TO DETERMINE YOUNG'S MODULUS OF ELASTICITY OF THE MATERIAL OF A BAR BY THE METHOD OF FLEXURE

Aim: To determine the Young's modulus of elasticity of the given material.

Apparatus: meter scale, screw gauge, spherometer and slide caliper

Theory: If a less weight bar of breadth b and depth d is placed horizontally on two knife-edges separated by a distance L, and a load of mass m, applied at the mid-point of the bar, produces a depression l of the bar, then Young's modulus Y of the material of the bar is given by

$$Y = \frac{gL^3}{4bd^3}\frac{m}{l} \qquad (1)$$

Where g is the acceleration due to gravity. This is the working formula of the experiment, and is valid so long as the slope of the bar at any point with respect to the unstrained position is much less than unity. Here Y is determined by measuring the quantities b, d, L and the mean depression l corresponding to a load m. If b, d, L and l are measured in cm, m in gm, g is expressed in cm/sec^2, and then Y is obtained in dyne/cm^2.

Procedure:

(i) Measure the length of the given bar with a meter scale and place the centre of the bar at the middle point of the two supports fixed to the table.

(ii) Place rectangular hook cum hanger at the centre of the scale. Place the spherometer such that screw of spherometer is on top of the rectangular hook cum hanger.

(iii) Make the electrical connections as shown in the figure (1) by connecting power supply, spherometer and galvanometer.

(iv) Switch on the power supply, adjust the circular scale such that screw of spherometer(S) touches rectangular hook, indicating deflection in the Galvanometer (G).

(v) Take the initial reading on the spherometer.

(vi) Hang a weight to the hook and then you notice that galvanometer reading come back to zero (why?). Again adjust the spherometer such that screw touches the hook and galvanometer deflects. Take the depression of the bar reading corresponding the weight hanged.

(vii) Continue the same procedure for all the weights. Avoid back lash error while using spherometer.

(viii) Repeat the experiment once again with all the weights

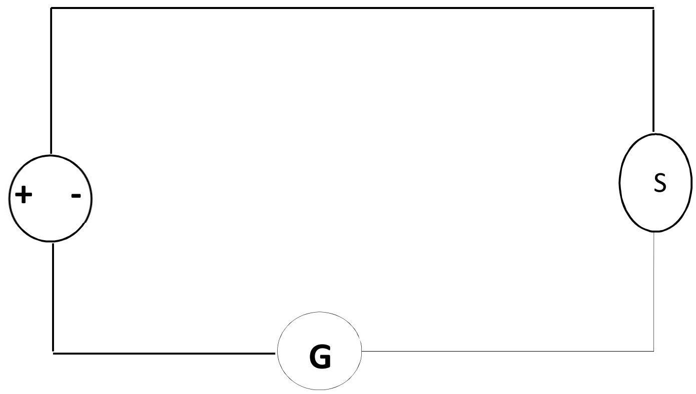

Figure 1: Schematic diagram of electrical connections

(ix) Determine the vernier constant (least count) of the slide caliper and measure with it the breadth *b* of the bar at three different places. Calculate the mean breadth of the bar. Note the zero error, if any, of the slide caliper and find the correct value of *b*.

(x) Determine the least count of the screw gauge and measure depth *d* of the bar at a number of places along the length of the bar. Find the mean value. Note the zero error, if any of the screw gauge and obtain the correct value of *d*.

(xi) Draw a graph with the load *m* in gram along the X-axis and the corresponding depression *l* in cm along the Y-axis and determine the value of *Y*.

Experimental Results:

Table-1

Least count of spherometer

Pitch of the screw *p* (cm)	No. of divisions n on the circular scale	Least count = *p*/n (cm)
…….	…………	……………

Table-2 : Load-depression data for chosen length

Distance between the knife-edges L = ……cm

No. of obs.	Load in (kg)	spherometer reading for Increasing load (cm)-first measurement			Spherometer reading for increasing load (cm)-second measurement			Mean reading (cm)	Depression l(cm)
		Main scale	Circular	Total	Main scale	Circular	Total		
1		..	..	..	..	..	..	….(a)	0
2		..	..	..	..	..	..	…..(b)	(b)-(a)
3		..	..	..	..	..	..	…….(c)	(c)-(a)
..		..	..	..	..	..	..	…	…
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To get average $\frac{m}{l}$, plot load in kg (m) versus l and obtain slope 's' and error in slope 'Δs'

Table-3

Vernier Constant (v.c.) of the slide caliper

….. Divisions of the vernier scale = ………… divisions of the main scale.

Value of l smallest main scale division (l_1)	Value of 1 vernier division ($l_2 = \frac{n}{m} l_1$) (cm)	Vernier constant v.c. = ($l_1 - l_2$) (cm)
…………	………………	…………………..

Table-4: Measurement of breadth (*b*) of the bar by slide caliper

No. of obs.	Readings (cm) of the		Total reading b(cm)	Mean b (cm)	Zero error(cm)	Correct b (cm)
	Main scale	Vernier				

Table-5: Least count (L.C.) of the screw gauge

Pitch of the screw p (cm)	No. of divisions n on the circular scale	Least count = p/n (cm)
…….	…………	……………

Table–6: Measurement of depth (*d*) of the bar by the screw gauge

No. of obs.	Readings (cm) of the		Total reading *d* (cm)	Mean *d* (cm)	Zero error (cm)	Correct *d* (cm)
	Main scale	Vernier				
1	…	…	…			
2	…	…	…	…	…	…
3	…	…	…			

Discussions:

Even though entire scale or bar deforms by applying stress to given bar or scale, length *L* in $Y = \frac{gL^3}{4bd^3}\frac{m}{l}$ (or $Y = \frac{gL^3}{4bd^3}s$) correspond to the portion between two knife edges but not the total length of the given bar or meter scale. ***Why?*** Refer to supporting material.

Computation of error: . The error in *Y* due to propagation of errors in the measurement of *L*, *b*, *d*, and *s* is given by

$$\frac{\delta Y}{Y} = \sqrt{\left(3\frac{\delta L}{L}\right)^2 + \left(\frac{\delta b}{b}\right)^2 + \left(3\frac{\delta d}{d}\right)^2 + \left(\frac{\delta s}{s}\right)}$$

Precautions:(i) In the expression for *Y*, both the length *L* between the knife-edges and the depth d of the bar occur in powers of three. But as d is much smaller than *L*, much care should be taken to measure to minimize the proportional error in *Y*.

(ii) Care should be taken to make the beam horizontal and to load the bar at its mid-point.

(iii) Try to avoid parallax and back-lash errors during measurements.

Questions: How the weight of the bar affect the experiment?