

Newton's Laws of Motion  
And Their Application  
Gary Latshaw, Ph.D.

The Laws:

1 & 2 :  $\mathbf{F} = m \mathbf{a} \Rightarrow F_x = m a_x, F_y = m a_y, \text{ and } F_z = m a_z$

The motion can be independently calculated in each of the perpendicular directions as long as the force is not dependent on the motion in other directions.

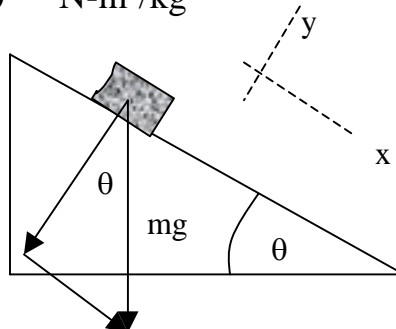
3:  $\mathbf{F}_{2,1} = -\mathbf{F}_{1,2} \Rightarrow F_{1,2,x} = -F_{2,1,x}$  and so on for the other directions.

For every action there is an equal (in magnitude) and opposite (in direction) reaction.

Application of the Laws:

1. Chose a convenient axis location and orientation (usually the axis is tilted in slanted plane problems).
2. Diagram all the external forces on the object of study.
3. Apply Newton's Laws of Motion to each axis.
4. Often you will need is connect the acceleration from Newton's Laws with the Equations of Kinematics.
5. Characteristic of Forces:
  - a. Contact Forces – when two bodies touch
    - i. Normal Force ( $F_N$ )– perpendicular to the touching surfaces
    - ii. Frictional Force ( $F_f$ )– along the touching surfaces
      1. Static Force  $F_f \leq u_s F_N$  The static frictional force will be large enough to keep touching objects from moving with respect to one another up to the limits of this formula.
      2. Kinematic Frictional Force  $F_f = u_k F_N$
  - b. Massless Strings and Wires – Conveys a force that pulls in the direction of the string or wire. This force is usually noted as Tension (T).
  - c. Massless Rods will transmit a force along the direction of the rod.
6. Ideal Springs have a force that is proportional to their displacement from equilibrium:  $F = -kx$ , where  $k$  is the spring constant and  $x$  is the displacement from equilibrium. The negative sign is to indicate that the force is restoring (i.e., it will tend to bring the displacement back to equilibrium).
7. Gravity is a force between point objects or spherically symmetric objects given by:  $F = G m_1 m_2 / r^2$ ; the force direction is always attractive between the objects.  
 $G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$

8. Incline Plane:



$$F_x^{\text{gravity}} = mg \sin(\theta)$$

$$F_y^{\text{gravity}} = -mg \cos(\theta)$$

$$F_f = u F_N = u F_y$$