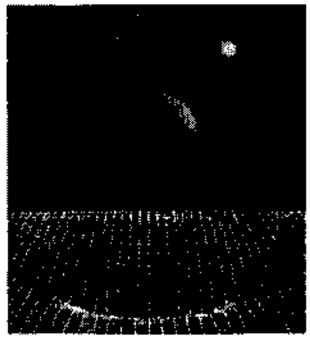
TIME SCIENCE AND HISTORY

Newton and the Plague



In Einstein's theory of general relativity, gravity is due to a distortion in space-time.

In 1665, the bubonic plague swept through England and other parts of Europe. Isaac Newton, then a 23-year-old university student, returned to his family's farm until Cambridge university reopened. To occupy his time, Newton made a list of 22 questions. During the next 18 months, Newton buried himself in the search for answers. And in that brief time, Newton developed calculus, the three laws of motion, and the universal law of gravitation!

The Laws of Motion

Earlier philosophers thought that force was necessary to keep an object moving. By analyzing the data collected by Galileo and others, Newton realized that forces did not cause motion. Instead, forces cause a change in motion. Newton came to understand that force and acceleration were related and that objects exert equal and opposite forces on each other. Newton's three laws of motion were able to explain how all things moved, from an apple falling from a tree to the motions of the moon and the planets, in terms of force, mass, and acceleration.

Isaac Newton was a university student when he developed the laws of motion.

What is gravity?

Using the calculus and data on the motion of the planets, Newton deduced the law of universal gravitation. This law enabled the force of gravity between any two objects to be calculated, if their masses and the distance between them were known.

Newton was able to show mathematically that the law of universal gravitation predicted that the planets' orbits should be ellipses, just as Johannes Kepler had discovered two generations earlier. The application of Newton's laws of motion and the law of universal gravitation also were able to explain phenomena such as tides, the motion of the moon and the planets, and the bulge at the Earth's equator.

A Different View of Gravity

In 1916, Albert Einstein proposed a different model for gravity called the general theory of relativity. In Einstein's model, objects create distortions in space-time, like a bowling ball dropped on a sheet. What we see as the force of gravity is the motion of an object on distorted space-time. Today, Einstein's theory is used to help explain the nature of the big bang and the structure of the universe.

Investigate: Research how both Newton's law of gravitation and Einstein's general theory of relativity have been used to develop the current model of the universe.

Online
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Isaac Newton was born January, 1643 in Lincolnshire, England

In 1687, Newton published "Mathematical Principles of Natural Philosophy," which explained the laws of motion. In this book, Newton used a calculus-like method to determine the attraction of planetary bodies

Legend has it that Newton was inspired when an apple fell onto his head.

As you are reading this, you are probably aware of the chair (or the floor) pushing your body up, but you might not be aware that your body is actually moving. As the earth spins and rotates around the sun, all of the bodies on it are in motion. We just don't realize it because we are part of the system that is moving. It's like when you're in a car that is moving, unless you're watching out the window you can do other things, like read or play video games or watch a movie.

Suppose you're doing your homework while riding in a car and the driver slams on the breaks, what happens to your motion within the car? It might feel like you get jolted forward, you may even mess up your homework or spill your drink. How objects move became a topic of interest for a scientist named Isaac Newton, around 1665. A familiar image of Newton is one where he is sitting under an apple tree and an apple falls on his head, an event that supposedly inspired Newton's studies of motion and mechanics. From his studies of how objects move, Newton developed three ideas that were verified by other scientists over the years and were eventually established as scientific laws. Recall that a law is something in science that describes what will happen.

Newton's First Law

The first law says that an object at rest tends to stay at rest, and an object in motion tends to stay in motion, with the same direction and speed. Motion (or lack of motion) cannot change without an unbalanced force. If nothing is happening to you, and nothing does happen, you will never go anywhere. If you're going in a specific direction, unless something happens to you, you will always go in that direction. Newton's First Law of Motion is also called the Law of Inertia.

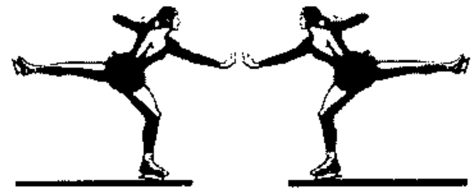
What if you threw a ball as hard as you could? Newton's Law of Motion would predict that the ball would continue to move forever, but you know that isn't the case. The ball will eventually come to a stop. You must then conclude that some other forces were acting on the ball. In this case, air resistance, gravity, and friction are forces that act on the ball and cause it to eventually come to a stop. However, in places without these opposing forces, like outer space, the ball would just keep moving.

Newton's Second Law

Now imagine also two sumo wrestlers, one weighs 250 lbs (113 kg) and the other weighs 50 lbs (23 kg). Which one is going to be easier to move? Objects that have more weight will require a greater unbalanced force to move. In this case, the heavier wrestler has an advantage over the lighter one. In sports, wrestling has heavyweight and lightweight categories to keep the competition fair.

Newton's second law states that the acceleration of an object produced by its total applied forces relate to the object's mass. The greater the mass, the greater the force needed to accelerate (or move) the object. Accelerations can be both positive and negative. It can require a lot of combined forces to push large truck (many people). Also a large truck will require much more force to stop once it gets going. Newton's second law also gives us an exact formula for determining how much force is needed to accelerate an object. Force = mass x acceleration.

Newton's Third Law The third law says that for every action (force) there is an equal and opposite reaction (force). Forces are found in pairs. For instance, the force of your body is pushing down on the chair you are sitting on while the chair is pushing you up. Imagine what happens when you step off a boat and onto a dock. When you step away from the boat, you actually push the boat in the opposite direction. Here's another example. You and your friend are ice skating and you stop to face each other. Your friend reaches out and shoves you. You slide backwards on the ice, but what happens to your friend? He moves in the opposite direction. For every action, there is an opposite reaction.



Questions:

1. In a wrestling match it is discovered that the athlete lied about his weight to gain an advantage over his opponent. Based on what you know about inertia, why did the cheater lie.

2. What is the formula for Newton's Second Law? How is it related to question 1?

3. You roll a ball down a hill. The ball rolls for a distance and eventually comes to a stop. What stopped the ball?

4. Two objects are sitting at the top of a building. One object weighs 16kg and other weighs 45kg. Which will be easier to push off the edge of the building and why?

5. You are in a canoe on a lake and another canoe floats next to you. You use your paddle to push the other canoe away so you don't bump. As the second canoe is pushed left what happens to your own canoe.

WHICH LAW?

We're told that Sir Isaac Newton discovered some things about motion when an apple dropped on his head. Whatever "force" was behind his discoveries, we have benefited from his discoveries.
Here are his three laws of motion. You should be familiar with them. Fill in the missing words in each of the three laws. Then tell which law fits each example below.

Which law? First, Second, or Third?

______ 1. A frog leaping upward off his lily pad is pulled downward by gravity and lands on another lily pad instead of continuing on in a straight line.

______ 2. As the fuel in a rocket ignites, the force of the gas expansion and explosion pushes out the back of the rocket and pushes the rocket forward.

______ 3. When you are standing up in a subway train, and the train suddenly stops, your body continues to go forward.

______ 4. After you start up your motorbike, as you give it more gas, it goes faster.

______ 5. A pitched baseball goes faster than one that is gently thrown.

______ 6. A swimmer pushes water back with her arms, but her body moves forward.

______ 7. As an ice skater pushes harder with his leg muscles, he begins to move faster.

______ 8. When Bobby, age 5, and his dad are skipping pebbles on the pond, the pebbles that Bobby's dad throws go farther and faster than his.

______ 9. When you paddle a canoe, the canoe goes forward.

______ 10. A little girl who has been pulling a sled behind her in the snow is crying because when she stopped to tie her hat on, the sled kept moving and hit her in the back of her legs.

NEWTON'S FIRST LAW OF MOTION:

An object at ______ stays at ______ or an object that is moving at a constant rate in a straight ______ keeps moving at that ______ unless another ______ acts on it.

NEWTON'S SECOND LAW OF MOTION:

The amount of ______ needed to make an object change its ______ depends on the ______ of the object and the ______.

NEWTON'S THIRD LAW OF MOTION:

For every ______ (or force), there is an ______ and ______ action (or force).

Name ______________________________