Newton’s Three Laws of Motion and Their Applications

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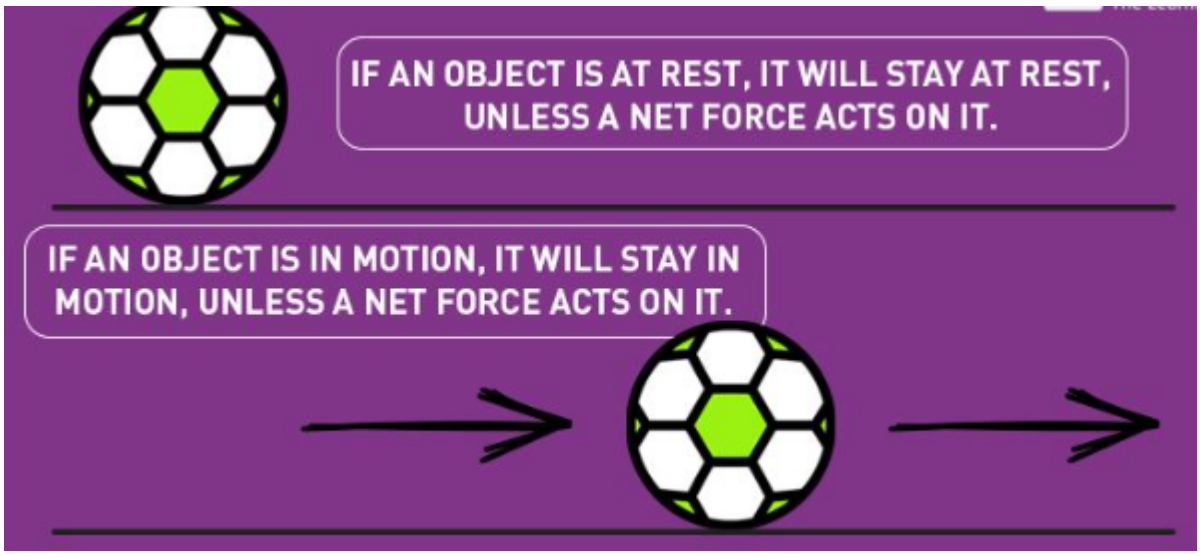
Newton, in his masterpiece *Principia*, explained why planets revolve in elliptical rather than circular orbits and developed three important “laws of motion”. These “three laws of classical mechanics” have revolutionized the physical world as they describe the motion of a body or an object and its relationship with the force that acts on a certain object. This paper explores these three laws of Newton related to motion through examples and a deep understanding of their implications by delving into how objects behave when at rest or in uniform motion. It also unravels the relationship between mass, acceleration, and external forces, as well as sheds light on how actions and reactions are interlinked.



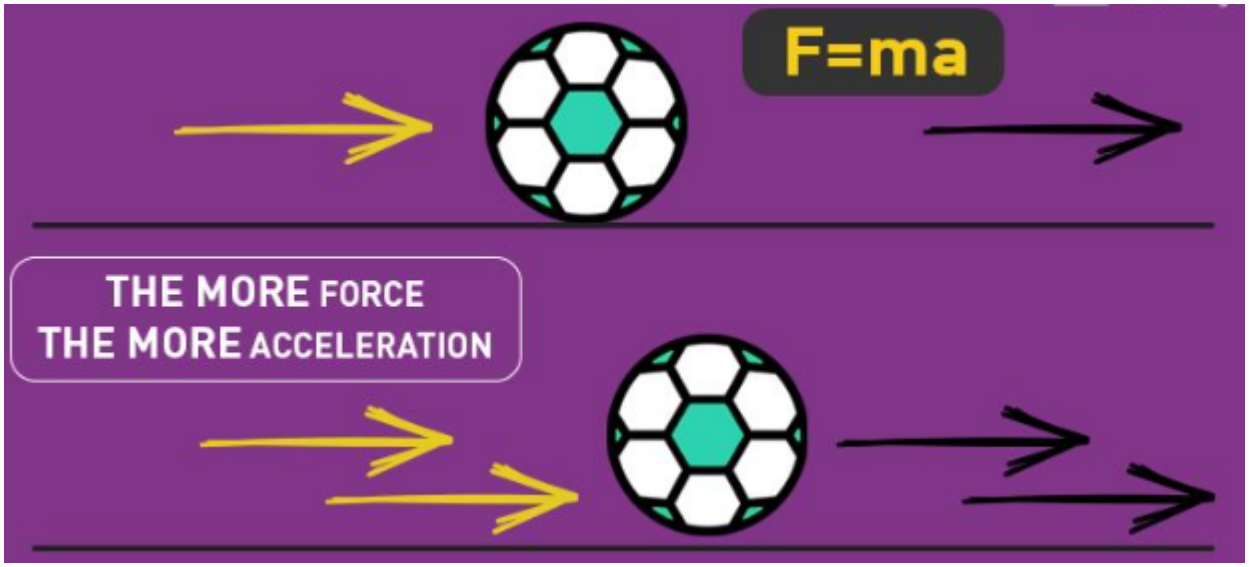
Newton’s First Law or Law of Inertia

Translated from Latin, the first law of motion put forward by Isaac Newton states a fundamental principle: “If a body is at rest or in uniform motion at a constant speed in a straight line, it will remain at rest or keep moving unless it is acted upon by a force,” referring to the property of massive objects that causes them to resist any change unless acted upon by a force (Newton, 1999). This describes the behavior of objects that naturally maintain their current state of rest or motion in the absence of external force or influence. Newton also named this postulate the “Law of Inertia” which highlights the “inherent property” of bodies or objects that they “persist in their current state of motion” unless

compelled to change their state or direction by a net external influence (Hughes et al., 2017).

Example

For instance, the book on the table stays in its place (resting position) unless someone dislodges it (external influence). Moreover, if the brakes are applied to the bus suddenly, the passengers fall forward due to the property of inertia which is the tendency to remain unchanged unless an external force is applied to the body as inertia would try to keep the passengers moving in the bus.



Newton’s Second Law or F = ma

The second law of motion in Newtonian mechanics describes how objects respond to external forces. The law states, “When a net force acts on a body, it produces acceleration in the body in the direction of the net force. The magnitude of this acceleration is directly proportional to the net force acting on the body and inversely proportional to its mass” (Newton, 1999). In simpler words, it states that the applied force produces acceleration in a body with a certain mass in its own direction.

Formula

The formula for “Newton’s second law of motion” is,

$$F = m \times a$$

Where:

F = Force

m = Mass of an object

a = Acceleration produced in the body

This formula reveals that the acceleration produced in the body varies directly with the force applied to the body and is inversely proportional to an object's mass.

Example

If a small ball is pushed with the hand, it accelerates quickly because the ball has a small mass. On the other hand, if a larger ball is pushed with the same force applied by the hand, it accelerates slowly because it has a large mass as compared to the smaller one. This is because the force applied to the small ball overcomes its inertia and causes the smaller-mass ball to accelerate. In addition to the examples, a rocket launching into space explicitly explains Newton's second law of motion. When the rocket launches into space, its engines generate a force that accelerates the rocket forward.

Newton's Third Law or Law of Action and Reaction

The third law of motion by Newton reveals a fascinating concept: forces always occur in pairs. The law reads, "To every action, there is an opposite and equal reaction" (Newton, 1999). This statement refers to the relationship between forces exerted by two interacting bodies. It means that when two objects collide or interact with each other, certain forces are applied to them that are opposite in direction but equal in magnitude. This postulate is also called the "law of action and reaction" because when two objects collide or interact, they produce a specific reaction that is "equal in magnitude and opposite in direction". For instance, whenever two bodies have an interaction, each body exerts the same force on the other one for the same length or period of time but in opposite directions. Thus, it is inferred that "each force in an action-reaction pair acts only on one of the two bodies, the action and reaction forces never act on the same body but on the opposite one" (Roberts, 2002). In addition, the law states that the total rate of momentum of an isolated system, before and after the collision of objects, remains constant regardless of the forces involved. Momentum refers to the property of moving objects that can be determined by the mass and velocity of the body or object.

Example

If a notebook rests on the table, it applies a downward force. The applied force is equal to the weight of the notebook placed on the table. This deforms the surface of the table while the notebook pushes down on the table's surface. Resultantly, the table exerts "an opposite but equal force" on the notebook, pushing it back upward due to the force that the notebook applies to the table.

Conclusion

In Newtonian mechanics, the first law of motion describes that "a body at rest will remain in its resting position" unless acted upon by an external force and "will continue moving with a constant velocity" unless the motion of an object is stopped by an external force. The second law relates "the force acting on an object to its acceleration and mass". The "law of action and reaction", the third law of motion, states that "when an object exerts a force on another object, the second object exerts an equal but opposite force of magnitude on the first object". These laws are essential because they relate to everyday life, telling humans how things move, bodies collide, objects stay still, and why we do not float through the floor of our house when we walk barefooted.

References

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