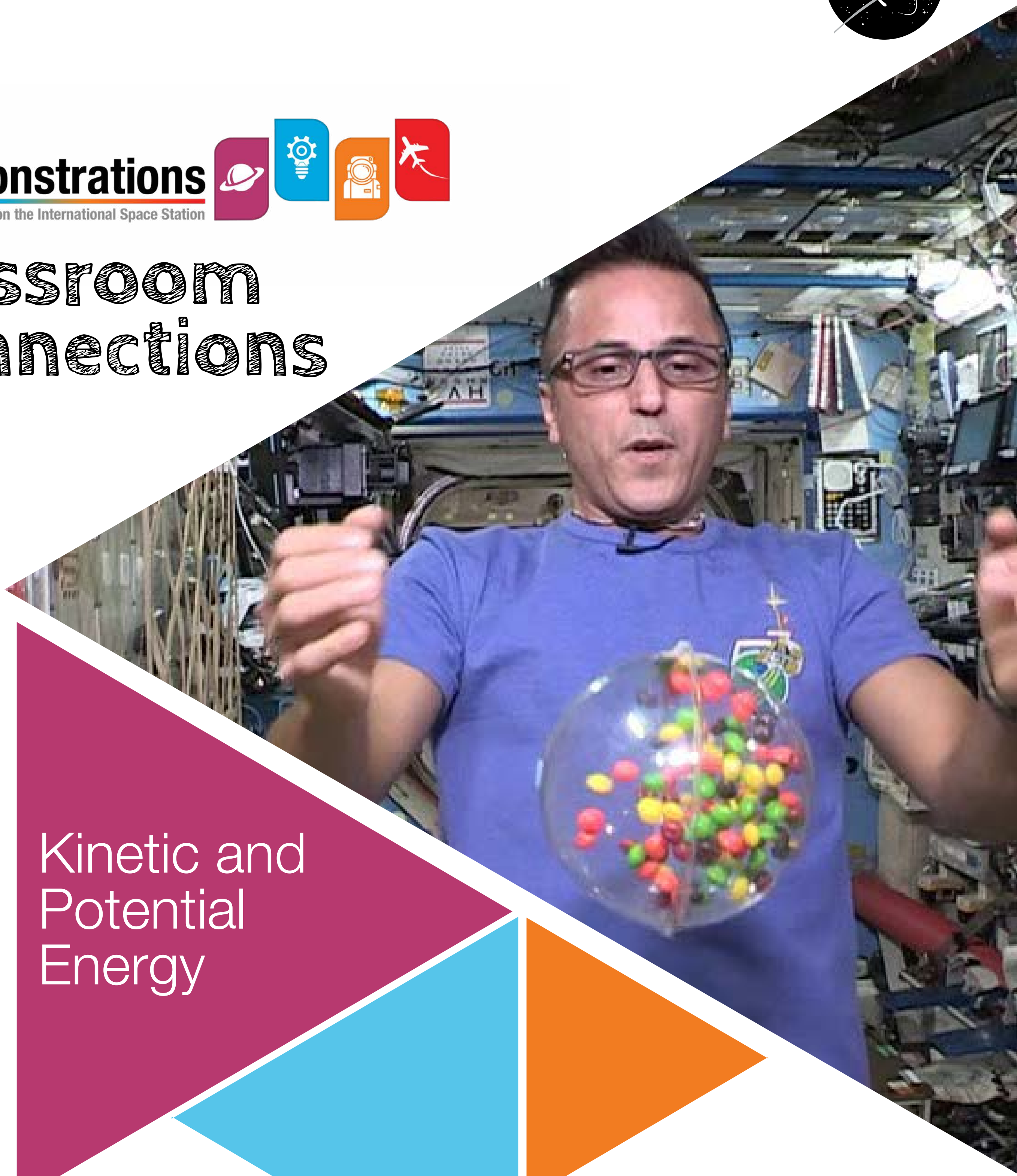
National Aeronautics and Space Administration

STEMonstrations
Education in Action on the International Space Station

Classroom Connections



Kinetic and Potential Energy

For more STEMonstrations and Classroom Connections, visit www.nasa.gov/stemonstation.

Kinetic and Potential Energy

Teacher Background

Grade Level: **6^{th}-12^{th}**

Suggested Time: **50 minutes**

Next Generation Science Standards (NGSS):

HS-PS3-1. *Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.* **Science and Engineering Practices:** *Using Mathematics and Computational Thinking.* **Disciplinary Core Ideas:** *PS3.A: Definitions of Energy; PS3.B: Conservation of Energy and Energy Transfer.* **Crosscutting Concepts:** *Systems and System Models.*

MS-PS3-1. *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 flows in and out of the system are known.* **Science and Engineering Practices:** *Analyzing and Interpreting Data.* **Disciplinary Core Ideas:** *PS3.A: Definitions of Energy.* **Crosscutting Concepts:** *Scale, Proportion, and Quantity.*

MS-PS3-2. *Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.* **Science and Engineering Practices:** *Developing and Using Models.* **Disciplinary Core Ideas:** *PS3.A: Definitions of Energy; PS3.C: Relationship between Energy and Forces.* **Crosscutting Concepts:** *Systems and System Models.*

Background

Amusement parks are one of the best places to experience some of the same forces that astronauts experience. During a launch, astronauts can experience forces up to three times Earth's gravity (3 g). Some roller coasters give riders the experience of up to 3.7 g. Likewise, weightless conditions experienced on orbit can also be felt on amusement park rides that plummet straight down or crest over hills.

Potential energy (PE) is a stored form of energy that can produce motion, i.e. the "potential for motion." Think of PE as stored energy that can become kinetic energy. You can calculate potential energy using an object's mass and its height. PE is measured in Joules (J).

PE = mgh where m = mass (kg), g = acceleration due to gravity (9.8m/s2 at the surface of the Earth), and h=height (m)

Kinetic energy (KE) is a form of energy related to an object's motion. KE could be translation (moving from one place to another), vibration, or rotation. KE is calculated using an object's mass and velocity. Like PE, KE is also measured in Joules (J).

KE = (1/2)mv2 where m = mass (kg), v = velocity (m/s).

The roller coaster car's KE and PE change as the car moves along the track. When the car is at the bottom of the hill, it is moving the fastest. This is because all of the PE has been converted to KE, which means more speed. When cars are at the top of the hill, they are moving the slowest because most of the KE has been converted to PE.

In real-life situations, friction and air resistance are present. For example, as a roller coaster falls, only part of its PE is converted to KE. Due to air resistance and friction, the part of the PE that is not converted to KE is converted to heat energy (and possibly sound energy). Friction is the reason roller coasters can't go on forever – and engineers work to minimize friction when they design roller coasters.

This lesson provides students the opportunity to explore kinetic and potential energy and how these concepts apply to both rollercoasters on Earth and the microgravity environment of the International Space Station.

Objective

Following this activity, students will be able to:

- Explain kinetic and potential energy and how these concepts apply to both the microgravity environment of space and Earth gravity.

Materials

- Half pieces of pipe insulation (gray, spongy) cut to 1.83 meters (6 ft)
- Masking tape
- Marbles
- Stopwatches
- Meter sticks

Procedure

- Inquiry Discussion

Ask students the following questions:

1. How many of you have ridden a roller coaster?
2. Can anyone describe how a roller coaster works? (Most roller coasters rely on gravity after the initial climb to the top of the first hill)
3. Can you explain how a roller coaster works using kinetic and potential energy?
4. Would a roller coaster work in space?

- Watch and Discuss

Watch STEMonstrations: Kinetic and Potential Energy available at www.nasa.gov/stemonstrations. After viewing the video, ask students to explain kinetic and potential energy in their own terms. Can they provide examples of kinetic and potential energy?

- Exploration Activity

Working in groups of two to three, students will build their own version of a roller coaster using marbles and pipe insulation to explore kinetic and potential energy. Students will build a roller coaster with three hills and identify areas of kinetic and potential energy. Marbles will be used to simulate roller coaster cars.

- Final Discussion

Have students share their findings with the class. How would students like to change their rollercoaster designs? Could you add a loop? Could you make a hill that is higher than the first hill?

- Extension Activities

Check out more activities in the "Amusement Park Physics with a NASA Twist" at https://spaceflightsystems.grc.nasa.gov/outreach/appd/documents/physics_nasatwist_guide.pdf

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Kinetic & Potential Energy

Student Activity

Names: ______________________ ______________________ ______________________

Procedure

1. Work as a group to build a roller coaster using two lengths (3.66m/12ft) of pipe insulation. Your roller coaster must have three hills (including the initial hill).
2. Use a marble to test your roller coaster design. If the marble does not stay on the track for the entire length, modify your design until it does. You can add turns to your design, but it can only have three hills. You may need to use classroom materials to help make the hills.
3. Draw your roller coaster below and label the height of each hill in centimeters. Also label the area on each hill where potential energy is decreasing and kinetic energy is increasing.

Roller Coaster Diagram

4. When does the marble appear to be going the fastest? When does the marble appear to be going the slowest? How does this relate to kinetic and potential energy?
5. Do some additional testing by modifying your design. Can the second or third hill be higher than the first hill? Why or why not?