- Newton's Laws of Motion
- Force acting on mass causes acceleration.
- ***Free Body Diagrams*** are necessary in the analysis of problems involving forces. These diagrams isolate each object and identify the forces acting on each. The equations should be written from the free body diagrams.
- The ***First Law of Motion*** is also called the "Law of Inertia"
    - Whenever the net force acting on an object is zero, the acceleration is also zero.
    - Whenever the acceleration of an object is zero, the net force acting on it is also zero.
    - Whenever the acceleration of an object is zero, its velocity is constant. This means that both the speed and the direction of motion are not changing.
- The ***Second Law of Motion*** describes the behavior of an object whenever the net force acting on it is not zero.
- $\boxed{\sum \mathbf{F} = m\mathbf{a}}$
- The ***First Law of Motion*** is a <u>special case</u> of the ***Second Law of Motion***.
- The acceleration of an object is in the same direction as the net force acting on it.
- The magnitude of the acceleration is directly proportional to the net force acting on the object.
  $\boxed{\mathbf{a} \propto \sum \mathbf{F}}$
- The magnitude of the acceleration is inversely proportional to the mass of the object.
  $\boxed{\mathbf{a} \propto \frac{1}{m}}$
- Whenever choosing a frame of reference for working with Newton's Laws, it is best to choose a reference frame such that the acceleration, if there is any, lies on an axis. This insures that the first law is operative along one axis and the second law is operative along the other. This usually results in simpler equations.
- The ***Third Law of Motion*** refers to forces acting between two objects and should be known word for word because of its close relationship to the ***Law of Conservation of Momentum*** and also because of the errors in more common way of expressing the law:
  "Whenever object "**A**" exerts a force **F** on object "**B**"; object "**B**" exerts a force **–F** on object "**A**".
- The Third Law describes interactions among different objects and explains how a force acting on one object can result in the acceleration of another object.

- Whenever two surfaces are in contact with one another, they can exert forces on each other. One of these forces is called the **normal** force and acts perpendicular (mathematically "*normal*") to both surfaces where they are in contact and prevents the surfaces from moving through one another. The normal force usually results from the action of other forces that push the surfaces closer together.
- Another force that two surfaces exert on each other is always parallel to the two surfaces where they are in contact. This force is called **sliding friction** and has two different forms: static and kinetic.

- The magnitude of the static friction is determined by the other forces acting parallel to the two surfaces but is limited by two things.
  - The maximum possible static friction is directly proportional to the normal force between the two surfaces.
  - The maximum possible static friction is directly proportional to a characteristic property of the two surfaces called the coefficient of static friction: μ_s
  - The actual magnitude and direction of the static friction is the equilibrant of the sum of the parallel components of the other forces acting between the two surfaces.
  - $\boxed{F_{fs} \le \mu_s F_N}$
  - If the static frictional forces needed to keep the surfaces from moving relative to one another is more than what is available then there is not static frictional force and the surfaces slide.
- If the two surfaces are sliding relative to one another, kinetic friction occurs. When kinetic friction occurs, as required by the third law of motion, equal and opposite forces are exerted on each of the two surfaces. The directions of these two forces are opposite the direction of motion of each surface relative to the other.
- The magnitude of the kinetic friction is determined only by the normal force and the coefficient of kinetic friction between the two surfaces.
  - $\boxed{F_k = \mu_k F_N}$

- Inclined planes are flat surfaces that are not horizontal. The angle of inclination is defined as the angle between horizontal and the plane.
- If an object is on an inclined plane and accelerates without leaving the plane, the acceleration must be parallel to the plane.
  - In this case, forces should be resolved into components that are parallel and perpendicular to the plane.
  - The net force perpendicular to the plane is zero (First Law)
  - The net force parallel to the plane is equal to ma (Second Law)
  - The gravitational force is resolved into parallel and perpendicular components.
  - The parallel component of the weight is $\boxed{F_{w\|} = mg\sin\theta}$
  - The perpendicular component of the weight is $\boxed{F_{W\perp} = mg\cos\theta}$

  - Normal forces can never draw two surfaces together.
  - A force of tension cannot be a pushing force (ideally).
  - Apparent weight is what the scale would read in an elevator.
  - g's of acceleration is the ratio of an object's acceleration to *g*.
  - g's of force is the ratio of the magnitude of an external force to the weight of an object.