Name: ________________________ Period: ________ Date: ______________________
Lab Partners: ____

Lab: Simple Harmonic Motion: Pendulum

Mr. Fineman

Objective:

Students will determine the factors that affect the period of a pendulum, and explain how their experimental results differ to theoretical results.

Materials:

(1) Ring Stand	(1) Ring Stand Clamp	(1) String with Tied Loop
(1) Meter Stick	(3) Masses – 50g, 100g, 200g	(1) Stopwatch (cell phone)

Purpose

Simple Harmonic Motion (SHM) occurs everywhere in our lives. Most of the time, this motion is too fast or too small for our eyes to see. Understanding SHM will serve as the foundation for more interesting topics, such as waves, light, and sound.

When a pendulum swings back and forth, it is said to be ***vibrating*** in SHM. The time (in seconds) it takes for a pendulum to complete *one* complete vibration is known as its ***period.*** The inverse of this – the number of waves that pass by in one second – is known as ***frequency*** (measured in Hz).

In today's lab, we will predict and test which factors affect the ***period*** and ***frequency*** of a pendulum. Using our results, we will compare it to the theoretical calculations for the period of a wave, and question why there are differences between what we should find and what we see.

Procedure

Pre-Question 1: How do you anticipate the ***mass*** of the pendulum affecting the ***period*** of the pendulum? Explain.

Pre-Question 2: How do you anticipate the ***length*** of the pendulum affecting the ***period*** of the pendulum? Explain.

Name: ________________________ Period: ________ Date: ______________________
Lab Partners: ____

1. If your string does not have a loop tied on the end of it, please tie one. The masses in today's lab will be hung from this loop.

2. Hang your string from any of the three suspension points on the clamp, which should be attached to the ring stand.
    a. The string may be shortened by looping the string about the suspension points.

3. The length of a pendulum is defined as the **distance from the top of the string to the middle of the mass**. Attach the 50g mass to the loop, and ensure that your pendulum measures a length of 55 cm.

4. Next, pull the pendulum back and prepare to release it. ***You are going to count the number of full swings the pendulum makes in 30 seconds***. (A full swing in considered when the mass swings and returns to its original starting position.) Release the pendulum.
    a. Write the number of swings you measured in Table 1 in the **Data** section.

5. Next, calculate the average number of swings that occurred per second. Write this answer down in Table 1 under "*Swings per Second*"

6. What you have just calculated is the ***frequency*** of the pendulum. To find the ***period*** of the pendulum, use the following formula:

$$Period = \frac{1}{Frequency}$$

    a. Write the period of the pendulum in Table 1 under "Period of Pendulum"

7. Next, replace the 50g mass with the 100g mass. Re-adjust the length of the pendulum so the distance from the top of the string to the middle of the mass remains 55 cm.
    a. Repeat steps 4 – 6 for the 100g mass.
    b. When you are finished using the 100g mass, replace it with the 200g mass, and repeat steps 4 – 6.

8. After you have found the period of the pendulum using the 3 masses, reduce the length of the pendulum to **50 cm**. Repeat steps 4 – 7 while filling out Table 2 in the **Data** section.
    a. When you are finished, reduce the length of the pendulum to **45 cm** and repeat steps 4 – 7 while filling out Table 3.
    b. Next, reduce the length of the pendulum to **40 cm** and repeat steps 4 -7 while filling out Table 4.
    c. Finally, reduce the length of the pendulum to **35 cm** and repeat steps 4 – 7 while filling out Table 5.

Name: ________________________ Period: ________ Date: ______________________
Lab Partners: ____

Data ***YOU NEED TO GET THIS PART OF THE LAB FINISHED IN CLASS***

Table 1 – 55 cm Pendulum Information

Mass on Pendulum (grams)	Swings in 30 sec.	Swings per Second (Hz)	Period of Pendulum (s)
50			
100			
200			

Table 2 – 50 cm Pendulum Information

Mass on Pendulum (grams)	Swings in 30 sec.	Swings per Second (Hz)	Period of Pendulum (s)
50			
100			
200			

Table 3 – 45 cm Pendulum Information

Mass on Pendulum (grams)	Swings in 30 sec.	Swings per Second (Hz)	Period of Pendulum (s)
50			
100			
200			

Table 4 – 40 cm Pendulum Information

Mass on Pendulum (grams)	Swings in 30 sec.	Swings per Second (Hz)	Period of Pendulum (s)
50			
100			
200			

Table 5 – 35 cm Pendulum Information

Mass on Pendulum (grams)	Swings in 30 sec.	Swings per Second (Hz)	Period of Pendulum (s)
50			
100			
200			

Name: ________________________ Period: ________ Date: ______________________
Lab Partners: ____

Data Analysis

1. What did you notice about the period of the pendulum as the **mass** at the end of the pendulum changed? ____
____
____

2. What did you notice about the period of the pendulum as the **length** of the pendulum changed? ____
____
____

   a. Based on your results above, what factor has the most significant effect on the period of a pendulum? ____________________________________

   b. Thinking about how far the pendulum swings when oscillating, why does this make sense? ____
   ____
   ____
   ____

   c. Knowing what you know about the rate in which heavy objects fall compared to lighter objects, why do your findings make sense? _________________________
   ____
   ____
   ____

The formula for the period of a pendulum is:

$$Period = 2\pi\sqrt{\frac{Length\ of\ Pendulum}{Acceleration\ due\ to\ Gravity}}$$

3. Looking at the formula above, what other factor *(that we can't test in this classroom)* affects the period of a pendulum? ____________________________________

   a. Theoretically speaking, if we had a LOT of money and resources at our disposal, how could we have changed this lab to test this this variable?
   ____
   ____
   ____
   ____

Name: ________________________ Period: ________ Date: ______________________
Lab Partners: ____

For the final portion of this lab, let's compare how your results differed from what we theoretically should have gotten for the period of a pendulum.

1. Using your results from Data Table 1, find the ***average*** period of the pendulum's vibration. Place this result in Table 6 under "Average Period of Pendulum".

2. Utilizing the formula for the period of a pendulum from the previous page, calculate the period of the 55 cm long pendulum. Place this result in Table 6 under "***Theoretical*** Period of Pendulum" (**Reminder**: Physics formulas are used assuming length is in **meters**.)

3. Using the formula for Percent Error, calculate your percent error from the average period of the pendulum versus the theoretical period of the pendulum. Place your percent error in the "Percent Error" column in Table 6.
    a. **NOTE:** the "Average Period of Pendulum" will be your *Experimental* value in the Percent Error formula.

Percent Error:

$$Percent\ Error = \left|\frac{Theoretical\ Value - Experimental\ Value}{Theoretical\ Value}\right| \cdot 100$$

Table 6 – Theoretical Period of Pendulum

Pendulum Length (cm)	Average Period of Pendulum (s)	***Theoretical*** Period of Pendulum (s)	Percent Error (%)
55			
50			
45			
40			
35			

5. Why could there be a difference between your group's experimental periods versus your theoretical periods? ____
____
____

6. The formula for the period of a pendulum based on the ***Small Angle Approximation***. This formula assumes that the pendulum is only pulled back a few degrees (approximately 15°) from the center resting point of the pendulum.

   Knowing this, why else could your experimental results differ from the theoretical results? ____
____
____

Name: __________________________ Period: _________ Date: ________________________
Lab Partners: ____

<u>Conclusion</u> – Answer these questions **<u>INDPENDENTLY</u>** or receive a <u>zero</u> for this lab.

1. What factors affect the period of a pendulum? ____
____
____

2. Why were we only able to test one variable from the formula for the period of a pendulum? ____
____
____

3. What external factors in the classroom could have also been slowing down the motion of your pendulum over time? ____
____
____
____

    a. Theoretically speaking, how could we eliminate this variable to get even more accurate results? ____
    ____
    ____
    ____

4. How did this lab aid in your understanding of pendulums and simple harmonic motion? ____
____
____
____

5. How could this lab be changed, improved, or modified for my students next year?
____
____
____
____