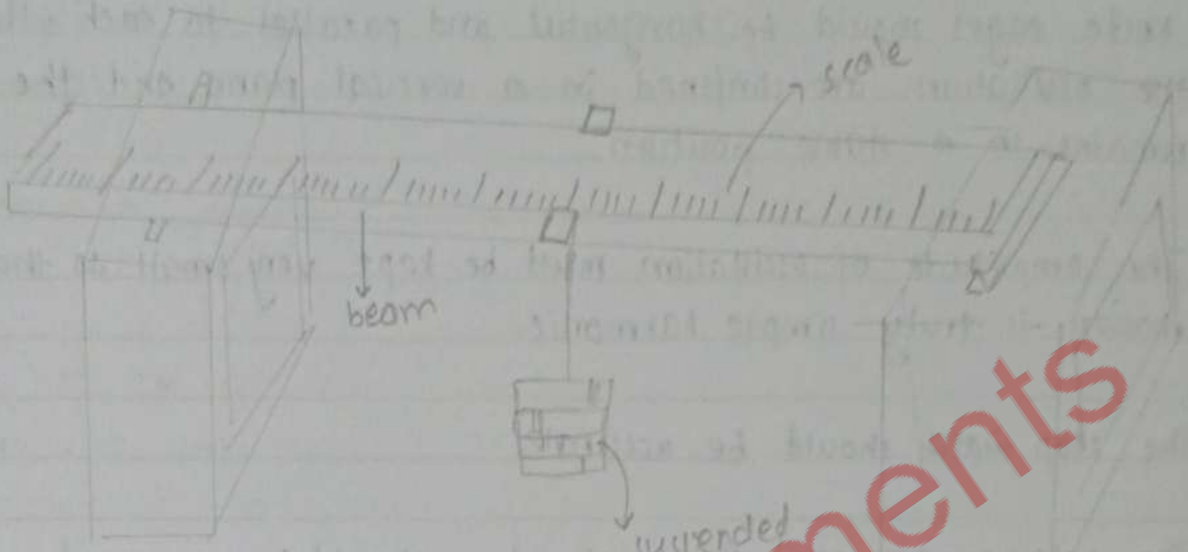

All Lab Experiments

AIM: To determine the young's modulus of the material of a given bar by bending.

APPARATUS: Two parallel knife edges on which beam is placed, a hook to suspend weights, a scale attached to the hook, 0.5 kg weights, a cathetometer, vernier calipers and a meter scale.

THEORY: let a beam be supported horizontally on two parallel knife edges A and B distance l apart and loaded in the middle C with weight W. The upward reaction at each knife edge being $W/2$ and the middle part of beam being horizontal, it may be taken to be combination of the two inverted cantilevers CA and CB each of effective length $l/2$ fixed at C and bending upward under a load $W/2$ acting on A and B. let the elevation of A and B above C or the depression of C below A and B be 'y'.

Bending couple due to load $W/2$ is

$$= \frac{W}{2}\left(\frac{l}{2} - x\right)$$

$$\frac{YI_g}{R} = YI_g \frac{d^2y}{dx^2}$$

$$= \frac{W}{2}\left(\frac{l}{2} - x\right)$$

which on integration gives

$$\frac{dy}{dx} = \left[\frac{W}{2YI_g}\right]\left[\frac{lx}{2} - \frac{x^2}{2}\right] + c$$

since at $x=0$, $\frac{dy}{dx}$ we have $c=0$ and therefore

All Lab Experiments

OBSERVATIONS:

Plate 1 (Iron)

Thickness, d = 0.6 cm Breadth, b = 2.5 cm

length, l = 100 cm

S.NO.	Load in kg	Microscope Reading		mean	δ
		load inc.	load dec.		
1.	0.0	0.090	0.044	0.062	0 (δ_1)
2.	0.5	0.110	0.148	0.0129	0.067 (δ_2)
3.	1.0	0.207	0.252	0.230	0.168 (δ_3)
4.	1.5	0.314	0.357	0.332	0.2701 (δ_4)
5.	2.0	0.436	0.456	0.466	0.404 (δ_5)
6.	2.5	0.581	0.581	0.581	0.518 (δ_6)

CALCULATIONS:

$$y = \frac{(\delta_4 - \delta_1) + (\delta_5 - \delta_2) + (\delta_6 - \delta_3)}{3} = 0.319 \quad \text{for } m = 1.5 \text{ kg}$$

$$\therefore Y = \frac{MgL^3}{4ybd^3} = \frac{1.5 \times 9.8 \times (1)^3}{4 \times \left(\frac{0.319}{100}\right) \times \frac{2.5}{100} \times \frac{(0.6)^3}{(100)^3}}$$

$$= 21.334 \times 10^{10} \ \frac{N}{m^2}$$

All Lab Experiments

$$\frac{dy}{dx} = \left[\frac{W}{2YI_g}\right]\left[\frac{lx}{2} - \frac{x^2}{2}\right]$$

$$dy = \left[\frac{W}{2YI_g}\right]\left[\frac{lx}{2} - \frac{x^2}{2}\right]dx$$

while on further integration between the limits $x = 0$ and $x = l/2$ gives

$$y = \left[\frac{W}{2YI_g}\right]\left[\frac{l^3}{16} - \frac{l^3}{48}\right]$$

$$y = \frac{Wl^3}{48YI_g}$$

If the cross section of the beam be rectangular of breadth 'b' and thickness 'd', we have $I_g = \frac{bd^3}{12}$. Hence above equation can be written as

$$y = \frac{Wl^3}{4Ybd^3}$$

$$y = \frac{Mgl^3}{4Ybd^3}$$ where M is the mass suspended from the hook.

The depression y of the mid point is noted directly with the help of cathetometer.

All Lab Experiments

PROCEDURE :

1. Adjust the cathetometer so that the vertical column that carries the microscope and scale is vertical.

2. Support the experimental beam symmetrically on the knife edges with equal lengths projecting beyond the knife edges.

Plate 2 (Brass)

Thickness, d = 0.5 cm

Breadth, b = 2.6 cm

length, l = 100 cm

S. NO.	load in kg	Microscope Reading load inc	load dec	mean	δ
1.	0.0	0.105	0.043	0.074	0
2	0.5	0.314	0.459	0.386	0.3125
3.	1.0	0.633	0.748	0.1905	0.6165
4	1.5	1.081	1.056	1.0685	0.9945
5	2.0	1.366	1.328	1.347	1.273
6.	2.5	1.654	1.635	1.6495	1.573

CALCULATIONS:

For calculation of

$$\delta = \frac{0.9945 + (1.273 - 0.3125) + (1.5755 - 0.6165)}{3}$$

$$= 0.9548$$

mass, $m = 1.5$

$$Y = \frac{MgL^3}{4ybd^3} = \frac{1.5 \times 9.8 \times (1)^3}{4 \times \frac{0.9548}{100} \times \frac{2.6}{100} \times \left(\frac{0.5}{100}\right)^3}$$

$$= 11.842 \times 10^{10} \ N/m^2$$

All Lab Experiments

3. measure the distance between knife edges with a meter scale. This gives the length l of the beam under flexure.

4. Suspend the hanger with a graduated scale attached to it, on the mid point of the beam. Take the reading of the vernier scale of cathetometer.

5. Suspend a weight of 1 kg on the hanger. A depression is produced in the beam. Take the reading of the vernier scale of the cathetometer. Repeat the previous steps for loads increasing by 1 kg at a time and then for loads decreasing in that order.

6. Measure the breadth 'b' and thickness 'd' of the beam precisely using vernier callipers and screw gauge respectively.

7. measure the distance between knife edges.

RESULT: The value of young's modulus of the material of the the beam is found to be 21.334×10^{10} N/m^2 of iron and 11.842×10^{10} N/m^2 for brass.

PRECAUTIONS AND SOURCES OF ERROR:

1. The beam must be symmetrically placed on the knife edges with equal lengths projecting out beyond the knife edges.

2. The hanger should be suspended from the centre of gravity of the beam

3. Avoid the backlash error in the cathetometer

All Lab Experiments

4. The loads should be placed or removed from the hanger as gently as possible and the reading should be recorded only after waiting for sometime, so that the thermal effects produced in the specimen, get subsided.

5. Since the depth (thickness) of the beam appears as its cube in the formula and is relatively a small quantity, it should be determined by measuring it at several places along length by screw gauge.

All Lab Experiments