



CANDIDATE  
NAME

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CENTRE  
NUMBER

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CANDIDATE  
NUMBER

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9702/53

October/November 2023

**1 hour 15 minutes**

You must answer on the question paper.

No additional materials are needed.

- 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.

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].

This document has 8 pages.

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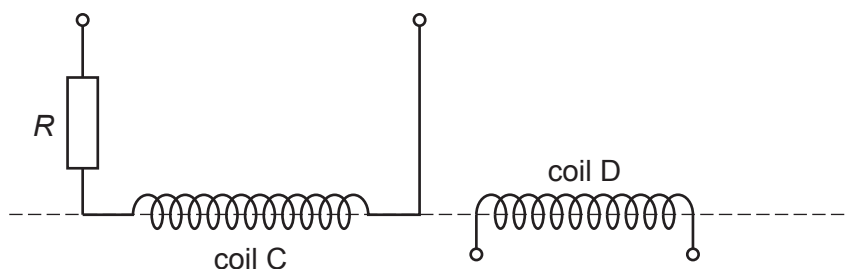


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- 1 Two coils, C and D, are placed with their axes on a straight line, as shown in Fig. 1.1.



**Fig. 1.1**

A resistor of resistance  $R$  is connected in series with coil C.

A changing magnetic flux of frequency  $f$  in coil C causes an electromotive force (e.m.f.)  $E$  to be induced across the terminals of coil D.

It is suggested that  $E$  is related to  $f$  by the relationship

$$E = \frac{pf^qV}{R}$$

where  $V$  is the potential difference across the resistor and coil C, and  $p$  and  $q$  are constants.

Plan a laboratory experiment to test the relationship between  $E$  and  $f$ .

Draw a diagram showing the arrangement of your equipment.

Explain how the results could be used to determine values for  $p$  and  $q$ .

In your plan you should include:

- the procedure to be followed
- the measurements to be taken
- the control of variables
- the analysis of the data
- any safety precautions to be taken.

**Diagram**

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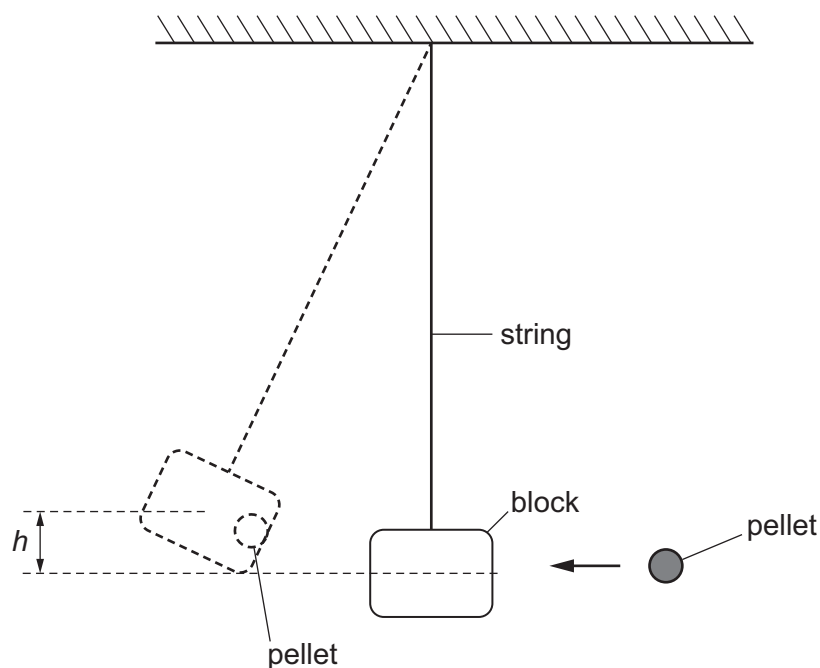
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- 2 A block of modelling clay of mass  $M$  is attached to a string as shown in Fig. 2.1.



**Fig. 2.1**

A pellet travelling at speed  $u$  enters the block and causes the block to move through a vertical height  $h$ .

The experiment is repeated for different values of  $M$ .

It is suggested that  $h$  and  $M$  are related by the equation

$$\frac{1}{h} = 2g \left( \frac{M+Z}{uZ} \right)^2$$

where  $g$  is the acceleration of free fall and  $Z$  is a constant.

- (a) A graph is plotted of  $\sqrt{\frac{1}{h}}$  on the  $y$ -axis against  $M$  on the  $x$ -axis.

Determine expressions for the gradient and  $y$ -intercept.

gradient = .....

$y$ -intercept = .....

[1]

(b) Values of  $M$  and  $h$  are given in Table 2.1.

**Table 2.1**

$M/\text{g}$	$h/\text{cm}$	$\sqrt{\frac{1}{h}}/\text{cm}^{-\frac{1}{2}}$
565	$21.0 \pm 0.2$	
637	$17.8 \pm 0.2$	
675	$16.2 \pm 0.2$	
723	$14.6 \pm 0.2$	
790	$12.6 \pm 0.2$	
892	$10.2 \pm 0.2$	

Calculate and record values of  $\sqrt{\frac{1}{h}}/\text{cm}^{-\frac{1}{2}}$  in Table 2.1.

Include the absolute uncertainties in  $\sqrt{\frac{1}{h}}$ . [2]

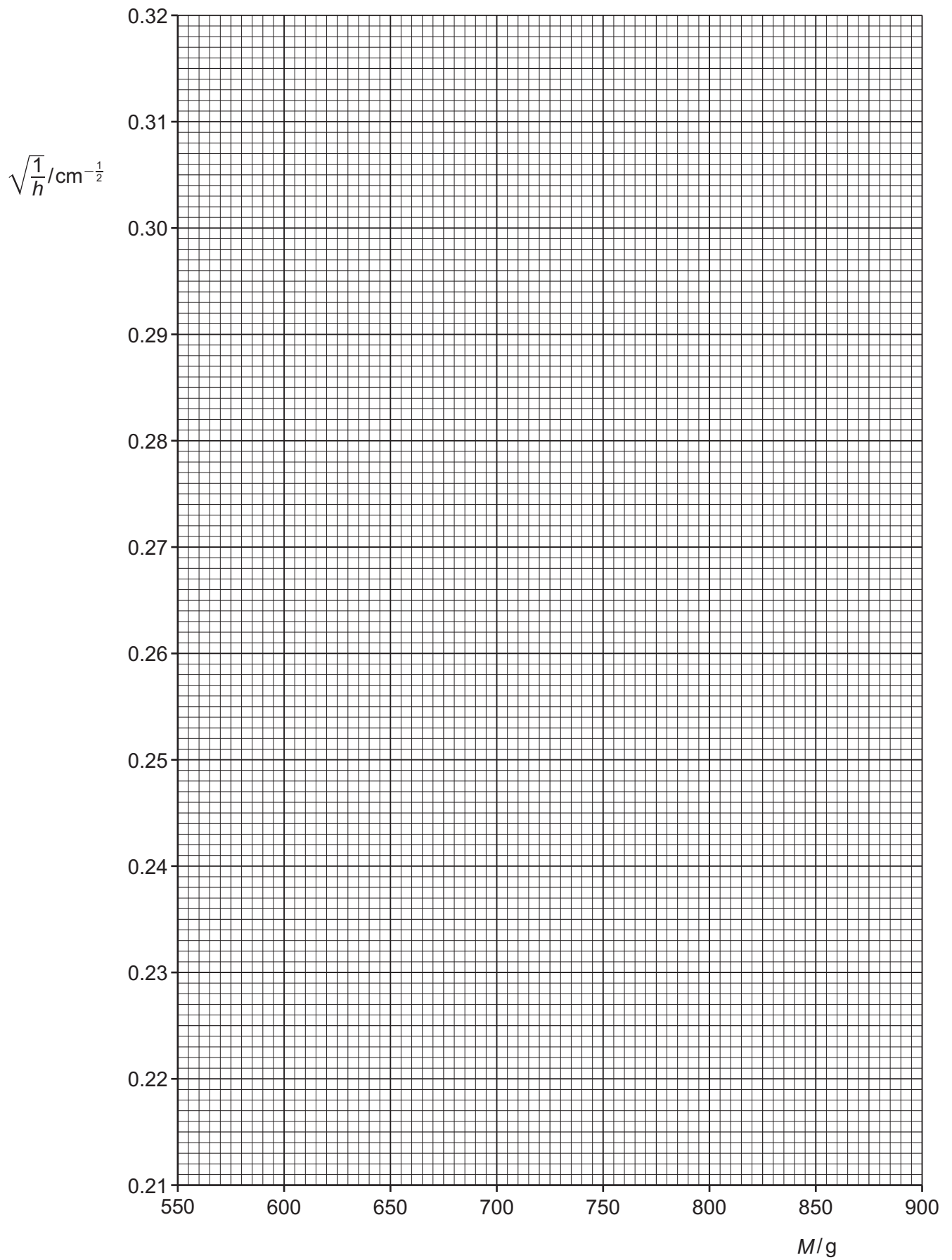
(c) (i) Plot a graph of  $\sqrt{\frac{1}{h}}/\text{cm}^{-\frac{1}{2}}$  against  $M/\text{g}$ .

Include error bars for  $\sqrt{\frac{1}{h}}$ . [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Label both lines. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

gradient = ..... [2]





- (iv) Determine the  $y$ -intercept of the line of best fit. Include the absolute uncertainty in your answer.

$y$ -intercept = ..... [2]

- (d) (i) Using your answers to (a), (c)(iii) and (c)(iv), determine the values of  $u$  and  $Z$ . Include appropriate units.

Data:  $g = 981 \text{ cm s}^{-2}$

$u = \dots\dots\dots$

$Z = \dots\dots\dots$  [2]

- (ii) Determine the percentage uncertainty in  $Z$ .

percentage uncertainty in  $Z = \dots\dots\dots$  % [1]

- (e) The experiment is repeated. Determine the mass  $M$  that gives a value of  $h$  of 25.0 cm.

$M = \dots\dots\dots$  g [1]

[Total: 15]