PHYSICS CONNECTION

Skateboarding with Sir Isaac Newton

Who knew that an apple falling from a tree would inspire flying acrobats? The popular story about Sir Isaac Newton sitting under the apple tree and the universal law of gravitation helps explain much of how skateboarding works. Skateboarders are defying gravity by leaping and skidding over and onto obstacles at top speeds. It also seems like they are defying the laws of physics. In reality, skateboarders are using the laws of physics to make their amazing moves. The sport demonstrates Newton's three laws.

The laws of motion

Sir Isaac Newton, a scientist from the 17th century, came up with the three laws of motion that explain why objects move or don't move.

- Newton's first law is the law of inertia states that an object that is at rest tends to stay at rest. An object that is in motion tends to stay in motion with the same speed and in the same direction unless an outside force acts on it. Once in motion, a skateboarder will continue to move forward (or stay in motion) unless some outside force affects them. If the outside force is a concrete wall, you can guess what happens. The skateboarder's motion changes fast. Since concrete so often provides the "outside force" that acts on their motion, skateboarders wear protective gear.
- Newton's second law of motion relates to the acceleration of an object. Acceleration depends upon the mass of the object and the force(s) acting on the object.
- Newton's third law is probably the best known of his laws of motion. It states that every action has an equal and opposite reaction.

How things have changed

When skateboarding was invented, a skateboard was simply a two-by-four on roller skate wheels. The goal was to start at the top of a hill and ride the skateboard to the bottom without crashing. It wasn't long before skateboarders wanted the sport to be more challenging.

Today, skateboarders use boards with wheels that reduce friction. They make incredible moves. Even the most basic skateboarding moves rely on the laws of physics. A good example is skateboarders in half-pipes. The half-pipe is a U-shaped ramp that usually has a flat section in the middle. In the half-pipe, controlled acceleration is absolutely essential.

On flat ground, gaining speed is easy. Push with one foot, and you accelerate. Half-pipes are a little trickier. They require "pumping." Pumping makes use of Newton's second law. When skateboarders pump, they drop down into a crouch as they roll through the flat bottom of the U-shaped half-pipe. As they enter the sloped part of the ramp, called the transition, they straighten their legs. By standing up in this way, skateboarders raise their center of mass. The sudden shift in their center of mass gives them more energy. More energy means acceleration. The shift in the center of mass is in the direction the skateboarder is moving. The skateboard accelerates in that direction.

This is like pumping on a swing. The swing goes higher if you lift your legs while passing through the bottom of the swing's arc. At the top of the arc, you drop your legs. The more times you repeat this movement, the more energy you gain. Gained energy translates into swinging higher. This same concept is what helps skateboarders gain speed in the half-pipe until they have the enough height and speed to perform all kinds of stunts.

Motion in action

How does Newton's third law affect skateboards? In essence, it is what allows them to move. For each of the skateboarder's actions, there is an equal and opposite reaction. A skateboarder pushes against the concrete at the top of a half-pipe. The concrete pushes back. The skateboarder is in motion. Friction between the wheels and the concrete is a force that acts on the motion. Gravity is another force that acts on the skateboarder's motion. Have you ever watched skateboarders in a half-pipe? If so, you know that they overcome the force of friction in some pretty dramatic ways.

In one impressive stunt, skateboarders soar above the half-pipe and perform a move called the "frontside 180." It's a trick that puts a little more spin on physics. Skateboarders appear to hang in the air for a moment after flying out of the half-pipe. Then they skate back down the ramp.

Physics tells us that if something is rotating, it will continue to rotate unless a twisting force stops it from rotating. The same also holds true if something is not rotating. It will need a twisting force to start it rotating. Skateboarders use their arms to create this twisting force. Also known as torque, this twisting force allows the skateboarder to turn around in mid-air. By pulling their arms in as they twist them, skateboarders create torque. That's how they seem to defy gravity in a successful frontside 180.

The evolution of skateboarding will continue to change with each new generation. Skating stunts and styles will change dramatically, but the science will remain the same.

Questions:

1. Do skateboarders actually defy the laws of physics? Why or why not?
2. How does "pumping" increase a skater's acceleration?
3. What is torque and how does a skateboarder use it?