# Lab: Skate Park (PhET) AP Physics

**Background**

The law of *Conservation of Mechanical Energy* states that the total mechanical energy in a closed system—kinetic and potential energies— remains constant over time. The more general law, *Conservation of Energy*, states that the total energy of a system remains constant, as long as one accounts for Work being done on the system, and/or energy leaving the system in other forms.

**Objectives**

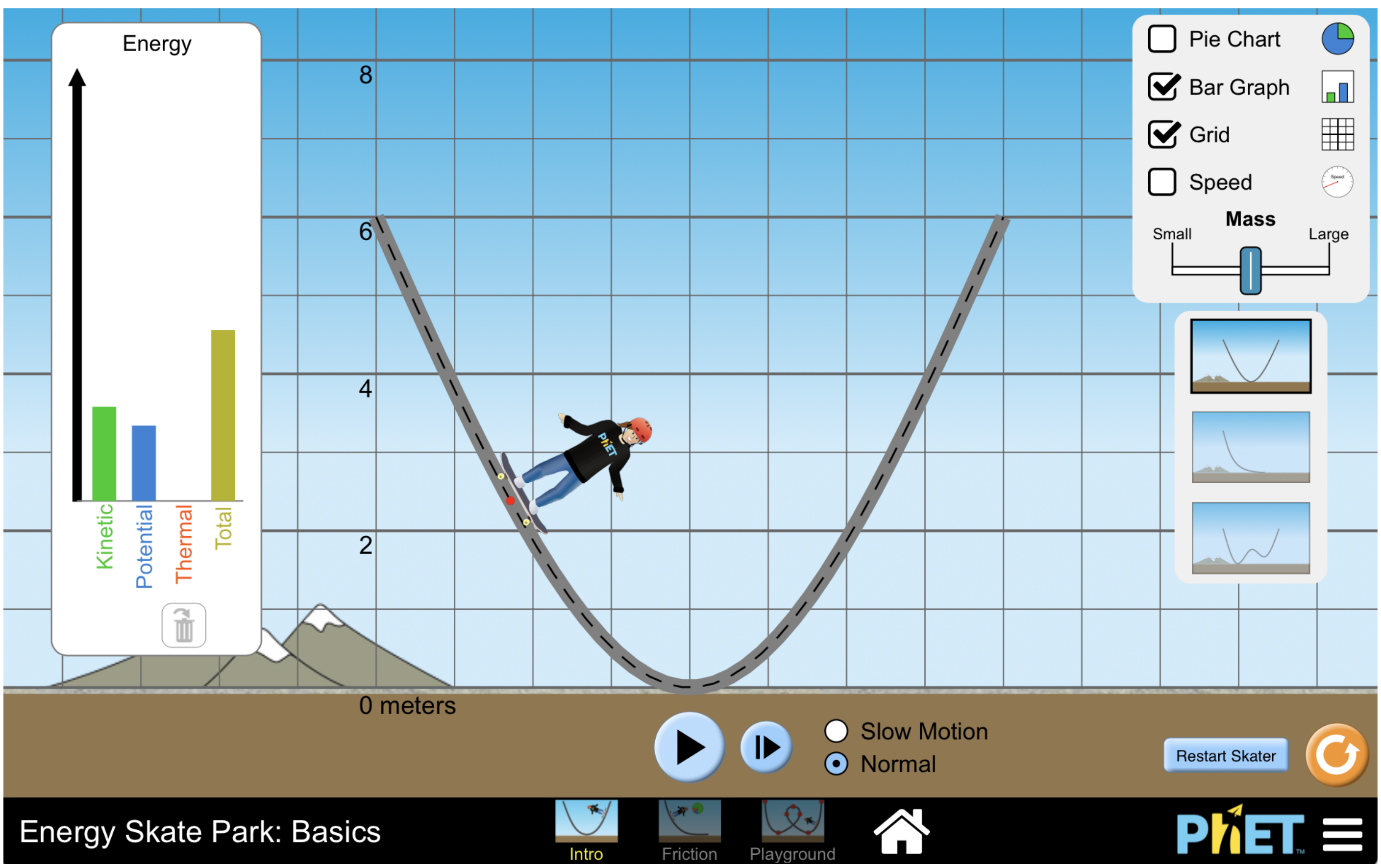
To use a computer model to develop an intuitive understanding of Conservation of Energy, and to practice solving energy-based problems.

**Equipment**

- Computer
- Internet connection (to access PhET website)

**Procedure**

In this online-based experiment you'll be running a series of simulations involving a skateboarder at an idealized skate park, and looking at the interplay between various types of energies.




***Part A. Familiarize yourself with the software***

1. Go to https://phet.colorado.edu/sims/html/energy-skate-park-basics/latest/energy-skate-park-basics_en.html and select the "Intro" scenario. (If you are unable to load the page from the PhET website, you can get the simulation at https://www.crashwhite.com/apphysics/materials/assignments/lab-dl/lab-dl7/index.html

2. Try choosing different track layouts, and activating the various display options, and watching how the skater's energies change over time.

3. Once you've had a chance to look at the basics, switch to the "Friction" scenario available at the bottom of the screen. You can adjust the amount of friction acting on the skater now, and this obviously affects her energies over time.

4. Finally, switch to the "Playground" scenario in which you can build your own track. Experiment with some different configurations briefly before moving on to the next section.

***Part B. Some experiments***

1. You're probably aware of the relationship $U_i + K_i = U_f + K_f$ which describes Conservation of Mechanical Energy. In the context of our skate park, the potential energy will only be gravitation-related. In the "Intro" scenario, there is no friction, so presumably it is this relationship that is being modeled.

2. In this "Intro" scenario, does changing the skater's mass change the amount of energy in the system? Does it change the skater's velocity at the bottom of the ramp, or maximum height reached on the sides of the ramp? Based on the Conservation of Mechanical Energy, what is the quantitative relationship between maximum height and maximum speed for the skater?

   Answer, briefly.

3. Can we collect some experimental evidence to support the relationship between *U* and *K*? Using the "Intro" scenario, design an experiment and record information that will allow you to identify the relationship between potential energy (related to height) and kinetic energy (related to speed). Describe the data that you observe, and/or include screenshots of your experiment, and support your conclusion with logical reasoning.

   Answer, briefly.

4. Use the "Playground" scenario to construct a loop that the skater can complete while Friction is set to a non-zero value. Run the simulation with the Bar Graph option activated so you can see how kinetic energy, potential energy, and thermal energy all change throughout the course of the skater's run. Then explain why physics teachers are reluctant to say "energy was *lost* to friction."

5. You can hit the Pause button to halt the skater mid-run, and you can use the “trash can” icon to reset the thermal energy to zero mid-run. Using these controls, compare the amount of thermal energy that appears in the *lower half* of your loop to the thermal energy lost in the *upper half* of your loop. Are they the same? Different? Explain your how observations are consistent with real-world factors.

   Answer, briefly.

6. **Potential Energy Diagrams** (Optional).
   A *potential energy diagram* plots **potential energy** on the *y*-axis versus **position** on the *x*-axis. Potential energy can be associated with gravitational force, with a spring force, or any other *conservative force* (although gravity and springs are the only ones we discuss in this course).

   Take a look at the “Intro” scenario, double-dip track, as shown on the next page. This physical (virtual) track can be considered as a kind of potential energy diagram for the gravity-track-skateboarder system.

   1. When is the potential energy of the system greater: when the skater is higher on the graph, or lower on the graph?

   2. At what positions does the graph indicate *equilibrium*?

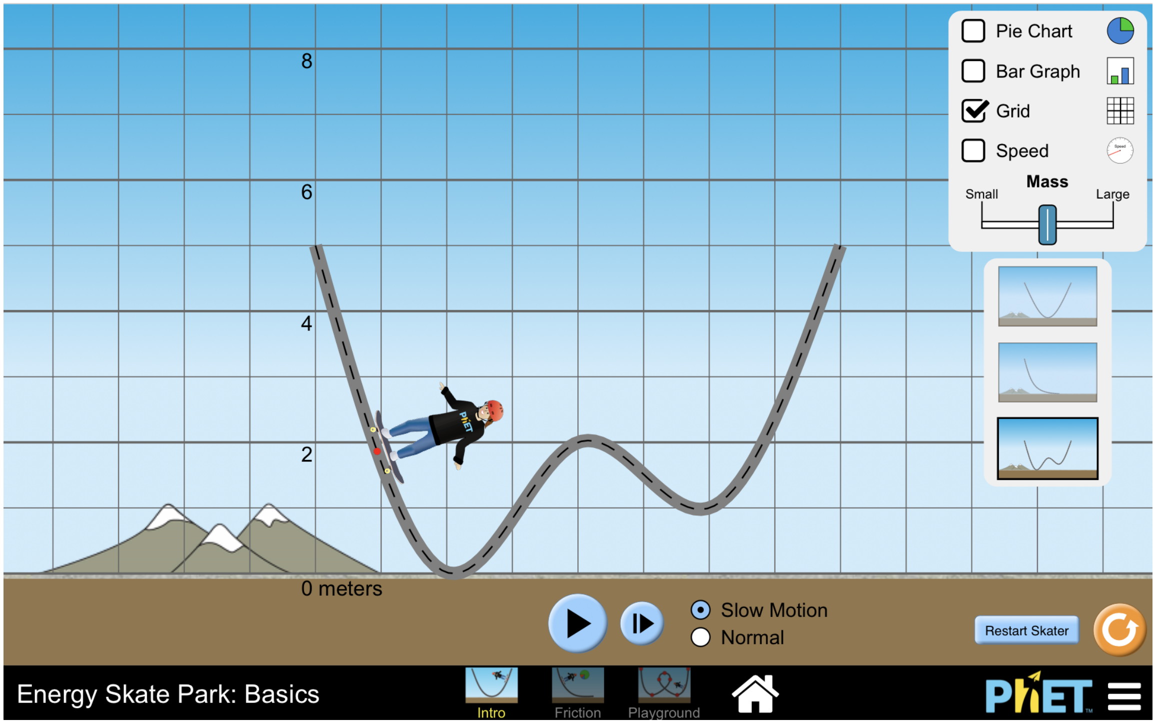
   3. Which of these positions is *stable* equilibrium? Which is *unstable* equilibrium?

   4. The relationship between a potential energy function and position is described by the equation $F=\frac{-dU}{dr}$, where *U* is a function of position *r*. The skater begins her motion ( $v_i=0$ ) from a vertical position *y* = 1.9 meters as shown in the diagram below. Considering the skateboarder on the ramp as a potential energy function, is the slope of the function at this position positive or negative? What is the direction of the *x*-component of the force on the skater, positive or negative? Is this consistent with *x*-component of the Force the skater actually experiences on the physical ramp?

   5. What is happening at the equilibrium positions based on the conservative force relationship $F=\frac{-dU}{dr}$ ?

   6. The skater accelerates down the ramp from her initial height of *y* = 1.9 m. How fast is she traveling at the lowest position on the ramp?

   7. The skater’s inertia carries her past the lowest position on the ramp. Will she be able to make it over the hump at *x* = 4.1 meters? How do you know?


8
6
4
2
0 meters
Pie Chart
Bar Graph
Grid
Speed
Mass
Small
Large
Slow Motion
Normal
Restart Skater
Energy Skate Park: Basics
Intro
Friction
Playground
PhET