Y by bending of beam

OBJECT: To determine the Young's modulus of the material of a given beam supported on two knife edges and loaded at the middle point.

Apparatus used: Two parallel knife edges on which the beam is placed, a hook to suspend weights, a meter scale, Spherometer, 500gm weights, d.c. source, bulb or galvanometer, wires, screw gauge, vernier callipers and a meter scale.

Formula: The following formula is used for the determination of Young's modulus (Y) for a beam material.

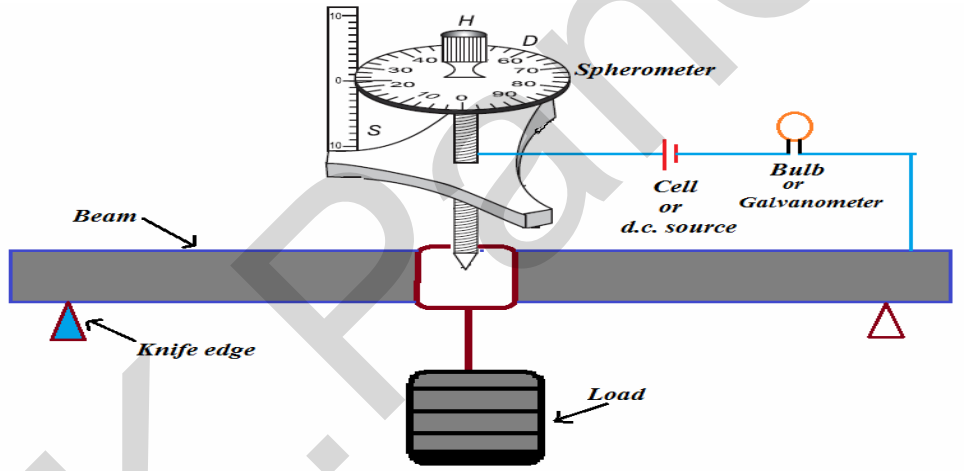
$$Y = \frac{Mgl^3}{4bd^3\delta} = \frac{gl^3}{4bd^3}\frac{M}{\delta}$$

Where M = load suspended from the beam, g = acceleration due to gravity,

l = length of the beam between the two knife edges, b = breadth of the beam,

δ = depression of the beam in the middle d = thickness of the beam

Figure:



Procedure:

(1) Measure the length of bar between knife edges using meter scale. This will give you value of l.

(2) Find out the least count of screw gauge and zero error in it.

(3) Using screw gauge, measure the thickness of bar/beam. It will provide the value of d.

(4) Find out the least count and zero error of Vernier calipers.

(5) Using Vernier calipers, measure the breadth of beam. It will provide the value of b.

(6) Find the least count of spherometer.

(7) Suspend the hanger with a graduated scale attached to it, on the mid-point of the beam. Now rotate the spherometer. As soon as it touches the beam, the bulb glows. Stop the rotation of spherometer and note its reading. This gives zero mass depression.

(8) Now load 500 gm on hanger. At this position, the bulb will not glow. Further rotate the spherometer till the bulb just glows. Stop the rotation of spherometer and note its reading. This gives depression for 500gm.

(9) Increase the mass on hanger till 2500gm in interval of 500gm and note the spherometer readings at the situation of bulb glow. This will give you the depressions at different masses.

(10) Note the same reading of depression, for M=2500gm in case of decreasing load.

(11) Now remove the 500gm mass from hanger and rotate the spherometer in opposite direction till the bulb just becomes off. Note the spherometer readings at the situation. This provides you the value of depression for 2000gm mass at load decreasing case.

(12) Similarly decrease the load up to zero mass in steps of 500gm and note the spherometer readings at the just off situation of bulb. This will give you the depressions at different masses in case of load decreasing.

(13) In the process of (7)-(12), you have recoded the depressions (spherometer reading) for different masses in case of load increasing and decreasing. Take the mean of spherometer readings for load increasing and decreasing for each masses.

(14) Now calculate the difference of mean spherometer reading of each mass with zero mass reading. This will provide the relative depression for each masses with respect to zero mass.

(15) Find out depression for 1500gm. This can be obtained by taking difference among 1^{st}& 4^{th}, 2^{nd}&5^{th} and 3^{rd} and 6^{th}. Put all the values in given formula and calculate the value of ***Y***.

(16) Plot graph in mass and relative depression and find out its slop. The slop of graph gives the value of $\tan\theta = \delta/M$. Put all the value in the given formula and calculate the value of ***Y***.

(17) Take mean of both calculated values of *Y*. This provides the final value of Young modulus of material of beam.

Observations:

(1) Length of beam between knife edges (l)=……..cm

(2) Least count of screw gauge= $\frac{pitch}{Number\ of\ \text{divisions on circular scale}}$ =…….cm

(3) Zero error in screw gauge=……..gm

(4) Table for thickness (d) of beam:

Sr. no.	M.S. (cm)	C.S. (div)	un-corrected diameter (T= MS + CS x LC) (cm)	Mean un-corrected diameter (T: cm)	corrected diameter (d=T± zero error) (cm)
1.					
2.					
3.					
4.					

(5) Least count of Vernier calipers = $\frac{value\ of\ one\ division\ on\ main\ scale}{Number\ of\ divisions\ on\ vernier\ scale}$ ……..cm

(6) Zero error in Vernier calipers=……..cm

(7) ***Table for breadth of beam:***

Sr. no.	M.S. (cm)	V.S. (div)	un-corrected breadth (T= MS + VS x LC) (cm)	Mean un-corrected breadthr (d: cm)	corrected breadth (b=T± zero error) (cm)
1.					
2.					
3.					
4.					
5.					

(8) Table for mass and depression:

Sr. no.	Mass M (gm)	Spherometer reading			Depression δ (cm)	Depression (δ) for M=1500gm (cm)	Mean δ for M=1500gm (cm)
		For load increasing y_1 (cm)	For load decreasing y_2 (cm)	Mean y (cm)			
1.	0			A	δ_1=A-A	$\delta_4-\delta_1$	
2.	500			B	δ_2=B-A		
3.	1000			C	δ_3=C-A	$\delta_5-\delta_2$	
4.	1500			D	δ_4=D-A		
5.	2000			E	δ_5=E-A	$\delta_6-\delta_3$	
6.	2500			F	δ_6==F-A		

Calculation: $Y = \frac{gl^3}{4bd^3}\frac{M}{\delta}$

(Using table and graph data of M/ δ, calculate the two values of Young Modulus with log method and find out their mean.)

Results: The Young Modulus of material of beam= …….N/m^2

Maximum possible error: Taking log and differentiating formula of Y, we get

$$\frac{\partial Y}{Y} = \frac{3\partial l}{l} + \frac{\partial b}{b} + \frac{3\partial d}{d} + \frac{\partial \delta}{\delta}$$

So, Maximum possible error= $\frac{\partial Y}{Y} x100$

Precautions:

1. The knife edges should be rigid and fixed on rigid support.
2. The knife edges should be at equal distances from the center of bar/beam.
3. The weights should be placed and removed gently on the hanger.
4. The load on beam should not exceed the elastic limit of beam.
5. To avoid the backless error, the circular scale of screw gauge and spherometer should be moved in one direction.