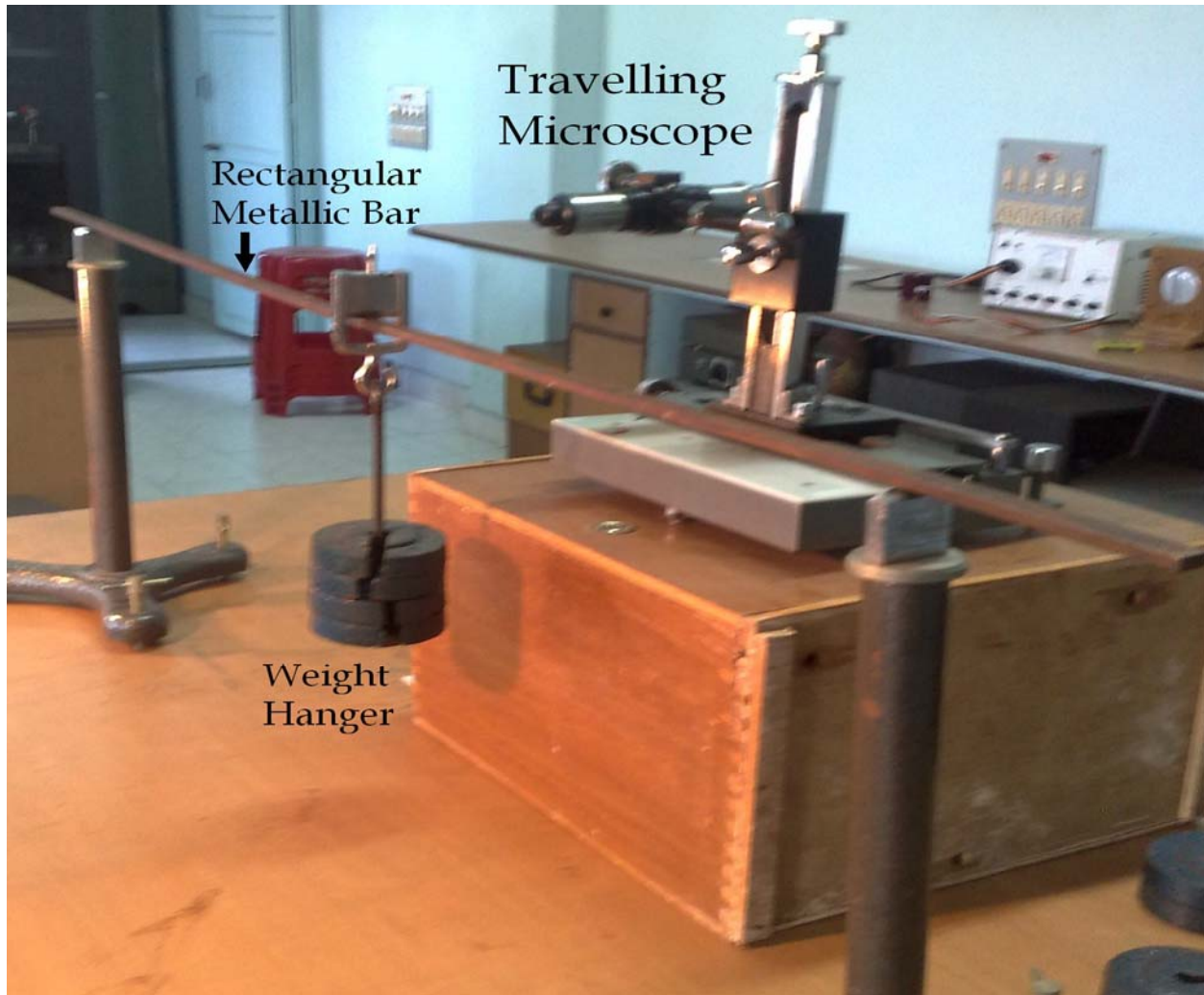


Expt. No.

DATE:

DETERMINATION OF THE YOUNG'S MODULUS OF THE MATERIAL OF A BAR BY THE METHOD OF FLEXTURE



APPARATUS : A bar of uniform rectangular cross section and of length about 1 m made of material whose Young's modulus is to be determined. Two stout iron stands with leveling screws at the base and sharp knife edge fixed at the top, a rectangular stirrup with a knife edge and a vertical pointer. A traveling microscope, standard weights, spirit level, a hanger, metre scale, a pair of slide calipers.

THEORY : Suppose a uniform rectangular bar supported symmetrically on two horizontal and parallel knife edge be depressed by a load of mass m gm. – suspended from the beam midway between the knife edges. Then the depression 'x' of the middle of the bar is given by

$$x = \frac{mgl^3}{4bd^3Y} \quad \text{or,} \quad Y = \frac{mgl^3}{4bd^3x} \quad \text{or,} \quad \boxed{Y = \frac{gl^3}{4bd^3} \left(\frac{m}{x} \right)}$$

Where,

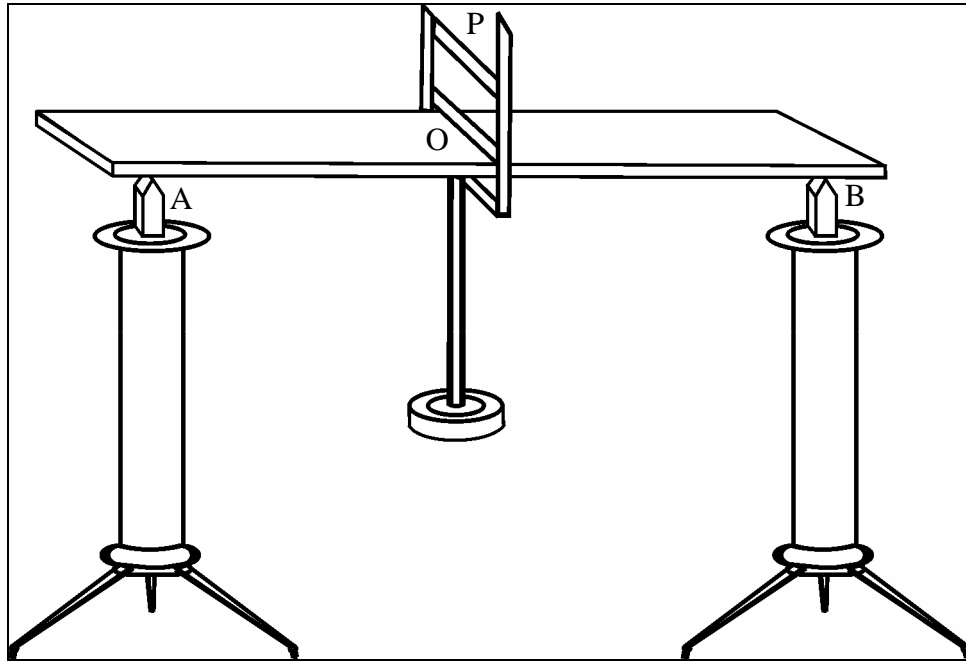
Y = Young's modulus,

l = Length of the bar between two knife edge,

b = breadth,

d = depth of the bar and

g = acceleration due to gravity.



Schematic diagram for Young's Modulus experiment.

PROCEDURE AND DATATABLES:

[A] Steps for the measurement of breadth and depth of the bar:

1. Take readings of breadth and depth of the bar with slide calipers at three different points respectively and calculate the mean reading.
2. Find the instrumental error of the slide calipers and correct the mean readings.

Vernier constant of the slide calipers = cm

TABLE 1: Measurement of breadth and depth of the bar:

Quantity to be measured	No. of Obs	Main scale reading (cm.)	Vernier scale reading	Total reading (cm.)	Mean reading (cm)	Instrumental error	Corrected reading (cm)
Breadth (b)	1						
	2						
	3						
Depth (d)	1						
	2						
	3						

[B] Steps for the measurement of length of the bar between the knife edges, A & B:

1. Measure the length of the bar with the help of a metre scale.
2. Mark the mid point (O) of the bar (if length of the bar is 100 cm. then the midpoint would be at the distance of 50 cm. from one of the edge of the bar).
3. Place the bar on two knife edges at the points A and B.

TABLE 2: Measurement of length of the bar between the knife edges:

No of Obs	Scale reading for the knife edge A (x cm)	Scale reading for the knife edge B (y cm)	Length (y ~ x) (cm)	Mean length (l cm)
1				
2				
3				

[C] Steps for measurement of depression of the bar at its mid-point for different loads(weights).

1. Put the hanger at the mid point of the bar.
2. Focus the traveling microscope on the tip of the pointer P and take the corresponding scale reading (zero load depression) from the vertical scale.
3. Put a load 0.5 kg on the hanger and again adjust the vertical scale (*move the fine adjustment screw clockwise only to avoid backlash error*) of the traveling microscope and align the horizontal cross-wire with the pointer P. Take the reading from the vertical scale.
4. Repeat the step 3 by increasing the load by 0.5 kg up to 3.0 kg.
5. Again take readings of vertical scale by decreasing the load from 3.0 kg to 0 kg in the steps of 0.5 kg.
6. For each load calculate mean reading $(a+b)/2$ by taking average of readings at increasing(a) and decreasing(b) load.
7. Calculate depressions(x) for each load by subtracting the corresponding values $(a+b)/2$ from the zero load.

For example:

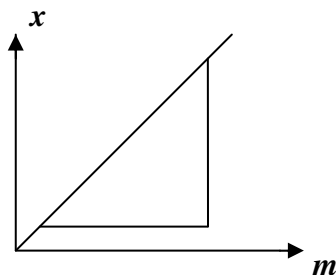
Load(kg) <i>m</i>	readings when load increasing	readings when load decreasing	Mean reading $(a+b)/2$	depression <i>x(cm)</i>
0	a_1	b_1	l_1	$l_1. l_1 = 0$
0.5	a_2	b_2	l_2	$l_1. l_2$
1.0	a_3	b_3	l_3	$l_1. l_3$
·	·	·	·	·
·	·	·	·	·
3.0	a_7	b_7	l_7	$l_1. l_7$

TABLE 3: Measurement of depression of the bar at its mid-point for different loads:

No. of Obs	Load on the hanger m (kg)	Readings when load increasing (cm) (a)			Readings when load decreasing (cm) (b)			Mean $\frac{1}{2}$ (a+b) cm.	Depressions (cm) x
		Main scale	Vernier scale	Total reading	Main scale	Vernier scale	Total reading		
1.	0.0								
2.	0.5								
3.	1.0								
4.	1.5								
5.	2.0								
6.	2.5								
7.	3.0								

[D] Steps for drawing load vs. depression graph and calculation of m/x (slope) from the graph:

1. Take the data of m and x for various observations from table 3 to table 4. Draw the graph m (horizontal axis) vs x (vertical axis) by using the data in table 4.



The characteristic of the graph will be a straight line passing through the origin(0,0).

2. Calculate m/x by using the inverse slope of the graph m vs x .

TABLE 4: Measurement of load and depression:

Quantity	1.	2.	3.	4.	5.	6.	7.
Load (in kg)	0.0	0.5	1.0	1.5	2.0	2.5	3.0
Depression (in cm)							

Slope of the load vs. depression graph is

CALCULATION :

MAXIMUM PERCENTAGE ERROR :

$$Y = \frac{gl^3}{4bd^3} \left(\frac{m}{x} \right)$$

$$\left(\frac{\delta Y}{Y} \right)_{\max} = 3 \frac{\delta l}{l} + \frac{\delta b}{b} + 3 \frac{\delta d}{d} + \frac{\delta x}{x}$$

Where,

$\delta l = 0.2cm$ (Two divisions of a metre scale)

$\delta b = 0.01cm$ (vernier constant of Slide calipers)

$\delta d = 0.01cm$ (vernier constant of Slide calipers)

$\delta x = 2 \times 0.001cm$ (2. vernier constant of Travelling microscope)

Maximum Percentage Error in Y is, $\left(\frac{\delta Y}{Y}\right)_{\max} \times 100 \% =$

STANDARD VALUE:

FOR IRON: $19.5 \times 10^{10} \text{ N/m}^2$

FOR BRASS: $10 \times 10^{10} \text{ N/m}^2$

(CONVERSION TO C.G.S UNIT: $1 \text{ N/m}^2 = 10 \text{ dyne/cm}^2$)

DISCUSSIONS: