For this paper you must have:

- Ruler
- Pencil and Rubber
- Scientific calculator, which you are expected to use when appropriate

Instructions

- Answer all questions
- Answer questions in the space provided
- All working must be shown

Information

- The marks for the questions are shown in brackets
An investigation was carried out to show how thinking distance, braking distance and stopping distance are affected by the speed of a car.

The results are shown in the table.

<table>
<thead>
<tr>
<th>Speed in metres per second</th>
<th>Thinking distance in metres</th>
<th>Braking distance in metres</th>
<th>Stopping distance in metres</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>6</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>15</td>
<td>9</td>
<td>14</td>
<td>43</td>
</tr>
<tr>
<td>20</td>
<td>12</td>
<td>24</td>
<td>36</td>
</tr>
<tr>
<td>25</td>
<td>15</td>
<td>38</td>
<td>53</td>
</tr>
<tr>
<td>30</td>
<td>18</td>
<td>55</td>
<td>73</td>
</tr>
</tbody>
</table>

(a) Draw a ring around the correct answer to complete each sentence.

As speed increases, thinking distance decreases.

As speed increases, braking distance decreases.

(b) One of the values of stopping distance is incorrect.

Draw a ring around the incorrect value in the table.

Calculate the correct value of this stopping distance.

Stopping distance = ................................ m

(2)
(c) (i) Using the results from the table, plot a graph of braking distance against speed.

Draw a line of best fit through your points.

(ii) Use your graph to determine the braking distance, in metres, at a speed of 22 m / s.

Braking distance = ................................ m

(1)
(d) The speed–time graph for a car is shown below.

While travelling at a speed of 35 m / s, the driver sees an obstacle in the road at time $t = 0$. The driver reacts and brakes to a stop.

![Speed-time graph]

(i) Determine the braking distance.

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Braking distance = ................................ m

(ii) If the driver was driving at 35 m / s on an icy road, the speed–time graph would be different.

Add another line to the speed–time graph above to show the effect of travelling at 35 m / s on an icy road and reacting to an obstacle in the road at time $t = 0$.

(e) A car of mass 1200 kg is travelling with a velocity of 35 m / s.

(i) Calculate the momentum of the car.

Give the unit.

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........................................................................................................................................
........................................................................................................................................

Momentum = ..........................................

(3)
(ii) The car stops in 4 seconds.

Calculate the average braking force acting on the car during the 4 seconds.

Force = ......................... N

(Total 19 marks)

2

A student carries out an investigation using a metre rule as a pendulum.

(a) **Diagram 1** shows a metre rule.

(i) Draw, on **Diagram 1**, an X to show the position of the centre of mass of the rule. (1)

(ii) State what is meant by the 'centre of mass of an object'.

.................................................................................................................................
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(1)
(b) The student taped a 100 g mass to a metre rule.

She set up the apparatus as shown in Diagram 2.

She suspended the metre rule from a nail through a hole close to one end, so she could use the metre rule as a pendulum.

The distance $d$ is the distance between the nail and the 100 g mass.

Diagram 2

(i) Draw, on Diagram 2, a Y to show a possible position of the centre of mass of the pendulum.

(1)
(ii) The student carried out an investigation to find out how the time period of the pendulum varies with \( d \).

Some of her results are shown in the table.

<table>
<thead>
<tr>
<th>( d ) in cm</th>
<th>First test</th>
<th>Second test</th>
<th>Third test</th>
<th>Mean value</th>
<th>Mean time for 1 swing in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0</td>
<td>15.3</td>
<td>15.4</td>
<td>15.5</td>
<td>15.4</td>
<td>1.54</td>
</tr>
<tr>
<td>30.0</td>
<td>14.7</td>
<td>14.6</td>
<td>14.7</td>
<td>14.7</td>
<td>1.47</td>
</tr>
<tr>
<td>50.0</td>
<td>15.3</td>
<td>15.6</td>
<td>15.4</td>
<td>15.4</td>
<td>1.54</td>
</tr>
<tr>
<td>70.0</td>
<td>16.5</td>
<td>16.6</td>
<td>16.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Complete the table.

You may use the space below to show your working.

................................................................................................................
................................................................................................................

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(3)
Describe how the student would carry out the investigation to get the results in the table in part (ii).

You should include:

- any other apparatus required
- how she should use the apparatus
- how she could make it a fair test
- a risk assessment
- how she could make her results as accurate as possible.
(c) A graph of the student’s results is shown below.

(i) Describe the pattern shown by the graph.

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(2)
(ii) The student thinks that the measurements of time for $d = 10$ cm might be anomalous, so she takes a fourth measurement.

Her four measurements are shown below.

| 15.3 s | 15.4 s | 15.5 s | 15.3 s |

State whether you consider any of these measurements to be anomalous.

Justify your answer.

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(2)
(Total 16 marks)
A bus is taking some children to school.

(a) The bus has to stop a few times. The figure below shows the distance–time graph for part of the journey.

(i) How far has the bus travelled in the first 20 seconds?

Distance travelled = ........................................... m

(ii) Describe the motion of the bus between 20 seconds and 30 seconds.

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.............................................................................................................

(iii) Describe the motion of the bus between 30 seconds and 60 seconds.

Tick (✔) one box.

<table>
<thead>
<tr>
<th>Tick (✔)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerating</td>
</tr>
<tr>
<td>Reversing</td>
</tr>
<tr>
<td>Travelling at constant speed</td>
</tr>
</tbody>
</table>

(1)
(iv) What is the speed of the bus at 45 seconds?

Show clearly on the figure above how you obtained your answer.

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..............................................................
..............................................................

Speed = ........................................... m / s

(3)

(b) Later in the journey, the bus is moving and has 500 000 J of kinetic energy.

The brakes are applied and the bus stops.

(i) How much work is needed to stop the bus?

..............................................................

Work = ........................................... J

(1)

(ii) The bus stopped in a distance of 25 m.

Calculate the force that was needed to stop the bus.

..............................................................
..............................................................

Force = ........................................... N

(2)

(iii) What happens to the kinetic energy of the bus as it is braking?

..............................................................
..............................................................
..............................................................

(Total 11 marks)
Levers and hydraulic systems can act as force multipliers.

(a) **Figure 1** shows a girl trying to lift a large rock using a long rod as a lever.

![Figure 1](image)

The girl is pushing down on the rod but is just unable to lift the rock.

Which of the following changes would allow her to lift the rock?

Tick (✓) **two** boxes.

<table>
<thead>
<tr>
<th>Change</th>
<th>Tick (✓)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move the pivot away from the rock</td>
<td></td>
</tr>
<tr>
<td>Make the rod longer</td>
<td></td>
</tr>
<tr>
<td>Push the rod upwards</td>
<td></td>
</tr>
<tr>
<td>Push down on the rod with a greater force</td>
<td></td>
</tr>
</tbody>
</table>

(b) Liquids are used in hydraulic systems because they are virtually incompressible.

Explain how the spacing of particles in a liquid cause it to be virtually incompressible.

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(2)
(c) **Figure 2** shows a man using a car jack to lift his car.

![Figure 2](https://www.examqa.com/image)

**Figure 3** shows a simple diagram of a car jack.

![Figure 3](https://www.examqa.com/image)

(i) The man pushes down with an effort force. This results in a much larger force acting upwards on the car.

Use information from **Figure 3** to explain how.

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(ii) Which of the following statements about the forces in **Figure 3** is correct?

Tick (✓) one box.

<table>
<thead>
<tr>
<th>Tick (✓)</th>
<th>The force acting on the car moves a greater distance than the effort force.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The force acting on the car moves less distance than the effort force.</td>
</tr>
<tr>
<td></td>
<td>The force acting on the car moves the same distance as the effort force.</td>
</tr>
</tbody>
</table>

(Total 9 marks)

**Figure 1** shows a set of tuning forks.

A tuning fork has a handle and two prongs. It is made from metal.

When the prongs are struck on a hard object, the tuning fork makes a sound wave with a single frequency. The frequency depends on the length of the prongs.

(a) Use the correct answer from the box to complete each sentence.

<table>
<thead>
<tr>
<th>direction</th>
<th>loudness</th>
<th>pitch</th>
<th>speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The frequency of a sound wave determines its ..........................................

The amplitude of a sound wave determines its ...........................................
(b) Each tuning fork has its frequency engraved on it. A student measured the length of the prongs for each tuning fork.

Some of her data is shown in the table.

<table>
<thead>
<tr>
<th>Frequency in hertz</th>
<th>Length of prongs in cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>320</td>
<td>9.5</td>
</tr>
<tr>
<td>384</td>
<td>8.7</td>
</tr>
<tr>
<td>480</td>
<td>7.8</td>
</tr>
<tr>
<td>512</td>
<td>7.5</td>
</tr>
</tbody>
</table>

(i) Describe the pattern shown in the table.

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........................................................................................................................................

........................................................................................................................................

(1)

(ii) Figure 2 shows a full-size drawing of a tuning fork.

Figure 2

![Diagram of a tuning fork with length of prongs marked]

Measure and record the length of the prongs.

Length of prongs = ......................... cm

(1)
Use the data in the table above to estimate the frequency of the tuning fork in Figure 2.

Explain your answer.
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.............................................................................................................
.............................................................................................................
.............................................................................................................
.............................................................................................................

Estimated frequency = ......................... Hz

(c) Ultrasound waves are used in hospitals.

(i) Use the correct answer from the box to complete the sentence.

| electronic | hydraulic | radioactive |

Ultrasound waves can be produced by ........................................... systems.

(ii) The frequency of an ultrasound wave used in a hospital is $2 \times 10^6$ Hz.

It is not possible to produce ultrasound waves of this frequency using a tuning fork.

Explain why.
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.............................................................................................................
.............................................................................................................
.............................................................................................................
.............................................................................................................
(d) **Figure 3** shows a tuning fork and a microphone. The microphone is connected to an oscilloscope.

**Figure 3**

When the tuning fork is struck and then placed in front of the microphone, a trace appears on the oscilloscope screen.

**Figure 4** shows part of the trace on the screen.

**Figure 4**

Each horizontal division in **Figure 4** represents a time of 0.0005 s.

What is the frequency of the tuning fork?
A student investigated the behaviour of springs. She had a box of identical springs.

(a) When a force acts on a spring, the shape of the spring changes.

The student suspended a spring from a rod by one of its loops. A force was applied to the spring by suspending a mass from it.

**Figure 1** shows a spring before and after a mass had been suspended from it.

**Figure 1**

(i) State two ways in which the shape of the spring has changed.

1 ........................................................................................................................................

2 ........................................................................................................................................

(Total 13 marks)
(ii) No other masses were provided.

Explain how the student could test if the spring was behaving elastically.
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..............................................................................................................
..............................................................................................................
..............................................................................................................

(2)

(b) In a second investigation, a student took a set of measurements of force and extension.

Her results are shown in Table 1.

<table>
<thead>
<tr>
<th>Force in newtons</th>
<th>0.0</th>
<th>1.0</th>
<th>2.0</th>
<th>3.0</th>
<th>4.0</th>
<th>5.0</th>
<th>6.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension in cm</td>
<td>0.0</td>
<td>4.0</td>
<td>12.0</td>
<td>16.0</td>
<td>22.0</td>
<td>31.0</td>
<td></td>
</tr>
</tbody>
</table>

(i) Add the missing value to Table 1.

Explain why you chose this value.
..............................................................................................................
..............................................................................................................
..............................................................................................................
..............................................................................................................

(3)

(ii) During this investigation the spring exceeded its limit of proportionality.

Suggest a value of force at which this happened.

Give a reason for your answer.

Force = ................................. N

Reason ..................................................................................................
..............................................................................................................
..............................................................................................................
..............................................................................................................

(2)
In a third investigation the student:

- suspended a 100 g mass from a spring
- pulled the mass down as shown in Figure 2
- released the mass so that it oscillated up and down
- measured the time for 10 complete oscillations of the mass
- repeated for masses of 200 g, 300 g and 400 g.

**Figure 2**
Her results are shown in Table 2.

<table>
<thead>
<tr>
<th>Mass in g</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>4.34</td>
<td>5.20</td>
<td>4.32</td>
<td>4.6</td>
</tr>
<tr>
<td>200</td>
<td>5.93</td>
<td>5.99</td>
<td>5.86</td>
<td>5.9</td>
</tr>
<tr>
<td>300</td>
<td>7.01</td>
<td>7.12</td>
<td>7.08</td>
<td>7.1</td>
</tr>
<tr>
<td>400</td>
<td>8.23</td>
<td>8.22</td>
<td>8.25</td>
<td>8.2</td>
</tr>
</tbody>
</table>

(i) Before the mass is released, the spring stores energy.

What type of energy does the spring store?

Tick (✓) one box.

- Elastic potential energy
- Gravitational potential energy
- Kinetic energy

(ii) The value of time for the 100 g mass in Test 2 is anomalous.

Suggest two likely causes of this anomalous result.

Tick (✓) two boxes.

- Misread stopwatch
- Pulled the mass down too far
- Timed half oscillations, not complete oscillations
- Timed too few complete oscillations
- Timed too many complete oscillations
(iii) Calculate the correct mean value of time for the 100 g mass in Table 2.

...............................................................................................................
...............................................................................................................
Mean value = ........................................... s

(1)

(iv) Although the raw data in Table 2 is given to 3 significant figures, the mean values are correctly given to 2 significant figures.

Suggest why.
...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................

(2)

(v) The student wanted to plot her results on a graph. She thought that four sets of results were not enough.

What extra equipment would she need to get more results?
...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................

(2)

(Total 17 marks)
(a) **Figure 1** shows the distance–time graph for a person walking to a bus stop.

**Figure 1**

![Distance–time graph](image)

(i) Which one of the following statements describes the motion of the person between points R and S on the graph?

Tick (✓) one box.

- Not moving
- Moving at constant speed
- Moving with increasing speed

(1)
(ii) Another person, walking at constant speed, travels the same distance to the bus stop in 200 seconds.

Complete Figure 2 to show a distance–time graph for this person.

![Figure 2](image)

(b) A bus accelerates away from the bus stop at 2.5 m/s².

The total mass of the bus and passengers is 14 000 kg.

Calculate the resultant force needed to accelerate the bus and passengers.

Resultant force = ........................................ N

(Total 4 marks)
A paintball gun is used to fire a small ball of paint, called a paintball, at a target. The figure below shows someone just about to fire a paintball gun. The paintball is inside the gun.

(a) What is the momentum of the paintball before the gun is fired?

..................................................................................................................................................

Give a reason for your answer.
..................................................................................................................................................
..................................................................................................................................................

..................................................................................................................................................

Give a reason for your answer.
..................................................................................................................................................
..................................................................................................................................................

..................................................................................................................................................

(2)

(b) The gun fires the paintball forwards at a velocity of 90 m / s.

The paintball has a mass of 0.0030 kg.

Calculate the momentum of the paintball just after the gun is fired.

..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................

Momentum = ........................................ kg m / s

(2)
(c) The momentum of the gun and paintball is conserved.

Use the correct answer from the box to complete the sentence.

| equal to | greater than | less than |

The total momentum of the gun and paintball just after the gun is fired
will be ....................................................... the total momentum of the gun and paintball
before the gun is fired.

(1)
(Total 5 marks)