

Name: _____

LAB 14. PHYSICAL PENDULUM

Introduction

Sometimes it is useful to know the rotational inertia of an object; for instance, in automobile collision analysis. In this lab, we will experimentally determine a rotational inertia of an object from its behavior as a physical pendulum.

Theory

An extended object hanging from an axis of rotation that does not pass through its center of mass acts as a pendulum. When its center of mass is directly below the axis; its weight mg produces no torque; however, when its center of mass is displaced by an angle θ , its weight produces a restoring torque τ of $-Lmg \sin\theta$, where L is the distance from the axis to the center of mass. If θ is small, we can make the small-angle approximation that $\sin\theta \approx \theta$, measured in radians. Then the pendulum behaves as a torsional Hooke's law oscillator with angular frequency ω set by $\omega^2 = Lmg/I$, where I is its rotational inertia. Therefore, I can be calculated from ω , L , and m .

By the parallel axis theorem, the rotational inertia I of the pendulum about its axis is $I = I_{CM} + mL^2$. So, $I_{CM} = I - mL^2$.

Experiment

In this activity you will measure the mass, find the center of mass of, and time the oscillations of a physical pendulum. From that, you will determine ω , I , and I_{CM} .

Supplies

Hoop, clamp stand, clamp with knife edge, stopwatch.

Data Collection

Setup

1. Measure the mass and dimensions of the hoop.

Mass: _____ Inner diameter: _____ Outer diameter: _____

2. Hang the hoop on the knife edge.

Measurements

1. Displace and release the hoop so that it swings back and forth.
2. Time a whole number of complete cycles of the oscillation. Use at least ten oscillations; more if the oscillation is rapid. Start the timer on "zero" and stop at the desired number of oscillations.

Number of oscillations: _____ Time: _____

Derivations

1. Write the formula for ω^2 in terms of T .

2. Solve $\omega^2 = Lmg/I$ for I .

3. Simplify $I_{CM} = I - mL^2$.

Data Processing

Show your work.

1. Divide the time by the number of oscillations estimate the period T .

T : _____

2. Calculate ω^2 .

ω^2 : _____

3. Calculate I_{CM} .

I_{CM} : _____

Analysis and Discussion

1. What is the theoretical moment of inertia I_{CM} of the object about its center of mass? Use the appropriate formula and the dimensions and mass of the pendulum.

2. Does your empirical I_{CM} match the theoretical I_{CM} ?

3. Comment on your empirical and theoretical I_{CM} .

Lab Report

Turn this in.