Newton's third law

By William Harris, How Stuff Works, adapted by Newsela staff on 08.27.19
Word Count **702**
Level **MAX**

Swimmers push off of the wall of the pool during the start of the C-Final of the women's 100-yard backstroke at the 2017 Swimming Winter National Championships at Ohio State University. Photo by: Kirk Irwin/Getty Images

Next to $E = mc^2$, $F = ma$ is the most famous equation in all of physics. Yet many people remain mystified by this fairly simple algebraic expression. It's actually a mathematical representation of Isaac Newton's second law of motion, one of the great scientist's most important contributions. The "second" implies that other laws exist, and, luckily for students and trivia hounds everywhere, there are only two additional laws of motion. All three are presented here, using Newton's own words:

1. Every object persists in its state of rest or uniform motion — in a straight line unless it is compelled to change that state by forces impressed on it.

2. Force is equal to the change in momentum per change in time. For a constant mass, force equals mass times acceleration.

3. For every action, there is an equal and opposite reaction.

Newton's third law is probably the most familiar. Everyone knows that every action has an equal and opposite reaction, right? Unfortunately, this statement lacks some necessary detail. This is a better way to say it:

A force is exerted by one object on another object. In other words, every force involves the interaction of two objects. When one object exerts a force on a second object, the second object also exerts a force on the first object. The two forces are equal in strength and oriented in opposite directions.

Many people have trouble visualizing this law because it's not as intuitive. In fact, the best way to discuss the law of force pairs is by presenting examples. Let's start by considering a swimmer facing the wall of a pool. If she places her feet on the wall and pushes hard, what happens? She shoots backward, away from the wall.

Clearly, the swimmer is applying a force to the wall, but her motion indicates that a force is being applied to her, too. This force comes from the wall, and it's equal in magnitude and opposite in direction.

Next, think about a book lying on a table. What forces are acting on it? One big force is Earth's gravity. In fact, the book's weight is a measurement of Earth's gravitational attraction. So, if we say the book weighs 10 N, what we're really saying is that Earth is applying a force of 10 N on the book. The force is directed straight down, toward the center of the planet. Despite this force, the book remains motionless, which can only mean one thing: There must be another force, equal to 10 N, pushing upward. That force is coming from the table.

If you're catching on to Newton's third law, you should have noticed another force pair described in the paragraph above. Earth is applying a force on the book, so the book must be applying a force on Earth. Is that possible? Yes, it is, but the book is so small that it cannot appreciably accelerate something as large as a planet.

You see something similar, although on a much smaller scale, when a baseball bat strikes a ball. There's no doubt the bat applies a force to the ball: It accelerates rapidly after being struck. But the ball must also be applying a force to the bat. The mass of the ball, however, is small compared to the mass of the bat, which includes the batter attached to the end of it. Still, if you've ever seen a wooden baseball bat break into pieces as it strikes a ball, then you've seen firsthand evidence of the ball's force.

These examples don't show a practical application of Newton's third law. Is there a way to put force pairs to good use? Jet propulsion is one application. Used by animals such as squid and octopi, as well as by certain airplanes and rockets, jet propulsion involves forcing a substance through an opening at high speed. In squid and octopi, the substance is seawater, which is sucked in through the mantle and ejected through a siphon. Because the animal exerts a force on the water jet, the water jet exerts a force on the animal, causing it to move. A similar principle is at work in turbine-equipped jet planes and rockets in space.

Quiz

1. Read the conclusion below.

   The size of an object can determine whether the force it applies is noticeable.

   Which sentence from the article provides the BEST support to the statement above?

   (A) There must be another force, equal to 10 N, pushing upward.

   (B) Earth is applying a force on the book, so the book must be applying a force on Earth.

   (C) Yes, it is, but the book is so small that it cannot appreciably accelerate something as large as a planet.

   (D) You see something similar, although on a much smaller scale, when a baseball bat strikes a ball.

2. Select the sentence from the article that suggests that there is an equal and opposite reaction at play with squids that use jet propulsion.

   (A) Used by animals such as squid and octopi, as well as by certain airplanes and rockets, jet propulsion involves forcing a substance through an opening at high speed.

   (B) In squid and octopi, the substance is seawater, which is sucked in through the mantle and ejected through a siphon.

   (C) Because the animal exerts a force on the water jet, the water jet exerts a force on the animal, causing it to move.

   (D) A similar principle is at work in turbine-equipped jet planes and rockets in space.

3. Which sentence from the article BEST introduces Newton's third law of motion to the reader?

   (A) Next to $E = mc^2$, $F = ma$ is the most famous equation in all of physics.

   (B) Force is equal to the change in momentum per change in time.

   (C) For every action, there is an equal and opposite reaction.

   (D) Newton's third law is probably the most familiar.

4. What is the MOST likely reason the author included the information about the swimmer pushing against a wall?

   (A) to demonstrate how $F=ma$ works in everyday situations

   (B) to help the readers better visualize Newton's third law of motion

   (C) to show that not every action has an equal and opposite reaction

   (D) to prove that objects with more mass have more acceleration