Squish Potential
3.23.15

Introduction	In this activity, students will drop a standard weight from different heights to track the results to investigate the connection between potential energy and drop.
Target Grade	Grades 4-6
Time	60 minutes
Lesson Preparation	For each working group of students, you will need: • Five empty rinsed soda cans, undented (Any kind, as long as they are all the identical in size and volume.) • a sturdy dishpan or plastic bin • a yardstick and tape • a plastic gallon of water, unopened (have an additional jug on hand). It doesn't have to be a water jug if you are concerned about possible water leaks. Any suitable sturdy object (such as a large dictionary) with a heavy weight will work. • large piece of paper or poster board to record your results, and marker • data sheet to record results
Prior Knowledge Required	Before dropping an object, you must lift it up from its resting surface. When you do this, you are transferring energy from your muscles to the object. You are giving it potential energy, specifically gravitational potential energy. Gravitational potential energy is the energy gained by an object as its height above ground level increases. As the object falls towards the ground, its gravitational potential energy is transformed into kinetic energy. The kinetic energy of the object will continue increasing as the object gains momentum, until it finally collides with a surface.
Background Information	How does water get from the mountains to the ocean? It melts and flows in down in rivers in response to gravity. How fast does the river flow? That depends upon the shape of the land beneath it. Most rivers flow at a gentle slant, down the hillsides into the valleys and into larger rivers and eventually into the sea, but sometimes land just drops out from under the river, and the water falls. Imagine standing underneath it while it falls on your head. What would that feel like? Does falling water have "power"? To answer this question, we can form a hypothesis about whether we think height of falling water does or does not change the potential energy and do an experiment designed to answer the question. Lowell's mills, and other factories during the early Industrial Revolution in the United States, relied on water to generate power for factory production. The scientists, engineers, and industrialists who built Lowell understood the basic physical forces of falling water that allowed them to maximize the power that they could get from the falling water and choose appropriate sites to build mills.

Vocabulary	• Gravity: The force of attraction by which terrestrial bodies tend to fall toward the center of the earth. • Potential Energy: The energy of a particle or system of particles derived from position, or condition, rather than motion. A raised weight, coiled spring, or charged battery has potential energy. • Hypothesis: A tentative explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation. • Scientific Method: A method of investigation in which a problem is first identified and observations, experiments, or other relevant data are then used to construct or test hypotheses that purport to solve it.
Anticipated Student Preconceptions/ Misconceptions	Some people confuse energy and power. They are two different things. This lesson demonstrates that water raised to a height has potential energy. Energy is the capacity of a body or system to do work. Height is a factor of energy. The scientific term "power" is a specific meaning – the amount of energy put out or produced in a given amount of time.
Frameworks	Massachusetts Science Frameworks: • 3-PS2-1. Provide evidence to explain the effect of multiple forces, including gravity, on an object. • MS-PS3- 7(MA). Describe the relationship between kinetic and potential energy and describe conversions from one form to another. Common Core State Standards: CCSS.ELA-LITERACY.RST.6-8.3 • Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Guiding Question	How does the height of an object correlate to its potential energy?
Objectives	Students will be able to: • Explain what occurs when an object drops from a height. • Describe the relationship between potential energy and the height of initial drop. • Make a hypothesis about the relationship between height and potential energy
Activity	1. Break students into groups. Each group should have supplies for testing. 2. Mark the bottom of the cans – 0”, 6”, 12”, 18”, 36”. Take the yardstick and set it vertically in the dishpan (you can do this experiment in a dishpan if you chose or on flat table or floor) against the side, with its lower edge

about 2½ inches from the bottom of the pan (the height of a can on its side). Tape the yardstick in place against the dishpan or wall.

3. Form a tape loop and use it to affix one of the cans to surface (Figure 1). The can should be lying on its side. Take the water jug, an analogy for the falling water of a waterfall, and gently balance it on the empty can. Make sure you use your hands just to balance the jug, not support it. You want the full weight of the jug on the can (Figure 2).

Figure 1 Tape on can

4. Remove the jug. Has anything happened to the can? Did it squish the can? What distance did the jug fall through? Record results on the data chart.

Figure 2 Jug resting on can

5. What do you predict will happen if we were to drop the jug from a height of 6 inches? Repeat the set-up above with the second can, except instead of balancing the jug on the can, and lift the jug six inches above the can. Use the yardstick to measure the drop distance (Figure 3 and 4). Aim carefully! Now drop the jug on the can. Measure the amount of dent in can and record results.

6. Pause the experiment and engage students in a discussion about their first two sets of results.
   - What happened when you dropped if from 6"? Was your prediction correct?
   - How does the degree of squish compare with the "0 inches" can? Mark "6 inches" on the bottom of the second can.
   - How do these data help you towards an answer to your original question, "Does falling water have power?"
   - If yes, what do the data indicate?
   - If falling water creates some squish at 6 inches, what will happen to the amount of squish if you increase the drop distance of the jug?

Figure 4 Jug raised above can

7. Additional testing:

Repeat the experiment with the remaining cans, using a different drop distance each time. We recommend distances of 12, 18, and 36 inches. Each time, compare the degree of squish of the can with the previous cans. Measure the amount of dent in can and record results

Figure 3 Can with Ruler

8. Have students create poster boards (see instructions below in “Assessment”).

9. While students share their poster boards, engage them in discussion with these questions:
   a. What relationship do you observe between the distances the jug falls and the degree of squish?
   b. Why was it necessary to have identical cans as the targets?
   c. Why did you need to use the same jug of water each time?
   d. What was the ONLY factor in your experiment that changed each time?
   e. Why was it important that this factor be the ONLY thing that changed?
   f. Challenge: How would you design an experiment that would more clearly demonstrate the answer to the original question? **"Does falling water have power?"**

Figure 5 Using a Book instead of a jug

Assessment

Presenting Results:
The process you have used to determine the answer to your question is the “Scientific Method.” It is the method used by scientists to find answers to questions about the physical world. An experiment is of little value unless the scientist presents the results and methodology to the rest of the world. Now, take your data and use it to present your results. Each group will a create a poster of their results:

- On the top third of your poster, write down the question you hoped to answer in your experiment and how you conducted the experiment.
- On the middle third, create five spaces, side by side, for your cans, each space labeled with the distance that you dropped the jug. Record the amount of dent for each can.
- On the bottom third, write one or two complete sentences that express what you have found out about falling water and power and the relationship

	between them. One of the key factors in the scientific method is that other researchers can repeat the experiment and come out with the same results that you do. Now compare your results to in the results from your class. How are their results similar to or different from your own? Discuss what caused the differences and how that impacts your answer to the guiding question.
Differentiation Suggestions	Do the activity as a whole class, instead of in small groups. Work together to record the data and answer the questions.
Adapting the Activity for Other Grades	Further Experiments: As we've seen, often the answer to one question suggests other questions you might want to know about. What other questions could you ask that you could answer using this experiment? How about: • What would happen if you used a two-gallon jug instead of a 1-gallon jug? Would the squish level be the same or different? If different, in what way? • What would happen if you used a different type of can or a stronger can? Would the squish level be the same, assuming you used the same gallon of water? If you used a sturdier target (can), would you predict the need for greater or lesser drop distances to achieve the same squish level?
Bibliography	Viegas, Jennifer. *Kinetic and Potential Energy: Understanding Changes within Physical Systems*. New York: Rosen Pub. Group, 2005. Welch, Catherine A. *Forces and Motion: A Question and Answer Book*. Mankato, Minn.: Capstone, 2006.

Squish Potential
3.23.15

CATEGORY	4	3	2	1
Participation	Used time well in lab and focused attention on the experiment.	Used time pretty well. Stayed focused on the experiment most of the time.	Did the lab but did not appear very interested. Focus was lost on several occasions.	Participation was minimal OR student was hostile about participating.
Evidence	Uses data powerfully as evidence to support statements.	Uses data to support statements.	Refers to data in the body of the report as support.	Does not use data to support arguments
Conclusion	Conclusion includes whether the findings supported the hypothesis, possible sources of error, and what was learned from the experiment.	Conclusion includes whether the findings supported the hypothesis and what was learned from the experiment.	Conclusion includes what was learned from the experiment.	No conclusion was included in the report OR shows little effort and reflection.

Squish Potential Instructions and Data Sheet

1. Mark the bottom of your five cans – each with one of the following numbers.
   - 0”
   - 6”
   - 12”
   - 18”
   - 36”

Take the yardstick and set it vertically, with its lower edge about 2½ inches from the bottom of the pan (the height of a can on its side). Tape the yardstick in place against the dishpan or wall. Figure 1 shows the ruler is just at top of can. This will allow you to measure the distance above the can for the weight you will drop.

Figure 1 Can with Ruler

2. Measure the diameter of one of the cans and record it on page 3.

Form a tape loop and use it to affix one of the cans to surface (Figure 2).

Figure 2 Tape on Can

3. Take the water jug (weight) and gently balance it on the empty can. Make sure you use your hands just to balance the weight, not support it. You want the full weight on the can (Figure 3).

Figure 3 Jug resting on Can

Squish Potential Instructions and Data Sheet

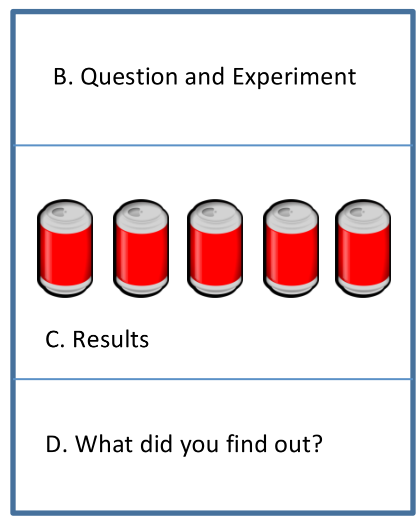
4. Remove the weight. Has anything happened to the can? Did it squish the can? Measure the squished portion of the can and record your data on the chart.	
5. Repeat steps 2-4 with the 6" can, except instead of balancing the jug on the can lift the jug six inches above the can and drop the jug on the can. Measure the squished portion of the can and record results.	 Figure 4 - Book as weight held 6 inches above can
6. Pause here and wait for the other groups to finish the first two drops.	
7. Repeat the experiment with the remaining cans, using distances of 12, 18, and 36 inches. Each time, compare the degree of squish of the can with the previous cans. Measure the squished portion of the can and record results.	

Squish Potential Instructions and Data Sheet

Names of Group Members: ____

Original diameter of can: _______________________

Height Dropped (inches above can)	**Amount Squished Measurement**	**To find out how much "squish potential" each height has, subtract the amount squished (AS) from the original diameter (OD) of the can and record the results below.** **OD – AS = Squish Potential**
0 inches		
6 inches		
12 inches		
18 inches		
36 inches		



Now, take your data and create a poster to present your results.

A. Fold your poster paper into thirds, creating three sections.

B. On the top third of your poster, write down the question you hoped to answer in your experiment and a sentence about how you conducted the experiment.

C. On the middle third, create five spaces, side by side, for your cans. Label each space with the distance that you dropped the jug and record the amount of squish potential you calculated for each can. Tape the corresponding can in each space.

D. On the bottom third, write one or two complete sentences that express what you have found out about falling water, power, and the relationship between them (see below).

While writing your response for "D," consider the following questions:

- What relationship did you observe between the distance the weight fell and the amount of squish?
- Why was it necessary to have identical cans as the targets?
- Why did you need to use the same jug of water each time?
- What was the ONLY factor in your experiment that changed each time?
- Why was it important that this factor be the ONLY thing that changed?