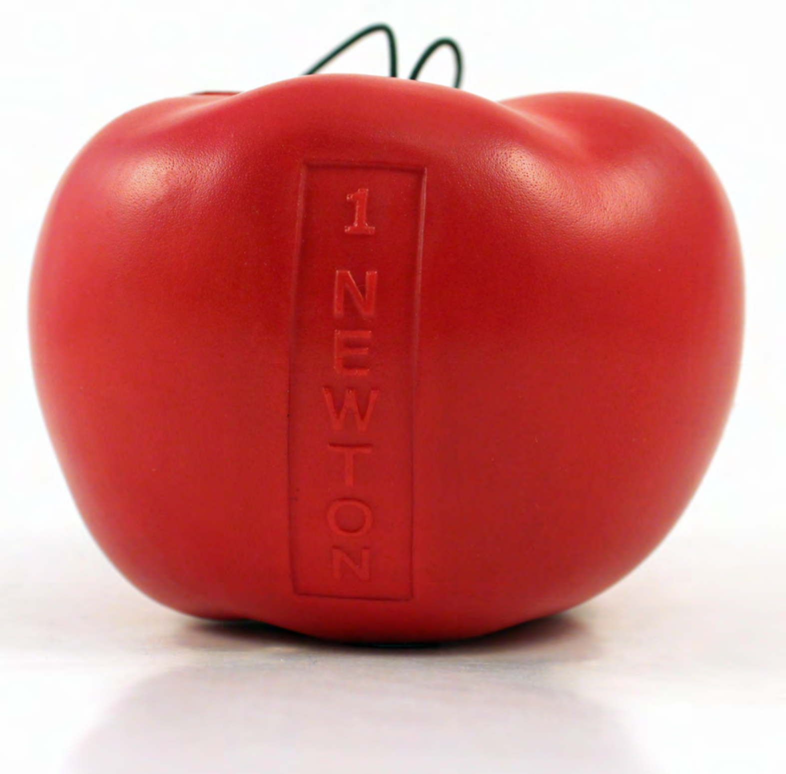
TEACHER GUIDE

6-PACK

1 NEWTON APPLES



grav·i·ty (gravitē) • noun

1. The force that attracts a body toward the center of the earth, or toward any other physical body having mass. For most purposes Newton's laws of gravity apply, with minor modifications to take the general theory of relativity into account.

Who was Isaac Newton?

On Christmas day in 1642, the same year that Galileo died, Isaac Newton was born in Woolsthorpe, Lincolnshire, England. Being very premature, he was not expected to survive, but he made it through and went on to become one of the world's greatest scientists.

Newton faced many challenges growing up but made his way through grammar school and later earned scholarships to further his education. In 1665 the Cambridge university was forced to close due to the plague, so Newton returned home where he spent the next two years concentrating on mathematics and physics. He realized many things about the world around him. He was the first to realize that white light is made up of the colors of the rainbow. He made many discoveries in mathematics and calculus, and how the law of gravitation was at work in the universe. He took his ideas, along with the ideas of earlier scientists, and combined them into a unified picture of how the universe worked.

What did Newton discover about gravity?

As the well-known story goes, Newton was sitting under an apple tree when one of the apples fell on his head. When the apple fell, Newton began to think about gravity and the apple. Newton realized that gravity was the force of attraction between to objects. He also understood that an object with more mass exerted a greater force. That meant that the large mass of the earth pulled the apple and other objects toward it. That is why the apple fell down instead of up and why people don't float in the air.

He considered that maybe gravity wasn't limited to the earth and objects on it. What if gravity extended to the moon, planets and beyond? To test his theory, he calculated the force necessary to keep the moon revolving around the earth. Then he compared it with the force that made the apple fall. After reasoning in the fact that the moon is much farther from the earth, and has a much greater mass, he discovered that the forces were the same. The moon is held in an orbit around earth by the pull of the earth's gravity!

Isaac Newton's calculations changed the way people understood the universe. No one had been able to explain why the planets stayed in their orbits, but Isaac proved that they were held in place by the sun's gravity. He also showed that the force of gravity was affected by distance and mass. He was the first to understand that the orbit of a planet was not circular, but elliptical, like an oval. Isaac published his most famous book, Principia, in 1687. In the Principia, Newton explained the three basic laws that control the way objects move. They are often called Newton's Laws.

1

Newton's First Law:

The First Law states that an object in motion will remain in motion, and an object at rest will remain at rest, unless acted upon by an outside force. This means that an object that is not being pushed or pulled by some force will stay still, or will keep moving in a straight line at a steady speed. This is easy to understand when we think about a skateboard that won't move unless something pushes or pulls it. It is harder to understand, though, that an object will continue to move without help. Think of the skateboard again. If someone is on the skateboard while it is moving and then jumps off before it is stopped, what happens? The skateboard continues moving until it hits a wall or gravity and friction slow it down. This tendency of an object to resist any change in motion is called inertia.

2

Newton's Second Law:

The Second Law explains how a force acts on an object. An object will accelerate in the direction of the force. The more force exerted on a given mass, the more the acceleration of the object. The more massive the object, the more force is needed to accelerate it. Think of a ping-pong ball and a basketball. The ping-pong ball needs only a puff of air to cause it to accelerate, but the basketball requires much more force to accelerate it the same amount.

3

Newton's Third Law:

The Third Law states that for every action, there is an equal and opposite reaction. If you sit down on a chair, you are exerting a downward force on it, but it is also exerting an upward force on you! If you throw a ball towards a brick wall, the ball will exert a force on the wall and the wall will exert an equal force in the opposite direction. Because the ball is much less massive than the wall, it comes bouncing back to you! Newton's Third Law also explains how rockets work. When the fuel inside a rocket is burned, it produces a gas, or exhaust. The rocket pushes backwards on its exhaust and the exhaust pushes forward on the rocket which propels the rocket forward!

WHAT IS A NEWTON?

Newton is the unit of measurement used to calculate force. One Newton (N) is the force required to accelerate a mass of 1 kilogram at a rate of 1 meter per second squared.

A Newton weighs .02248 pounds on earth or 102 grams.

EXPERIMENT #1

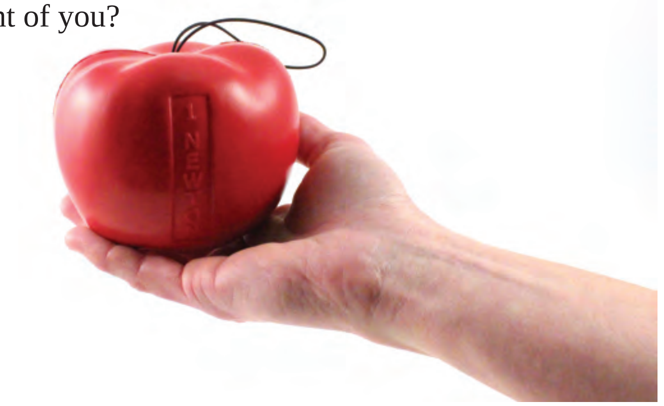
Feeling a Newton:

Materials: 1 Newton Apple

Steps: Hold the Newton Apple in your hand and extend your arm straight out in front of you. The force you are experiencing from the apple sitting on your palm is the gravitational pull on the apple. This force is equal to 1 Newton, or approx. 102 g or .2248 lbs.

Exploration:

1. In holding the apple straight out in front of you, 1 Newton was pressing down on your hand. How much force did you feel you needed to apply in an upward direction to keep your arm level?
2. If you apply more/less than one Newton in an upward/downward direction, what do you predict will happen to the Newton Apple in your hand?
3. If you place more than one Newton Apple in your hand, how much force is needed to keep your arm straight out in front of you?



EXPERIMENT #2

Balanced and Unbalanced Forces:

Materials: 2 Newton Apples, 2 meter-sticks, two desks or tables, a piece of sturdy string approx. 2 feet long, and a variety of objects that you predict will weigh the same, more or less than 1 Newton.

Steps: Move the two desks or tables so that they are approx. 2 feet apart and lay the meter-sticks across them. Tie one end of the string to a Newton Apple and the other end of the string to any of the objects that students predict will be the same as 1 Newton. Dangle the string over the metersticks and observe what happens.

Exploration:

1. What happens to the objects when the forces are the same?
2. Untie the object that balances the apple and tie an object on the string that you predict will be more/less than 1 Newton. What do you observe?

What does it all mean? When you tie objects that weigh the same as the apple, 1 Newton, then the forces are equal and the string hangs in balance. When you add an object that weighs more than 1 Newton, it will have a greater pull and will lift the apple as it falls to the ground. When the object you add weighs less than 1 Newton, it rises into the air as the apple falls to the ground. This shows us that opposing forces that are equal, create no movement, but opposing forces that are unbalanced cause movement!

EXPERIMENT #3

The Force of Friction:

Materials: 6 Newton Apples, a piece of sturdy string approx. 2 feet long, 2 hardback books (like your science book!), a table or desk top, a piece of sand paper.

Steps: Tie one end of the string around a book and the other end of the string to one apple. Place the book in the middle of the table with the string and apple hanging off of one side. Is the Newton Apple able to pull the book off the table? If not, add another Newton Apple until there is just enough force to cause the book to start moving. Now place the book on the sandpaper in the middle of the table. Does the number of Newton Apples that pulled the book off the first time have the same effect?

Exploration:

1. How many Newton Apples were needed to move the book the first time?
2. What happened when you placed the book on sandpaper?
3. Now add more apples to the string until you get the book on sandpaper to move. Why do you need to add more than with just the book alone?
4. What effect do you think friction has on motion?
5. Now remove the sandpaper and place the second book on top of the first one. How many apples do you need to move them now?

What does it all mean? You likely observed that you needed more Newton Apples tied to the string to move the book when it was on sand-paper. This experiment shows that friction opposes motion and more force is needed to overcome it. You also discovered that when you doubled the mass by placing a second book on top of the first, you needed to double the force in order to move them. Gravity is a constant force, and the lower the friction and mass, the easier it is to move an object. The greater the friction and mass, the more force is required to move it.

EXPERIMENT #4

The Force of Gravity:

Materials: 6 Newton Apples, tape or string to secure them together

Steps: Hold an apple in each hand out in front of you at equal heights. Drop them both at the same time and observe what happens. Now with tape or string, attach two apples together and hold them in one hand and a single apple in the other hand. Drop them both at the same time and observe what happens. Finally, tape or tie three apples together and drop them at the same time as the single apple and observe what happens.

Exploration:

1. What did you observe when you dropped one apple vs. more? Did they all hit the ground at the same time?
2. If there was no air resistance to slow the apples down, you should have observed that they all hit the ground at the same time. What does this tell you about how the force of gravity acts on all objects?

What does it all mean? Newton stated that gravity acts on all objects the same amount, no matter what they weigh. Whether you are dropping one apple or three apples, gravity will act on them the same amount. If there is no force to slow them down, such as friction or air resistance, you will see that the apples all fell at the same time. In other words, all objects fall at the same rate.

EXPERIMENT #5

Acceleration Due to Gravity:

Materials: 1 Newton Apple, stopwatch timer, tape measure

Steps: Measure the height from a second-story window to the ground (with adult supervision). Use a tape measure and record your results in meters. Position one Newton Apple at the place where the measurement was taken and hold a stopwatch in your other hand. Start the stopwatch the moment you let go of the apple and stop the stopwatch the instant it strikes the ground. Repeat the drop at least twice and then average the three results to determine the average time.

Exploration:

1. Find the average time of the apple drop by adding up the times and dividing that number by how many times you dropped it. Record this number as your time, or T.
2. Using the equation $A = 2D / T^2$, where T is the average time of your drops and D is the height of the window, calculate for A. This number will be your calculated acceleration due to gravity.
3. Find an object that is heavier than the apple that can be safely dropped out of the window. Repeat the steps above and calculate the acceleration due to gravity again. Was it similar to the first time you calculated A?

What does it all mean? Newton stated that objects fall at the same rate due to gravity. We call this rate the acceleration due to gravity and it is $9.8\ m/s^2$. This means that if an object is in the air one second, at the end of that second it is traveling 9.8 m/s, or approximately 10 m/s. After two seconds, it is traveling 20 m/s. After three seconds, it is going 30 m/s and the pattern continues. The force of gravity on earth is approximately 10 Newtons, meaning that it will accelerate a 100 kg object 10 meters per second. So an object weighing approx. 100 g (like the apple) has a pull of 1 Newton! If you were able to make accurate measurements of height and time, you should have gotten a similar number when solving for A.

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