You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions

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 will be allowed to work with the apparatus for a maximum of 1 hour for each question.
● You should record all your observations in the spaces provided in the question paper as soon as these observations are made.
● 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 [ ].

For Examiner's Use

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This document has 12 pages. Any blank pages are indicated.
In this experiment, you will investigate an electrical circuit.

(a) You have been provided with two identical wooden strips labelled A and B. Measure and record the length $L$ of the wire between the nails on strip A, as shown in Fig. 1.1.

\[
L = \text{..........................................................} \quad [1]
\]
(b) • Set up the circuit shown in Fig. 1.2.

![Circuit diagram](image)

Fig. 1.2

• F, G, H and J are crocodile clips.

Attach G to the wire on wooden strip A so that the distance $x$ between the nail on strip A and G is approximately 30 cm, as shown in Fig. 1.2.

• Attach H to the wire on wooden strip B so that it is the same distance $x$ from the nail on strip B.

• Close the switch.

• Record $x$ and the ammeter reading $I$.

\[ x = \ldots \]

\[ I = \ldots \]

• Open the switch.

[1]
(c) Vary $x$ and repeat (b) until you have six sets of readings of $x$ and $I$. Include your values from (b).

Record your results in a table. Include values of $\frac{1}{I}$ in your table.

(d) (i) Plot a graph of $\frac{1}{I}$ on the $y$-axis against $x$ on the $x$-axis.

(ii) Draw the straight line of best fit.

(iii) Determine the gradient and $y$-intercept of this line.

gradient = ...............................................................

$y$-intercept = ...............................................................

[9]  [3]  [1]  [2]
(e) It is suggested that the quantities \( I \) and \( x \) are related by the equation

\[
\frac{1}{I} = Px + Q
\]

where \( P \) and \( Q \) are constants.

Using your answers in (d)(iii), determine values for \( P \) and \( Q \).
Give appropriate units.

\[
P = \quad \text{...........................................................}
\]
\[
Q = \quad \text{...........................................................} \quad [2]
\]

(f) Theory suggests that

\[
\frac{P}{Q} = \left( \frac{\rho_A}{\rho_B} - 1 \right) L
\]

where \( \rho_A \) is the resistivity of the wire on strip A and \( \rho_B \) is the resistivity of the wire on strip B.

Calculate \( \frac{\rho_A}{\rho_B} \).

\[
\frac{\rho_A}{\rho_B} = \quad \text{...........................................................} \quad [1]
\]

[Total: 20]
2 In this experiment, you will investigate the oscillations of a loaded wooden strip.

(a) You have been provided with a rectangular wooden strip with a hole in its centre.

- Use some of the adhesive putty to attach the two 100 g masses as near as possible to one end of the strip, as shown in Fig. 2.1 and Fig. 2.2.

![Fig. 2.1](image1)

![Fig. 2.2](image2)

- The distance between the centre of the masses and the hole is $d$, as shown in Fig. 2.1. Measure and record $d$.

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

(b) Estimate the percentage uncertainty in your value of $d$. Show your working.

\[ \text{percentage uncertainty} = \text{.........................................................} \quad [1] \]
(c) (i) Attach the two 50 g masses to the other end of the strip so that the distance between the centres of these masses and the hole is also equal to \( d \).

- Set up the apparatus as shown in Fig. 2.3.

\[ b = \text{..........................} \quad [1] \]

(ii) Calculate \( \alpha \) where

\[ \alpha = \frac{b}{d}. \]

\[ \alpha = \text{..........................} \quad [1] \]

(iii) Justify the number of significant figures that you have given for your value of \( \alpha \).
(d) • Move the end of the strip with the 100 g masses down through a short distance.
• Release the end of the strip. The strip will oscillate up and down.
• Take measurements to determine the period $T$ of these oscillations.

$$T = \text{..........................................................} \quad [2]$$

(e) • Change the value of $b$ to approximately 20 cm.
• Adjust the heights of the bosses until the strip is horizontal and the spring and string loop are vertical.
• Measure and record $b$.

$$b = \text{..........................................................}$$

• Repeat (c)(ii) and (d).

$$\alpha = \text{..........................................................}$$

$$T = \text{..........................................................} \quad [2]$$
(f) It is suggested that the relationship between $T$ and $\alpha$ is

$$T = \frac{C}{\alpha}$$

where $C$ is a constant.

(i) Using your data, calculate two values of $C$.

first value of $C = .............................................................................................................$

second value of $C = .............................................................................................................$ [1]

(ii) Explain whether your results support the suggested relationship.

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

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

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

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

(g) Theory suggests that

$$C = 2\pi \sqrt{\frac{3m}{k}}$$

where $m$ is 0.100 kg and $k$ is the spring constant of the spring.

Use your second value of $C$ to determine a value for $k$. Give an appropriate unit.

$$k = .............................................................................................................$$ [1]
(h) (i) Describe four sources of uncertainty or limitations of the procedure for this experiment.
1. ............................................................................................................................................
2. ............................................................................................................................................
3. ............................................................................................................................................
4. ............................................................................................................................................

(ii) Describe four improvements that could be made to this experiment. You may suggest the use of other apparatus or different procedures.
1. ............................................................................................................................................
2. ............................................................................................................................................
3. ............................................................................................................................................
4. ............................................................................................................................................

[Total: 20]