1 A student investigates a spring of width w made from a metal wire, as shown in Fig. 1.1.

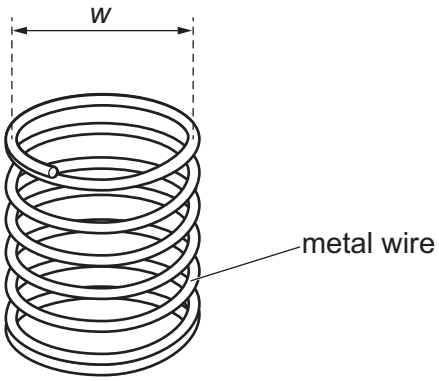

Fig. 1.1

The student constructs several springs, each made from a metal wire of different cross-sectional area A. The student investigates how the extension x of each spring varies with A when a load of mass m is applied.

It is suggested that the relationship between x and A is

$$x = \frac{mgw^3NA^n}{\gamma\rho}$$

where g is the acceleration of free fall, ρ is the density of the metal, N is the number of turns of wire in the spring and γ and n are constants.

Design a laboratory experiment to test the relationship between x and A.
Explain how your results could be used to determine values for γ and n.

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.

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Diagram

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.... [15]

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2 A student investigates the image of an object formed on a screen by a converging lens, as shown in Fig. 2.1.

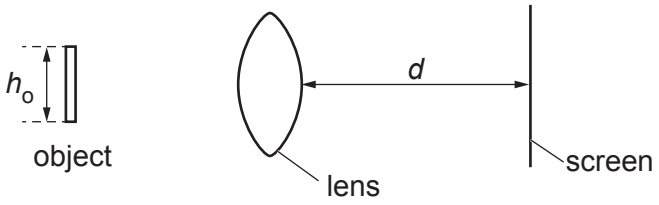

Fig. 2.1

The student measures the height h_o of the object and the distance d from the lens to the screen. The height h_i of the image is measured as shown in Fig. 2.2.

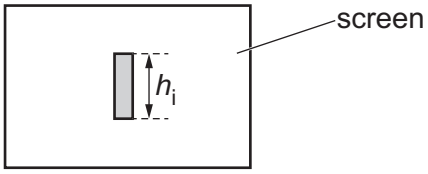

Fig. 2.2

The experiment is repeated for different values of d.

It is suggested that h_i and d are related by the equation

$$\frac{1}{f}\left(d+\frac{t}{2}\right)=\frac{h_i}{h_o}+1$$

where f is a property of the lens called the focal length and t is the thickness of the lens.

(a) A graph is plotted of $\frac{h_i}{h_o}$ on the y-axis against d on the x-axis.

Determine expressions for the gradient and y-intercept.

gradient = ...

y-intercept = ...

[1]

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(b) The value of h_o is (2.4 ± 0.1) cm.
Values of d and h_i are given in Table 2.1.

Table 2.1

d / cm	h_i / cm	$\frac{h_i}{h_o}$
54.0	1.7 ± 0.1	
57.5	1.9 ± 0.1	
61.5	2.2 ± 0.1	
67.0	2.6 ± 0.1	
74.0	3.1 ± 0.1	
80.5	3.6 ± 0.1	

Calculate and record values of $\frac{h_i}{h_o}$ in Table 2.1.

Include the absolute uncertainties in $\frac{h_i}{h_o}$. [2]

(c) **(i)** Plot a graph of $\frac{h_i}{h_o}$ against d / cm.

Include error bars for $\frac{h_i}{h_o}$. [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]

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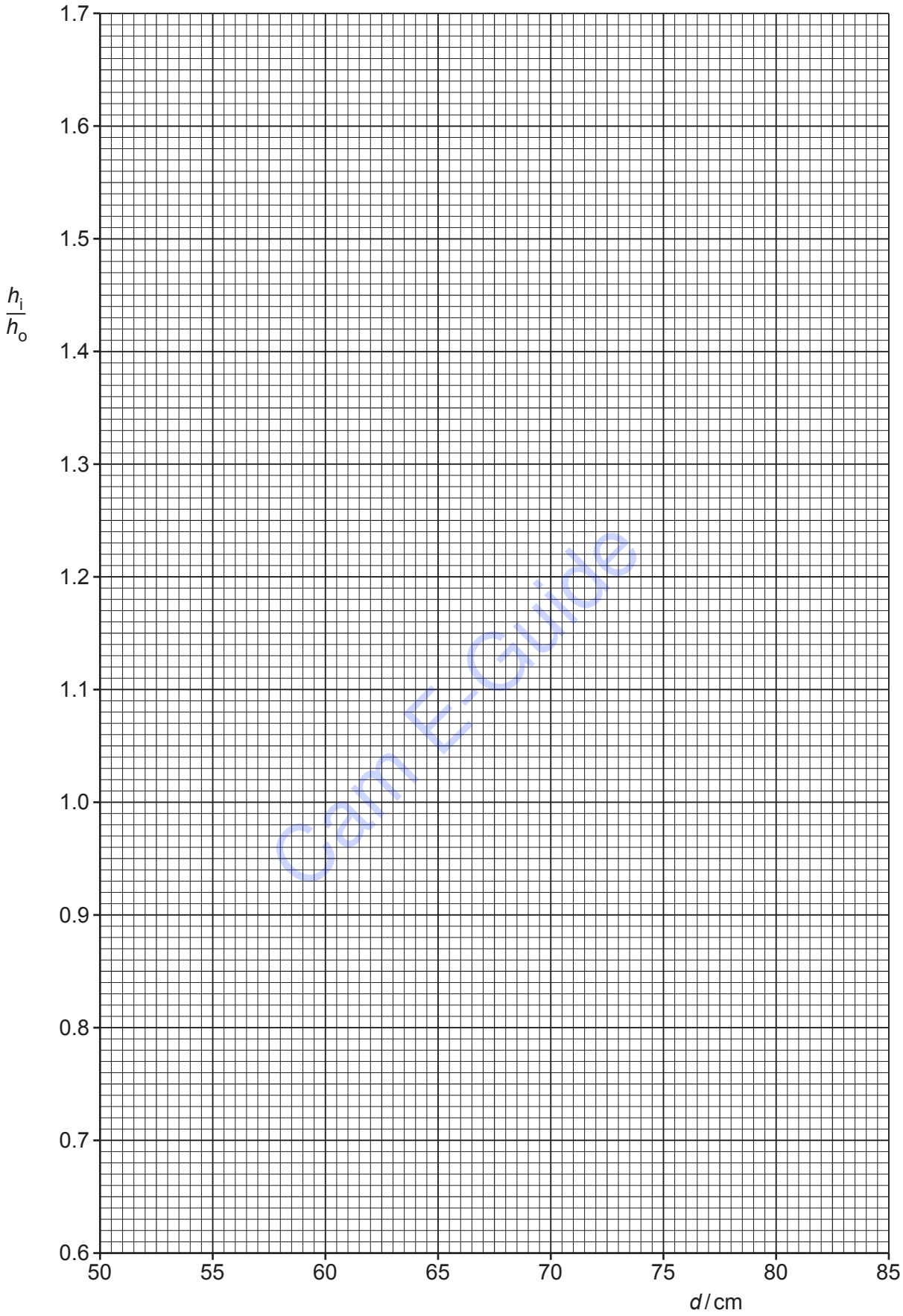
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
$\frac{h_i}{h_o}$
50
55
60
65
70
75
80
85
d / cm

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