

Harmonic Motion

Goals:

1. To learn about the basic characteristics of periodic motion – period, frequency, and amplitude
2. To study what affects the motion of a mass oscillating on a spring.
3. To explore the harmonic oscillations of the simple pendulum and the relationship between period, mass, and length of the pendulum

Mass on a Spring

Open the file called **Mass on Spring** (in Physics Experiments / Physics 220-221 / Harmonic Motion). Connect the detectors according to the directions on the screen. Calibrate the Force Probe with no mass and a 100-g mass.

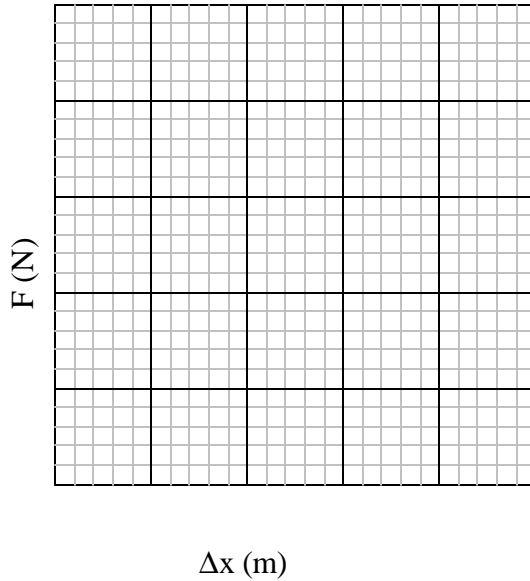
Experimentally Determine Spring Constant, k

Hang a spring from a hook. Use the force probe and a meter stick to measure the force needed to stretch the spring for several distances between 5 and 20 cm. Be sure to measure how far the spring is stretched from its equilibrium length, not the total length of the spring. Be sure to **Zero** the force probe before each time a force is applied to it. To read a value from the plot, Hit the STAT button below the menu bar and hold the mouse button while dragging across the data of interest.

1. Enter measurements in the table below:

Distance (m)	Force (N)

2. Graph the force vs. the distance stretched.



3. **Pre-Lab** How can the spring constant (k) of a spring be found from a plot of force vs. distance?

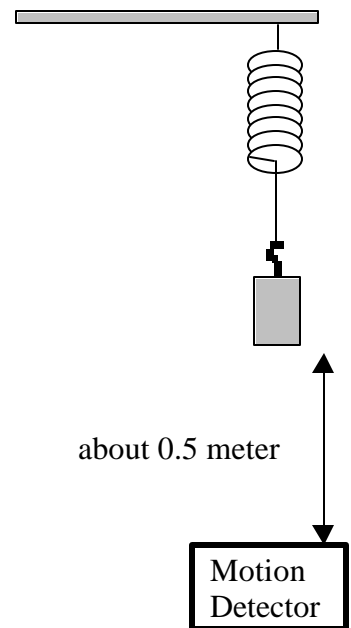
4. Determine the spring constant (k) of your spring. Don't forget units.

$k =$ _____

Experimentally Determine the Period, T

The setup used to take data for oscillations of a mass attached to the spring is shown in the figure. Attach a hooked mass (start with 100 grams) to the end of the spring and position the motion detector directly below it as shown in the diagram.

To get a sense for how much mass you'll need and how far to pull it, do a dry run first. Pull down on your spring to obtain a reasonable amplitude. (Do not overstretch the spring so much that it remains permanently distorted. Also don't get the mass closer than 0.1 m from the detector since it doesn't work at that distance.) Let



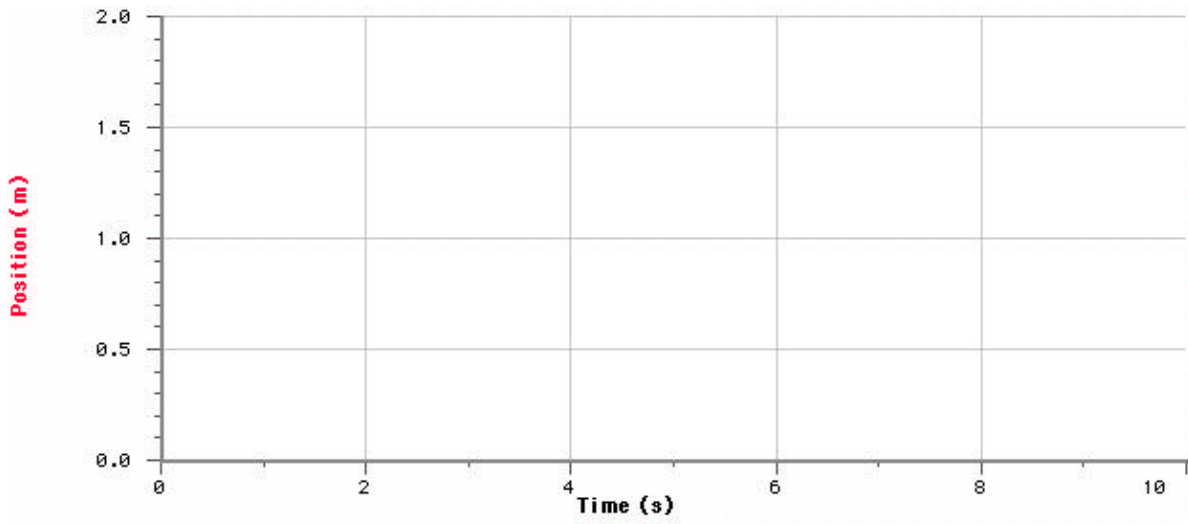
the mass go. The mass should oscillate smoothly up and down. If the mass oscillates too violently, replace it with a larger one.

5. Record the equilibrium position of the mass and the mass you used:

$$d_{\text{equil}} = \underline{\hspace{2cm}}$$

$$m = \underline{\hspace{2cm}}$$

6. Give your mass approximately the same amplitude you gave it for your dry run, then push “Collect” to collect data. Carefully sketch your results below. Only graph the first few cycles. Change the axes, if necessary.



7. For the first two cycles, label your graph as follows
- Points where the mass is farthest from the motion detector.
 - Points where the mass is closest to the motion detector.
 - Points where the mass is standing still.
 - Points where the mass is moving the fastest.
8. Use the graph to find the period (T_{exp}) and frequency (f_{exp}) of the oscillations. Also find the amplitude of the motion (x_0).

$$T_{\text{exp}} = \underline{\hspace{2cm}}$$

$$f_{\text{exp}} = \underline{\hspace{2cm}}$$

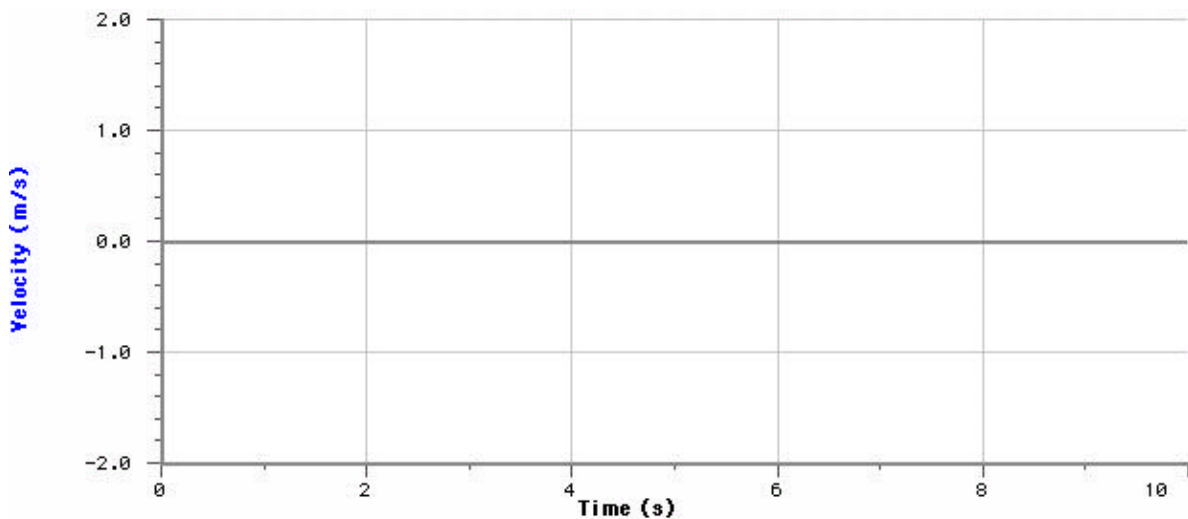
$$x_0 = \underline{\hspace{2cm}}$$

9. **Pre-Lab** In terms of the spring constant, what do you expect the period of oscillation to be (give a formula)?

10. Plug in your values to calculate T_{th} (the theoretical value of the period).

11. How does the experimentally measured value compare to the theoretical? (Compute the percentage difference.)

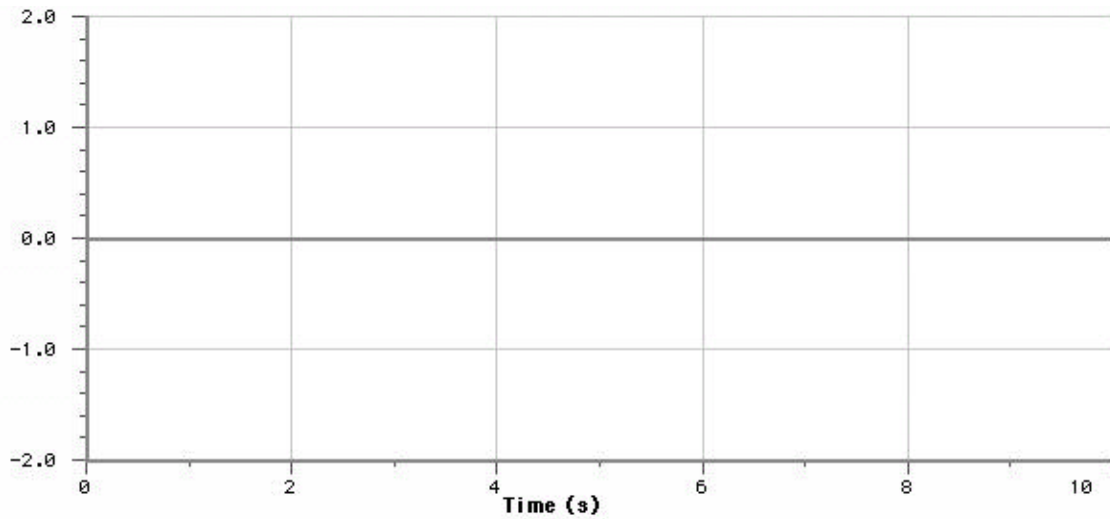
12. For the position vs. time graph in step 9, sketch a prediction for the shape of the corresponding velocity vs. time graph below.



13. Switch to page 2 to display the velocity vs. time for the oscillations. Use a dotted line or a different color of pen or pencil to sketch this on the velocity graph above. (Clearly indicate which curve is which.) Was your prediction correct? Why or why not?

14. Where is the mass when the speed of the oscillating mass is at its maximum value? Where is it when the speed is at its minimum value? (Note: we're talking about speed = velocity's magnitude).

15. Plot the potential energy of the spring-mass-earth system as a function of time. (You may do the math with this program or excel, if you wish.)



16. Mark on the graph the stable and unstable equilibrium points.
17. Plot the total mechanical energy in the system on the graph above also. Be sure to indicate which curve is which.
18. Where is the mass when the kinetic energy is at its maximum value? Where is it when the kinetic energy minimum value? Mark these points on the graph.
19. **Pre-lab** If the experiment were carried out with a different mass (say heavier), how would the measured period change. (Answer in words and give an equation.)

20. Measure the periods with a slightly smaller mass and a slightly larger mass hanging from the spring. Record the masses and periods.

$$m_{\text{light}} = \underline{\hspace{4cm}} \qquad T_{\text{light}} = \underline{\hspace{4cm}}$$

$$m_{\text{heavy}} = \underline{\hspace{4cm}} \qquad T_{\text{heavy}} = \underline{\hspace{4cm}}$$

21. Do your measurements match your predictions? If not, why?

Lab #6: Pre-lab

Name: _____

3. **Pre-Lab** How can the spring constant (k) of a spring be found from a plot of force vs. distance?

9. **Pre-Lab** In terms of the spring constant, what do you expect the period of oscillation to be (give a formula)?

19. **Pre-lab** If the experiment were carried out with a different mass (say heavier), how would the measured period change (answer in words and give an equation)?