Conservation of Energy: Designing a Roller Coaster
Lesson Plan

Grade Level: 6-8	**Curriculum Focus:** Energy	**Lesson Duration:** Three class periods

Student Objectives

- Review energy types and how they affect movement.
- Create a miniature roller coaster that demonstrates the forces of mechanical energy.

Materials

- Discovery School video on *unitedstreaming*: *Roller Coaster Physics*
  Search for this video by using the video title (or a portion of it) as the keyword.

  Selected clips that support this lesson plan:
- The Ties That Bend: The Science of Roller Coasters
- Galileo's "Stop Height": Gravity and Potential and Kinetic Energy at Work
- The Thrill of It All: G-Forces, Inertia, and Newton's First Law of Motion

- One tennis ball (or similar-sized ball) per group
- Two pieces corrugated cardboard or foam board (70 × 200 cm) per group
- Heavy-duty scissors
- Box knives
- Meter sticks
- Hot glue and glue guns

Procedures

1. Review the principle of “conservation of energy” by analyzing a roller coaster ride from start to finish. You may want to view *Roller Coaster Physics* as an introduction to the discussion. Make sure you discuss the names of all relevant energy forms and where and when on the ride energy transformations are occurring.

2. Tell students they will be designing and constructing cardboard "tennis ball" roller coasters with three hills. The tennis ball in each design must start at the top of the first hill, roll up and down the other two hills, and exit the end of the track. Each roller coaster will be judged in a class competition. The track with the greatest total of vertical heights for all three hills—if the tennis ball completes the course—will be named the winning design.
3. Have students consider the following when designing their roller coasters:
   - Can all the hills be the same height? If not, why? Can they get bigger, or must they get smaller?
   - How will you determine how big or how small the hills can be and still win this contest?
   - Does the steepness of the hill count? Is it better to make the hills steep or not so steep? Why?
   - How curvy should the tops of the hills and the valleys be?
   - Should your design have sharp or smooth turns? Why?
   - What provides resistance on the roller coaster, causing the tennis ball to slow down? How can this resistance be reduced?
4. Divide students into small groups, give each group the materials listed earlier, and then provide the following directions.
   - The left and right roller coaster tracks will be made from the two pieces of corrugated cardboard and must be cut out as identical shapes.
   - Each valley in the roller coaster must dip to a low height of 20 centimeters from the bottom of the cardboard.
   - Have students use heavy-duty scissors or box knives to cut out both tracks. They can shape the roller coaster however they want as long as each hill is smaller than the previous one.
   - From the excess cardboard, students should cut out 25 rectangles, each 4 × 12 cm. These will serve as spacers between the two tracks. Put glue along the rectangles' 12-centimeter edges, and then fasten them between the two tracks so that the tracks are rigid and separated by a distance of 4 centimeters.
5. After the initial construction of the roller coasters, give students time to make revisions to their original design—an important factor in the worlds of design and engineering.
6. Hold the roller coaster competition. To score the contest, measure the heights of each of the three required hills and add them up. The roller coaster with the greatest total height of the three hills is the winner as long as its tennis ball successfully completed the journey.

Assessment

Use the following three-point rubric to evaluate students' work during this lesson.

- **3 points:** Students recalled key principles of energy types and how they affect the motion of a roller coaster; participated actively in discussing the design features needed for a roller coaster to function properly; designed and built a cardboard roller coaster that successfully demonstrated the concepts of energy and motion.

- **2 points:** Students recalled some key principles of energy types and how they are used to design a roller coaster; participated somewhat in discussing the design features needed for a roller coaster to function properly; designed and built a cardboard roller coaster that was somewhat successful in demonstrating the concepts of energy and motion.
- **1 point:** Students recalled few or no key principles of energy types and how they are used to design a roller coaster; did not participate in discussing the design features needed for a roller coaster to function properly; did not design and build a cardboard roller coaster that demonstrated the concepts of energy and motion.

Vocabulary

conservation of energy

Definition: The principle that within the universe, or any closed system, the total energy remains constant, although the energy may transform from one kind to another

Context: The conservation of energy principle states that as potential energy transforms into kinetic energy (and vice versa), the total energy should remain constant at all times and in all places on the roller coaster.

friction

Definition: The resistance to relative motion of two surfaces that are in contact with each other as they roll or slide across one another

Context: Due to frictional interactions between the roller coaster car and the track, mechanical energy is lost and transformed into heat.

gravitational potential energy (GPE)

Definition: The energy that a mass has because of its vertical separation (height) from the earth; calculated with GPE = mgh, where *m* is the mass, *g* is the acceleration due to gravity (-9.80m/s2 on Earth), and *h* is the height from some arbitrarily defined initial height

Context: All the energy needed to run a roller coaster car to the end of the track comes from the gravitational potential energy that it has when lifted to the top of the first and highest hill.

heat (thermal energy)

Definition: The atomic and molecular energy of matter due to the kinetic energy of the atoms and molecules vibrating and moving with random motions

Context: As the mechanical energy of a system, such as a roller coaster, is transformed into heat, we can expect that the temperature of that system and the environment in which it exists will rise somewhat.

kinetic energy

Definition: The energy a mass has because it is moving; calculated with KE = mv2/2, where *m* is the mass, and *v* is the velocity

Context: As the roller coaster car glides down each hill, gravitational potential energy is converted into kinetic energy; this makes you and the car go faster and faster.

mechanical energy

Definition: Energy generally associated with a moving mass or the action, or potential action, of a force being applied through a distance

Context: The two forms of mechanical energy that are relevant to the understanding of how a roller coaster works are gravitational potential energy and kinetic energy.

Academic Standards

National Academy of Sciences

The National Science Education Standards provide guidelines for teaching science as well as a coherent vision of what it means to be scientifically literate for students in grades K-12. To view the standards, visit http://books.nap.edu.

This lesson plan addresses the following science standards:

- Physical Science: Transfer of energy
- Science and Technology: Abilities of technological design

Mid-continent Research for Education and Learning (McREL)

McREL's Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education addresses 14 content areas. To view the standards and benchmarks, visit http://www.mcrel.org/.

This lesson plan addresses the following national standards:

- Science—Physical Sciences: Understands the sources and properties of energy, Understands forces and motion
- Language Arts—Viewing: Uses viewing skills and strategies to understand and interpret visual media

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Support Materials

Develop custom worksheets, educational puzzles, online quizzes, and more with the free teaching tools offered on the Discoveryschool.com Web site. Create and print support materials, or save them to a Custom Classroom account for future use. To learn more, visit

- http://school.discovery.com/teachingtools/teachingtools.html