NEWTON'S FIRST LAW OF MOTION

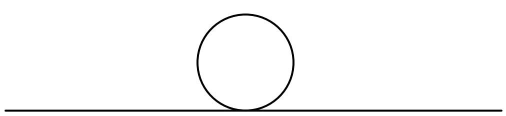
"Law of Inertia"

"An object at rest will remain at rest unless acted on by an unbalanced force. An object in motion continues in motion with the same speed and in the same direction unless acted upon by an unbalanced force."

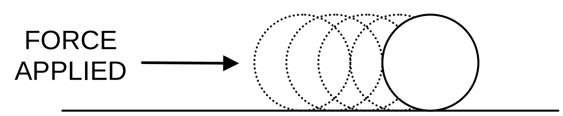
Inertia is a property of matter that describes the tendency of an object to resist a change in it's state of motion. Some objects have greater inertia than other objects. For example, it is easier to push a small go-cart than it is to push your parents car. The car has greater mass than the go-cart and therefore greater inertia.

The following example demonstrates how the law of inertia affects objects at rest. Applying sufficient force to an object at rest will cause that object to move.

An object at rest will stay at rest…

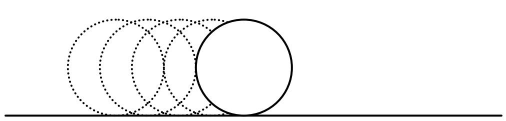


Until acted upon by an outside force…

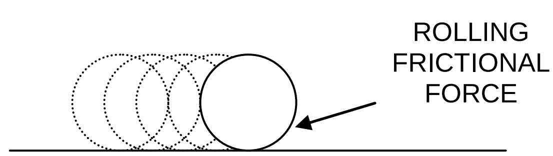


In the example below, an object such as a ball will continue to roll until acted upon by an outside force. In this case, friction is the force that causes the ball to slow to a stop on a level surface. We will find that frictional forces influence most things that move. Attempts are made to reduce friction, but it is very difficult to prevent all frictional forces from influencing the motion of an object.

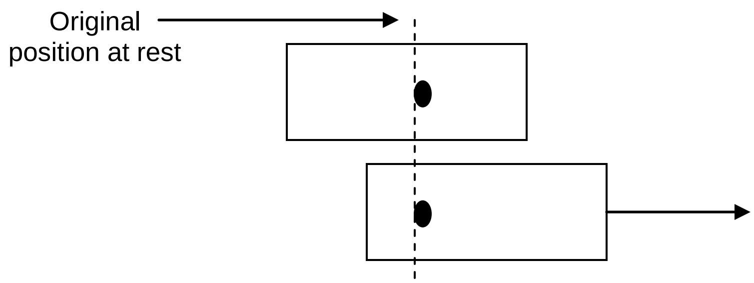
An object will remain in uniform motion in a straight line…



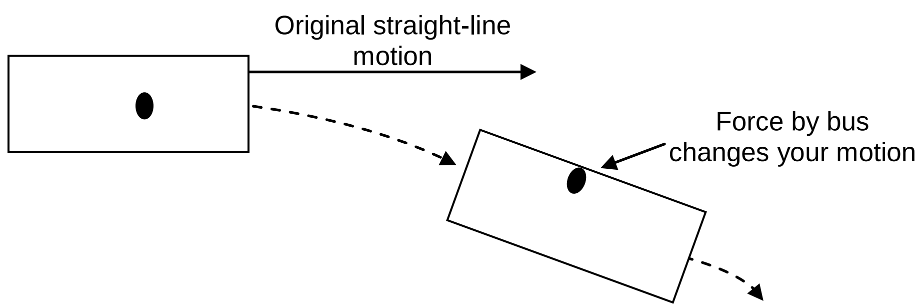
Until acted upon by an outside force…



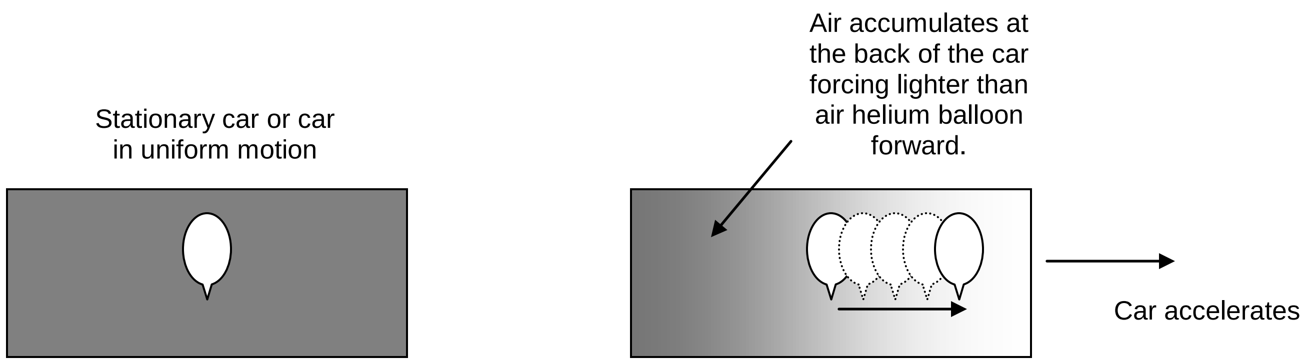
You might also be familiar with the following scenario which happens as a result of Newton's first law.   This top down view shows a person standing in the aisle of a bus. The bus is at rest, then starts to move forward. Inertia (the object wants to stay at rest) causes the person to remain the original position while the bus moves forward. The result is that the person appears to move backwards (perhaps falling) while the bus moves underneath them.



In this example, the bus turns to the right but inertia causes the person to stay in the original straight-line motion until forced by the bus into a new direction. You may recall the sensation of being "forced" to the outside of the bus during the turn.



Now here's a neat application of Newton's First Law. The next time you are in the car with your parents and just happen to have a balloon filled with helium. Make note of what happens to the balloon as your parents speed up or slow down. In a car that speeds up (accelerates), air inside the car resists motion due to it's inertia and accumulates (piles up) in the back of the car in the same way as described with the student on the bus in the example above. Except in this case, helium is lighter than air and the result is that the balloon is "forced" to the front of the car since it is lighter than the air at the back of the car. A sudden slowing of the car has the opposite effect and the helium filled balloon moves backward.



NEWTON'S SECOND LAW OF MOTION

> *"Acceleration is produced when a force acts on a mass. The greater the mass (of the object being accelerated) the greater the amount of force needed (to accelerate the object)."*

Newton's second law can be described using the following equation:

F = ma

force = mass x acceleration

Force is measured in a unit appropriately called newtons, mass is measured in kilograms and acceleration in meters/seconds^2.

Using the equation above, the following statements (postulates) can be made:

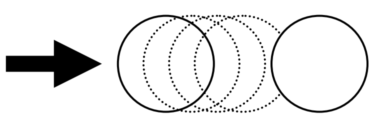
1. The force (F) required to accelerate an object is directly proportional to it's mass. In other words, objects with larger mass require larger forces to accelerate similarly.

1newton of force required to accelerate at 1 m/sec^2

1 kilogram

1 newton required = (**1 kilogram**) x (1 meter/second^2)

10 newtons of force required to accelerate at 1 m/sec^2



10 kilogram

10 newtons required = (**10 kilograms**) x (1 meter/second^2)

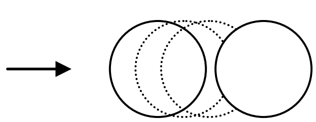
2. Using the same amount of force, objects smaller in mass will accelerate faster than objects larger in mass (remember inertia!) by rearranging the equation to: **a=F/m**

1newton of force applied

1 kilogram

1 meter/second^2 = (1 Newton) / (**1 kilogram**)

1 newton of force applied



10 kilogram

0.1 meters/second^2 = (1 Newton) / (**10 kilogram**)

Additionally, you can predict the relative force that an object with known mass and acceleration will exert.

1. Objects with very small masses can exert tremendous force if they are accelerated or are moving fast enough.

250 newtons = (.0025 kilograms) x **(100, 000 meters/second^2)**

2. Objects with very large masses can exert tremendous force even if they are accelerated very slow.

250 newtons = (10,000 kilograms) x **(0.025 meters/second^2)**

You might have noticed that F=ma can be rearranged to determine any one unknown as long as the other two are known.

Known: mass (kilograms)
acceleration (meters/second^2)

Unknown: Force (newtons)

Use: F=ma

Known: mass (kilograms)
Force (newtons)

Unknown: acceleration (meters/second^2)

Use: a=F/m

Known: acceleration (meters/second^2)
Force (newtons)

Unknown: mass (kilograms)

Use: m=F/a

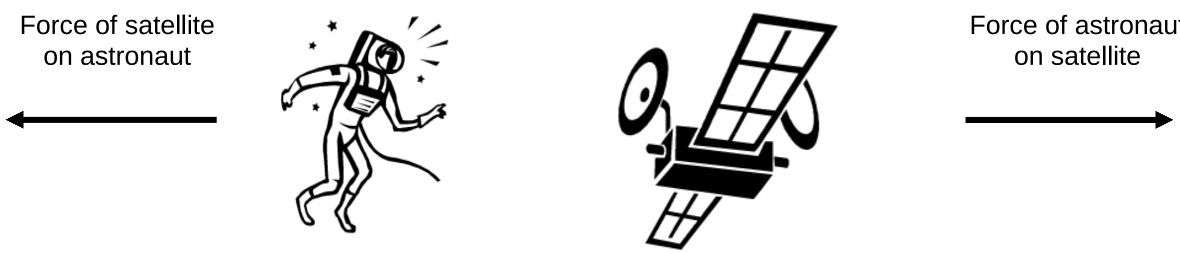
NEWTON'S THIRD LAW OF MOTION

"For every action there is an equal and opposite reaction."

Newton concluded that forces cannot act alone. Force is always produced by the interaction of two or more objects. There is always a second object pushing or pulling on the first object to produce a force.

Newton couldn't imagine astronauts in space, but he used the following reasoning to develop his third law of motion.

Imagine an astronaut and a satellite in space. The astronaut reaches out and momentarily pushes on the satellite. The satellite begins to move from it's initial position and accelerate away from the Astronaut. However, the Astronaut will also begin to move away from his initial position, except in the opposite direction.



Remember that a single force does not exist by itself. There is always a matched and opposite force that occurs at the same time. So… the Astronaut exerted a force on the satellite and according to Newton's reasoning, the satellite exerted an equal and opposite force on the Astronaut.

Spacecraft take advantage of Newton's third law to move and maneuver in space. While they don't directly push or place a force on some physical object in space, they use rocket engines that expel hot gases in the opposite direction in which they would like to move. It is this same principle that a rocket or spacecraft such as the space shuttle uses to travel into space.