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THE SIMPLE PENDULUM

OBJECTIVE

To measure the effects of amplitude, mass, and length on the period of a simple pendulum and by graphing to understand which of these parameters matter.

INTRODUCTION

A simple pendulum consists of a point mass suspended at the end of a cord of zero mass. A close approximation to this is a small metal mass on a long, light string or thread. In this experiment you will time how long it takes to swing back and forth. The time for one complete swing is the period. The only variables you have are: (1) the mass, (2) the length of the string, and (3) the amplitude (that is, the size of the angle that the pendulum swings through). By changing one variable at a time and measuring the period, you can figure out which of these variables affect the period.

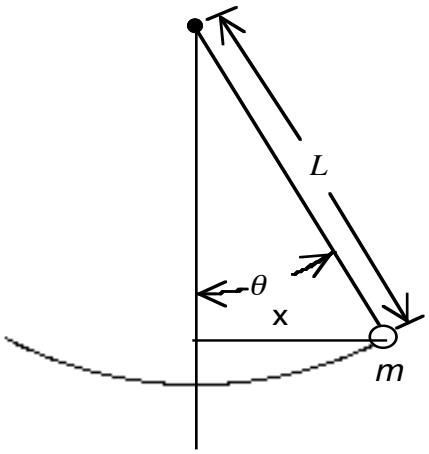

Fig. 1. A simple pendulum. The symbols are: m is the mass, L is the length, θ is the angle of amplitude, and x is the horizontal displacement.

The angle of amplitude, θ, may be measured with a protractor or calculated from the relationship $\theta \approx x/L$. This computation gives

the angle in units of radians. The conversion to/from degrees is
1 radian = 57.3° and 1° = 0.0175 rad.

ACTIVITY 1 VARIABLE AMPLITUDE

1. Make a simple pendulum by suspending a mass hanger from a string tied to a support rod. Start with a string about 1.5 m long.

2. Place about 200 g on the hanger to make a pendulum with a total mass of 250 g and a length of 1.50 m. Note that the length L is the distance from the point of support to the center of mass.

3. Pull the pendulum aside about 15 cm (for x). **What is the amplitude angle? Show all calculations.**

4. Release the pendulum, timing about 25 complete swings. **Calculate the period.**

5. Repeat step 4 for displacements of 30, 45, and 60 cm. **What are the amplitude angles? Show all calculations.**

6. **Make a graph** of period T vs. initial amplitude (θ). **What conclusions can you draw from your graph?**

ACTIVITY 2 VARIABLE MASS

7. Keep the length constant at 1.50 m. Using a total mass of 100 g pull the pendulum aside 15 cm. Release the pendulum, timing about 25 swings. **Calculate the period.**

8. Repeat for total masses of 250 g, 400 g, and 550 g. **Plot the period vs. the mass. What conclusions can you draw from your graph?**

ACTIVITY 3 VARIABLE LENGTH

9. Place 200 g on the hanger and determine the period for lengths of 25, 50, 75, 100, 125, 150, and 175 cm. Make sure to keep the angles under 15 degrees. **What horizontal displacements must you use for each length to keep the angle at 10 degrees?**

10. **Plot the observed period vs. length.** You may use DataStudio to plot the graph and get the linear fit.

11. **Calculate T^2 and plot a graph of L vs. T^2.** You may use DataStudio to plot the graph and get the linear fit.

12. **Which of the graphs has the better fit?**

DISCUSSION

Detailed analysis of the simple pendulum shows that for small amplitudes the period is given by

$$T = 2\pi\sqrt{\frac{L}{g}}.$$

If you square both sides of the equation for the period and rearrange you get

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

ACTIVITY 4 COMPUTATION OF *g*

13. Calculate the slope of your L vs. T^2 graph. **Determine the value of *g* from your value of the slope.**

14. **Compare your result to the standard value of g = 9.81 m/s²** by computing the percent error.

Tear out and hand in. Name _____

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DATA SHEET

ACTIVITY 1 VARIABLE AMPLITUDE

Mass _____ kg.

Length L = _____ m.

X (m)	θ (rad)	No. of swings	Total time (s)	Period (s)

Graph your results.

Does the period depend on amplitude?

ACTIVITY 2 VARIABLE MASS

Length *L* = _____ m.

Horizontal position _____ m, Initial angle *θ* _____ rad.

m (kg)	No. of swings	Total time (s)	Period (s)

Graph your results.

Does the period depend on mass?

ACTIVITY 3 VARIABLE LENGTH

Mass m = _____ kg.

Horizontal position _____ m, Initial angle θ _____ rad.

L (m)	No. of swings	Total time (s)	Period (s)

Graph T vs. L.

Graph L vs. T^2.

Obtain a linear fit to both graphs. Which fit is better?

ACTIVITY 4 COMPUTATION

Calculate the slope of the L vs. T^2 graph and find the value of *g*.

Calculate the % error of your value for *g*.