Name:___________________________ Class:___________ Date:___________

Core Skill Lab

Conservation of Mechanical Energy

A mass on a spring will oscillate vertically when it is lifted to the length of the relaxed spring and released. The gravitational potential energy increases from a minimum at the lowest point to a maximum at the highest point. The elastic potential energy in the spring increases from a minimum at the highest point, where the spring is relaxed, to a maximum at the lowest point, where the spring is stretched. Because the mass is temporarily at rest, the kinetic energy of the mass is zero at the highest and lowest points. Thus, the total mechanical energy at those points is the sum of the elastic potential energy and the gravitational potential energy.

A Hooke’s law apparatus combines a stand for mounting a hanging spring and a vertical ruler for measuring the displacement of a mass attached to the spring. In this lab, you will use a Hooke’s law apparatus to determine the spring constant of a spring. You will also collect data during the oscillation of a mass on the spring and use your data to calculate gravitational potential energy and elastic potential energy at different points in the oscillation.

OBJECTIVES

Determine the spring constant of a spring.

Calculate elastic potential energy.

Calculate gravitational potential energy.

Determine whether mechanical energy is conserved in an oscillating spring.

MATERIALS LIST

- Hooke’s law apparatus
- meterstick
- rubber bands
- set of masses
- support stand and clamp

SAFETY

- Tie back long hair, secure loose clothing, and remove loose jewelry to prevent their getting caught in moving or rotating parts. Put on goggles.
- Attach masses securely. Perform this experiment in a clear area. Swinging or dropped masses can cause serious injury.

Procedure

PREPARATION

1. Read the entire lab procedure, and plan the steps you will take.

2. Record your data for steps 4–9 in Data Table 1 below.

DATA TABLE 1

Trial	Mass (kg)	Stretched Spring (m)	Force (N)
1			
2			
3			
4			
5			
6			

Initial Spring (m) =

3. Record your data for steps 10–14 in Data Table 2 below.

DATA TABLE 2

Trial	Highest Point (m)	Lowest Point (m)
1		
2		
3		
4		
5		
6		

Initial Distance (m) =

SPRING CONSTANT

4. Set up the Hooke's law apparatus.

5. Place a rubber band around the scale at the initial resting position of the pointer, or adjust the scale or pan to read 0.0 cm. Record this position of the pointer as *Initial Spring (m)* on Data Table 1. If you have set the scale at 0.0 cm, record 0.00 m as the initial spring position.

6. Measure the distance from the floor to the rubber band on the scale. Record this measurement in Data Table 2 under *Initial Distance (m).* This distance must remain constant throughout the lab.

7. Find a mass that will stretch the spring so that the pointer moves approximately one-quarter of the way down the scale.

8. Record the value of the mass. Also record the position of the pointer under *Stretched Spring* in Data Table 1.

9. Perform several trials with increasing masses until the spring stretches to the bottom of the scale. Record the mass and the position of the pointer for each trial.

CONSERVATION OF MECHANICAL ENERGY

10. Find a mass that will stretch the spring to about twice its original length. Record the mass in Data Table 2. Leave the mass in place on the pan.

11. Raise the pan until the pointer is at the zero position, the position where you measured the *Initial Spring* measurement.

12. Gently release the pan to let the pan drop. Watch closely to identify the high and low points of the oscillation, as shown in **Figure 1.**

13. Use a rubber band to mark the lowest position to which the pan falls, as indicated by the pointer. This point is the lowest point of the oscillation. Record the values as *Highest Point* and *Lowest Point* in Data Table 2.

14. Perform several more trials, using a different mass for each trial. Record all data in Data Table 2.

15. Clean up your work area. Put equipment away safely so that it is ready to be used again.

Analysis

1. Organizing Data Use your data from Data Table 1 to calculate the elongation of the spring. Use the equation *elongation* = *initial spring* − *stretched spring.*

2. Organizing Data For each trial, convert the masses used to measure the spring constant to their force equivalents. Use the equation $F_g = ma_g$.

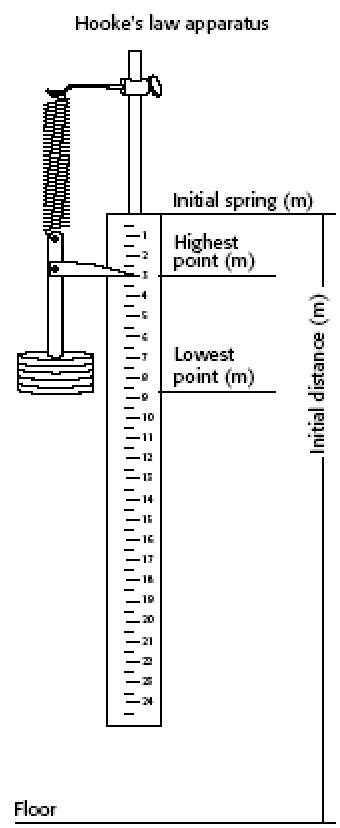

Figure 1

3. Organizing Data For each trial, calculate the spring constant using the equation $k = \frac{force}{elongation}$. Take the average of all trials, and use this value as the spring constant.

4. Organizing Data Using your data from Data Table 2, calculate the elongation of the spring at the highest point of each trial. Use the equation *elongation* = *highest point* − *initial spring.* Refer to **Figure 1.**

5. Organizing Data Calculate the elongation of the spring at the lowest point of each trial. Use the equation *elongation* = *lowest point* − *initial spring.* Refer to **Figure 1.**

6. Organizing Data For each trial, calculate the elastic potential energy, $PE_{elastic} = \frac{1}{2}kx^2$, at the highest point of the oscillation.

7. Organizing Data For each trial, calculate the elastic potential energy at the lowest point of the oscillation.

8. Analyzing Results Based on your calculations in items 6 and 7, where is the elastic potential energy greatest? Where is it the least? Explain these results in terms of the energy stored in the spring.

9. Organizing Data Calculate the height of the mass at the highest point of each trial. Use the equation *highest* = *initial distance* − *elongation.*

10. Organizing Data Calculate the height of the mass at the lowest point of each trial. Use the equation *lowest* = *initial distance* − *elongation.*

11. Organizing Data For each trial, calculate the gravitational potential energy, $PE_g = ma_gh$, at the highest point of the oscillation.

12. Organizing Data For each trial, calculate the gravitational potential energy at the lowest point of the oscillation.

13. Analyzing Results According to your calculations in items 11 and 12, where is the gravitational potential energy the greatest? Where is it the least? Explain these results in terms of gravity and the height of the mass and the spring.

14. Organizing Data Find the total potential energy at the top of the oscillation and at the bottom of the oscillation.

Conclusions

15. Drawing Conclusions Based on your data, is mechanical energy conserved in the oscillating mass on the spring? Explain how your data support your answers.

16. Making Predictions How would using a stiffer spring affect the value for the spring constant? How would this change affect the values for the elastic and gravitational potential energies?

Extensions

17. Extending Ideas Use your data to find the midpoint of the oscillation for each trial. Calculate the gravitational potential energy and the elastic potential energy at the midpoint. Use the principle of the conservation of mechanical energy to find the kinetic energy and the speed of the mass at the midpoint.

18. Designing Experiments Based on what you have learned in this lab, design an experiment to measure the spring constants of springs and other elastic materials in common products, such as the springs inside ball point pens, rubber bands, or even elastic waistbands. Include in your plan a way to determine how well each spring or elastic material conserves mechanical energy. If you have time and your teacher approves your plan, carry out the experiment on several items, and make a table comparing your results for the various items.