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T3 – Elasticity of solids. Young's Modulus

Objective

- Study of the elasticity of solids. Determination of Young's modulus of materials.

Introduction

When forces are applied to a body, both its shape and dimensions can change. The corresponding deformations depend on the applied forces. Often, the deformation disappears when the sample is no longer under the action of these forces, returning to its initial configuration. In this situation, the behavior of the material is said to be **elastic** and is characteristic of many materials, within certain limits, particularly for small applied forces. When exceeds the elasticity limit, the solid does not return to its initial condition, thus having a permanent deformation. If we subject the solid to gradually increasing tensile forces, it initially undergoes elastic deformation (reversible), then plastic deformation (irreversible), and finally the rupture. This behavior is illustrated in figure 1 where a curve of stress/strain:

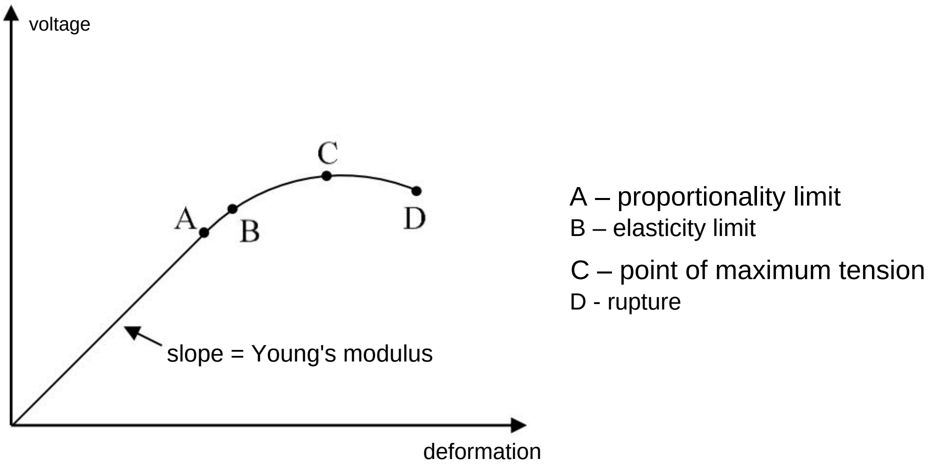

Figure 1

In the elastic region, the applied stress, ÿ, is proportional to the deformation ÿ, that is:

=

To the proportionality factor, E, that exists between stress and strain in the elastic region, when the material is subjected to stresses lower than that at point A, it is called **Young's modulus** and is characteristic of the material of which the sample is composed. Young's modulus can then be determined by the slope of the stress-strain curve in the elastic region.

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To determine Young's modulus in this work, the bending of a bar is used (fig. 2). The theory of elasticity of materials shows that a bar of rectangular cross-section subjected to a force of traction F, as indicated in figure 2, undergoes a bending X, at a distance ***y*** from the support, given by:

$$= \frac{(3\ {}^{2}\ \text{ÿ}\,4\ {}^{3})}{4\ \text{ÿ}\ 3}$$

Measuring the bending ***X*** of the center of the sample, Young's modulus, E, will be given by:

$$= \frac{(3\ {}^{2}\ \text{ÿ}\,4\ {}^{3})}{4\ \text{ÿ}\ 3}$$

where ***L*** is the length of the bar, ***b*** its width and ***h*** its thickness. As in the center of the sample *y = L / 2,* Young's modulus comes:

$$= \frac{{}^{3}}{4\ \text{ÿ}\ 3}$$

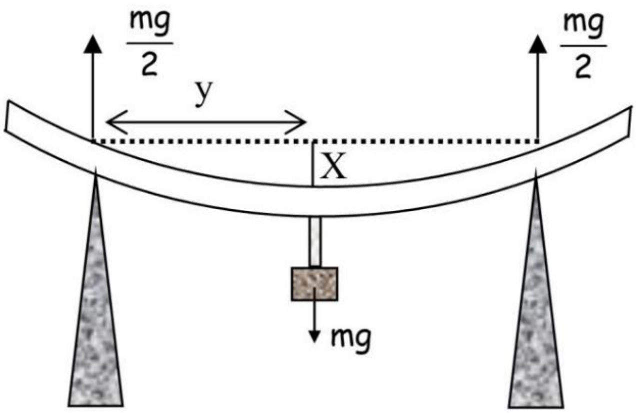

Figure 2

Samples

glass; aluminum; steel; brass; copper

Experimental Procedure

- Measure as accurately as possible the dimensions of the bar ***(L, b*** and h)

- Place the bar on the support and adjust the positioning of the measuring device's scale.

- To determine Young's modulus, measure the deformation of the bar as a function of loads different, **progressively increasing to the maximum** (without breaking or deforming permanently) the samples) **and decreasing equally.**

- Repeat the procedure for the different materials available.

Results

- Plot the stress *vs.* strain graph for each material.

- Identify the main causes of uncertainty associated with this process.

- Determine Young's modulus and compare it with the values indicated in the table*.

material	**Young's Modulus (N/m2)**
glass	(40 – 90) ÿ 109
aluminum	(41 – 73) ÿ 109
	(190 – 220) ÿ 109
brass steel	98 ÿ 109
copper	123 ÿ 109

* These values should be taken as indicative, since factors such as the degree of purity of the elements, their oxidation state and the precise composition of the alloys studied (steel and brass).