



CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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9702/31

May/June 2024

2 hours

You must answer on the question paper.

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

- 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	
1	
2	
Total	

This document has **12** pages.

You may not need to use all of the materials provided.

- 1 In this experiment, you will investigate an electrical circuit.

You have been provided with a metre rule with a wire attached. You have also been provided with six identical resistors. Four of the resistors are connected in series and attached to a wooden block. The other resistors are labelled X and Z.

- (a) • Set up the circuit shown in Fig. 1.1.

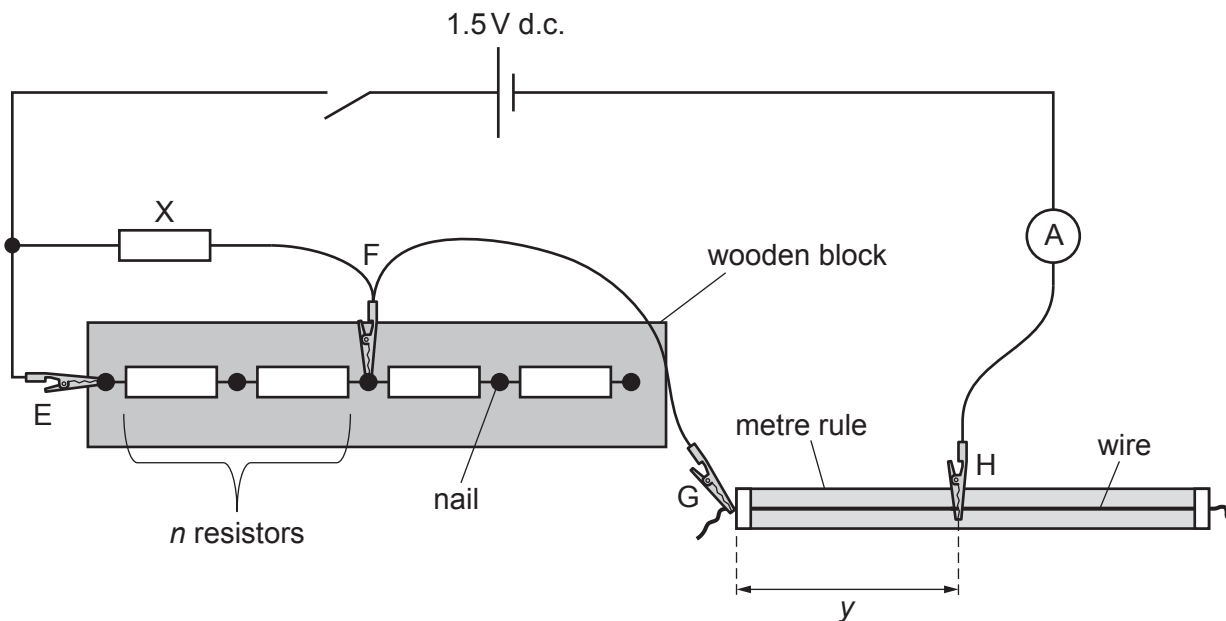


Fig. 1.1 (not to scale)

- E, F, G and H are crocodile clips.

n resistors on the wooden block are connected in parallel with X. Connect F so that $n = 2$, as shown in Fig. 1.1.

- The distance between G and H is y . Attach H to the wire so that y is approximately 50 cm.
- Close the switch.
- Record n , y and the ammeter reading I .

$n =$

$y =$

$I =$

- Open the switch.

[2]

- (b) • Connect Z as shown in Fig. 1.2.

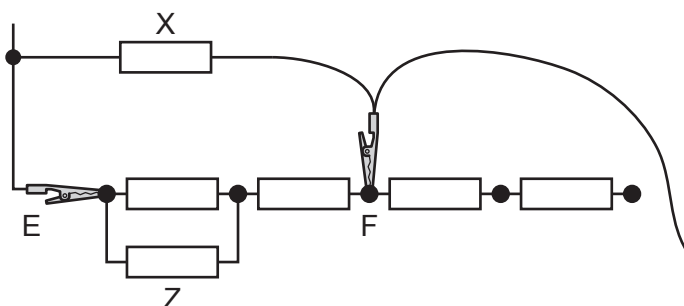


Fig. 1.2

When Z is connected in parallel with the first of the resistors on the block, the total value of n is reduced by 0.5.

For the arrangement in Fig. 1.2, the value of n is 1.5.

- Close the switch.
- Change the position of H on the wire until the value of I is as close as possible to your value in (a).
- Record n and y .

$n = \dots\dots\dots$

$y = \dots\dots\dots$

- Open the switch.
- Disconnect Z.

[1]

- (c) Vary n by changing the position of F and connecting and disconnecting Z.

For each value of n , change the position of H until the value of I is as close as possible to your value in (a).

Repeat until you have six sets of values of n and y . Include your values from (a) and (b).

Record your results in a table. Include values of $\frac{n}{n+1}$ to two significant figures in your table.

[8]

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

[3]

- (ii) Draw the straight line of best fit.

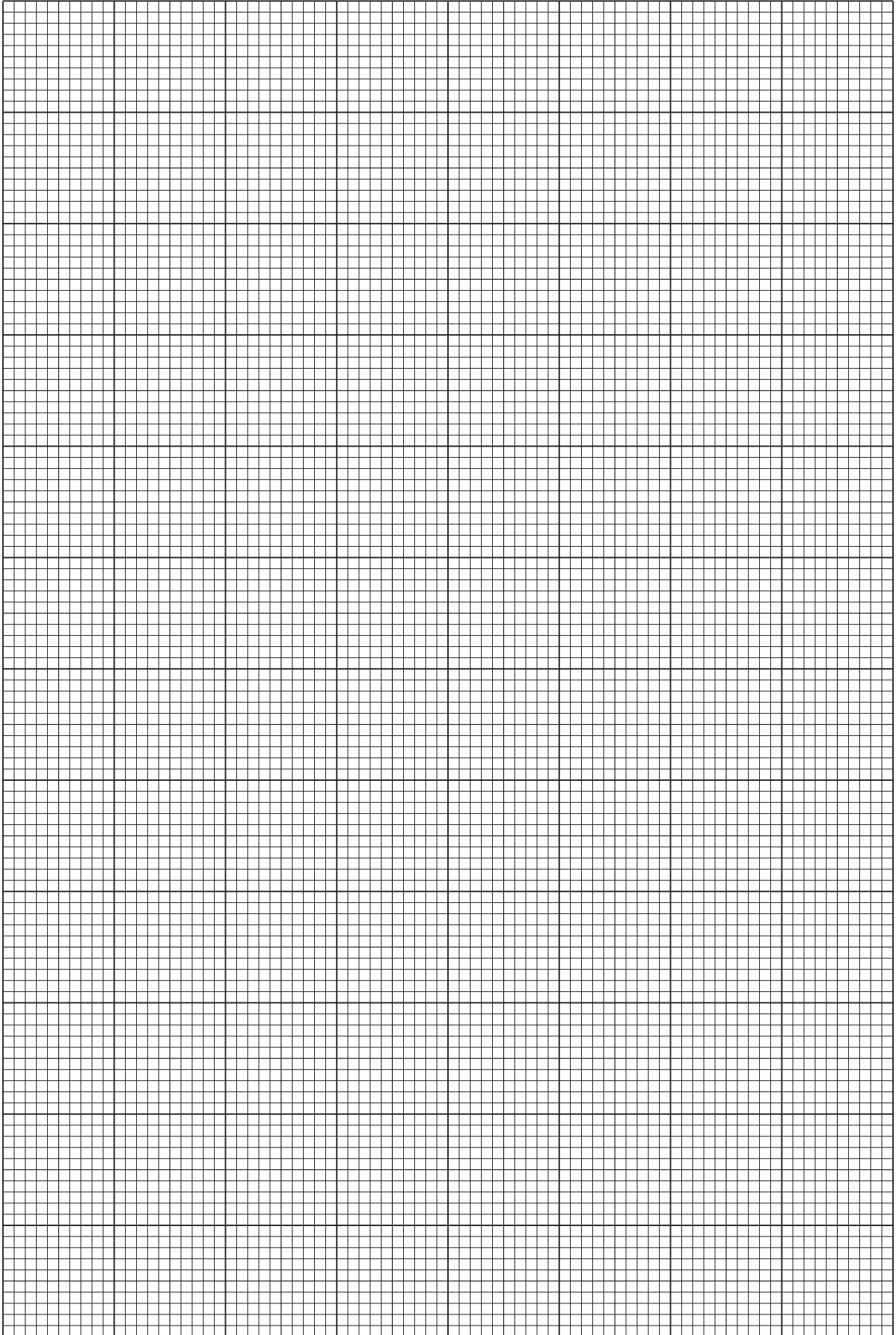
[1]

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

gradient =

y -intercept =

[2]



- (e) It is suggested that the quantities y and n are related by the equation

$$y = -\frac{Pn}{n+1} + Q$$

where P and Q are constants.

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

$$P = \dots\dots\dots$$

$$Q = \dots\dots\dots$$

[2]

- (f) Theory suggests that

$$\frac{P}{Q} = \frac{X}{C}$$

where the resistance X of resistor X is 12Ω and C is the resistance of the whole circuit.

Use your values in (e) to determine a value for C .

$$C = \dots\dots\dots \Omega \text{ [1]}$$

[Total: 20]

You may not need to use all of the materials provided.

2 In this experiment, you will investigate the oscillations of a rod.

(a) (i) The length of the rod is L , as shown in Fig. 2.1.

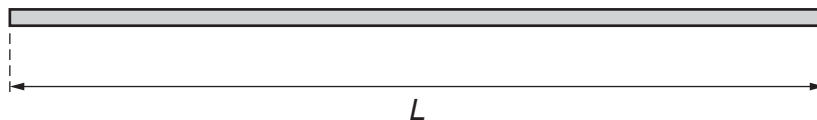


Fig. 2.1

Measure and record L .

$L =$ [1]

(ii) The mass of the rod is M .

Measure and record M .

$M =$ [1]

(iii) Calculate S , where

$$S = \frac{ML^2}{12}.$$

$S =$ [1]

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

.....

 [1]

- (b) (i) • Wrap one end of the copper wire tightly three times around the centre of the rod, as shown in Fig. 2.2.

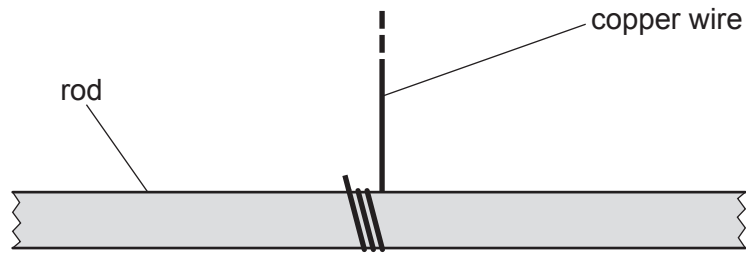


Fig. 2.2

- Slide a 50 g slotted mass onto each end of the rod.
- Record the mass m on **one** end of the rod.

$m = \dots\dots\dots$ g

- Adjust the positions of the masses so that they are equally spaced from the centre of the rod and their centres are approximately 3 cm apart, as shown in Fig. 2.3. You may need to use some of the adhesive putty to keep the masses in position.

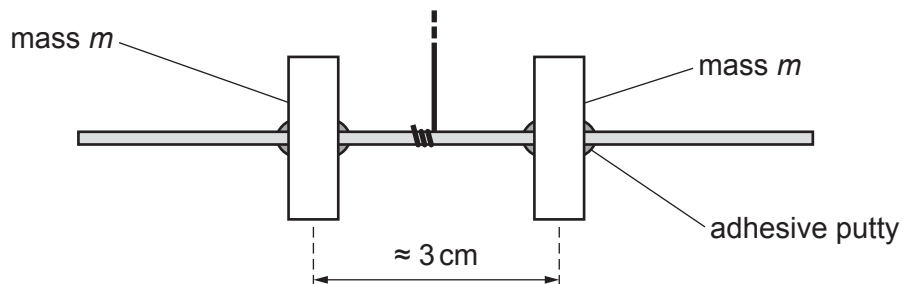


Fig. 2.3

- Set up the apparatus as shown in Fig. 2.4.

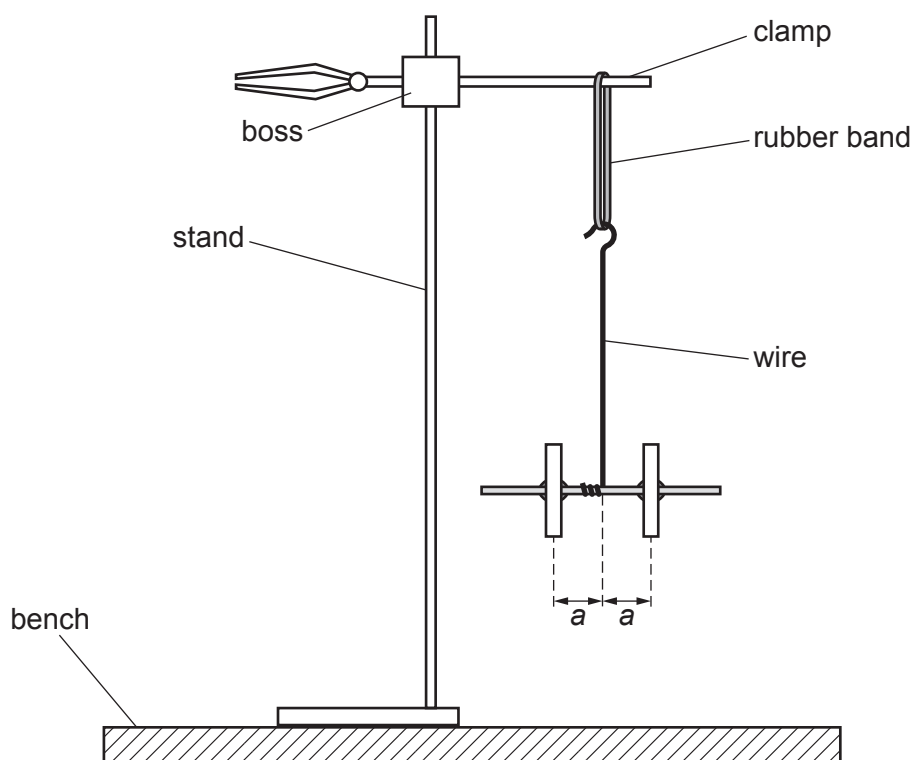


Fig. 2.4

- Make a hook in the wire and place the hook on the rubber band.
- The distance between the centre of each mass and the wire is a .

Adjust the position of the masses until the rod is parallel to the bench and each mass is the same distance a from the wire.

- Measure and record a .

$a =$ [1]

- (ii) Estimate the percentage uncertainty in your value of a . Show your working.

percentage uncertainty = % [1]

- (c)
- Rotate the rod horizontally through 90° .
 - Release the rod. The rod will oscillate.
 - Take measurements to determine the period T of these oscillations.

$T = \dots\dots\dots$ [2]

- (d)
- Remove the hook from the rubber band.
 - Remove the 50 g masses from the rod.
 - Place the 10 g masses on the rod so that their centres are approximately 9 cm apart.
 - Record m .

$m = \dots\dots\dots$ g

- Place the hook on the rubber band.
- Adjust the position of the masses until the rod is parallel to the bench and each mass is the same distance a from the wire.
- Measure and record a .

$a = \dots\dots\dots$

- Repeat (c).

$T = \dots\dots\dots$ [2]

- (e) It is suggested that the relationship between T , S , a and m is

$$T^2 = k(S + a^2m)$$

where k is a constant.

Using your data, calculate two values of k .

first value of k =

second value of k = [1]

- (f) It is suggested that the percentage uncertainty in the values of k is 10%.

Using this uncertainty, explain whether your results support the relationship in (e).

..... [1]

- (g) (i) Describe **four** sources of uncertainty or limitations of the procedure for this experiment.

For any uncertainties in measurement that you describe, you should state the quantity being measured and a reason for the uncertainty.

1

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2

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3

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4

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[4]

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

1

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2

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3

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4

.....

[4]

[Total: 20]

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