Large Amplitude 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

This experiment explores the oscillatory motion of a physical pendulum for both small and large amplitudes. Waveforms are examined for angular displacement, velocity and acceleration, and the dependence of the period of a pendulum on the amplitude of oscillation is investigated.

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. In PASCO Capstone, set the sample rate to 50 Hz. Create a graph of Angle (in degrees) vs. Time.

3. Attach the black rod to the pulley of the Rotary Motion Sensor using the thumbscrew. Note that the large step of the pulley is facing away from the Rotary Motion Sensor.

4. Place the two brass masses on the black rod. One mass should be even with the end of the rod. Position the other to leave about 3 cm of rod exposed above the mass.

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Figure 1. Pendulum Oscillating at Large Angles

Procedure: Small Amplitude

1. With the pendulum stationary, zero the sensor.

2. Take a run of data with the amplitude between 10° and 20°. You only want two or three periods.

3. Rename this run "Small".

4. Does the data look sinusoidal? Try a Sine curve fit.

5. Use the Capstone calculator to create the following calculations:

    vel = derivative(15,[Angle (rad)],[Time (s)])   with units of rad/s
    accel = derivative(15,[vel (rad/s)],[Time (s)])   with units of rad/s²

6. Add two new vertical axes to the graph and put the angular velocity calculation (vel) and the angular acceleration calculation (accel) on them. Does that data look sinusoidal?

Procedure: Large Amplitude

1. Take a run of data with the amplitude greater than 160°. You only want two or three periods.

2. Rename this run "Large".

3. Does the Angle data look sinusoidal? Try a Sine curve fit.

4. Do the angular velocity and the angular acceleration data look sinusoidal?

Dependence of Period on Amplitude

θ_o (°)	T (s)
5	
10	
20	
30	
40	
50	
70	
90	
110	
130	
150	
170	

1. Create a table with two columns. Create User-Entered Data sets for each column and fill the column with the initial angle (θ_o) with the values shown.

2. Take a run of data with an amplitude of approximately 5°. You want to measure the period over several oscillations, with the amplitude being 5° during the middle of the measurement. Use the Delta (coordinates) tool.

3. Record the period in the table.

4. Repeat for the other values in the table.

5. Create a graph of T vs. θ_o.

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6. Textbooks usually claim that the period of a pendulum is independent of amplitude for "small angles". Looking at your data, how small does the amplitude need to be for this to be true?

7. You only took data up to 170°. In theory, what is the period for 180°?