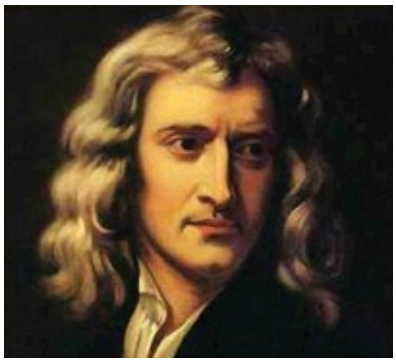
Reflect

Have you ever thrown a ball into the air and watched it come back down? No matter how high you throw it, the ball will always fall back to Earth. This is because of Earth's gravitational pull.

You have probably heard of gravity, but do you know what it is? Why does gravity pull objects such as the ball toward the ground?

Scientists in the Spotlight: Sir Isaac Newton

In the mid-1600s, a young scholar named Isaac Newton developed some fundamental ideas in the history of science. According to legend, Newton had one of his most important ideas after watching an apple fall from a tree to the ground. This experience caused Newton to think about the different forces in the universe: Perhaps a certain force pulls objects toward Earth?



In 1687, Sir Isaac Newton explained his concept of gravity in an important book, *The Mathematical Principles of Natural Philosophy*.

By Newton's time, scientists had begun to accept that the Sun is the center of the solar system. However, they still didn't know which force held the planets in orbit around the Sun. Newton's answer was gravity. Newton's concept of gravity has been crucial to our understanding of the universe.

Gravity

Gravity is a force of attraction between two or more objects with **mass**. In other words, gravity is the force that pulls one object with mass toward another. The more mass an object has, the stronger its gravitational pull. All objects have a gravitational pull, but the gravitational pull of most objects is too weak for you to feel. Earth is massive enough that you can feel its gravitational pull. Earth's gravitational pull is what keeps you on the ground.

mass: the amount of matter in an object or a substance

Astronauts in space are still affected by Earth's gravity. Earth's gravity is what keeps them in orbit.

Reflect

Sir Isaac Newton developed the law of universal gravitation.

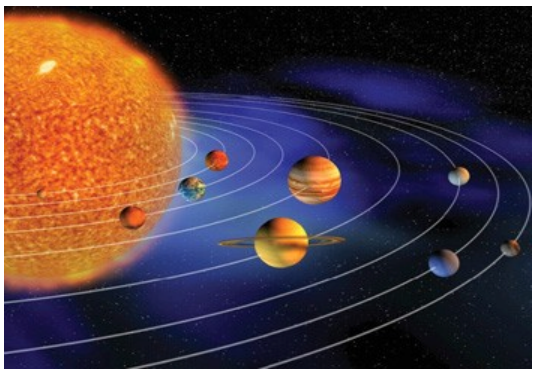
According to the law of universal gravitation, as the distance between objects with mass increases, the gravitational attraction between those objects decreases. In other words, the farther apart two objects move, the weaker their gravitational attraction becomes. Earth is massive, so it has a strong gravitational pull. You would have to move very far away from Earth to escape its gravitational pull.

Look Out!

People often use mass and weight as though these terms mean the same thing. However, mass and weight are different properties of objects. Mass is a measurement of the amount of matter in an object. Your mass is the same no matter where you are in the universe.

Weight is a measurement of the force of gravity on an object. Objects with more mass than Earth have stronger gravitational pulls, whereas objects with less mass than Earth have weaker gravitational pulls. This would make your weight different on other planets and moons. For example, if you weigh 100 pounds on Earth, you would weigh only 16.6 pounds on the Moon! However, you would weigh 236.4 pounds on Jupiter. This is because the Moon is much less massive than Earth while Jupiter is much more massive. Astronauts floating in space appear to weigh nothing. However, an astronaut's mass remains the same regardless of where he or she is in space.

The Solar System



Gravity holds the solar system together. The Sun is the most massive object in the solar system. Therefore, it has the strongest gravitational pull. The Sun's gravity causes other objects in the solar system—including planets, comets, and asteroids — to orbit, or move around, the Sun. (An orbit is also the path an object follows as it revolves around a more massive object.) The planets, comets, and asteroids all have their own gravitational pulls. They revolve around the Sun because the Sun is much more massive.

Look Out!

Other objects in the solar system with orbital paths include moons and man-made satellites. Instead of revolving the Sun, these objects revolve planets. For example, the Moon revolves around Earth because it is much closer to Earth than to the Sun. Though the Moon is less massive than Earth, its gravitational pull is strong enough to affect the planet. The Moon's gravity pulls on Earth's oceans as it revolves the planet. When the Moon is closer to an ocean or a lake, it pulls the water away from Earth. As the Moon moves away, the water falls back toward Earth. We call these regular movements of water tides.

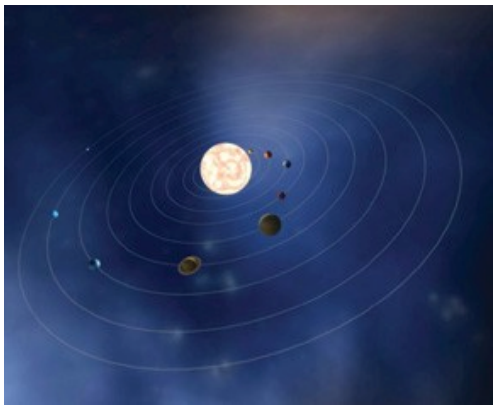
The planets and comets orbit the Sun, while moons orbit planets.

What Do You Think?

You have learned that the planets and other objects in the solar system revolve the Sun because the Sun is so massive. Why do you think these objects do not crash into the Sun?

Elliptical Orbits

As an object in space moves around the Sun, it has a certain amount of forward momentum. The object's orbital path represents a balance between this momentum and the Sun's gravitational pull. As long as this balance is maintained, the object will continue to orbit the Sun.



The planets follow elliptical, or oval- shaped, orbits around the Sun.

Now, suppose the object collides with a large asteroid. The force of the collision could move the object closer to the Sun. At a closer distance, the Sun's gravity might be strong enough to overcome the object's forward momentum. If this were to happen, the object would spiral toward—and eventually collide with— the Sun. On the other hand, suppose the collision moved the object farther from the Sun. At a greater distance, the object's forward momentum might be strong enough to overcome the Sun's gravitational pull. If this were to happen, the object would break free of its orbital path and move out of the solar system entirely.

What Do You Think?

The orbital paths of objects in the solar system are not perfect circles. Instead, their orbital paths are elliptical, or oval-shaped. This means that these objects are sometimes closer to and sometimes farther away from the Sun. When an object is closer to the Sun, it is affected more by the Sun's gravity. As a result, the object moves faster along its orbital path. When the object is farther from the Sun, it is affected less by the Sun's gravity. As a result, the object moves slower along its orbital path.

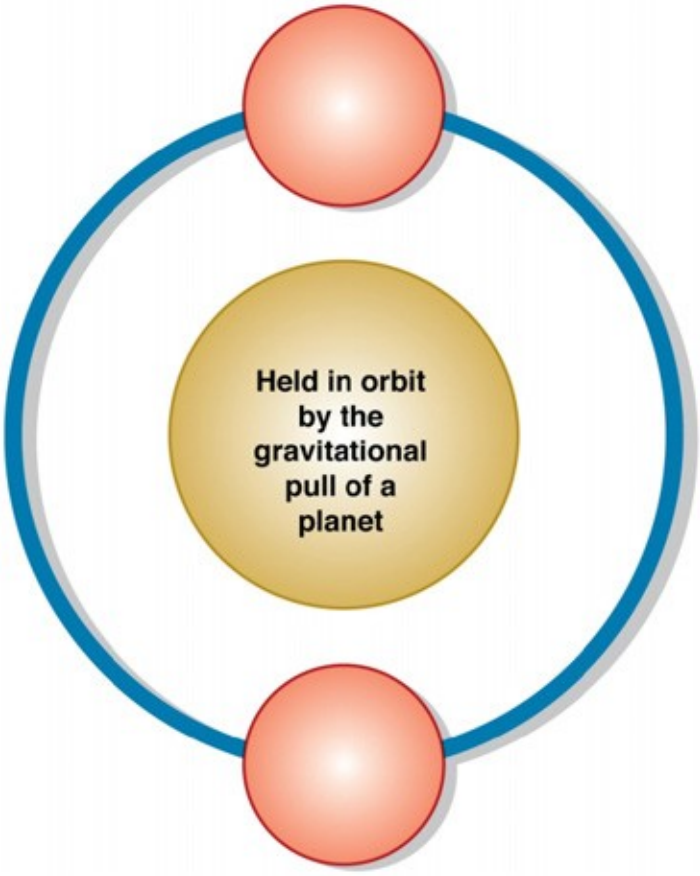
Try Now

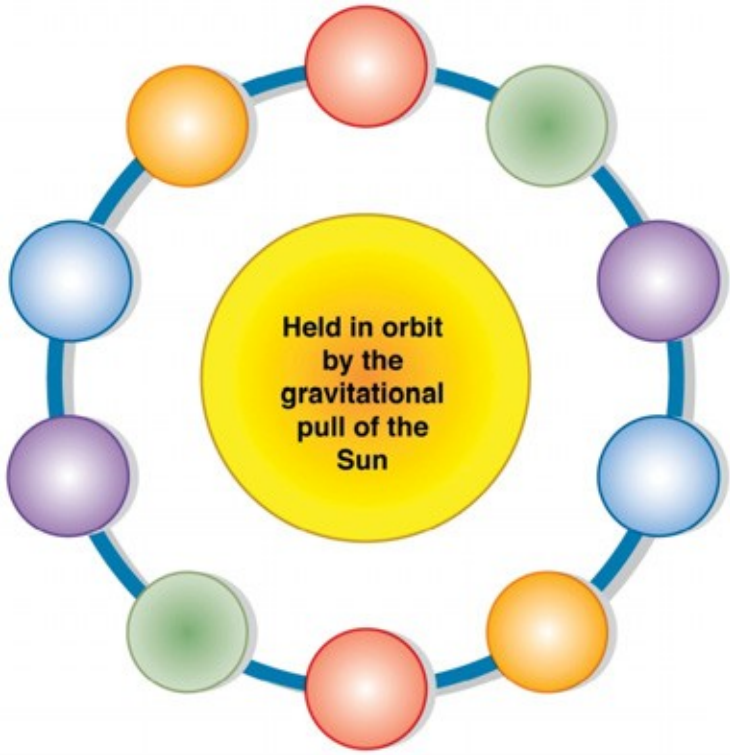
What Do You Know?

The solar system is made up of the Sun, planets, moons, and other celestial objects. Read the names of celestial objects in the box below. Decide whether each name describes an object that is held in orbit by the gravitational pull of the Sun or of a planet. Write each name in the correct circle on the next page.

Names of Celestial Objects		
• Mars • Asteroids • Moons • Uranus	• Neptune • Mercury • Comets • Manmade Satellites	• Venus • Earth • Saturn • Jupiter

Try Now





Connecting With Your Child

Exploring Gravity
Here are several activities for exploring the effects of gravity with your child.

Activity 1: In the Balance
You can learn about how gravity affects an object by attempting to balance the object on the edge of a surface. For example, try balancing a meter stick on the arm of a chair or a spoon on the edge of a bowl. Keep inching the object farther over the edge until it no longer balances; the point where the object balances perfectly is the object's center of gravity.

Here are some questions to discuss with your child:

- How is Earth's gravitational pull affecting each end of this object when it is not balanced correctly?
- How is Earth's gravitational pull affecting each end of this object when it is balanced correctly?
- When the object is placed off-center, is Earth's gravity pulling evenly on both sides? How about when it is placed on its center of gravity?

Activity 2: Gravity versus Momentum
Follow this procedure to study the balance between Earth's gravitational pull and an object's forward momentum.

1. Cut a piece of twine or string about 2–3 feet long.
2. Tie one end of the string around a small object, such as a ball or keychain.
3. Go outside or to an area with plenty of open space. Make sure you are far away from any breakable objects!
4. Hold onto the other end of the string, letting the object dangle toward the ground.
5. Begin to spin around very slowly.
6. Now spin faster and faster until the string becomes horizontal and the object moves parallel to the ground. Make sure to slow down before you get dizzy!

When you ride a swing, your momentum speeds you up away from Earth. Earth's gravity slows you down as you rise and then pulls you back toward the ground.

Connecting With Your Child

Ask your child to explain the object's movement in terms of gravity and forward momentum. (When you are standing still, the object has no forward momentum. The object hangs down on the string because Earth's gravity is always pulling the object toward the ground. When you spin very slowly, the object still hangs down. The momentum you give it by spinning is not enough to overcome Earth's gravitational pull. As you spin faster, the object's momentum increases until the object rises into the air. When you stop spinning, the object loses momentum; it is pulled back down toward Earth.)

Here are some questions to discuss with your child:

- How is the object's motion similar to a planet's orbital path?
- How is the object's motion different from a planet's orbital path?
- What do you think would happen if you continued to spin faster and faster?