Determination of Youngs Modulus by Flexure Method

IDENTIFY
1) The long iron beam placed on two posts. You have to find the Young’s Modulus of the MATERIAL of the beam.
2) Traveling microscope placed in front of the iron beam. Also trace the following in the traveling microscope.
   a) Eye piece
   b) Main Scale of the microscope
   c) Vernier Scale.
   d) The screw by which you can move the microscope from right to left.
   e) The screw, which can move the eyepiece up and down.
3) An iron pointer attached to the rod on which we hang weights. This rod is placed at the center of the iron bar.

DIAGRAM

THEORY:
If a light bar of breadth $b$ and thickness $d$ is placed horizontally on two knife edges separated by a distance $L$, and a load of mass $m$ is 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

$$ Y = \frac{gL^3}{4bd^3} \cdot \frac{m}{l} \quad (i) $$

Here the bar can be considered as an inverted cantilever with fixed end at the middle and load $\frac{mg}{2}$ is applied at the end at a distance $\frac{L}{2}$ from the mid-point. Hence the bending moment

$$ M = \frac{Ybd^3}{12R} = -\frac{mgx}{2} \quad (ii) $$
where, \( x \) is any distance from the supported end and at that position shearing force
\[ F = \frac{M}{x} \]  

**(iii)**

**PROCEDURE**

1) Use a micrometer screw gauge to measure the breadth and depth of the iron beam and note the data in Table 1.

2) Try to see the pin through the eyepiece of the traveling microscope. Focus the eyepiece by a screw at the side so that the pointer is seen sharply.

3) You can now see the inverted image of the pointer the tip of which has to be focused on the horizontal cross-wire.

4) Take the reading of the main scale as well as the Vernier scale. Get the total reading by adding the main scale to the Vernier scale.

5) Introduce a weight of 500gms into the slot. If you look into the eyepiece you can see the tip of the pointer moving up above the horizontal level. Adjust the vertical screw so that the tip of the pointer moves down and touches the horizontal crosswire.

6) Take the reading of the main scale and Vernier scale. Get the total reading.

7) Repeat this procedure for weights increasing from 0.0 kg to 3.5 kg in steps of 0.5 kg.

8) Also repeat the same procedure for decreasing weight, i.e., from 3.5 kg to 0.0 kg.

**EXPERIMENTAL RESULTS**

**Table 1: Determination of breadth and thickness of the bar**

**FIND THE LEAST COUNT OF THE SCREW GUAGE**

<table>
<thead>
<tr>
<th>Measuring quantities</th>
<th>No. of obs.</th>
<th>Linear scale readings (l.s.r) in m.m.</th>
<th>Circular scale reading (c.s.r) in m.m</th>
<th>Total ((l.s.r + c.s.r) \times l.c) in m.m</th>
<th>Mean In m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breadth (b)</td>
<td>1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>2.</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Thickness (d)</td>
<td>1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.</td>
<td></td>
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</tbody>
</table>
Table 2: Determination of depression of the bar with load

FIND THE VERNIER CONSTANT OF THE TRAVELING MICROSCOPE
V.C. = _______________ cm

<table>
<thead>
<tr>
<th>No. of Obs.</th>
<th>Load In K.g. (m.)</th>
<th>Reading when increasing (a)</th>
<th>Readings when decreasing (b)</th>
<th>Mean ( \frac{a + b}{2} \times 10^{-2} ) cm</th>
<th>Depression (l) in m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M.S.R in c.m</td>
<td>V.S.R in c.m</td>
<td>Total in c.m</td>
<td>M.S.R in c.m</td>
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<tr>
<td>0.0</td>
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<td></td>
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<td>1.0</td>
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<td>2.0</td>
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<tr>
<td>4.0</td>
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</tbody>
</table>

CALCULATIONS:
Draw a graph with load m along x-axis and depression l along y-axis. Find the slope

\[
\text{Length } L \text{ (m)} \quad g \text{ (m/s}^2\text{)} \quad \frac{gL}{4bd^3\text{ (s}^2\text{)}} \quad m/l \text{ (Kg/m)} \quad Y \text{ (Pa or N.m}^{-2}\text{)}
\]

MAXIMUM PROPORTIONAL ERROR CALCULATIONS:

\[
\frac{\delta l}{Y} \times 100\% = \left( \frac{\delta b}{b} + \frac{\delta d}{d} + \frac{\delta l}{l} \right) \times 100\%
\]

\( \delta b = \delta d = \text{least count of the screw gauge} \)
\( \delta l = \text{Vernier constant of the traveling microscope} \)
For maximum error use the least values