Newton's first law

Our common sense seems to tell us that most moving objects which we encounter in our daily lives eventually stop moving, or at least slow down, unless an external force is applied to keep them moving. For example, a car engine has to work constantly to keep a car moving. If the engine doesn't work the car will slow down and eventually stop. In other words, our common sense seems to suggest that ``not moving'' is the most natural state, as to give the reason why the objects eventually stop moving.

However, Galilei realized that this common sense was wrong, and later Newton further developed Galilei's idea. The idea is that the most natural state for a moving body is keeping moving and the most natural state for a body not moving is not moving. Precisely speaking, Newton's first law states that an object keeps moving at a constant velocity if no external force is exerted, and an object keeps being at rest if no external force is exerted. The tendency that an object's velocity wouldn't change is called "inertia." Newton's first law is sometimes called "Law of inertia."

Notice how subversive is this idea. If no external force is exerted, a moving car will not slow down, but keep moving at a constant velocity. Moreover, if a car slows down without its brake pedal being pressed, it's not because no external force is applied, but because an external force is applied! (If no external force were applied, it would keep moving at a constant velocity.) In this case, the external force is the frictional force between the wheels and the ground.

Let me give you some examples which Newton's first law implies. Suppose a fly is flying in a car that moves at speed 100 km/h. Would the flying be physically demanding for the fly as it needs to keep up with the speed of the car? No, it isn't. The fly is moving with a constant velocity with the car. Newton's first law implies that there is no force needed to keep up with a constant velocity. Therefore, all the energy required for the fly to keep up with that speed in the car is the one required for just hovering around.

Another example: Suppose you are on a bus, and the bus suddenly stops. Then, as you may be familiar, you will move forward. The reason is following. You were moving with the bus at the same velocity before it suddenly stopped, but you tend to keep moving forward even though the bus stops because of Newton's first law. Similarly, if a bus suddenly starts to move, you will move backward, because you tend to be at rest even though the bus starts to move because of Newton's first law.

Such a force that you feel on the bus, because the bus changes velocity, is called "inertial force,"

because the origin of the force lies on your inertia. This is not a real force but a fictitious force in the sense that nobody is actually pushing you to move forward or backward; if the bus didn't suddenly change its velocity, you would not have felt the force. Moreover, an observer outside the bus won't think that any force is being exerted on you when the bus suddenly stops; you just keep moving as you were moving.

A system in which you don't feel the inertial force is called "inertial reference frame." The reference frame of an observer inside a bus or a car moving at constant velocity is a good example. On the other hand, the reference frame inside a bus accelerating (i.e. speeding up) or decelerating (i.e. speeding down) is not an example of inertial reference frame. From a point of view of an observer in an inertial reference frame, another inertial reference frame always either moves at a constant velocity or doesn't move at all. For example, an observer on a ground, an inertial reference frame, will see a bus moving at a constant velocity if the bus can be regarded as a good inertial reference frame.

Galilean principle states that the laws of physics are faithfully well applied to any inertial reference frame. If an airplane is moving at a constant velocity, without jerking, physicists in the airplane will see that all the physical phenomena happening in the airplane respect the laws of physics. They won't see any unusual things happen. Therefore, they won't know that the airplane is moving without actually looking outside the window. The Galilean principle is one of the two postulates on which Einstein's theory of relativity is constructed. We will return to this issue in our second article on Faraday's law of induction.

Summary

- Newton's first law, also called "Law of inertia," states that an object keeps moving at a constant velocity if no external force is exerted, and an object keeps being at rest if no external force is exerted.
- A force, which an observer in a reference frame feels, because the reference frame is accelerating is called "inertial force."
- A system in which you don't feel the inertial force is called "inertial reference frame."
- Galilean principle states that the laws of physics are faithfully well applied to any inertial reference frame.