

# Forces 6

Name: \_\_\_\_\_

Class: \_\_\_\_\_

Date: \_\_\_\_\_

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Time: **73 minutes**

Marks: **67 marks**

Comments:

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1.

The photograph below shows a girl bowling a ball along a ten-pin bowling lane.



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

As the ball travels along the lane the velocity of the ball decreases.

(a) Velocity is a vector.

Which statement describes a vector?

Tick (✓) **one** box.

Vectors have direction only.

Vectors have magnitude and direction.

Vectors have magnitude only.

(1)

(b) Why does the velocity of the ball decrease as the ball travels along the lane?

Tick (✓) **one** box.

The force of gravity slows the ball down.

There are no forces acting on the ball.

There is a resultant force acting on the ball.

(1)

(c) The ball travels along the lane at an average speed of 4.5 m/s

It takes the ball 4.0 seconds to travel the length of the lane.

Calculate the length of the lane.

Use the equation:

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

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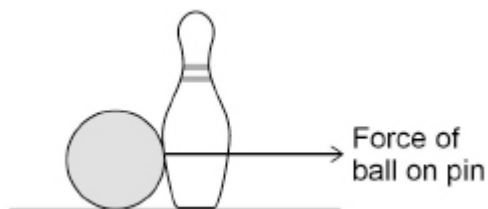
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Length of the lane = \_\_\_\_\_ m

(2)

The diagram below shows the ball hitting one of the pins.



(d) Draw an arrow on the diagram above to show the force of the pin on the ball.

(2)

(e) The velocity of the pin changes from 0 to 12 m/s

It takes 0.15 seconds for the velocity to change.

Calculate the acceleration of the pin.

Use the equation:

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

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Acceleration = \_\_\_\_\_ m/s<sup>2</sup>

(2)

(f) When the pin is struck it accelerates.

Complete the sentences.

Choose answers from the box.

Each answer can be used once, more than once, or not at all.

<b>decreases</b>	<b>increases</b>	<b>stays the same</b>
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The displacement of the pin from the girl \_\_\_\_\_.

The mass of the pin \_\_\_\_\_.

The kinetic energy of the pin \_\_\_\_\_.

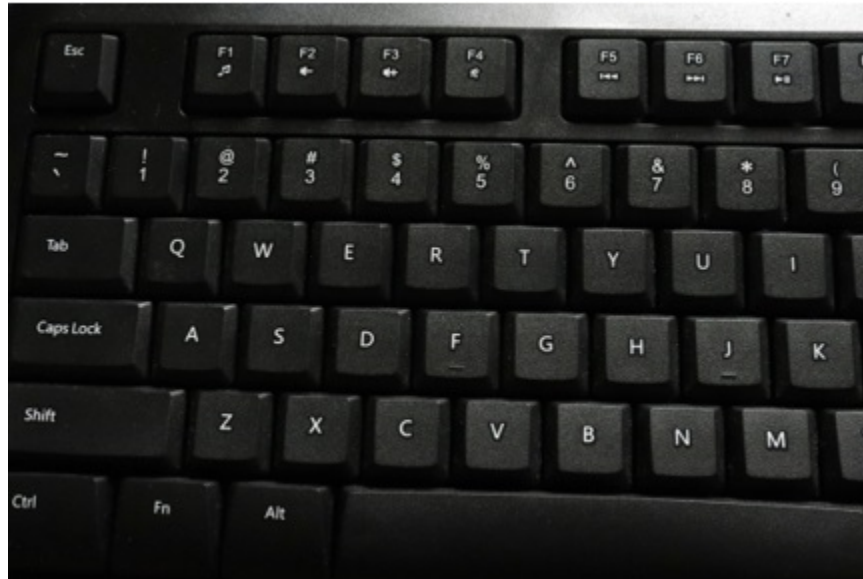
(3)

(Total 11 marks)

2.

The photograph below shows a computer keyboard.

There is a spring under each key.



(a) Why do the keys have springs under them?

Tick (✓) **one** box.

Springs make the keys easier to press.

Springs make the keys lighter.

Springs push the keys back to their original position.

(1)

(b) Why does every spring used in the keyboard have the same spring constant?

Tick (✓) **one** box.

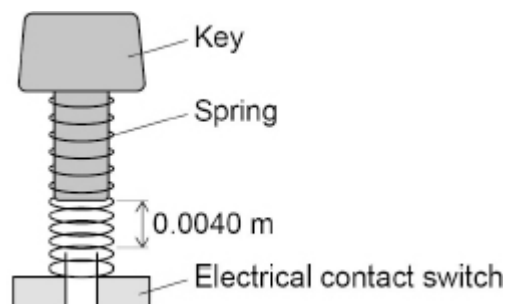
So that more than one key can be pressed at the same time.

So that the same force is needed to press each key.

So that the springs are all the same length.

(1)

The diagram below shows one of the keys and its spring.



(c) What happens to the length of the spring when the key is pressed?

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(1)

(d) How far must the key move before it touches the switch?

Tick (✓) **one** box.

4.0 mm

4.0 cm

4.0  $\mu\text{m}$

(1)

(e) If a key is not pressed with enough force, no signal is sent to the computer.

Explain why.

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(2)

(f) The spring in the diagram above has a spring constant of 200 N/m

Calculate the force on the spring when the key moves a distance of 0.0040 m

Use the equation:

$$\text{force} = \text{spring constant} \times \text{compression}$$

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$$\text{Force} = \text{_____ N}$$

(2)

(g) Suggest **two** ways the spring in the key in the diagram above could be changed so that the switch can be closed more quickly.

1. \_\_\_\_\_

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2. \_\_\_\_\_

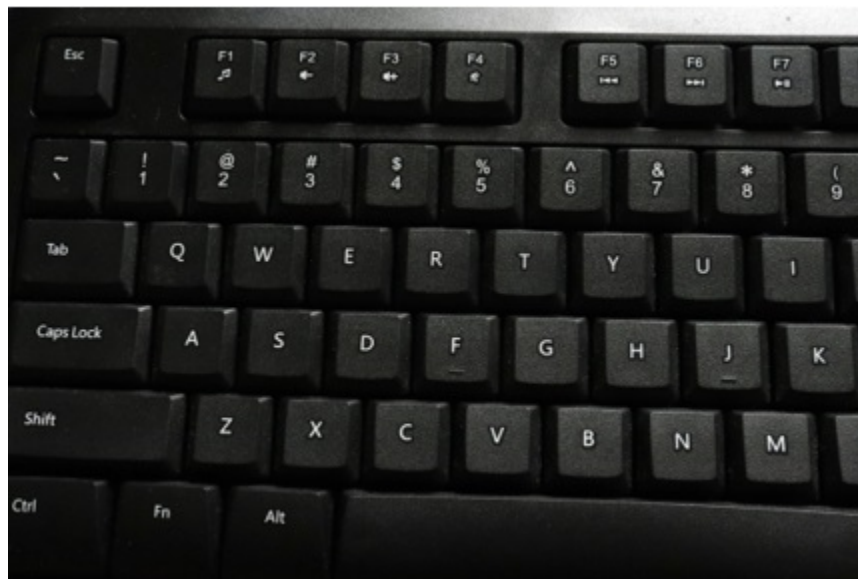
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(2)

(Total 10 marks)

**3.** The photograph below shows a computer keyboard.

There is a spring under each key.



(a) The springs behave elastically when a force is applied.

What is meant by elastic behaviour?

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.

(1)

(b) Suggest **two** properties that should be the same for each spring.

1. \_\_\_\_\_

\_\_\_\_\_

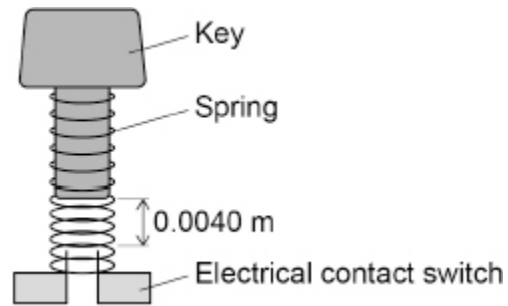
2. \_\_\_\_\_

\_\_\_\_\_

(2)

(c) **Figure 1** shows one of the keys and its spring.

**Figure 1**



The key must be pressed with a minimum force of  $0.80\text{ N}$  before the key touches the switch.

Calculate the spring constant of the spring in **Figure 1**.

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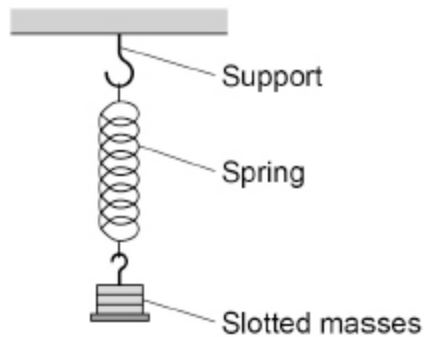
Spring constant = \_\_\_\_\_ N/m

**(3)**

(d) **Figure 2** shows a spring that has been hung from a support.

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

**Figure 2**



Which **two** statements are true for the spring in **Figure 2**?

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.

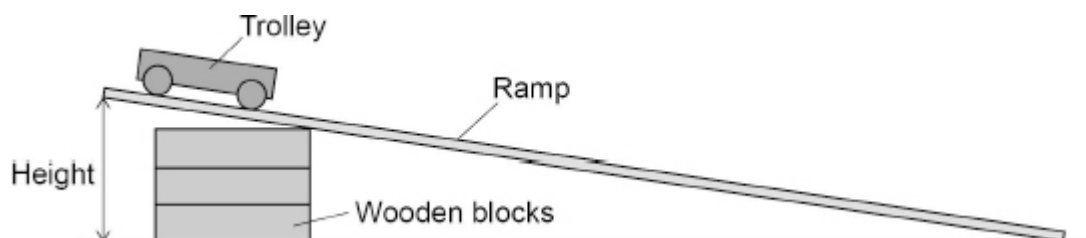
(2)

(Total 8 marks)

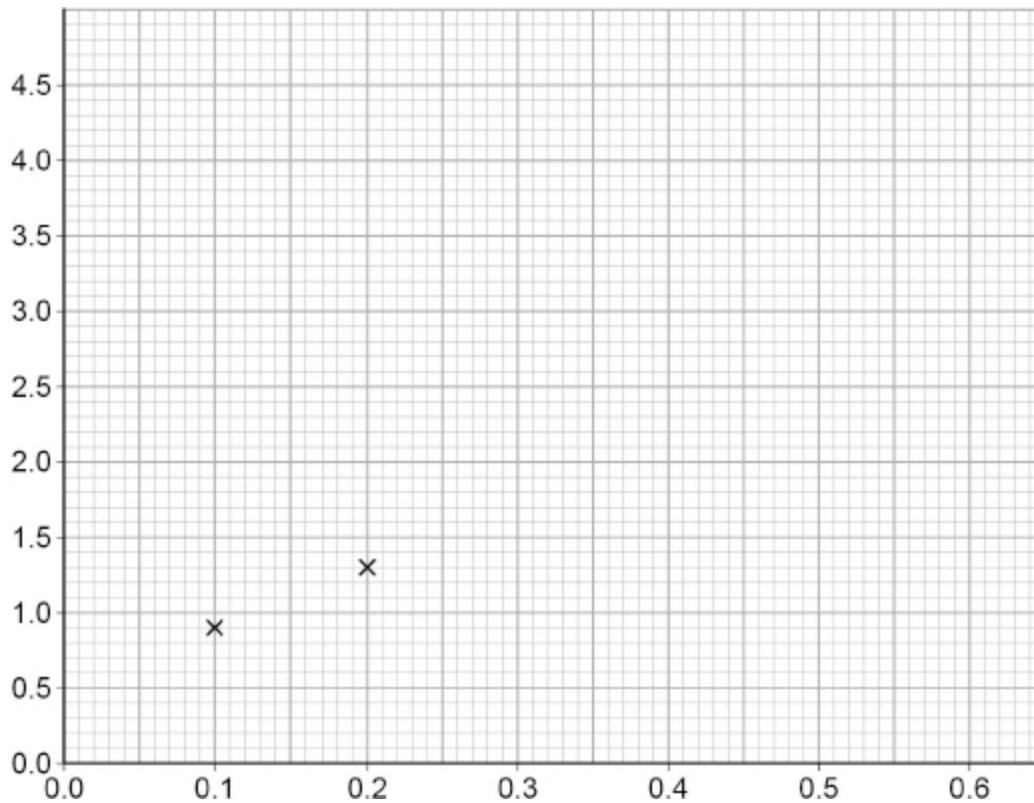
4.

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

The diagram below shows some of the equipment used.







(b) Complete the graph above.

You should:

- label the axes
- plot the remaining results from the table above
- draw a line of best fit.

(4)

(c) Write down the equation that links acceleration ( $a$ ), mass ( $m$ ) and resultant force ( $F$ ).

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(1)

- (d) When the resultant force on the trolley was 0.63 N the acceleration of the trolley was 2.1 m/s<sup>2</sup>

Calculate the mass of the trolley.

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Mass of trolley = \_\_\_\_\_ kg

(3)

(Total 14 marks)

5.

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

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

- (a) Calculate the reduced speed limit.

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Reduced speed limit = \_\_\_\_\_ m/s

(2)

- (b) A reduced speed limit may reduce air pollution.

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

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(2)



(d) **Figure 2** shows a delivery van full of packages.

**Figure 2**



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.

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**(3)**  
**(Total 13 marks)**

6.

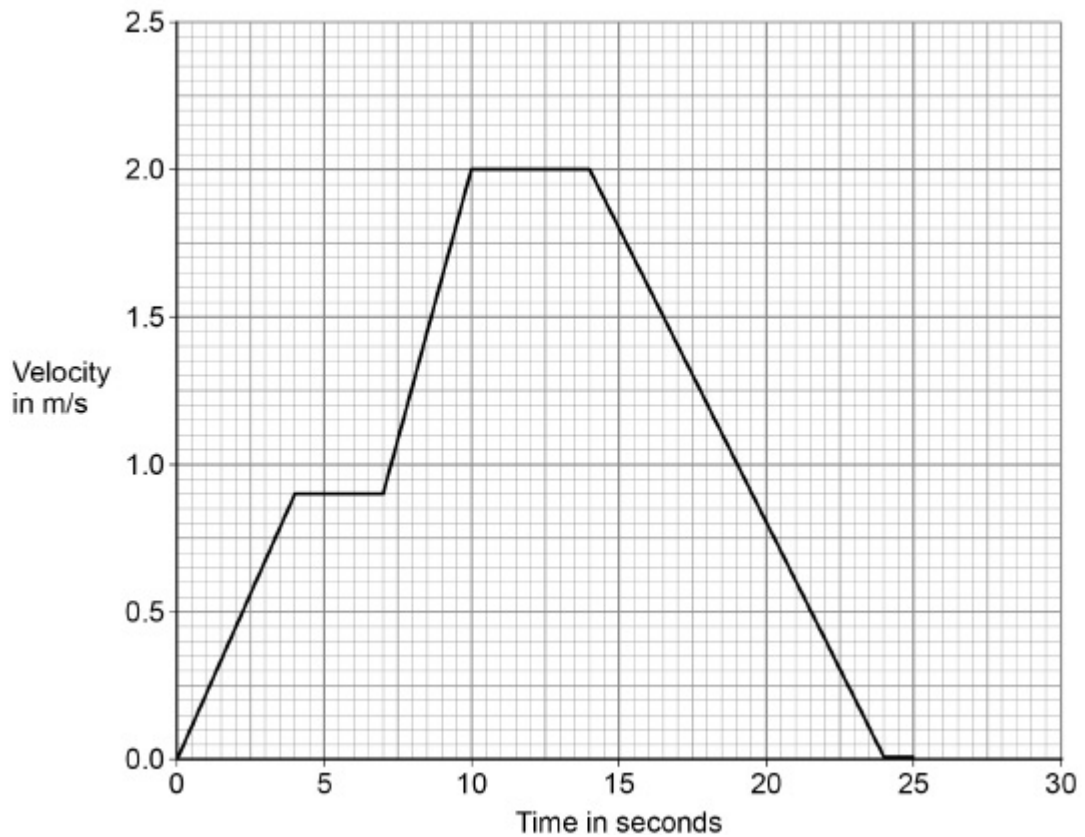
Figure 1 shows a runner using a smart watch and a mobile phone to monitor her run.

Figure 1



Figure 2 is a velocity–time graph for part of the runner’s warm-up.

Figure 2



(a) Determine the total time for which the velocity of the runner was increasing.

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Time = \_\_\_\_\_ s

**(2)**

(b) Determine the deceleration of the runner.

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Deceleration = \_\_\_\_\_ m/s<sup>2</sup>

**(2)**

The smart watch and mobile phone are connected to each other by a system called Bluetooth.

Bluetooth is wireless and uses electromagnetic waves for communication.

(c) Suggest why the phone and watch being connected by a wireless system is an advantage when running.

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**(1)**

(d) Write down the equation that links frequency, wave speed and wavelength.

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**(1)**

(e) The electromagnetic waves have a frequency of 2 400 000 000 Hz

The speed of electromagnetic waves is 300 000 000 m/s

Calculate the wavelength of the electromagnetic waves.

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Wavelength = \_\_\_\_\_ m

(3)

(f) The table shows some information about four types of Bluetooth.

Type	Power in milliwatts	Range in metres
1	100	100
2	2.50	10.0
3	1.00	1.00
4	0.50	0.50

Mobile phones use type **2** Bluetooth to communicate with other devices.

Suggest **two** reasons why.

1 \_\_\_\_\_

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2 \_\_\_\_\_

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(2)

(Total 11 marks)

## Mark schemes

- 1.** (a) vectors have magnitude and direction 1
- (b) there is a resultant force acting on the ball 1
- (c) length of lane =  $4.5 \times 4.0$  1
- length of lane = 18 (m) 1
- (d) arrow in opposite direction 1
- arrow same length drawn from the ball 1
- (e)  $a = \frac{12 - 0}{0.15}$  1
- $a = 80 \text{ (m/s}^2\text{)}$  1
- (f) increases 1
- stays the same 1
- increases 1
- [11]**
- 2.** (a) springs push the keys back to their original position 1
- (b) so that the same force is needed to press each key 1
- (c) (the length) decreases 1  
*allow the spring compresses*
- (d) 4.0 mm 1
- (e) the spring/key will not move far enough 1
- so will not press the (electrical contact) switch 1

(f)  $F = 200 \times 0.0040$

1

$F = 0.80 \text{ (N)}$

*allow 0.8 (N)*

1

(g) shorter spring

1

spring with a lower spring constant

*allow spring that requires less force to compress*

*allow weaker spring*

*allow spring that is easier to compress*

1

**[10]**

**3.**

(a) the spring will return to its original length when the force is removed

1

(b) Any **two** from:

- spring constant
- (original) length
- diameter

2

(c)  $0.80 = k \times 0.0040$

1

$$k = \frac{0.80}{0.0040}$$

1

$$k = 200 \text{ (N/m)}$$

1

(d) the upward force on the spring is equal to the downward force

1

the spring is inelastically deformed

1

**[8]**

<b>4.</b>	<p>(a) <b>Level 3:</b> The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.</p> <p style="text-align: right;">5–6</p> <p><b>Level 2:</b> The method would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.</p> <p style="text-align: right;">3–4</p> <p><b>Level 1:</b> The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.</p> <p style="text-align: right;">1–2</p> <p><b>No relevant content</b></p> <p style="text-align: right;">0</p> <p><b>Indicative content</b></p> <p><b><u>measurements</u></b></p> <ul style="list-style-type: none"> <li>• place one wooden block under the ramp</li> <li>• vary the height by placing a different number of wooden blocks</li> <li>• measure the height of the ramp using a metre rule</li> <li>• measure the distance travelled using a metre rule</li> <li>• measure time taken using light gates (and computer/datalogger)</li> <li>• measure time taken using a stopclock or ticker timer</li> <li>• release trolley from the same position each time</li> <li>• release the trolley without applying a force</li> </ul> <p><b>results</b></p> <ul style="list-style-type: none"> <li>• repeat at the same height and calculate a mean</li> <li>• repeat for different heights</li> <li>• calculate acceleration using <math>a = (v-u)/t</math> or <math>a = \frac{v^2 - u^2}{2s}</math></li> </ul>
	<p>(b) all points plotted correctly</p> <p style="padding-left: 40px;"><i>allow 1 mark for 3 points plotted correctly</i></p> <p style="text-align: right;">2</p> <p>height of ramp in metres on x-axis <b>and</b> acceleration in <math>m/s^2</math> on y-axis)</p> <p style="padding-left: 40px;"><i>both quantity and unit required for both axes</i></p> <p style="text-align: right;">1</p> <p>correct line of best fit</p> <p style="text-align: right;">1</p>
	<p>(c) resultant force = mass × acceleration</p> <p>or</p> <p><math>F = ma</math></p> <p style="text-align: right;">1</p>

(d)  $0.63 = m \times 2.1$

1

$$m = \frac{0.63}{2.1}$$

1

$$m = 0.30 \text{ (kg)}$$

*allow 0.3 (kg)*

1

[14]

5.

(a)  $13.5 \times \frac{2}{3}$

1

$$9.0 \text{ (m/s)}$$

*allow 9 (m/s)*

OR

$$13.5 \times \frac{1}{3} = 4.5 \text{ (1)}$$

$$13.5 - 4.5 = 9.0 \text{ (m/s) (1)}$$

1

(b) reduced speed reduces stopping distance

*allow reduces thinking / braking distance*

1

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)

1

(c)  $14 = v \times 0.70$

1

$$v = \frac{14}{0.70}$$

1

$$v = 20 \text{ (m/s)}$$

1

$$0^2 - 20^2 = 2 \times (-6.25) \times s$$

1

$$s = \frac{20^2}{(2 \times 6.25)}$$

*ignore minus signs throughout*

1

$$s = 32 \text{ (m)}$$

1

(d) same maximum force applied by the brakes

1

because mass is less there is a greater deceleration

*allow momentum for mass*

1

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)

1

[13]

6.

(a)

*an answer of 7 (s) gains 2 marks*

$$(4 - 0) + (10 - 7)$$

$$\text{or } 4 + 3$$

$$\text{or } 10 - 3$$

1

$$7 \text{ (s)}$$

1

(b)

*an answer of 0.2 (m/s<sup>2</sup>) gains 2 marks*

$$\text{gradient} = \frac{0-2}{24-14}$$

*allow readings from any two points correctly substituted*

1

(-) 0.2 (m/s<sup>2</sup>)

*allow correct use of  $a = \frac{\Delta v}{t}$*

1

(c) (there are no wires) to get tangled / disconnected

*allow easier to move arms*

*allow wires are inconvenient*

*allow easier to transfer data*

1

(d) wave speed = frequency × wavelength

*allow  $v = f \lambda$*

*allow any correct re-arrangement*

1

(e)

*an answer of 0.125 (m) or 0.13 (m) scores 3 marks*

$$300\,000\,000 = 2\,400\,000\,000 \times \lambda$$

1

$$\lambda = \frac{300\,000\,000}{2\,400\,000\,000}$$

1

$\lambda = 0.125$  (m)

*allow  $\lambda = 0.13$  (m)*

1

(f) range is far enough (for most uses)

1

power is not too great so the battery will not drain quickly

*allow power not too great so the phone will not overheat*

*allow the range per milliwatt is greatest or 4 metres*

1

[11]