

Physics and the Fair: Forces and Motion

WHAT IS A FORCE?

Forces change the way that objects move. A force can push or pull an object, and is based on an interaction from another object. In his publication, "The Principia," Sir Issac Newton defined three laws of motion, which describe much of what we now know about forces:

- **Law 1:** An object in motion will stay in motion; an object at rest stays at rest. This is also known as **inertia**, or the tendency for objects to keep doing what they are doing unless acted upon by an outside force.
- **Law 2:** The force that it takes to move an object is dependent on how much matter, or "stuff" is moving and how fast the "stuff" is moving. It takes more force to move a heavy object (like a wall) than it would take to move a lighter object (like a tennis ball) the same distance.
- **Law 3:** For every action, there is an equal and opposite reaction. When one object exerts force on a second object, the second object will exert an equal force on the first object.

GRAVITY DEFYING STRENGTH

Gravity is the force that pulls matter together. Gravity pulls us (Object A) to the earth (Object B).

All objects on earth experience gravity. When we measure this pull, it is called **weight**. It is important to differentiate weight (the force of gravity) from **mass** (the amount of matter, or atoms in an object).

The pull of gravity is different depending on where the gravity is coming from. For instance, if you were to stand on the moon, which has a smaller mass and therefore a less strong gravitational pull (approximately 1/6th of Earth's), you would find it much easier to lift objects. You would also weigh about 1/6th the amount that you weigh on earth. This is because the gravity is not pulling as hard.



In contrast, Krypton, the fictional planet where Superman is from, has a much stronger gravitational pull than earth, which could be one explanation for why superman has no trouble lifting cars or other weighty objects here on Earth.

EXTREME SCREAM

Many rides at The Washington State Fair use physics!

The Extreme Scream relies largely on gravity to thrill riders. Using an air compression pump to propel 12 riders to the top at a speed approaching 3 Gs, the ride then drops riders to the Earth at a speed of negative 1 G! To put this in perspective, 1 G is the amount of force that Earth's gravitational pull exerts on you. In 0 Gs you would feel weightless. Negative G-force occurs when you accelerate downwards faster than the rate of a natural free fall.



Under the influence of gravity, an object in free fall accelerates toward the center of the Earth. All objects in free fall accelerate at the same rate. In the case of the Extreme Scream, all the passengers, regardless of their masses, will fall at the exact same rate. You can test this concept in your classroom or home by dropping objects of different masses from the same height and observing when they hit the ground in relation to one another. If this experiment were done in a vacuum, all of your objects would hit the ground at the exact same time. Since you are not in a vacuum, what might prevent a feather from hitting the ground as quickly as a tennis ball?



energy and **kinetic energy**. Most roller coasters start out by building a maximum amount of potential energy as they climb to the top of the first hill.

The higher that the coaster gets and the more distance that gravity has to pull it to the ground, the more potential energy it has. This is why the first hill on roller coasters is usually the biggest! After the coaster reaches the top of the hill, it starts to descend down the other side, converting potential energy into **kinetic energy**. The kinetic and potential energy of the roller coaster will continue to change throughout its entire run. Slowly as the coaster travels, the total energy level of the ride is lost due to **friction**.

ROLLER COASTERS

Did you know that roller coasters don't have motors to power them throughout the entire ride? Instead, roller coasters, such as those at the Washington State Fair, rely on the constant conversion between **potential**

MAX POTENTIAL ENERGY

Potential energy is the energy an object has due to its position relative to other objects. A roller coaster car sitting at the top of a very tall hill has a LOT of potential energy.

ACCELERATION

As the track slopes downwards, it causes the coaster to accelerate, or increase velocity (speed in a specific direction).



GRAVITY

The force that attracts a body towards the center of the earth or all matter towards each other.

MAX KINETIC ENERGY

Kinetic energy is the energy an object possesses due to its motion. A roller coaster car zooming down a very tall hill has a LOT of kinetic energy!

INERTIA

Because of Newton's first law of motion, or inertia (objects will keep doing what they are doing), the coaster will continue to travel forward as long as it stays on the track.

CLOTHOID LOOPS

The shape of these loops resemble the middle of two circles overlapping. This shape allows for both a change in speed and a change in direction.