Teacher packs in Experimental Science

PHY Pack 7

Determination of the Weight of a meter Rule using the Principle of Moment

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Curriculum areas covered: Equilibrium of Forces / Principle of Moments

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Title: Determination of the Weight of a meter Rule using the Principle of Moment

Target group: Diploma in Basic Education Students

Also suitable for: Senior High Students

Duration of Activity: 50 minutes plus discussion time

Learning outcomes: At the end of the lesson the student should be able to:

1. Knowledge and Understanding (KN)	KN1	State the Principle of Moments
	KN2	Describe an experiment to determine the center of gravity of a uniform rod
	KN3	Describe the weight of a meter rule using the principle of moments
	KN4	Define moment of a force about a point
2. Cognitive Skills (CS)	CS1	Relate the center of gravity of the rule to its weight
	CS2	Relate the mass of an object to its weight.
3. Key Skills (KS)	KS1	Make observations and measurements
	KS2	Record observations and measurements
	KS3	Use the Principle of Moments to compute the mass of an object
	KS4	Do accurate calculations based on principle of moments
4. Practical Skills (PS)	PS1	Balance the meter rule on a knife edge
	PS2	Make and record observations and measurements

A. **Teacher's Guide**

OVERVIEW

Students are to find the weight of the meter rule using the principle of moments. They will determine the center of gravity of the meter rule. They will use a known mass to determine the weight of the meter rule by suspending it at different positions on the rule.

AIM

The experiment is to enable students determine the weight of a meter rule using the principle of moments**.**

Practical skills to be developed

Correct balancing of the metre rule on a knife edge.

Equipment / Material

1. Metre Rule.
2. Knife Edge
3. Known masses
4. Thread.

Advice to Tutors

1. Experiment should be repeated using the same mass at different positions
2. Create time to discuss the theory of the experiment.

Sample Assessment Questions with Answers

1. State the principle of moment.

Answer: The Principle of Moments: When a body is in equilibrium, the sum of the anti-clockwise moment about any point is equal to the sum of the clockwise moments about that point.

2. A uniform metre rule is freely pivoted at the 15cm mark and it balances horizontally when a body of mass 40g is hung from the 20cm mark. Draw a clear force diagram of the arrangement and calculate the mass of the rule.

Answer:

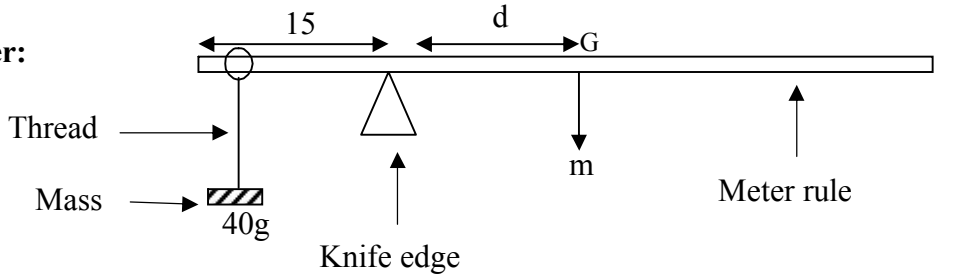

Figure 3: Experiment set up for sample question

From Eqn. 1.3 $m = \frac{d_1}{d} m_1$, but $m_1 = 40g$, $d_1 = 15cm$, $d = 20cm$

$\Rightarrow m = \frac{15cm}{20cm} \times 40g = 30g$. This implies the mass of the metre rule is 30grammes.

3. A non-uniform rod has a mass of 80g, what is its weight? [Take g=10m/s^2]

Answer: 0.08 kg x 10 m s^{-2} = 0.8 N

4. What do you understand by moment of a force about a point?

Answer: It is the product of the force and the perpendicular distance of its line of action from the point.

B. Student Guide

Purpose: The purpose of this experiment is to use known masses to determine the mass and hence the weight of a metre rule by the principle of moments.

Background

The force of gravity acts on all bodies on earth. Every bit of mass in the body has weight. The whole weight seems to be concentrated inside or outside the body. This point is the centre of gravity of the body. The weight of a body or object acts through its centre of gravity.

Definition: Centre of gravity of an object is the point through which the total weight of the body can be considered to act.

The point where the total mass of the body seems to act is the centre of gravity.
The centre of gravity of all bodies can be determined by balancing the body on a knife edge or by suspension with a plumb line from several points. In most cases, the centre of gravity of a body lies in the body itself, but in few cases such as the horse-shoe magnet, the retort stand, Bunsen burner, wine glass and conical flask, the centre of gravity lies outside. For centre of gravity outside the body itself, the body will balance at any point on it which lies along a vertical line passing through the centre of the body.

Definition of the Principle of Moments: When a body is in equilibrium, the sum of the anti-clockwise moment about any point is equal to the sum of the clockwise moments about that point.

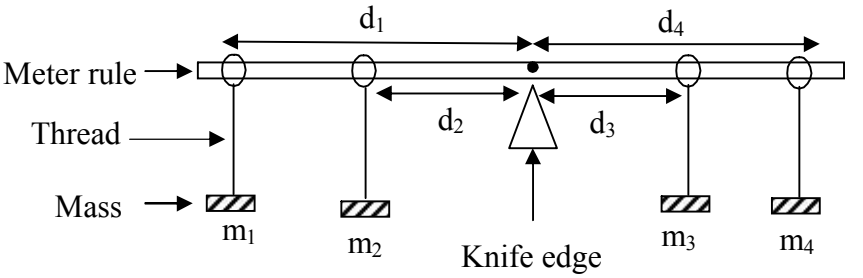

Figure 1. Principle of moments

Unequal masses m_1, m_2, m_3 and m_4 are hung on either side of a rule and their distances d_1, d_2, d_3 and d_4 from the knife edge (or pivot) are adjusted until the rule once more comes to rest horizontally. The weights W_1, W_2, W_3 and W_4 of the masses are now exerting equal and opposite movements about the knife edge or pivot. Making allowance for experimental error, the sum of the products *weight x distance* on the right-hand side is equal to the sum of the products *weight x distance* on the left-hand side,

$$W_1 d_1 + W_2 d_2 = W_3 d_3 + W_4 d_4 \qquad 1.1$$

W is equal to the product of the mass, m and the acceleration due to gravity, g (i.e. $W = mg$). Thus it can be shown that

$$m_1 d_1 + m_2 d_2 = m_3 d_3 + m_4 d_4 \qquad 1.2$$

Equipment/ Materials

1. Metre Rule
2. Knife edge (piece of wood)
3. Known Masses
4. Thread

Other requirements

Exercise Books, pencils, pens and Graph book.

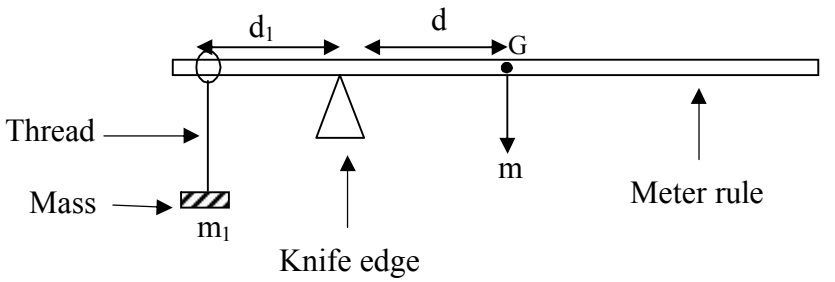

Figure 2: Experiment set up

Experimental Procedure

1. Determine the position of the centre of gravity, G of the metre rule by balancing on a knife edge.
2. Tie a known mass, m_1 to the thread and hang it at one end of the rule.
3. Adjust the position of the rule such that another balance is obtained.
4. Read and record the values d_1 and d as shown in the Fig 2 above.
5. Repeat the experiment by shifting the mass m_1 to different positions and balance the metre rule again.
6. Tabulate your results as shown below.

Table 1: Table of results

d_1/cm	d/cm

7. Plot a graph of d_1 against d.
8. Find the slope of the graph.

9. The equation relating d_1 to d is derived from Eq. 1.2 and is given as

$$d_1 = \frac{m}{m_1} d \qquad 1.3$$

Find the mass m, of the meter rule.

10. What is the weight, W of the meter rule? [g=10m/s^2]

C. Assessment – Student's sheet

On completion of the experiment, you should answer the following questions:

A. State the principle of moment. (KN1)

B. A uniform metre rule is freely pivoted at the 15cm mark and it balances horizontally when a body of mass 40g is hung from the 2cm mark. Draw a clear force diagram of the arrangement and calculate the mass of the rule. (KS4)

C. A non-uniform rod has a mass of 80g, what is its weight? [take $g=10m/s^2$] (CS2)

D. What do you understand by moment of a force about a point? (KN4)

D. Extensions to experiment

The experiment can also be performed using a metre rule and different masses. A graph of m_1 against d/d_1 is plotted from the recorded values and its slope is determined. The value of the slope is the mass of the rule which when multiplied by the acceleration due to gravity, gives the weight of the rule.

E. References and Other Useful Links

1. Abbot A. F. (1980), *Ordinary Level Physics*, 3rd Edition, Heinemann Books International, London.

2. Nelkon M. and Parker P., (1987), *Advanced Level Physics*, Heinemann Educational Publishers, London.

F. Health and Safety

Ensure proper handling of equipment to avoid breakages.