

Nothing Lost, Nothing Gained

Mairlyn Kiser, WBRA

Overview: Kinetic and Potential Energy. This lesson centers on the conservation of energy and how energy can convert from kinetic to potential and back again. Students will use interactive sites on the Internet to identify and differentiate between gravitational potential, potential, and kinetic energy. Students will build a roller coaster, explain where the kinetic and potential energy is the greatest, and demonstrate how gravity affects the energy involved in the roller coaster ride and explain the relationship between friction and energy.

Grade Levels:

6th – 8th grade

Time Allotment:

3 – 45 minute blocks

Subject Matter:

Science

Learning Objectives:

Students will be able to:

- explain the Law of Conservation of Energy.
- define/differentiate between kinetic, potential, and gravitational energy.
- describe the role of friction in energy conversion.
- explain how energy conversion occurs on a roller coaster.
- identify where kinetic or potential energy is located on a roller coaster.
- construct a roller coaster, calculate the gravitational potential energy at certain points, and identify where energy transfers occur.

Standards:

State Standards:

The objectives listed may be used in part to address the Virginia Standards of Learning at <http://pen.k12.va.us>

- The student will investigate and understand states of energy and how energy is transferred. (VA. SOL Science PS.6, 6.3)
- The student will investigate potential and kinetic energy. (VA. SOL Science PS.6, 6.3)

The student will use wide-area networks and modem-delivered services to access and retrieve information from electronic databases. (VA. SOL Computer/Technology C/T8.4)

Media Components:

Video:

Newton's Apple's Greatest Hits

Web Sites:

<http://www.Funderstanding.com/k12/coaster>

Funderstanding Roller Coaster

At this site, students can manipulate the height of the hills, size of loop, amount of gravity and amount of friction when they design a roller coaster. The students can work the roller coaster to find out if the coaster can run the complete track. Also, at this site are the definitions for kinetic energy, potential energy, friction, gravity, and the Law of Conservation of Energy.

<http://sciencejoywagon.com/physicszone/leson/05work/rolcoast/rollcoast.htm>

Energy of a Roller Coaster

Students can use an animated roller coaster to demonstrate how the potential energy and kinetic energy are converted. Here, they will see how the total energy always equals the kinetic energy plus the potential energy.

<http://www.learner.org/exhibits/parkphysics/coaster.html>

Amusement Park Physics

Here, the students can learn about the workings of roller coasters and can design a roller coaster by choosing the loops, hills, and slopes. Students will then discover if the coaster's design will work.

<http://www.discovery.com/exp/rollercoasters/build.html>

High Anxiety – Build a Roller Coaster

At this site students can build their own roller coaster by choosing hills, valleys, loops, and tunnels. After completing the roller coaster, the coaster is evaluated at to whether it will or will not work and whether it is exciting or not exciting.

Materials:

Materials needed for Introductory Activity

- Television
- VCR
- Video: Newton's Apple's Greatest Hits/*Bungee Slingshot*

Materials needed for Learning Activity for each group of two students:

- Computer
- One copy of the four handouts entitled "Roller Coaster Data Sheet #1,2,3, and 4"
- One copy of "Let's Roll" Practice Sheet
- Pencil

Materials needed for Culminating Activity for each group of two students:

- 20 – 25 feet of clear 3/4- inch vinyl tubing
- roll of duct tape
- scissors (for cutting tape)
- meter stick
- stopwatch
- 1 – ¼ inch steel hunting shot (found in Sporting Goods department of Wal-Mart and such stores)
- calculator
- triple-beam balance or electronic balance
- pencil

Preparation for Teachers:

- ✓ Prior to teaching the unit, bookmark the Web sites.
- ✓ Have your videotape ready at the beginning of Bungee Slingshot.
- ✓ Photocopy all student handouts for distribution as needed during the lesson.
- ✓ The 20 –25 feet of clear ¾ inch vinyl tubing can be purchased at a hardware store.

Make sure you go through the instructions from the student materials handouts to make certain that you understand and are familiar with the lesson format and what the students need to do or understand for the lesson.

When using media, always provide the students with a Focus for Media Interaction, which is a specific task to complete during or after viewing video segments, Web sites, or other media material.

Prior to this lesson, students should have been introduced to what energy and work are and how they are related.

Introductory Activity: Setting the Stage

1. Provide the students with a **Focus for Media Interaction**, and say, "Students, I'm going to show a segment of a video on an amusement park ride. I want you to watch and at the end of this segment, I want you to be able to tell me what

amusement park ride this video is about and what Susanne wants to know.”

Start Newton’s Apple’s Greatest Hits - *Bungee Slingshot* at the beginning of the segment. **Pause** after the words “Wow” and see the boy bungee jumping. Ask, “What amusement park ride did we see?” (Bungee Jumping or Ejection Seat) “What does Susanne want to know?” (She wants to know more about the ride and who can explain how it works.)

- 2. Focus for Media Interaction:** Say, “Next, I want you to listen for the purpose of the frame and the harness. I also, want you to find out how many rubber bands are used and what their purpose or job is?” **Resume** the video and **stop** when you hear “... to do very much work at all” and see Susanne looking closely at the many rubber bands. Ask, “What is the purpose for the frame? (To give the ride good balance and rigidity.) “What is the purpose for the harness?” (This holds you in tight, gives you a good sense of security, and keeps you from falling out onto your head.) “How many rubber bands are used?” (Thousands) “Why are the rubber bands used?” (They power the ejection seat.)
- 3. Focus for Media Interaction:** Say, “You are now going to watch how the ejection seat works. I want you to be able to explain how it works.” **Resume** and **stop** when you hear “...from potential energy to kinetic energy and back again” and see the ejection seat being ejected up again for the second time. Ask, “Can someone explain how the ejection seat works?” (The wench raised the cables and stretches the cords to the top of the tower. A latch at the end of the stabilizer arm holds the ejection seat in place. When this handle is pulled, the latch is released. The cords quickly snap back to their original length, flinging the seat and the occupants.) *Note: The students will not*

be able to recall the steps of how the ejection seat works. Say, “I’m going to rewind this segment for you to watch again. When the segment is finished, I want you to be able to tell me how the ejection seat works.” **Rewind** to where you see Susanne looking closely at the many rubber bands. **Start** and **stop** when you hear “...from potential energy to kinetic energy and back again” and see the ejection seat being flung into the air again. Ask, “How does the ejection seat work?” (The wench raised the cables and stretches the cords to the top of the tower. A latch at the end of the stabilizer arm holds the ejection seat in place. When this handle is pulled, the latch is released. The cords quickly snap back to their original length, flinging the seat and the occupants.)

- 4. Focus for Media Interaction:** Say, “Jack is going to explain that the reason why the ejection seat works the way that it does is because of energy transfer. I want you to be able to tell me what energy transfer is, what two forms of energy Jack is talking about, and explain the difference between the two energies.” **Start** and **pause** when you hear “Kinetic energy is when you are moving and potential energy is when it is stored” and see Susanne jump from the swing. Ask, “What is energy transfer?” (When one form of energy changes to another form of energy) “What are the two forms of energy Jack is talking about?” (potential and kinetic energy) “How are the energies different?” (kinetic energy is the energy of motion and potential energy is stored energy.)

- 5. Focus for Media Interaction:** Say, “We know that the ejection seat has kinetic energy after it is launched because it is moving, but how does it have potential energy? What happens to the potential energy when the ejection seat is shot into the air? I want you to tell me why the ejection seat will slow down and stop.” **Resume** and **pause** when you hear “...here I go. Good

luck for me, Jack's going to come along" and you see Susanne and Jack giving their ticket to the attendant. Ask, "When does the seat have potential energy?" (It is stored in the bungee cords when they are stretched.) "What happens to the potential energy when the ejection seat is shot into the air?" (When the seat is shot into the air, the potential energy converts to kinetic energy.) "Why does the seat slow down and stop?" (Friction)

6. Focus for Media Interaction: Say, "Watch as the potential energy converts to kinetic energy as Susanne and Jack take a ride. Do Jack and Susanne enjoy the ride?" **Resume** and **stop** the video at the end of this segment where Susanne tells Jack goodbye. Ask, "Did Jack enjoy the ride?" (Yes) "Do you think that Susanne enjoyed her ride?" (Students' opinion.) "Why?" (She screamed the whole time.)

Learning Activities

Note to teacher: Have the web sites bookmarked on the computers to be used by the class. Students may work individually or in groups of two.

1. **Focus for Media Interaction:** After the video, tell the students. "We are now going to use the computer to find out more about kinetic energy and potential energy. You will have questions that are to be answered for each web site. These questions will be evaluated for a grade."
2. Pass out the stapled worksheets to the students. Say, "These pages have directions for each site that you will be accessing. Be sure to follow the directions on the worksheets and NOT on the Internet site. Now, let's go over the directions for the worksheets." Hold up **Roller Coaster Data Sheet #1** and say, "At this site, there is a roller coaster and underneath the roller coaster are controls that can be changed. You can increase or decrease the size of

hill #1 or hill #2. You can increase or decrease the amount of gravity and/or friction on the track. Follow the directions on the worksheet and write down your results." Read over the directions and questions on Sheet # 1 and ask, "Are there any questions?"

3. Turn to Sheet #2 and say, "Let's turn to **Roller Coaster Data Sheet #2** and go over the directions. At this site, you will see an animated roller coaster. I want you to see how the energy will go from one form to another form. I want you to find out what the total energy is and what happens to the total energy. Be sure to answer these questions before you go on to the next site." Go over the questions with the students and ask, "Are there any questions?"
4. Turn to **Roller Coaster Data Sheet #3** and say, "When you go to this site, you will see another roller coaster. Here, you will choose the height of the hills of your roller coaster, the shape of the exit path, and the shape of the loop. Again, follow the directions on the worksheet and answer the questions." Read the directions with the students and ask, "Are there any questions for this worksheet?"
5. Have the students look at **Roller Coaster Data Sheet #4** and say, "At this site you will design your own roller coaster. If you do not have time to finish this in class, you are to take it home and do as homework." (Those who do not have a computer with Internet access at home can design one on paper and write 2 paragraphs explaining how it works.)
6. Allow the students to go to the computers and log on. Tell the

students to go to *bookmark* and click on [www.funderstanding](http://www.funderstanding.com) site.

Again, **Focus for Media**

Interaction: Say, “Remember to read your directions. I want you go find out about the different forms of energy and how they work with a roller coaster. Hold your hand up each time when you have completed a worksheet. I will look it over and let you go on to the next sheet. You may begin.”

7. As each student completes his/her worksheet, check that it is completed and have him/her go to the next sheet and go to the next site that is bookmarked. Remind students that the worksheets need to be turned in so that they can be evaluated.
8. After the students have completed the Roller Coaster Data Sheets, ask the class and give them time to answer, “What is potential energy?” (energy that is stored) “What is kinetic energy?” (energy of motion) “What is energy transfer?” (when energy in one form converts to energy in another form) “Can you give me an example of an energy transfer?” (when potential energy changes to kinetic energy) “Can energy be lost?” (No) “Why can’t energy be lost?” (Energy is never lost, only transferred.) “What is the difference between gravitational potential energy and potential energy?” (Potential energy is stored energy, as a stretched rubber band. Gravitational potential energy is stored energy due to height.) “What is the relationship between gravity and roller coasters?” (A roller coaster had to have gravity to work.) “How does friction affect the mechanics of roller coasters?” (Because of friction, energy is changed to heat energy as it meets resistance with the track and the

air.) “What is the total energy?” (The kinetic energy plus the potential energy.)

Culminating Activity

This activity emphasizes discovering the physics behind roller coasters. Many of the principles of energy can be experienced by the students, as they construct a model roller coaster.

Tell the students, “You are going to build a model roller coaster. Each group will be given the same materials and only those materials will be used. The roller coaster has to have 2 hills (one steep hill and one low hill) and a loop and the coaster must work. You may use the desks, chairs, tables, and/or books in the room to form the hills and valleys of the roller coaster. After it is constructed, see if it will work. If it does not, reconstruct until it does. When it is working, measure the height of the hills from the floor to the top of the hill. Find the gravitational potential energy of each hill, using the formula: $GPE = mgh$ (mass x gravity {9.8 m/s} x height). After this is finished, measure the speed, using the stopwatch, of the steel ball from the time the steel ball is released until it leaves the end of the roller coaster. Record these measurements in the Roller Coaster Data Collection Sheet. When I come around to see your coaster, I want you to point out where the kinetic energy will be and where the potential energy is. I am available if you have any questions.”

1. The students are going to build a working roller coaster using the materials provided. (Students will not cut their tubing.) The roller coaster shall have at least one steep hill and one low hill. It should also contain at least a single loop.
2. Each group will receive 20 – 25 feet of clear $\frac{3}{4}$ inch vinyl tubing, 1- $\frac{1}{4}$ inch steel ball, a role of duct tape, a meter stick, and a stopwatch.
3. Give the students the requirements:

- a. The roller coaster has to work.
 - b. The roller coaster has to have at least one steep hill, one low hill and a single loop. Remember: first hill has to be taller than the second.
 - c. No extra material will be given.
 - d. Start the beginning of the roller coaster at the top of the first hill.
4. After the roller coaster construction is complete, test it and see if it works, by rolling a steel ball down the first hill. The steel ball should go over the second hill and around the loop. If not, re-design until it works.
 5. When the roller coaster works, the students will measure the height of each hill and find the gravitational potential energy. The student will then measure the time it takes the steel ball to go from the top of the first hill to the end of the roller coaster. The students will record this in the provided data collection sheet.
 6. The students should try another design with a different height for each hill. (The first hill should still be steeper than the second hill and the coaster has to work.) Again, they are to measure the height of each hill and find the gravitational potential energy. After this, they are to measure the time it takes for the steel ball to make the complete trip from the top to the bottom. Record this information. (Walk around the room and ask the students to point out on the roller coaster where the kinetic energy is and the potential energy is. Ask them where the greatest potential energy is. (At the top of the first hill.) Ask them where the greatest kinetic energy is. (At the bottom of the first hill.)
 7. When this activity has been completed, have the students complete the data collection sheet. Ask the students, “What was the effect of the height of the hill on the

gravitational potential energy?” (Should say that the higher the hill, the more gravitational potential energy the coaster had.) “What was the effect of the height of the hill on the speed of the steel ball?” (Should say that the higher the hill, the more kinetic energy the coaster had.) “If we changed the mass of the steel ball, would it affect the kinetic energy? If so, how?” (Their response should relate mass to gravity and kinetic energy.)

Assesment

- 1) The Roller Coaster Data Sheets #1,2, and 3 will be evaluated.
- 2) The paragraph from the Roller Coaster Data Sheet #4 will be given a grade.
- 3) A grade will be given for “Let’s Roll” worksheet.

Cross-Curricular Extensions

Science:

Students can use the knowledge gained from this lesson to explain and investigate the transfer of energy from one state to energy in any other form. Example: mechanical energy to heat and light energy. Using the roller coaster, they can calculate velocity, momentum, and acceleration.

Social Studies:

Students can research the history of roller coasters. Some of the Web sites that may be used are:

www.cinternet.net/~bowersda/history.htm

History of Roller Coasters

This site traces the origin of the roller coaster back to the Russian ice slides. The history of the roller coaster goes from the ice slides to the present day coasters.

www.cedarpoint.com/public/inside_park/ride/thrill/magnum10/coasterhistory.cfm

A Brief History of Roller Coasters

This site includes where the scream machine came from, where the phrase “roller coaster” originated, and how some earlier coasters worked.

www.iaapa.org/media/roll-hst.htm

Roller Coaster History

At this site, readers can find where the first specially-built roller coaster was located, where and when the first loop was put in the roller coaster track, and how rides were first tested.

Art:

Students can design an amusement park, placing 2 or more different types of roller coasters in the park. Imagination is the key here.

Math:

As students calculate kinetic and potential, they will be using formulas taught in math. Other formulas used are for velocity, acceleration, speed, and momentum.

Language Arts:

Students can write a paper on a ride (preferably one on a roller coaster) that they were on that was very exciting and thrilling. Encourage the students to tell of the emotions they experienced while on the ride.

Community Connections

- ★ Invite the contact person of the county fair board to speak to the class. This person will be able to tell the class whom he/she contacts for the carnival part of the county fair and how the types of carnival rides are chosen for the fair.
- ★ Work with other curriculum-based teachers to create a family night at school where the students can demonstrate and display their work.
- ★ Have the students find this article on the Internet, read the article, and write a brief report: [ON A ROLL.\(Using virtual reality to defy the laws of gravity in roller coaster design\)\(Brief Article\)](#)
WITH COMPUTER MODELING,
ROLLER COASTER DESIGNERS
ACCOMPLISH WHAT VIRTUAL
REALITY HASN'T: USING DIGITAL
TECHNOLOGY TO EXPLOIT THE

LAWS OF GRAVITY

From Industry Standard, The,
September 06 2001 by Harold Goldberg
Page(s): 2