Laboratory 3: Calculate Inertia / Measure Deflection / Estimate Modulus of Elasticity

The deflection of a cantilever beam is a function of the applied load, the position of the load, the material's stiffness, the beam's cross sectional area and shape. The Modulus of Elasticity measures the material's stiffness. The area moment of inertia accounts for both the overall shape and the amount of material. The flexural rigidity is an indication of a beam's ability to resist bending.

We will design and build a composite beam and calculate the area moment of inertia using the equations for the appropriate cross section and the parallel axis theorem. Using the materials provided, we must construct the beam, mount it as a cantilever beam and apply a known load. The deflection will then be measured. Applying the equation for the maximum deflection of a beam we will estimate the material's modulus of elasticity. This will be repeated in a least two other configurations and the results compared. It is important to note all sources of errors and to carefully describe how your beam is constructed and tested so that your experiment can be repeated by others.

$$\delta = -\frac{PL^3}{3EI}$$

$\delta =$ maximum deflection

$P =$ load

$L =$ length

$E =$ modulus of elasticity

$I =$ area moment of inertia

$EI =$ flexural rigidity

Rectangle

$$I_{x_c} = \frac{bh^3}{12}$$

$$I_{y_c} = \frac{b^3h}{12}$$

$$I_x = \frac{bh^3}{3}$$

$$I_y = \frac{b^3h}{3}$$

Parallel Axis Theorem

$$I_x = I_{x_c} + Ad^2 = \frac{bh^3}{12} + (bh)\left(\frac{h}{2}\right)^2$$

Circle

$$I_{x_c} = I_{y_c} = \frac{1}{4}\pi r^4$$

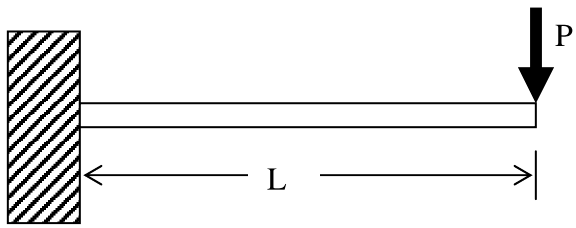

Figure 1: Cantilever Beam

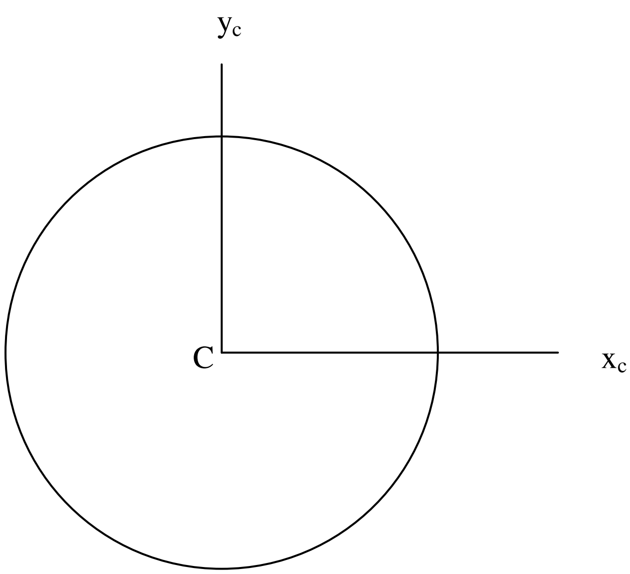

Figure 2: Circle with Coordinate System

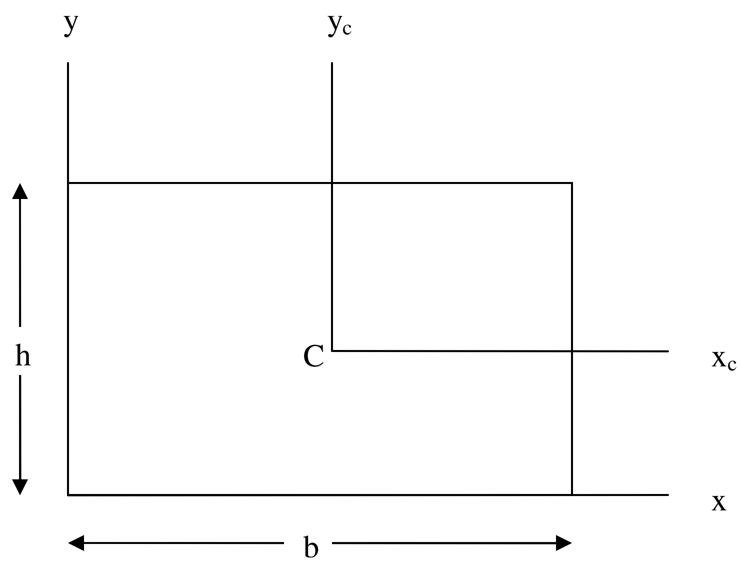

Figure 3: Rectangle with Coordinate Systems