Energy Skate Park

Part 1: Warm-up

1. Google search: "*phet skate park*" to find the simulation.
2. Click "Choose Skater", and choose your favorite one.
3. Build a track for your skater! Have fun and see what you can do in a couple minutes. After you get the hang of it, try building a track that starts and ends at the same height and that *minimizes* the time it takes the skater to travel from one end to the other. This is just for fun, though; take only a couple of minutes.

Part 2: Energy in a pie chart

1. Now build a skate ramp that resembles the diagram of the potential energy between two atoms, as a function of the distance between them. You may recall this as the Lennard-Jones potential, but if you don't that's OK: It looks like this!

2. **Double check!**

a. The track should go up higher on the left than on the right.
b. Make sure the right side doesn't dip down.
c. Make sure that the skater can roll smoothly back and forth across the track without jumping or crashing.

3. Turn on the Pie Chart, which displays kinetic and potential energy as they change.
    a. At what point or points on the track is the potential energy the largest? Why?
    b. When is the kinetic energy the largest? Why?
    c. What is the skater doing as the kinetic energy drops to zero and then gets larger again?

4. As the skater moves across the track, where does her potential energy *change* most rapidly? Could you explain this without watching the pie chart?

5. Is your answer to question 4 also the place where the *kinetic* energy is changing most rapidly? How do you know?

Part 3: Energy on a bar chart

1. Press the button to display the Bar Graph.

2. The bar chart shows four energies: KE, PE, Thermal, and Total.
    a. Of the four, which ones are changing?
    b. What might be more clear on the bar chart than on the pie chart, if anything? What's less clear?

3. Which representation(s) most clearly show that energy is conserved?

Part 4: What's up with negative potential energy?

1. Turn on the "Potential Energy Reference" to see and change where we measure potential energy from.

2. We don't have to measure the PE from zero at ground level, but moving it may affect our pie and bar charts.

3. **Before** moving the PE=0 line to the bottom of the track, **predict:**
    a. What will happen to the skater's potential energy? Why?
    b. What about her kinetic energy? Why?
    c. Sketch the bar chart at the moment when the skater's at the bottom of the track.

4. **Next**, try it! Move the PE=0 line to set zero at the lowest point of the track.
    a. How does this compare to your predictions?
    b. In terms of explaining what's going on with the potential and kinetic energy as the skater moves back and forth, what are the advantages of setting PE=0 at the bottom of the track?

5. Now, move the PE=0 to the “textbook” Lennard-Jones position just above the end of the flattest part of the ramp, like this:

   a. Why is there no pie chart when the skater is below the PE=0 line?
   b. What does negative potential energy mean in this case, if anything?
   c. Could you imagine a situation where the Kinetic energy is negative? If so, explain. If not, why not?

6. Release the skater from rest from the very right end of the track. Observe the bar chart.
   a. What is the total energy? Does this make sense?

7. How do the potential and kinetic energy relate, at any given moment? Why?

8. Without moving the PE=0 line, restart the skater so that her total energy is negative. In this case, will she stay “trapped” on the track forever or can she break free eventually?

9. Now you're going to give the skater a rocket-propelled "boost" to make her total energy positive. Here's how: Press the down arrow key as the skater is moving down the ramp. Try to boost the skater once or twice, keeping her total energy negative.
    a. What changes about the skater's path as her energy grows?

10. Boost her again, but now keep doing this until the total energy becomes positive.
    a. What happens to the skater when her total energy is positive? Why?
    b. With the "PE=0" line where it is, can you give the skater an overall positive energy in such a way that she does NOT fly off the ramp? Why or why not?
    c. Here's a major punchline of this tutorial: What are the advantages of setting PE=0 at the right end of the track, in terms of predicting and explaining whether the skater remains "bound" or "unbound" to the track?
    d. And now here's the whole point: When describing the attractive interaction of two atoms that are capable of bonding, chemists set PE=0 when the atoms are very far apart. Why? If you can't answer this now, the next part of the tutorial will relate the skater to atoms more explicitly.

Part 5: From skaters to atoms…

1. Leave your skate park, google search "*phet atomic interactions*", and run that simulation.
    a. Rather than Neon–Neon, select "Adjustable Attraction" in the "Atoms" box.
2. You can either drag the unpinned atom directly or drag its representation on the PE graph.
    a. Which initial positions would have a Total energy that's *negative*?
    b. Can you move the atom to a position with a *positive* Total energy?
3. Here's the point of the tutorial, revisited: In terms of describing and predicting whether two atoms will remain bonded or break free of each other (e.g., the bond breaks), what's the advantage of setting PE=0 when the atoms are very far apart? And how does this all relate to the skater?

Part 6: …and back again.

1. The skater in the Lennard-Jones potential goes back and forth the same distance, just like the atoms do in the *Atomic Interactions* simulation. However, if you select Oxygen–Oxygen, you'll find a Lennard-Jones potential that's qualitatively different from any of the others.
    a. Describe the differences between the Oxygen–Oxygen potential and the other interaction potentials.
    b. When the oxygen is dropped from a distance, it behaves differently than the other atoms, too. Describe the differences in the motion of the oxygens compared to other pairs.
    c. This seems a lot more like a chemical bond, but why doesn't the second oxygen get back up out of the well? Where does the energy go?
2. Go back to the *Energy Skate Park* and modify your track to look more like the O_2 potential.
    a. See if you can get your skater to fall in from a distance and get stuck at the bottom.
    b. Where did the energy go?
    c. Could actual atoms interact in this way? How could this help explain chemical bonding?