

Newton's Laws of Motion

(Chapter 2)

Student Learning Outcomes: Recall each of Newton's Laws and describe how they apply to the natural world, and be able to add vector quantities.

1. *What is Newton's 1st Law of Motion?*
2. *What is Newton's 2nd Law of Motion?*
3. *What is terminal velocity?*
4. *What is Newton's 3rd Law of Motion?*
5. *How are vectors added?*

What is Newton's 1st law of Motion?

❖ **Newton's 1st Law of motion: Inertia**

An object at rest will remain at rest, and an object in motion will maintain a constant velocity unless a force causes the object's motion to change.

- ❖ Objects resist changes in motion.
- ❖ All objects have the same motion within a specific reference frame, for example everything in your car has the same motion as your car.

Examples:

- ✚ Quick stops
- ✚ Cornering
- ✚ Something sliding across your dash as you turn
- ✚ The tablecloth trick

Go To: <http://www.physicsclassroom.com/mmedia/newtlaws/cci.cfm>

What is Newton's 2nd Law of Motion?

❖ **Newton's 2nd Law:**

$$\mathbf{F}_{\text{net}} = \mathbf{ma}$$

An unbalanced force acting on a mass gives the mass an acceleration in the same direction as the unbalanced force.

- ❖ The standard unit of force is the Newton.

$$1 \text{ Newton} = 1 \frac{\text{kg m}}{\text{s}^2}$$

- ❖ In most cases, there are multiple forces acting simultaneously on an object.
 - Balanced forces = no acceleration
 - Unbalanced forces = acceleration in direction of greatest force

Question: Constant velocity = acceleration or no acceleration?

- ❖ Weight is a force; it is the amount that a mass is accelerated due to the force of gravity.

$$\mathbf{W = mg}$$

Questions:

- 1) If the force on a 5 kg mass is tripled, what will happen to the rate of acceleration?
- 2) A 150 lb person is standing in on the floor. What is the net force?
- 3) A 2000 kg car is pushed south with a horizontal force of 9800 Newtons. The opposing frictional force is 1200 Newtons. What is the average acceleration?
- 4) A 150 lb person has a mass of 68 kg. What is their weight on Mars ($g = 3.72 \text{ m/s}^2$) in Newtons and pounds?

What is terminal velocity?

- ❖ The acceleration due to Earth's gravity is **9.81 m/s²** downward.
- ❖ An object in **free fall** is only affected by gravity. We assume there is no air resistance.

Question: Does the downward acceleration change if the mass doubles?

- ❖ Air resistance provides acceleration upward.
 - Surface area increases air resistance.
 - Speed increases air resistance.
- ❖ When air resistance (a force) matches the force of gravity, a falling object will no longer accelerate.
 - A constant speed is maintained for the rest of the fall.
 - The net force is zero; the net acceleration is zero
 - The object has reached **terminal velocity** (93-125 mi/hr)

Go To: <http://www.physicsclassroom.com/mmedia/newtlaws/efff.cfm>
<http://www.physicsclassroom.com/mmedia/newtlaws/efar.cfm>
<http://www.physicsclassroom.com/mmedia/newtlaws/sd.cfm>

What is Newton's 3rd Law of Motion?

❖ **Newton's 3rd Law: Action-Reaction**

When two objects interact, they create equal and opposite forces on each other.

$$\mathbf{F}_{12} = -\mathbf{F}_{21}$$

- ❖ To every action force there is an equal (in magnitude) and opposite (in direction) reaction force.

Examples:

- ✚ Pushing on a wall
- ✚ Bat and Ball
- ✚ Rocket

Question: If I give the chair a good push, it goes from rest to having a velocity, and then stops. Describe how each of Newton's laws apply to this system.

