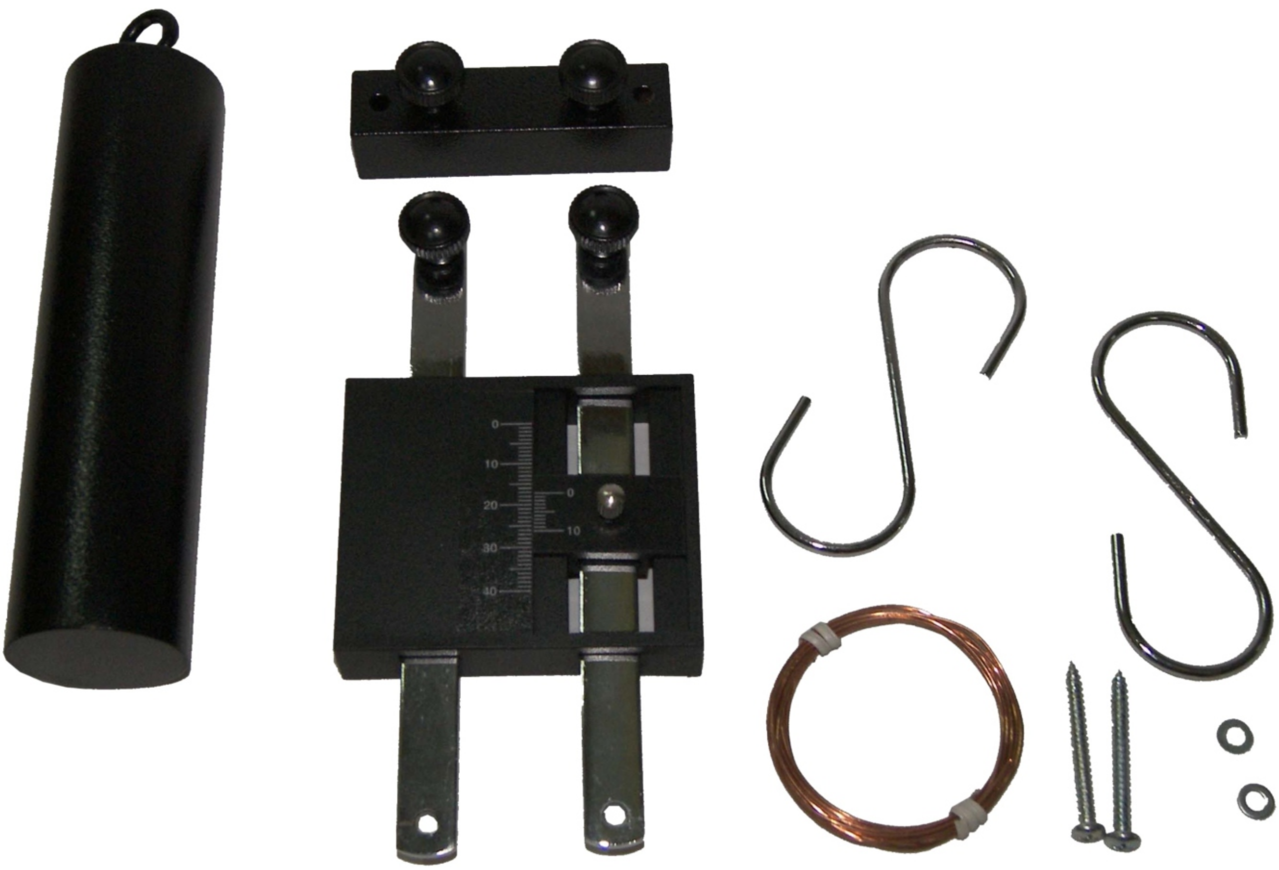
YOUNG'S MODULUS APPARATUS



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Young's Modulus Apparatus

The apparatus consists of a scale plate carrying a 0 to 30mm scale and a moving vernier readable to 0.1mm. The two bars have clamping screws to hold the wires, and ceiling bracket has a pair of corresponding clamping screws.

The ceiling bracket comes with two woodscrews to secure the bracket to a convenient overhead beam or door frame. This is typically a permanent installation in the laboratory.

Finally, 1.3kg tension weight is included.

Theory

The Young's modulus of a material describes how it behaves under a load. It is defined as the ratio of stress to strain, and is given as E:

$$E = \frac{\text{stress}}{\text{strain}} = \frac{F/A_0}{e/l} = \frac{Fl}{A_0 e}$$

F: force applied
A_0: original cross sectional area
l: original length
e: extension under load

Stress is force per unit area, or pressure, measured in Pa, and strain is a ratio of lengths so has no units. Therefore, Young's modulus is a measure of pressure and has SI units of Pa.

Requirements

To carry out the experiment requires the following:

- Set of wires
- Micrometer screw gauge
- Slotted 100g masses
- Safety goggles

Safety

The load on the wires should not exceed 2kg to reduce the risk of the wires breaking suddenly.

Safety goggles should be worn at all times during the experiment to reduce the danger presented by wires "whipping" if they break under a load.

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Procedure

1. Select two 2m lengths of similar wire.
2. Using the micrometer screw gauge, measure the diameter *d* of the wire. For best accuracy, measure at multiple points and take an average.
3. Calculate the cross sectional area A_0 of the wire, assuming it to be circular.

$$A_0 = \frac{\pi d^2}{4}$$

4. Secure the wires in the screw clamp of the ceiling bracket so they're hanging free.
5. Attach the apparatus to the bottom of the wires with the screw clamps.
6. Attach the 1.3kg tension weight to the left-hand wire – this is to remove any kinks on the wire.
7. To compensate, attach 1.3kg of slotted weights to the right-hand wire.
8. Remove and replace these loads a dozen or so times to accustom the wires to stretching.
9. Slide the vernier up to 0, taking care not to stretch the wire.
10. Add weights to the right-hand wire, and measure the extension of the wire.

Mass (kg)	Force (N)	Stress (Pa)	Extension (m)	Strain	E (pa)
1.4					
1.5					
…					

Plot the stress against strain and draw a line of best fit. The gradient is Young's modulus.

You may wish to plot Young's modulus againstforce a plot a line of best fit. What does this line tell you? If it's roughly horizontal, then the Young's modulus remains constant as the load increases. Do you think this is true for all materials?

As well as wire, you can repeat the experiment with lengths of cotton and rubber and compare the results.

Material	Wire diameters (mm)		
Copper	0.8	-	-
Brass	0.7	0.8	-
Steel	0.56	0.7	0.8

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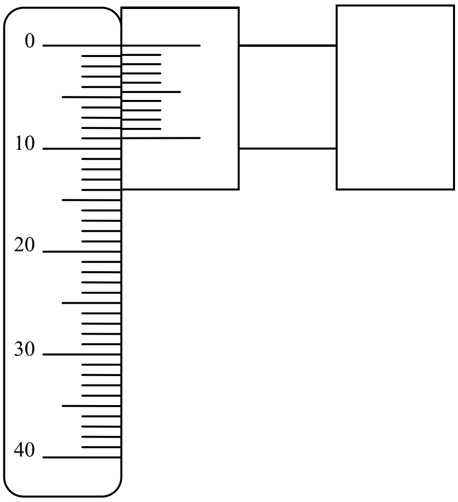
Reading the Vernier

How to read a vernier scale is not obvious at first. This brief description and set of examples should help.



Scale Set to Zero

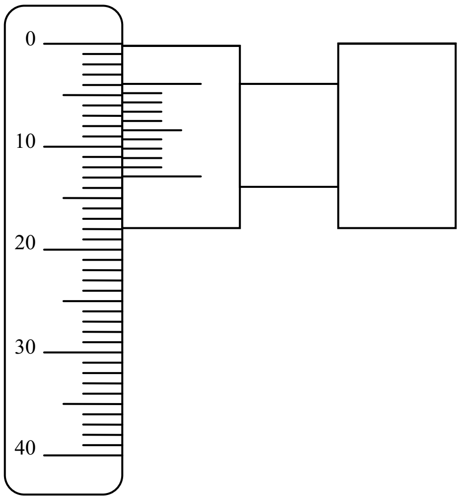
The device consists of a large, fixed scale and a smaller, moving scale. To set the vernier to zero, slide the moving scale to the top.

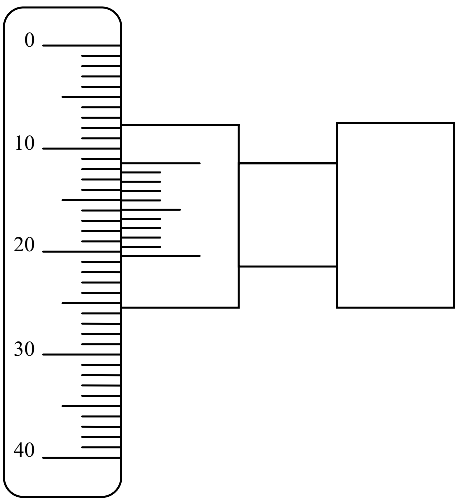
Note that the top line of the sliding scale aligns with the top line of the fixed scale, and the bottom line of the sliding scale aligns with the line *before* the next major division. The two scales are not identically spaced.

Reading the Scale

Look at the example on the right. You can see on the large scale, the small scale has moved by between 3 and 4 divisions, so it is reading 3.x mm.

To find the ".x", we need to find the *first* line on the sliding scale which best lines up with a line on the fixed scale. In this case, it's the 9th line. This means our reading is 3.9mm.





Example

Can you read the vernier on the left?

Look for the *first* line on the *sliding scale* that *most closely* lines up with a line on the fixed scale.

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