Young's modulus by uniform bending

- **Define elasticity.**

  Elasticity is the property of a material by virtue of which they regain their original shape and size after the removal of deforming forces. Such a body is called an **elastic body**.
  Example: Metals.

- **Define plasticity.**

  It is the property of a material by virtue of which they do not regain their original shape and size after the removal of deforming forces. Such a body is called a **plastic body**.
  Example: Wet clay.

- **Define stress.**

  The ratio of deforming force F acting on a body to its area A normal to the force applied.

  $$\text{Stress} = \frac{F}{A}$$

  SI unit: Nm^{-2} or Pa.

- **Define longitudinal stress.**

  Force per unit area to change the length of the body.

- **Define strain.**

  The ratio of change in dimension (length, volume, etc) of a body to its original dimension when force is applied.
  Strain has no units.

- **Define longitudinal strain.**

  The ratio of change in length ΔL of a body to its original length L when force is applied.

  $$\text{Longitudinal strain} = \frac{\Delta L}{L}.$$

- **What is elastic limit?**

  The maximum value of stress above which the relationship between stress and strain is non-linear. Within elastic limits stress - strain relationship is linear, i.e., graph of stress versus strain is a straight line.

- **State Hooke's law.**

  Within the elastic limits, stress is proportional to strain.

  $$\text{Stress} \propto \text{Strain}.$$

  $$\frac{\text{Stress}}{\text{Strain}} = e(\text{constant}).$$

  e is the modulus of elasticity, measured in Nm^{-2}.
  e is material dependent property only.

- **Define Young's modulus.**

  Young's modulus Y is defined as

  $$Y = \frac{\text{Longitudinal stress}}{\text{Longitudinal strain}},$$

$$Y = \frac{F/A}{\Delta L/L}.$$

If $\Delta L = 1\,\mathrm{m}$, $A = 1\,\mathrm{m}^2$, $L = 1\,\mathrm{m}$ then $Y = F$. Young's modulus of the material of a wire of unit area of cross section is numerically equal to the force required to double the length of the wire.

- **Say A and B are two materials of same length. If material A has higher Young's modulus than material B, what does it mean?**

  Material A requires higher deforming force than material B to elongate it by the same amount ΔL.

Material	Y(GPa)
Aluminium	69
Copper	117
Brass	120
Iron	170
Nickel	210
Steel	200

Table 1: Young's modulus of some materials (No need to memorize this table).

- **How is the least count for the traveling microscope calculated?**
- **What is the purpose of using the traveling microscope in the experiment?**
- **Why is the method called uniform bending method?**

  The load is attached equally on either sides of the material. As the load increases, the material bends and the pin placed in the centre elevates. The bent material forms an arc of uniform radius of curvature, hence the name.

- **In the experiment, the material is bent by applying load. How then are we determining Young's modulus, which has to do with elongation and contraction of the material?**

  The material can be assumed to be made of many layers from top to bottom. When the material bends the bottom layer contracts and the top layer elongates. Somewhere in the middle there is a neutral layer which neither contracts nor elongates when bent. So, when load is applied, elongations and contractions occur in the material. In this sense, we measure the Young's modulus by measuring the elevation of the pin (the elevation of the beam is related to the Young's modulus).

- **Does changing the length, breadth or mass of the material change the value of Young's modulus?**

  Young's modulus depends only on the nature of the material, independent of the rest.

- **What is the purpose of taking more than one trial for the same load?**

  There is always a possibility that we make mistakes while taking readings from the instrument. Taking more number of trials and averaging will reduce errors.