Determination of Young Modulus of a Metal in the Form of a Wire

Practical question — PH3 2005 Question 3

Total	/20

INSTRUCTIONS

Test 1

The candidate will be expected to determine the Young Modules of the material of a metre rule by two separate methods.

1. Two metre rules, one of them labelled “A”.
2. Two 100 g masses [e.g. slotted masses]
3. One G-clamp.
4. Elastic band of appropriate size and strength to bind the masses firmly to the rule.
5. Set square.
6. Stop watch reading to 0·01 s.
7. Micrometer reading to 0·01 mm.

The candidate should be able to clamp the rule to the horizontal bench surface so that up to 93 cm is projecting.

The supervisor should ensure that at least one of the metre rules has a measurable but not excessive deflection when projecting by 93 cm and loaded at the end with 200 g. This rule should be labelled “A”.

Test 2

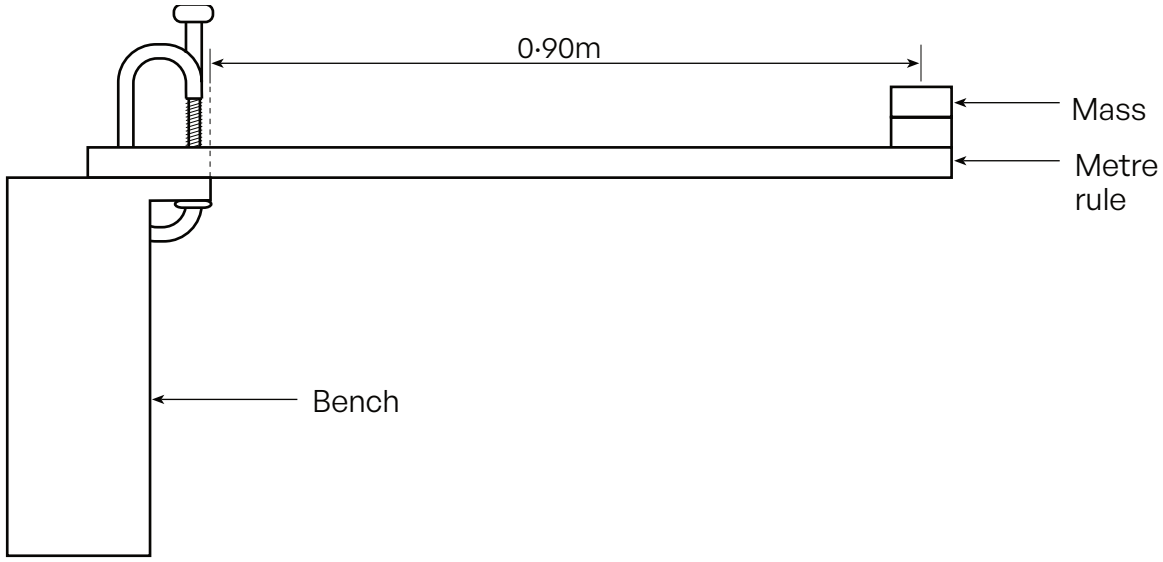
The apparatus is as for Test 1.

You are going to use a sheet of aluminium foil to determine the density of aluminium by two different methods.

You are going to determine the Young modulus of the material of a metre ruler using two different methods.

METHOD 1

Attach the two 100g masses to the metre rule using the elastic band. Clamp the metre ruler to the bench allowing an overhang of 0·90 metres.



1. (a) By displacing the metre rule a small amount and releasing determine the period of oscillation. Record your results below. [2]

(b) Repeat this procedure for an overhang of 0·60 metres. [1]

2. Theory shows that the Young modulus is given by

$$E = \frac{30l^3}{bd^3T^2}$$

where l = length of overhang in m

b = width of rule in m

d = thickness of rule in m

T = period of oscillation in s.

(a) Using the apparatus available, measure a value for b and d for your metre rule. [3]

(b) Hence use the above equation to calculate values for the Young modulus at 0·9m and 0·6 m. [2]

(c) Which of the measurements you have made will have caused the largest error in your calculation, l, b, d, or T? Explain your answer. [2]

METHOD 2

3. (a) With the masses still attached to the rule re-clamp it to the bench with an overhang of 0·90 m. Accurately measure the height of the free end of the rule from the floor. Carefully explain how you did this. [3]

(b) Remove the masses from the rule and measure its new height from the floor. Use this measurement to calculate the depression of the rule. [2]

(c) Repeat steps **3.**(a) and **3.**(b) to find the depression of the rule for an overhang of 0·60m. Record all your results below. [2]

4. Theory also shows that the Young modulus in pascal (Pa) for this mass is given by:

$$E = \frac{8t^3}{hbd^3}$$

where l = length of overhang in m

b = width of rule in m

d = thickness of rule in m

h = depression in m.

Use your results in **2.**(a) and **3.** to calculate two new values for the Young modulus. [2]

5. Which of the two methods do you consider to be the more accurate? Explain your answer. [2]

MARK SCHEME

Question			Marks available
1.	(a)	Accurate results ± 0·1 s [no unit penalty] (1) Repeat readings taken or more than 1 oscillation measured (1)	2
	(b)	Correct result – smaller than in (a) – to nearest 0·01 s [accept 0·005] – units – 2/3 d.p.	1
2.	(a)	Repeat readings for either (1) Correct values: b ± 1 mm; d ± 0·2 mm (1) 2 [N.B. Only 2 marks here – error on printed paper]	2
	(b)	Calculations correct (1) -2 Correct unit – Pa or N m (1)	2
	(c)	d (1) [accept T] Smallest value / cubed (1) [difficulty of counting rapid 2 oscillations]	2
3.	(a)	metre rule used (1) rule vertical / use of set square / parallax (1) measurement to nearest mm / 0·5 mm; units; repeats (1)	3
	(b)	Measurements to nearest mm (1) Correct calculation (1)	2
	(c)	All readings shown with units (1) Readings to nearest mm (1)	2
4.		Correct calculations (1) Correct number of s.f. [2 d.p. max] (1) [If only 1 value found – 1_{max}]	2
5.		Correct method (2^{nd}) (1) Correct reason (T^2 in method 1, but only h in method 2) (1) [Accept: any valid reason]	2