Science Objectives

- Students will describe the variables that affect potential energy and kinetic energy
- Students will explore the conversion of potential energy to kinetic energy
- Students will describe the total energy as the sum of potential energy and kinetic energy
- Students will explore the effect of friction on kinetic energy and potential energy

Vocabulary

- potential energy (PE)
- total energy (TE)
- velocity
- gravitational force
- kinetic energy (KE)
- mass
- friction
- acceleration due to gravity

About the Lesson

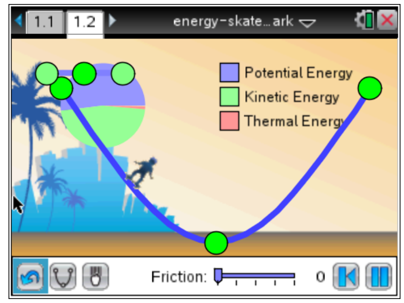
- This lesson involves students simulating the motion of a skateboarder on a ramp under a number of different conditions that affect the potential and kinetic energies of the skateboarder-celestial body system.
- As a result, students will:
  - Describe the variables used to calculate potential energy;
  - Describe the variables used to calculate kinetic energy;
  - Explore conservation of energy;
  - Explore how potential energy, kinetic energy, and the energy from friction account for the total energy of the skateboarder.

TI-Nspire™ Navigator™

- Send out the *energy-skatepark.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to allow students to show how they manipulate variables that effect results.

Activity Materials

- Compatible TI Technologies: TI-Nspire™ CX Handhelds, TI-Nspire™ Apps for iPad®, TI-Nspire™ Software



Tech Tips:

- This activity includes screen captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

Lesson Files:

Student Activity

- Energy_Skate_Park_Student_HS.doc
- Energy_Skate_Park_Student_HS.pdf

TI-Nspire document

- energy-skate-park.tns

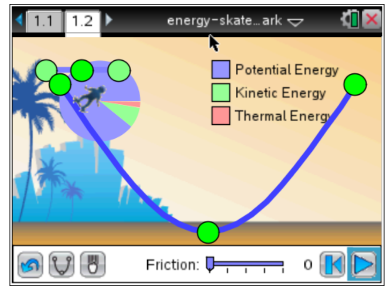
Discussion Points and Possible Answers

Allow students to read the information on page 1.1.

Move to page 1.2.

Part 1: Exploring Potential Energy

In this part of the lesson students explore the skateboarder's potential energy as she moves up and down the ramp. They investigate how potential energy is converted to kinetic energy.

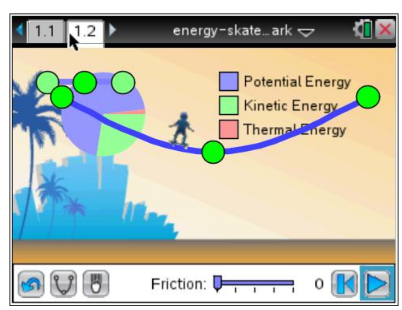


Tech Tip: Make sure students are familiar with the different buttons of the simulation. They can:

- select to change the track shape
- select the Gravity button to change the force of gravity
- select to reset the skateboarder, press to stop the motion of the skateboarder, press to start the motion of the skateboarder
- select to reset the skateboarder, track, and gravity
- grab and drag the slider 25 next to "Friction" to change the amount of friction between the skateboard and the track
- grab and drag to change the shape of the track

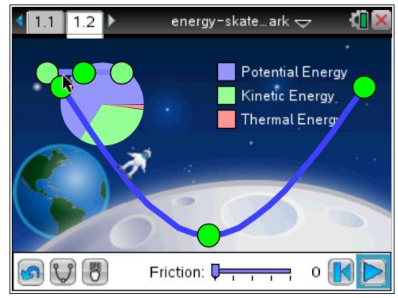
1. Start the simulation with the skateboarder at the top of the ramp. Make sure the skateboarder is stationary. Reinforce that the skateboarder, even while stationary, has energy. Potential energy is based on position.
   Show the annotated illustration and show how the variable *h* is determined. As the skateboarder moves along the ramp focus on how the potential energy changes, since the height along the ramp changes. The change in potential energy affects the skateboarder's motion, turning the potential energy into kinetic energy.

2. To more fully explore the potential energy's dependence on the variable *h*, have the students vary the depth of the skateboarding ramp. Having them change the ramp to a flat line brings the skateboarder to a stop. Because potential energy is based on the value of *h*, in a situation in which *h* is zero, then the skateboarder has no potential energy when the ramp is flat. With less potential energy, there is less kinetic energy available, which affects the skateboarder's motion.



Q1. How does shortening the height of the ramp change the potential energy of the system? How does the decreased height affect its kinetic energy? What happens when $h = 0$?

Answer: Decreasing the value of h decreases the potential energy of the system. With less potential energy, there is less kinetic energy available to the skateboarder. When $h = 0$, there is no potential energy.



3. To more fully explore the potential energy's dependence on the variable g, have the students change the location of the ramp from Earth to the Moon and from Earth to Jupiter using the Gravity button. The Moon's gravity is less than Earth's, and Jupiter's gravity is greater than Earth's. Changing the value of g changes the potential energy and therefore the available kinetic energy.

Q2. What happened to the skateboarder's motion when you switched from the Earth to the Moon? What does this tell you about the potential energy that skater has in the skater-Moon system? Compare the acceleration due to gravity g_E on Earth and g_M on the Moon.

Answer: The skateboarder slowed down. This means the amount of potential energy available on the Moon is less because $g_M < g_E$.

4. Help students see that once they quickly change to Jupiter, the skateboarder's speed increases.

Q3. What happened to the skateboarder's motion when you switched from the Earth to Jupiter? What does this tell you about the potential energy that skater has in the skater-Jupiter system? Compare the acceleration due to gravity gE on Earth and gJ on Jupiter.

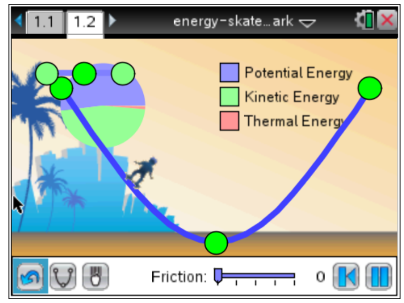
Answer: The skateboarder went faster. This means the amount of potential energy available on Jupiter is more because $g_J > g_E$.

TI-Nspire Navigator Opportunities

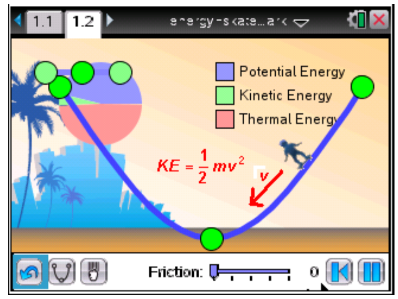
Allow students to volunteer to be the Live Presenter and demonstrate how to adjust the parameters of height, gravity, and friction.

Part 2: Exploring Kinetic Energy

In this part of the lesson students explore the skateboarder's kinetic energy as she moves up and down the ramp. They investigate how kinetic energy is converted to potential energy.



5. Reinforce that the KE for the skateboarder varies throughout the trip back and forth along the ramp. In fact, the KE cycles through values ranging from zero to a maximum and back to zero. Also, because the amount of KE is dependent on the amount of PE, changing gravitational acceleration from the Earth to the Moon and to Jupiter has a marked effect on the skateboarder's speed.



6. Ensure students understand the variables shown in the diagram and discuss various points along the curve.

Q4. At the top of the ramp, where the skateboarder has zero KE, what is the potential energy of the system?

<u>**Answer**</u>**:** The skateboarder has maximum PE.

Q5. At the bottom of the ramp, where the skateboarder has maximum KE, what is the potential energy of the system?

<u>**Answer**</u>**:** The skateboarder has zero PE.

Q6. At what part of the skateboarder's motion is KE converted back to PE?

<u>**Answer**</u>**:** As the skateboarder is moving from the bottom of the ramp to the top, the KE is converted to PE, as the skateboarder begins to slow down and come to a momentary stop at the top of the ramp.

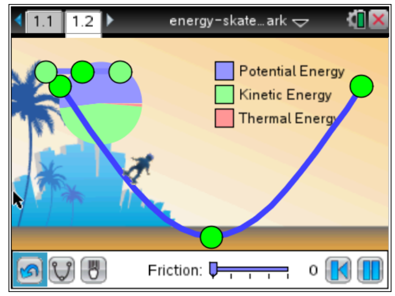
Q7. In which system is the maximum KE the greatest, the Earth, the Moon, or Jupiter?

<u>**Answer**</u>**:** Because Jupiter has the greatest acceleration due to gravity, *g,* then the skateboarder has the greatest KE on this planet.

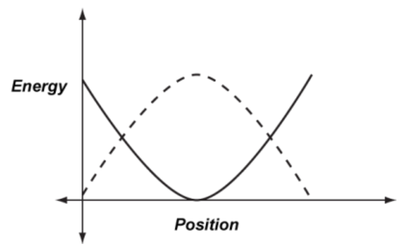
Q8. In which system is the maximum KE the least, the Earth, the Moon, or Jupiter?

Answer: Because the Moon has the least acceleration due to gravity, *g,* then the skateboarder has the least KE on the Moon.

Part 3: Exploring the Total Energy



8. In this part of the lesson students explore the total energy of the system and that this encompasses the sum of the KE and PE. In fact, because of the law of conversation of energy, the sum of KE and PE is constant throughout the skateboarders trek along the ramp.



9. Have students take a number of measurements of the values of KE and PE using a ruler. Have students add these measurements. Gather data for different measurements and among different groups of students. Show that the values are consistently close to each other, and barring slight measurement errors, the sums of PE and KE are constant.

Q9. Identify several different Position points and find the values of the corresponding Energy coordinates for both PE and KE. Use a ruler to measure the height of each Energy value. Add the two values for PE and KE to find TE. What do you notice about the TE for any positions along the curve?

Answer: The sum of PE and KE are about the same for different positions along the ramp.

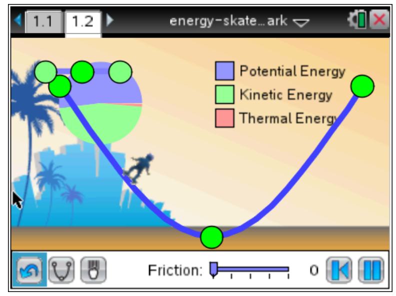
10. Discuss the included diagram and have students explain the relationship between PE, KE and skateboarder's location on the ramp.

Q10. Suppose that energy conservation didn't occur. Describe how this could affect the motion of the skateboarder.

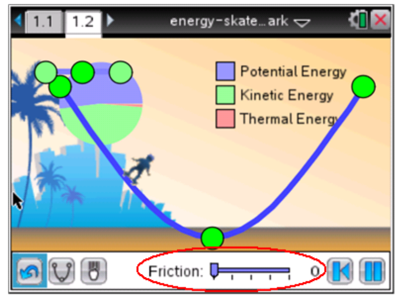
Answer: If the skateboarder's total energy was not constant, then the motion of the skateboarder would be unpredictable, and not the steady back and forth shown in the simulation.

Part 4: Exploring the Impact of Friction

11. In this part of the lesson students see the effect of friction on the skateboarder's motion. While the total energy of the system is constant, the energy from friction cannot be converted back to KE or PE.



12. In the frictionless scenario, students saw that PE is converted to KE and KE is converted to PE, as the motion of the skateboarder is like a pendulum swinging back forth. Friction changes this scenario. PE is converted to KE and some of the KE is converted to heat energy due to friction. This heat energy is lost to the system and cannot be converted to PE or KE. Eventually, the skateboarder comes to a stop. But even in this scenario, the total energy is conserved.



Q11. What happens to the motion of the skateboarder as the friction increases?

Answer: Eventually, the skateboarder comes to a stop.

13. Discuss the included diagram and have students explain the relationship between PE, KE and skateboarder's location on the ramp.

Q12. Once the skateboarder comes to a stop due to friction, describe the energy needed to have the skateboarder resume moving up and down on the ramp.

Answer: Once the skateboarder stops, she is at the bottom of the ramp. To get her moving again, a new source of KE is needed to move the skateboarder back to the top of the ramp, where she will once again have maximum PE.

TI-Nspire Navigator Opportunities

Allow students to volunteer to be the Live Presenter and demonstrate how to adjust the parameters of height, celestial body, and friction. Use Quick Poll to check for understanding during the course of the activity.

Wrap Up

When students are finished with activity, collect students' worksheets.

Assessment

- Formative assessment will consist of questions embedded in the student worksheet. Analyze questions in the student worksheet with the students.
- Summative assessment will consist of questions/problems on the chapter test.
- In groups, have students construct another example of where PE is converted to KE and back. Some examples could include a ball rolling off a table and bouncing, bungee jumping, or a yo-yo.