

Physical Pendulum

Equipment

1	Rotary Motion Sensor	PS-2120A
1	Rotational Inertia Accessory	ME-3420
1	Large Rod Base	ME-8735
1	45 cm Rod	ME-8736
Required but not included:		
1	550 Universal Interface	UI-5001
1	PASCO Capstone Software	
1	Meter Stick	SE-8827

Introduction

The rod (shown in Figure 1) oscillates as a physical pendulum. The period is measured directly by the Rotary Motion Sensor, and the value is compared to the theoretical period calculated from the dimensions of the pendulum.



Figure 1: Setup

Theory

The period of a physical pendulum (for small oscillations) is given by

$$T = 2\pi\sqrt{I/Mgx} \quad (1)$$

where I is the rotational inertia of the pendulum of mass, M , and " x " is the distance from its center of mass to the pivot point.

For the rod of length, L , the pivot point is the hole near the end (see Fig. 2), a distance " x " from the center of mass. Combining the rotational inertia of a thin rod about its center of mass ($I_{\text{rod}} = 1/12 ML^2$) with the Parallel Axis Theorem and Equation (1) yields

$$T_{\text{Rod}} = 2\pi\sqrt{\frac{\frac{1}{12}L^2 + x^2}{gx}} \quad (4)$$

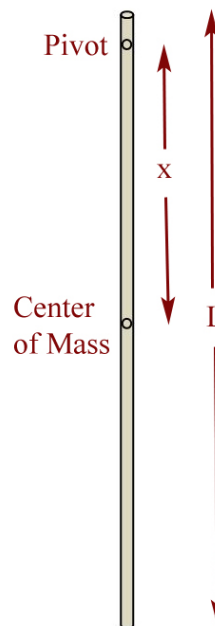


Figure 2: Rod

For the rod, the distance x is not just $1/2 L$, and must be measured separately. You can assume the center of mass of the rod is at the center hole, or you can try to balance it to find the position more accurately. Measurements are made in the last section (Analysis).

Setup

1. Use the base and 45 cm rod to support the Rotary Motion Sensor as shown in Figure 1.
2. Plug the sensor into the interface.
3. In PASCO Capstone, set the sample rate to 100 Hz.
4. Create a graph of Angle (in degrees) vs. Time.

Procedure

1. Attach the rod to the pulley of the Rotary Motion Sensor as shown in Figure 1. Note that the largest step on the pulley is facing away from the Rotary Motion Sensor.
2. With the pendulum stationary, zero the sensor.
3. Take a run of data for low amplitude ($<10^\circ$) and use the coordinates tool to measure the period.
4. Take several runs and calculate the average period.

Note: You can also use a Sine curve fit to measure the period.

Analysis

1. Use the meter stick to measure the total length, L , of the rod. Measure the distance, x , from the end pivot hole to the rod's center of mass.
2. Use equation (2) to calculate the theoretical period of the rod. Compare to the measured period using percent difference and record your answers.
3. The period of a physical pendulum appears, from Equation (1), to depend on the mass of the pendulum. Why did you not have to measure the mass of the disk and rod?