

Name:

Partners:

Energy in a Mass–Spring System

In this experiment, you will examine the kinetic and potential energy of a mass oscillating at the end of a vertical spring. This will be done by measuring the position and velocity as a function of time and using the data to construct and examine graphs of kinetic and potential energies of the system.

Energy is present in three forms for the mass and spring system. The mass m , with velocity v , can have kinetic energy KE

$$KE = \frac{1}{2}mv^2$$

The spring can hold elastic potential energy, or PE_{elastic} . We calculate PE_{elastic} by using

$$PE_{\text{elastic}} = \frac{1}{2}ky^2$$

Where k is the spring constant and y is the extension or compression of the spring measured from the equilibrium position.

The mass and spring system also has gravitational potential energy ($PE_{\text{gravitational}} = mgy$), but we do not have to include the gravitational potential energy term if we measure the spring length from the hanging equilibrium position. We can then concentrate on the exchange of energy between kinetic energy and elastic potential energy.

If there are no other forces experienced by the system, then the principle of conservation of energy tells us that the sum $\Delta KE + \Delta PE_{\text{elastic}} = 0$, which we can test experimentally.

Materials

slotted mass set, 50 g to 250 g
in 50-g steps
slotted mass hanger

ring stand
Motion detector

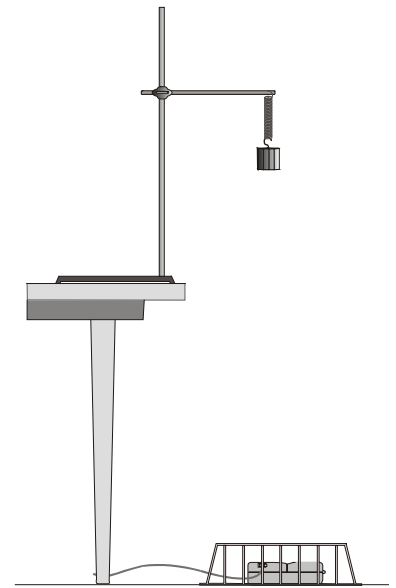
spring (small PASCO spring)

Procedure

1. To calculate the spring potential energy, it is necessary to measure the spring constant k . Hooke's law states that the spring force is proportional to its extension from equilibrium, or $F = -kx$. You can apply a known force to the spring, to be balanced in magnitude by the spring force, by hanging a range of weights from the spring.
2. Hang the spring vertically and measure its equilibrium length. Then hang a 50g mass from mass from the spring and allow the mass to hang motionless. Measure **the change in length** of the spring. Repeat with 100g, 150g, 200g, and 250g masses, each time measuring the **change in length relative to the spring equilibrium length**. Organize the data in a table. Then use the data to construct a graph from which you can determine the spring constant of the spring. Include a free body diagram in your report and clearly explain how the spring constant can be obtained from the graph.

Hanging mass	Force applied by the spring	Change in length of spring

3. Remove the 250-g mass and replace it with a 150-g mass for the following experiments.
4. Prepare the computer for data collection by opening “Exp 17C” from the *Physics with Vernier* experiment files of Logger Pro and set the sample rate to 25 samples per second. Enter the mass and the spring constant in LoggerPro.
5. With the mass hanging from the spring and at rest, click to zero the Motion Detector. From now on, all distances will be measured relative to this position. When the mass moves closer to the detector, the distance reported will be negative. **Note: after zeroing the motion detector, leave the mass motionless and collect data to verify that the position recorded by the computer is indeed zero.**
6. Start the mass oscillating in a vertical direction only, with amplitude of about 10 cm. Click to gather position, velocity, and energy data.



Analysis

- a. Concentrate on **one cycle** of the position and velocity graphs to answer these questions. What do you expect the velocity to be when the mass is farthest away from the equilibrium? Measure and record that velocity. Does it agree with you expected?

- b. What is the velocity when the mass is passing the equilibrium on its way up? What is it on its way down? Does this make sense? Explain.

2. Go to page 3 of the experiment file to see the graphs of Kinetic Energy, Elastic Potential Energy, and the Total Energy vs time. You can click on the label along the vertical axis and look at one graph at a time. To interpret these graphs determine the kinetic energy and the potential energy of the system at five different times **in one cycle**. Record these values in the following data table. Calculate the total energy of the system.

	Time	Kinetic Energy	Potential Energy	Total Energy
KE is max				
KE is between max and zero				
KE is zero				
KE is between zero and max				
KE is max				

Based on these results, what can you say about the Total Energy of the system? Does your answer agree with the graph of Total Energy vs time? Explain.

3. Go to **Print Preview** and print Page 1 and Page 3. Attach the graphs to your report.