Introduction	This ball drop activity demonstrates how potential energy is impacted by a loss of energy with the collision with the ground.
Target grade	Grades 8-12
Time	45 minutes
Lesson Preparation	Need three balls (tennis, golf and rubber balls) for each group Meter sticks Chart to record results
Prior Knowledge Required	Students should have a basic understanding of potential and kinetic energy.
Background Information	The Law of Conservation of Energy states that energy cannot be created or destroyed, but can be transformed. In this activity, we see that the balls do not return to the same height and can infer that there has been a change in energy. Before dropping a ball, you must lift it up from its resting surface. When you do this, you are transferring energy from your muscles to the ball. You are giving the ball 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 ball falls towards the ground, its gravitational potential energy is transformed into kinetic energy. The kinetic energy of the ball will continue increasing as the ball gains momentum, until it finally collides with a surface. When the ball collides, the kinetic energy is transformed into other forms of energy. When a ball hits a surface, some energy is transformed into sound energy, some is transformed into thermal energy from the friction created, and some becomes elastic potential energy resulting from the instantaneous deformation of the ball when it collides. Here is a video that shows the golf ball hitting a wall in slow motion. This shows how much the ball is deformed though invisible to the naked eye. https://www.youtube.com/watch?v=AkB81u5IM3I This elastic potential energy is why the ball is able to bounce, or rebound. After the ball rebounds, the elastic potential energy is transformed into kinetic energy, but it will **never possess as much kinetic energy** as during its original fall because some of the original kinetic energy has been transformed into sound, friction, and deformation of the ball. Potential and kinetic energy of waterpower was important to operation of the mills in Lowell. At its most basic, the height of water is crucial to creating waterpower. Friction, turbulence, and other factors reduced the actual energy in the mills. “Conservation of Energy” concepts are also evident in the “loss” of energy in the

	mills, as the energy created by the falling water moves through the mill's power-transfer system. As the energy moves through belts, gears, and machines, energy is lost to friction and other causes is demonstrate in heat, vibration and noise. *This lesson draws from a teacher lesson by the Museum of Science and Industry Chicago*. http://www.msichicago.org/fileadmin/Education/teacher_courses/Get_Re-Energized/ME_Ball_Drop.pdf
Vocabulary	• Potential energy: the energy possessed by a body due to its position relative to others, stresses within itself, electric charge, and other factors • Kinetic energy: energy of a body in motion • Law of Conservation of Energy: Energy can be neither created nor destroyed, but can change form, for instance potential energy can be converted to kinetic energy. • Inelastic collision: A perfect elastic collision is defined as one in which there is no loss of kinetic energy in the collision. An inelastic collision is one in which part of the kinetic energy is changed to some other form of energy in the collision. • Friction: the resistance that one surface or object encounters when moving over another
Anticipated Student Preconceptions/ Misconceptions	Students may assume that reduced energy (rebound) is due to a loss in energy and not that the energy has been transformed into other forms of energy that they might not be able to see/hear/feel. Students may also see an increased rebound if additional energy is applied in the drop (i.e. they push or throw the ball). This could be accidental and possibly even unnoticed by the student.
Frameworks	Massachusetts Science Frameworks: • 3-PS2-1. Provide evidence to explain the effect of multiple forces, including friction, on an object. Include balanced forces that do not change the motion of the object and unbalanced forces that do change the motion of the 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	What change occurs in the energy of a falling ball after it bounces?
Objectives	Students will be able to: • Explain what occurs when a ball drops from a height. • Describe the difference between the initial potential energy and the return energy.
Activity	*Introduction* As a demonstration, drop a ball onto a table where all of your students can see it. • When the ball is at its highest point, it has potential energy. • When the ball is falling towards the table, it has kinetic energy. It has the most kinetic energy at the very end of its descent when it is moving the fastest. • Even though we can't see it, as the ball hits the table, it changes shape for a split second. This requires energy. There is a transfer of energy from kinetic to sound (in the noise it makes upon impact) and thermal energy (friction with the table.) • The ball is not able to bounce to its original drop height because of these energy transfers. The ball will never have as much kinetic energy as it originally had. *Activity* 1. Give each group a golf ball, tennis ball and rubber ball. Set a timer, and let them experiment with the bouncing of each ball for one minute. 2. Have each group set up a testing station and follow the directions: • Remind students that they need consistent results. Drop the ball the same way each time!! *Do not put any force on the ball by throwing it down in any way!!* • Hold the meter stick and observe the height at which the ball rebounds (the first bounce.) • Record the measurements in the data tables on the student worksheet. 3. Begin the experiment with the golf ball and find the 100 cm mark on the meter stick. 4. Drop the golf ball, the same way, for all five trials. For each trial, the measurer should tell the recorder the rebound height of the first bounce. After your group has completed five trials for the golf ball, calculate the average rebound height. 5. Repeat the experiment by dropping the tennis ball for five trials, and then the rubber ball. Record the average rebound height for each of these balls. 6. Repeat the experiment as you just did, but this time drop the balls from a

	height of 200 cm. 7. Review the experiment results and worksheet questions with the whole class – asking them to share their findings and discussion results
Assessment	Each group should complete their activity sheet and the questions.
Differentiation Suggestions	Work in a group or as individual. Can rotate tasks in group.
Adapting the Activity for Other Grades	Students can create their own experiment to test the balls with additional variables. Examples might include: INDEPENDENT VARIABLES — DEPENDENT VARIABLES How does the…. — Affect ... Temperature of the ball — How many times the ball bounces Height the ball is dropped from — How many times the ball bounces Surface the ball collides with — The height of the first bounce Material of the ball — The height of the first bounce
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.

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.

Ball Drop Rebound Test

Hypothesis: What do you anticipate the result to be for ball return height? _____

_____

Drop the golf ball, the same way, for all five trials. For each trial, the measurer should tell the recorder the rebound height of the first bounce. After your group has completed five trials for the golf ball, calculate the average rebound height. Repeat for Tennis Ball and Rubber Ball

100 cm Drop Height

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Average Rebound Height	Average Difference between Rebound and Drop
Golf Ball							
Tennis Ball							
Rubber Ball							

Repeat the experiment as you just did, but this time drop the balls from a height of 200 cm.

200 cm Drop Height

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Average Rebound Height	Average Difference between Rebound and Drop
Golf Ball							
Tennis Ball							
Rubber Ball							

1. Did the balls rebound to the drop height? _____
2. Why do you think that is?

_____

3. Which ball bounced the highest? _____
4. Why do you think that is?

_____

5. In your own words, explain what is happening when the balls rebound and why.