ACTIVITY

AIM

To study the effect of load on depression of a suitably clamped meter scale loaded at its end.

MATERIAL REQUIRED

Meter scale, thread, slotted weights with hanger (10 g, 20 g, 50 g, 100 g), graduated scale to measure depression, pin, Cello tape, G-clamp, iron stand with clamp and graph paper.

THEORY

A beam whose one end of a horizontal side is fixed and the other end is free is known as cantilever. The depression of a cantilever d of a length l clamped at one end and loaded at the free end with a load m (weight = mg) is given by,

The depression (Buckling) δ produced in the wooden rod of length l, is given by:

$$\delta = \frac{mgl^3}{4Ybd^3}$$

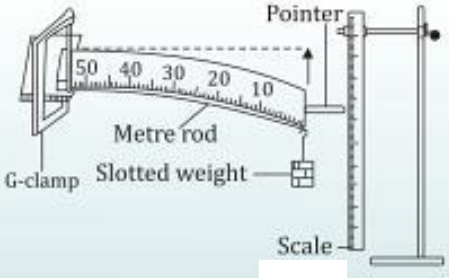
m = Total mass of slotted weights
Y = Young's modulus
b = breadth
d = depth
For a given rod, $\delta \propto mg$

PROCEDURE

SETTING UP THE MATERIALS

1. Find the least count of both the meter scales.
2. With the help of G-clamp, clamp the meter scale firmly to the edge of the clamp stand in such a way that the length and breadth of the scale should be in horizontal plane and 90 cm of the length of the scale should be projected out.
3. Fix a pin with tape at the free end of the meter scale along its length to act as a pointer.
4. Fix a graduated scale vertically near the free end of the clamped meter scale.
5. Ensure that the pointed end of the pin attached with scale is just above the graduation marks of the vertical scale but does not touch it.

READ THE POINTER (P) WHEN CANTILEVER IS WITHOUT ANY LOAD



EFFECT OF LOAD ON DEPRESSION OF THE CLAMPED HORIZONTAL SCALE

1. Now, tie a thread at the free end of the horizontal scale and then suspend some known slotted weight (20 g) with the help of hanger from the thread to depress the free end of the cantilever.
2. Read the position of pointer on the vertical scale and note the observation.
3. Now add 20 g mass more to the hanger and note the reading of the pointer. Keep on adding 20 g masses at the free end of the clamped horizontal scale and note the respective positions of the pointer every time when it stops vibrating.
4. Take 6 to 7 observations with increasing load and thereafter start removing the slotted weights gradually one by one and note the readings while unloading.
5. Note all the observations in the tabular form.
6. Plot a graph between the depression and the load.

OBSERVATIONS

1. Least count of the vertical scale = _____ cm.
2. Least count of the horizontal clamped scale = _____ cm.
3. Length of the cantilever, l = _____ cm.
4. Width of the meter scale, b = _____ cm.
5. Thickness of the meter scale, d = _____ cm.
6. Reading of the free end of the cantilever with no load, l_0 = _____ cm.

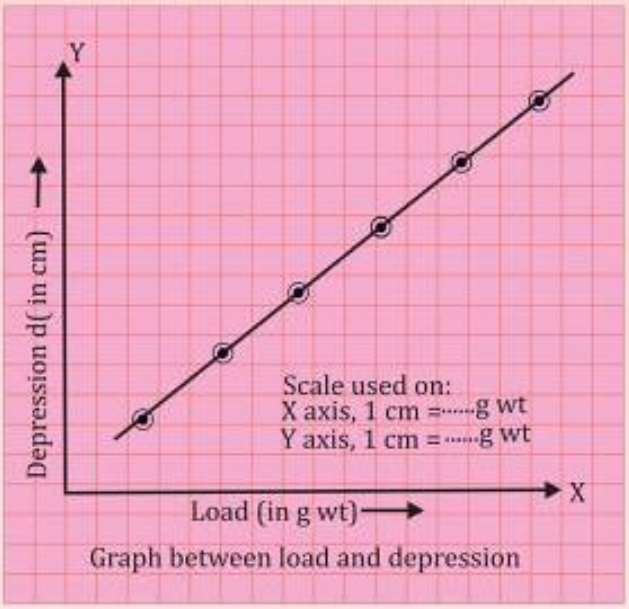
TABLE TO STUDY THE EFFECT OF LOAD ON DEPRESSION OF CANTILEVER

S. No.	Load m, (g)	Reading of free end of the cantilever		Mean $l_m = \frac{l_1 + l_2}{2}$ (cm)	Depression $Y = l_m - l_0$ (cm)	Ratio $\frac{y}{m}$ (cm/g)
		Load increasing, l_1 (cm)	Load decreasing, l_2 (cm)			
1.						
2.						
3.						
4.						
5.						
6.						
7.						

From the observation table, it can be said that within the experimental error, the value of remains constant for all observations.

PLOTTING GRAPH

On plotting a graph between depression d and load m by taking them along y and x-axes respectively, we get a straight line passing through the origin.



Graph between load and depression

RESULT

It can be seen from the graph, as the load increases, the depression of the scale (or cantilever) also increases. Hence, depression y is directly proportional to the load.

PRECAUTIONS

1. The horizontal scale should be rigidly clamped at one end.
2. The meter scale should not be loaded beyond elastic limit to avoid breaking.
3. The meter scale should be horizontal and it's about part of the length should be projected out so that the depression can take place easily.
4. The vertical scale should be adjusted close to the pointer in such a way that the pointer moves along it freely.
5. Thickness of cantilever should be small so that even small weight can produce the depression.
6. While loading and unloading is done, it should be taken care that the position of the
7. thread does not disturb.

SOURCES OF ERROR

1. The scale may be overloaded beyond its elastic limit.
2. There may be a vibratory motion of the beam while taking a reading.
3. The eye may be inclined to the tip of the pin and the graduated scale while taking observations. This may produce parallax error.
4. The beam used may not be having uniform thickness and density throughout its length.
5. The tip of the pointer may not be sharp.

VIVA VOCE

Q1. What do you understand by the term beam?

Ans. A beam is a rod or a bar of uniform cross-section supported horizontally at its ends. Its length is very

large as compared to its breadth and thickness.

Q2. How is depression related to loading?

Ans. Depression is directly proportional to the load applied.

Q3. How is Young's modulus affected by increasing the load?

Ans. It is the property of the material of the beam. It has no effect on the dimension or load of the beam.

Q4. What is the effect of (i) width and (ii) thickness of cantilever on depression?

Ans. Depression decreases with the increase of width and thickness of cantilever.

Q5. Write one application of this activity you have performed.

Ans. Iron grinder is one application of this activity.

Q6. How does Young's modulus change with the rise of temperature?

Ans. Young's modulus decreases with the rise of temperature.

Q7. Write the dimensional formula of Young's modulus.

Ans. The dimensional formula of Young's modulus is, $[ML^{-1}T^{-2}]$

ACTIVITY

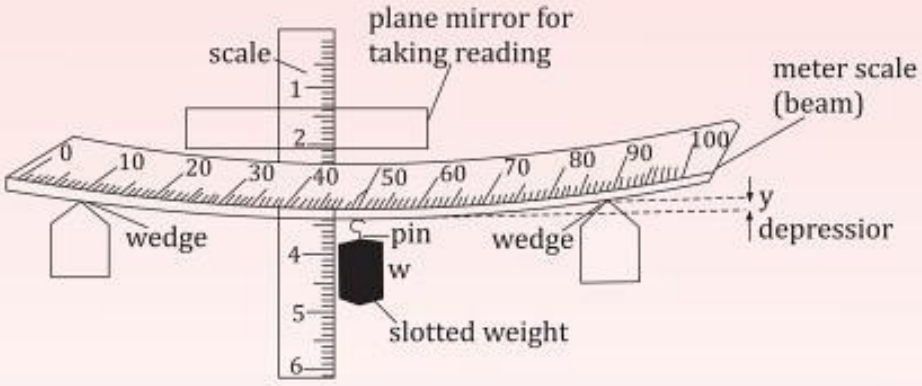
AIM

To study the effect of load on depression of a suitably clamped meter scale loaded in the middle.

MATERIAL REQUIRED

Meter scale, two wedges to rest the ends of the meter scale, thread, slotted weights each 200g, hanger for slotted weights, graduated scale with a stand to hold the scale vertical, plane mirror, pointer and plasticine.

DIAGRAM



THEORY

Description of apparatus

A horizontal meter scale is held on two wedges; a hanger is provided at the middle of the meter scale for applying load. A pointer is fixed at the mid-point to measure depression. A graduated scale with a plane mirror strip attached to it is held in a vertical position in a stand behind the horizontal meter scale.

Let a beam be loaded at the center and supported near its ends with wedges as shown in the figure. Suppose L be the length, b be the breadth, and d be the thickness of the bar which is loaded at the center by a load

$$W = mg.$$

Then, the depression y is given by,

$$Y = \frac{wL^3}{4bd^3Y}$$

Where, Y is Young's modulus of the material of the rod/beam, w is the load (mg).

Depression is directly proportional to the load (mg). Hence, there is a linear relationship between depression and load. On plotting the graph between the load (m) and depression (y) by taking them along x and y-axes respectively, we get a straight line passing through the origin.

PROCEDURE

Setting up the Apparatus

1. Find the least count of the vertical scale.

2. Place the meter scale on two wedges with 10 cm length projecting out on either side. The meter scale supported at both ends is like a beam.
3. Now, tie a loop of thread tightly in the middle of the scale placed on two wedges so that a hanger with slotted weights each 200 g can be suspended from it. It is to be ensured that the thread does not slip.
4. Place the graduated scale (having least count 0.1 cm) vertically in a stand at the center of the meter scale used as a beam. The vertical scale should be kept on the far side of the meter scale placed on the wedges. This facilitates the reading.
5. Fix a pin to the hanger such that its pointed end is close to the edge of the vertical scale which has graduation marks on it, but it should not touch the graduation marks.
6. Hold the mirror strip in a stand at the back of the beam or place the mirror on a stool using plasticine in the middle of the beam.
   NOTE: The mirror strip is used to keep away from the parallax error at the time of taking the reading.
7. Read the position of the pointer on the vertical scale when no load is suspended from the beam.

Effect of Load on the Depression of the Beam

1. Suspend the hanger of mass 200 g and note the position of the pointer attached with the hanger when the pointer comes to rest after vibration.
2. Keep on adding 200 g slotted masses gradually to the hanger and note the readings of the position of the pointer on the meter scale each time.
3. Take about six observations.
4. Now start removing the masses of 200 g one by one and note the position of the pointer on the meter scale each time while unloading.
5. Find the depression y for the load m and hence, depression per unit load (or $\frac{y}{m}$).
6. Plot a graph between depression y versus load m and interpret your result.

OBSERVATIONS AND CALCULATIONS

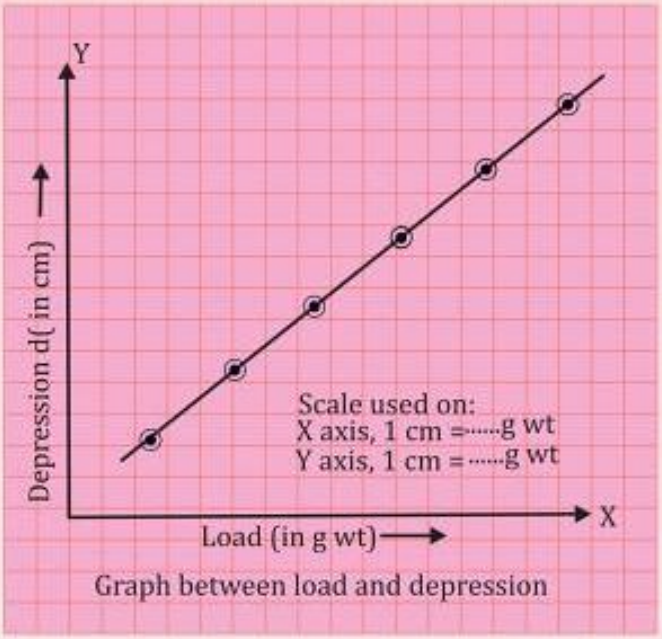
1. The least count of vertical scale = _____ cm
2. Length of the beam between the wedges, L = _____ cm
3. Width of the beam between the wedges, b = _____cm
4. The thickness of the beam, d = _____cm

Table to Study the Effect of Load on Depression of a Beam Loaded in the Middle

S. No.	Load m, (g)	Reading of the center of the cantilever			Depression for load, y (cm)	Depression per unit load, $\frac{y}{m}$ (cm/g)
		Load increasing, r_1' (cm)	Load decreasing, r_2' (cm)	Mean reading $r = \frac{r_1' + r_2'}{2}$ (cm)		
1				r_0	0	
2				r_1	$r_1 - r_0$	
3				r_2	$r_2 - r_0$	
4				r_3	$r_3 - r_0$	
5				r_4	$r_4 - r_0$	
6				r_5	$r_5 - r_0$	

From the observation table, the value remains almost constant for all observations.

PLOTTING GRAPH



Graph between load and depression

On plotting a graph between the values of depression d on y axis and load m on x axis, we get a straight line.

RESULT

It has been observed that as the load increases, the depression of the scale placed on the two wedges also increases. Hence, the depression y is directly proportional to the load m.

PRECAUTIONS

1. The beam should be placed symmetrically on the wedges.
2. The load hung should not exceed the maximum permissible load within the elastic limit.
3. The weight should be added or removed gently.
4. A mirror strip should be used to eliminate any error due to parallax in reading the scale.
5. The thickness of the meter scale placed on the wedges should be uniform and it should be as small as possible.
6. The reading should be taken after some time when the load is applied because the meter scale takes some time to come in the rest position.

SOURCES OF ERROR

Same as Activity 6 (a).

VIVA VOCE

Q1. Give any two significances of this activity.

Ans. The two signs of this activity are:

(i) It helps us to determine Young's modulus of the materials of a given rod or meter scale.

(ii) We can find that how much load we can put on the given rod or beam.

Q2. What is the main source of error in this activity?

Ans. The cantilever may not have uniform thickness and density.

Q3. After loading, one should wait for some time before noting a reading. Why?

Ans. It is because it takes some time for the oscillations generated at the time of loading to stop.

Q4. There is a need to use a plane mirror to take measurements of depression. Why?

Ans. There is a need to use a plane mirror to take measurements of depression because it minimizes any error due to parallax.

Q5. Are there certain filaments in the bar which are neither extended nor compressed?

Ans. Yes, there are certain filaments which remain unchanged or unstrained.

Q6. What is the geometrical shape of the bar that you are using as a cantilever?

Ans. The geometrical shape of the bar used as a cantilever is a rectangular bar.

Q7. How does the curvature vary along the bent beam?

Ans. The curvature is minimum in the middle and increases towards both ends.