



CANDIDATE  
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CENTRE  
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## 9702/51

May/June 2021

**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.

- 1 A student investigates the current in a coil and a resistor connected in series, as shown in Fig. 1.1.



Fig. 1.1

The student connects a high-voltage d.c. power supply and a switch across the series combination.

When the switch is closed, it takes time  $t$  for the current in the resistor of resistance  $R$  to reach a maximum value. The time  $t$  is a few milliseconds.

There are a number of different unmarked resistors available.

It is suggested that the relationship between  $t$  and  $R$  is

$$t = \frac{KN^2A}{LR}$$

where  $N$  is the number of turns of wire on the coil,  $A$  is the cross-sectional area of the coil,  $L$  is the length of the coil and  $K$  is a constant.

Design a laboratory experiment to test the relationship between  $t$  and  $R$ .

Explain how your results could be used to determine a value for  $K$ .

You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to:

- 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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- 2 A student investigates the collision of two gliders A and B on a linear air-track. A card is attached to glider B, as shown in Fig. 2.1.

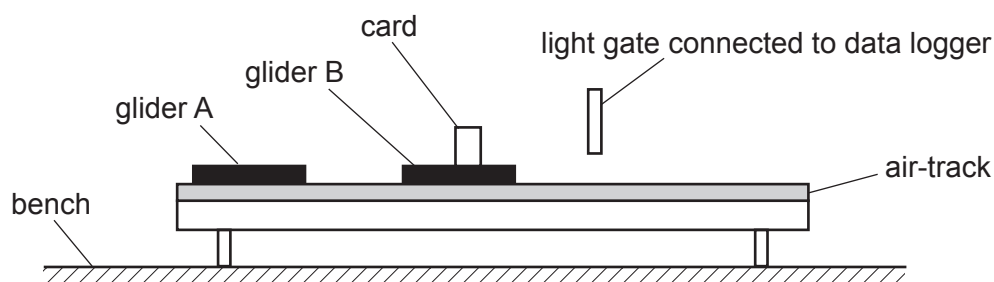


Fig. 2.1

Glider B has a mass  $M$ . A mass  $m$  is added to glider B.

Glider A travels at a constant velocity  $u$  towards the stationary glider B. The gliders then collide and move together towards the light gate.

The card passes through the light gate which is connected to a data logger. The student records the velocity  $v$  of the two gliders from the data logger.

The student changes the mass  $m$  and repeats the experiment.

It is suggested that  $v$  and  $m$  are related by the equation

$$Au = (M + m + A)v$$

where  $A$  is the mass of glider A.

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

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

gradient = .....

$y$ -intercept = .....

[1]

(b) Values of  $m$  and  $v$  are given in Table 2.1.

The value of  $M$  is  $330\text{ g} \pm 5\%$ .

Each value of  $m$  has a percentage uncertainty of  $\pm 5\%$ .

**Table 2.1**

| $m/\text{g}$ | $(M + m)/\text{g}$ | $v/\text{cm s}^{-1}$ | $\frac{1}{v}/\text{s cm}^{-1}$ |
|--------------|--------------------|----------------------|--------------------------------|
| 50           |                    | 4.42                 |                                |
| 150          |                    | 3.92                 |                                |
| 250          |                    | 3.40                 |                                |
| 350          |                    | 3.02                 |                                |
| 500          |                    | 2.58                 |                                |
| 600          |                    | 2.33                 |                                |

Calculate and record values of  $(M + m)/\text{g}$  and  $\frac{1}{v}/\text{s cm}^{-1}$  in Table 2.1.

Include the absolute uncertainties in  $(M + m)$ .

[2]

(c) (i) Plot a graph of  $\frac{1}{v}/\text{s cm}^{-1}$  against  $(M + m)/\text{g}$ .

Include error bars for  $(M + m)$ .

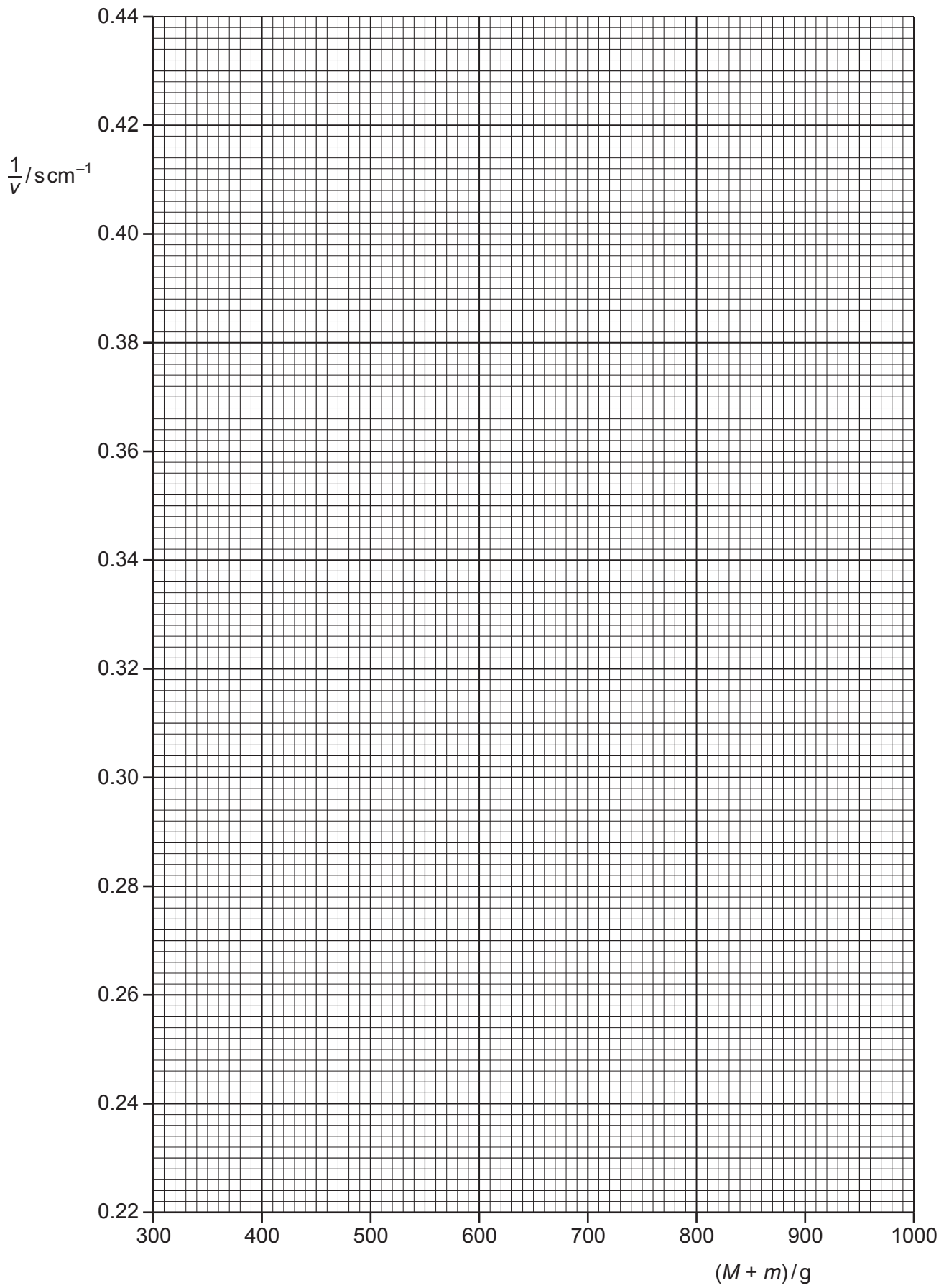
[2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled.

[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  $A$ . Include appropriate units.

$u$  = .....

$A$  = ..... [2]

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

percentage uncertainty in  $A$  = ..... % [1]

- (e) The experiment is repeated. Determine the value of  $m$  that would give a velocity  $v$  of  $2.0\text{ cm s}^{-1}$ .

$m$  = ..... g [1]

[Total: 15]