

Newton's Laws of Motion - Applications in Practical Situations

Newton's Laws of Motion are the fundamental laws concerning movement of objects. We see motion everywhere, from rustling of leaves to planets around the sun. The three laws are considered revolutionary as they deal with behaviour of objects when moving, when standing still, and the factors that make them move or still. We shall see more about these laws and how they can be applied in practical situations.



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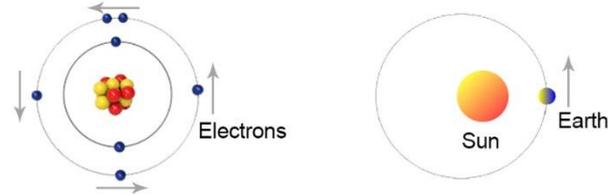
What Is Motion?

When a body changes its position from its original position, we say it has moved. This process of changing the place, location or position is defined as motion or movement. Everything in the universe, from the electrons in the atoms to galaxies, has motion. There are three types of motion – Linear, Rotary and Oscillatory.

Linear Motion



Rotary Motion



Oscillatory Motion



What causes this motion? It is a force. Force is a factor that makes things move, stop, change speed or direction of motion. For example, a ball stopping by itself after rolling for some time is also due to a force called friction.

Newton's Laws Of Motion

There are three laws formulated by Sir Isaac Newton, an English scientist in the 17th century. They were first compiled in his *Philosophiæ Naturalis Principia Mathematica* (Mathematical Principles of Natural Philosophy), published in 1687. They deal with the motion of objects and the forces that act on them.

First Law Of Motion

It states that a body in motion will continue to be in motion with the same speed and direction, or a body at rest will continue to be at rest unless acted upon by an external force.

Ball at rest.

Ball moves only when a force is applied.



The property of an object to remain at rest or to remain in motion with constant velocity is called Inertia. Inertia means the opposition to change in motion. So, this law is also known as the Law of Inertia, first postulated by Galileo Galilei of Italy and later modified by Rene Descartes of France. Galileo was the first to write about friction force.

Examples And Applications Of The First Law Of Motion

- a. An athlete continues to run for some time, even after reaching the finishing line. This is because they cannot stop suddenly due to inertia.
- b. A switched off fan will continue to turn for some time till friction stops it.
- c. An application of using the first law is in car safety equipment like seatbelt and airbag. When there is a crash or sudden braking of the car, the passengers are pushed forward. The top part of their bodies is still at the same velocity as that of the car before the crash and continues to move forward due to inertia. The seatbelt prevents them from lunging forward. An airbag inflates quickly in case of a crash and prevents the driver or passenger in the next seat from hitting the dashboard.



Second Law Of Motion

It states that the acceleration of an object is dependent on two factors – the force acting on it and the mass of the object.

Acceleration is the rate of change of velocity of a moving object. According to this law, acceleration (a) of an object is,

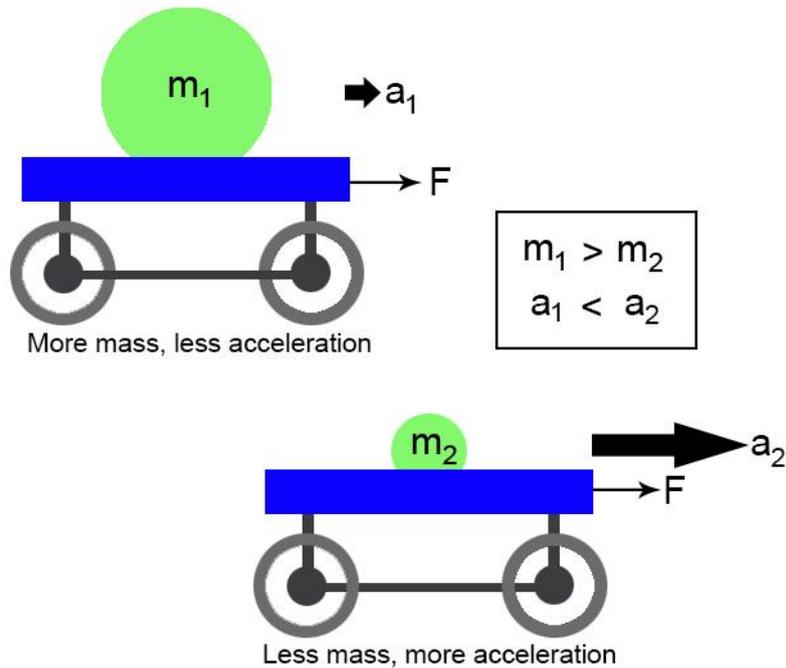
- i. directly proportional to the force (F) acting on it, and
- ii. inversely proportional to the mass (m) of the object

$$a = \frac{F}{m}$$

To put it in another way, force is the product of mass and acceleration.

$$F = ma$$

Force = mass (m) x acceleration (a)



The SI unit of force is newton, in honour of Isaac Newton. 1 newton is the force that makes a body with a mass of 1 kg move with an acceleration of 1 m/s^2 .

$$1 \text{ N} = 1 \text{ kg} \times 1 \text{ m/s}^2$$

Examples And Applications Of The Second Law Of Motion

- A ball kicked with a stronger force moves farther distance due to higher acceleration.
- Pushing a heavy object requires more force to be applied due to higher mass.
- An application of using the second law is in designing fighter jets. Fighter jets need to quickly turn around to dodge artillery fire from the ground or enemy planes. Jets with lighter mass are easy to turn around quickly with lesser force. Heavy aeroplanes take more time to change direction due to inertia.



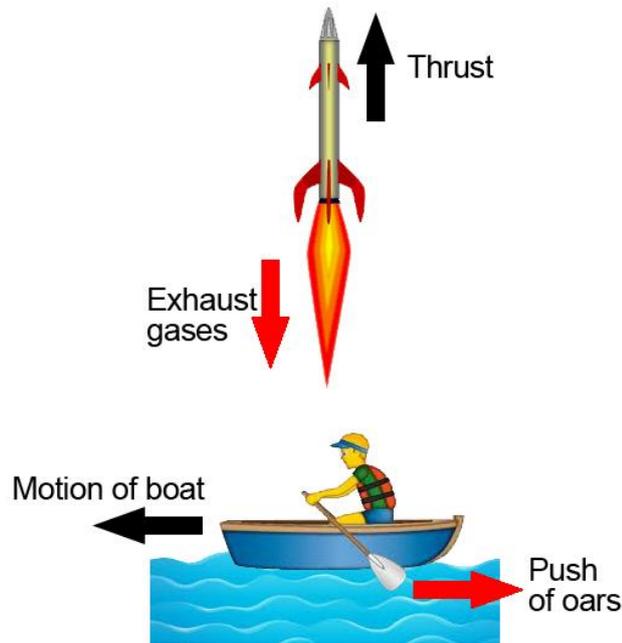
Third Law Of Motion

It states that for every action, there is an equal and opposite action.

Two bodies in contact with each other exert a force equal in magnitude but opposite in direction.

Examples And Applications Of The Third Law Of Motion

- a. We see examples of the third law every day. For example, while walking, we push the ground back. This causes our body to move forward.
- b. While swimming, we push the water back, making our body move forward.
- c. Birds push down the air with their wings causing them to stay up in the air and move forward.
- d. A gun recoils while firing. It means that the gun is pushed back when the bullet is fired at high speed.
- e. Rockets are an excellent example of the application of the third law. The thrust of high-pressure gases by burning fuel from the engines pushes the rockets up with a very high velocity, enough to escape the earth's gravitational force.



Applications Of The Three Laws Of Motion

Newton's three laws are the basis for mechanics. The study of the motion of objects and the forces acting on them is called Mechanics. It is a significant branch of physics and has applications in engineering and technology. For example, the design of vehicles, spacecraft, and control of them are all based on these three laws.

Newton's Laws Of Motion – Sample Problem

1. A ball of mass 10 kg is pushed with a force of 10 N. What will be the ball's acceleration if its mass is reduced to 5 kg?

Solution:

According to Newton's second law,

$$F = ma$$

$$a = \frac{F}{m}$$

$$\Rightarrow a = \frac{10}{10} = 1 \text{ m/s}^2$$

For a mass of 5 kg,

$$a = \frac{10}{5} = 2 \text{ m/s}^2$$

For a lighter object, the same force causes higher acceleration, making it move quickly.

FAQs On Newton's Laws Of Motion

1. What makes the bicycle stop when we press its brakes?

Ans: The bicycle continues to move as long as it is pedalled. Brakes hold the rim of the wheel tightly. This creates a friction force that opposes its turning and reduces the speed of the wheel. Newton's first law of motion explains this.

2. Where are Newton's laws of motion used?

Ans: Newton's laws have applications in various activities of our life. Walking, swimming, pushing a cart, rockets are all examples where these laws are applicable.

3. Which is easy to control, a small car or a large bus? Which law of Newton is applicable?

Ans: A small car has lesser mass and weight. According to Newton's second law, acceleration is inversely proportional to mass. Heavier the object, more acceleration is required to move it. The heavier object has more inertia and takes a long time to control.

4. Why do we feel pain when we hit a wall with our fist?

Ans: According to Newton's third law, for every action, there is a reaction. When we hit a wall or any hard object, we apply force. Equal force in the opposite direction is applied by the hard object on our fist, causing pain. This is equivalent to the wall hitting us.

5. Are there any situations where Newton's laws are not applicable?

Ans: Newton's second law states that acceleration is dependent on the force applied and the mass of the object. The mass has to be constant. For variable mass situations, this law is not applicable.