Newton's Laws of Motion

- **Force** = any kind of push or pull on an object.
- Force, being a vector, has magnitude, units, and direction.

What is the connection between force and motion?

What happens if you stop pedaling your bike on a flat surface?

If you roll a ball along the grass?

- (350 BCE) This is why Aristotle believed that in order for an object to keep moving, a force was needed.
- (1600) Galileo came up with a different conclusion. He said it is just as natural for an object to be in horizontal motion with constant speed as it is for it to be at rest.
- **Inertia**: Tendency of a body to maintain its state of rest or uniform motion in a straight line.

- Galileo was able to determine this property existed because he was able to envision a frictionless world.
- **Ex:** Picture yourself pushing a book across a rough table, then a smooth table, then an oiled table, then an air hockey table…

- **Less _____ is required each time.**
- **If there was no friction, _____ would be needed.**

- Upon Galileo's work, Newton built his theory of motion.

"If I have seen further [than others], it is by standing on the shoulders of giants."

- Isaac Newton (1642-1727), British physicist, mathematician, with reference to his dependency on Galileo's and Kepler's work in physics

Newton's 3 Laws

- 1st: **Law of Inertia:** A body at rest will remain at rest; a body in motion will continue moving at constant speed in a straight line until acted upon by an external force.

- 2nd: The acceleration of a body is directly proportional to the net force acting on it and inversely proportional to its mass. The direction of the acceleration is in the direction of the net force. [**Net external forces cause objects to accelerate.**]

$$\sum \vec{F} = m\vec{a}$$

Unit of force = Newton

1 N = 1 kgm/s^2

1 lb = 4.45 N

Ex: A 4 kg object has velocity 3.00**i** m/s at one instant. Eight seconds later, its velocity has increased to (8.00**i** + 10.0**j**) m/s. Assuming the object was subject to a total constant force, find:

(a) The components of the force.

(b) Its magnitude.

2nd Law: Force of Gravity & Weight

1. **Mass** = "stuff." It is related to the type and number of atoms in an object. [kg]
2. **Weight = F_g** = The planet's pull on an object. [N]
3. **g** = acceleration due to gravity = the contribution of a planet in creating the weight of an object. [on earth, g = 10 m/s^2]

$$F_g = mg$$

Ex: Ken, who weighs 700 N on earth, flies to Jupiter where g = 26.4 m/s^2. Note, mass does not change as we visit other planets, since mass is related to the number of atoms in our body.

a) Find his mass

b) Find his weight on Jupiter

- 3rd: For every action, there is an equal and opposite reaction.

  If Body A exerts a force on Body B, Body B exerts an equal and opposite force on Body A.

  Ex: Tug of War

  - The forces of pull are equal and opposite. The winner of the competition will be the athlete who generates the greater F_f.
  - Newton's 3rd Law is the reason only external forces cause acceleration. Any internal forces will have an equal, opposite reaction force which will cancel out.