SIEMENS STEM DAY | Science Technology Engineering Math

GRADES 9–12

SIEMENS STEM DAY ACTIVITY

ENERGY TRANSFORMATION

OBJECTIVES

Students will be able to:

- Conduct an experiment and gather data to create a computational model that demonstrates the mathematical changes in energy transformation from potential to kinetic energy.

THIS LESSON FOCUSES ON

Engineering Design Cycle

- Designing Solutions
- Communicating Results

21st-Century Skills

- Collaboration
- Communication
- Critical Thinking

OVERVIEW

Students will investigate how the changes in potential energy produce a change in kinetic energy. By conducting a lab investigation, students will experiment using a pull-back toy car to gather data, make calculations and draw conclusions about the change in energy.

STEM incorporates Science, Technology, Engineering, and Mathematics to focus on real-world issues and problems guided by the engineering design process. This type of instruction supports students in developing critical thinking, collaboration, reasoning, and creative skills to be competitive in the 21st-century workforce.

Each Siemens STEM Day classroom activity highlights one or more components of the engineering design cycle and an essential 21st-century skill.

MATERIALS

- Variety of pull-back toy cars
- Toy car tracks
- Books of varying heights
- Tape
- Digital Scales
- Metersticks
- Computers with internet access
- **Energy Transformation** Handout—one per student pair

HAVE YOU EVER WONDERED . . .

How is a wrecking ball an example of energy transformation?

SIEMENS | Foundation   Discovery EDUCATION

NATIONAL STANDARDS

Standards for Technology Literacy	Standard 13: Students will develop Abilities for a Technological World. This includes becoming able to assess the impact of products and systems. Standard 16: Students will develop an understanding of The Designed World. This includes selecting and using energy and power technologies.
Next Generation Science Standards	HS-3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flow in and out of the system are known. SEP3: Planning and Carrying Out Investigations. SEP4: Analyzing and Interpreting Data. SEP5: Using Mathematics and Computational Thinking.
Common Core Math State Standards	CCSS.MATH.CONTENT.HSA.REI.C.7 Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically. MP2: Reason Abstractly and Quantitatively. MP4: Model with Mathematics.

MAKE CONNECTIONS!

How does this connect to students?

Roller coasters and skate parks are excellent examples of energy transformation. Kids can commonly be found riding roller coasters and hanging out in skate parks. It is **mechanical movement** that allows potential energy to be converted into kinetic energy. Increasing student awareness of the science behind these activities broadens students' understanding.

How does this connect to careers?

A **mechanical engineer** is responsible for designing a variety of industry and consumer devices that use mechanical motion. This role uses both analysis and computer-aided design to develop and test prototypes. A mechanical engineer may work in research and development, in manufacturing or even at companies that utilize engineering services.

Physicists are responsible for investigating and explaining how forces work in our world. There are so many areas of employment within the field of physics. Some physicists explore space science, while others research renewable energy and even medical physics, just to name a few.

How does this connect to our world?

Energy transformation occurs in our natural world every moment of every day. From wrecking balls demolishing a building to a coiled spring, rubber band, and yo-yo, there are countless examples of energy transfer from potential to kinetic energy.

The law of conservation of energy states that energy is never created or destroyed, but rather transferred or transformed. Think about all the examples of conservation of energy found in sports.

BLUEPRINT FOR DISCOVERY

1. To engage students in what they will be learning, tie a weight onto a suspended piece of string or rope to create a basic pendulum. Pull back the weight and release it a few times. When you pull the string back, be sure to release it from different heights. As you do this, ask the students to make observations of what they are observing. Students may mention concepts such as forces, gravity, momentum, potential energy, kinetic energy, conservation of energy, speed, weight, energy transfer, etc. Listen as the students share their thoughts. Be careful not to correct their misconceptions at this time, but rather take note of them so you can revisit them later in the lesson.
2. Ask the students if they can think of anything else that behaves in a similar manner to the pendulum. Someone might suggest a pull-back toy car. If no one does, hold up a pull-back toy car and wait to see their reactions. At this time, pass out the **Energy Transformation** Handout and a pull-back toy car

to each pair of students. Encourage them to take some time to play around with the toy car and record their observations on the **Energy Transformation** Handout.

3. Instruct students to share their observations with the class. Then play "Our World: Potential and Kinetic Energy" by Adventure Academy https://www.youtube.com/watch?v=zCKenikIH_c
4. Tell students that they will now apply what they have learned about potential and kinetic energy transformation to a hands-on investigation. Direct the students to work with their partner to experiment, collect data, and analyze their results.
5. As the students are experimenting, move around the room to answer questions and assist the students as needed.
6. Conclude the lesson by engaging students in a discussion about what they learned. Here are a few thought-provoking questions to pose:
    - Was there anything you found surprising about the results from this investigation? Explain your thinking.
    - What are some other real-life examples of energy transformation?
    - Do potential and kinetic energies represent a direct or inverse variation? Explain your thinking.
    - What are some careers that involve the study of energy transformation?
    - How did this lab investigation demonstrate the law of conservation of energy?

TAKE ACTION!

Students can experiment with forces at a skate park by using the Phet Energy Skate Park interactive simulation. They can investigate the energy transformations that take place and even design an experiment to gather and communicate their data. https://phet.colorado.edu/en/simulation/energy-skate-park

ENERGY TRANSFORMATION
PE AND KE LAB INVESTIGATION

Play around with the pull-back toy car and record your observations below.

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Background Information

	Potential Energy	**Kinetic Energy**
Definition	Energy an object has and that is dependent upon the object's mass and its height	Energy that is possessed by an object in motion which is dependent upon the object's mass and velocity
Formula	$PE = mgh$ m = mass of the object (kg) g = acceleration due to gravity (9.8 m/s^2) h = height of object (m)	$KE = \frac{1}{2} mV^2$ m = mass of the object (kg) V = velocity calculate by distance/time (m/s)
Unit of Measurement	Joule (J)	Joule (J)

Pull-back toy cars use springs to store energy. When you pull a toy car back, your mechanical energy is transformed into potential energy. When the toy car is released, the potential energy becomes kinetic energy.

PE AND KE LAB INVESTIGATION (CONT.)

Use the digital scale to find the mass of the pull-back toy car. Mass = _______________ kg

Procedure:

1. Put a piece of tape on a tile floor in an open area.
2. Position the pull-back car on the tape and then pull the toy car back for the corresponding distance below.
3. When the car stops travelling, measure the distance the car travelled from the top edge of the tape.
4. Repeat this procedure two more times for a total of three trials.
5. Then average the three trials and convert this result into meters.

Pull-back distance (cm)	Distance travelled Trial 1 (cm)	Distance travelled Trial 2 (cm)	Distance travelled Trial 3 (cm)	Average distance travelled (cm)	Average distance travelled (m)
2					
4					
6					
8					
10					
12					

**Conversion Reminder:14 cm = 0.14 meters*

Analyze your data table results. As the pull-back distance increases, what happens to the average distance the car travels?

Consider that direct variation occurs when one number increases, as another number also increases. Whereas an inverse variation is the result of one number increasing as another number decreases. Do the pull-back distance and distanced travelled represent a direct or inverse relationship?

EXPERIMENT AND CALCULATE POTENTIAL ENERGY

How does height impact potential energy? For this investigation, the height released will vary whereas the pull-back distance of 6 cm will remain constant.

Procedure:

1. Put a piece of tape on a tile floor in an open area.
2. Create a car ramp using the toy car tracks and a book.
3. Position the car at the various heights and always pull back 6 cm.
4. When the car stops travelling, measure the distance the car travelled from the released height.
5. Repeat this procedure two more times for a total of three trials.
6. Then average the three trials and convert this result into meters.
7. Solve for the potential energy by applying the formula: PE = mgh

Height (cm)	Distance travelled Trial 1 (cm)	Distance travelled Trial 2 (cm)	Distance travelled Trial 3 (cm)	Average distance travelled (m)	Potential Energy (Joules)
2					
4					
6					
8					
10					
12					

PE = mgh (When calculating the PE, be sure to convert the height in cm to meters.)

m = mass of the object (kg)
g = acceleration due to gravity (9.8 m/s2)
h = height of object (m)

Analyze your data table results. As the height of the ramp increases, what happens to the potential energy? Does this represent a direct or inverse relationship?

EXPERIMENT AND CALCULATE KINETIC ENERGY

How does height impact kinetic energy? For this investigation, the height released will vary whereas the pull-back distance of 6 cm will remain constant.

Procedure:

1. Put a piece of tape on a tile floor in an open area.
2. Create a car ramp using the toy car tracks and books.
3. Position the car at the various heights and always pull back 6 cm.
4. Use a cell phone or stopwatch to time the car travel from start to stop.
5. When the car stops travelling, measure the distance the car travelled from the released height.
6. Solve for the velocity by dividing the distance (m) by the time (sec).
7. Square the velocity.
8. Solve for the kinetic energy by applying the formula: $KE = \frac{1}{2} mV^2$
   (Hint: Don't forget to multiply by ½)

Height (cm)	Distance travelled (cm)	Distance travelled (m)	Time (sec)	Velocity-distance time (m/s)	Velocity squared	Kinetic Energy (Joules)
2						
4						
6						
8						
10						
12						

Use the digital scale to find the mass of the pull-back toy car. Mass = ______________ kg

$KE = \frac{1}{2} mV^2$

m = mass of the object (kg)
V = velocity calculate by distance/time (m/s)

Analyze your data table results. As the height of the ramp increases, what happens to the kinetic energy? Does this represent a direct or inverse relationship?