Experiment 11
Torque and Moment of Inertia

by

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Introduction

The purpose of this experiment is to explore the various physical properties of torque, moment of inertia, and center of mass.

Data

(See attached pages)
**Data Analysis**

*Part 1*

The torque is given by the cross product of the position vector and the corresponding force acting on it. To determine the first torque in the data set, for instance:

\[ \tau = r \times F \]

\[ \tau = 24 \cdot (-2.009) \cdot \sin(142) = -0.0297 \text{ Nm} \]

The sum of the torques acting on an object at equilibrium should be zero. Any leftover torque is residual, and determines error for the computation:

\[ \frac{\tau_{\text{res}}}{\tau_{\text{min}}} = \frac{-0.035}{0.009} = 3.52\% \]

*Part 3*

The second moment of inertia is given by:

\[ I = \iint r^2 \, dm \]

\( dm \) refers to linear mass density. Since we are dealing with area mass density, we need to deal with change in both axes, therefore \( dx \ dy \). This is the change in area. Once all substitutions have been made, inertia is given by:

\[ I = \frac{M(a^2 + b^2)}{3} \]

Experimental values for inertia are determined using periods. The results can be compared:

\[ I = \frac{T^2 M g h}{4\pi^2} \quad I = \frac{M(a^2 + b^2)}{3} \]

\[ I = \frac{(1.1)(239 \text{ g})(26.6\text{ cm})g}{4\pi^2} \quad I = \frac{(239\text{ g})(81 \text{ cm}^2 + 324 \text{ cm}^2)}{3} \]

\[ I = 0.0173 \quad I = 0.00322 \]
**Discussion**

The first part of the experiment was relatively successful. A small percent error was obtained, since there was little residual torque present. An intrinsic error might result from the fact that the friction in the pulleys and the springs might make the system appear at equilibrium while, in fact, it is not.

The third part of the experiment, instead, was beyond experimental limits by orders of magnitude. Although factors such as friction and air resistance might have affected the result, the error is so great that something else must have been done incorrectly to obtain such results.

**Conclusion**

Torques and centers of masses were explored successful throughout the experiment. Part 2 was not included in this report, but was successful. The part concerning moments of inertia was less successful, and yielded a high percentage error.