Vibrations

Simple harmonic motion is one of the most important ideas in mechanics (precisely because it IS simple). Furthermore its ideas are directly carried into atomic and nuclear physics – molecules and nuclei vibrate, atoms are bound in solids by restoring forces which can often be well-described by an appropriate spring constant, etc.

If you thoroughly understand the ideas of simple harmonic motion, you can understand all oscillatory motions because any complicated oscillation can be thought of as a linear superposition of various simple harmonic motions.

In this lab we would like everyone to analyze a real situation in simple harmonic motion using the MacMotion equipment.

MacMotion force probe and calibration

Be sure to calibrate the force probe before you use it. Hang a 350 gram mass on the probe and make the calibration.

Measurements

- Determine the spring constant (the k in $F = - k x$) by creating a graph in MacMotion of force versus distance. You can measure the distance by placing the motion detector on the floor under the spring. Then, just place your hands over a pencil extended through the end of the spring to present a flat surface to the motion detector; slowly extend the spring after you ask MacMotion to acquire data. Show the graph of force versus distance (make sure the sign of the slope is correct - it should be a line with negative slope) and ask MacMotion to fit a straight line to the graph. The spring constant is the magnitude of the slope.

- Bring a 500 gram mass to equilibrium at the end of the spring. Now, you can add a negative offset to the distance measurement so that the distance measurement is zero when the mass is at equilibrium.

- Set the spring and 500 gram mass in motion. You should measure the displacement, velocity, and acceleration of the mass as well as the force of the spring on the mass (Think carefully about the force. Does the force probe directly measure the force of the spring on the mass?) as a function of time. If you do not see the data on the MacMotion graph, you may have to change the y-axis scales (double click on the graph to see the menu to change the axes).

- Measure the period of the motion. Is the period in agreement with your expectations? Could you use this method to measure an unknown mass?

- Compare all four graphs in detail, especially the phase relationships, and explain each. Notice that you can plot velocity versus acceleration, force versus velocity, etc. Are these graphs as you expect? Do these graphs appear as circles (with appropriate choice of scales on the axes) or straight lines? Why?

- There are other possibilities, such as taping a cardboard square on the bottom of the mass to create air resistance and viewing the motion over a longer time. Or, you could set up a non-linear oscillator by "tying off" part of the spring (there is a neat way to do this).