You Spin Me Right Round (Circular Pendulum) Lab

Oscar Rodriguez

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1 Synopsis

This lab's focus was to observe the uniform circular motion of a pendulum and how the change in certain properties will affect the time it takes to make one full revolution (full circle) also known as the period.

2 Bill of Materials

Here's a bulleted list of materials that you will need to re-create this lab.

- Sturdy table
- Clamps with adjustable rods and proper knobs
- A roll of string to be able to cut different lengths of rope
- Pendulum bobs of various masses
- A small scale to measure the pendulum bobs
- Portable white-board
- Dry erase markers
- Measuring tape or meter stick
- Stop-watch
- Scientific calculator

3 Procedure

Before beginning the lab, I illustrated a free-body diagram of a pendulum in uniform circular motion. As well as organize the forces using Newton's Second Law.

3.1 Free-body Diagram & Newton's Second Law Derivations

Free-Body Diagram

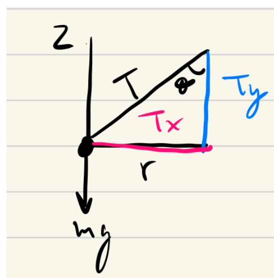

Figure 1: Free-body diagram of a pendulum in uniform circular motion with the axis and forces labeled

3.2 Z Axis Forces Derivation

$$T\cos\theta - mg = 0$$

$$T\cos\theta = mg$$

$$T = \frac{mg}{\cos\theta}$$

We can then substitute this into our T variable in our radial forces derivation.

3.3 Radial Forces Derivation

$$\sum F = \frac{mv^2}{r}$$

$$\frac{rT}{m} = v^2$$

$$v = \sqrt{\frac{rT\sin\theta}{m}}$$

$$v = \sqrt{Lg\sin\theta\tan\theta}$$

With our forces decomposed, we can now begin to set up our lab environment and collect numerical data points. We'll revisit these derivations later.

3.4 Lab Environment Setup

First, we had to attach the rods and clamp them to the table, which would enable us to tie the string and bob and create our circular pendulum.

Secondly, we decided on a length for the first string and the radius for our first path. We then sketched an outline of our desired circular path on the whiteboard to ensure that our pendulum was in a circular motion.

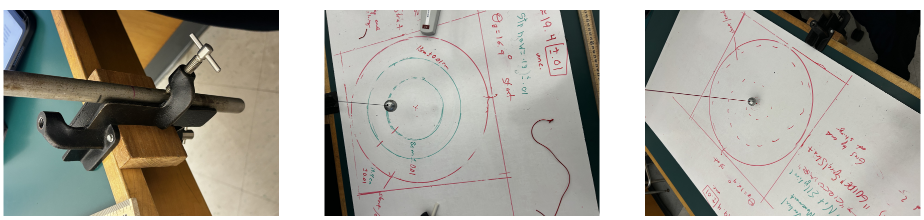

Figure 2: Initial Lab Setup

4 First Trial

4.1 Measurements of System's Components

We decided to make the radius of the first path 19.4 cm. The length of the string was 66.4 cm (+/- 0.02 cm), the mass of the pendulum bob was 23.51 g (+/- 0.6 g), and the mass of the string was 0.6 g. With the use of trig, our angle from the top z axis intersect was $\sin^{-1}\left(\frac{r}{\ell}\right)$, which renders 16.9°.

Parameter	**Value**
Length of string	$66.4 \pm 0.02\,cm$
Mass of pendulum bob	$23.51 \pm 0.6\,g$
Weight of string	$0.6\,g$
Radius	$19.4\,cm$
Angle measurement	$16.9°$

Table 1: Measured parameters of the pendulum setup.

Note: Upon completing our first measurements and suspending our pendulum bob, we developed a technique that will allow us to set the pendulum onto a uniform circular motion around our intended circular path. The technique requires you to lightly pinch the string from above and slowly "stir" the string in a circular motion, creating momentum. Once the bob begins to pick up circular acceleration, you have to then guide it gently around the traced path, and once you have the desired motion, let go and pay attention for when the bob is no longer in uniform circular motion.

4.2 Data Points of 1st Trial

Here's the table data of the measured period times. After setting the pendulum in motion, we took multiple time readings with a stop watch each time the bob made a full revolution.

Period	**Time (s)**
1	1.52
2	1.67
3	1.62
4	1.55
5	1.53
6	1.62
7	1.57
8	1.65

Table 2: Eight recorded period measurements for the pendulum.

4.3 Trial Analysis

To find the tension in our first trial, we will construct a free-body diagram and revisit our z component derivation from section 3.2.

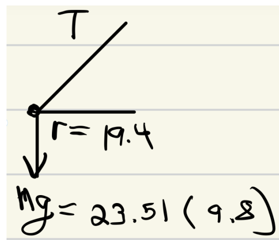

Figure 3: Trial 1 Free Body Diagram

$$T\cos\theta - mg = 0$$

$$T\cos\theta = mg$$

$$T = \frac{mg}{\cos\theta}$$

If we plug in our known variables to find tension, we get:

$$T = \frac{23.51 \times 9.8}{\cos(16.9°)} = 241\,\mathrm{N}$$

For further trials, we'll be using the same derivation to solve for tension, given their respective variables.

5 Trials 2 - 5

The first property we began to alter was the radius. We shortened the radius from 19.4 cm to 13 cm for the second trial and 8 cm for the third trial. The average periods for both of these trials were virtually identical, at 1.6375 for the second trial and 1.6475 for the third trial.

After realizing that the change in radius wasn't going to affect our period, we decided to experiment with a change in mass.

In our fourth trial, we added 20 g to our preexisting 23.51 g, totaling 43.51 g, which yielded a change in tension to 446 N with barely any change in period to 1.57 s.

In our fifth trial, we added another 50 g to get a new total mass of 93.51 g. The only property that was altered again was our tension, at an astonishing 958 N. The period stayed virtually identical to our previous trials at a negligible 1.56 s.

5.1 Graphs Representing Negligible Differences In Periods Due To Radius and Mass

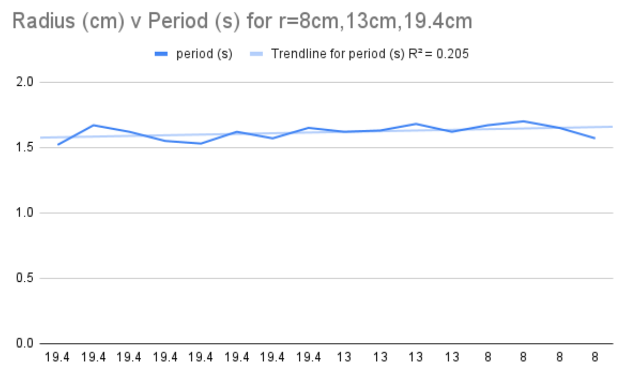

Figure 4: Negligible Difference In Period With Respect To A Change In Radius

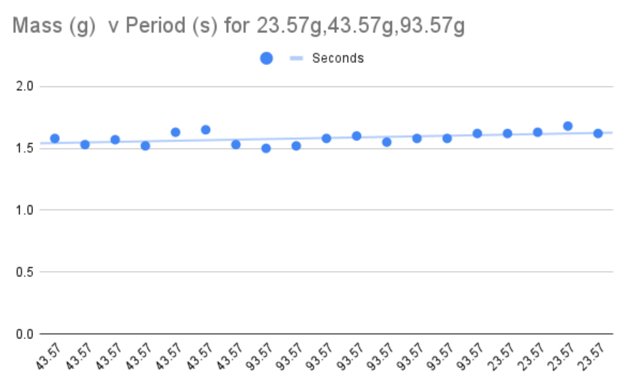

Figure 5: Negligible Difference In Period With Respect To A Change In Mass

6 The Trial That Altered The Period!

The last thing we figured we could alter was the length of the string. Upon doing so, we changed the length of our string and went back to using the original mass and radius. Upon running the trial, we noticed that the period made a drastic change! It had slowed down by a whole second!

6.1 Length Vs Period Graph

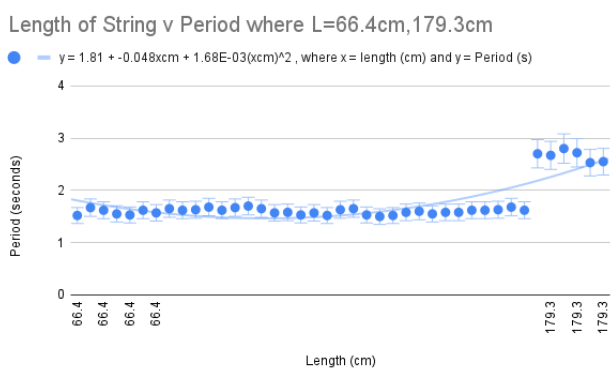

Figure 6: Length Vs Period Graph With Error Line