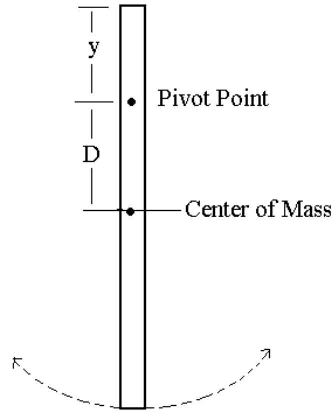
AP Physics C – The Physical Pendulum

Purpose: To experimentally determine the minimum period of a physical pendulum as the point of rotation changes and calculate at what distance this point of rotation must be away from the center of mass.



Materials: Hurricane strapping with pre-drilled holes, table stand, stopwatch

Pre-Lab Analysis: *Include in Introduction*
Here we have a rectangular piece of metal that is basically rotating around a fixed point of rotation. At first you might think that to find the MOMENT OF INERTIA for this rectangular piece of metal you would use:

$I = \frac{1}{12} M(a^2 + b^2)$,with "a" and "b" being the sides of the rectangle. But when you take the actual measurements you discover that you get the same answer as if this behaved as a THIN ROD. $I_{ThinRod} = \frac{1}{12} ML^2$, so using this is just fine!

HOWEVER: Our "rod" is NOT rotating around the center of mass. **Using the PARALLEL AXIS THEOREM, calculate the moment of inertia for this "rod" in terms below. Use the picture above as a guide for the terms to use.**

$$I_p = I_{cm} + MR^2$$

Procedure:

1. Slide the strapping on a horizontally mounted rod so that the strapping can rotate freely back and forth. Support the strapping on each side so it does not wobble side to side as it rotates.
2. Pull back the pendulum **LESS** than 10 degrees measured from the vertical.
3. Use the stopwatch to time 10 swings.
4. Measure and record the displacement between where the strapping is rotating as the CENTER OF MASS as "D"
5. Repeat the entire procedure for all of the displacement holes.

Data Table

Trial	Time for 10 swings	Period(T)	D	T^2
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

The equation for the period of an oscillating physical pendulum is: $T = 2\pi\sqrt{\frac{I}{mgD}}$

Insert the expression you derived for the **MOMENT OF INERTIA (I)** of the strapping earlier and COMPLETELY reduce the resulting fraction. The actual expression you should get is below. Show all to work to prove that the period of a pendulum with a variable "D" is:

$$T = 2\pi\sqrt{\frac{(L^2 + 12D^2)}{12gd}}$$

Now SQUARE both sides of the equation to get a more convenient expression for T^2. Keep the expression under the radical in parenthesis and DO NOT distribute the 4, pi, or g.

Separate the expression in the parenthesis so that you have TWO fractions that are ADDED together.

Is there a "D" in each fraction?

What is the **relationship** between the PERIOD and D for **<u>EACH</u>** fraction?

Using your DATA make a graph of T^2 (y-axis) vs. D (x-axis)

Suppose we wanted to know WHERE on the GRAPH is the expression a MINIMUM.
In other words, I want to know when the PERIOD a minimum**. Looking at the graph, what do you notice about the SLOPE of the line at the minimum period?**

And what does the slope of the line represent in CALCULUS?

What can we label the 4, pi, and "g" as? Do we have to use them?

Using the TI-89, enter the PART of expression that is CHANGING and find the derivative with respect to “D”. **Show the expression below.**

Using your graph, IDENTIFY the value of the PERIOD and the Distance from the CM or “D” when the SLOPE is a MINIMUM.

Period at minimum slope = ________________________

Distance from CM = ______________________

Since you found the derivative and you know that when the PERIOD is a minimum the slope is ZERO. Set your derivative equal to ZERO and SOLVE for D using the period from the graph. First show the expression in terms, then calculate.

Determine a % difference between the CALCULATED displacement and the MEASURED displacement below.

Did your sketch of the graph look anything like the ACTUAL graph plotted? Compare and Contrast the two graphs.