Engineering For Kids®

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.

Potential energy is simply stored energy that has not been used. Specifically, it is the energy possessed by an object by virtue of its position relative to others, stresses within itself, electric charge, and other factors. Potential energy can be converted into kinetic energy or other kinds as well.

Kinetic energy is just energy in motion. We can calculate kinetic energy the following way, KE=.5 x Mass x Velocity^2. Kinetic energy can be converted into other kinds, such as gravitational or electric potential energy, which is the energy that an object has because of its position in a gravitational or electric field.

Inertia is the observed natural tendency of an object in motion to keep moving in the same direction and at the same speed, or if at rest, to stay at rest. Inertia simply tells us that to change the motion of an object requires applying a force to it.

To fully describe the property of Inertia with units we can measure, we must quantify an object's speed of motion, direction of motion, and resistance to change of motion. We combine these three things into a single parameter for each object called its **Momentum**.

The resistance to change of motion does not depend upon direction, so it is what we call a "scalar" quantity, and has been named **Mass**. We quantify Mass using units such as kg or lb-mass. We actually measure the Mass of an object indirectly by applying a known **Force** to it and measuring its change in motion (acceleration) according to the equation Mass = Force / Acceleration. Objects that require a lot of Force to accelerate a little bit have large Mass. Objects that accelerate a lot with a little bit of Force have small Mass. When we combine speed with direction, we get a quantity called **Velocity**. Momentum has both a magnitude and a direction. We quantify the Momentum of an object as the product of the Mass times its Velocity.

Momentum is also a measurable property of a set of objects. Their individual Momenta can be added together and be represented by a virtual object we call a **Center of Mass** moving with a specific speed.

Momentum is "conserved", which simply means that it does not change over time for any closed system unless some external force is applied. For a collection of objects, their collective Momentum does not change, even if they bang into each other and bounce apart again or clump together, or one object goes spinning off away from its neighbors. These collisions, if not perfectly elastic, will reduce the Kinetic Energy of the system, especially if they clump together into a single object, but the Momentum of the clump will be the same as the net momentum of all the original individual pieces -- the **Center of Mass** will continue to move with the same speed.

There are programs that engineers use called physics 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 and conservation of energy 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? How does friction apply to Newton’s first law of motion?
7. Explore different track shapes, velocity, gravity, mass, 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. To measure it, we would need his velocity, mass and direction. When we added friction, we added an external force to the equation. This slowed the skater down until he came to a stop.