Lab 12: Periodic Motion

Objectives:

• To devise an experiment to test variables that might affect the period of a pendulum
• To carry out an experiment testing variables that might affect the period of a pendulum, including statistical analysis of the data
• To determine a mathematical relationship between variables that affect the period of a pendulum and the period of the pendulum

Equipment:

• Washers for pendulum bobs
• Strings of different lengths
• Stand to hang pendulum from
• Stopwatch
• Protractor

Periodic motion is the name given to any motion that follows a repeatable pattern. This pattern could be complicated or simple. If the motion can be described mathematically as a sine or cosine, then the motion is called simple harmonic motion.

One object that undergoes periodic motion is a simple pendulum. A simple pendulum consists of a mass (called the bob) suspend by a string or light rod oscillating back and forth. For the pendulum to be considered a simple pendulum, the mass of the string or rod must be negligible compared to the mass of the bob. The string or rod is usually considered to be massless in textbook problems. In reality, the mass of the string or rod is small enough to be ignored. In general, a simple pendulum does not undergo simple harmonic motion. However, for small oscillations (<30°), the motion is approximately simple harmonic motion.

The period is the time it takes the bob to return to its release point, or the time for the bob to move through one complete cycle before the motion repeats. In this lab, you will experimentally determine which variables affect the period of a simple pendulum.

Exploration 1 Among your group members, discuss what variables could influence the period of a pendulum. In the space below, list three or four variables your group agrees upon, along with possible reasons for your choosing those variables. Discuss your list with your TA before continuing.

Exploration 2 Explain how you will determine if a variable affects the period of the pendulum. Suppose, for example that you are testing to see if the mass of the bob affects the period. How would you set up the experiment? What would have to be kept constant? What would be allowed to change? How many masses would you need to test? If the mass does affect the period, would it be possible to determine a mathematical relationship between the mass and the period?

Exploration 3 How would you measure the period? Would there be uncertainty in the measurement of the period? How could you minimize that uncertainty?

Investigation 1

In this experiment you will examine three variables that could influence the period of a simple pendulum: mass of the bob, amplitude of the swing, and length of the string. This is not to say these are the only three variables that could influence the period, but these are the three we will test.

For the mass, you will be using washers, so the number of washers will determine the mass; you can test by using 1, 2, 3 washers, etc. For the amplitude of the swing, you will measure the initial angle of the pendulum with a protractor. *Measure the angle from the vertical.* Do not use angles > 25°. For the length, you will use different lengths of string.

For each measurement of the period, you should measure at least three times, take the average and also calculate the standard deviation to use as a measure of the uncertainty. In addition, to decrease the uncertainty of the measurement, you should measure the period of 10 oscillations and then divide by 10. This will make the reaction time, which contributes to the uncertainty, a smaller percentage of the actual measurement. It is also useful for one student to release the pendulum and another person to time the measurement. However, if the student releases the pendulum and simultaneously tells the student timing to start the stopwatch, this introduces another uncertainty. Instead, the student with the stopwatch should let the pendulum swing through one oscillation before starting the stopwatch. This will decrease the uncertainty in the measurement.

Investigation 1.1 Follow your procedure from Exploration 2 and the measurement procedure described above. Test the three variables of mass, amplitude of the swing and length of the string to see, if they influence the period. You should choose at least three different values for each of the variables being tested. (So use three different masses, if you are testing mass, etc.) The variables not being tested should be held constant. For example, if you test length first, the mass and amplitude will be held constant for all measurements of length. Because it is difficult to return to a previous length, the length should be measured first or last.

There is a table available on the next page to record your data. For every measurement, repeat the measurement at least three times and record the mean and standard deviation of those measurements.

Mass	Amplitude of swing = , Length =	
	Measurement	Average and Uncertainty

Amplitude of swing	Mass = , Length =	
	Measurement	Average and Uncertainty

Length	Amplitude of swing = , Mass =	
	Measurement	Average and Uncertainty

Investigation 1.2 For each variable, determine whether or not your measurements are the same or different within the uncertainty. In the space below, for each variable discuss, based on your measurements, whether it affects the period of a pendulum and why or why not.

Mass:

Displacement:

Length:

Investigation 1.3.a If you found that one or more of the variables affected the period of the pendulum, try to determine how the period depends mathematically on that variable. You should do this from the data (not from prior knowledge). You may need to graph the data. You might try to graph it as a straight line or use a curve-fitting program. You may need to take more measurements, as three measurements might not be sufficient. Record your other measurements below.

Variable affecting period	Other variable 1 = , Other variable 2 =	
	Measurement	Average and Uncertainty

Investigation 1.3.b What is the mathematical form of the relationship between a variable that you found affects the period and the period? Express your answer mathematically.