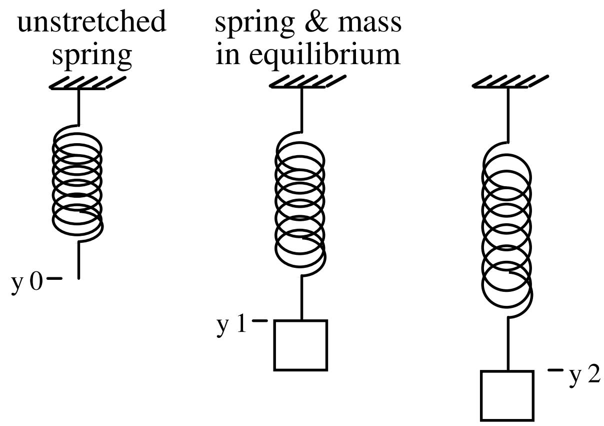
Team Physics 312
Activity 5A
Date: ___________

Name: ___________________________

Team: ___________________________

Aspects of Simple Harmonic Motion

A) Technical Point: Is a vertical mass on a spring SHM?



If we hang a mass on a spring, there's the extra complication that gravity pulls the spring down in its equilibrium state. Does the math all work out that it's still simple harmonic motion? (SHM is when the restoring force is proportional to the displacement from equilibrium).

More specifically, consider a mass m attached to a spring with spring constant k. If we lower the mass slowly, it will come to equilibrium, stretching the spring by an amount y_1 - y_0. Note that the displacement down is negative, and the restoring force up is positive. If we pull the mass farther down, to a position y_2, and release it, will the mass and spring move with simple harmonic motion?

Steps to determine this:

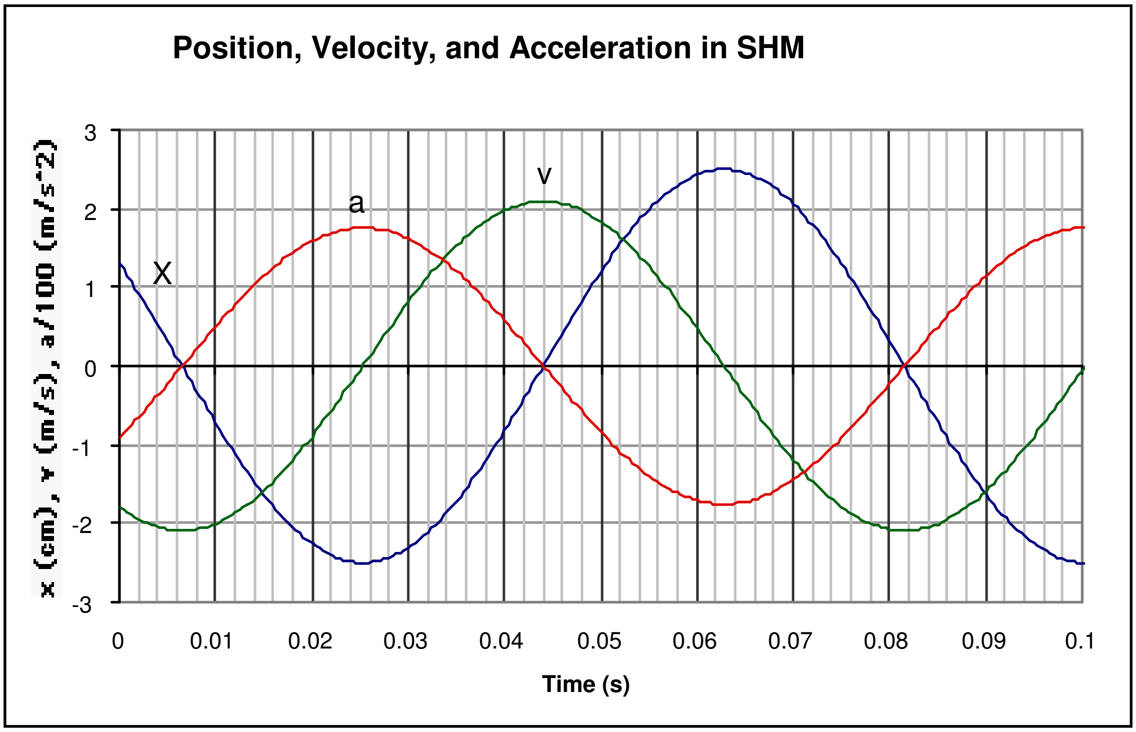
1. Draw the force diagram for the mass when it is in equilibrium, and find an expression for y_1-y_0 in terms of m, g, and k. (Don't be a trouble-maker; pick up to be positive).

2. Draw the force diagram for the mass when it is pulled down farther (right hand diagram) and then released. Determine the net force on the mass just *after* its released in terms of m, g, y_0, y_2, k and a. Be careful with the signs!

3. Simple harmonic motion occurs when there is a restoring force proportional to the displacement. Combine 1) and 2) to show that this is true for the mass hung from a vertical spring. From where must the displacement be measured?

B) Determining Parameters from Data Plots

A mass of 50 grams is attached to a spring and set into simple harmonic motion.



Using the plots above, determine the following parameters for this simple harmonic motion:

Period, T ________________________________

Frequency, f ________________________________

Angular frequency, ω ________________________________

Amplitude, x_m ________________________________

Maximum velocity, v_m ________________________________

Maximum acceleration a_m ________________________________

Spring Constant, k ________________________________

Initial Phase, ϕ or ϕ_0 ________________________________

Total Mechanical Energy, E ________________________________

C) What factors determine the period of oscillation? (Intuitive predictions)

On the next page, you will make measurements on a pendulum and a mass hanging from a spring to determine which variables will be most important in setting the period of the motion. Before you do that, what do you expect to find? Without looking at the equations for a spring or pendulum worked out in the theory lectures, fill out the following, indicating which variables you expect to have the most influence on the period of motion, which will have smaller but easily measurable effects, and which will little or no measurable effect. Try to come to a consensus as a group, and don't worry about whether the answer is actually correct, just that it reflects your honest gut feeling about it. We're just going to take an overall vote of the groups.

Rank the following as: Definite effect, small but possibly measurable effect, or no effect.

Mass on a spring:

Mass: ____

Amplitude of motion: ____

(We will only use the one spring so the spring constant will not be a variable in the experiment)

Pendulum:

Mass: ____

Length: ____

Amplitude of motion: ____

D) What factors determine the period of oscillation? (Mathematical predictions)

Human intuition can often be incorrect in physics. The purpose of mathematics to is to carry out the consequences of our fundamental principles to make predictions of what will actually happen. (If the math is done correctly, and the answer doesn't match physical reality, then the underlying principles must be altered, possibly supplanted with more general principles, or even abandoned altogether. This is science).

Look at the equations we derived for the period of oscillation of a mass on a string and a simple pendulum. Are there any answers above that your group would now change? If so, cross them out and replace them.

E) Measurement of Periodic Parameters

In this section, you will make measurements on a pendulum and a mass hanging from a spring to determine which variables have the most influence on the period of the motion. You will investigate all of the five variables on the previous page.

First, your team should decide on a strategy or procedure you will use to determine how important these variables are. You need to make enough measurements to rank how important the variables are, but you should not make so many measurements that you'll be sitting there all day. Make each measurement by timing about five to ten cycles of the motion with a stopwatch (do not average several measurements). Summarize your team's strategy here, and explain why you thought the number of trials you did was sufficient:

Why is measuring over roughly ten cycles a better idea than trying to carefully time one cycle? Is there any danger in timing too many cycles within a given measurement?

Write your measurements in an easy-to-understand table on the back of this page. Summarize your conclusions by indicating which variables had the most influence on the period of motion, which had small but still measurable effects, and which had no measurable effect.

Mass on a spring: Mass: ____________________

Amplitude of motion: ____________________

Pendulum: Mass: ____________________

Length: ____________________

Amplitude of motion: ____________________

Data Tables:

If you finish early: Using the period T and the mass m of the spring on the mass, calculate the force constant k of the spring, and see if it agrees with the value you found in last day's activity. (It won't be the same spring, but the values should be very similar).