

Newton's Three Law of Motion

As is well known, Isaac Newton is regarded as one of the greatest geniuses of all time. Born on January 4, 1643 in England, he became one of the most influential scientists of the 17th-century scientific revolution. He was not only a physicist and mathematician, but also a scholar who engaged with various scientific disciplines.

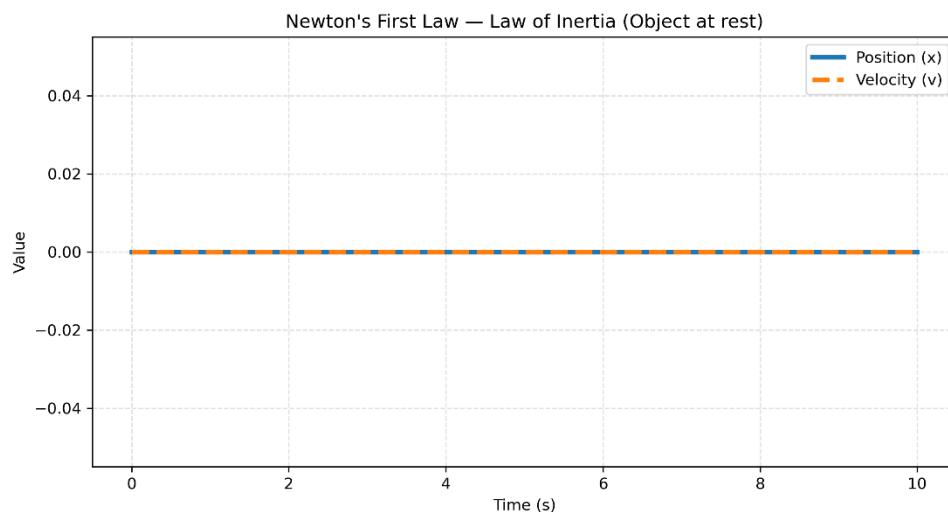
Newton made highly valuable contributions to science, many of which remain fundamental today. In particular, he played a key role in establishing the foundational principles of mass, force, and motion in physics. Newton's three laws of motion form the basis for understanding not only how objects move, but also the universal relationship between force and acceleration. Nearly all topics in classical mechanics are built upon these three laws. In this article, we examine Newton's laws of motion in detail and deepen our understanding through examples from daily life and astronomy.

These laws are known as the law of inertia, the law of acceleration, and the law of action–reaction.

Newton's First Law of Motion is the law of inertia. So, what is inertia? Inertia is the tendency of an object to maintain its current state of motion. This “state of motion” refers to the magnitude and direction of velocity. If no net force acts on an object, it naturally retains its velocity. In other words, if the net force on an object is zero, it either stays at rest or continues moving in a straight line at constant speed. In this case, the object's acceleration is zero.

In everyday life, objects eventually come to rest due to friction and air resistance. However, if these resistive forces did not exist, an object would move indefinitely. The law of inertia shows us that force is what *changes* motion, not what *sustains* it. For example, when a car brakes suddenly and passengers lunge forward, this occurs because their bodies attempt to preserve their original state of motion. This law applies to areas such as spacecraft navigation and vehicle safety systems.

Figure 1:



Only a net force can change an object's velocity or direction. If the net force is zero, the motion remains unchanged. The law of inertia also introduces the concept of inertial mass—the resistance of an object to changes in its state of motion. A greater mass implies greater resistance to acceleration.

How the state of motion changes when a net force is applied is explained by Newton's Second Law of Motion: the law of acceleration.

The second law is also known as Newton's fundamental law of motion. It describes the relationship between the net force acting on an object and the acceleration it produces, expressed in one of the most important equations in the history of physics:

$$\mathbf{F} = \mathbf{m} \cdot \mathbf{a}$$

This equation states that the net force on an object equals the product of its mass and acceleration.

If the net force acting on an object is nonzero, the object accelerates. If the net force is in the direction of motion, the object speeds up; if it is in the opposite direction, the object slows down. When the net force is constant, the acceleration is constant as well. If the net force changes, the acceleration changes proportionally. In general, force and acceleration are directly proportional. Additionally, the greater the mass, the smaller the acceleration produced by the same force.

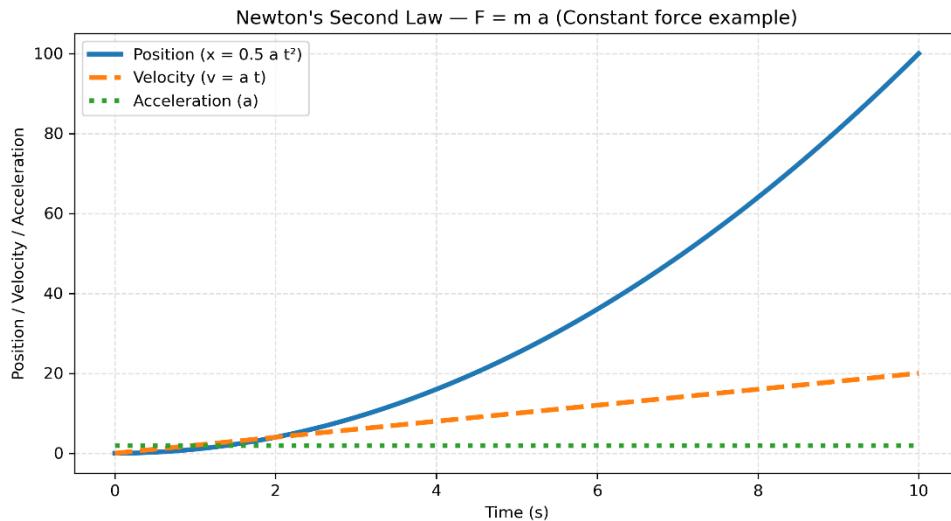
For example, if the same force acts on a 3-kg object and an 8-kg object, the 3-kg object accelerates more quickly because a smaller mass corresponds to less inertia.

If multiple forces act on an object, their vector sum gives the net force:

$$\mathbf{F}_{\text{net}} = \mathbf{m} \cdot \mathbf{a}$$

For instance, if you push a box to the right with 15 N while friction pushes left with 5 N, the net force is 10 N.

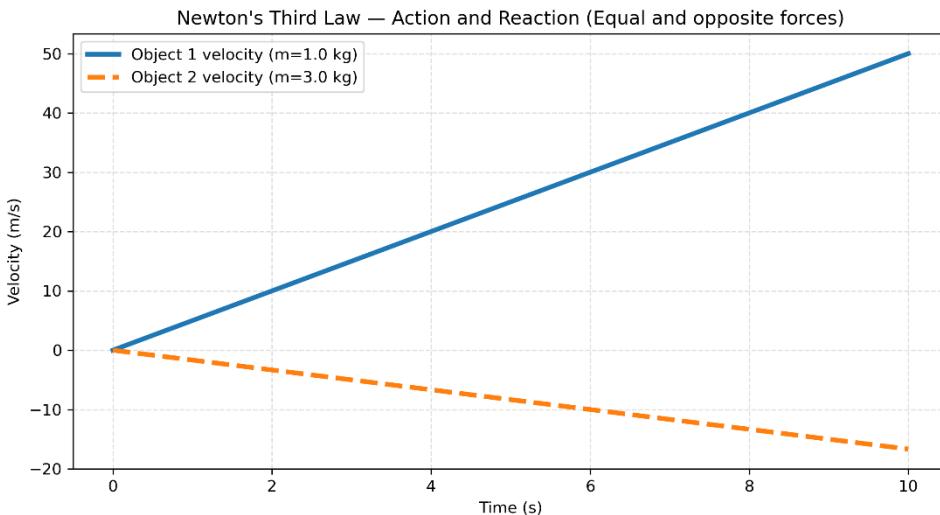
Figure 2:



Newton's Third Law of Motion describes how forces always occur in pairs. Every action force has a corresponding reaction force of equal magnitude and opposite direction.

When one object exerts a force on another, the second object exerts an equal and opposite force back. For example, when walking, your feet push the ground backward while the ground pushes you forward. Similarly, a rocket pushes exhaust gases downward, and the gases push the rocket upward.

Figure 3:



These three laws apply not only to objects on Earth but also to all physical phenomena in the universe. For example:

- The motion of planets is explained through the second law together with the law of universal gravitation.
- The gravitational pull between the Earth and the Moon is directly related to the action–

reaction principle.

- The more massive a star, the more strongly it accelerates nearby objects.

Newton's universal perspective laid the foundation of classical physics.

In daily life, Newton's three laws are used in astronomy, engineering, and rocket science. The motion of planets, satellites, and artificial spacecraft is calculated using Newtonian mechanics. Rocket propulsion systems rely entirely on the law of action and reaction.

Engineering fields such as building design, bridge construction, and vehicle dynamics depend on force–acceleration relationships.

Newton's laws give exceptionally accurate results on everyday scales. However, at extremely high speeds or very small scales, modern physics must be used: Special Relativity for near-light-speed motion, and Quantum Mechanics for subatomic systems.

Nevertheless, Newton's laws remain applicable across many fields—from engineering to astronomy—and form the core of modern physics.

Newton's laws of motion represent the simplest yet most powerful principles that describe how motion occurs in the universe. The first law explains the natural tendency of motion, the second quantifies the relationship between force and acceleration, and the third reveals the mutual nature of all forces. These laws not only transformed the history of science but also paved the way for modern technological advances. Understanding Newton's laws is essential for grasping physics and appreciating the mathematical elegance underlying the structure of the universe.