Potential and Kinetic Energy, Inertia and Momentum

Have you ever wondered how a roller coaster works? How can it keep going even when there is no power driving the wheels? The simple answer is actually not very simple. First, we have to understand what potential and kinetic energy are and how they affect an object.

Activity: Take a rubber band and stretch it. What do you feel? Is the rubber band pulling against you? It's trying to go back to its normal shape. The more you pull it, the more it pulls against you until it breaks. This is potential energy. **Potential** energy is simply energy that has not been used. The energy is built up within an object, and given the right circumstances, it will cause something to happen. What happens if you let go of one end? Does it stay in the exact same shape? No. It snaps back to its normal shape very fast. In fact, if you don't hold onto the end it will fly out of your hands.

So, what happened? In our test we stretched the rubber band and built up potential energy within the rubber band. When we let go of it, the rubber band snapped back into its normal shape. This movement is called kinetic energy. **Kinetic** energy is just energy in motion. It's causing something to move, in this case, our rubber band.

Activity: Choose an area about 30 feet long that is safe for you to run. Start by walking at a normal pace. Halfway across your area try to stop as fast as you can. Not very difficult, huh? You stopped right away without any problem. Now go to one end of your area and try it again. But this time, run as fast as you can and try to stop really fast. What happened? Did you stop right away or did you have to take an extra step of two. Was it easier or more difficult to stop when running compared to walking?

Isaac Newton came up with the idea of how objects move in his first law of motion: An object that's moving will stay moving, and an object that is still will remain still, unless an external force pushes against it. For instance, if we threw a baseball in space and there was no gravity or drag on it, the baseball would continue in the same direction and at the same speed forever. Another word for this behavior would be **inertia**. Now on Earth we do have gravity and drag. So, if we throw a baseball, it eventually will fall to the ground. And since we also have friction, the ball will roll to a stop very quickly. To make a roller coaster, engineers must design a track that uses the idea of inertia. To do this they have to calculate the speed, direction and mass of the cars. When we do this, we are calculating momentum. **Momentum** is just like inertia except that it explains in mathematics how the object is moving and how difficult it is to change its speed and direction.

There are programs that engineers use called simulations that help them to see how a roller coaster will work before it is built. They can test hills, loops, different weights of cars, speed of the coaster and

friction as it rolls along the track. By doing this, they can design a coaster that will use less energy to start and let its momentum carry it through the entire ride.

Activity: Click on the Energy Skate Park simulation. (You may need java installed on your computer. To install Java, go to https://www.java.com/en/download/manual.jsp.)

1. Click on energy-skate-park_en.jar.
2. Build a skate ramp and choose a skater to test it. You can add track by clicking on the top left image of a track and dragging it to where you want it to be. You can add it to an existing track on the screen. Draw a diagram of what happened to your skater on the first try.
3. Adjust your ramp (if needed) to keep the skater from flying off and dying! Draw a second diagram of your answer.
4. What did you change? Why did it help the skater survive?
5. Click on the box next to the word "moon" and then test again. What happened to your skater? How did he behave differently? On the moon there is less gravity which means our skater does not speed up or slow down as fast.
6. Now click on the button marked "Track Friction". Move the slider to the right a little bit. What happened to your skater? Why did he stop?
7. Explore different track shapes, planets, and friction.

Conclusion: When we started our skater at the top of a hill, he had potential energy. Then as he rode through the track, he had kinetic energy. Since we did not have to push him after we first let him go, he had inertia as well. Isaac Newton's first law of motion tells us that an object that is moving will continue to move unless an external force pushes against it. When we added friction, we added an external force. This slowed the skater down until he came to a stop.