INSTRUCTIONS
● Answer all questions.
● Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
● Write your name, centre number and candidate number in the boxes at the top of the page.
● Write your answer to each question in the space provided.
● Do not use an erasable pen or correction fluid.
● Do not write on any bar codes.
● You may use a calculator.
● You should show all your working and use appropriate units.

INFORMATION
● The total mark for this paper is 40.
● The number of marks for each question or part question is shown in brackets [ ].
1 A student investigates the motion of an oscillating metre rule.

He uses the apparatus shown in Fig. 1.1.

![Fig. 1.1](image)

(a) The student ensures that the metre rule is horizontal.

Briefly describe how to check that the metre rule is horizontal. You may draw a diagram or draw on Fig. 1.1 if it helps to explain your answer.

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[1]
(b) The student moves the stands so that the vertical threads are at the marks on the metre rule shown in Fig. 1.2.

Fig. 1.2

Calculate the distance \( d \) between the threads.

\[
d = \underline{\text{................................................. cm}} \quad [1]
\]

(c) He twists the metre rule a small amount, as shown in Fig. 1.3, and then lets it go so that it oscillates in a rotating motion.

Fig. 1.3

He measures the time \( t \) for 5 complete oscillations of the metre rule.

\[
t = \underline{\text{.......................................................... s}}
\]

3.63

Suggest why it is useful to take a trial reading for this experiment.

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...................................................................................................................................................  [1]
(d) The student carries out the same procedure for \( d \) values of 20.0 cm, 30.0 cm, 40.0 cm, 50.0 cm and 60.0 cm. His readings are shown in Table 1.1.

Table 1.1

<table>
<thead>
<tr>
<th>( d / \text{cm} )</th>
<th>( t / \text{s} )</th>
<th>( \frac{1}{T} / \text{s} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.0</td>
<td>17.85</td>
<td></td>
</tr>
<tr>
<td>30.0</td>
<td>11.36</td>
<td>0.44</td>
</tr>
<tr>
<td>40.0</td>
<td>8.77</td>
<td>0.57</td>
</tr>
<tr>
<td>50.0</td>
<td>6.93</td>
<td>0.72</td>
</tr>
<tr>
<td>60.0</td>
<td>5.68</td>
<td>0.88</td>
</tr>
</tbody>
</table>

For distance \( d = 20.0 \) cm, calculate and record in Table 1.1, the value of \( \frac{1}{T} \) where \( T \) is the time for 1 oscillation of the metre rule.
Use the value of time \( t \) from Table 1.1 and the equation \( \frac{1}{T} = \frac{5}{t} \).

\[ \text{[1]} \]

(e) Plot a graph of distance \( d / \text{cm} \) (y-axis) against \( \frac{1}{T} / \text{s} \) (x-axis).

(f) Determine the gradient \( G \) of the graph. Show clearly on the graph how you obtained the necessary information.

\[ G = \ldots................................................. \text{[1]} \]
(g) (i) Explain why it is more accurate to measure the time for 5 oscillations rather than for 1 oscillation.

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(ii) Describe how the experiment could be improved to make the readings more reliable.

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...........................................................................................................................................
........................................................................................................................................... [1]

[Total: 11]
Students investigate the cooling of hot water in two different cups.

They use the apparatus shown in Fig. 2.1.

Cup A is made from thin plastic. The top of cup A has an inside diameter of 7 cm. Cup B is made from expanded polystyrene. The top of cup B has an inside diameter of 8 cm.

Fig. 2.1

(a) (i) Record the room temperature $\theta_R$ shown on the thermometer in Fig. 2.1.

$\theta_R =$...................................................... [1]

(ii) Describe one precaution that you would take to ensure that temperature readings in the experiment are as accurate as possible.

...........................................................................................................................................
........................................................................................................................................... [1]
(b) A volume of 100 cm$^3$ of hot water is poured into each cup and the initial temperature $\theta$ is recorded in Table 2.1. The temperature of the water in each cup is recorded every 30 s. The values are shown in Table 2.1.

<table>
<thead>
<tr>
<th>T / s</th>
<th>$\theta$ / A</th>
<th>$\theta$ / B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>87.5</td>
<td>88.0</td>
</tr>
<tr>
<td>30</td>
<td>84.5</td>
<td>86.0</td>
</tr>
<tr>
<td>60</td>
<td>82.0</td>
<td>84.5</td>
</tr>
<tr>
<td>90</td>
<td>80.5</td>
<td>83.0</td>
</tr>
<tr>
<td>120</td>
<td>79.0</td>
<td>82.0</td>
</tr>
<tr>
<td>150</td>
<td>78.0</td>
<td>81.0</td>
</tr>
<tr>
<td>180</td>
<td>77.0</td>
<td>80.5</td>
</tr>
</tbody>
</table>

Complete the headings in Table 2.1. [1]

(c) Write a conclusion stating which cup, A or B, is the more effective in reducing the cooling rate of the hot water in this experiment. Justify your answer by reference to the results.

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................................................................................................................................................... [2]

(d) (i) Calculate $x_A$, the average cooling rate for cup A over the whole experiment. Use the readings for cup A from Table 2.1 and the equation

$$x_A = \frac{\theta_0 - \theta_{180}}{T}$$

where $T = 180$ s and $\theta_0$ and $\theta_{180}$ are the temperatures at time $t = 0$ and at time $t = 180$ s. Include the unit for the cooling rate.

$x_A =$ ...................................................... [2]
(ii) Suggest an additional experiment to show how the lid affects the cooling rate of cup A. Explain how to use the additional results to show the effect.

additional experiment ........................................................................................................
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explanation ........................................................................................................................
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(e) A student wishes to compare the effect of the materials of the cups on cooling rates. Suggest two variables that she should control to make this test fair.

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2. ...............................................................................................................................................
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[2]

[Total: 11]
3 A student investigates a resistor and a lamp connected in series. She uses the circuit shown in Fig. 3.1.

![Circuit diagram](image)

**Fig. 3.1**

(a) The student moves the crocodile clip on the resistance wire so that the value of the potential difference $V_L$ across the lamp is 2.0 V.

She measures the current $I$ for the lamp and resistor in series.

She then connects the voltmeter to measure the potential difference $V_R$ across the resistor.

![Ammeter and Voltmeter](image)

**Fig. 3.2** **Fig. 3.3**

Read, and record in Table 3.1, the values of $I$ and $V_R$ shown on the meters in Fig. 3.2 and Fig. 3.3.

[2]
(b) The student repeats the steps in (a) for values of $V_L = 1.0 \, \text{V}$ and $V_L = 0.5 \, \text{V}$. Her readings are shown in Table 3.1.

<table>
<thead>
<tr>
<th>$V_L / \text{V}$</th>
<th>$I / \text{A}$</th>
<th>$V_R / \text{V}$</th>
<th>$R_L / \Omega$</th>
<th>$R_R / \Omega$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>0.15</td>
<td>3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>0.12</td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Calculate, and record in Table 3.1, the resistance of the lamp $R_L$ for each value of $V_L$. Use the values of $V_L$ and $I$ from Table 3.1 and the equation $R_L = \frac{V_L}{I}$.

Calculate, and record in Table 3.1, the resistance of the resistor $R_R$ for each value of $V_L$. Use the values of $V_R$ and $I$ from Table 3.1 and the equation $R_R = \frac{V_R}{I}$.

(c) (i) Describe the pattern of any change in the value of $R_L$ as $V_L$ decreases.

(ii) A student suggests that $R_R$ should be constant.

State whether your results support this suggestion. Justify your statement by reference to values from Table 3.1.

statement ...........................................................................................................................................

justification .......................................................................................................................................
(d) A student wishes to determine the resistance of the lamp $R_L$ when the potential difference across the lamp $V_L = 0.0\, \text{V}$.

Describe how the experiment can be extended to do this with the help of a suitable graph.

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...................................................................................................................................................  [2]

(e) It is possible to use a variable resistor instead of a resistance wire to change the potential difference across the lamp.

Complete the circuit in Fig. 3.4 to show:

- a variable resistor used for this purpose
- the voltmeter connected to measure the potential difference across the resistor

![Fig. 3.4](image-url)  [2]

[Total: 11]
A student investigates the motion of a ball rolling down a slope.

Plan an experiment which enables him to investigate how one factor affects the average speed of the ball.

Average speed can be calculated using the equation:

\[
\text{average speed} = \frac{\text{distance travelled}}{\text{time taken}}
\]

The apparatus available includes:

- balls of various sizes and materials
- a board which can act as a slope
- blocks to support one end of the board.

In your plan, you should:

- state a factor which can be measured
- list any additional apparatus needed
- explain briefly how to carry out the experiment including exactly which measurements are to be taken
- state the key variables to be kept constant
- draw a table, or tables, with column headings, to show how to display the readings (you are not required to enter any readings in the table)
- explain how to use the readings to reach a conclusion.

You may draw a diagram if it helps to explain your plan.