

CHANGES IN POTENTIAL ENERGY

OVERVIEW

The law of conservation of energy states that the total energy in an isolated system remains constant at all times. If there is no friction, this energy will remain mechanical energy. That is it can be exchanged between one form of potential energy and another, or it can be exchanged between kinetic and potential energy. Suppose a spring is hung vertically with a mass attached to its lower end. The force exerted on the spring by the mass will cause the spring to stretch and the mass will come to rest at its equilibrium position. If the mass is lifted a few centimeters above its equilibrium position and dropped, it will oscillate with simple harmonic motion. At the top and bottom of its motion the mass will be momentarily at rest and thus have zero kinetic energy. Choosing the lowest point in the oscillation as the reference level for gravitational potential energy, the total mechanical energy at this point will all be in the form of elastic potential energy of the spring. Similarly, at the top of the oscillation, the total mechanical energy will again be all potential energy with most of it in the form of gravitational potential energy. In this lab you will study the conservation of energy in a mass hanging from a spring. You will compare the change in gravitational potential energy of the system, ΔU_g , with the change in elastic potential energy, ΔU_s , as the mass oscillates between its two extreme positions.

1. First, you will measure the extension of a spring as you hang progressively larger masses from it.
2. Next, you will use the extension data to calculate the spring constant.
3. Finally, you will determine the gravitational potential energy and elastic potential energy of the spring when it is oscillating.

TIME REQUIREMENTS

This lab activity requires one 50-minute class period.

LAB EQUIPMENT AND MATERIALS

A list of equipment and materials needed to perform this lab is given below.

Equipment	Amount Needed
spring, 5-7 cm, 4-8 N/m (e.g., PASCO SE-8749)	1
mass set , 5-100 g (e.g., PASCO ME-9348)	1
support stand, with 1/2" rod (e.g., PASCO ME-9355)	1
rod, from support stand (e.g., PASCO ME-9355)	1
rod clamp (e.g., Fisher 05-754)	1
meter stick	1
Materials	Amount Needed
graph paper, linear	1 sheet/student

LAB PROCEDURE

Hints for a successful lab:

- Do not use a very stiff spring.
- Be sure to use the same spring throughout this experiment because each spring in the set has a different spring constant.
- Remember that the mass holder weighs 5 g.

Prepare the spring

1. Set up a support stand with a thin cross bar.
2. Choose one of the softer springs in the set and hang it from the cross bar.

Measure spring extension

1. Use a meter stick to measure the height of the bottom of the spring and record it on the data sheet. This is the zero extension position.
2. Add a mass holder to the spring, measure the height and record it on the data sheet.
3. Add a 5 g mass to the holder, measure the height and record it on the data sheet.
4. Continue to add masses, measure the heights and record data on the data sheet until the spring has stretched about 5 cm. This should require about 20-50 g if you chose a proper spring.

Measure oscillating spring

1. Leave the final mass from the previous section attached to the spring.
2. Lift the mass so that the spring is in its unextended position.

3. Drop the mass, measure its lowest height with the meter stick and record the data on the data sheet.
4. Repeat this procedure three times.

Perform calculations and record the data

1. Calculate the difference between the unextended height and the lowest height for each of the three trials and record the data.
2. Calculate an average average difference between the unextended height and the lowest height and record on the value on the data sheet.
3. Calculate the extension of the spring for each mass and record on the data sheet.
4. Calculate the force on the spring for each mass and record on the data sheet.

Cleanup lab

1. Remove the masses from the holder and put them away.
2. Remove the hold from the spring and put it away.
3. Remove the the spring from the stand put it away.
4. Put away the support stand.

LAB REPORT / ANALYSIS QUESTIONS

Provide answers to the following questions using complete sentences.

1. Make a plot of force vs. extension on the linear graph paper. Draw a best fit line through the data.
2. What is the experimentally determined spring constant?
3. What are the the gravitational potential energy and elastic potential energy of the mass at the highest (unextended) spring position?
4. What are the the gravitational potential energy and elastic potential energy of the mass at the lowest spring position?
5. By conservation of energy the total potential energy at the highest and lowest points should be the same. Determine the % difference between your values. How can you account for any difference between the values?

DATA SHEET 1			
Mass (kg)	Height (m)	Extension (m)	Force (N)
0			

DATA SHEET 2				
	Mass (kg)	Unextended Height, h_0 (m)	Lowest Height h_{max} (m)	$x_{max} = \Delta h$ (m)
1				
2				
3				
			Average Δh :	

DATA SHEET 3			
Mass (kg)	x_{max} (m)	ΔU_s (J)	ΔU_g (J)