1 **(a)** A student is trying to confirm Hooke's Law which states
"The extension of a spring is directly proportional to the force extending it."

The apparatus is set up as shown in Fig. 5.1.

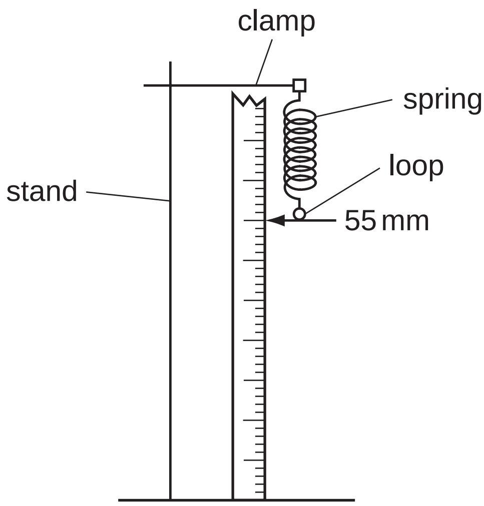


Fig. 5.1

He records in Table 5.1 the position of the pointer on the rule.

He now hangs a holder, weight 1 N, to the loop and reads the new position of the pointer. He calculates the extension. These measurements are placed in Table 5.1.

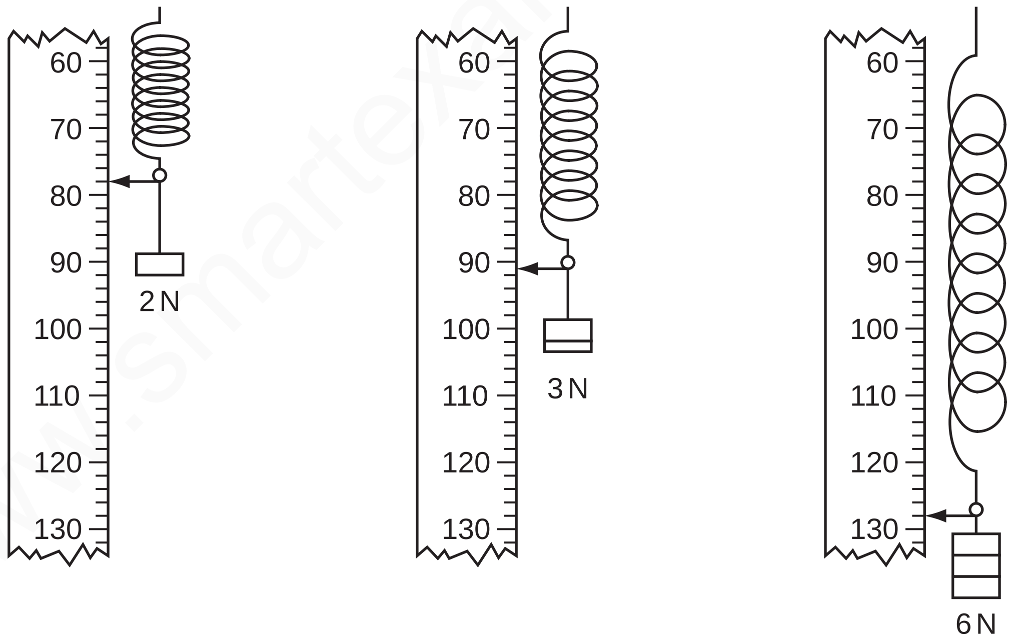


Fig. 5.2

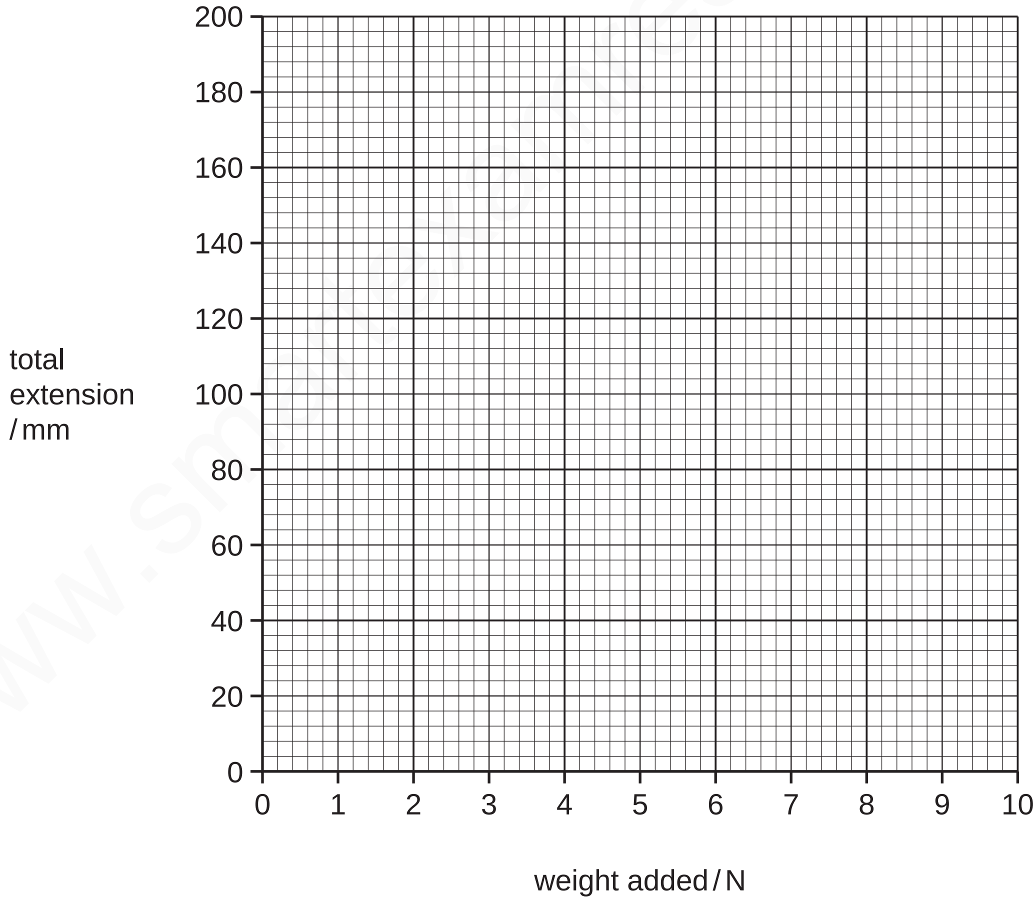
(i) Fig. 5.2 shows the springs with 2 N, 3 N and 6 N weights attached. Read off the position of the pointer each time, and record the values in Table 5.1. [3]

Table 5.1

weights / N	position of pointer, d / mm	total extension / mm
0	55	0
1	67	12
2		
3		
5	115	60
6		
9	165	110
10	235	180

(ii) Calculate the missing extensions for weights 2 N, 3 N and 6 N and complete Table 5.1. [1]

(b) (i) Plot a graph of total extension against weight. Draw the best line.



[2]

Fig. 5.3

(ii) Does the graph confirm Hooke's Law?

Explain your answer.

....

....

....

.... [3]

(c) The student removes all the weights from the spring and observes that the pointer does not return to the 55 mm mark. Give a reason for this.

....

....

.... [1]

MARKING SCHEME

(a) **(i)** 78 ; 91 ; 128 ; [3]

(ii) 23, 36, 73 (all three) ; [1]

(b) **(i)** points ;
straight line joining the first 7 points (ignore line for last plot) ; [2]

(ii) (yes)
straight line ;
between 0 and 9 N / at first;
(then) not followed / elastic limit reached / owtte ;
(award 1 mark if note the jump between 9 N and 10 N, but do not score any points above) [3]

(iii) permanent deformation / exceed elastic limit / spring broken / misshaped / stretched too far ; [1]

[Total: 10]

2 **(a)** A student is finding the value of an unknown mass, M, of a fixed load by balancing it against a range of known masses on a metre rule.

The apparatus is set up as shown in Fig 6.1.

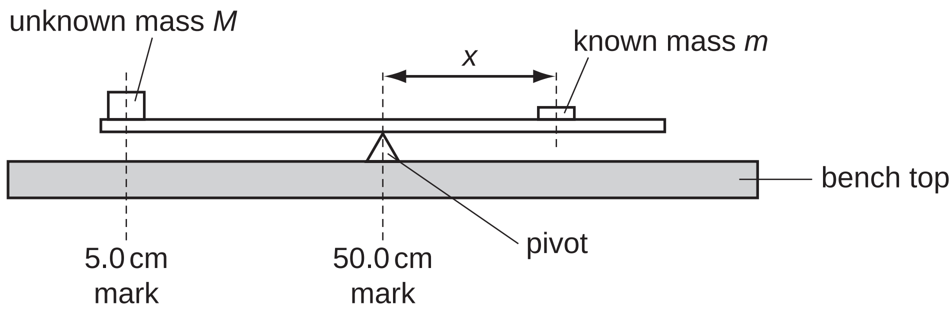


Fig. 6.1

The unknown load of mass M, is fixed at the 5.0 cm position. The student places a 60 g mass, m, on the ruler. He adjusts the position of mass m, until the ruler is balanced. He records the distance, x cm, from the 50.0 cm balance point in Table 6.1.

Table 6.1

mass m / g	distance x / cm	$\frac{1}{x}$
60	37.4	
70	31.9	
80		
90		
100	22.7	

(i) Use Fig 6.2 to find the distance, x, for masses equal to 80 g and 90 g and complete column 2 of Table 6.1. Measure to the centre of the mass. [2]

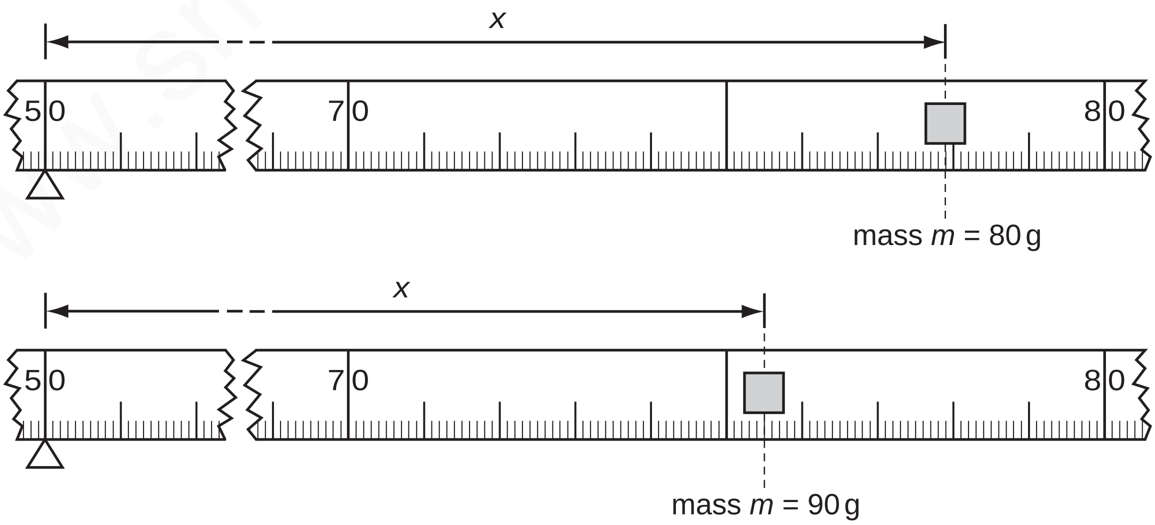
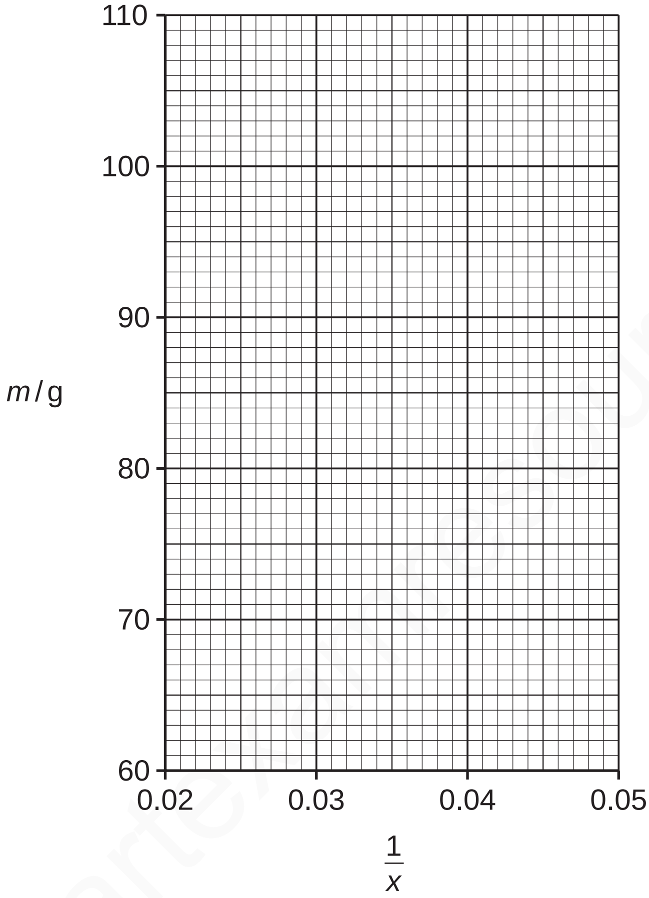


Fig. 6.2

(ii) Calculate $\frac{1}{x}$ for each value of x and record your answers to 3 decimal places in Table 6.1. [2]

(b) (i) On the grid provided, plot a graph of mass, m, (vertical axis) against $\frac{1}{x}$.

Draw the best straight line.



[2]

(ii) Calculate the gradient of the line. Show clearly, on the graph, how you did this.

gradient of the line .... [2]

(c) Calculate the value of the unknown load of mass M, using the equation

$$M = \frac{\text{gradient}}{45}$$

M = ... g [1]

(d) This method of finding unknown masses is unsuitable for very small or very large masses.

Suggest a reason for either of these.

.... [1]

MARKING SCHEME

(a) **(i)** 27.9 ; 25.5 ; [2]

(ii) 0.027
0.031
0.036
0.039
0.044
all recorded to 3 decimal places ;
any two correct ; [2]

(b) **(i)** points correct by eye ;
straight line of best fit ; [2]

(ii) gradient 2353 (allow between 2000 to 2600) ;
method clearly shown on graph ; [2]

(c) M = 2353/45 = 52 (g) ; (ecf) [1]

(d) metre rule will break (if mass very large) ;
rule not long enough (for large mass) ;
too difficult to achieve a balance ;
x too small (or large) to measure ; (ignore 'difficult to measure') [max 1]

[Total: 10]

3 A student is finding the spring constant k of a spring. The spring constant of a spring is a measure of the spring's stiffness.

She sets up the apparatus as shown in Fig. 2.1.

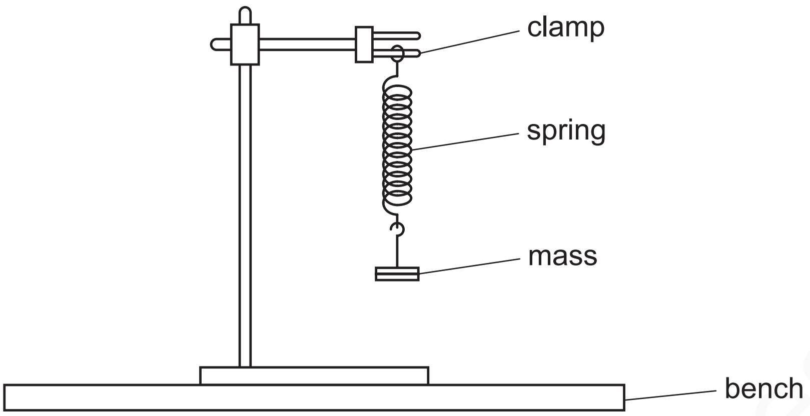
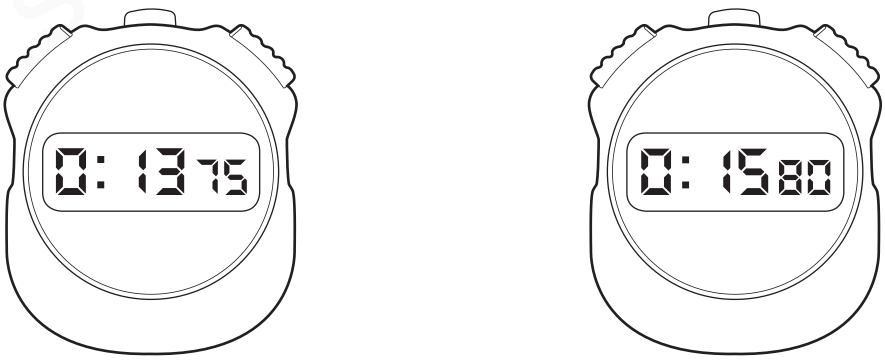


Fig. 2.1

- She hangs a mass m of 0.20 kg on the spring.
- She pulls the 0.20 kg mass down a small distance and releases it.
- The mass oscillates up and down.
- The period T of the oscillations is the time taken for **one** oscillation. This is difficult to measure accurately so she measures the time taken t for 20 oscillations.
- She enters this value in Table 2.1.
- She calculates the values of T and T^2 and enters them in Table 2.1.
- She repeats this with masses m of 0.30 kg, 0.40 kg and 0.50 kg.

(a) Fig. 2.2 shows the stopwatches for the time taken for 20 oscillations when m = 0.30 kg and 0.40 kg.

Read the stopwatches and record the times, to the nearest second, in Table 2.1. [1]



m = 0.30 kg m = 0.40 kg

Fig. 2.2

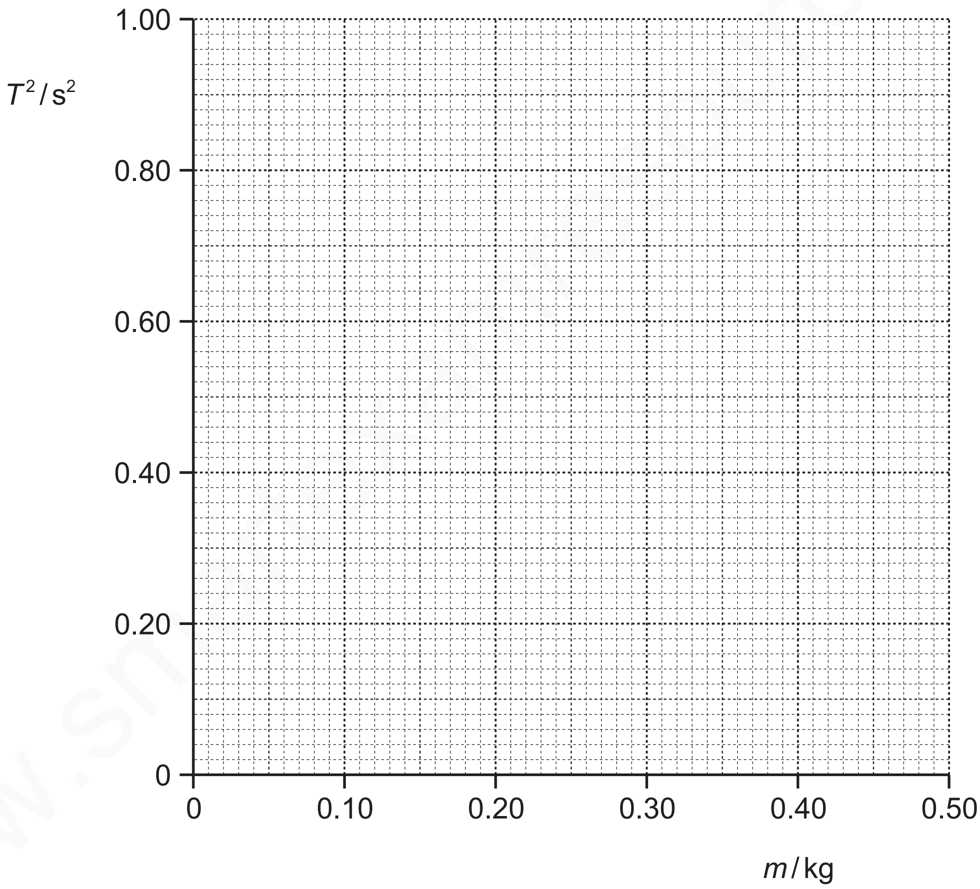
(b) (i) Complete Table 2.1 by calculating T and T^2, for m = 0.30 kg and 0.40 kg to two decimal places. [3]

Table 2.1

mass m / kg	time for 20 oscillations t / s	period T / s	T^2 / s^2
0.20	11	0.55	0.30
0.30			
0.40			
0.50	18	0.90	0.81

(ii) On the grid provided, plot a graph of T^2 against m.

Draw the best fit straight line through the origin.



[2]

(iii) Calculate the gradient of the line. Show **clearly**, on the graph, how you did this.

gradient = ... [2]

(iv) Use your value from **(iii)** to calculate the value of the spring constant k of the spring from the equation

$$k = \frac{39.5}{\text{gradient}}$$

Give your answer to two significant figures.

k = ... N/m [2]

MARKING SCHEME

(a) 14 and 16 ; [1]

(b) **(i)** 0.7(0) 0.8(0) ; [3]

0.49 and 0.64 ;

T^2 to 2 d.p. ;

Allow ecf

(ii) 4 plots correct ± 1/2 small square ; [2]
best fit straight line through origin ± 1/2 small square ;

(iii) gradient shown clearly on graph (triangle at least 1/2 of graph); [2]
1.6 ;

(iv) 39.5/gradient from **(b)(iii)** = 25 ; [2]
quoted to 2 sig figs ;

[Total: 10]

4 A student measures the mass of a metre rule using a balancing method.

He uses a load **L** of 100 g, a metre rule and a pivot.

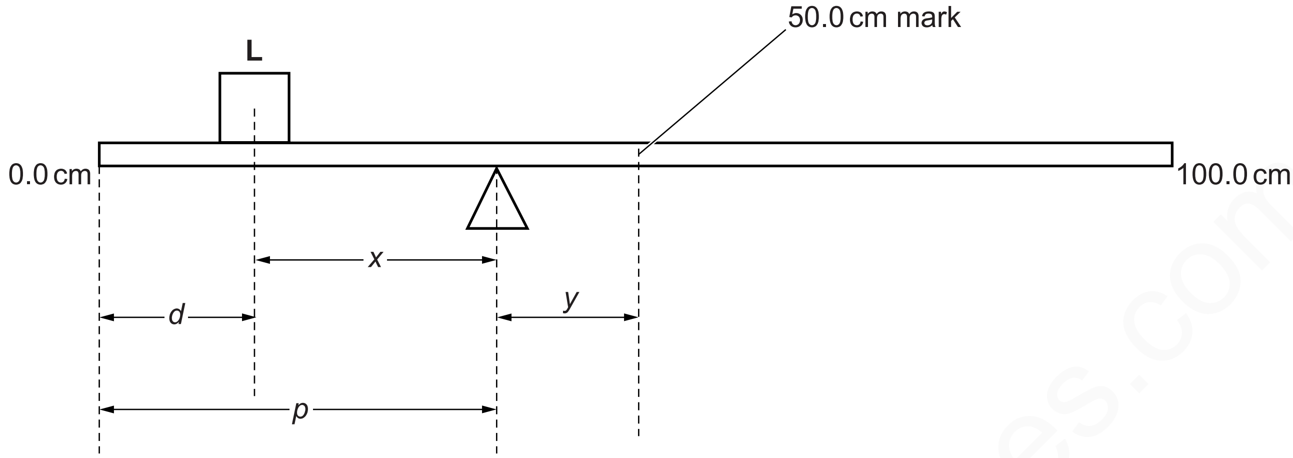


Fig. 3.1

- He places the load on the rule so that its centre is at a distance d = 5.0 cm from the zero end of the rule, as shown in Fig. 3.1.
- He adjusts the position of the pivot so that the rule balances on it.

(a) Fig. 3.2 shows the position of the pivot at balance.

Record in Table 3.1 on page 8, to the nearest 0.1 cm, the distance p from the pivot to the zero end of the rule. [1]

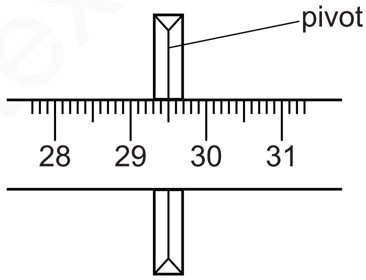


Fig. 3.2

(b) The student repeats the procedure in **(a)** for values of *d* of 10.0 cm, 15.0 cm, 20.0 cm and 25.0 cm.

His results are given in Table 3.1.

Table 3.1

d / cm	p / cm	$x = (p - d)$ / cm	$y = (50 - p)$ / cm
5.0			
10.0	31.8	21.8	18.2
15.0	34.1		
20.0	36.4		
25.0	38.6		

For each value of d, calculate the distances x and y as shown in Table 3.1 using the equations shown. One has been done for you.

$$x = (p - d)$$

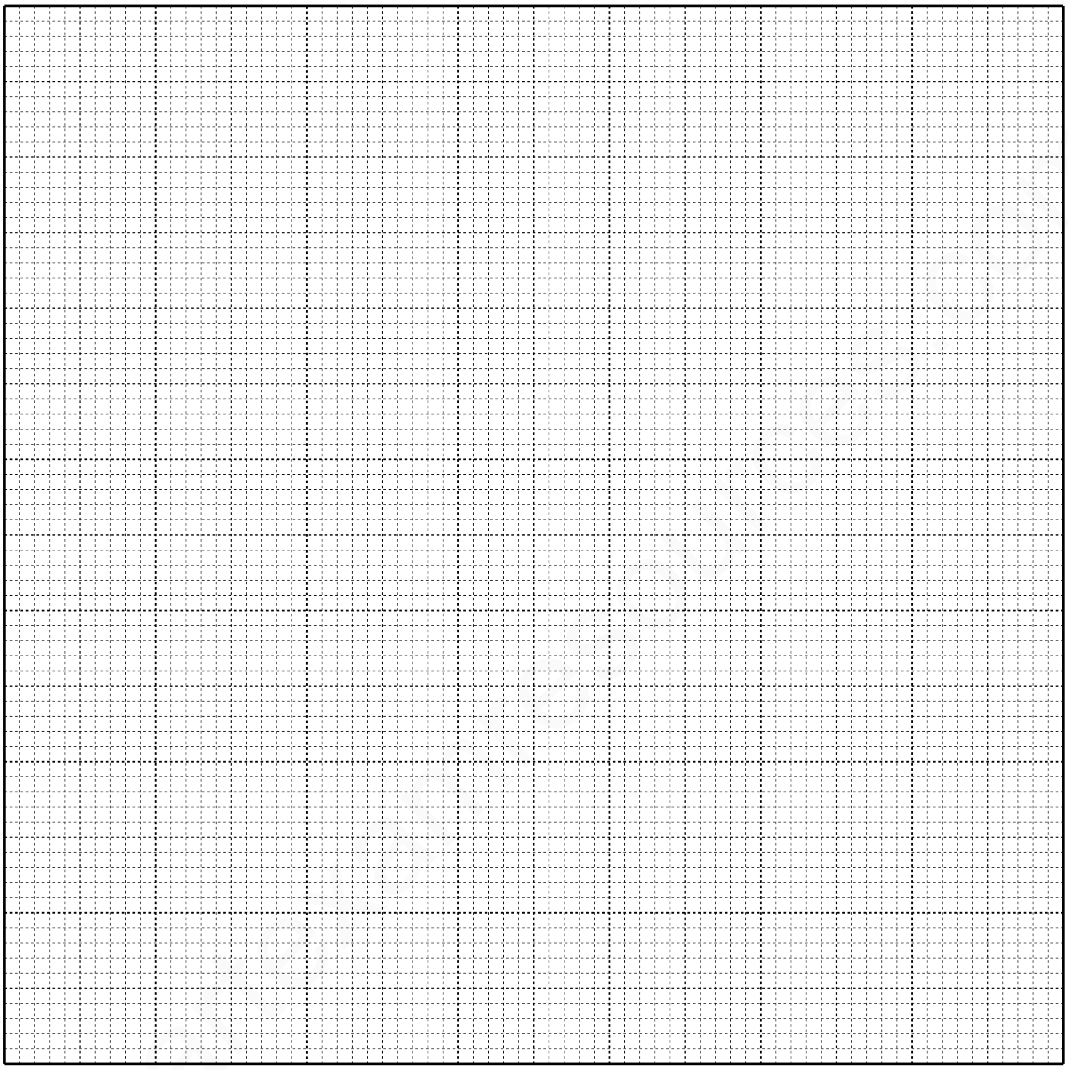
$$y = (50 - p)$$

Record in Table 3.1 your calculated values of x and y. [2]

(c) **(i)** On the grid provided plot a graph of y against x. You do **not** need to start your axes from the origin (0, 0).

Draw the best-fit straight line.

y / cm



x / cm

[3]

(ii) Calculate the gradient of your line.

Show all working and indicate on your graph the values you chose to enable the gradient to be calculated.

gradient of line = ...[2]

(d) The mass in grams of the metre rule is given by the equation shown.

$$\text{mass} = \frac{100}{\text{gradient}}$$

Use this equation to calculate the mass of the rule, giving your answer to an appropriate number of significant figures.

mass of rule = ...g [1]

(e) The student now checks his result and measures the mass of the rule using a digital balance.

Suggest **one practical** reason why, despite carrying out the experiment with care, the value for the mass calculated in **(d)** may be different from the value recorded by the digital balance. Assume that the digital balance used is accurate.

....

....[1]

MARKING SCHEME

(a) p = 29.5 cm ; [1]

(b) x values correct (e.c.f. p)
24.5 ecf, (21.8), **19.1, 16.4, 13.6** ;

y values correct
20.5 ecf, (18.2), **15.9, 13.6, 11.4** ; [2]

(c) **(i)** suitable choice of scales ⩾ ½ the grid (can plot the 5 points) used AND linear ;
minimum 4 plots correct to ½ small square on easy to read scale ;
good best fit straight line judgement ; [3]

(ii) indication on graph of how the data were obtained AND more than half the line ;
calculation correct ; [2]

(d) m correct to 2 / 3 significant figures ; [1]

(e) **Any one from:**

difficulty in obtaining balance ;
centre of mass of rule not at the 50.0 cm mark ;
load not uniform ;
difficulty in placing the centre of load over the mark on the rule ; [1]

[Total: 10]

5 A student did an experiment with an **L**-shaped piece of card. He wanted to find its centre of mass. You do not need to know the meaning of the term *centre of mass*.

- The card was suspended on a pin pushed through a hole 5 mm from point **A** (distance **x**). A plumb-line was also hung on the pin.

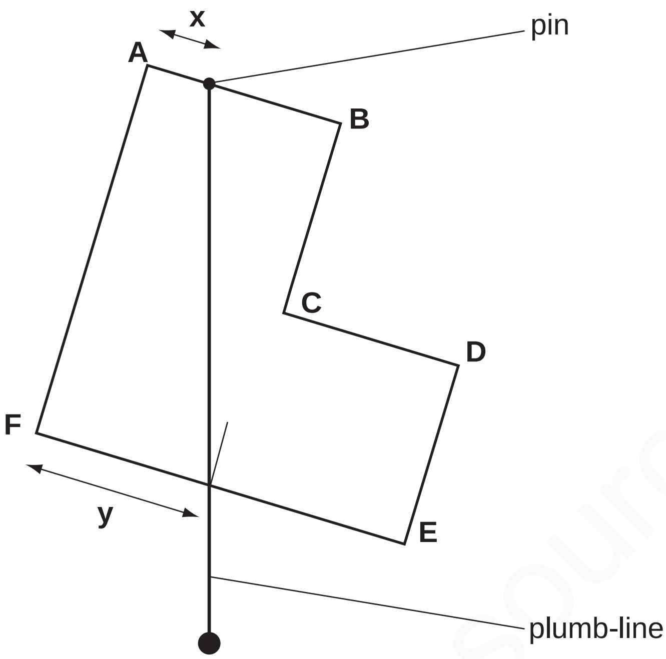


Fig. 2.1

- When he was sure that the card was hanging freely, he marked the point at which the plumb-line crossed line **FE** (distance **y** from **F**).
- He recorded the distances **x** and **y** in Fig. 2.2.
- He moved the position of the pin towards **B** and repeated the experiment until he had obtained 5 sets of readings.

reading number	1	2	3	4	5
x/ mm	5			20	25
y/ mm	67			57	53

Fig. 2.2

(a) Figs. 2.3 and 2.4 show distances **x** and **y** for the two missing readings. Measure the distances **x** and **y** and record them in Fig. 2.2. [4]

reading 2

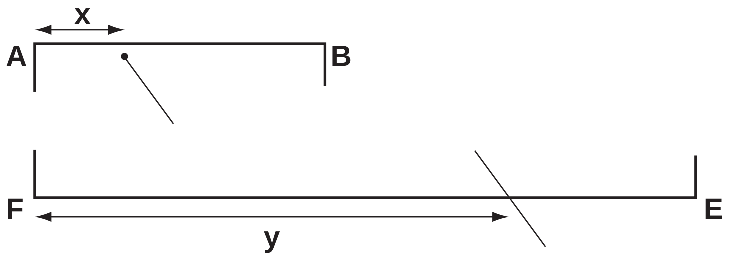


Fig. 2.3

reading 3

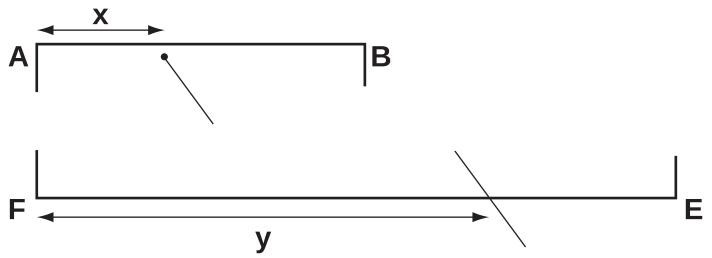


Fig. 2.4

(b) (i) Plot a graph of **y** (vertical axis) against **x** and draw the best fit straight line. Extend the line to cut the vertical axis. [3]

(ii) From the graph determine $\mathbf{y_0}$, the value of **y** when **x** = 0.

$\mathbf{y_0}$ = ... mm [1]

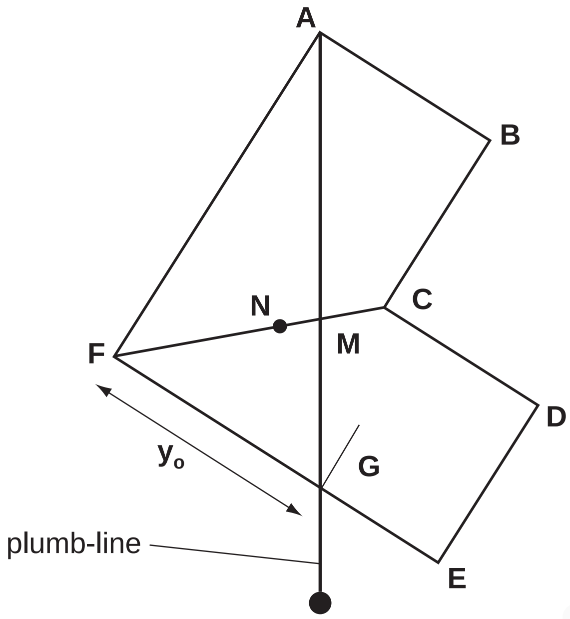


Fig. 2.5

(iii) Use the value of $\mathbf{y_0}$ from **(ii)** to mark, **on Fig. 2.6**, the position of the plumb-line **AG**. (See Fig. 2.5)
Label point **M**, where **AG** crosses **FC**. [1]

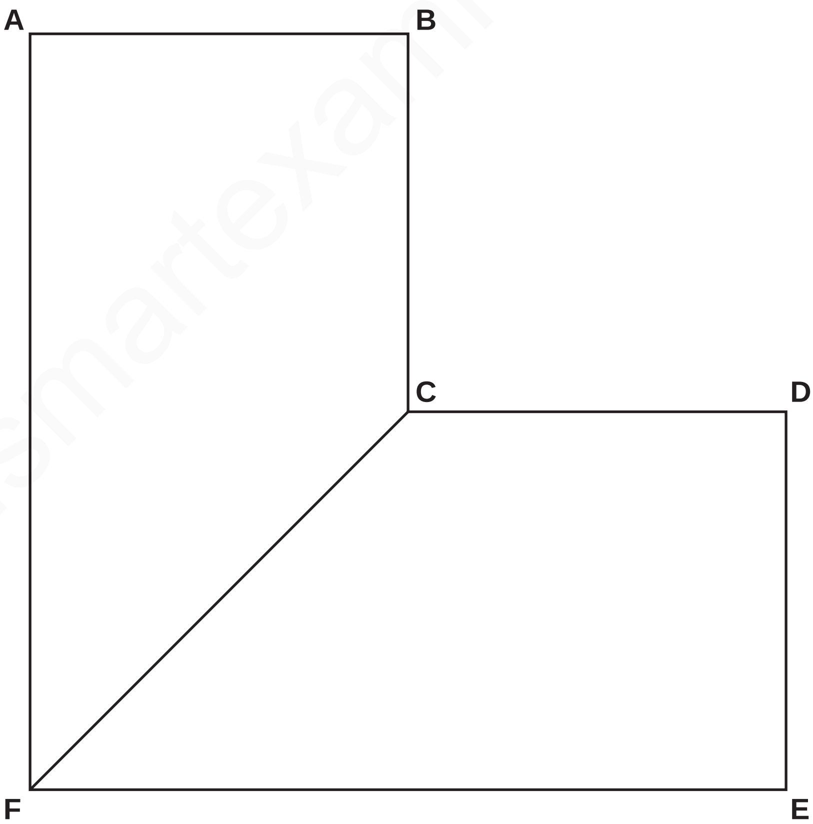


Fig. 2.6

(c) The student thought that the centre of mass of the card was at **M**.

He pushed the pin through the card at point **M**. He turned the card upside down so the pin was underneath it. The card balanced on the pin.

He tried to make the card balance on point **N**. (See Fig. 2.5)

Explain why the card would not balance on point **N**.

....

.... [1]

MARKING SCHEME

(a) $p = 29.5\,\text{cm}$; [1]

(b) x values correct (e.c.f. p)
24.5 ecf**,** (21.8), **19.1, 16.4, 13.6** ;

y values correct
20.5 ecf**,** (18.2), **15.9, 13.6, 11.4** ; [2]

(c) (i) suitable choice of scales ⩾ ½ the grid (can plot the 5 points) used AND linear ;
minimum 4 plots correct to ½ small square on easy to read scale ;
good best fit straight line judgement ; [3]

(ii) indication on graph of how the data were obtained AND more than half the line ;
calculation correct ; [2]

(d) m correct to 2 / 3 significant figures ; [1]

(e) **Any one from:**

difficulty in obtaining balance ;
centre of mass of rule not at the 50.0 cm mark ;
load not uniform ;
difficulty in placing the centre of load over the mark on the rule ; [1]

[Total: 10]

6 A student is doing an experiment with a spring to which a weight hanger is attached. This is shown in Fig. 2.1.

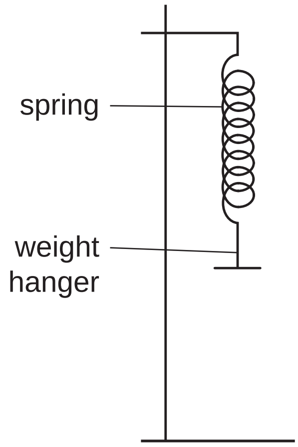


Fig. 2.1

A 200 g mass is attached to the weight hanger.
When the mass is pulled down and then released, it oscillates (bounces up and down). This is shown in Fig. 2.2.

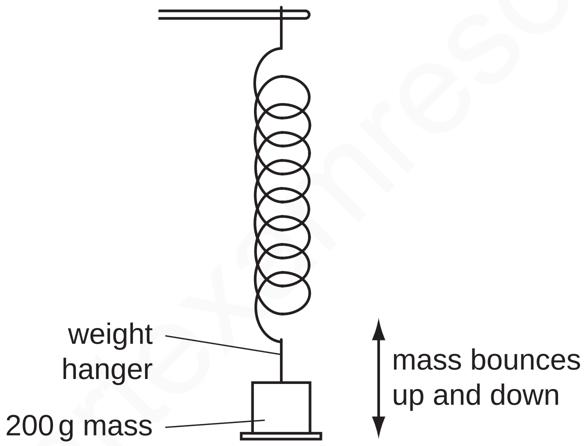


Fig. 2.2

- Using a stopclock, the student finds the time in seconds taken for 20 oscillations.
- He records the results in Fig. 2.3.
- He increases the mass to 300 g and finds the new time.
- The student repeats the experiment using 400 g and 500 g masses.

mass on weight hanger / g	time for 20 oscillations / s	time **T**, for one oscillation / s	$\mathbf{T}^2$ / s^2
200	13.0	0.65	0.42
300			
400			
500	19.0	0.95	0.90

Fig. 2.3

(a) Fig. 2.4 shows the missing times for 20 oscillations of the 300 g and 400 g masses.

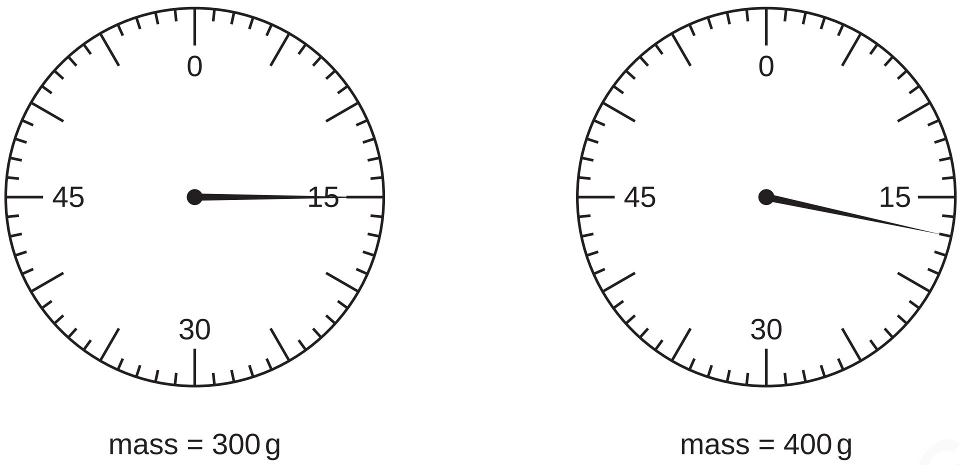


Fig. 2.4

(i) Read the times and record them in column 2 of Fig. 2.3. [2]

(ii) Complete column 3 of Fig. 2.3 by calculating **T**, the time for one oscillation. [1]

(iii) Find the values of $\mathbf{T}^2$ for the 300 g and 400 g masses and complete column 4. [1]

(b) On the graph grid, Fig. 2.5, plot $\mathbf{T}^2$ (vertical axis) against the mass. Draw the best straight line. It will **not** pass through the point (0, 0). [2]

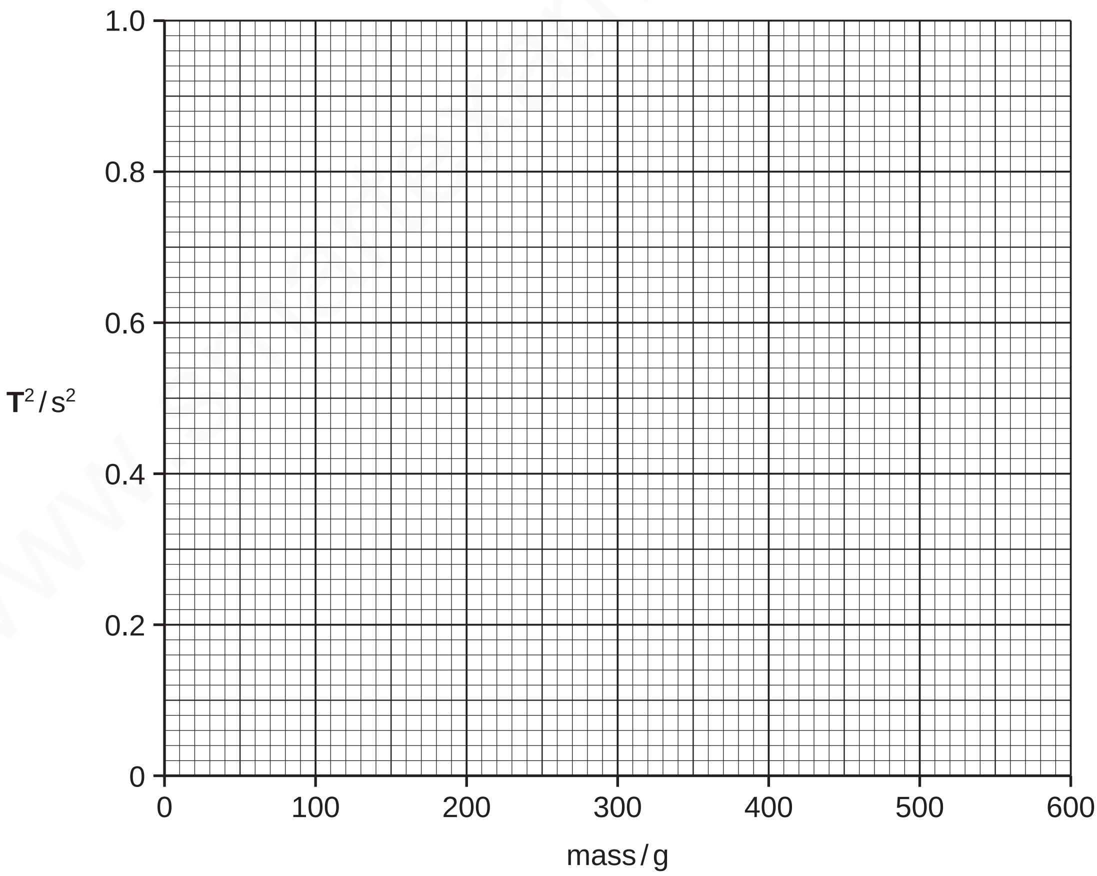


Fig. 2.5

(c) Find **f** , the gradient of the line, showing on the graph how you did this.

f = ... s^2/g [2]

(d) A mass of 200 g extended the spring by 75 mm.
Use the gradient, **f**, from **(c)** and the equation below to calculate a value for **g**, the acceleration of free fall. (The extension of 75 mm produced by the 200 g mass has been included in the equation.)

$$\mathbf{g} = \frac{75 \times 0.0002}{\mathbf{f}}$$

[1]

(e) Suggest a reason why the straight line of the graph does **not** pass through the point (0,0).

....

.... [1]

MARKING SCHEME

(a) (i) readings: 15.0s, 17.0s (no tolerance)
if 1st decimal place is missing, maximum 1 mark [2]

(ii) 15 / 20 = 0.75, 17 / 20 = 0.85 (one or both correct) e.c.f.
(answers must show 2 d.p.) [1]

(iii) $0.75^2 = 0.56$, $0.85^2 = 0.72$ (e.c.f.) (one or both correct)
(at least one answer must show 2 d.p.) [1]

(b) 3 or 4 points correctly plotted; vertical tolerance +/– 0.01 (half small square) (e.c.f.)
horizontal; no tolerance (1)
straight line drawn, not passing through the origin (1) [2]

(c) **any** x- and y- distances marked or triangle drawn on the graph
from which gradient may be calculated (1)
gradient calculated as y / x (e.c.f.)
example:
$\dfrac{0.90 - 0.42}{(500 - 200)} = \dfrac{0.47}{300}$ (working must be shown) = 1.56×10^{-3} (accept 1 d.p.) (1) [2]

(d) $\dfrac{75 \times 0.0002}{1.56 \times 10^{-3}} = 9.57$ (accept 1 d.p.) (e.c.f.) working need not be shown [1]

(e) The spring and weight hanger has a mass/
the spring will oscillate even if no weights are added OWTTE [1]

[Total: 10]

7 A metre rule balances when it is suspended from a hook at the 50 cm mark. A toy metal dog is tied to one side, 40 cm from the balance point. A block of iron is hung on the other side so that the rule balances again, as in Fig. 6.1.

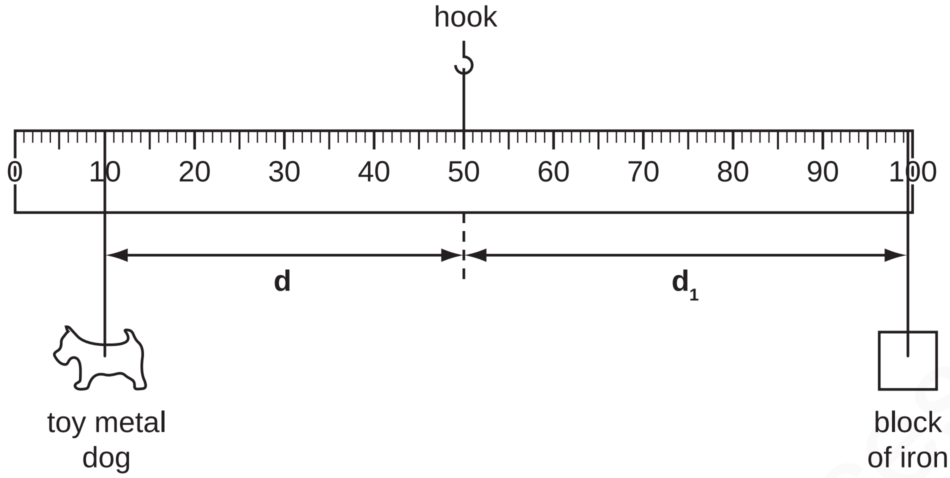


Fig. 6.1

The dog is moved to another position and the block is moved until the rule balances again. This is repeated several times and the results recorded in Table 6.1.

Table 6.1

distance of dog from hook d / cm	40.0	35.5	29.5	26.0	21.0	15.5	10.0
distance of iron from hook d_1 / cm	49.5	44.5		32.5		20.0	12.5

(a) **(i)** Read the rulers in Fig. 6.2 and Fig. 6.3. Calculate the distances $\mathbf{d_1}$ of the block of iron from the balance point.

Record these distances in Table 6.1. [2]

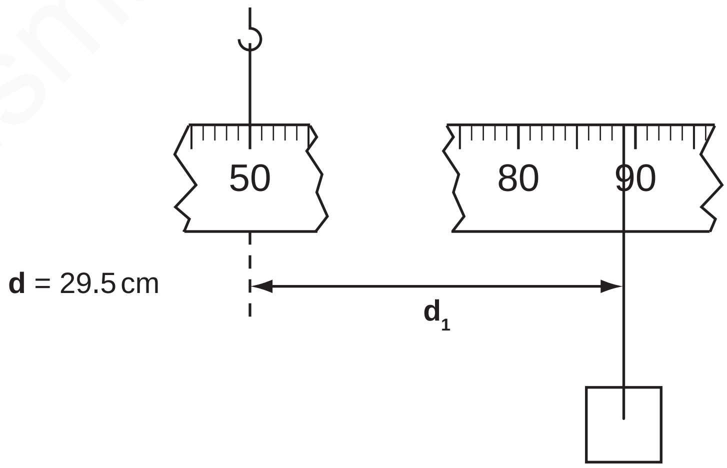


Fig. 6.2

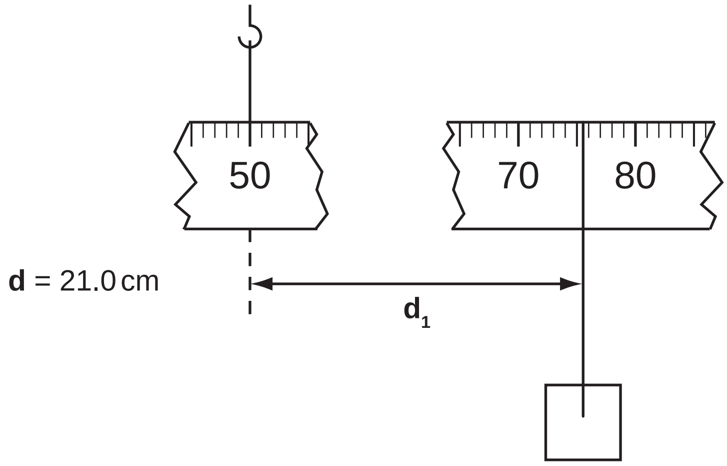


Fig. 6.3

(ii) The experiment is repeated, but this time the toy dog is immersed in a large beaker of water, as in Fig. 6.4.

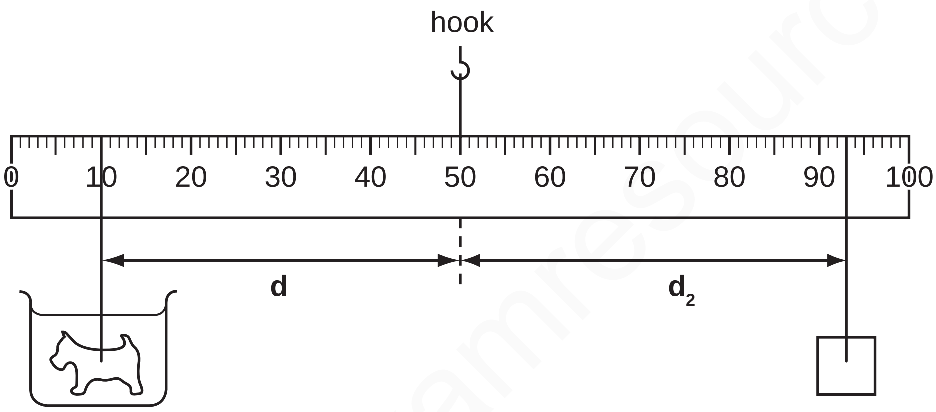


Fig. 6.4

The same values of **d** are used and the iron block moved to balance the rule each time.

Read the rulers in Fig. 6.5 and Fig. 6.6, then calculate the distances $\mathbf{d_2}$ of the block of iron from the balance point.

Record these distances in Table 6.2. [2]

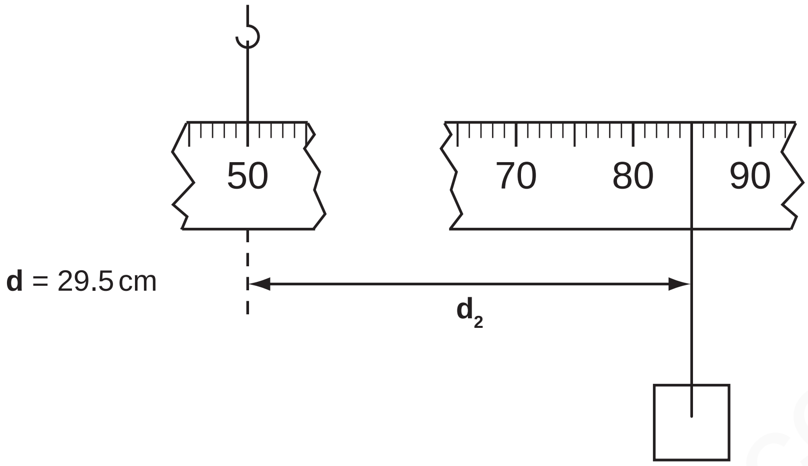


Fig. 6.5

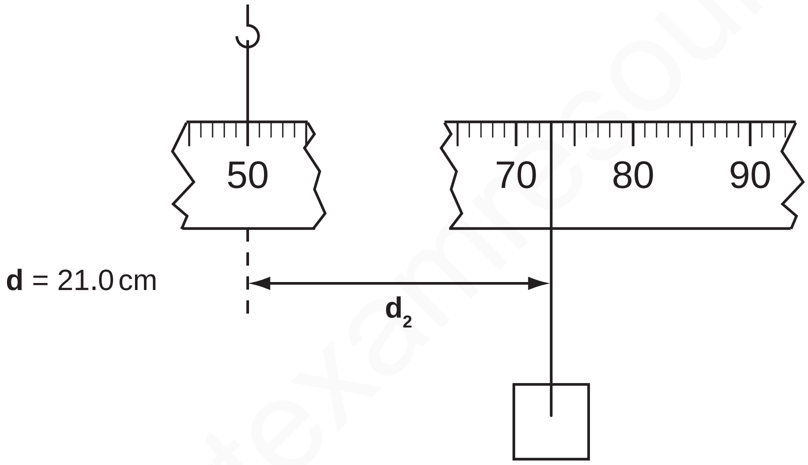


Fig. 6.6

Table 6.2

distance of dog from hook d / cm	40.0	35.5	29.5	26.0	21.0	15.5	10.0
distance of iron from hook $\mathbf{d_2}$ / cm	43.0	40.5		29.5		18.0	11.5

(iii) The distances, $\mathbf{d_2}$, of the block are subtracted from the distances, $\mathbf{d_1}$.

Use data from Table 6.1 and Table 6.2 to help you complete Table 6.3. [1]

Table 6.3

distance of dog d / cm	40.0	35.5	29.5	26.0	21.0	15.5	10.0
$(\mathbf{d_1} - \mathbf{d_2})$ / cm	6.5	4.0		3.0		2.0	1.0

(b) The results of a similar experiment were plotted in a graph, Fig. 6.7 and the line of best fit drawn.

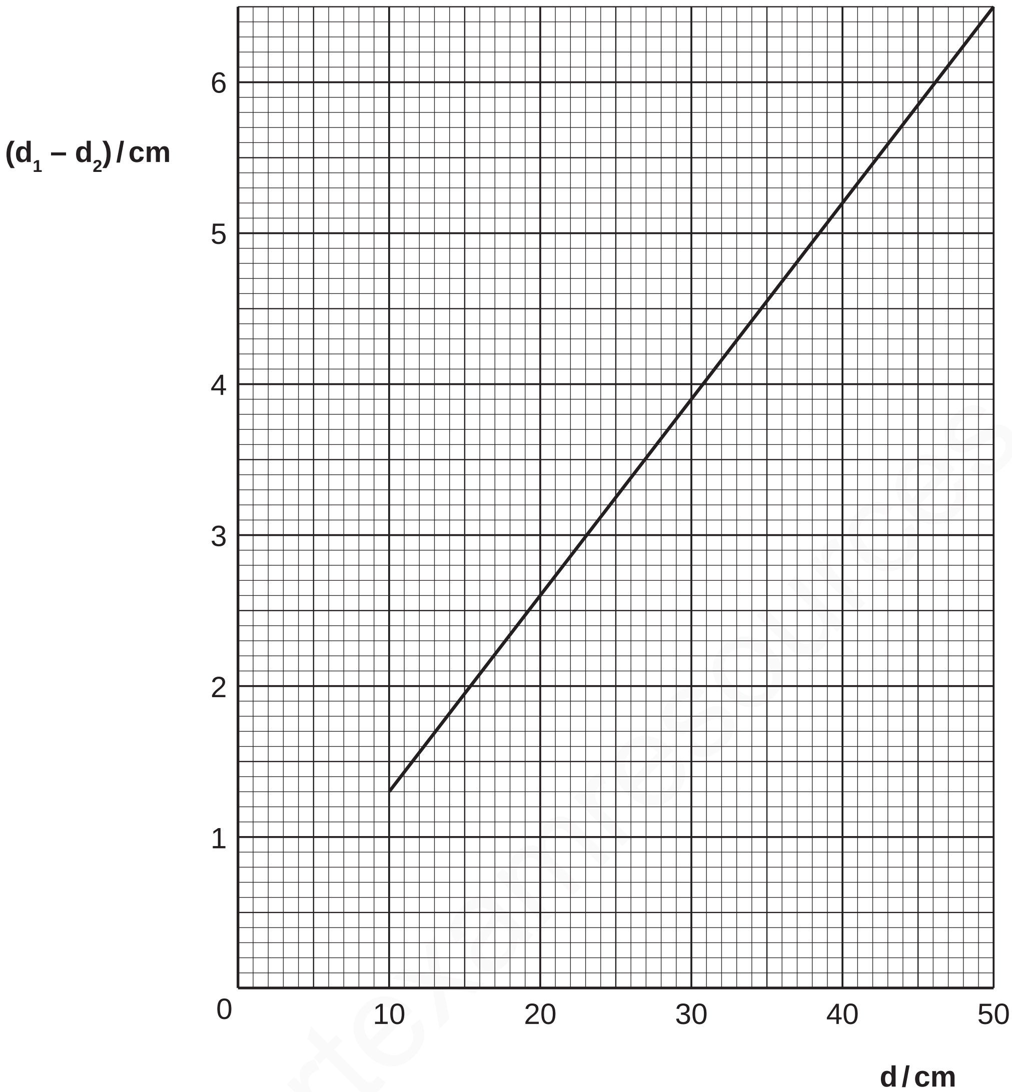


Fig. 6.7

Calculate the gradient of the line, which is equal to the density of the metal of the toy dog.

Show on the graph how you did this.

density of the metal of the toy dog = ... g / cm^3 [2]

(c) The density can also be found using the mass of the toy dog in grams, and its volume in cubic centimetres.

Describe in detail how you would find the volume of the toy dog.

....

....

....

.... [3]

MARKING SCHEME

(a) rheostat / variable resistor ; [1]

(b) 0.35, 0.48 ; (+/– 0.1) [2]

(c) (i) scales correct and at least one axis fully labelled ;
points correct ;;
straight line ; [4]

(ii) proportional / linear ; [1]

(d) circuit broken / wire melted / ammeter broken / owtte ; [1]

(e) decreases / goes down ; [1]

[Total: 10]