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 [ ].
1 In this experiment, you will investigate the oscillations of a metre rule.

(a) ● Set up the apparatus as shown in Fig. 1.1, with the scales on the metre rules facing upwards.

● Adjust the clamp so that the upper rule is parallel to the bench.

● Adjust the positions of the string loops so that each loop is approximately 40 cm from the nearest ends of the two rules.

● The vertical distance between the two rules is $H$.

Measure and record $H$.

\[ H = \text{ .........................................................} \]  \[1\]
(b) • For both rules, the distance between the 50 cm mark and each string loop is $w$, as shown in Fig. 1.1.

Adjust the positions of the string loops until the distances $w$ are equal and approximately 10 cm.

• Measure and record $w$.

$$w = \text{................................................................. cm}$$

• Gently rotate the lower rule and release it. The lower rule will oscillate as shown in Fig. 1.2.

Fig. 1.2

• Take measurements to determine the period $T$ of the oscillations.

$$T = \text{................................. s}$$

[2]
(c) Vary \( w \) in the range 5.0 cm \( \leq w \leq 20.0 \) cm and determine six sets of readings of \( w \) and \( T \). Record your results in a table. Include values of \( \frac{1}{w} \) in your table.

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

(ii) Draw the straight line of best fit.

(iii) Determine the gradient of this line.

gradient = ......................................................... [1]
(e) (i) It is suggested that the quantities $T$ and $w$ are related by the equation

$$T = \frac{B}{w}$$

where $B$ is a constant.

Using your answer to (d)(iii), determine a value for $B$.
Give an appropriate unit.

$$B = ......................................................... \quad [2]$$

(ii) It is suggested that $B$ is given by the equation

$$B^2 = \frac{3\pi^2 H^3}{g}$$

where $g$ is the acceleration of free fall.

Using your answers to (a) and (e)(i), determine a value for $g$.

$$g = ..................................................... \text{ ms}^{-2} \quad [1]$$

[Total: 20]
In this experiment, you will determine the weight of a metre rule.

(a) (i) • Attach the spring to the clamp.

• Suspend the mass hanger from the spring as shown in Fig. 2.1.

![Diagram of experiment setup](image)

- The length of the coiled section of the spring is \( L_0 \).

Measure and record \( L_0 \).

\[ L_0 = \dots \quad \text{cm} \quad [1] \]

(ii) Estimate the percentage uncertainty in your value of \( L_0 \). Show your working.

\[ \text{percentage uncertainty} = \dots \quad [1] \]
(b) (i)  ● Add an additional mass of 0.100 kg to the mass hanger.
    ● The new length of the coiled section of the spring is $L_1$.

    Measure and record $L_1$.

    $L_1 = \ldots\ldots$ cm

    ● Remove the 0.100 kg mass.

(ii) Calculate $(L_1 - L_0)$.

    $(L_1 - L_0) = \ldots\ldots$ cm [1]

(iii) The spring constant $k$ is given by the equation

    $$k = \frac{F}{(L_1 - L_0)}$$

    where $F$ is 0.981 N.

    Calculate $k$.

    $k = \ldots\ldots$ [1]

(iv) Justify the number of significant figures that you have given for your value of $k$.

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    ...........................................................................................................................................
    ...........................................................................................................................................
    ........................................................................................................................................... [1]
(c) (i) Set up the apparatus as shown in Fig. 2.2.

- Support the rule on the mass hanger. You may need to use some of the adhesive putty to stop the rule from slipping off the mass hanger.
- The distance between the lower end of the rule and the mass hanger is $d$, as shown in Fig. 2.2. The length of the coiled section of the spring is $L$.

Adjust the apparatus so that $d$ is approximately 90 cm and the spring is vertical.
- Measure and record $d$ and $L$.

\[ d = \ldots \text{ cm} \]
\[ L = \ldots \text{ cm} \]

- Using your answer to (a)(i), calculate $(L - L_0)$.

\[ (L - L_0) = \ldots \text{ cm} \quad [1] \]

(ii) Repeat (c)(i) with a distance $d$ of approximately 60 cm.

\[ d = \ldots \text{ cm} \]
\[ L = \ldots \text{ cm} \]

\[ (L - L_0) = \ldots \text{ cm} \quad [2] \]
(d) It is suggested that the relationship between \((L - L_0)\) and \(d\) is

\[ C = d(L - L_0) \]

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.

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

(e) The constant \(C\) is given by

\[ C = \frac{Wd_0}{2k} \]

where \(d_0\) is the length and \(W\) is the weight of the metre rule.

Use your second value of \(C\) to determine \(W\).

\[ W = \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \ \[1\]
(f) (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.
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2. ...........................................................................................................................................
3. ...........................................................................................................................................
4. ...........................................................................................................................................