

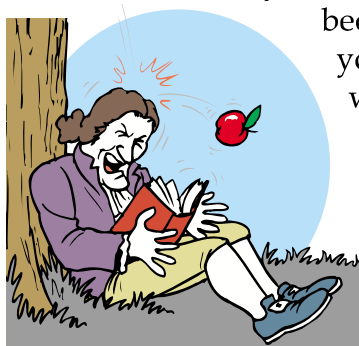
Introduction

You have learned that **force** is any push or pull on an object. Force does not always cause an object to move. Press down as hard as you can on your desk. The desk does not move. That's because your force is equal to the force of the desk pushing against your hand. When forces are equal, they are **balanced** and do not cause movement. Forces on an object are not always equal. One force can overpower another force. The force of two horses pulling one end of a rope would overpower a man pulling on the other end of the rope. This is an example of **unbalanced** forces. Unbalanced forces cause an object to move. In this unit, forces and motion will be discussed.

Gravity

There are many different kinds of forces. **Gravity** is the force that attracts any two bodies with mass toward each other. Earth pulling on an object is gravity. About 300 years ago, Isaac Newton explained the way the force of gravity works. He stated that the force of gravity on an object depends on the mass of the object and how far the object is from Earth. Remember that **mass** is how much there is of a material. This means that **weight** is based on mass. As mass increases, the force due to gravity increases. As distances increases, however, the force due to gravity decreases in proportion to the square of the distance.

Weight is the measure of the force of gravity. As you travel away from Earth, your mass will not change, but your weight will. This is because of the way gravity behaves. Every time you double your distance from Earth, your weight becomes one fourth what it was. This is

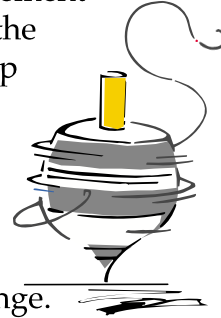


Sir Isaac Newton

because the force acting on you grows weaker as you move away from it. On the moon, you would weigh $\frac{1}{6}$ what you do on Earth. This is because the moon has only $\frac{1}{6}$ of Earth's mass. The result is it has less force to pull on you. In the **Systeme Internationale (SI)** there is a special unit to measure force. This unit is called a **newton** or **N**. Of course, it was named after Sir Isaac Newton, who first described force.

Motion

Forces are responsible for motion. **Motion** is simply a movement of an object from one place to another. Motion can also be the change in direction or alignment of an object. Think of a top spinning on a desk. As it spins, it may not move anywhere across the desk. It still has motion, though, because it is constantly changing directions. Other terms are needed to help us understand motion. **Speed** tells us the distance an object moves in a certain amount of time. **Velocity** is speed in a definite direction. Speed and direction may change. Any change in either speed or direction is called **acceleration**.

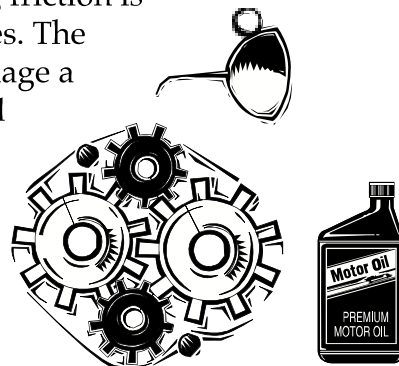


Friction

There are also forces that stop or slow down motion. Any force that prevents or slows down motion is called **resistance**. Push a box across the floor. Let go. It may move a little way and then stop. Why didn't the box keep moving? Friction made it stop. **Friction** is a type of resistance caused when one surface touches another surface. Friction is a force that makes objects slow down. Whenever we try to move something, friction pushes against it. The movement of objects through air causes a type of friction. Airplanes and cars are shaped so they can overcome some of the friction caused by air.

Friction produces heat. What happens if you drag a piece of wood across asphalt? It feels warm to the touch. Car tires heat up during a trip because of friction. The higher the friction, the greater the amount of heat produced. Rough surfaces produce more friction than smooth surfaces.

The force of friction can be reduced. Reducing friction is important to the reliable operation of machines. The friction caused by its moving parts could damage a machine. **Lubrication** reduces this friction. Oil and grease are used on surfaces that rub against each other. This kind of lubrication is common in cars, bicycles, lawn mowers, and gasoline engines. The use of rollers and ball bearings will also reduce friction. Think about pushing the box across the floor. It would be easier to move it if you put rollers between the floor and the box.

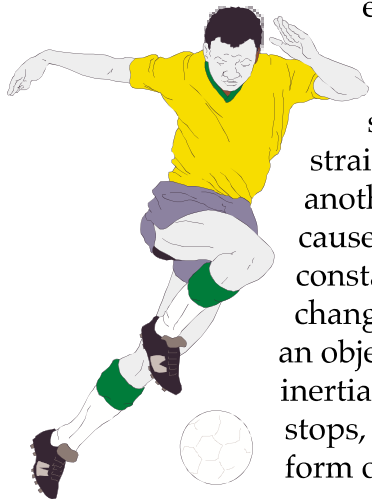


Oil is used as a lubrication to reduce friction on moving parts of machines.

Friction can be a helpful force. Without it, objects would slide around. Walking would be difficult. Imagine walking on ice. You might need to increase the friction between your feet and the ice to keep from falling. On the other hand, you could reduce the friction by putting on skates. Could you go faster on skates or on foot?

Laws of Motion

Sir Isaac Newton developed three basic **laws of motion** that explain the relationship between force and motion. His *first law of motion* states that



every object tends to remain at rest or move in a straight line until an outside force acts on it. For example, a soccer ball will stay still until someone kicks it. Once kicked, it will travel in a straight line unless another player hits it or it hits another object. **Inertia** is the property of matter that causes the velocity or speed of an object to be constant as long as there is no outside force to change that speed. That is to say that inertia means an object tends to keep its present state of motion. The inertia of an object is related to its mass. When a car stops, your body continues to move forward. This form of inertia can be overcome by using seat belts.

The *second law of motion* explains how speed and force are related. It states that the acceleration of an object is set by the size of the force acting on it. This is easy to understand. A strong force will move an object faster than a weak force. The direction of the force will also affect the object. Picture two men trying to move a refrigerator. If they push in the same direction, the refrigerator will move. If six men try to move the refrigerator, it will move faster. What would happen if three men pushed from the front and three men pushed from the side? The direction of the refrigerator would change. A part of this law also states that a large mass will need a large force to make it follow a curved path. A moving car requires a large force to keep it on a curved road.

Newton also discovered that forces do not exist alone. His *third law of motion* explains that for every action, there is an equal and opposite reaction. This is not difficult to understand. You know that gravity exerts a force on you. It pulls you toward Earth. Your weight is the "equal, but opposite" force that pushes down on Earth.

Sending astronauts into space is possible because of our understanding of the laws of force and motion. Car and airplane designs are also affected by these laws.

Summary

Unbalanced forces cause motion. Friction is a form of resistance that slows objects down. Gravity is the force that pulls an object to Earth. Sir Isaac Newton developed three laws that explain how force and motion are related.

Newton's 3 Laws of Motion



The *first law of motion* states that every object tends to remain at rest or move in a straight line until an outside force acts on it.



The *second law of motion* states that the acceleration of an object is set by the size of the force acting on it.



The *third law of motion* states that for every action, there is an equal and opposite reaction.