Energy Skate Park

Science Objectives

- Students will observe how variations in the dips and inclines of a skateboard track affect a skateboarder's motion.
- Students will analyze the affects of gravity and friction on the motion of the skateboarder.
- Students will apply knowledge of potential and kinetic energy to designing their own track.

Vocabulary

- gravity
- potential energy
- kinetic energy
- friction
- domain
- speed
- force
- function
- energy system

About the Lesson

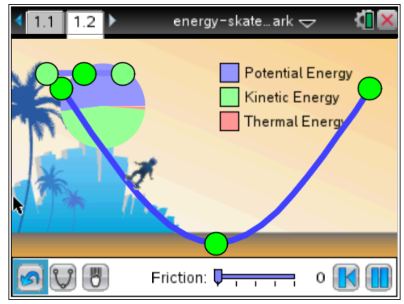
- This lesson involves students using TI-Nspire technology to simulate, observe, and manipulate some variables that affect the way a skateboarder moves on a track.
- As a result, students will:
  - Reinforce understanding of how gravity and friction affect motion within a system.
  - Understand that an object has potential energy due to its position above the surface of a body in the universe.
  - Understand that kinetic energy is energy due to motion relative to a system.
  - Recognize that potential energy can be transformed to kinetic energy and how this is related to the motion of a skateboarder.
  - Infer that some kinetic energy will be transformed to thermal energy due to friction.

TI-Nspire™ Navigator™

- Send out the *energy-skate-park.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

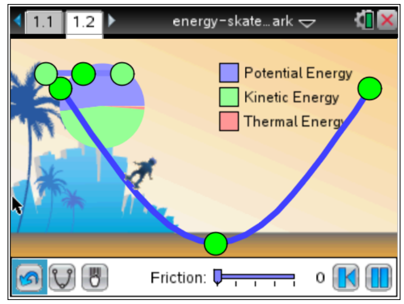
Lesson Files:
Student Activity

- Energy_Skate_Park_Student_MG.doc
- Energy_Skate_Park_Student_MG.pdf
- energy-skate-park.tns

Discussion Points and Possible Answers

Part 1: Friction and Gravity

In this part of the simulation, students adjust a skateboard track to observe the movement of a skateboarder. Then they use the friction slider to investigate how friction affects his ride. Finally, they will experiment with how the force of gravity changes the motion of the skateboarder.



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

- select to change the track shape
- select change the amount of gravity
- select to reset the skateboarder and select to pause 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.

Move to page 1.2.

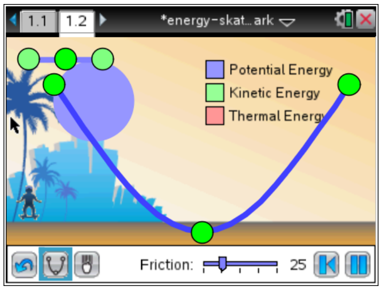
1. The gravitational force should be set for Earth and the track should be a "U" shape. If not, students should select the Track button until a "U" shape is displayed. The amount of friction should be on 0.
2. They should drag the skateboarder, placing him at the top of the hill and then releasing him to ride down the track.

Tech Tip: If students are having difficulty observing the motion, they can increase or decrease the speed of the skateboarder on the track. Select **> Speed** and then select a speed from the drop down menu. Note that in some cases, a student may need to back-out to the main Tools Menu to see the desired menu option.

Q1. What do you notice about the motion of the skateboarder as he travels along the track?

Answer: The skateboarder increases his speed as he moves down the track, but then loses speed as he nears the top of the hill. The skateboarder is able to make it from the top of one hill to the top of the other without stopping or jumping off the track.

3. Students will now change the amount of friction to 25 using the slider in the bottom center. The track should remain a "U" shape. Students are to run the simulation several times by placing the skateboarder at the top of the track and letting him go. Then they will change the friction to 50, 75, and 100 and watch the skateboarder ride the track.



Tech Tip: If students have difficulty setting the friction exactly to 25, 50, 75, or 100, let them know the setting does not need to be exact.

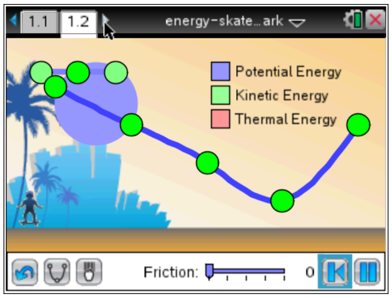
Q2. As you increase the amount of friction, how does the distance covered by the skateboarder change?

<u>Answer</u>: The skateboarder is not able to reach the top of the hill. The skateboarder ends up at the bottom of the track.

Q3. How does the motion of the skateboarder change?

<u>Answer</u>: The skateboarder slows down when the friction of the track is increased.

4. Students change the shape of the track to a "dipper." Run the simulation with the friction set at 0, 25, 50, 75, and 100.



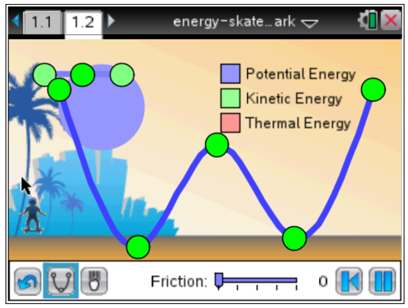
Q4. What do you notice about the skateboarder's ride with a dipper shape as compared to the U-shaped track?

<u>Answer</u>: His motion is slower than with the U-shaped track and with no friction he falls off the end of the track.

Q5. As the amount of friction increases, what happens to the skateboarder's motion?

<u>Answer</u>: Each increase in the amount of friction slows down the skateboarder. When the amount of friction is between 25 and 100, the skateboarder stays on the track and does not fall off the end. However, between 50 and 100, he does not complete the entire track.

5. Students change the shape to a "W." They are to once again run the simulation with the friction set at 0, 25, 50, 75, and 100.

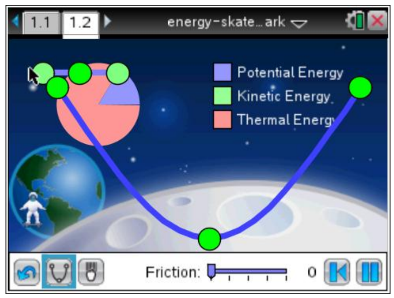


Q6. What happens to the skateboarder's motion when the friction is set to 0? 25? More than 25?

<u>Answer</u>: When the amount of friction is 0, the skateboarder jumps off the middle hill in the track, lands on the right side and starts back down in the other direction. At 25, he stays on the track and makes it almost to the top of the middle hill, but does not make it over the middle hill. At 50, 75, and 100, he makes it halfway or less up the middle hill.

6. Students are to reset the simulation and change the location to the moon. The background will be black with Earth partially in the background. The friction should be set to 0.

7. Students will run the simulation, allowing the skateboarder to ride each of the three track shapes.

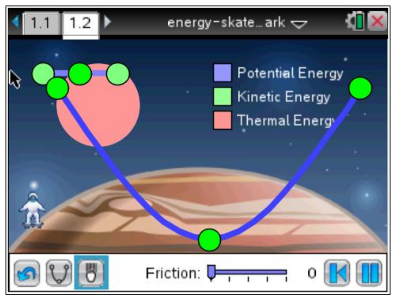


Q7. How does the motion of the skateboarder on the moon compare to the motion on Earth?

<u>Answer</u>: The skateboarder moves much slower, but has the same reaction to the tracks as on Earth: he reaches the top of both hills on the U-shape, he falls off the end of the dipper-shape, and he jumps the track on the W-shape.

8. Students are to reset the simulation and change the location to Jupiter. The background will be dark grey. The friction should be set to 0.

9. Students will run the simulation, allowing the skateboarder to ride each of the three track shapes.



Q8. How does the motion of the skateboarder on Jupiter as compared to the motion on Earth?

<u>Answer</u>: The skateboarder moves much faster, but has the same reaction to the tracks as on Earth: he reaches the top of both hills on the U-shape, he falls off the end of the dipper-shape, and he jumps the track on the W-shape.

10. Now students go to the moon to watch the skateboarder ride the U-shape track with the friction at 25, 50, and 100. Then they will repeat this on Jupiter.

Q9. What happens to the motion of the skateboarder when you increase the friction on the moon? On Jupiter?

Answer: On both the moon and Jupiter, the skateboarder's ride is slower and he completes less of the track.

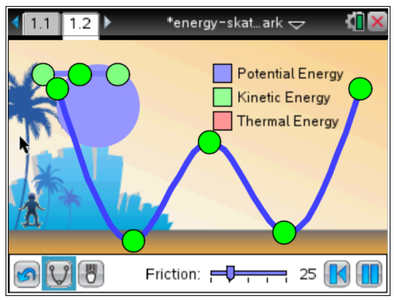
Q10. In general, how does gravity affect the skateboarder's ride? How does friction affect the skateboarder's ride?

Answer: The greater the gravity, the faster the skateboarder goes and the lesser the gravity, the slower the skateboarder goes. The greater the friction, the slower the skateboarder goes and the lesser the friction, the faster the skateboarder goes.

Part 2: Create Your Own Track

In this part of the simulation students will change the design of the track. Their goal is to construct a track that gives the skateboarder a ride that meets certain motion constraints.

11. Set the track shape to a W and the gravity location to Earth. Set the amount of friction to 25. Grab and drag the green dots to change the shape and size of the track. When you release the skateboarder, he must:
    1) complete the entire track, and
    2) stay in contact with the track without jumping or falling off.



Q11. What adjustments did you make in the shape and/or length of your first track to meet the requirements?

Answer: Students may answer that they changed the size and shapes of the hills according to where they saw the skateboarder needing more or less potential and kinetic energy.

Q12. Draw your track shape to the right.

Answer: Drawings will vary. Check that drawing appears appropriate.

Q13. How did you figure out the best possible potential energy (stored energy), meaning how high to start the first hill for the skateboarder so he had enough energy to complete the track?

Answer: Answers will vary.

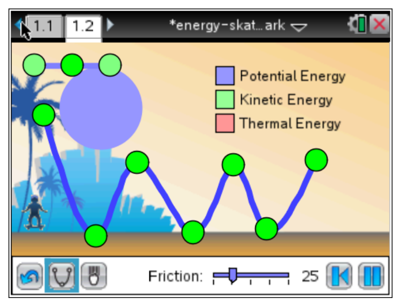
Q14. How did you figure out the best possible kinetic energy (energy in motion), meaning how high/low and long for the hill in the middle to be so the skateboarder remained in contact but had enough energy to make it up the hills?

Answer: Answers will vary.

TI-Nspire Navigator Opportunities

Allow students to volunteer to be the Live Presenter and demonstrate how to change the track.

12. Students are to now use the track enhancer in the top left corner to make more hills in the ride. Grab the center dot and drag it to one end of the track so that a light green dot is touching the track. The light green dots will turn yellow when connected to the track. Release the dot.
13. They should change the track so that it has more hills than the W-shape. Remember the skateboarder has to complete the entire track and stay in contact with the track without jumping or falling off. Keep the amount of friction at 25.



Tech Tip: If students experience difficulty using the track enhancer, have them first move the green dots of the existing track to the left. This will make more room on the right for them to add a length of track.

Q15. Draw your track shape to the right.

Answer: Drawings will vary. Check that drawing appears appropriate.

Q16. How do the height and length of the hills on this track compare to the hills on your W-shape track?

Answer: Students may answer that they made the hills less steep and more spread out.

Analysis Questions.

Q17. Since friction was involved in this experiment, how might some of the kinetic energy been transformed to another kind of energy? Explain.

Answer: Some energy was also transformed to thermal because of friction.

Q18. How does the size of the first hill affect the travel of the skateboarder? Why do you think this is so?

Answer: The first hill is important because the height determines how much potential energy could be transformed to kinetic energy during the rest of the ride.

Q19. How do these same physics principles apply to a roller coaster?

Answer: The car in a roller coaster need enough potential energy to make it through the entire track and the friction between the car and the track needs to be the right amount so that the car does not go too fast or too slow .

TI-Nspire Navigator Opportunities

Use Quick Poll to check for understanding during the course of the activity.

Wrap Up

When students are finished with the 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.