

The Simple Pendulum

Purpose

In this exercise we will attempt to verify the relationship between the length and the period of a simple pendulum.

Introduction

A simple pendulum consists of a small object called a bob suspended by a light string. The bob being small means its size is small compared to the length of the string. The string being light means it has a mass much smaller than that of the bob. The period is defined to be the time for one oscillation, one back and forth motion.

The period of a simple pendulum for small amplitudes is $T = 2\pi\sqrt{\frac{L}{g}}$.

In this formula, L is the length of the pendulum measured from the pivot point to the center of mass of the bob and g is the acceleration of a freely-falling object (9.80 m/s² on Earth).

If we square both sides of the equation, $T^2 = 4\pi^2 \frac{L}{g} = \frac{4\pi^2}{g} L$.

We find a linear relationship between the square of the period and the length of the pendulum. We will find the period of 5 pendula each with a different length, but using the same bob. We will attempt to verify the relation by graphing our results.

Equipment

Each group will have:

A table clamp	A two-way clamp
A threaded rod	A hooked mass to be used as the bob
5 lengths of string	2 meterstick caliper jaws
A meterstick	A stopwatch
A sheet of paper to record data	

Procedure

Since the length of the pendulum is defined to be from the pivot point to the center of mass of the bob, we need to determine the location of the center of mass of the bob. Place the bob on the meterstick with its hooked end extended past the 0 cm mark. Slowly move the bob so that more and more of it is extended off the meterstick. Record the location of the bottom of the bob when it just begins to tip. This will be the distance the center of mass is above the bottom of the bob.

Make a table with 3 columns. The first column will be the distance of the bottom of the bob from the pivot point for each pendulum. The other two columns will be the time for 20 oscillations for each pendulum.

Attach the table clamp to the lab bench. Attach the two-way clamp and threaded rod to the vertical rod of the table clamp. Attach one of your strings to the threaded end of the rod. Hang the bob from the other end.

Move the bob so that the string makes an angle of about 10° with the vertical and release. Time 20 back and forth oscillations of the pendulum. Make sure you wait for one complete back and forth motion before counting "1". Repeat the process to obtain a second timing of 20 oscillations. If your two times are off by more than 0.5 s, perform a third trial. If none of the three times are within 0.5 s of each other, inform your instructor.

Using the meterstick and caliper jaws, measure the distance from the pivot point to the bottom of the bob. The location of the pivot point will depend on how you have the string attached to the rod.

Repeat the process using each of the other four strings.

Have your instructor check your data for reasonableness.

Analysis

Answer each question on separate paper.

Create a second table containing three columns. The first column should be the "Pendulum Length (cm)"; the second column, "Period (s)"; the third column, "Period Squared (s^2)".

Use your data to fill the table with the appropriate values.

Make a graph showing how the square of the period is related to the length of the pendulum. Choose a scale that will allow you to calculate a slope to three significant figures. Which variable belongs on the horizontal axis?

Does your data appear to fall along a straight line?

Regardless of your answer to the previous question, draw the straight line which best fits your data. The line should come close to all data points.

Determine the slope of the line you have drawn to three significant figures. And write an equation for your line.

From the equation, $T^2 = \frac{4\pi^2}{g}L$, the theoretical value for the slope of the line is

$$4\pi^2/(9.80 \text{ m/s}^2) = 4.03 \text{ s}^2/\text{m}$$

Compute the percent error in your slope based on this value.

From your graph or the equation for your line determine the length of a simple pendulum that will have a period of 1.00 s. Give your answer to the nearest millimeter.

A grandfather clock has a pendulum with a period of 2.00 s. Each "tic" and each "toc" is one second long. Based on your experiment what length of simple pendulum will have a period of 2.00 s? Is your answer reasonable based on the size of grandfather clocks?

What would be the period of a simple pendulum which has a length of 3.00 m?