FORCES-SET-1-QP-MS

1 A student did an experiment to investigate the relationship between the applied force and the extension of a spring.

He used the apparatus shown in the diagram, Fig. 3.1.

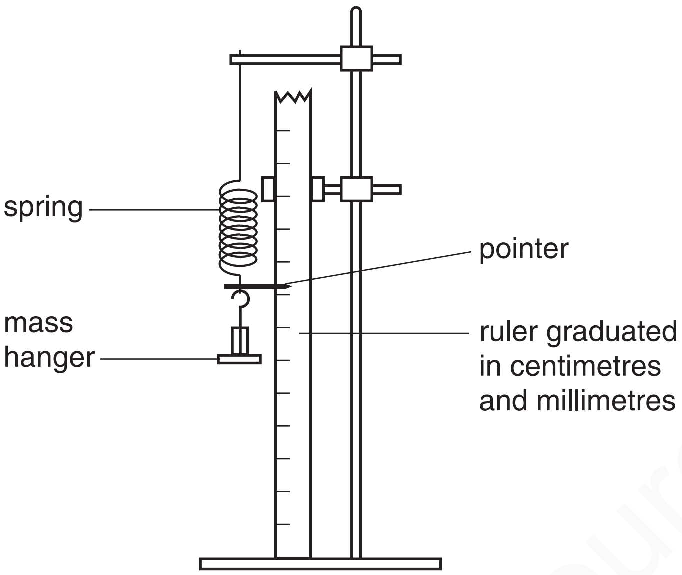


Fig. 3.1

The student hung a mass hanger on the spring.

- He read off the height , $\mathbf{h_0}$, of the pointer and recorded it in the table, Fig. 3.3.
- He added a 50 g mass to the mass hanger.
- He found the height, $\mathbf{h_1}$, of the pointer and recorded it in the table.
- He added more 50 g masses, each time recording the height, **h**, until 250 g had been added.

Fig. 3.2 shows the heights of the pointer and the scale of the ruler for the masses 150, 200 and 250 g.

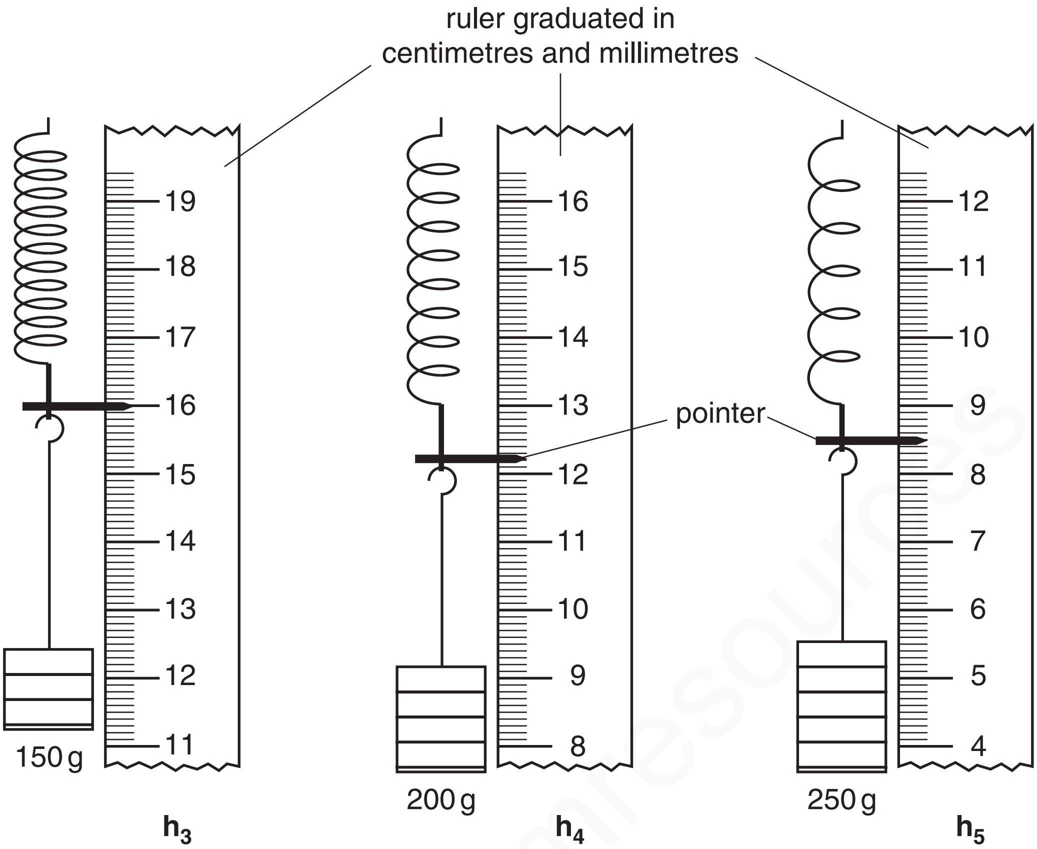


Fig. 3.2

(a) Read the heights, $\mathbf{h_3}$, $\mathbf{h_4}$ and $\mathbf{h_5}$ in Fig. 3.2, to the nearest mm, and record them in the table, Fig. 3.3. [2]

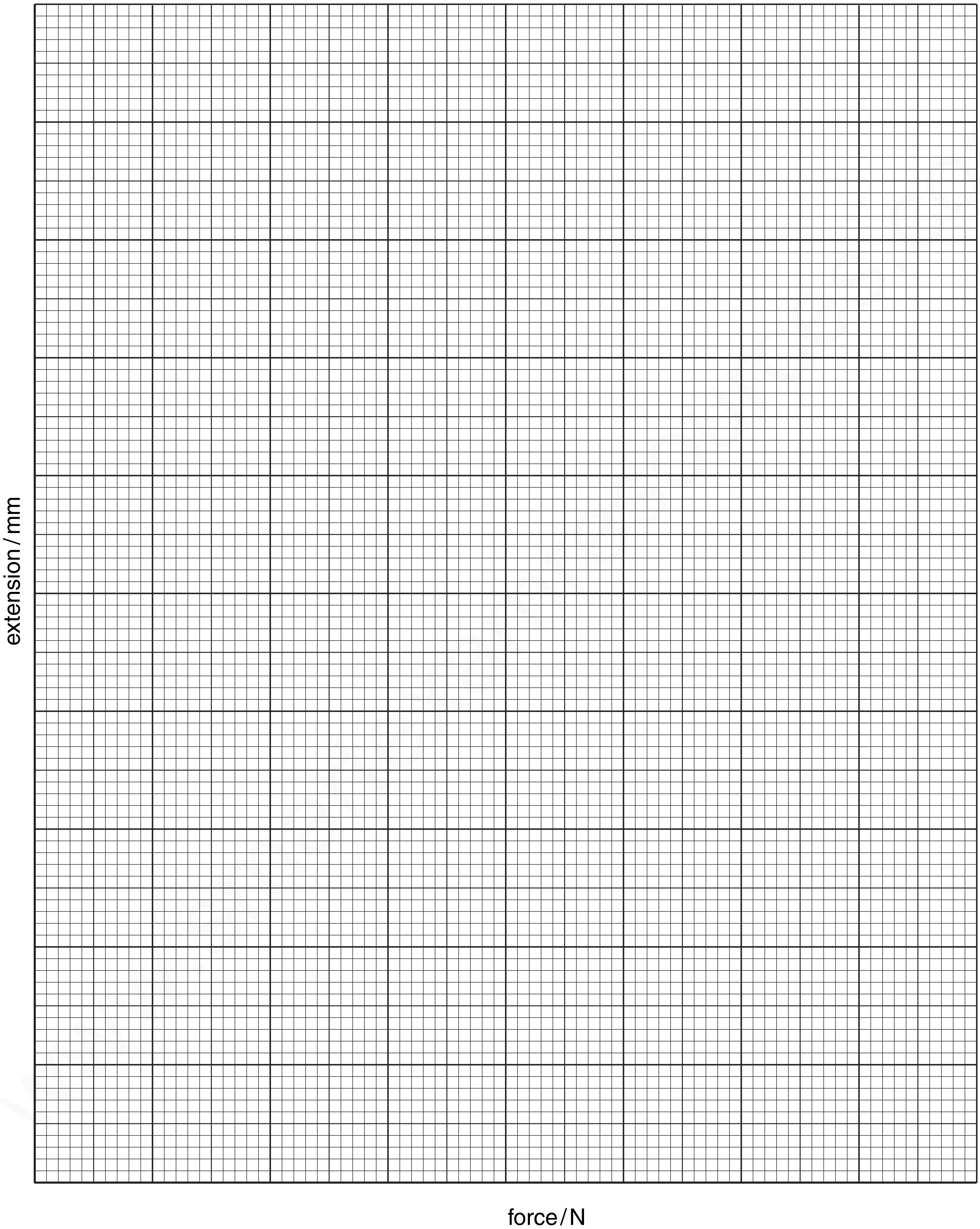
(b) Complete Fig. 3.3, noting that you are required to convert each mass into a force. (1000 g = 10 N) Calculate the total increase in length of the spring (the extension) for each mass added. [2]

total mass added / g	force / N	height **h** / mm	total increase in length (extension) / mm
0	0	$\mathbf{h_0}$ = 270	0
50	0.5	$\mathbf{h_1}$ = 233	37
100	1.0	$\mathbf{h_2}$ = 195	75
150		$\mathbf{h_3}$ =	
200		$\mathbf{h_4}$ =	
250		$\mathbf{h_5}$ =	

Fig. 3.3

(c) On the graph grid provided, plot a graph of the extension (vertical axis) against the force (horizontal axis).

Draw the best straight line through these points. [3]



(d) What is the relationship between the applied force and the extension of the spring?

....[1]

(e) Describe how you would find the mass of an object using the same apparatus.
You need to state the measurements you would make and show how the mass can be calculated.

....

....

....

....[2]

MARKING SCHEME

(a) 160,122,85 +/- 1 mm,
recorded in correct column (-1 for each error)

[2]

(b) forces: 1.5, 2.0, 2.5 N (-1 only if 2 or more incorrect)
extensions: 110, 148, 185 (ecf) (-1 for each error)

[2]

(c) sensible scales used (1)
plotting points including origin

[3]

(d) proportional OR obeys Hooke's Law (1)
Reject "as mass increases, extension increases" OWTTE

[1]

(e) place mass on hanger instead of masses and find the extension (1)
factor to convert extension or weight to mass in grams OWTTE (1)

[2]

Total 10 marks

2 The teacher gives a student a steel spring. He wants the student to find out whether or not the extension of the spring is directly proportional to the applied force.

The student sets up the apparatus as shown in Fig. 5.1.

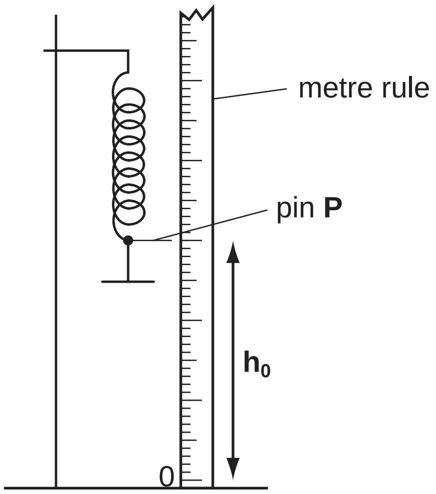


Fig. 5.1

The student sets up the apparatus as shown in Fig. 5.1.

- He attaches a weight hanger to the spring.
- He fixes a pin, **P**, to the lower end of the spring so that the pin acts as a pointer.
- He fixes a metre rule next to the spring.
- He notes the position of pin **P** with no weight added.
- Then he adds weights to the spring, each time noting the reading of the pointer, pin **P**, in Fig. 5.2.

total mass added / g	force / N	pointer reading **h** / mm	total increase in length (extension) ($\mathbf{h_0}$ - **h**) / mm
0	0	$\mathbf{h_0}$ = 304	0
50	0.5		
100			
150			
200		230	74

Fig. 5.2

(a) Convert the total mass added in grams to the force exerted in newtons and fill in the second column in Fig. 5.2. [1]

(b) Fig. 5.3 shows the position of the pointer on the metre rule for the **three** missing readings of **h**. Record the readings in the third column of Fig. 5.2. [3]

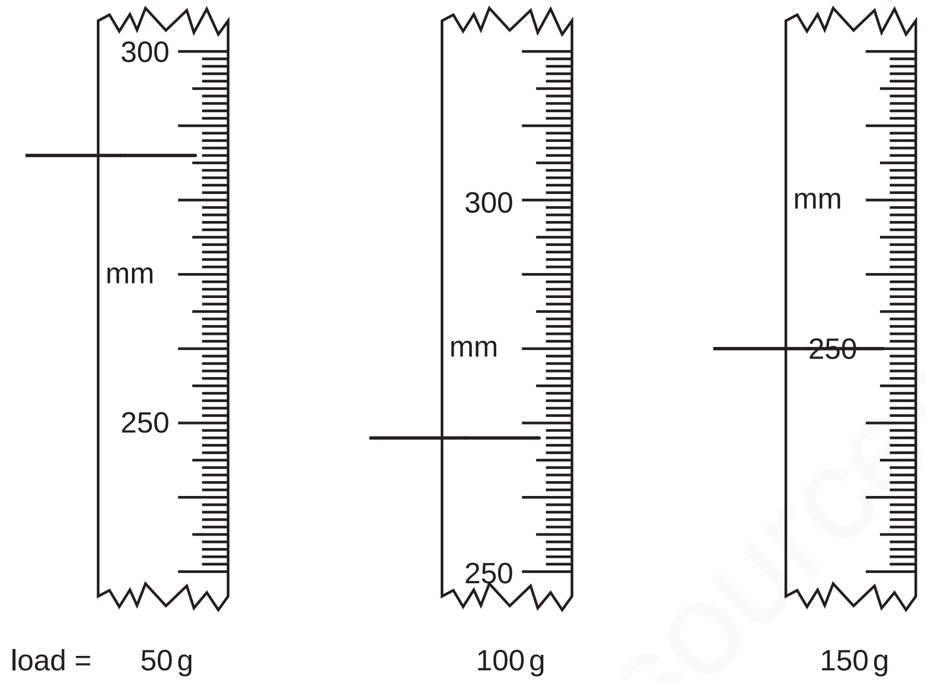
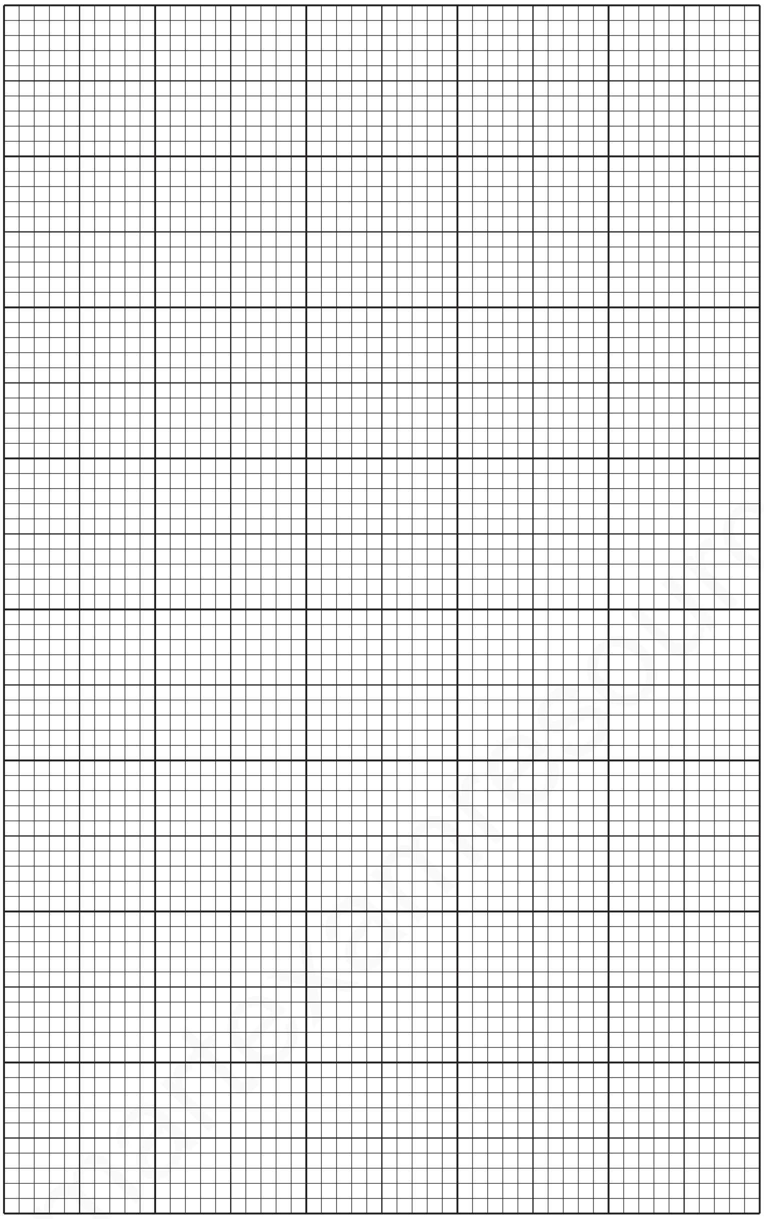


Fig. 5.3

(c) Calculate the total increase in length of the spring for each mass and complete the fourth column of Fig. 5.2. [1]

(d) On the graph grid provided, plot a graph of the **extension of the spring** / mm (vertical axis) against the **force** / newtons (horizontal axis). Draw the best straight line.



[3]

(e) Use your graph to find the extension produced by a force of 0.8 N. Show how you do this on the graph.

extension = ...mm [1]

(f) The student suggested that if larger masses were used, the graph would not be a straight line because the spring might become over-stretched.

On the axes in Fig. 5.4, draw a line to show the result he can expect if larger masses are used.

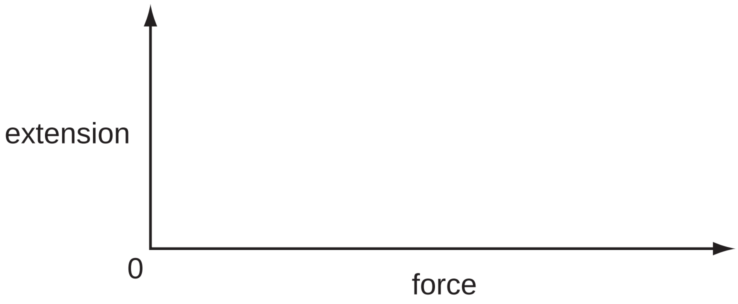


Fig. 5.4

[1]

MARKING SCHEME

(a)	1, 1.5, 2 (newtons) no tolerance, all correct	[1]
(b)	286, 268, 250 (+/– 1 mm)	[3]
(c)	18, 36, 54 mm (ecf) (2 or 3 correct)	[1]
(d)	suitable scale used and at least 1 axis labelled correctly (1) all points plotted (1) line drawn passing through the origin (1) (subtract 1 mark if axes are reversed)	[3]
(e)	extension produced by 80g found using graph, 29 mm (+/– 1mm) (ecf)	[1]
(f)	graph shows a curved line with extension increasing	[1]

[Total: 10]

3 A student does an experiment to investigate the acceleration of a trolley. The trolley has a mass of 1 kg. It runs along a horizontal track 1 metre long. The trolley is pulled by a string that runs over a pulley, with a 1 kg mass fixed to it. When the hanging mass is allowed to fall, it pulls the trolley so that it accelerates along the track. Fig. 3.1 shows this apparatus.

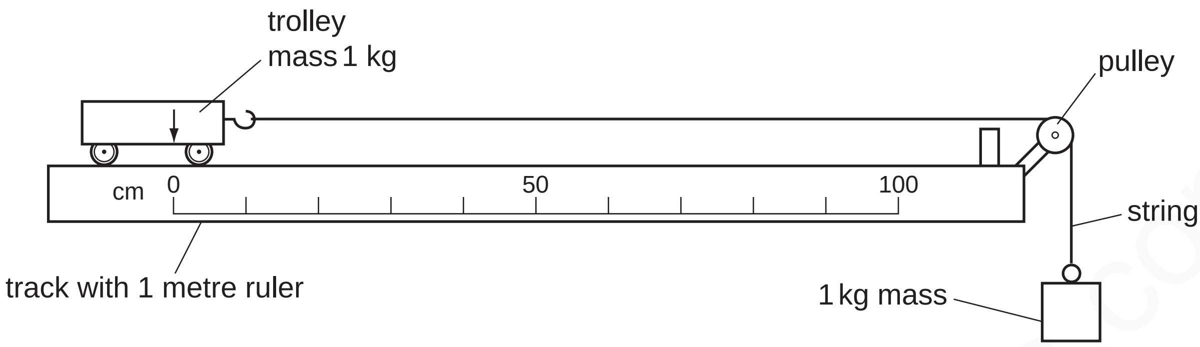


Fig. 3.1

- the 1 kg mass is released at time 0 seconds
- a camera photographs the trolley at 0.1 s intervals
- the pictures of the trolley are used to find the distances it travelled
- the distances, in centimetres, are recorded in Fig. 3.2

time **t** / s	0	0.1	0.2	0.3	0.4	0.5
distance / cm	0				76	96

Fig. 3.2

(a) The images of the trolley and the metre rule at **t** = 0.1, 0.2 and 0.3 s are shown in Fig. 3.3. Read the scales and record the distances in centimetres in Fig. 3.2. [3]

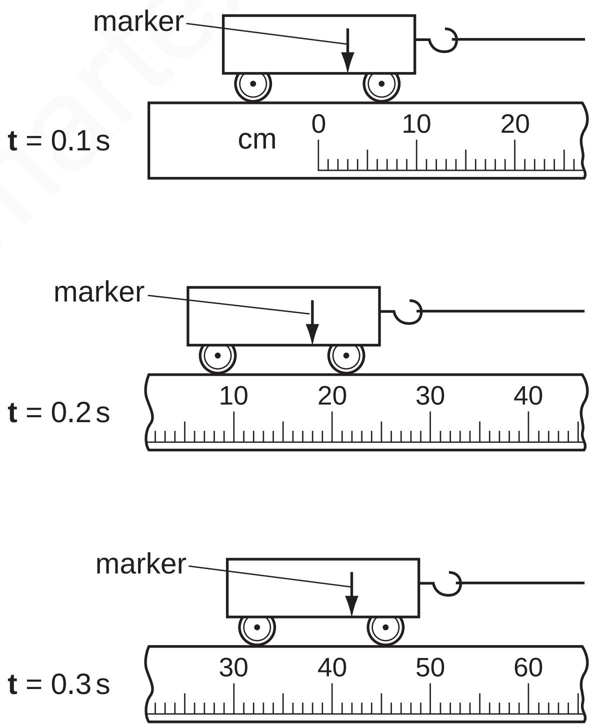


Fig. 3.3

(b) Plot a graph of distance moved in centimetres (vertical axis) against time **t** in seconds (horizontal axis) on the grid provided. Draw a smooth curve through the points. [3]

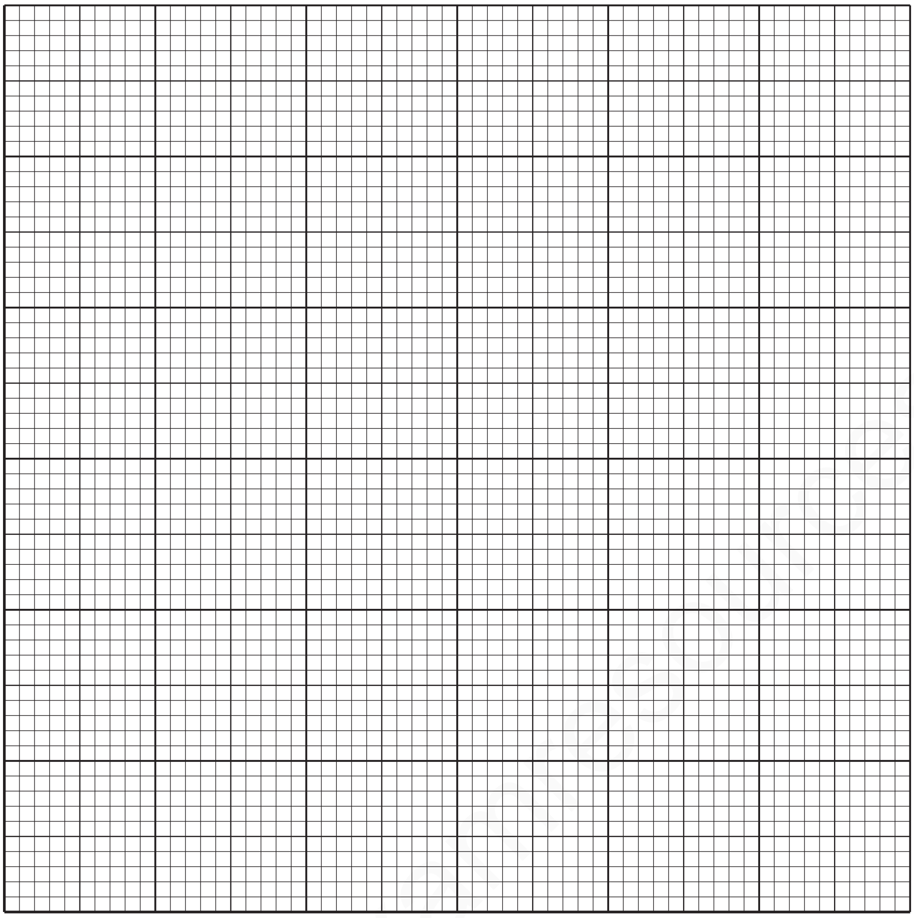


Fig. 3.4

(c) Show that the trolley accelerates as it moves along the track. You may show this on the graph or write an explanation below.

....

....

....

.... [2]

(d) The student wants to change the mass of the trolley and the 1 kg mass. Suggest how the results will change if

(i) the trolley has a mass of 2 kg instead of 1 kg,

....

.... [1]

(ii) the 1 kg hanging mass is replaced by a 2 kg mass.

....

.... [1]

MARKING SCHEME

(a)	3, 18, 42 cm (no tolerance)		[3]
(b)	at least one of the axes correctly labelled and suitable scale chosen	(1)	
	points correctly plotted +/- one small square (allow one error)	(1)	
	smooth curve drawn (0,0 may be omitted)	(1)	[3]
(c)	EITHER gradient/slope/steepness of the graph	(1)	
	increases	(1)	
	OR use of the data to show greater distance moved	(1)	
	in equal time intervals	(1)	[2]
(d) **(i)**	EITHER acceleration will be less/trolley will move more slowly	(1)	
	OR the distance moved in equal time intervals will be smaller	(1)	[1]
(ii)	EITHER the acceleration will be greater/trolley will move faster	(1)	
	OR the distance moved in equal time intervals will be greater	(1)	
	If **(i)** distance moved is less and **(ii)** distance moved is greater, award 1 mark only for both **(i)** and **(ii)**		[1]

[Total: 10]

4 **(a)** A student is investigating how an elastic band stretches when different masses are hung on it.

The apparatus is set up as shown in Fig. 2.1.

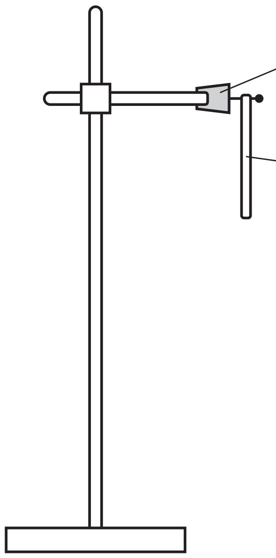


Fig. 2.1

The length of the elastic band is measured with a metre rule, and is recorded in Table 2.1.

A hanger of mass 100 g is added to the elastic band and the new length is measured and recorded in Table 2.1. A 100 g mass is added to the hanger and the new length of the elastic band is measured and recorded.

Table 2.1

total mass / g	force / N	length of elastic band / mm	total increase in length / mm
0	0	80	0
100	0.1	98	18
200		114	34
300		130	
400		148	
500	0.5	165	85

(i) Complete column two of Table 2.1 to show the force in Newtons. [1]

(ii) Calculate the total increase in length of the elastic band for 300 g and 400 g.

Complete column four of Table 2.1.

[1]

(iii) Plot a graph of total increase in length / mm (vertical axis) against force / N (horizontal axis). Draw the best fit straight line.

[3]

(iv) Use your graph to describe and explain the relationship between the applied force and the total increase in length.

....

....

.... [2]

(v) Use your graph to find the total increase in length produced by a mass of 250 g.

Show how you do this on the graph.

total increase in length = ... mm [2]

(b) If masses were added beyond 500 g, the elastic band would eventually break. On the axes below, sketch the shape of graph that would be obtained.

[1]

MARKING SCHEME

(a) **(i)** current / electron flow changes direction **or** polarity changes / OWTTE ; [1]

(ii) current causes a (changing) magnetic field ;
alternately attracts and repels permanent magnet OWTTE ; [2]

(b) **(i)** 9.4 cm, 12.4 cm, 15.6 ± 1 mm ;;; [3]

(ii) 0.094, 0.124, 0.156 (e.c.f.) ; [1]

(iii) (data from Fig. 2.2 used to show that) successive distances in the same time interval are greater OWTTE [1]

(c) e.g. **g** = $\frac{2 \times 0.0156}{(0.18)^2}$;
= 9.63 ; [2]
(1 mark only if no calculation is shown but value of **g** is between 8.6 and 10.0)

[Total: 10]

5 **(a)** A student is finding the mass of a metre rule using the principle of moments.

He sets up the apparatus as in Fig. 3.1.

A pin to act as a pivot is pushed through the 100 mm mark of a metre rule into a cork clamped to the stand.

The rule is kept horizontal by a newton meter at the 900 mm mark.

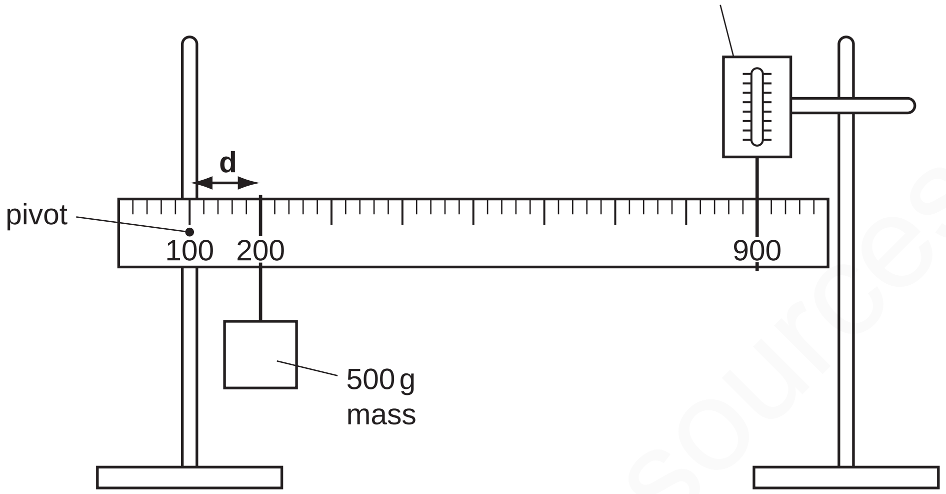


Fig. 3.1

A 500 g mass is hung at the 200 mm mark, 100 mm from the pivot, this is distance **d**.

The force on the newton meter required to keep the rule horizontal is measured and recorded in Table 3.1.

(i) Read the newton meters in Fig. 3.2, for, **d** = 200 mm and **d** = 300 mm and record the values in Table 3.1. [2]

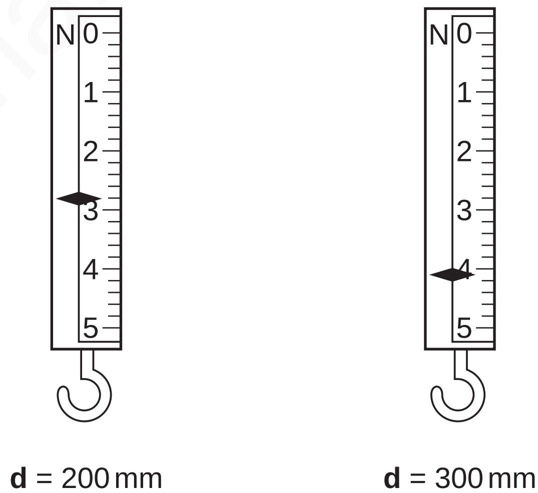


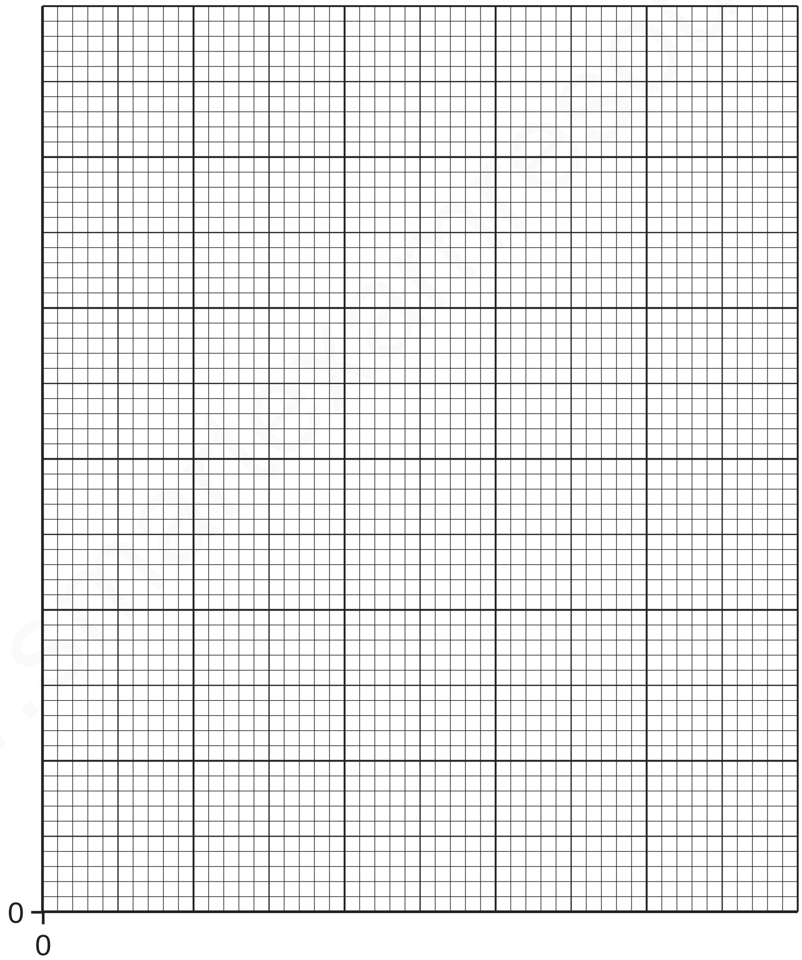
Fig. 3.2

Table 3.1

d / mm	force / N
100	1.8
150	2.3
200	
250	3.5
300	
350	4.6
400	5.2

(ii) On the grid below, plot a graph of force (vertical axis) against distance.

Draw the best straight line, it will not pass through the point (0,0).



[4]

(iii) Extend the line you have drawn until it cuts the vertical axis.

Read off the value of the force when the distance **d** = 0.

force = ... N [1]

(b) (i) Convert the force from **(a)(iii)** into a mass in grams. Remember that the force of gravity on 100 g is 1 N.

mass = ... g [1]

(ii) The mass of the metre rule is twice the value found in **(b)(i)**.

Calculate the mass of the rule.

mass of rule = ... g [1]

(c) The accuracy could be improved by making sure the rule is exactly horizontal when taking the measurements.

Suggest how the student can make sure the rule is horizontal.

....

....

.... [1]

MARKING SCHEME

(a) **(i)** 2.8 (± 0.1) ; 4.1 (± 0.1) ; [2]

(ii) sensible scales and labels ;
correct points ;;
line drawn to intersect y-axis ; [4]

(iii) from graph, (0.7) ; [1]

(b) 70 (ecf) ; [1]

140 (ecf) ; [1]

(c) use of spirit level / measure same height at each end / use a protractor to measure right angle between stand and rule ; [1]

[Total: 10]

6 **(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.

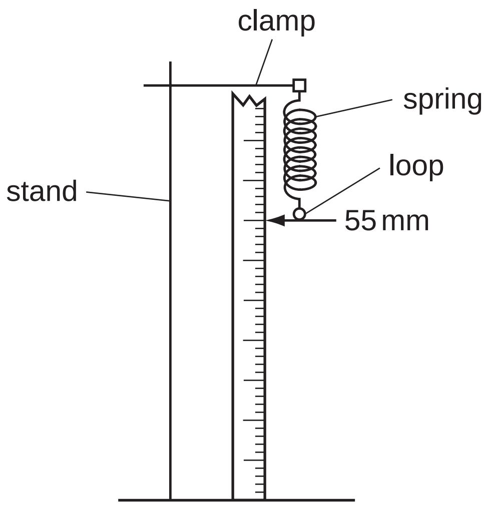


Fig. 5.1

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.

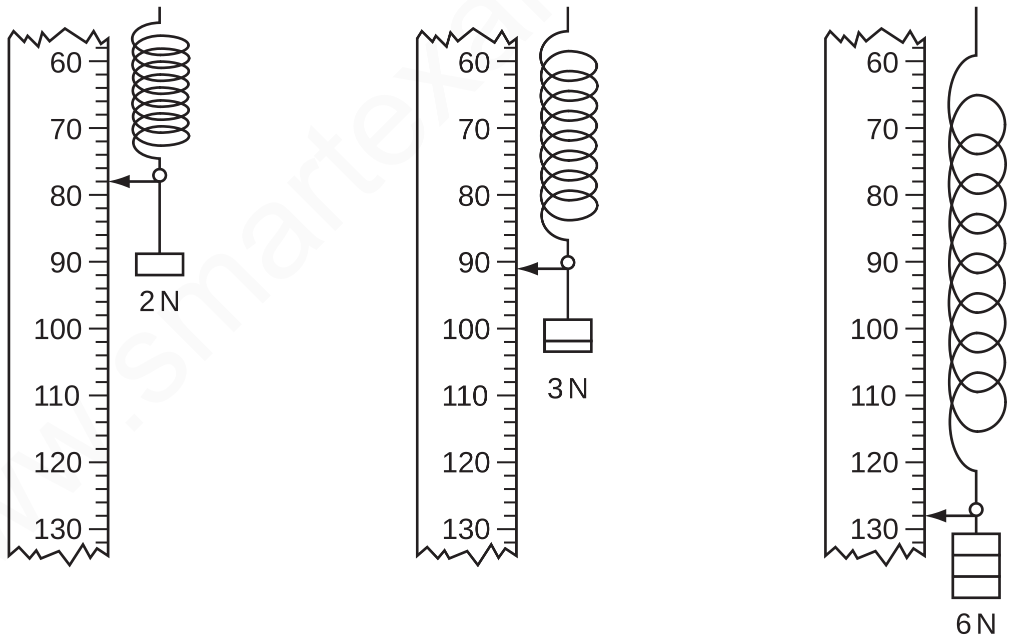


Fig. 5.2

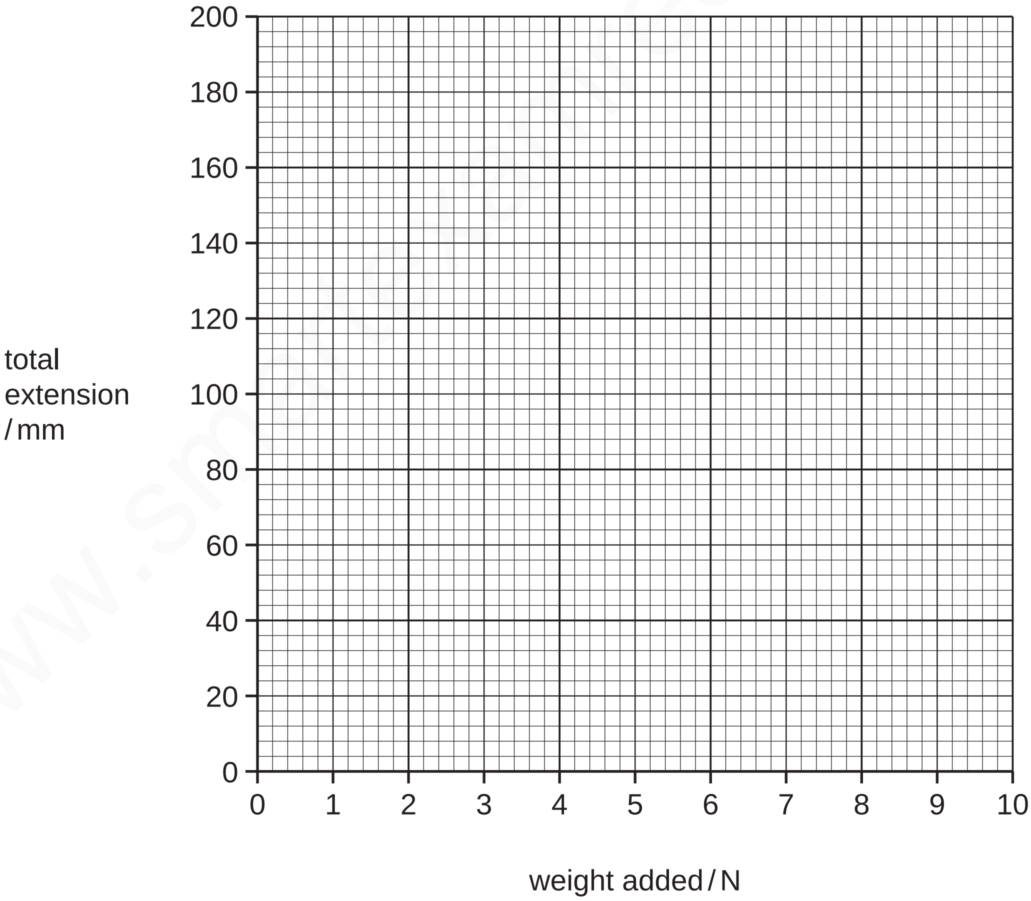
(i) Fig. 5.2 shows the springs with 2 N, 3 N and 6 N weights attached. Read off the position of the pointer each time, and record the values in Table 5.1. [3]

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]

7 **(a)** A student is finding the mass of a metre rule using the principle of moments. He sets up the apparatus as in Fig. 3.1.

A pin to act as a pivot is pushed through the 100 mm mark of a metre rule into a cork clamped to the stand.

The rule is kept horizontal by a newton meter at the 900 mm mark.

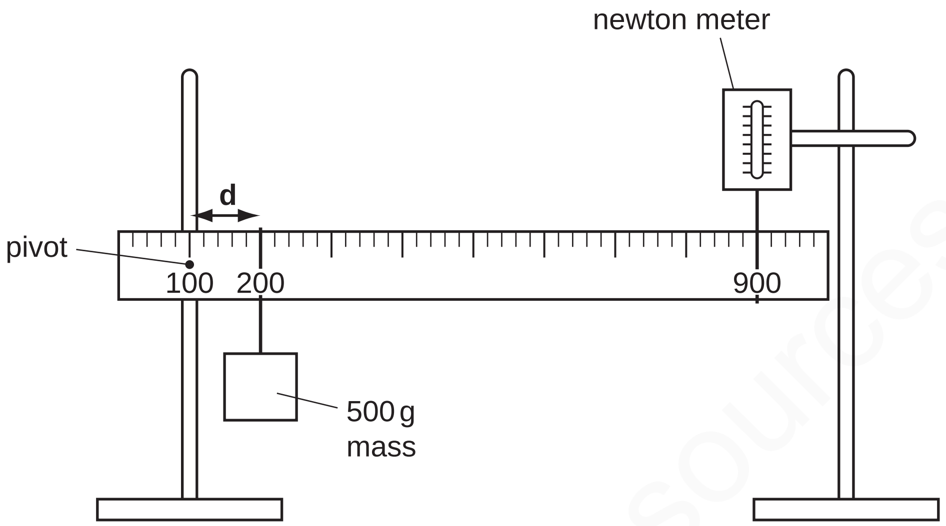


Fig. 3.1

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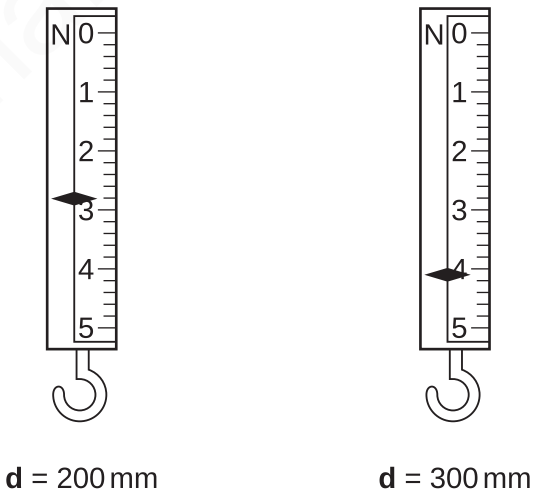


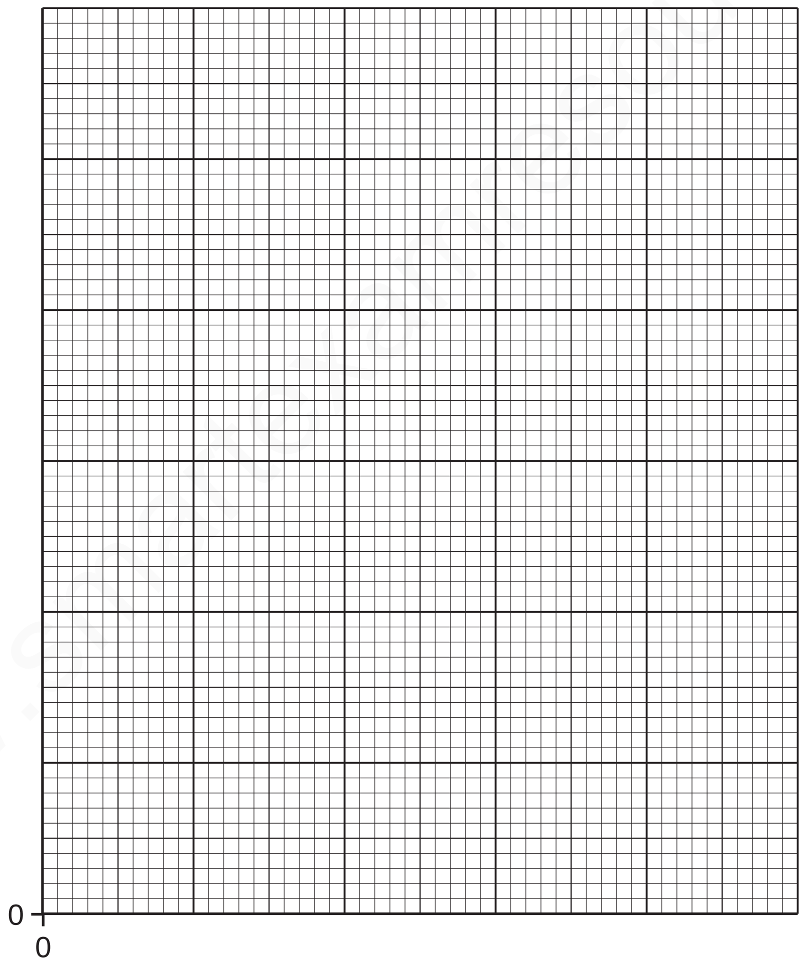
Fig. 3.2

Table 3.1

d / mm	force / N
100	1.8
150	2.3
200	
250	3.5
300	
350	4.6
400	5.2

(ii) On the grid below, plot a graph of force (vertical axis) against distance.

Draw the best straight line, it will not pass through the point (0,0).



[4]

(iii) Extend the line you have drawn until it cuts the vertical axis.

Read off the value of the force when the distance **d** = 0.

force = ... N [1]

(b) **(i)** Convert the force from **(a)(iii)** into a mass in grams. Remember that the force of gravity on 100 g is 1 N.

mass = ... g [1]

(ii) The mass of the metre rule is twice the value found in **(b)(i)**.

Calculate the mass of the rule.

mass of rule = ... g [1]

(c) The accuracy could be improved by making sure the rule is exactly horizontal when taking the measurements.

Suggest how the student can make sure the rule is horizontal.

....

....

.... [1]

MARKING SCHEME

(a) **(i)** 2.8 (± 0.1) ; 4.1 (± 0.1) ; [2]

(ii) sensible scales and labels ;
correct points ;;
line drawn to intersect y-axis ; [4]

(iii) from graph, (0.7) ; [1]

(b) 70 (ecf) ; [1]

140 (ecf) ; [1]

(c) use of spirit level / measure same height at each end / use a protractor to measure right angle between stand and rule ; [1]

[Total: 10]