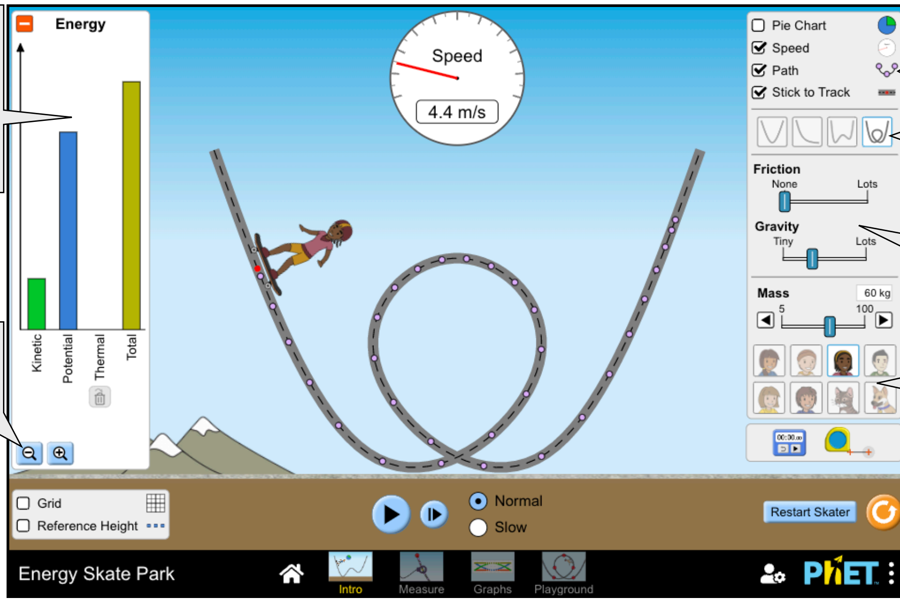
Energy Skate Park

Intro Screen

Explore different tracks and skaters, and investigate the relationship between the kinetic energy, potential energy, and thermal energy. Measure the speed and adjust the friction, gravity, and mass.

OBSERVE the energy in the system in real time

ZOOM to adjust scale



DRAW dot along path every 0.1s

EXPLORE different tracks

ADJUST friction and gravity

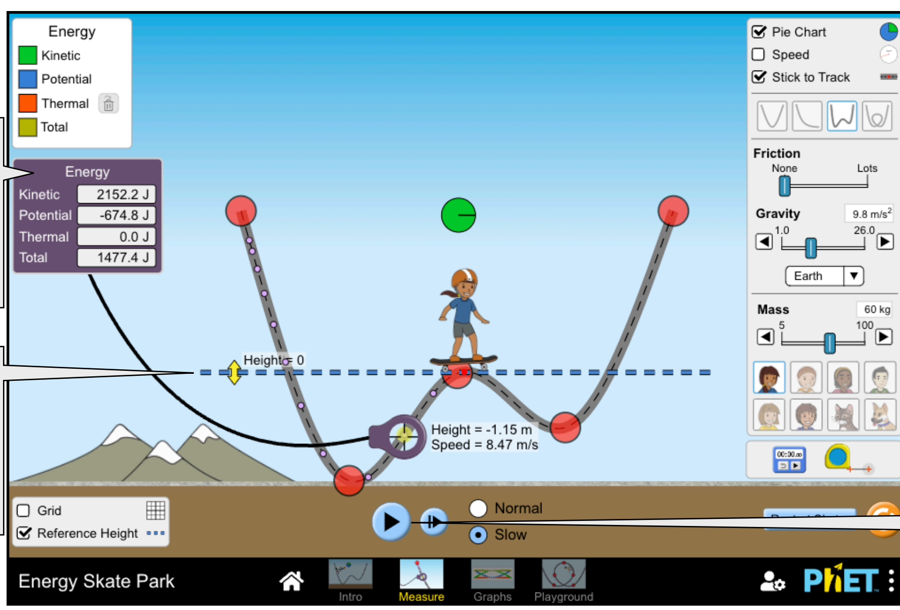
SELECT skater; **SET** their mass

Measure Screen

Measure the energy at points along the skater's path. Experiment with different tracks and adjust the shape of the track by dragging the control points.

MEASURE the energy at the dots along the path

SET the reference point for gravitational potential energy



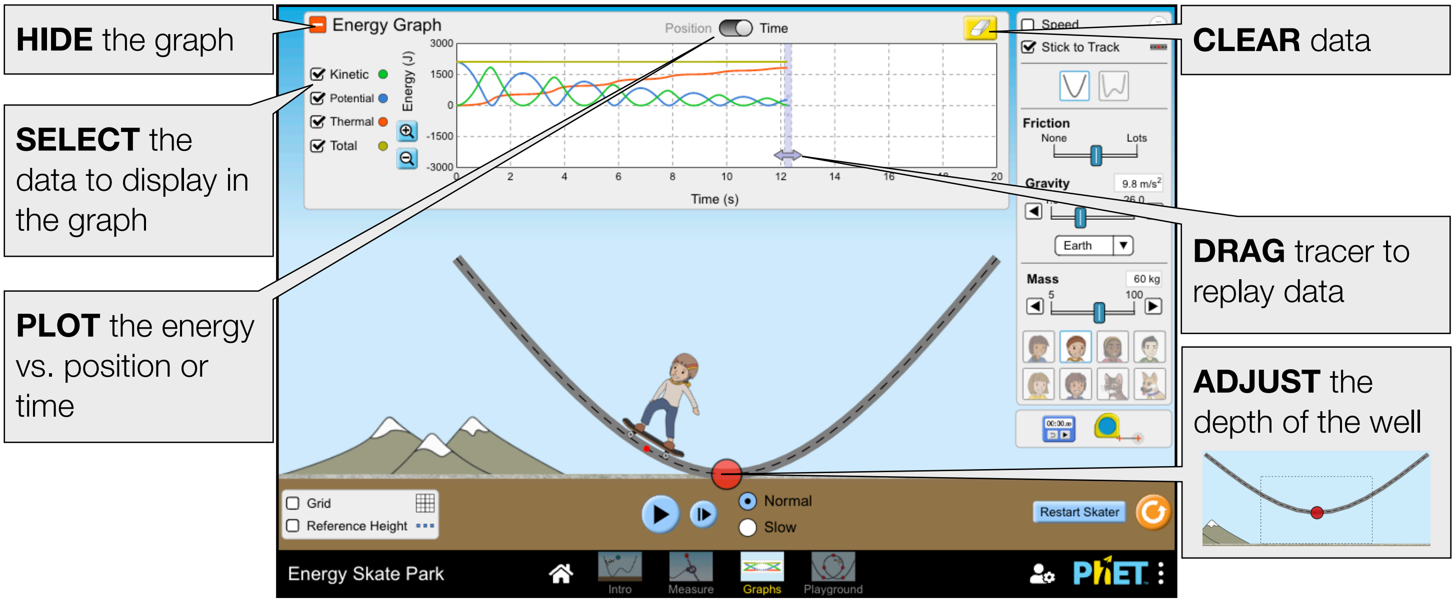
VIEW the skater's energy in a pie chart

PAUSE to facilitate measurement

Rouinfar, January 2024

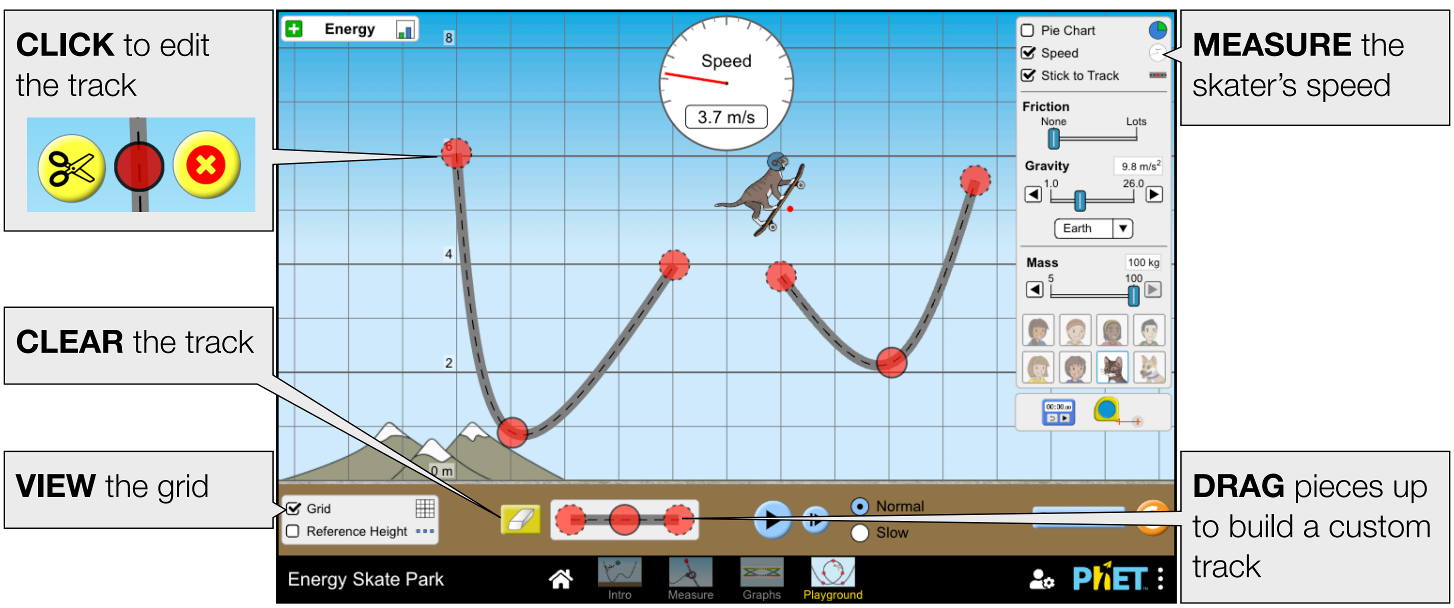
Graphs Screen

Plot the skater's energy vs. position or time, and explore the conservation of energy. Drag the control points on the track to alter its shape.



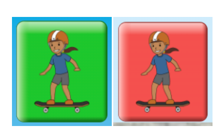
Playground Screen

Build your own custom tracks, ramps, and jumps for the skater.

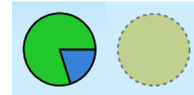


Complex Controls

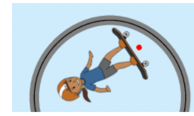
- When the skater exits the screen, two additional return skater buttons appear on the screen. Clicking on either button will return the skater to the location of the button. The green button appears where the skater was most recently released, and the red button appears on the ground at the skater's starting position.



- The pie chart cannot display negative values. When the potential energy is negative, the pie chart displays only the total energy (right).



- The Stick to Track checkbox is on by default on all screens. When on, the track has a dashed midline. When off, the track midline is solid and the skater can fall off.



Customization Options

Query parameters allow for customization of the simulation, and can be added by appending a '`?`' to the sim URL, and separating each query parameter with a '`&`'. The general URL pattern is:
`…html?queryParameter1&queryParameter2&queryParameter3`

For example, in Energy Skate Park, if you only want to include the 1st and 2nd screens (`screens=1,2`), with the 2nd screen open by default (`initialScreen=2`) use:
https://phet.colorado.edu/sims/html/energy-skate-park/latest/energy-skate-park_all.html?screens=1,2&initialScreen=2

To run this in Spanish (`locale=es`), the URL would become:
https://phet.colorado.edu/sims/html/energy-skate-park/latest/energy-skate-park_all.html?locale=es&screens=1,2&initialScreen=2

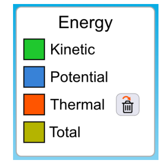
⚙ Indicates this customization can be accessed from the Preferences menu within the simulation.

Query Parameter and Description	Example Links
⚙ `altAccelerationUnits` - displays the units of acceleration due to gravity in N/kg. The units can also be toggled within the Preferences menu.	`altAccelerationUnits`

`screens` - specifies which screens are included in the sim and their order. Each screen should be separated by a comma. For more information, visit the Help Center.	`screens=1`
	
	`screens=2,1`

`initialScreen` - opens the sim directly to the specified screen, bypassing the home screen.	`initialScreen=1` `initialScreen=3`
`locale` - specify the language of the simulation using ISO 639-1 codes. Available locales can be found on the simulation page on the Translations tab. Note: this only works if the simulation URL ends in "_all.html".	`locale=es` (Spanish) `locale=fr` (French)
⚙ `regionAndCulture` - Select the portrayal of people, places, or objects in the sim. Images are not intended to represent the entire diversity of a region or culture. Possible values: `usa`, `africa`, `africaModest`, `asia`, `latinAmerica`, `oceania`	`latinAmerica`
`allowLinks` - when `false`, disables links that take students to an external URL. Default is `true`.	`allowLinks=false`

Insights into Student Use



- Students may not notice or use the remove heat button located in the bar graph and pie chart. This feature is particularly useful to remove the heat that is created by the skater's initial collision with the track when the goal is to consider only the PE and KE in a frictionless environment.
- When setting up an experiment, it may be helpful to first pause the simulation. The step forward button is a good way to incrementally analyze.
- The path dots are drawn every 0.1s and are cleared when the skater turns around. When collecting data on the Measure Screen, pause the simulation before the path dots are cleared.

Suggestions for Use

Sample Challenge Prompts

- Determine the factors that affect the skater's kinetic, potential, and thermal energy.
- Explain the Conservation of Mechanical Energy.
- Design an experiment to determine the relationship between kinetic energy and speed.
- Determine where along the track most of the energy get transferred to thermal energy.
- Compare the skater's energy for various reference heights. What changes? What stays the same?
- Build a track with a loop that the skater can complete.

Clicker Questions

- Match the skater's energy pie chart with their location on the track.
- If the skater's kinetic energy is getting larger, determine the direction of their motion.
- Determine if the skater can make it over a hill (or around a loop) given their starting position.

Model Simplifications

- When the skater lands on the track, the vertical component of their kinetic energy is converted to thermal energy. You can do experiments where there is no loss to thermal energy (only PE and KE conversions) by turning friction off and by making sure the skater doesn't leave the track.
- The height in the model is relative to the Reference Height, which is adjustable. When the Reference Height checkbox is off, potential energy will be zero at ground level.
- When the Reference Height is changed, the data in the Bar Graph, Pie Chart, and energy probe on the Measure screen will update dynamically. However, the data in the Energy vs. Position/Time graph on the Graphs screen will not be re-drawn.
- On the Measure screen, the data associated with the path dot represents the state of the model at the time it was drawn. If the mass, gravity, or friction is changed, the data associated with previously drawn dots will not retroactively change.
- The energy, height, and speed data displayed on the Measure screen is rounded to the nearest hundredths place. Due to rounding, calculations using the displayed values may result in small discrepancies.
- When Stick to Track is checked, the only factor that will affect the skater's ability to make it around the loop will be the energy in the system

See all published activities for Energy Skate Park here.
For more tips on using PhET sims with your students, see Tips for Using PhET.

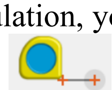
Rouinfar, January 2024

Name ____________________________
Date ______________ Period ________

Energy Skate Park

Location: https://phet.colorado.edu/en/simulation/energy-skate-park

Part A: Intro

1. Go to the simulation at the URL above. It will give you a choice of 4 sections to click on (Intro, Measure, Graphs, and Playground). Start by clicking on Intro.
2. Click and drag on the skateboarder to move her to the top of the track. Let go, and observe her go back and forth.
3. Try out the slow motion feature. Click on *Slow* next to the play/pause button at the bottom. You can answer any of the following questions at full or slow speed.
4. Try out the *step* feature. Pause the simulation and hit the *step* button  to the right of the *pause/play* button to step forward one frame of animation at a time.
5. On the right side, you will see that Friction is set to "None." Keep it that way for now…
6. What do you notice about the maximum height that the skater reaches on the left side compared to the maximum height on the right side? (Note: if you look in the bottom left of the simulation, you can turn on a *Grid* that will help to answer this, or you can use the tape measure  found in the bottom right corner.)

7. In the top right, turn on *Pie Chart*. A Pie Chart displaying a visual of the different form of energy in the skater-track-earth system will now follow your skater around.
   a) At what point or points in the skater's motion is kinetic energy at a maximum?

   b) At what point or points in the skater's motion is potential energy at a maximum?

8. Turn on *Speed*. A Speedometer will now appear.
   a) When the skater reaches the uppermost position(s), what is the speed value?

   b) Multiple Choice: At what point is the speed at a maximum? .
      A. Just before the skater reaches the very bottom
      B. At the exact bottom
      C. A little bit after reaching the bottom

9. Based on your previous observations, in what way is Speed related to Kinetic Energy?

10. Turn on *Path*. Dots will now trail your skater in the style of a motion diagram. Equal time intervals exist between each new dot's creation.
    1. When are the dots furthest apart along the path? What does this indicate?

    2. Explain how this makes sense in consideration of the equation for speed (speed = distance / time)

11. Experiment with the other three tracks . Try turning off the *Stick to Track* feature and see what happens on each.
12. On the left side of the simulation, click on 

to turn on an animated Energy Bar Chart. Pause the simulation, and drag your skater up and down. What do you notice is happening to the amount of potential energy as you do this?

13. Generally speaking, in what way is Height related to Potential Energy?

14. With your skater paused in midair, adjust the Gravity slider back and forth between *Tiny* and *Lots*. Generally speaking, in what way is potential energy related to Gravity?

15. Turn on Reference Height (bottom left corner). A dotted line will appear with a pair of yellow arrows on it. You can raise and lower this dotted line. What can you do to make the amount of Potential Energy shown on the bar chart become *negative*?

16. Put your skater all the way to the top of the track set the simulation into motion. Pause your simulation when the skater is about half-way up the curve so that both Kinetic Energy and Potential Energy exist on the Energy Bar Chart. Adjust the mass slider.
    a) Generally speaking, in what way is Mass related to Potential Energy?

    b) Generally speaking, in what way is Mass related to Kinetic Energy?

17. Set the skater into simple back and forth motion as before on the first track that is a simple U shape, and look at the Energy Bar Chart. Can you see how the rightmost bar labeled Total is remaining constant? The fact that is stays constant is a demonstration of the Law of…

18. Now look at the Kinetic and Potential bars. As Kinetic Energy increases, Potential Energy….

19. Try turning on friction and letting your skater start from the top of the track. Notice how the available energy is transforming into Thermal Energy.
    a) If you wait long enough, will the Thermal Energy transform back into Kinetic and Potential Energy?

    b) Will the skater eventually stop moving with the friction turned on? Describe what you observe about the amounts of the different forms of energy as time goes on.

    c) Try hitting the *trash*  icon below the Thermal bar. This will "dump out" the Thermal Energy. In reality this would represent the Thermal Energy dissipating into the environment surrounding the system.
20. There is one more way to increase Thermal Energy aside from using friction. Figure out what it is and describe it below.

Part B: Measure

1. At the bottom of the screen, switch to the Measure section.
2. On either the 3rd or the 4th track , bring your skater to the top left, and let your skater go. Keep *Stick to Track* turned on so that your skater cannot fall off the track or jump off the surface. Set friction to *none*.
3. Release your skater from the top left side of the track, and then pause when your skater reaches the top right side of the track. There will be a trail of dots visible on the track. You can click and drag the target of the data measuring tool onto different dots. It will then display the values of the different forms of energy as well as the speed and height of the skater when they were at the position of the dot your target is over.
4. Choose 10 data points that are distributed around the track. Try to pick data points on the left, bottom, middle, right, top. In other words, a "random" sampling. Record the statistics of these data points in the chart below. Double click on the cells to enter values

Data Point	Height (m)	Speed (m/s)	Potential Energy (J)	Kinetic Energy (J)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

5. Using http://thephysicsaviary.com/Physics/Programs/Tools/Graphing/ , graph Potential Energy (*y*-axis) vs. Height (*x*-axis). Choose an appropriate Curve Fit. Screenshot and paste your results below, or simply sketch the graph.

6. Describe the exact mathematical relationship between Height and Potential Energy in words.

7. Now graph Kinetic Energy (*y*-axis) vs. Speed (*x*-axis). Choose an appropriate Curve Fit. Screenshot and paste your results below, or simply sketch the graph.

8. Describe the exact mathematical relationship between Speed and Kinetic Energy in words.

9. Switch to track 2 . Set skater mass to 5 kg. With friction off, drop your skater from the uppermost track position, and measure the speed just after the end of the track.

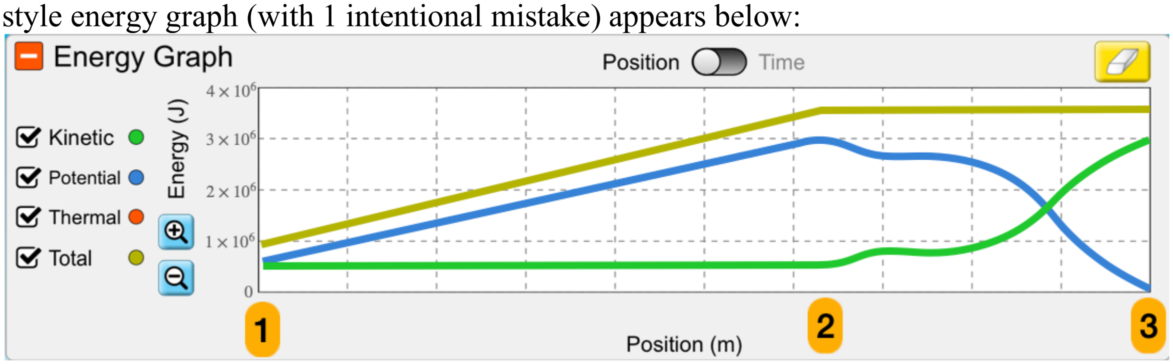
10. Repeat this procedure using a skater mass of about 50 kg, and measure the speed just after the end of the track again. Are the results significantly different, or basically the same?

11. Just to make sure you aren't imagining things, try the experiment one more time with skater mass set to 100 kg. What do you notice about final speed relative to the previous two answers?

Part C: Graphs

1. At the bottom of the screen, switch to the Graphs section. Take a few minutes to fully explore this section of the simulation. Click or tap on anything you can, slide all the sliders, and *Carefully* study the graphs that are produced as your skater moves around on either of the two tracks.

2. This is a picture of the Raging Bull ride at Six Flags Great America in Gurnee, IL. A section of the track is highlighted in yellow for our analysis. From point 1 to point 2, the cars are being pulled upward at a constant low speed. From point 2 to point 3 the carts are rolling down the track under the influence of gravity. Assume friction is negligible. A PhET style energy graph (with 1 intentional mistake) appears below:



a) How can the total energy be increasing from point 1 to point 2? Where is that energy coming from?

b) How come the Total Energy is greater than the potential energy from point 1 to point 2?

c) How come the Kinetic Energy is constant between points 1 and 2?

d) At what point in the graph do you notice there is a mistake? Look for something that is physically impossible, describe what you see and explain how you know that it is wrong.

Part D: Playground

1. At the bottom of the screen, switch to the Playground section. Create your own course and either draw it below, or screenshot/paste it!