XIX IBERO-AMERICAN PHYSICS OLYMPIAD
ASUNCION – PARAGUAY
30 – SEP – 2014
EXPERIMENTAL EXAMINATION

Experimental determination of a metal's Young modulus

A rod of length L_0 deforms by ΔL under force F; see Figure 1.'

Strain ϵ is the length change per unit original length $\left(\epsilon = \dfrac{\Delta L}{L_0}\right)$. The force per unit cross-sectional area of the rod $\sigma = \frac{F}{A}$ is called *stress*. For an elastic body at small strain:

$$\sigma = Y\epsilon.$$

The constant Y is the *Young modulus*, the elastic modulus of the rod material.

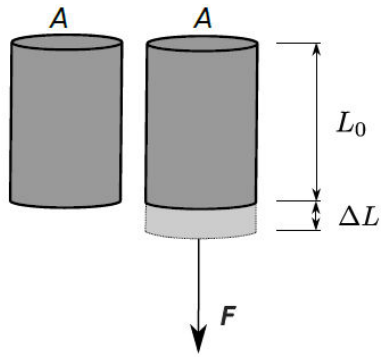


Figure 1: A wire of length L_0 and cross-section A extends by ΔL under force F. '

Here we determine Young modulus from the bending of a rod under a transverse force. Hanging mass m from a rod with a fixed point bends it by an amount depending on its geometry (Figure 2). For a uniform-section rod of negligible mass, the deflection is:

$$y = \frac{mg}{2YI_a}\left(Ld^2 - \frac{d^3}{3}\right), \tag{1}$$

where L is rod length, d the distance from the fixed point to the load, and I_a the *second moment of area*:

$$I_a = \frac{ba^3}{12}, \tag{2}$$

where a is rod thickness and b its width.

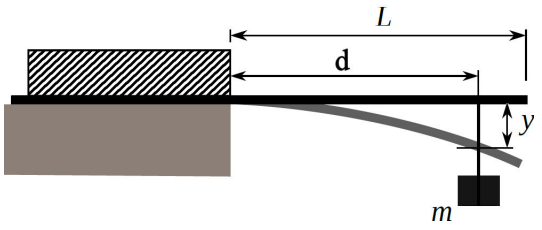


Figure 2: Bending of a rod under load.

The following equipment is supplied:

- Rod approximately 1 m long.
- Measuring tape.
- Two clamps.
- Two wooden boards.
- Labelled masses, weighed with an electronic balance of precision 0,01g.
- Vernier caliper.
- Graph paper.
- Thread.
- Adhesive tape.

Considerations and questions:

1. Report a, b, d and L and the instruments used to measure them. To minimise the effect of rod mass, it is recommended that L be less than or equal to 0,60 m. (2.0 points)
2. Measure transverse deflection y versus suspended mass m and tabulate the data. (5.0 points)
3. Plot the tabulated data. (2.0 points)
4. Determine the material's Young modulus. (6.0 points)
5. Estimate the uncertainty in Y and justify your estimate. (5.0 points)

Express the result in SI units. Use $g = 9{,}81\ \text{m/s}^2$.