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Simple Harmonic Motion

Purpose

In this lab you will study simple harmonic motion with the use of a spring.

Introduction

Simple Harmonic Motion occurs when a restoring force acting on an object is proportional to and in the opposite direction of the displacement of the object.

$F = -kY$

k = spring constant

This results in periodic, or a continuous back and forth motion in equal time intervals, along a fixed path, in which the velocity and acceleration both vary along the path, but in the opposite way.

In today's experiment, a spring will be set into simple harmonic motion with an attached mass to provide an additional restoring force and to increase the period of the oscillations. Though the mass has a constant weight, a constant force will not be acting on the spring. During the oscillation, the stiffness of the spring will be pulling or pushing the spring to displace towards the equilibrium position. The magnitude and direction of this force is determined both by the position of the spring and the spring constant.

The greatest displacement of the spring from its equilibrium position is called the amplitude (Y_{max}). Theoretically, this value should not change once the spring is set into motion, thus the system has a constant amount of energy. The sum of the kinetic energy plus the potential energy does not change, but the individual values certainly do.

The table below summarizes the important characteristics of an oscillating spring.

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position	displacement	velocity	acceleration	kinetic energy	potential energy
$+Y_{max}$	max positive	zero	max negative	zero	max
equilibrium	zero	max	zero	max	zero
$-Y_{max}$	max negative	zero	max positive	zero	max

At any point between amplitude and the equilibrium position, the total energy is partly kinetic and partly potential.

The potential energy of the spring at any point in its oscillation is given by the equation below:

$$PE = \frac{k \cdot Y^2}{2}$$

When the spring is at its maximum amplitude, all of the energy is elastic potential energy, so:

$$Energy_{total} = \frac{k \cdot Y^2{}_{max}}{2}$$

At any point in the spring's oscillation, the kinetic energy is the difference between the total energy and the potential energy

$$KE = \frac{k \cdot Y^2{}_{ma}}{2} - \frac{k \cdot Y^2}{2}$$

When the spring and mass system is set into simple harmonic a constant time, or period, is required to complete one cycle. For small oscillations the following equation can be used:

$$T = 2\pi\left(\frac{m}{k}\right)^{\frac{1}{2}}$$

Materials

Spring stand with mirrored ruler, spring with weight holder, various slotted weights, stopwatch

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The maximum weight load for the spring is that which stretches it about 1/3 of its total length. If you go beyond this you will permanently stretch, and thus pay for, the spring.

Procedure

1- Set up the apparatus and zero it. Then add successively larger masses to the weight holder, recording the position of the spring for each mass. Record at least 7 data points. After converting the masses to weights(N), and the positions to meters, use your calculator STAT function to determine the **k value**, or the spring constant, of the spring. This will be the slope of the line produced by plotting *force vs. displacement*. **Do not** average the slopes between successive data points, go ahead and do a linear regression.

2- Pick out three different masses, all below the maximum allowable. One at a time, place them on the weight holder and set the spring into simple harmonic motion. Use the stopwatch to time 30 cycles; then find the period for one cycle.

3- Use the equation given in the introduction to calculate the period. Find the % difference between the two values for period, using the period calculated from the equation as the accepted value.

Analysis

1- What are the units of the spring constant?
2- What does your k value tell you about your spring?
3- How linear was your data?
4- Describe any other observations that you made during the experiment.

Conclusion

Your conclusion should address, but is not limited to addressing, the following questions.
1- Show that both sides of the equation for finding the period have the same units.

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2- Use your k value to find the maximum energy for amplitude of 5 cm.
3- What would be the kinetic and potential energies at 2 cm?
4- What kind of motion would result if the restoring force were in the same direction as the displacement?
5- How do the period and maximum energy vary with the amplitude of oscillation?
6- Should the mass of the spring be accounted for in the period equation, or is it already accounted for? Explain!!!!!!