AP Physics: Lab #9

Simple Harmonic Motion

Name ______________________ Hour ______

Lab Partners ____________________________________

Purpose:

* Calculate the experimental time period of a spring in simple harmonic motion and compare it to an accepted value.
* Write an equation for simple harmonic motion and compare it to an accepted equation.
* Determine kinetic and potential energies for a spring in simple harmonic motion.

Equipment:

Spring	LabQuest Mini with USB cord
Assorted Masses	Computer with LoggerPro software
Meter Stick	CBR and adapter cord
Electronic Balance	Paper plate

Introduction:

When a spring is stretched or compressed, it follows a law of physics called Hooke's Law. Hooke's law states that the amount of force exerted by the spring is proportional to the distance it is stretched or compressed. This constant of proportionality is called the spring constant, *k*, and represents the stiffness of the spring.

According to Hooke's Law, when a mass on a vertical spring is stretched downwards, the spring exerts a force on the mass. This causes the mass to move upwards and its inertia carries it past its original position. The weight of the mass then causes it to move back downwards, again stretching the spring. This pattern of motion is known as simple harmonic motion and is shown in the diagrams below. When the movement of a spring in simple harmonic motion is graphed over time, the resulting curve is sinusoidal. This can be modeled with the general equation:

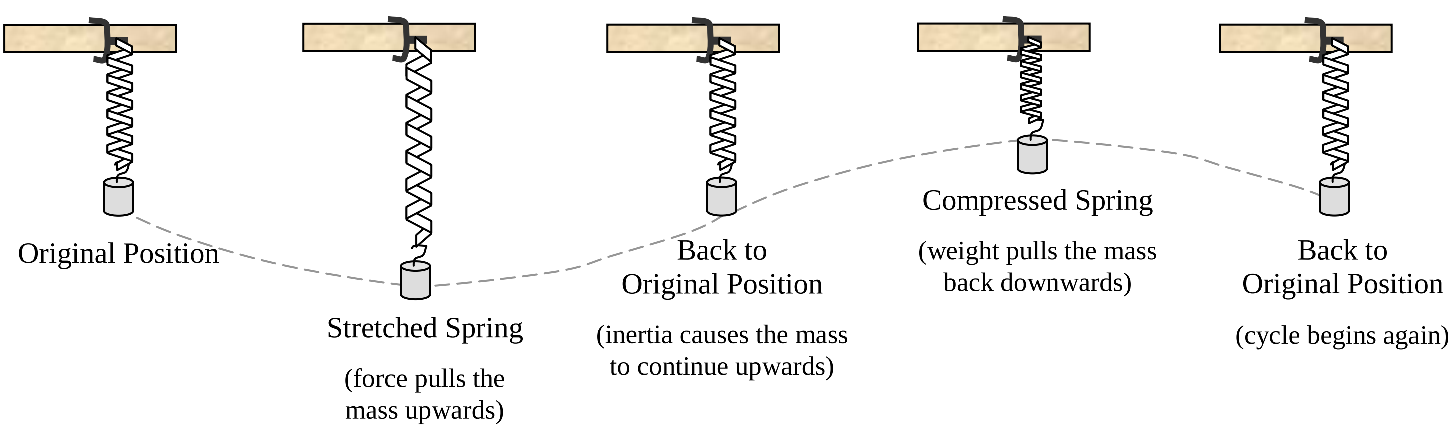
$$y = A \cdot \sin(B \cdot x + C) + D$$

In this equation, the variable *A* represents the amplitude of motion and the variable *B* represents the quantity $2 \cdot \pi$ multiplied by the frequency of motion. The variables *C* and *D* are correcting variables representing the horizontal and vertical shifts of the equation.

In addition, the time period of motion can be determined from the mass on the spring and the spring constant of the spring. This relationship is expressed in the equation:

$$T_s = 2 \cdot \pi \cdot \sqrt{\frac{m}{k}}$$

This equation is often modified to allow for the mass of the spring itself. The correct mass amount includes the mass attached to the spring added to 1/3 of the mass of the spring itself.



Procedures: Determining the Spring Constant

Attach the spring securely to a support, allowing at least 1 meter beneath the lower end of the spring. Attach a mass to the spring and record the corresponding displacement of the spring in Data Table A. Repeat this step for four varying masses, recording each mass and displacement in Data Table A. Calculate the force caused by the weight of the mass, and the resulting spring constant of the spring. Use the average spring constant from the 4 masses as the spring constant for the spring in the remainder of the lab.

Procedures: Simple Harmonic Motion

Measure the mass of the spring itself and record this amount in Data Table B. Choose an appropriate mass to suspend from the spring in simple harmonic motion. Too large a mass may distort the spring, while too little mass will make it difficult to create simple harmonic motion with sufficient amplitude. When you have chosen an appropriate mass, attach a paper plate to the bottom of the mass and attach the mass to the spring.

Connect the CBR to the adapter cord and insert the plug of the CBR adapter cord into the DIG I port of the LABQUEST. Use the USB cord to connect the LABQUEST to the computer. Then open the "*Lab #9 Template*" LOGGERPRO file from the class web site or Shared folder.

Place the CBR directly below the spring and mass, aimed so that the sensor will record the displacement of the paper plate as the mass moves. Displace the mass to create simple harmonic motion, and click the green COLLECT button on the LOGGERPRO toolbar to begin recording data. Use the ANALYZE → AUTOSCALE commands to view the data collected. If necessary, repeat the experiment until the data collected is acceptable for analysis. Then save the LOGGERPRO file for Trial #1 on your home folder for future analysis. Use the ANALYZE → EXAMINE commands to examine the data and obtain the required measurements from the Position-Time and Velocity-Time graphs. *(NOTE: Include an explanation with your final report of how the amplitude and time period were determined from the graph.)* Conduct three trials for the mass in simple harmonic motion, recording all measurements in Data Table B and saving each trial in a separate LOGGERPRO file. Print copies of your data, graphs and regression line from one of your trials to include in your report. *(NOTE: For best printing results, use the FILE → PAGE SETUP command to change the orientation to landscape and the FILE → PRINTING OPTIONS command to add a footer with your Name and Trial #.)*

Calculations:

Calculate and record the frequency of simple harmonic motion for each trial.

Calculate and record the theoretical time period of simple harmonic motion. Adjust the mass to allow for the mass of the spring itself.

Calculate and record the percent error between the experimental and calculated values for time period.

Calculate and record the spring potential energy of the spring at its amplitude positions.

Calculate and record the kinetic energy of the spring at its equilibrium positions.

Analysis:

To summarize the lab report, answer the application questions below in complete sentences. In addition, include a brief statement of the overall results for the lab.

- Use the data from your last trial in Data Table B to write the position equation for the mass as a function of time t. Use the general form $y = A \cdot \sin(2 \cdot \pi \cdot f \cdot t)$. Then use the ANALYZE → CURVE FIT commands in LoggerPro to create a best fit line for the selected set of data. How does the best fit line equation from the computer compare to the equation you wrote? Which variables are different? Why?
- Use the data from your last trial in Data Table B to sketch a graph showing the general shape of kinetic energy versus time. Create the graph for a time period from the spring's lowest position to its highest position (half of a complete cycle). Label the maximum and minimum points with their kinetic energy values.
- On the same graph, sketch the general shape of spring potential energy versus time for the same trial over the same time period. Label the maximum and minimum points with their spring potential energy values. What is the total energy of the spring system at each point on the graph?
- Why is it possible to use different amplitudes throughout the lab without compromising the accuracy of the data? Do changes in amplitude affect the frequency of the simple harmonic motion? Do changes in amplitude affect the maximum velocity of the mass in simple harmonic motion?

Data Table A: Spring Constant

Mass	Force	Displacement
		Average

Spring Constant

Data Table B: Simple Harmonic Motion

Mass of the Spring = ______________

Mass Attached = ______________

Total Adjusted Mass = ______________

Trial	Time $_{Exp}$	Frequency $_{Exp}$
1		
2		
3		
Average		

Time $_{Calc}$

Percent Error = _________

Trial	Amplitude	Potential Energy $_{Max}$	Velocity $_{Max}$	Kinetic Energy $_{Max}$
1				
2				
3				

Lab Report:

Title Page, Objectives, & Overall Report – 5 pts
Procedures – 3 pts
Data Table – 6 pts
Calculations – 8 pts
Analysis – 11 pts