Experiment 1.09: The Simple Pendulum

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I. EXPERIMENT 1.09: SHM: THE SIMPLE PENDULUM

A. Abstract

The behavior of the simple pendulum is investigated.

B. Formulas

$$T^2 = \frac{4\pi^2}{g} L \tag{1}$$

where L is the length of the pendulum, g the acceleration due to gravity, and T the pendulum's period.

C. Description and Background

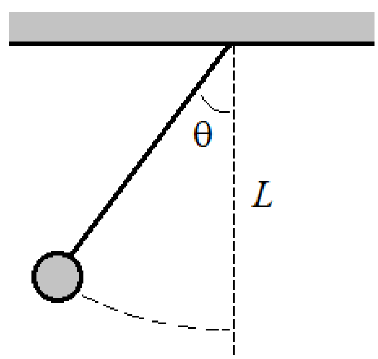

FIG. 1. Pendulum.

In this experiment, the dependence of a simple pendulum's period, T, on its length, L, is confirmed and exploited to indirectly determine the acceleration due to gravity, g. The simple pendulum consists of a light string fixed at one end with a massive bob attached to the other end. For *small angle oscillation*, Eq. (1) holds true. Note that the period depends on the length of pendulum but not on the bob's mass. This will be tested in the experiment by determining the period of the pendulum for two different masses but the same length.

Giovanni Battista Riccioli is credited with performing the first accurate experiment on the acceleration due to gravity in 1651 [doi: 10.1063/PT.3.1716]. His interest was to investigate the claims of Galileo and not to determine the acceleartion due to gravity however. He used meticulously calibrated pendulums to time the free fall of bodies from different heights. As this experiment shows, g can be determined without using free falling bodies but just using the pendulum itself. Christian Huygens deduced (1), and in 1660 used it to arrive at the first accurate estimate of the acceleration due to gravity (9.81 m/s^2 in SI units) [doi: 10.17704/eshi.26.2.7460m485n5701845].

The experiment calls for the measurement of ten cycles of the pendulum with a certain mass, m_A, and length, L. This is repeated with a second mass, m_B to investigate the period's mass independence. By measuring the time for ten cycles, one reduces the uncertainty in the calculated (single cycle) period. If the length is changed and the precedure repeated, the data can be used to plot the period squared, T^2 versus length, L. A linear regression analysis would yield a slope, ς, that theoretically equals

$$\varsigma = \frac{4\pi^2}{g} \tag{2}$$

This can then be used to indirectly determine the acceleration due to gravity.

D. Procedure

1. Determine the masses of the two pendulum bobs (m_A, m_B) to be used in the experiment.

2. Adjust the length of the pendulum. The length is measured from the pivot point to the center of mass of the bob.

3. Attach one of the pumb bobs (m_A) to the end of the string, and measure the exact length (from pivot to center of bob), and record it in the table.

4. To set the pendulum into motion, displace the pendulum from the vertical by no more than 10^0, and release it.

5. Use a timer to time ten cycles of the pendulum.

6. Change to the second bob (m_B), and repeat step 5.

7. Change the length of the pendulum and repeat steps 3-6.

8. Repeat step 7 according to your instructors directions.

E. Measurements

mass A, m_A [$gram$]	
mass B, m_B [$gram$]	

L [cm]	$10T_A$ [sec]	$10T_B$ [sec]

F. Instructions

1. Complete the Plotting Table on the next page using

$$g = \frac{4\pi^2 L}{T_A^2}$$

   to determine g.

2. Use the Excel file provided, **PendulumLabPlot**, to plot T_A^2 $vs.L$ (include the point $(0,0)$ in the plot), and submit the plot as part of your work.

3. Use the slope, ς, of the regression line to determine the acceleration due to gravity, g_{slope}, from (2).

4. Determine a mean, $\bar{g}$.

5. Determine the associated standard error, $\delta\bar{g}$.

6. What is the percent difference between $\bar{g}$ and g_{slope}?

G. Calculations

Plotting Table					
L [m]	T_A [sec]	T_B [sec]	%-diff (T_A, T_B)	T_A^2 [sec^2]	g [m/sec^2]
0	0	0	0	0	N/A

T_A^2 *vs.* L: slope, ς [sec^2/m]	
g_{slope} [m/s^2]	
$\bar{g}$ [m/s^2]	
$\delta\bar{g}$ [m/s^2]	
%-Diff ($\bar{g}, g_{slope}$)	