of 0.80 N before the key touches the switch.

Calculate the spring constant of the spring in **Figure 6**.

[3 marks]

$F = ke \qquad k = \frac{F}{e} = \frac{0.80\,N}{0.004\,m}$

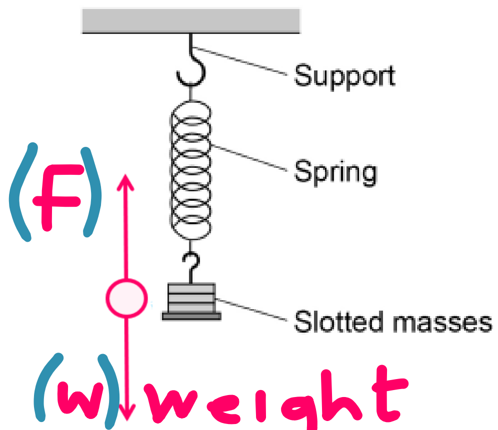
$k = 200\ \frac{N}{m}$

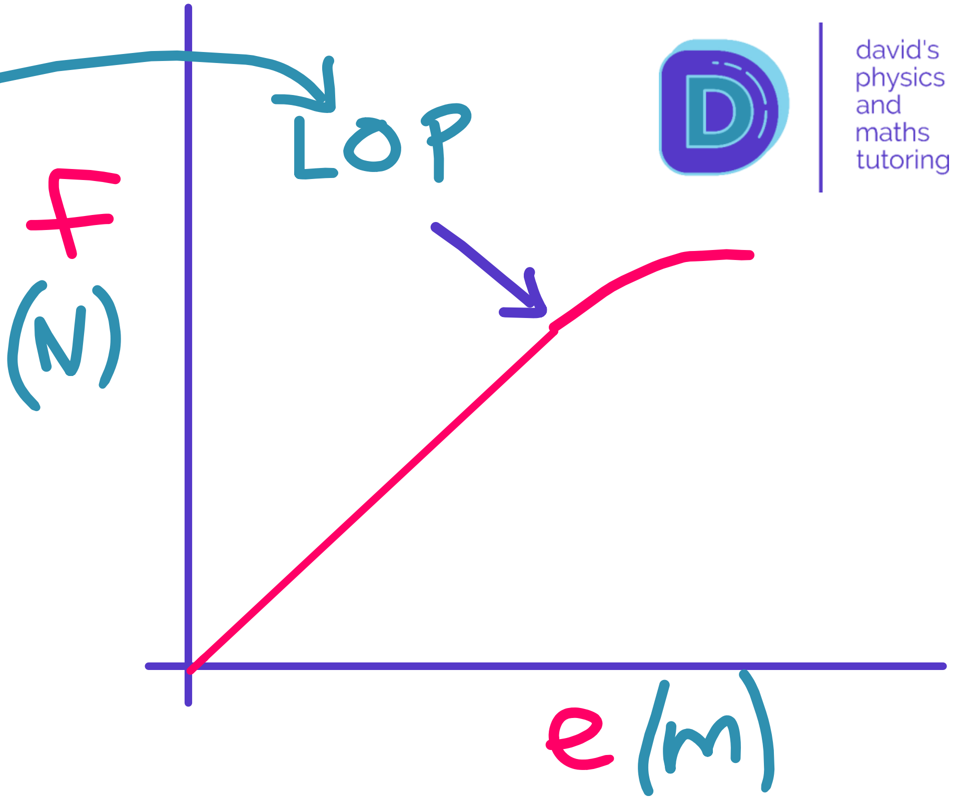
Spring constant = 200 N/m

0 3 . 4 **Figure 7** shows a spring that has been hung from a support.

The spring is stationary and has been stretched beyond its limit of proportionality.

Figure 7

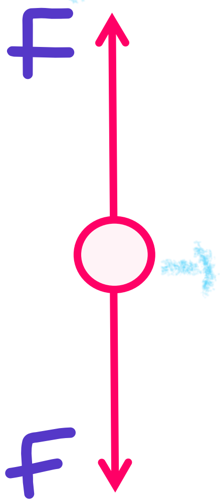




Which **two** statements are true for the spring in **Figure 7**?

[2 marks]

Tick (✓) **two** boxes.



The elastic potential energy of the spring is zero.	☐
The extension of the spring is directly proportional to the force applied.	☐
The upward force on the spring is equal to the downward force.	✓
The spring cannot be stretched any further.	☐
The spring is inelastically deformed.	✓

0 4 **Figure 8** shows a girl bowling a ball along a ten-pin bowling lane.

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Figure 8

The girl is trying to knock down the ten pins at the end of the bowling lane.

0 4 . 1 Velocity is a vector quantity, speed is a scalar quantity.

Describe what is meant by a vector quantity and a scalar quantity.

[2 marks]

Vector quantity (vector quantity) has magnitude and a direction

Scalar quantity (scalar quantity) has magnitude only

0 4 . 2 The bowling lane is horizontal.

Explain why the bowling ball decelerates as it travels along the lane.

[2 marks]

resistive force acts on the ball so (resultant) force in opposite direction to velocity

or so work is done on the ball

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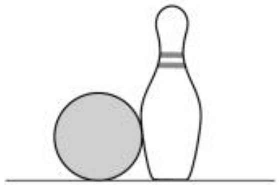
Figure 9 shows the bowling ball hitting one of the pins.

Figure 9



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0 4 . 3 Write down the equation that links mass (*m*), momentum (*p*) and velocity (*v*).

[1 mark]

$p = m \times v$

0 4 . 4 The bowling ball has a velocity of 5.0 m/s when it hits the pin.

The momentum of the bowling ball is 26 kg m/s

Calculate the mass of the bowling ball.

[3 marks]

$p = m \times v \qquad m = \frac{p}{v} = \frac{26 \text{ kg m/s}}{5 \text{ m/s}}$

$= 5.2 \text{ kg}$

Mass = 5.2 kg

0 4 . 5 Explain why the bowling ball slows down when it hits the pin.

You should use ideas about momentum in your answer.

[3 marks]

momentum is conserved in the collision

(assuming no external forces)

momentum of the pin increases therefore the

momentum of the ball must decrease

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0 6 The speed limit on many roads in towns is 13.5 m/s

Outside schools this speed limit is often **reduced by** one-third.

0 6 . 1 Calculate the reduced speed limit.

[2 marks]

$\frac{1}{3} \times 13.5 = 4.5$

$13.5 - 4.5 = 9$ m/s

Reduced speed limit = 9 m/s

0 6 . 2 A reduced speed limit may reduce air pollution.

Explain **one** other advantage of a reduced speed limit.

[2 marks]

reduced speed reduces stopping distance means less chance of collision OR the car will have less kinetic energy (1) so less likely to cause injury in the event of a collision (1)

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0 6 . 3 **Figure 11** shows a car being driven at a constant speed past a speed camera.

Figure 11

The camera recorded two images of the car 0.70 s apart.

The car travelled 14 m between the two images being taken.

The maximum deceleration of the car is 6.25 m/s^2

Calculate the minimum braking distance for the car at the speed it passed the speed camera.

[6 marks]

$v^2 = u^2 + 2as$

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

$v = \frac{14}{0.7} = 20\ m/s$

$0^2 = 20^2 + 2(-6.25)s$

$s = \frac{-400}{-12.5}$

$s = 32m$

0 6 . 4 **Figure 12** shows a delivery van full of packages.

Figure 12

The driver delivers all the packages.

The empty van has a shorter stopping distance than the full van when driven at the same speed.

Explain why.

[3 marks]

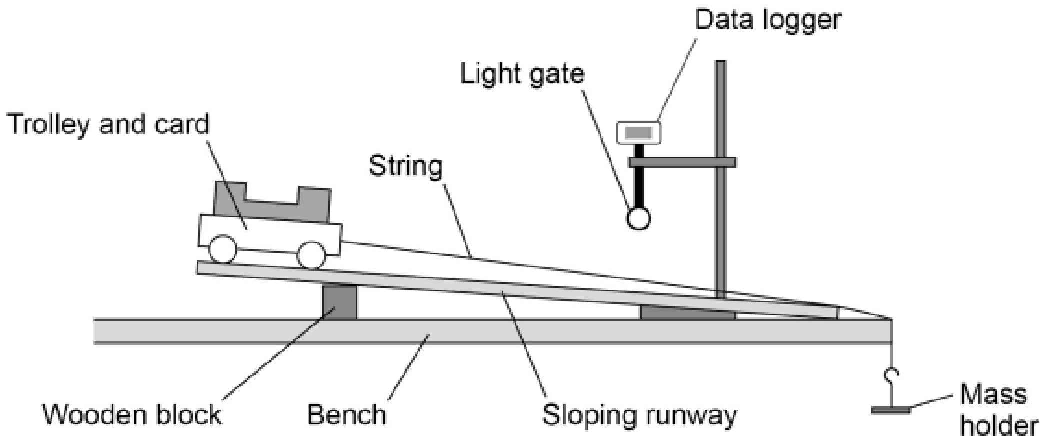
same maximum force applied by the brakes because mass is less

there is a greater deceleration braking distance is less OR reducing the mass reduced the kinetic energy of the van (at a given speed) (1) less work needed to be done to bring the van to a stop (1) (force from the brakes is the same) so braking distance is less (1)

0 1 A student investigated the acceleration of a trolley.

Figure 1 shows how the student set up the apparatus.

Figure 1



0 1 . 1 Before attaching the mass holder the student placed the trolley at the top of the runway. The trolley rolled down the runway without being pushed.

What change to the apparatus in **Figure 1** could be made to prevent the trolley from starting to roll down the runway?

[1 mark]

Tick (✓) **one** box.

Move the wooden block to the left. ☐

Shorten the length of the runway. ☐

Use a taller wooden block. ☐

0 1 . 2 The student attached the mass holder to the string.

The string rubbed along the edge of the bench as the mass holder fell to the floor.

Suggest what the student could do to prevent the string from rubbing.

[1 mark]

use a pulley (on the edge of the bench)

The light gate and data logger were used to determine the acceleration of the trolley.

The student increased the resultant force on the trolley and recorded the acceleration of the trolley.

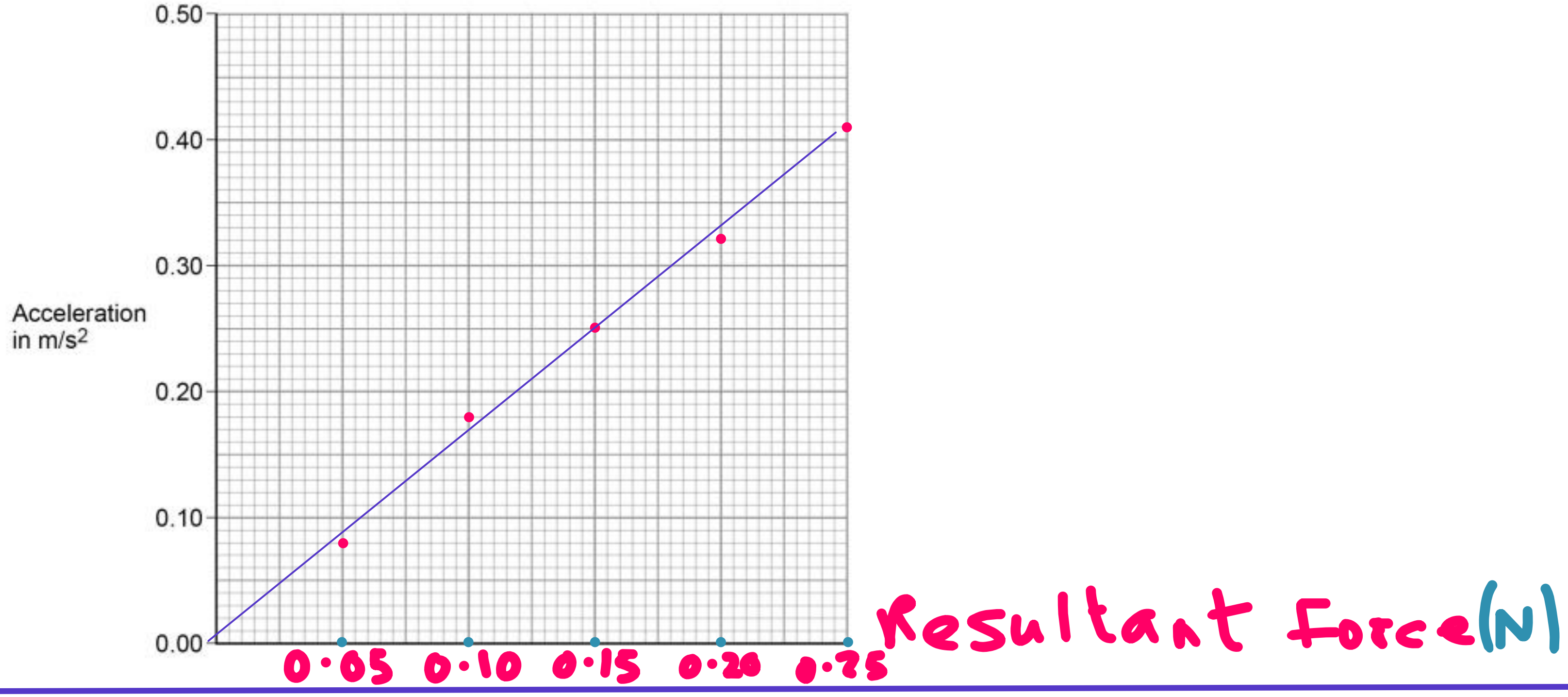
Table 1 shows the results.

Table 1

Resultant force in newtons	Acceleration in m/s²
0.05	0.08
0.10	0.18
0.15	0.25
0.20	0.32
0.25	0.41

Figure 2 is an incomplete graph of the results.

Figure 2



0 1 . 3 Complete **Figure 2**.

- Choose a suitable scale for the x-axis.
- Plot the results.
- Draw a line of best fit.

[4 marks]

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0 1 . 4 Describe the relationship between the resultant force on the trolley and the acceleration of the trolley.

[1 mark]

(directly) proportional

0 1 . 5 Describe how the investigation could be improved to reduce the effect of random errors.

[2 marks]

repeat the measurements/investigation

ignore anomalies and calculate the mean / average

0 1 . 6 Write down the equation that links acceleration (*a*), mass (*m*) and resultant force (*F*).

[1 mark]

$F = m \times a$

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0 1 . 7 The resultant force on the trolley was 0.375 N. F

The mass of the trolley was 0.60 kg. m

Calculate the acceleration of the trolley. a

Give your answer to 2 significant figures.

[4 marks]

$F = m \times a$

$a = \frac{F}{m} = \frac{0.375\,N}{0.60\,kg} = 0.625\,\frac{N}{kg}$

Acceleration (2 significant figures) = 0.63 m/s^2

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0 5 **Figure 7** shows two ice hockey players moving towards each other.

They collide and then move off together.

Figure 7

Before the collision

Player A
Mass = 78 kg
Velocity = +7.5 m/s

Player B
Mass = 91 kg
Velocity = –5.5 m/s

During the collision, the total momentum of the players is conserved.

0 5 . 1 What is meant by 'momentum is conserved'?

[1 mark]

(total) momentum before = (total) momentum after

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0 5 . 2 Immediately after the collision the two players move together to the right.

Calculate the velocity of the two players immediately after the collision.

[4 marks]

$(78 \times 7.5) + 91 \times (-5.5)$ (Before)

$(78 + 91) \times V$ (After)

Before = After

$585 + (-500.5) = 169 \times V$

$V = 0.5$ m/s

Velocity = 0.5 m/s

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0 5 . 3 The ice hockey players wear protective pads filled with foam.

Explain how the protective pads help to reduce injury when the players collide.

[3 marks]

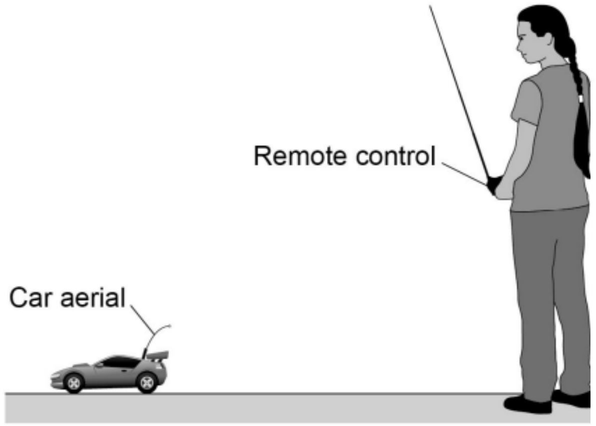
(protective pads) increase the time taken to stop (during the collision)

so the rate of change of momentum decreases

reducing the force (on the ice hockey player)

0 6 **Figure 8** shows a student playing with a remote-controlled car.

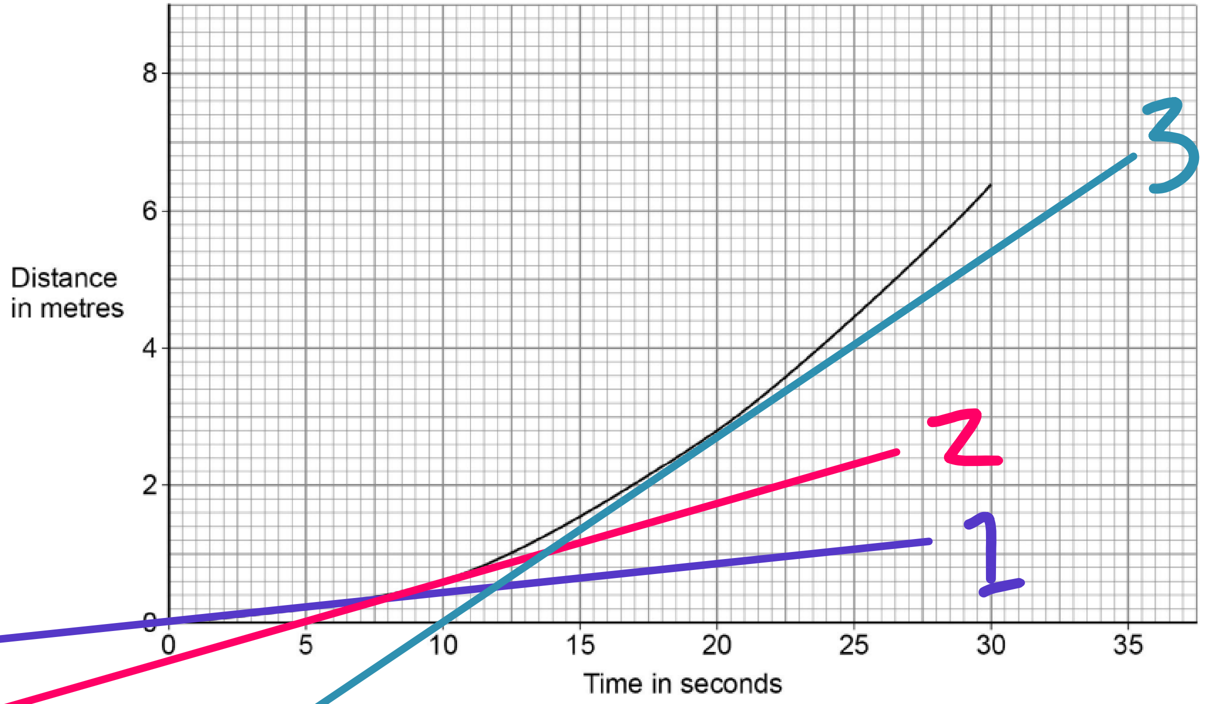
Figure 8



Curve

Figure 9 shows the distance-time graph for the first 30 seconds of the car's motion.

Figure 9



Velocity 1

Velocity 2

Velocity 3

Steepness increases

→ velocity changes

0 6 . 4 Describe the motion of the car during the first 30 seconds.

[1 mark]

accelerating

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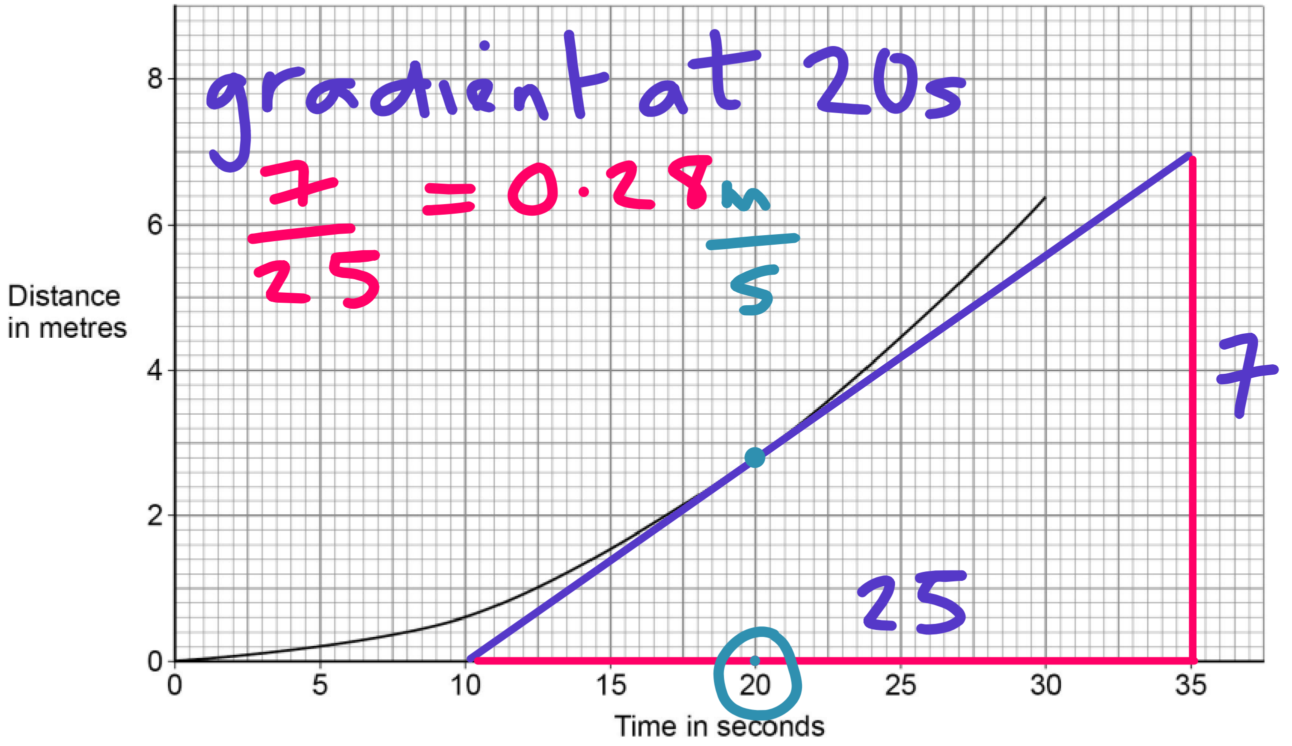
0 6 . 5 Determine the speed of the car 20 seconds after it started to move.

[4 marks]

gradient at 20s

$= \frac{7}{25} = 0.28 \frac{m}{s}$

Speed = 0.28 m/s



0 6 . 6 A different car accelerated from 0.12 m/s to 0.52 m/s.

The acceleration of the car was 0.040 m/s^2.

The work done to accelerate the car was 0.48 J.

Calculate the resultant force needed to accelerate the car.

[6 marks]

u v a Wd

$Wd = F \times S$

$v^2 = u^2 + 2as$ $\quad 0.52^2 = 0.12^2 + 2 . 0.04 . S$

$0.2704 = 0.0144 + 0.08 . S$

$S = 3.2\,m$

$Wd = F \times S$

$0.48 = F \times 3.2$ $\quad F = \frac{0.48}{3.2}$

$F = 0.15\,N$

Resultant force = 0.15 N

0 6 . 7 Explain why the car has a maximum speed.

[4 marks]

there is a maximum forward force (provided by the motor)

as the speed of the car increases air resistance increases

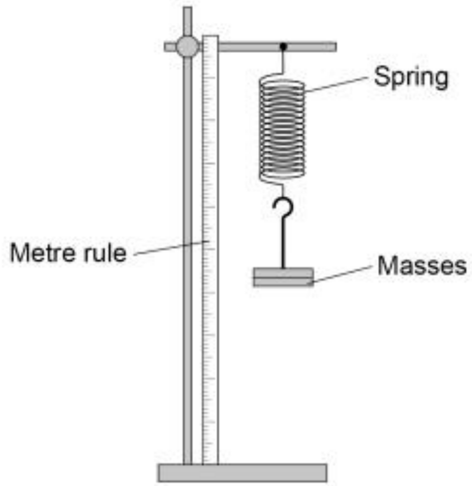
until air resistance is equal in size to forward force

so the car can no longer accelerate

0 1 **Figure 1** shows a stretched spring.

The spring is elastically deformed.

Figure 1



0 1 . 1 What is meant by 'elastically deformed'?

[1 mark]

Tick (✓) **one** box.

As the force on the spring increases the length of the spring increases.	☐
Only a very small force is needed to stretch the spring.	☐
The force on the spring causes it to change shape.	☐
The spring will return to its original length when the force is removed.	☑

0 1 . 2 Describe a method to determine the extension of the spring.

[2 marks]

measure the original length of the spring and the extended length of the spring (with the metre rule)

extension = extended length – original length

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0 1 . 3 The extension of the spring is 80 mm. → $\frac{80}{1000}$ m = (0.08 m = e)

spring constant = 40 N/m → K

Calculate the elastic potential energy of the spring. → E_e

Use the Physics Equations Sheet.

[3 marks]

$$E_e = \frac{K \times e^2}{2}$$

$$E_e = \frac{40 \times 0.08^2}{2} = 0.128\ \text{J}$$

Elastic potential energy = 0.128 J

0 1 . 4 Write down the equation which links extension (e), force (F) and spring constant (k).

[1 mark]

$F = k \times e$

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0 1 . 5 A force of 300 N acts on a different spring.

F

The force causes the spring to extend by 0.40 m.

e

Calculate the spring constant of the spring.

k

[3 marks]

$F = k \times e$ so $k = \frac{F}{e}$

$k = \frac{300}{0.40} = 750$ N/m

Spring constant = 750 N/m

0 2 Professional rugby players wear a tracking device that measures their velocity and acceleration.

Figure 2 shows a player wearing a tracking device.

The player is tackling another player who is running with the ball.

Figure 2

0 2 . 1 Velocity and acceleration are both vector quantities.

What is a vector quantity?

[1 mark]

Tick (✓) **one** box.

A quantity with both magnitude and direction ☑

A quantity with direction only ☐

A quantity with magnitude only ☐

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0 2 . 2 Which of the following is a vector quantity?

[1 mark]

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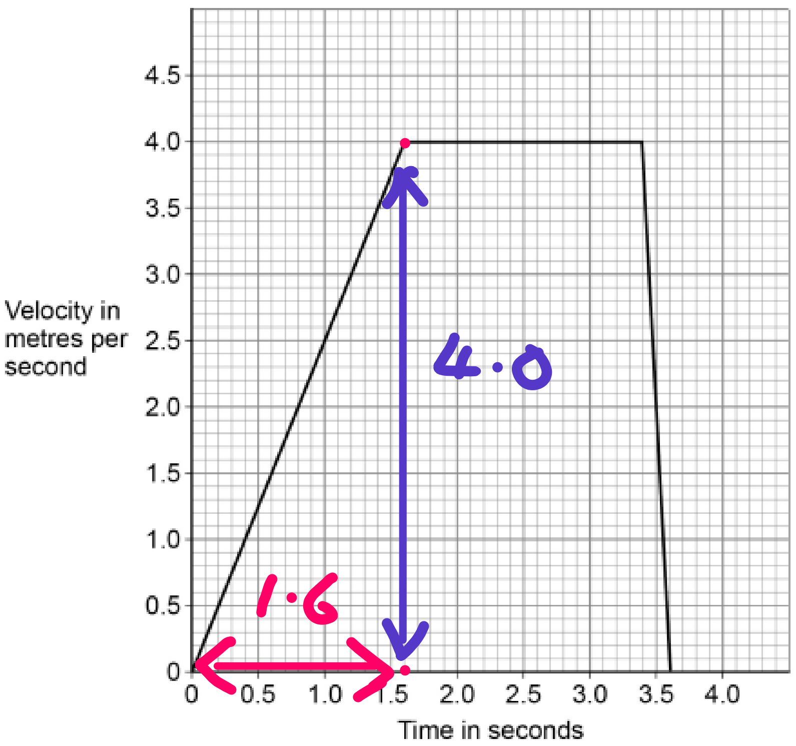
Tick (✓) **one** box.

Displacement	✓
Distance	
Time	
Work done	

Displacement is the distance moved in a straight line, in a given direction, from the starting point. Displacement is a vector quantity as it has size and direction.

Figure 3 shows a velocity–time graph for the player running with the ball.

Figure 3



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$$a = \frac{\text{change in vel}}{\text{time}}$$

$$a = \frac{4 \cdot 0}{1 \cdot 6} = 2 \cdot 5\ m/s^2$$

0 2 . 3 Determine the acceleration of the player between 0 and 1.6 s.

[2 marks]

Acceleration = 2·5 m/s²

0 2 . 4 Describe the motion of the player between 3.4 s and 3.6 s.

[1 mark]

constant deceleration

The force exerted on the player when she is tackled causes her to accelerate.

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0 2 . 5 Write down the equation which links acceleration (*a*), mass (*m*) and resultant force (*F*).

[1 mark]

$F = m \times a$

0 2 . 6 The player accelerates at 25 m/s² when a resultant force of 1800 N acts on her.

Calculate the mass of the player.

[3 marks]

$F = m \times a$ so $m = \frac{F}{a}$

$m = \frac{1800}{25} = 72\,kg$

Mass = 72 kg

0 6 Scientists are developing a hypersonic aeroplane that will travel much faster than normal aeroplanes.

0 6 . 1 An aeroplane accelerates from a low speed to a high speed with the engines at maximum power.

Explain why the acceleration is **not** constant.

[5 marks]

at maximum power the forward force of the engines is constant

as it accelerates the air resistance increases

resultant force = force from engines – air resistance

therefore

resultant force decreases acceleration is

directly proportional to resultant force

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0 6 . 2 The hypersonic aeroplane will have jet engines and a rocket engine.

The speed of aeroplanes can be measured on a uniform scale called the Mach scale.

Mach 1 = 330 m/s

The jet engines will accelerate the aeroplane to Mach 5.5. $(5.5 \times 330)\ \text{m/s}$ — u

The rocket engine will accelerate the aeroplane from Mach 5.5 to Mach 25.5 in 300 s. — t

$(25.5 \times 330)\ \text{m/s}$ — v

The average resultant force on the aeroplane when the rocket engine is used will be 630 000 N. — F

Calculate the mass of the hypersonic aeroplane. — m

Give your answer to 2 significant figures.

[6 marks]

$$F = ma$$

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

$$a = \frac{8415 - 1815}{300} = 22\ \text{m/s}^2$$

$$F = m \times a$$

$$m = \frac{F}{a} = \frac{630000\ \text{N}}{22\ \text{m/s}^2} = 28636\ \text{kg}$$

$$= 29000\ \text{kg}$$

0 2 **Figure 3** shows competitors in the wheelchair race at the London Marathon.

The distance of the London Marathon is 42 000 m

Figure 3

0 2 . 1 Write down the equation that links distance (s), force (F) and work done (W).

[1 mark]

$W = F \times S$

$S = 42000\,m$

0 2 . 2 During the race competitors work against air resistance.

The work done against air resistance by the winner of the race was 3 360 000 J (W)

Calculate the average air resistance acting on the winner of the race.

[3 marks]

(F)

$W = F \times S \Rightarrow F = \frac{W}{S}$

$F = \frac{3\,360\,000}{42000}$

Average air resistance = 80 N

0 2 . 4 The distance of the London Marathon is 42 000 m — s

The winning time for the race was 5600 seconds. — t

Calculate the average speed of the winner of the race. — v

[3 marks]

$v = \frac{s}{t}$

$= \frac{42000\,m}{5600\,s} = 7.5\,\frac{m}{s}$

Average speed = 7.5 m/s

0 2 . 5 Explain why the speed of a competitor changes during the race.

[4 marks]

the effect on speed must be consistent with the cause of the change

- competitors accelerate at the start
- so speed increases
- the road is not flat
- so speed increases going downhill and / or speed decreases going uphill
- the competitor goes round a bend
- so speed decreases
- competitors may tire towards the end (so the force they exert decreases)
- so they slow down
- competitors may sprint during the race
- causing speed to increase
- may get a puncture
- so speed would decrease or they would stop
- resistive forces on competitors may increase/decrease
- so speed would decrease/increase

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0 3 **Figure 4** shows a child playing with a toy train.

The train is on a bridge.

Figure 4

When the child lets go of the train, the train rolls down the bridge.

0 3 . 1 The momentum of the train at the bottom of the bridge is 0.216 kg m/s

mass of the train = 180 g

Calculate the velocity of the train at the bottom of the bridge.

Use the Physics Equations Sheet.

[4 marks]

$\frac{180}{1000} = 0.18$ kg (m)

$p = m \times v$

$0.216 = 0.18 \times v$

$\frac{0.216}{0.18} = v = 1.2$ m/s

0 3 . 2 The train collides with a stationary carriage on the track.

Explain why the velocity of the train after the collision is less than it was before the collision.

Use ideas about momentum in your answer.

[4 marks]

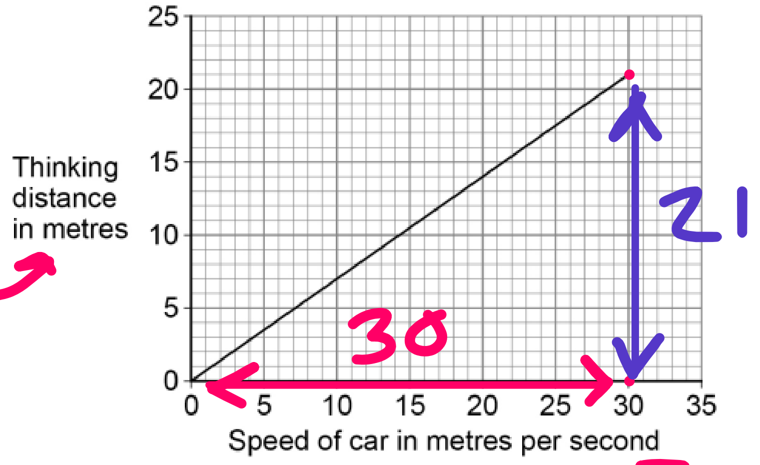
(total) momentum is conserved in the collision during the collision the momentum of carriage increases so the momentum of train decreases since

momentum = mass × velocity, velocity (of train) decreases

0 6 The distance a car travels during the driver's reaction time is called the thinking distance.

0 6 . 1 **Figure 9** shows how thinking distance depends on speed for a car.

Figure 9



Determine the driver's reaction time. (t)

Use the Physics Equations Sheet.

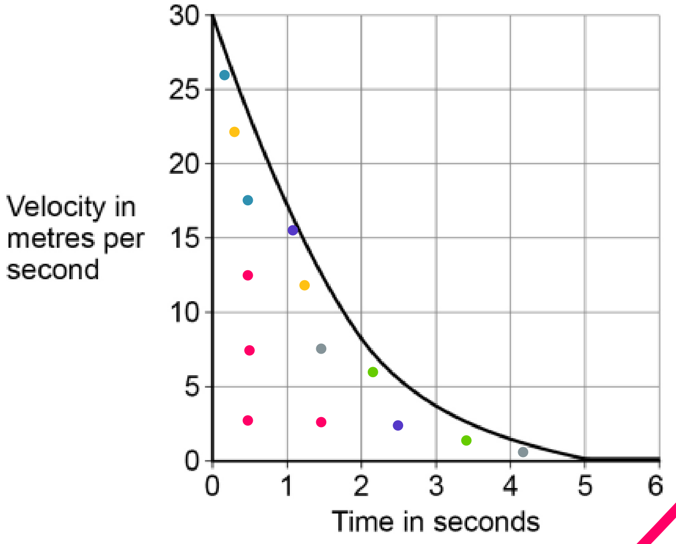
[3 marks]

$v = \frac{s}{t}$

$t = \frac{s}{v}$ ⇒ gradient of graph. $\frac{21}{30} = 0.7\,s$

0 6 . 2 **Figure 10** shows how the velocity of a car changes during braking.

Figure 10



Area under graph = distance

Determine the braking distance of the car.

[3 marks]

9 full squares

Each square = 5m

So = 45m

Braking distance = 45 m

0 6 . 3 Explain how the gradient of the line on **Figure 10** shows that the resultant force on the car was **not** constant.

[3 marks]

gradient is equal to acceleration gradient / acceleration is not constant so resultant force is not constant because resultant force is directly proportional to acceleration (for constant mass)

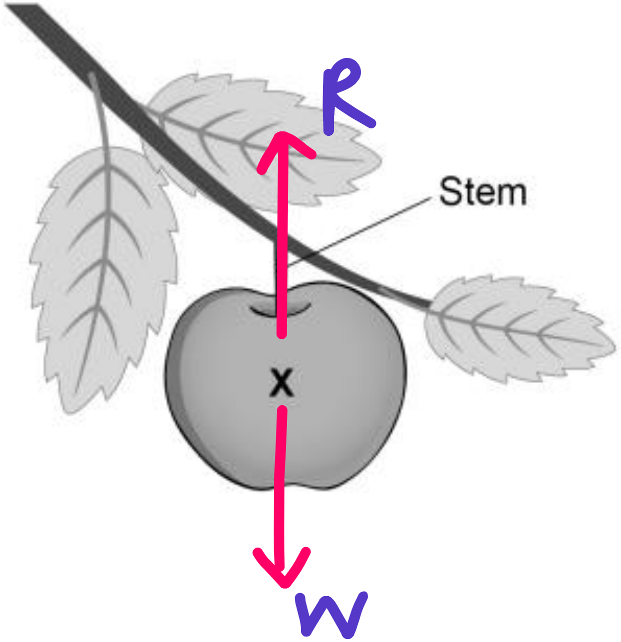
$F \propto a$

$F = m \times a$

0 7 **Figure 11** shows a stationary apple hanging from a tree.

The **X** marks the centre of mass of the apple.

Figure 11



0 7 . 1 Draw **two** arrows on **Figure 11** to show the forces acting on the apple.

[2 marks]

0 7 . 2 It takes 0.50 s for the apple to fall to the ground. t

The initial velocity of the apple is 0 m/s u

acceleration due to gravity = 9.8 m/s² (g or a)

Calculate the distance fallen by the apple. s

Use the Physics Equations Sheet.

[6 marks]

$v^2 = u^2 + 2as$

$a = \frac{v-u}{t} \Rightarrow 9.8 = \frac{v-0}{0.5} \Rightarrow v = \frac{9.8}{2}$

$v = 4.9$ m/s

$4.9^2 = 0^2 + 2 . 9.8 . s$

$\frac{24.01}{(2 . 9.8)} = s = 1.225$ m

Distance = 1.225 m

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0 7 . 3 In Question **07.2** it was assumed that the acceleration was a constant 9.8 m/s^2

Evaluate this assumption.

[4 marks]

as the apple falls / accelerates air resistance increases so resultant force decreases so acceleration will decrease acceleration will not be constant, so not a good assumption OR the apple only falls for a short time/distance (1) air resistance is negligible (1) so resultant force is constant (1) therefore acceleration is constant, so good assumption (1)

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0 1 **Figure 1** shows an electric super-car.

Figure 1

0 1 . 1 The battery in an electric car needs to be recharged.

Suggest **two** factors that affect the distance an electric car can travel before the battery needs to be recharged.

[2 marks]

1 any two from: • capacity of the battery • speed • mass / weight • uphill / downhill • stopping at traffic lights • condition of the

2 road • (air) temperature • (incorrect) tyre pressure • streamlining of the car

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0 1 . 2 Write down the equation which links acceleration (a), change in velocity (Δv) and time taken (t).

[1 mark]

$a = \frac{\Delta v}{t}$

0 1 . 3 The maximum acceleration of the car is 20 m/s^2.

Calculate the time taken for the speed of the car to change from 0 m/s to 28 m/s at its maximum acceleration.

[3 marks]

$a = \frac{v-u}{t}$ or $\frac{\Delta v}{t}$

$t = \frac{\Delta v}{a} = \frac{28}{20} = 1.4\,s$

Time taken = 1.4 s

0 1 . 4 In a trial run, the car accelerates at 10 m/s^2 until it reaches its final velocity.

distance travelled by the car = 605 m — s

initial velocity of the car = 0 m/s — u

— a

Calculate the final velocity of the car. — v

Use the Physics Equations Sheet.

[3 marks]

$v^2 = u^2 + 2as$

$v^2 = 0^2 + 2 \cdot 10 \cdot 605$

$v = \sqrt{12100} = 110\ m/s$

Final velocity = 110 m/s

0 1 . 5 Write down the equation which links distance (*s*), force (*F*) and work done (*W*).

[1 mark]

$W = F \times S$

0 1 . 6 When travelling at its maximum speed the air resistance acting on the car is 4000 N. (F)

Calculate the work done (W) against air resistance when the car travels a distance of 7.5 km at its maximum speed. (7500 m (S))

[3 marks]

$V = 110\ m/s$

$W = F \times S$

$= 4000 \times 7500 = 30\ MJ$

Work done = 30 000 000 J

0 3 Speed limits on roads increase safety.

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0 3 . 1 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.

[2 marks]

1 any two from: • wet / icy road conditions • poor condition of brakes • poor condition of tyres • increased mass of car • negative gradient of the

2 road

0 3 . 2 Explain why the driver's reaction time affects the thinking distance of a car.

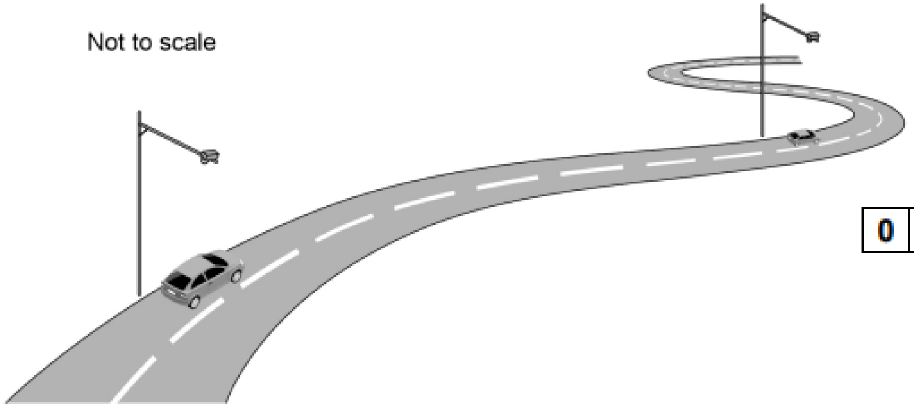
[2 marks]

distance = speed × time (so) longer reaction time = longer distance

Figure 6 shows some speed cameras on a road.

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

Figure 6



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0 3 . 4 The speed limit on the road in **Figure 6** is 20 m/s. → v

The cameras in **Figure 6** are 1.5 km apart. → 1500 m (s)

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

Use the Physics Equations Sheet.

[4 marks]

$v = \frac{s}{t}$

So $t = \frac{s}{v} = \frac{1500}{20} = 75\text{ s}$

Minimum time = 75 s

0 3 . 5 The average speed of a car between the cameras and the average velocity of the car between the cameras are different.

Explain why.

[3 marks]

velocity is a vector and speed is a scalar - road is not straight therefore direction changes so the velocity changes

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0 4 Hailstones are small balls of ice. Hailstones form in clouds and fall to the ground.

Figure 7 shows different-sized hailstones.

Figure 7

A hailstone falls from a cloud and accelerates.

0 4 . 1 Why does the hailstone accelerate?

[1 mark]

there is a resultant force acting

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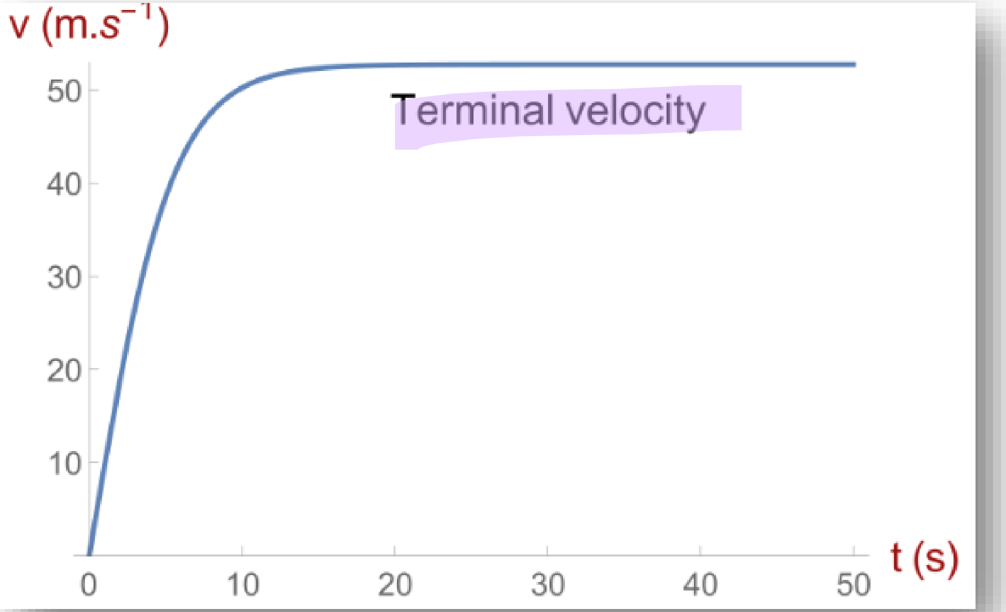
0 4 . 2 The hailstone stops accelerating and reaches terminal velocity.

Explain why the hailstone reaches terminal velocity.

[3 marks]

as the velocity of the hailstone increases air resistance increases until air resistance becomes equal to the weight of the hailstone so the resultant force is (equal to) zero



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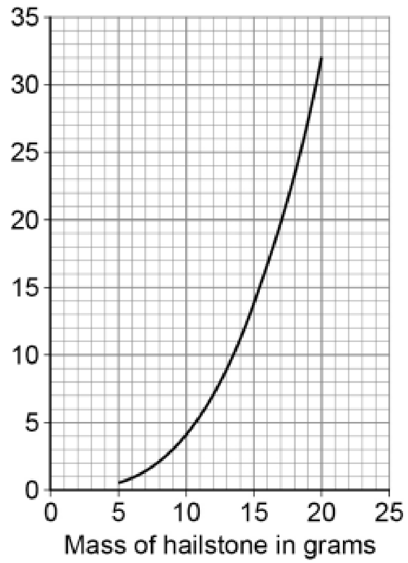
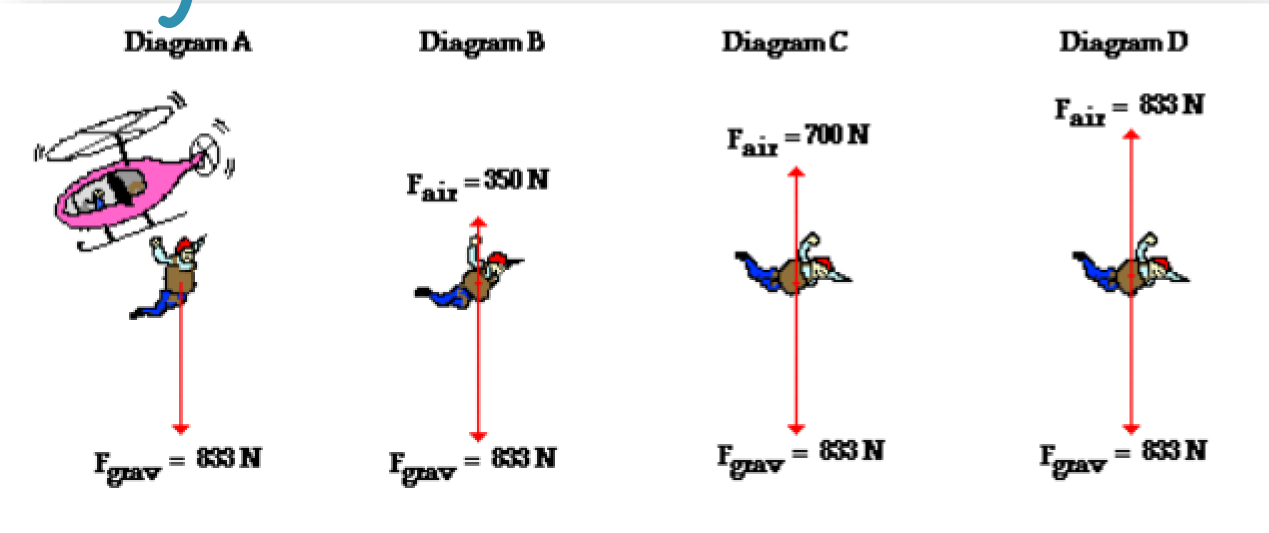
A scientist investigated how the mass of hailstones affects their terminal velocity.

Figure 8 shows the results.

Figure 8



Eg.



0 4 . 3 Why does terminal velocity increase with mass?

[1 mark]

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.	✓

So if F_{grav} is bigger, then F_{air} is bigger.

0 4 . 4 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 marks]

kinetic energy depends on both mass and velocity as mass increases so does terminal / maximum velocity kinetic energy ∝ m and kinetic energy ∝ velocity squared so as **mass doubles** kinetic energy **more than doubles**

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0 4 . 5 The kinetic energy of a hailstone is measured in joules.

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Which of the following is the same as 1 joule?

[1 mark]

Tick (✓) **one** box.

Example

Work done = F × s

(J) (N) (m)

- 1 N m ☑
- 1 N/m ☐
- 1 N/m^2 ☐
- 1 N m^2 ☐

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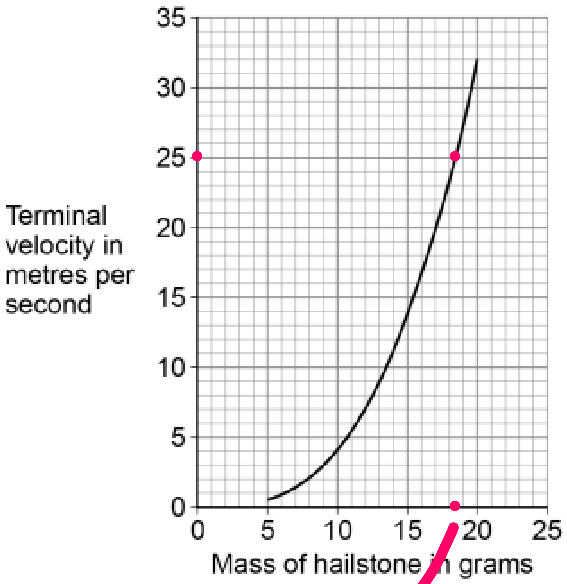
Figure 8 is repeated below.

Figure 8



0 4 . 6 A hailstone hit the ground at its terminal velocity of 25 m/s. — v

The hailstone took 0.060 s to stop moving. — t

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

Use information from **Figure 8**.

Use the Physics Equations Sheet.

[3 marks]

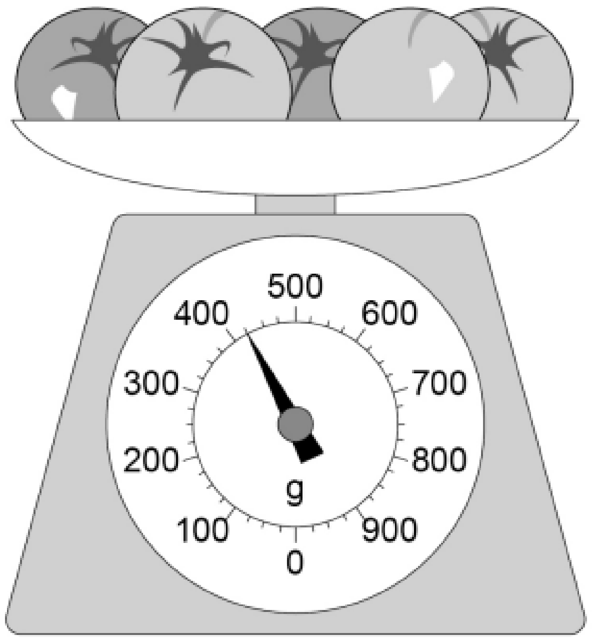
18.5g = 0.0185 kg

$F = \frac{mv}{t} = \frac{0.0185 \times 25}{0.06}$

$F = 7.708\ N$

0 5 **Figure 9** shows a balance used to measure the mass of five tomatoes.

Figure 9



0 5 . 1 What is meant by 'centre of mass'?

[1 mark]

the point from which weight may be considered to act or the point where the mass appears to be concentrated

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0 5 . 2 Calculate the mean weight of a tomato in **Figure 9**.

Use the Physics Equations Sheet.

gravitational field strength = 9.8 N/kg

[3 marks]

(m) from scales = 425g = 0.425 kg

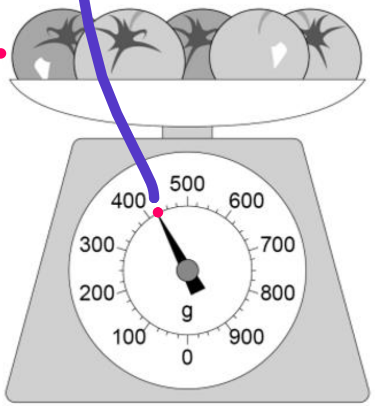
$W = m \times g$

$W = 0.425 \times 9.8$

$W = 4.165\,N$ (5 tomatoes)

$W = \frac{4.165}{5} = 0.833\,N$

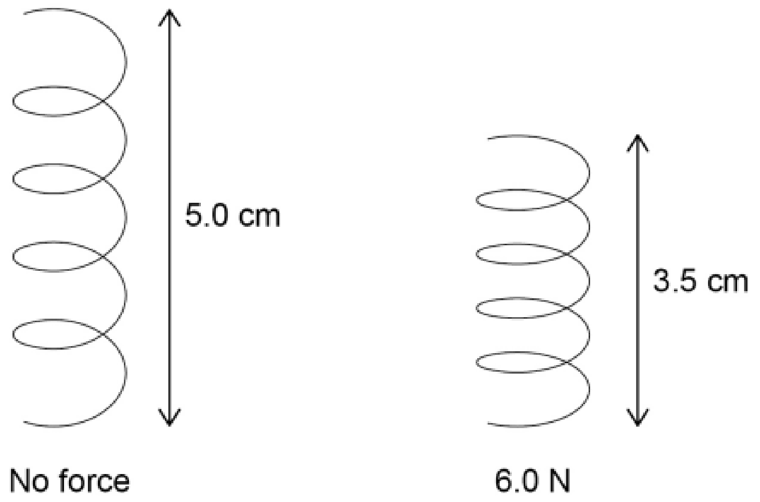
Weight = 0.833 N



0 5 . 3 The balance in **Figure 9** contains a spring that compresses when the tomatoes are placed on the balance.

Figure 10 shows the spring with no force acting and with a 6.0 N force acting.

Figure 10



Extension (e) = 5.0cm − 3.5cm

e = 1.5cm

e = 0.015m

Determine the spring constant of the spring.

Use the Physics Equations Sheet.

[3 marks]

$F = ke$

$k = \frac{F}{e} = \frac{6N}{0.015m} = 400 \frac{N}{m}$

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0 5 . 4 Explain **one** property of the spring that makes it suitable for use in the balance.

[2 marks]

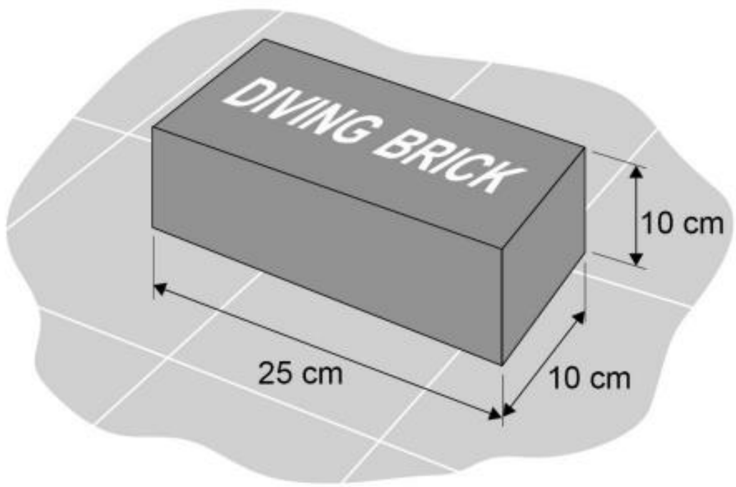
deforms elastically (so) will return to its original length / shape (after force is removed)

OR compression is directly proportional to the force (applied) (1) (so) gives a linear scale (1)

0 8 Diving bricks sink to the bottom of a swimming pool.

Figure 14 shows a diving brick.

Figure 14



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

0 8 . 1 Explain why the forces on the brick at the bottom of the pool cause the brick to be stationary.

[3 marks]

upthrust acts (upwards on the brick) normal contact force acts upwards (on the brick) weight is equal to upthrust plus normal contact force

0 8 . 2 When the brick from **Figure 14** is at the bottom of the pool, the top surface of the brick is 2.50 m below the surface of the water. — h

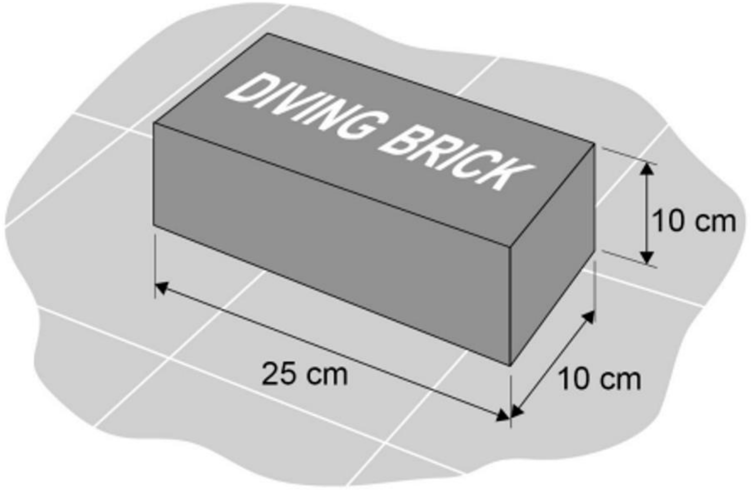
The force acting on the top surface of the brick due to the weight of the water is 637 N. — F

gravitational field strength = 9.8 N/kg — g

Calculate the density of the water in the swimming pool. — ρ

Use the Physics Equations Sheet.

[6 marks]



$P = \frac{F}{A}$ $P = h\rho g$

$\frac{F}{A} = h\rho g$

Area (A) = 0.25 × 0.10
A = 0.025 m²

$\frac{637}{0.025} = 2.5 \times \rho \times 9.8$

$\rho = 1040 \frac{kg}{m^3}$

Density of water = 1040 kg/m³

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0 8 . 3 Professional divers are trained in a very deep swimming pool.

The density of the water in this pool is **not** the same as the density of the water in Question **08.2**

The diving brick was dropped into the very deep swimming pool.

When the brick was at a depth of 2.50 m, the force due to the weight of the water on the top surface of the brick was 618 N. — F

$P = \frac{F}{A} = \frac{618}{0.025} = 24720\ \text{Pa}$

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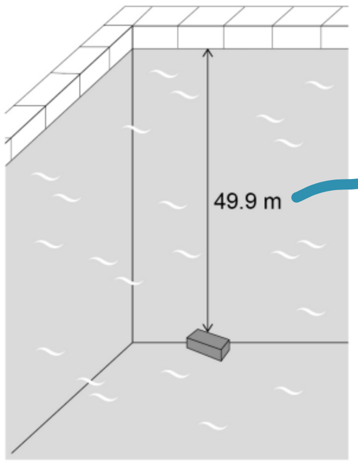
Figure 15 shows the diving brick at the bottom of the very deep swimming pool.

Figure 15



— h

Determine the force due to the weight of the water on the top surface of the brick in **Figure 15**.

Use the Physics Equations Sheet.

Give your answer to 3 significant figures.

[3 marks]

$P = h\rho g$ to get ρ

$\rho = \frac{P}{hg} = \frac{24720}{2.5 \times 9.8} = 1008.97959\ \text{kg/m}^3$

So, $P = h\rho g$ at bottom $= 49.9 \times 1008.97 \times 9.8$

$P = 493411.2\ \text{Pa}$ $\quad F = P \times A = 493411.2 \times 0.025 = 12335.28$

Force (3 significant figures) = 12300 N