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TO DETERMINE YOUNG'S MODULUS OF ELASTICITY OF THE MATERIAL OF A STEEL BAR

Aim : To determine the Young's modulus of elasticity of a given material (Steel bar)

Apparatus: Pin and microscope arrangement, scale, vernier callipers, screw gauge, weight hanger, material bar or rod.

Theory :- If a light bar of breadth 'b' and depth 'd' is placed horizontally on two knife-edges seperated 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

$$Y = \frac{g l^3 m}{4 b d^3 l} \quad \text{— (1)}$$

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,

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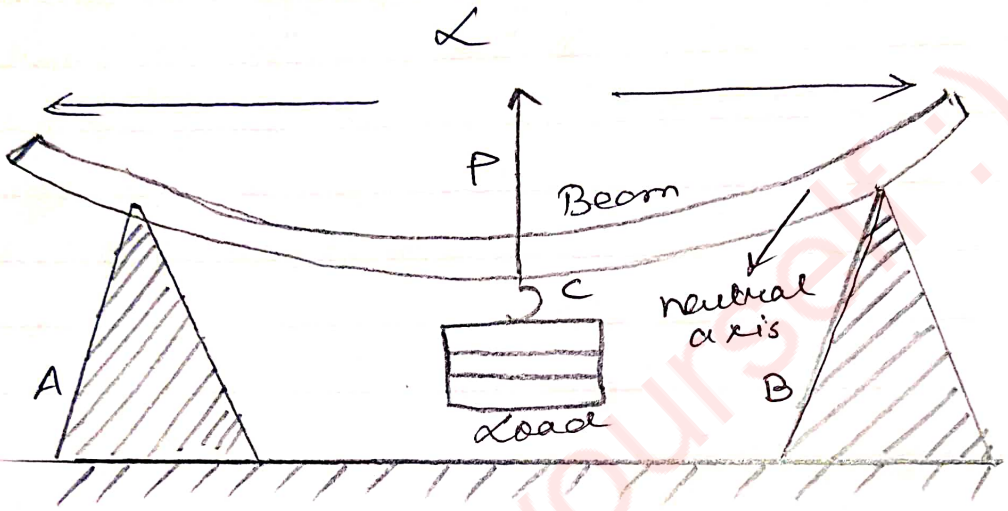

A, B → knife edges

C → Midpoint

P → Pin

α → Distance between the two knife edges.

(1) Diagram

OBSERVATION TABLE

Sl No.	Load/ mass (gm)	Microscopic Radius for increasing load (cm)			Load/ Mass (gm)	Microscopic Radius for decreasing load (cm)			Mean (cm)	Depression L in cm
		M.S.R	V.S.R	Total (cm)		M.S.R	V.S.R	Total (cm)		
1	0	5.50	12	5.50+ (12×0.001) = 5.512	0	5.50	12	5.50+ (12×.001) = 5.512	A = 5.512	A-A = 0
2	50	5.55	10	(5.55+ 0.001×10) = 5.560	50	5.55	10	(5.55+ 0.001×10) = 5.560	B = 5.560	B-A = 0.048
3	100	5.60	10	5.6+ 0.001×10 = 5.610	100	5.60	10	5.60+ 0.001× 10 = 5.610	C = 5.610	C-A 0.098
4	150	5.65	21	(5.65+ 0.001× ~~25~~ 21) = 5.671	150	5.65	21	5.65+ 0.001×21 = 5.671	D = 5.671	D-A = 0.159
5	200	5.65	29	(5.65+ 0.001×29) = 5.679	200	5.65	29	5.65+ 0.001×29 = 5.679	E = 5.699	E-A = 0.167
6	250	5.70	25	5.70+ 0.001×25 = 5.725	250	5.7	25	5.7+ 0.001×25 = 5.725	F = 5.725	F-A = 0.215
7	300	5.75	24	5.774	300	5.75	24	5.774	G = 5.774	G-A = 0.262
8	350	5.80	23	5.8+0.001×23 = 5.833	350	5.8	33	5.80+ 0.001× 33 = 5.833	H = 5.833	H-A = 0.321
9	400	5.85	32	5.85+ 0.001×32 = 5.882	400	5.85	32	5.85+ 0.001× 32 = 5.882	I = 5.882	I-A = 0.370
10	450	5.90	31	5.9*0.001 ×31 = 5.931	450	5.90	31	5.9+0.001 × 31 = 5.931	J = 5.931	J-A = 0.419
11	500	5.95	31	5.95+ 0.001× 31 = 5.981	500	5.95	31	5.95+ 0.001× 31 = 5.981	K = 5.981	K-A = 0.469

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 expected in cm/sec^2 and then Y is obtained dyne/cm^2.

Calculation: Vernier constant of travelling microscope (L.C) = 0.001 cm

Distance between the two knife edge (L) = 55cm

Slope from the graph, $\frac{\Delta L}{\Delta m} = \frac{0.419 - 0.048}{450 - 50}$

$= \frac{0.371}{400}$

$\approx 9.27 \times 10^{-4}$ cm/g

Young's Modulus $Y = \frac{gL^3 m}{4bd^3 l}$

$g = 9.8 m/s^2$, $L = 55$cm, $b = 1.5$cm

$d = 0.25$cm

L.C of vernier scale = 0.001 cm

Thus, $Y = \frac{980 \times 55^3}{4 \times 1.5 \times 0.25^3 \times 9.27 \times 10^{-4}}$

$\boxed{Y \approx 1.88 \times 10^{12} \text{ dyne/cm}^2}$

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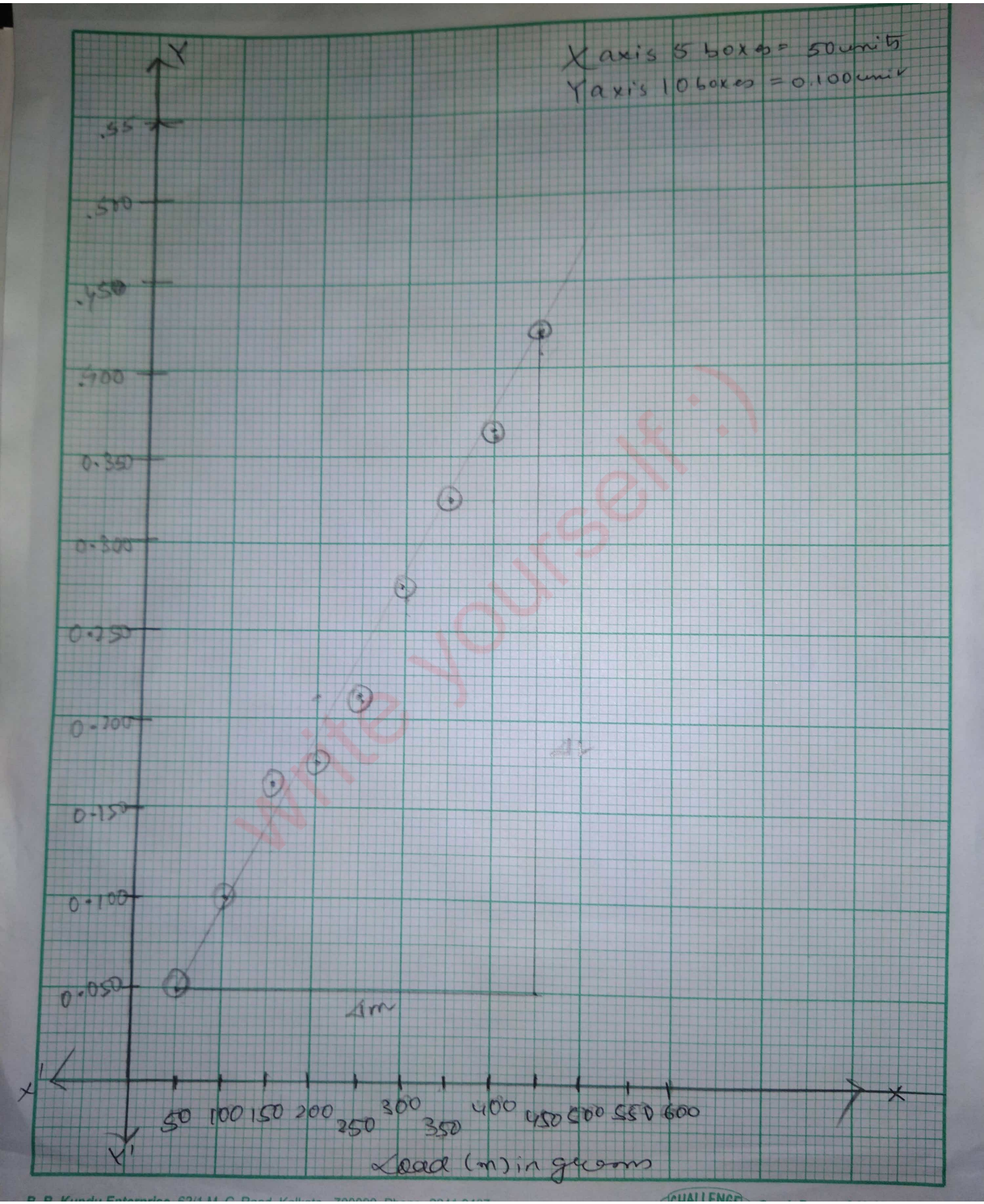
X axis 5 boxes = 50 units
Y axis 10 boxes = 0.100 units
Y
.55
.500
.450
.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
Δm
X'
X
50 100 150 200 250 300 350 400 450 500 550 600
Y'
Load (m) in grams
Write yourself :)

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Conclusion: The Young's Modulus is 1.88×10^{12} dyne/cm^2