

MARKING SCHEME

Section A

- 1 In this experiment, you will determine a value for the focal length of a thin convex lens.

You are provided with:

- a convex lens
- a lens holder
- illuminated cross wires (object)
- a lamp
- a screen
- a metre rule
- a piece of *Blu-tack*
- a stand, a boss and a clamp.

You will assemble the apparatus as shown in Fig. 1.1.

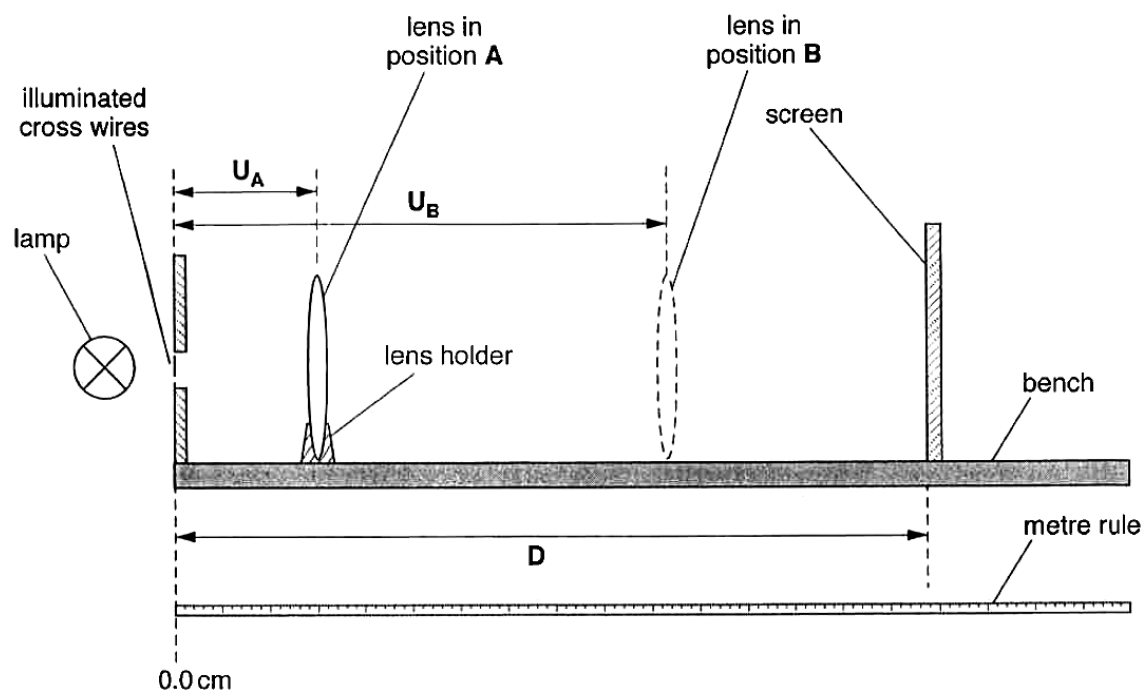


Fig. 1.1

(a) Setting up the apparatus

1. Secure the metre rule to the bench with two small pieces of *Blu-tack*. Place one small piece under each end of the rule and press the rule firmly onto the bench.
2. Place the cross wires, lens holder and screen **behind** the rule so that they **touch** it. It is important that you are able to read the position on the rule of each of them.
3. Place the cross wires at the 0.0 cm position on the rule. Once in this position, the cross wires **must not** be moved.

4. The lens holder with the lens, and the screen are to be positioned as described in the instructions given in parts **(b)(i)** and **(b)(ii)**.
5. Turn on the lamp **close** to the left of the cross wires so that light passes through the cross wires and lens, and shines on the screen.

(b) (i) 1. Position the screen so that it is at the 90.0 cm mark on the metre rule. This is distance **D**.

2. Start with the lens close to the cross wires. Move the lens towards the screen until a sharp image of the cross wires is observed on the screen. This is position **A**.

3. The distance of the lens from the cross wires is **U_A**. Record **U_A**. Calculate $1/U_A$.

$$U_A = \underline{0.181 \text{ m}}$$

$$1/U_A = \underline{5.52 \text{ m}^{-1}}$$

*[B1] based on student's answer where **U_A** is to 3 d.p. in m / 1 d.p. in cm, $1/U_A$ to 3 S.F. and correct units for **U_A** and $1/U_A$

4. Without moving the cross wires or screen, move the lens closer to the screen until a second sharp image is observed. This is position **B**.

5. The distance of the lens from the cross wires is **U_B**. Record **U_B**. Calculate $1/U_B$.

$$U_B = \underline{0.718 \text{ m}}$$

$$1/U_B = \underline{1.39 \text{ m}^{-1}}$$

*[B1] based on student's answer where **U_B** is to 3 d.p. in m / 1 d.p. in cm, $1/U_B$ to 3 S.F. and correct units for **U_B** and $1/U_B$

(ii) Position the screen at 85.0 cm mark on the metre rule (**D** = 85.0 cm). Repeat the instructions **(b)(i)2** to **5(b)(i)** and record **U_A** and **U_B**. Calculate $1/U_A$ and $1/U_B$.

$$U_A = \underline{0.188 \text{ m}}$$

$$1/U_A = \underline{5.32 \text{ m}^{-1}}$$

*[B1] based on student's answer where **U_A** is to 3 d.p. in m / 1 d.p. in cm, $1/U_A$ to 3 S.F. and correct units for **U_A** and $1/U_A$

$$U_B = \underline{0.610 \text{ m}}$$

$$1/U_B = \underline{1.64 \text{ m}^{-1}}$$

*[B1] based on student's answer where **U_B** is to 3 d.p. in m / 1 d.p. in cm, $1/U_B$ to 3 S.F. and correct units for **U_B** and $1/U_B$

*Don't penalise the same mistake more than once.

- (c) Determine gradient of the line passing through the coordinates ($1/U_B$, $1/U_A$) that you have obtained in (b)(i) and (b)(ii).

$$\begin{aligned}\text{gradient} &= (5.52 - 5.32) / (1.39 - 1.64) \\ &= -0.800\end{aligned}$$

$$\text{gradient} = \underline{\underline{-0.800}}$$

[B1] for showing working,

[B1] for calculating correctly based on student's values (to 3 S.F.)

- (d) Use the magnitude of the gradient and the formula below to determine a value for the focal length, f , of your lens.

$$f = \frac{100}{(1.2 \times \text{magnitude of gradient}) + 5.72}$$

$$\begin{aligned}f &= 100 / [(1.2 \times 0.800) + 5.72] \\ &= 15.0\end{aligned}$$

$$f = \underline{\underline{15.0 \text{ cm}}}$$

[B1] for showing working,

[A1] for the value of f between 13.5 cm and 16.5 cm (to 3 S.F.)

- (f) On Fig. 1.2, draw a ray diagram to show the formation of the image you obtained at position **A** in part (b)(i). The focal points of the lens are marked and labelled with **F** on the diagram. The diagram is **not** drawn to scale.

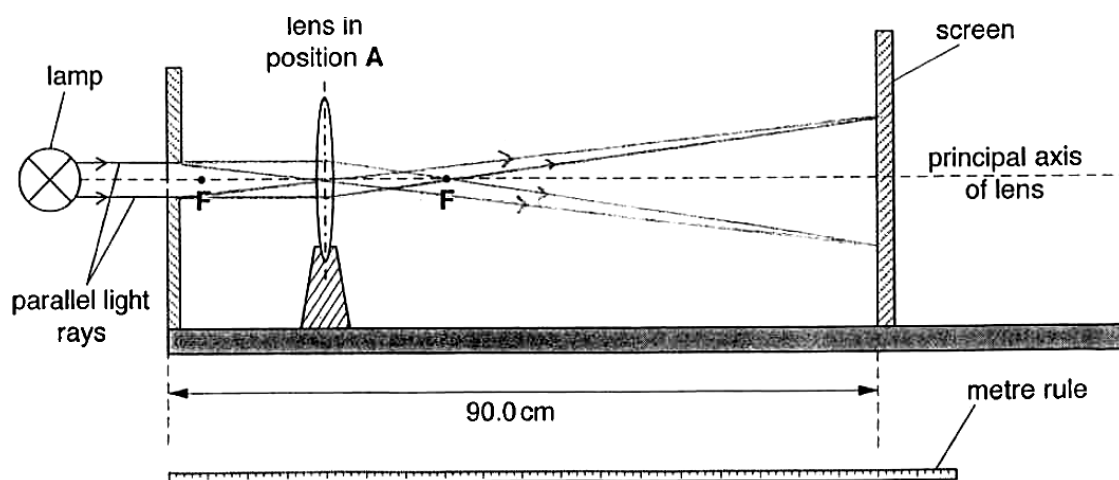


Fig. 1.2

[B1] for drawing the light rays correctly with arrows

- (f) Identify one possible source of error in this experiment. Suggest an improvement that would reduce this error.

source of error **Image is too small to be observed for D**

improvement **Use shorter D to obtain larger image / Use a lens with shorter focal length**

[B1] for correct source of error and corresponding improvement

[Total: 10]

2 In this experiment, you will investigate an electrical circuit.

You are provided with:

- two 1.5 V dry cells in holders
- a voltmeter
- a switch
- a resistor **R**
- a resistance wire attached to a metre rule
- seven connecting leads with crocodile clips at both ends
- a connecting lead labelled 'C'
- a digital micrometer.

(a) Set up the circuit as shown in Fig. 2.1.

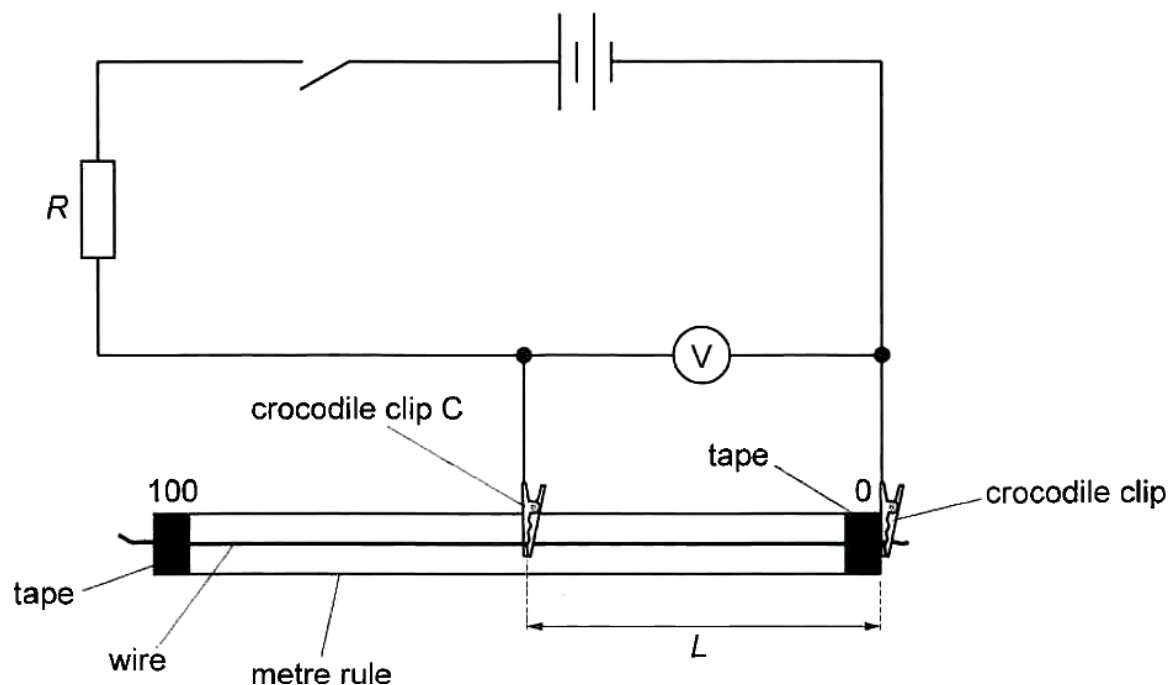


Fig. 2.1

The distance between the two crocodile clips is L .

Adjust the position of the crocodile clip C so that L is about 0.60 m.
Close the switch.

Measure and record L and the voltmeter reading V .
Open the switch.

$$L = \underline{0.600 \text{ m}}$$

$$V = \underline{1.40 \text{ V}}$$

[1]

[B1] based on student's value with L around 0.600 m or 60.0 cm
and V to 2 d.p. ending with 0 or 5

- (b) Determine an accurate value for the thickness d of the resistance wire.

d_1 / mm	d_2 / mm	$\langle d \rangle$ / mm
0.310	0.315	0.313

[B1] for measuring diameter at more than one position of the resistance wire

[B1] for calculating $\langle d \rangle$ and record to 3 d.p.

$$d = \underline{\underline{0.313 \text{ mm}}} [2]$$

- (c) Calculate the cross-sectional area A of the resistance wire where $A = \frac{1}{4} \pi d^2$.

$$\begin{aligned} A &= \frac{1}{4} \pi d^2 \\ &= \frac{1}{4} \pi (0.313 \times 10^{-3})^2 \\ &= 7.69 \times 10^{-8} \text{ m}^2 \end{aligned}$$

[B1] for showing working and correct calculation to 3 S.F. with unit

$$A = \underline{\underline{7.69 \times 10^{-8} \text{ m}^2}} [1]$$

0.0769 mm² is also acceptable

- (d) A student claims that $\frac{V}{L} = \left(-\frac{\rho}{AR}\right)V + b$, where b is a constant and V is the voltmeter reading.

Plan an experiment to investigate the student's claim.

In your plan, you should:

- explain briefly how to do the experiment
- state **one** key variable to control
- draw a table, with column headings, to show how to display the range of readings
- explain how to determine R and b if the student's claim is correct, given ρ is a constant with a value of $1.5 \times 10^{-6} \Omega \text{ m}$.

Constant variables: thickness of resistance wire, electromotive force of the power supply [B1]

Set up the apparatus as shown in Fig. 2.1. Record the readings from (a) to (c). Repeat (a) for five different lengths of L . Calculate V/L for every different length of L . [B1] Tabulate the readings of L , V and (V/L) as shown below.

L / m	V / V	$\frac{V}{L} / \text{V m}^{-1}$
0.150		
0.300		
0.450		
0.600		
0.750		
0.900		

[B1] for correct headings with units

[B1] for six readings of L with wide range (at least 70.0 cm apart)

Plot a graph of $\frac{V}{L}$ against V where gradient = $-\frac{\rho}{AR}$ and V -intercept = b . [B1]
 $R = -\rho / (A \times \text{gradient})$
 $= - (1.5 \times 10^{-6}) / (A \times \text{gradient})$ [B1]

[Total: 10]

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Section B

- 3 In this experiment, you will investigate the extension of two springs connected in parallel.

You are provided with:

- a stand, boss and clamp
- two springs
- two wooden rods
- 100 g mass hanger
- two 50 g masses
- two 100 g mass
- a string loop
- a metre rule.

- (a) You are provided with two springs. The length of each **unstretched** spring between the centres of the loops is l , as shown in Fig. 3.1.

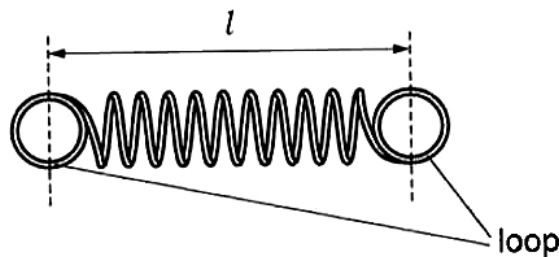


Fig. 3.1

Measure and record l for each of the provided springs.

l for first spring = **4.0 cm**

l for second spring = **4.0 cm**

[B1] for l to 1 d.p. in cm / 3 d.p. in m; $3.6 \text{ cm} < l < 4.4 \text{ cm}$

Determine the mean length L of the two springs.

$$L = (4.0 + 4.0) / 2 \\ = 4.0 \text{ cm}$$

$L = \textbf{4.0 cm}$

[B1] for calculating L and record to 1 d.p. in cm / 3 d.p. in m

- (b) Add one 50 g mass and one 100 g mass to the 100 g mass hanger.

Set up the apparatus as shown in Fig. 3.2.

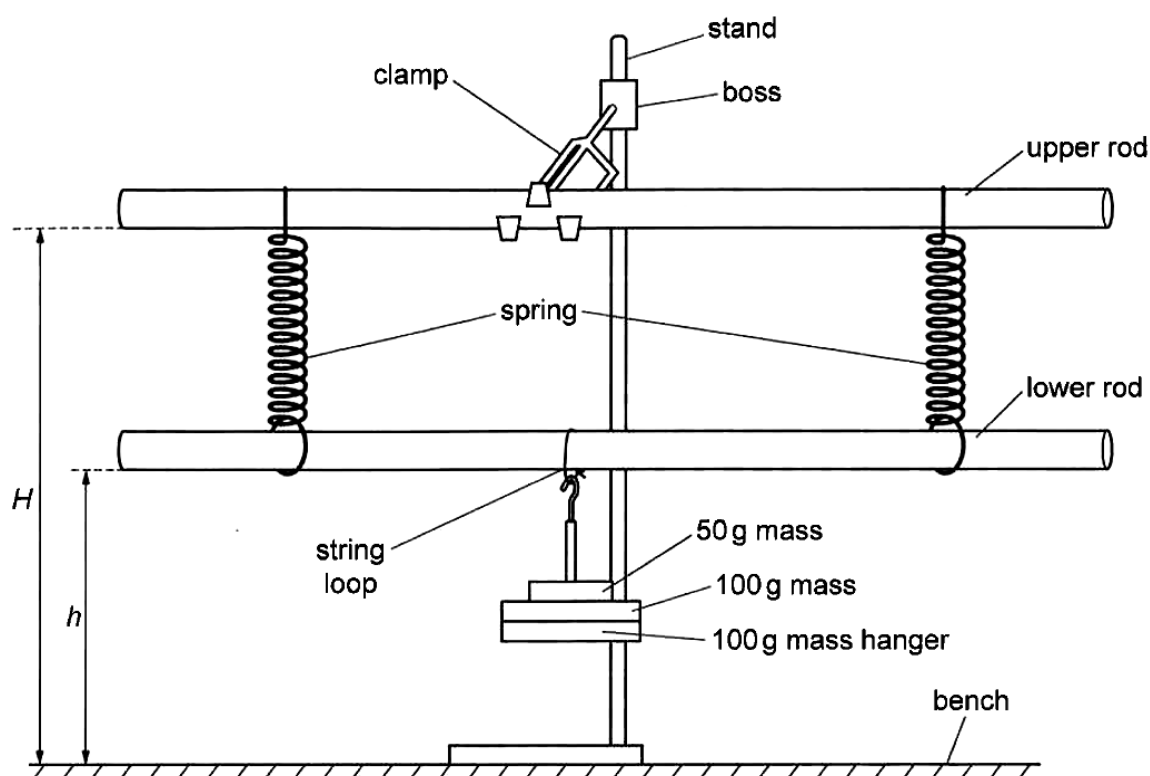


Fig. 3.2

The upper rod should be **horizontal** and the springs should be **vertical**.

The height of the upper rod above the bench is H , as shown in Fig. 3.2.

Adjust the apparatus so that H is approximately 54 cm.

- (i) Measure and record H .

$$H = \underline{54.0 \text{ cm}} [1]$$

[B1] for H to 1 d.p. in cm and $53.0 \text{ cm} < H < 55.0 \text{ cm}$

Do not change the position of the upper rod during the experiment.

- (ii) The total mass of the mass hanger and any added masses is m .

Use the stated values on each mass and the mass hanger to determine the value of m .

$$m = \underline{250 \text{ g}}$$

Adjust the position of the mass hanger so that the lower rod is **horizontal**.

You may also need to adjust the position of the springs so that the springs are still vertical.

The height of the lower rod above the bench is h , as shown in Fig. 3.2.

Measure and record h .

$$h = \underline{45.1 \text{ cm}}$$

Calculate $(H - h)$.

$$54.0 - 45.1 = 8.9 \text{ cm}$$

$$(H - h) = \underline{8.9 \text{ cm}}$$

[B1] for recording m as 250 g, h and $(H - h)$ to 1 d.p. in cm and calculating $(H - h)$ correctly

- (iii) Repeat the procedure in (b)(ii) using different values of m .

Record all measurements and calculations in a suitable table.

m / g	h / cm	$(H - h) / \text{cm}$
150	47.1	6.9
200	46.1	7.9
250	45.1	8.9
300	44.1	9.9
350	43.1	10.9
400	42.1	11.9

[4]

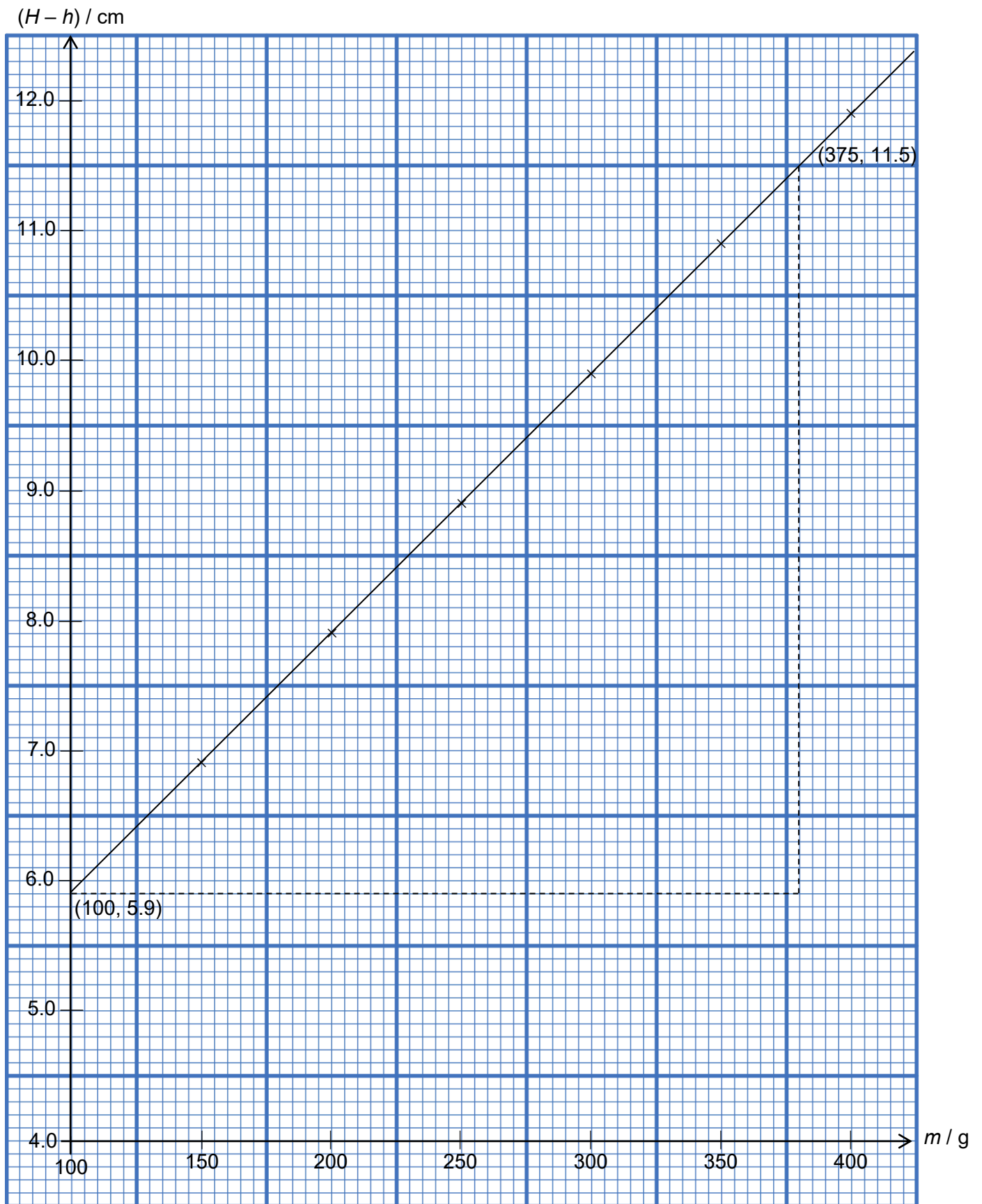
[B1] for correct headings with units

[B1] for six different readings of m at 50 g interval

[B1] for recording h and $(H - h)$ to 1 d.p. in cm

[B1] for $(H - h)$ increases as h decreases and calculating $(H - h)$ correctly

(c) On the grid provided, plot a graph of $(H - h)$ against m . Draw the line of best fit.



[4]

- (d) (i) Determine the gradient of your line, showing clearly on your graph how you did this.

$$\begin{aligned}\text{gradient} &= (11.5 - 5.9) / (375 - 100) \\ &= 0.020 \text{ cm/g}\end{aligned}$$

$$\text{gradient} = \underline{\underline{0.020 \text{ cm/g}}} \text{ [2]}$$

[B1] for drawing big dotted right-angled triangle and labelling the two sets of coordinates used to calculate gradient on the graph (based on student's graph)

[B1] for calculating gradient correctly, to 2 S.F. with unit

- (ii) Determine the y-intercept of the line of best fit.

$$\begin{aligned}\text{At } (200, 7.9), 7.9 &= (0.020 \ 364 \times 200) + y \\ y &= 3.8 \text{ cm}\end{aligned}$$

$$\text{y-intercept} = \underline{\underline{3.8 \text{ cm}}} \text{ [1]}$$

[B1] for reading y-intercept from graph (based on student's graph) or calculating y

- (iii) The mass M of the lower rod is given by the equation:

$$M = \frac{\text{magnitude of (y-intercept - } L)}{\text{gradient}}$$

Using this equation and your answers in (a), (d)(i) and (d)(ii) to determine a value for M .

$$\begin{aligned}M &= |(3.8 - 4.0)| / 0.020 \ 364 \\ &= 9.8\end{aligned}$$

$$M = \underline{\underline{9.8 \text{ g}}} \text{ [2]}$$

[B1] for showing working and calculating correctly

[B1] for correcting to 2 S.F. with unit

- (e) Suggest how to use calipers to improve the measurements of l .

Use outside jaws of calipers to measure from loop to loop the length of spring, L_1 . Use inside jaws of calipers to measure diameter of loop, L_2 . l can be calculated by $l = L_1 - L_2$. [B1]

- (f) Describe how you ensure the upper rod is **horizontal** and the springs are **vertical**.

Use a metre rule to measure the perpendicular distance between one end of the upper rod and the bench. Do the same for the other end of the rod.

Ensure both distances are the same so that the rod is horizontal. [B1]

Use a set square to ensure the spring makes an angle of 90° with the upper rod and the lower rod. Do the same for the other spring. [B1]

[Total: 20]

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