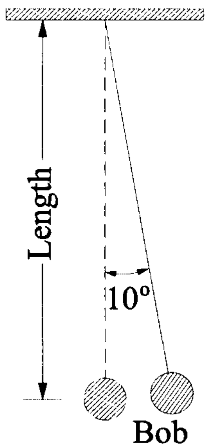
Name **Section #**

Measuring Time and Gravity with a Pendulum

Introduction

Have you ever considered what the word *time* means. For example what do you mean when you say it takes two minutes to boil an egg? Try to define time without using the words *length* or *time.*



The *second* that we measure with a clock is related to the repeating changes inside a clock which we assume to be uniform, or *periodic.* Time involves the counting of periodic events such as seconds. The period T for recurring events is obtained by comparing them to a clock and counting the number of seconds from each event's beginning to its end. To illustrate, imagine water falling at a rate of 200 drops every 13.25 seconds; then $T = 13.25$ seconds / 200 $= 0.0663$ s.

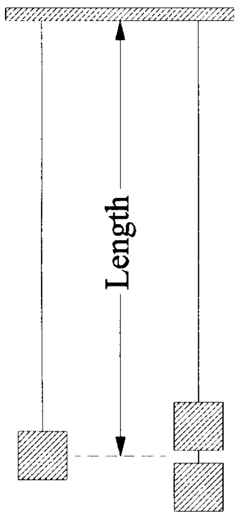
As shown at the left, a simple pendulum consists of a string and a bob. In this experiment you will compare the motion of the pendulum with that of a standard time piece such as a clock or metronome. You will also try to answer the following questions:

- Is the motion of a simple pendulum periodic?
- What factors govern the motion of a pendulum? The possibilities to consider are:
  - a- the mass of the bob
  - b- the length of the pendulum, as measured from the top of the string to the center of the bob
- How can the pendulum be used to measure the local value of gravitational acceleration, g.

Procedure

Connect 0.8 meter of string to a 500 gram mass. Attach the other end to a fixed support on the table-clamp ring stand. Then displace the bob no more than10 degrees from the vertical and allow it to swing freely. Consider one event or cycle to be a complete back-and-forth motion. If the pendulum is periodic, then all cycles will take an equal amount of time. Enter your data in the table below.

Number of Elapsed Cycles	Elapsed Time (s)	Time per 10 Cycle Interval (e.g., from the 30th - 40th) (s)	Average Period Within Each Interval, T (s)
10			
20			
30			
40			
50			
60			
70			
80			



Use the string with 100, 200 and 500-gram masses varying the bob's mass by increments of 100 grams. In this part of the experiment keep the pendulum's length equal to 50 cm (i.e., from the top of the string to the middle of the bob) while you vary its mass. You will have to adjust the string's length each time you change masses in order to keep the pendulum's length fixed at 50 cm. (Compare with the diagram at the left.) Enter your data in the left-hand table below. Divide the time for 30 cycles by 30 to obtain the average period T. Plot a graph with the bob's period, T as the ordinate versus its mass, M as the abscissa.

To determine what effect the length L has on the pendulum's period, attach a bob with a mass of 100 grams and vary the sting's length from 70.0 cm to 10.0 cm in 10 cm intervals. This can be done by looping the string around the support. (Remember to measure the length from the support to the center of the bob.) Enter your data in the right-hand table below. You should find that the period is proportional to the square root of the pendulum's length L. Plot the period T as the ordinate versus the $\sqrt{L}$ as the abscissa. Draw a straight line that best fits your data points, determine its slope, and then enter, and highlight, the value for the slope on your graph paper.

Mass, M (kg)	Time for 30 cycles (s)	Average Period, T (s)
0.100		
0.200		
0.300		
0.400		
0.500		
0.600		
0.700		

Length, L (m)	$\sqrt{L}$ ($m^{1/2}$)	Time for 30 cycles (s)	T (s)
0.700			
0.600			
0.500			
0.400			
0.300			
0.200			
0.100			

Conclusions

Answer the following questions based on your observations, tables and, where applicable, your graphs.

Is the motion of the pendulum periodic? Explain.

Graph of *T* versus *M*.

Does the period of the pendulum depend on the mass of the bob?

The period of the pendulum is given by the relationship $T = \left(\frac{2\pi}{\sqrt{g}}\right)\sqrt{L}$ where $\left(\frac{2\pi}{\sqrt{g}}\right)$ should ideally be equal to the slope of your best fit line in this graph. Designate the value of your slope as m. Then $m = \frac{2\pi}{\sqrt{g}}$, from which, $g = \frac{4\pi^2}{m^2}$. Use this last equation to obtain the value for g at your location.

Graph of T versus $\sqrt{L}$.

Slope of this graph, $m =$, Calculated value for local gravity at BTHS, $g =$