Newton not only derived the Universal Gravity Law but he also developed three laws that effectively described the motion of all objects in the universe. (These laws where considered to be the absolute final word in physics until the beginning of the 19th century when other physical phenomenon where being discovered that seemed to defy Newtonian mechanics.)

Forces come in many varieties. Such as:

- gravity
- the normal force
- friction (static and kinetic)
- air resistance
- electrostatic
- magnetic
- tensions and compressions
- spring
- nuclear force

Newton's Laws

Newton's First Law: "Every object maintains a state of rest or uniform motion in a straight line unless acted upon by an unbalanced external force."

Newton's first law is also called the law of **inertia** where inertia is defined as ***an object's resistance to a change in motion*.**

Ex: A car skidding off a curved icy road. As the car attempts to negotiate the turn, the wheels fail to turn the vehicle because of the reduced friction. The car continues to move in a straight line until it hits the ditch.

The heavier an object is, the harder it is to change its state of motion. This resistance to a change in motion is called inertia

Large mass = Large inertia
Small mass = Small inertia

Net Force and Inertia: If the net force is zero, there will be no change in the objects state of motion. In other words, the object will stay at rest or constant motion in a straight line.

Newton's Second Law: An object's acceleration is **proportional** the **applied unbalanced force** and **inversely proportional to the object's mass**.

$$\vec{F}_{net} = m\vec{a}$$	Where $\vec{F}_{net}$ is the **NET FORCE** action on the object in Newtons (N) or $kg\ m/s^2$ m is the mass of the object in kg, and $\vec{a}$ is the acerbation of the object in m/s^2 or N/kg

In simplified terms:

- The heavier an object is (i.e. more massive), the greater the force is required to accelerate it, when compared to a lighter object. **EX:** a pickup truck requires a much larger engine (=larger force) compared to a small compact car.
- To increase the rate of acceleration requires a greater force as well. **EX**: consider the acceleration of a "Dodge Omni" compared to a "Viper" the bigger the engine, the greater the force, the greater the rate of acceleration.

EX 1: Find the net force acting on a $10.0\ kg$ object that is accelerating at $5.00\ m/s^2\ [S]$

Given	**RTF**	**Formula**
$m = 10.0\ kg$ $\vec{a} = 5.00\ m/s^2\ [S]$	Net Force	$F_{net} = ma$
Solution Find F_{net} $F_{net} = ma$ $= (10.0)(-5.00)$ $= -50.0\ N$ $\therefore \vec{F}_{net} = 50.0\ N\ [S]$		

EX 2: Find the acceleration of a $15.0\ kg$ object that is experiencing a net force of $30.0\ N\ [R]$

Given	**RTF**	**Formula**
$m = 15.0\ kg$ $\vec{F}_{net} = 30.0\ N\ [R]$	Acceleration	$F_{net} = ma$
Solution Find $\vec{a}$ $F_{net} = ma$ $a = \frac{F_{net}}{m}$ $a = \frac{30.0}{25.0}$ $a = 2.00\frac{m}{s^2}$ $\therefore \vec{a} = 2.00\ m/s^2\ [R]$		

Newton's Third Law: Every action has an equal and opposite reaction. This means that if one object exerts a force on a second object, the second object exerts the exact same force back on the first object but in the opposite direction.

Ex: A jet engine, a snowmobile, a rocket. These objects require a propellant in order for motion to occur.

Implications of this law: If you exert 10N of force on an object, the object will exert 10N of force back on you! This why the following occur

a) You punch a wall, it punches back and it breaks your hand with an equal but opposite force
b) You kick a table, it kicks you back with an equal but opposite force and stubs your toe
c) You turn on a high-pressure garden hose to full and whips around aggressively. The pressure in the hose push the water out of the hose but the water pushes back with an equal but opposite force, causing the hose to flop around.
d) A shotgun recoils. The gun exerts a force on the bullet to move it forward, the bullet exerts and equal but opposite force against the gun, causing it to recoil violently.
e) Literally any and all motion
    i) Walking: you exert a force backwards on the ground in turn the ground applies and equal but opposite force on in the forward direction
    ii) Rowing: you a apply a force backwards on the water, the water applies and equal but opposite force on your oar propelling you forward
    iii) Flight: the propellers apply a force backwards on the wind and the wind applies and equal but opposite force on the propellers causing the plane to move forward

EX: 3 Andrew and Eric are standing on perfectly smooth ice. Eric pushes Andrew with a force of $42.0N$ to the right. If Eric and Andrew have a mass of $70.0kg$ and $60.0\ kg$ respectively, Find:

a) The reaction force that Andrew applies against Eric
b) Andrew's acceleration
c) Eric's Acceleration

Given	**RTF**	**Solution**
$m_E = 70.0\ kg$ $m_A = 60.0\ kg$ $\vec{F}_{EonA} = 42.0\ N\ [R]$	a) $\vec{F}_{AonE}$ b) $\vec{a}_A$ c) $\vec{a}_E$	$F_{net} = ma$

Solution

a)
Since Eric pushes Andrew with a force of $42.0\ N$ to the right. Therefore, Andrew produces a reaction force of $42.0\ N$ to the left (Newton's 3rd Law)

Or

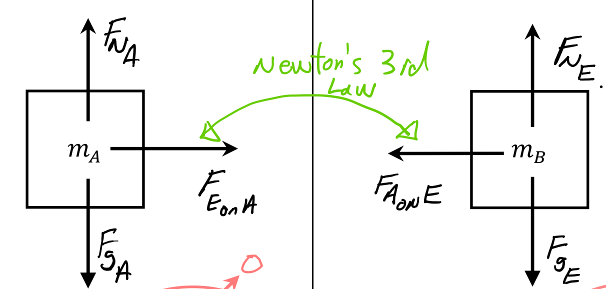
$\because\ \vec{F}_{AonE} = -\vec{F}_{EonA}\ (Newton's\ 3rd\ Law)$

and

$\vec{F}_{EonA} = 42.0\ N\ [R]$

$\therefore\ \vec{F}_{AonE} = 42.0\ N\ [L]$

b) FBD (A) c) FBD (E)



b)

$$\vec{F}_{net_A} = \vec{F}_{EonA} + \vec{F}_{N_A} + \vec{F}_{g_A}$$
$$F_{net_A} = +F_{EonA}$$
$$m_A a_A = +F_{EonA}$$
$$a_A = \frac{+F_{EonA}}{m_A}$$
$$a_A = \frac{42}{60}$$
$$a_A = +0.700\ m/s^2$$
$$\therefore\ \vec{a}_A = 0.700\ m/s^2\ [R]$$

c)

$$\vec{F}_{net_E} = \vec{F}_{AonE} + \vec{F}_{N_E} + \vec{F}_{g_E}$$
$$F_{net_E} = -F_{AonE}$$
$$m_E a_E = -F_{AonE}$$
$$a_E = \frac{-F_{AonE}}{m_E}$$
$$a_E = \frac{-42}{70}$$
$$a_E = -0.600\ m/s^2$$
$$\therefore\ \vec{a}_E = 0.600\ m/s^2\ [L]$$