LAB 6: The Simple Pendulum*

Equipment List:
a long string
a mass to act as the bob of the pendulum
stop watch timer
a two meter stick
one long rod and one short rod and one right-angle clamp

Purpose: To investigate relation between the length of a simple pendulum and the period of its swing and learn about simple harmonic motion.

Introduction: In this experiment we examine the periodic motion of a simple pendulum. The parameters involved are the length of the pendulum, ℓ, the period of one oscillation, T, and, in the additional procedure section, the mass of the bob, m and the amplitude of the swing, $\theta_{\rm max}$. These parameters are related by an equation derived from Newton's second law.

Theory: In your lab book, clearly derive the equation that relates the period of oscillation to the length of a simple pendulum. You should assume that for small angles $\sin\theta \approx \theta$ (where θ is measured in radians) and you can solve the second order differential equation by inspection.

Procedure:

1. Construct the apparatus as shown in Figure 1.

2. Set up a neat table in your lab book where you can record in the first column the pendulum length, the next column the stopwatch time, and the last column the time for one period.

3. Choose a mass of at least twenty grams and use that same mass for the different pendulum lengths. Tie the string to it. The string should be long enough so that the first pendulum length that you use is at least one or one and a half meters long. Measure the length of the pendulum string with the two meter stick.

4. Set the pendulum swinging by pulling the mass back through a small angle (less than $\sim 20°$) and release the mass. One person should hold the stopwatch and begin timing when the mass passes through the lowest point in the swing. You will see it pass the vertical support when this happens. Another person counts out ten full oscillations.

*Based on the lab by Prof. Newton.

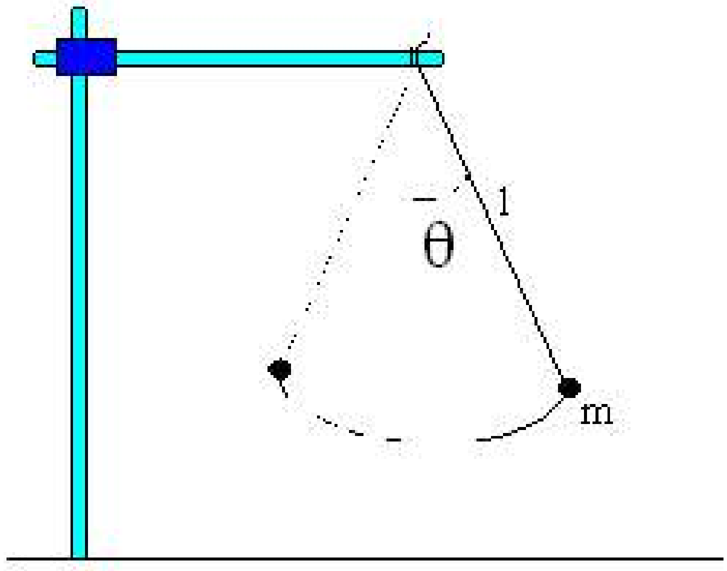

Figure 1: The rods arranged to support the pendulum.

On the tenth one, when the bob swings back through the position where the string is vertical, stop the stopwatch. The time on the stopwatch should be the total time for 10 periods. To calculate the actual period divide the total time by ten. Record the time on the stopwatch and the period in the table in your lab book.

5. Repeat the above step for for another nine different lengths (for a total of 10 different lengths), recording each length in your table. Use a big range of different lengths. One length should be as short as ten centimeters or so. To make it easy to change different string lengths, you need only wrap the string around the upper pole a few times, which will save you from tying and untying a knot on the pole.

Analysis:

Use the computers to draw two graphs:

1. The first graph will be Period versus Length. This graph should yield a square root, non-linear curve. If you use Excel for this, you should enter the data in two columns, one for each axis. Highlight the data, then go to the dropdown menu at the top. Go to Insert → Chart. You will then be able to select the XY (Scatter) option (points only). Once you have the data, you should label your axes. Right click on the plot and choose Add Trendline. Choose a power fit (in the Type tab) with power 0.5, and see how close the power is to 0.5. Have the equation displayed on the graph and a correlation coefficient printed on this graph as well (in the Options tab). You should expect an excellent fit. Also, check the coefficient of the length and see how close it is to the theoretical expected value.

2. For the second graph choose different axes for the same data. You will choose those axes that give a straight line whose slope is equal to g. Use the linear trendline analysis

and see how close the slope is to the gravity field, g. Have the correlation coefficient printed on your graph.

Compare the value of g from your graph to the accepted value, 9.81 m/s^2 , with a discrepancy test. You should expect two percent or less. If the discrepancy is large, look for mistakes and errors.

Additional Procedure:

In a few trials, investigate the dependence of the period of the pendulum on the amplitude of the swing and investigate the dependence of the period of the pendulum on the mass of the bob. What effect do these changes have? What effect would you expect them to have? (Hint: consider your derivation in the theory section.)

Conclusion:

What errors are there in this experiment? Are they systematic or random? For each length, you measured the total time for ten periods. What error does this help to minimize? How else might you experimentally investigate simple harmonic motion? Could you investigate other kinds of oscillatory motion and how? What affect do you think air resistance has?