Energy skate park

The simulation developed by PhET Interactive Simulations, University of Colorado Boulder, uses the example of a skateboarder riding on a track to illustrate the interaction of kinetic, potential, and thermal energy. The students can observe the physical correlations in an entertaining way. The skate park is a system where the law of conservation of energy applies. Changes in the individual forms of energy during the movement can be observed on bar graphs and pie charts. If the one form of energy decreases, the other form must increase so that total energy remains constant. In addition, it’s clear how the system changes when individual parameters (mass and friction) are changed. The students can try out various tracks to explore the connection between kinetic energy, potential energy, and thermal energy.

The students will learn …

- to explain the law of conservation of energy in the interaction between kinetic, potential, and thermal energy.
- to describe bar graphs and pie charts.
- to describe how the skater’s mass affects the energy.
- to describe how the friction on the track affects the energy.
- to make predictions about the skater’s position based on the values in the energy bar graph and pie chart.
- to estimate the speed based on the values in the energy bar graph and pie chart.

With additional information, the students can perform specific calculations. For example, with the skater’s mass as additional information and the reading of the height, the potential energy can be calculated. The students could also calculate the skater’s speed from the difference in the two read heights.

1 Tips on how to use

The simulation provides three screens that are selected using the buttons at the lower edge:

- Introduction
- Friction
- Playground

In the simulation, the things that remain the same for all screens are described below, and then the special features of the individual screens are addressed.

1.1 Moving the skater

Drag the skateboard rider to the desired starting position on the track. You can also choose a starting point above the track. The red dot under the skateboard marks the position that applies to measurements (for instance, height for the calculation).
When the skater figure “rides off the screen” because she has gone off the track, two skater buttons appear, one red and one green. Click the green button: The skater reappears on the track where she last started. Click the red button: The skater appears at the home position next to the track.
Click “Restart Skater” to have the skater resume from the position where she last started.

The simulation has two running speeds: normal and slow motion. Use the arrow button to the right of the large arrow button at the bottom to gradually move the skater forward. This allows you to move the skater precisely to the zero-point situations (for example, $E_{kin} = 0$).

1.2 Displays

Click the boxes at the upper right to display a pie chart and/or a bar graph; both show the energy levels at any given time.
You can display a meter grid for the height. The students can use the grid later to read values for calculations.
You can also display a speedometer. The scale doesn't include a unit of measurement.
On all three screens, you can change the skater's mass from small to large. The skater figure changes size accordingly. However, the mass is not indicated in kilograms.

1.3 The screens

1.3.1 Introduction

On the "introduction" screen, the track doesn't have friction. Only the interconversion between potential energy and kinetic energy is observed. The basic track is shaped like a parabola. You can select two other tracks using the buttons at the right.

1.3.2 Friction

Now friction comes into play. You can change it from "none" to "lots."
As with the "introduction" screen, you can choose between three different tracks.
When the skater lands on the track, the vertical component of her kinetic energy is converted to thermal energy. By setting the friction to "none," you can show an experiment without friction losses, but then you have to be careful that the skater stays on the track.
You can also "dispose of" the thermal energy using the wastebasket symbol; the thermal energy is set to zero. As you continue the experiment, the thermal energy builds up again. In this way, you can remove the heat that develops the first time you place the skater on the track.

1.3.3 Playground

Now you can design your own tracks. Drag pieces of track from the bottom of the screen to the skating area, one after another. Click a connection to edit that piece. The scissors stand for "separate," and the X for "delete."
Use the two buttons under the "Friction" display to select whether the skater should remain on the track or fall off when the forces are too great. This can be important for loops.

2 Possible tasks

- Design a track with a loop that the skater can ride completely from one end to the other.
- Think of a skater experiment that shows the dependence between kinetic energy and speed.
- Answer the questions: At what point on the track is the most energy converted to thermal energy? Why?
- Find situations in which the full amount of energy is present in only one form (once in the "introduction" model, once in the "friction" model).