

Determination of unknown masses by using the principle of moments

Practical question — PH3 2004 Experiment 1

Total

/20

INSTRUCTIONS

Test 1

Candidates will be expected to investigate the weight of a metre ruler, and find the weight of a reel of wire.

Apparatus required:

1. 1 retort stand boss and clamp.
2. 1 metre wooden ruler with holes drilled near the top edge at 55cm, 60cm, 65cm, 70cm and 75cm.
3. 1 flat headed nail to act as a pivot — must be free to move when placed through the holes drilled in the ruler.
4. 200g mass.
5. Pre-tied loop to allow suspension of 200g mass.
6. Reel of wire of mass 110g to 130g with a pre-tied loop of thin string to allow it to be suspended over the ruler.

The nail pivot should be set up in the clamp stand at a suitable height.

Test 2

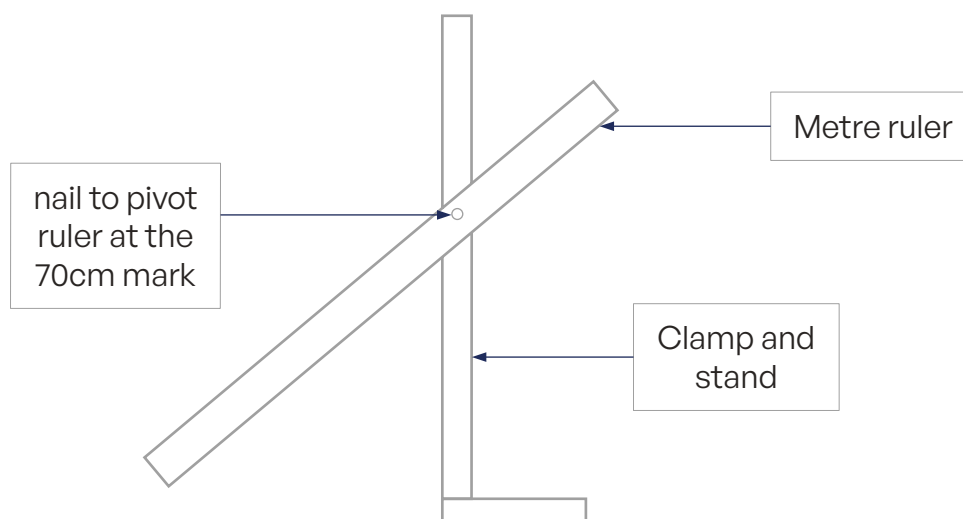
The apparatus is as for Test 1, except that the mass of the reel of wire should be in the range 140–160g.

EXPERIMENT 1

You are going to determine the weight of a uniform metre ruler, and then use this result to find the weight of a reel of wire.

1. (a) Carefully, draw on the diagram the point through which all of the weight of the ruler can be considered to act. [2]
- (b) What is the name given to this point? [1]

2. Set up the apparatus as shown, with the ruler pivoted at the 70cm mark.



- (a) Loop the 200 g mass over the metre ruler and adjust it until the ruler is horizontal. Note down the distance of the mass from the pivot. [1]
- (b) Calculate the weight (in newtons) of 200g. (for the purpose of this question take the acceleration due to gravity as 10ms^{-2}) [1]
- (c) A moment about a pivot is defined as force \times perpendicular distance from pivot. Calculate the moment about the pivot due to the weight of the 200g mass. [1]

- (d) State the Principle of Moments, and then calculate the weight of the ruler. [2]

3. You are now going to use the weight of the ruler to find the weight of a reel of wire.

Remove the 200g mass and replace it with the reel of wire. Pivot the ruler at the 55cm hole and move the reel of wire until it balances.

By calling the weight of the reel of wire W , the moment of the weight of the wire will become $W \times$ perpendicular distance to pivot.

- (a) Complete the table with the ruler pivoted at each of the drilled holes. [4]

| Distance from centre of ruler to pivot (cm) | Distance from pivot to wire reel (cm) | | | Moment due to the weight of the ruler (Ncm) | Moment due to the wire reel (Ncm) | Weight of the wire reel (N) |
|---|---------------------------------------|---|-----|---|-----------------------------------|-----------------------------|
| | 1 | 2 | Ave | | | |
| 5.0 | | | | | $\times W$ | |
| 10.0 | | | | | $\times W$ | |
| 15.0 | | | | | $\times W$ | |
| 20.0 | | | | | $\times W$ | |
| 25.0 | | | | | $\times W$ | |

- (b) Which of your results for the weight of the wire reel would you expect to give the greatest error? Explain your reasoning. [2]

- (c) Use your results to calculate an average value for the weight of the reel of wire. [2]

4. The uncertainty, $\text{Unc}(W)$ in the value for the wire reel's weight can be calculated using the expression

$$\text{Unc}(W) = \frac{W_{\text{max}} - W_{\text{min}}}{2}$$

where W_{max} and W_{min} are the maximum and minimum values of the wire's weight W .

- (a) Calculate the uncertainty in your result. [1]

- (b) Your results for this experiment can be said to be reliable if they are all within 5% of the average value. Comment on the reliability of your results. [2]

- (c) How could you adapt this experiment to further improve its reliability? [1]

MARK SCHEME

| Question | | | Marks available |
|----------|-----|---|-----------------|
| 1. | (a) | Point in middle of ruler (1) Diagonals/axes of symmetry drawn to show exact centre | 2 |
| | (b) | Centre of gravity [accept centre of mass] | 1 |
| 2. | (a) | Correct distance (to nearest mm) with unit | 1 |
| | (b) | $0.2 \times 10 = 2 \text{ N}$ [accept 1.96 N] | 1 |
| | (c) | Correct calculation [(i) \times (ii)] — no unit penalty | 1 |
| | (d) | Principle of Moments stated [allow lack of reference to a particular point] (1) Weight correctly calculated(1) | 2 |
| 3. | (a) | All readings taken [table complete] (1) [Allow 4 sets of readings, if the ruler is too heavy] All readings to 1 d.p. [rule resolution] (1) Moment and weight calculated correctly (1) Moment and weight quoted to 2 or 3 s.f. (1) | 4 |
| | (b) | Smallest distance from pivot/ 55 cm pivot (1) 1 mm error gives largest % error [or equiv.] (1) | 2 |
| | (c) | Correct calculation (1) Accurate value to 2 or 3 s.f. (1) [no unit penalty] | 2 |
| 4. | (a) | Correct calculation [no unit penalty] (1) | 1 |
| | (b) | 5% of average calculated (1) Compared with (d)(i) and reliability correctly reported (1) [or equivalent method using the uncertainty formula] | 2 |
| | (c) | Take more repeat readings or use a larger range. | 1 |