CENTRE OF MASS

1 The IGCSE class is investigating the downward deflection of a metre rule clamped at one end.

The apparatus has been set up as shown in Fig. 1.1. The 0.0 cm mark is at the free end of the rule.

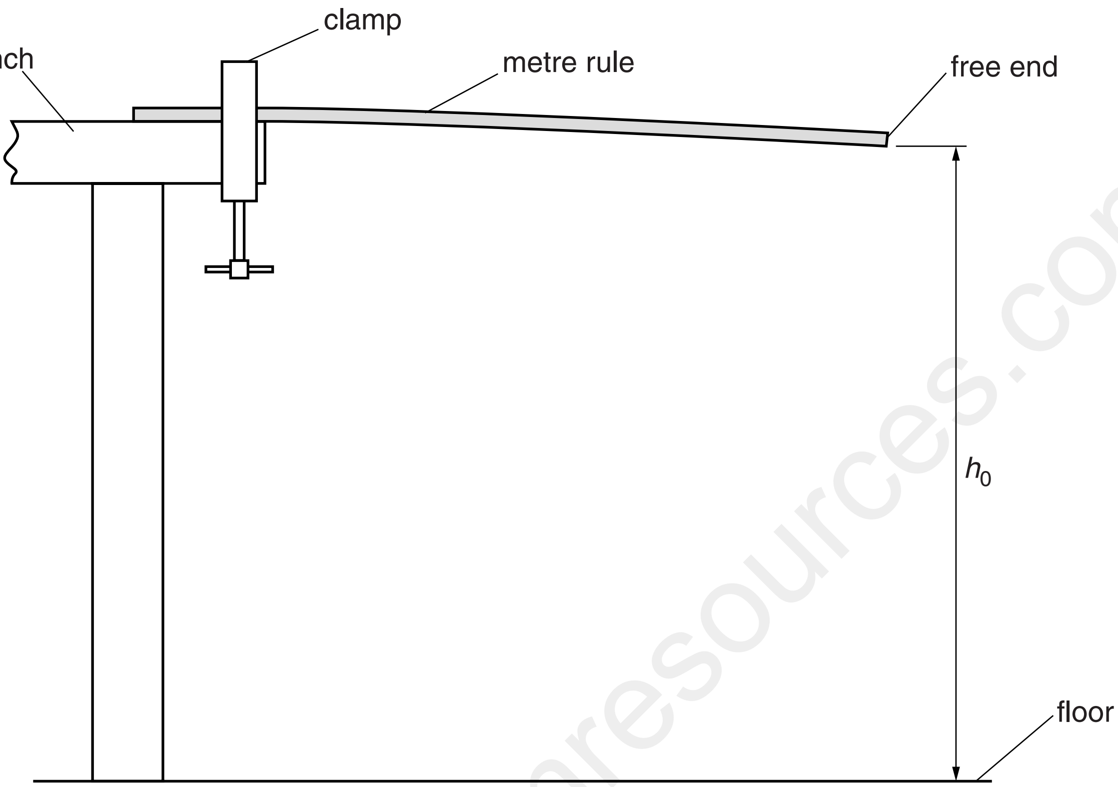


Fig. 1.1

(a) (i) On Fig. 1.1, measure h_0.

h_0 = ... cm

(ii) Fig. 1.1 is drawn to 1/10th scale.

Calculate and record the actual height H_0 of the free end of the metre rule above the floor.

H_0 = ... cm
[1]

(b) A student carefully places a mass on the rule at a distance d = 60.0 cm from the free end of the rule.

Explain how he could make sure that the centre of the mass was at this 60.0 cm mark. You may use a diagram.

....

....

.... [1]

(c) Fig. 1.2 shows the mass in place on the rule.

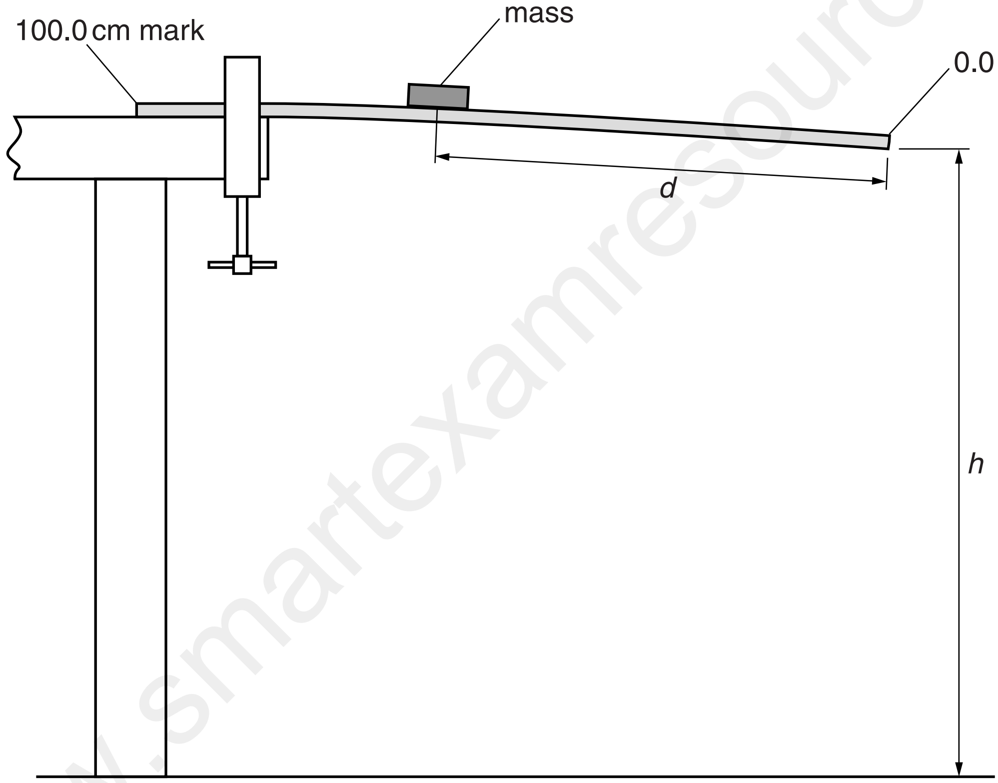


Fig. 1.2

(i) On Fig. 1.2, measure h.

h = ... cm

(ii) Fig. 1.2 is also drawn to 1/10th scale.

Calculate, and record in Table 1.1, the actual height *H* of the free end of the rule above the floor.

Table 1.1

d/cm	*H*/cm	*D*/cm	$(d \times D)$/cm^2
60.0			
50.0	82.5	1.5	
40.0	81.5	2.5	
30.0	80.3	3.7	
20.0	79.0	5.0	

[2]

(d) The procedure is repeated for *d* values of 50.0 cm, 40.0 cm, 30.0 cm and 20.0 cm. The results are shown in the table.

(i) For *d* = 60.0 cm, calculate and record in the table the downward deflection *D* (change in height) produced by the mass. Use the results from **(a)(ii)** and from the table, and the equation $D = H_0 - H$.

(ii) For each value of *d*, use the results from the table to calculate and record in the table the value of $(d \times D)$.

(e) A student suggests that the downward deflection *D* is inversely proportional to the distance *d* (that is, *D* is proportional to 1/*d*).

Using some appropriate figures from Table 1.1, explain why this cannot be the case.

....

....

.... [1]

(f) **(i)** Although the metre rule is flat when placed on the bench, one student notices that the free end is slightly deflected downwards when clamped as shown in Fig. 1.1, even when the mass is not placed on it.

Explain why this deflection occurs.

....

....

.... [1]

(ii) Suggest how to find the value of this deflection. You may draw a diagram.

....

....

.... [2]

[Total: 8]

(a) h_0 present and H_0 = 84(.0) (cm) [1]

(b) suitable explanation,
e.g. same no. of graduations between 60 cm mark and each end of mass owtte,
or mark on side of rule and mass [1]

(c)(d) *h* present and *H* = 83(.0) [1]

D = 1(.0) and $d \times D$ calculations correct: 60, 75, 100, 111, 100 [1]

(e) $d \times D$ not constant / *D* doesn't always double when *d* halves owtte [1]

(f) **(i)** reference to mass/weight of rule [1]

(ii) measure height at bench [1]

subtract H_0 [1]

[Total: 8]

2 An IGCSE student is determining the position of the centre of mass of a triangular card.

The apparatus is shown in Fig. 1.1.

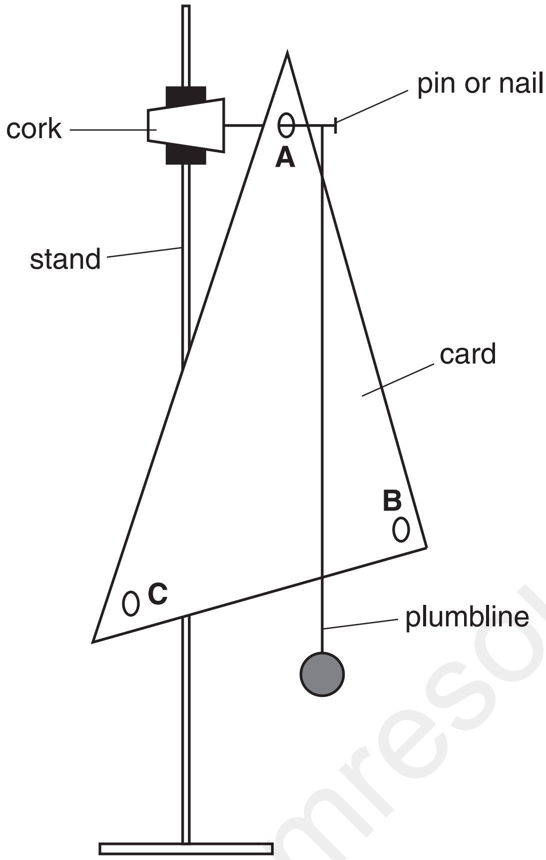


Fig. 1.1

(a) The student hangs the card on the nail through hole **A**. He checks that the card is able to swing freely and then hangs the plumbline from the nail so that it is close to, but not touching, the card. When the card and plumbline are still, he makes a small mark at the edge of the card where the plumbline crosses the edge. He removes the card and draws a line from the mark to hole **A**.

He repeats the procedure using holes **B** and **C**.

Fig.1.2 is a drawing of the card.

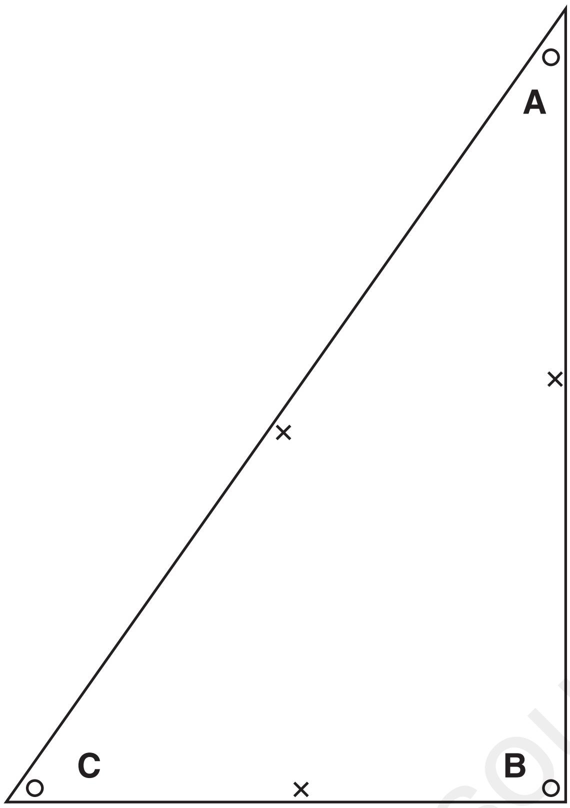


Fig.1.2

On Fig.1.2, the position of each of the marks the student makes is shown with a small cross. On Fig. 1.2, draw in the lines between the positions of the holes **A**, **B** and **C** and the corresponding crosses on the card. [2]

(b) If the experiment is completely accurate, the centre of mass of the card is at the position where the three lines meet. On Fig. 1.2, judge the best position for the centre of mass, marking it with a small cross. Draw a line from this position to the right-angled corner of the card and measure the distance *a* between the centre of mass and the right-angled corner of the card.

a = ...[3]

(c) In this experiment, it is important that the card is able to swing freely. For this reason, the plumbline should not touch the card but be a small distance from it. This could cause an inaccuracy in marking the card at the correct position. Describe how you would minimise this possible inaccuracy. You may draw a diagram.

....

....[1]

[Total: 6]

(a) Three straight lines in correct positions [1]
All lines continuous, straight, neat and thin [1]

(b) a = 4.2 – 4.4 (cm) no ecf [1]
Well-judged position in triangle [1]
Line correctly drawn [1]

(c) Viewing line directly in front of card (owtte) [1]

[Total: 6]

3 A student is determining the position of the centre of mass of an object using a balancing method.

Fig. 1.1 shows the apparatus used.

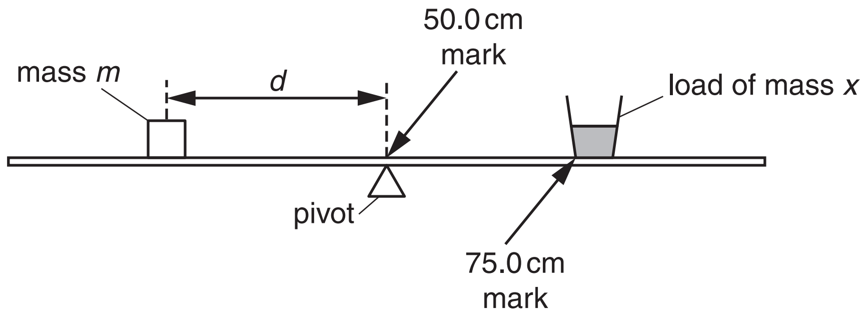


Fig. 1.1

A load of mass x is taped to the metre rule so that one side of the base is exactly on the 75.0 cm mark. The student places a mass m of 30 g on the rule and adjusts its position so that the rule is as near as possible to being balanced with the 50.0 cm mark exactly over the pivot, as shown in Fig. 1.1.

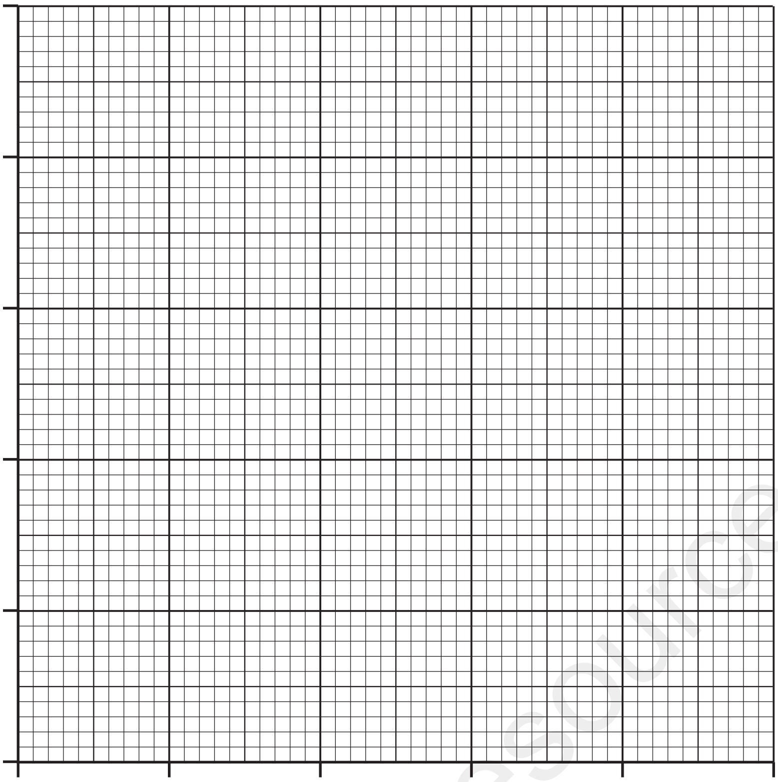
The student records the distance d from the centre of the 30 g mass to the 50.0 cm mark on the rule. He then repeats the procedure using different masses. The readings are shown in Table 1.1.

Table 1.1

m/g	d/cm	$\frac{1}{d} / \frac{1}{\text{cm}}$
30	45.0	
40	34.0	
50	27.0	
60	22.5	
70	19.3	

(a) For each value of d, calculate $1/d$ and enter the values in the table. [2]

(b) Plot a graph of m/g (y-axis) against $\frac{1}{d}\Big/\frac{1}{\mathrm{cm}}$ (x-axis).



[4]

(c) Determine the gradient G of the graph. Show clearly on the graph how you obtained the necessary information.

G = ...[2]

(d) Determine the horizontal distance z from the 75.0 cm mark on the rule to the centre of mass of the load using the equation

$$z = \frac{G - k}{x},$$

where k = 1250 g cm and x = 50 g.

z = ... [2]

[Total: 10]

(a) correct 1/*d* values 0.0222, 0.0294, 0.0370, 0.0444, 0.0518 [1]
all to 2 significant figures or all to 3 consistent significant figures [1]

(b) graph:
axes suitable and labelled [1]
all plots correct to ½ small square [1]
good line judgement (position) [1]
thin line, single, no blobs (quality) [1]

(c) gradient by triangle method using at least ½ candidate's line [1]
clear, on graph, how obtained [1]

(d) *z* value 0.9 – 2.5 [1]
2 or 3 significant figures and unit cm given [1]

[Total: 10]