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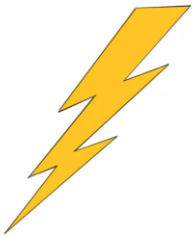
Static Electricity

What is electricity?



Energy is defined as the ability to do work (the ability to affect the world). **Energy** is different than matter. Energy can exist in many forms, such as potential (stored) energy, kinetic (movement) energy, sound, heat, nuclear, and of course, electricity.

Electricity is a form of energy resulting from the existence of charged particles (such as electrons or protons), either statically as an accumulation of charge or dynamically as a current.

The energy from electricity can move around and power everyday objects, but it **NEVER** disappears. This is because of the ***__law of conservation of energy__***: Energy cannot be created or destroyed.

How does electrical energy move in our world?

Remember from chemistry that the world is made up of atoms. Each atom has **protons** (positively charged), **electrons** (negatively charged), and **neutrons** (no charge).

Different materials can have an overall (net) charge depending on the balance between the positive and negative charges. A material can be neutral, have a positive charge, or have a negative charge. If it has a charge that stays in the same place for a length of time, it is known as a **static charge** (or static electricity), because static means no movement.

If two materials are rubbed, electrons from the atoms of one material may move to the atoms of another material. This leads to a change in the charge of the affected atoms. This can happen, as some atoms want to give up electrons to become ions, and some atoms want to become ions do so by losing electrons.

If the proton number is higher than the electron number, the atom becomes a positively charged ion.

If the proton number is lower than the electron number, the atom becomes a negatively charged ion.

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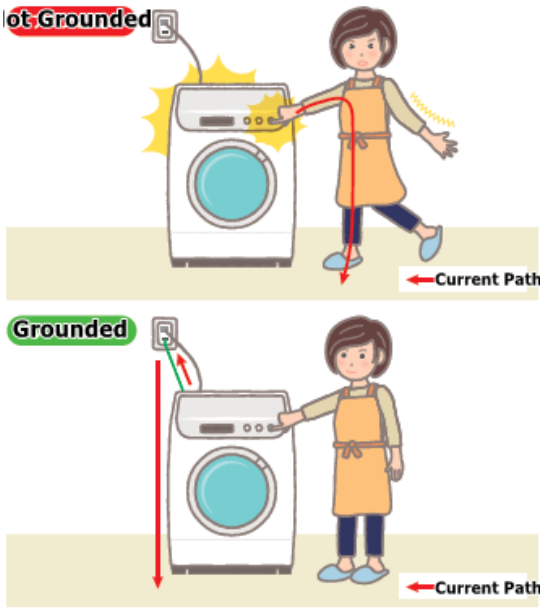
Where do charges move?

Charges on insulator

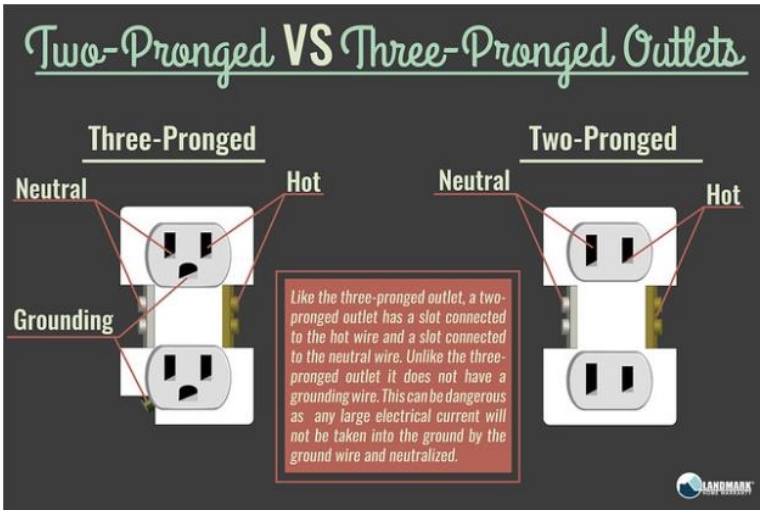
Charges on conductor

Different materials can affect how easily electrons flow through them.
Materials such as Rubber, wool, glass and, plastic (like acetate), are called **insulators**, which do not allow easy electron flow.
Materials such as many substances that contain metal elements are called **conductors**, as they allow for easy electron flow.

Sometimes, a conductor is used to transfer electrons out of a material (called **discharging**) into the Earth to prevent a build-up of charges. This is called **grounding**. The most common reason humans ground electrically charged materials is to prevent the charge from flowing through our bodies, as cells have an outer positive charge. Electricity can cause electrical burns, damage the nervous system and brain (because they use electrical currents), and, with some particular amounts of charges, stop a human heart.



The third, bottom hole of an electrical socket is always the one for the ground wire. If there are only two prongs on the socket, it can be dangerous, because a build-up of charge will not be moved to the ground.



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How do charges interact?

Charges move due to **electrical force**, which is the pull (attraction) or push (repulsion) between materials that are charged. The **laws of static charge** describe what happens when charged and uncharged objects come close to each other.

The law of Static Charges

1. Objects with the same charge repel each other
2. Objects with opposite charges attract each other
3. Charged objects attract neutral objects

The amount of electric force that acts on any pair of objects depends on:

- the type of charge on the objects (positive, negative, or neutral)
- the amount of charge on the objects
- the distance between the objects

Examples: If you increase the amount of charge on objects, you increase the electric force. If you increase the distance between objects, you decrease the electric force.

How to generate and move charges:

1) One way to move electrons from one object to another is by using conduction (not to be confused with conducting). **Conduction** is where objects must touch each other to transfer electrons. This method can be reversed, but is not temporary, as the charges will stay with their new materials after contact.

An example of this is by using **friction**. We often can generate a static charge with a balloon by rubbing it against our hair. **Friction**, which is the force between two objects moving in opposite directions, strips electrons from one object and places it on another.

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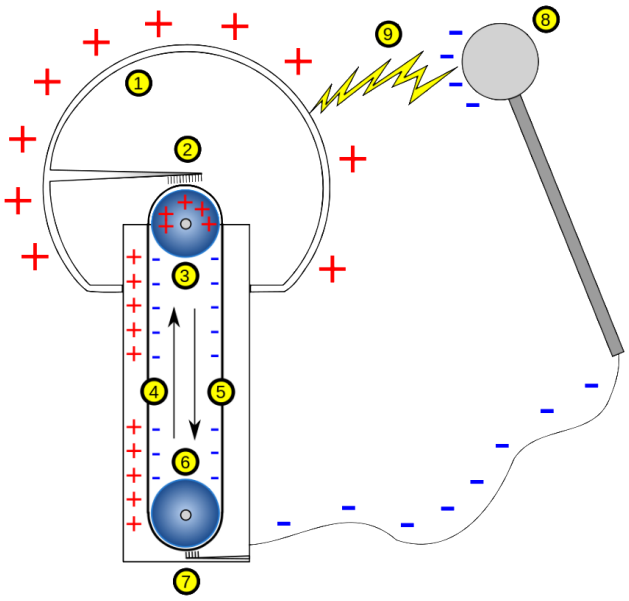
We can use a machine called a **Van der Graaff** to generate materials with a charge using friction.

Van der Graaf machines work by using a belt moved by a motor to constantly rub against a material, creating a positive charge that draws the electrons into the middle of the sphere. This causes a positive charge on the outside of the top sphere that will interact with charged materials. (The wand just contains the displaced electrons)

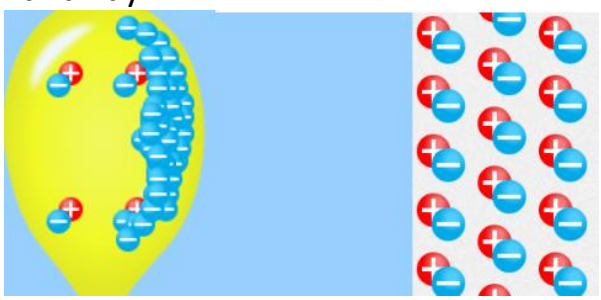


2) Another way to move electrons is called **induction**, where two materials get close enough to each other that the location of charges are **<u>temporarily</u>** changed to create charged sides of a material.

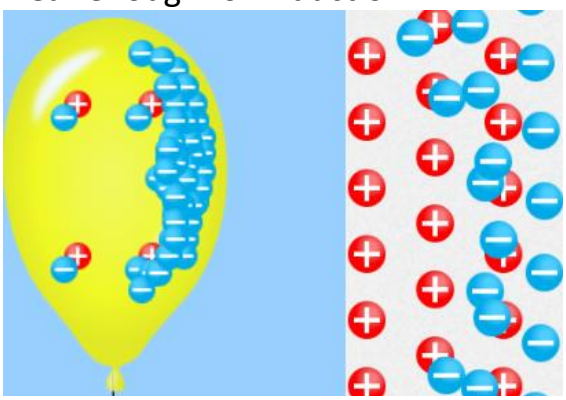
Let's look at a negatively charged object approaching a neutral object. The negatively charged object will repel the negative charges in the neutral object away to the opposite side. The effect will be reversed if the materials are separated.

In the following diagram, the balloon with a negative charge can cause movement in the negative wall charges for as long as it is near enough. The wall will return to normal after the balloon is gone.

Far away



Near enough for induction



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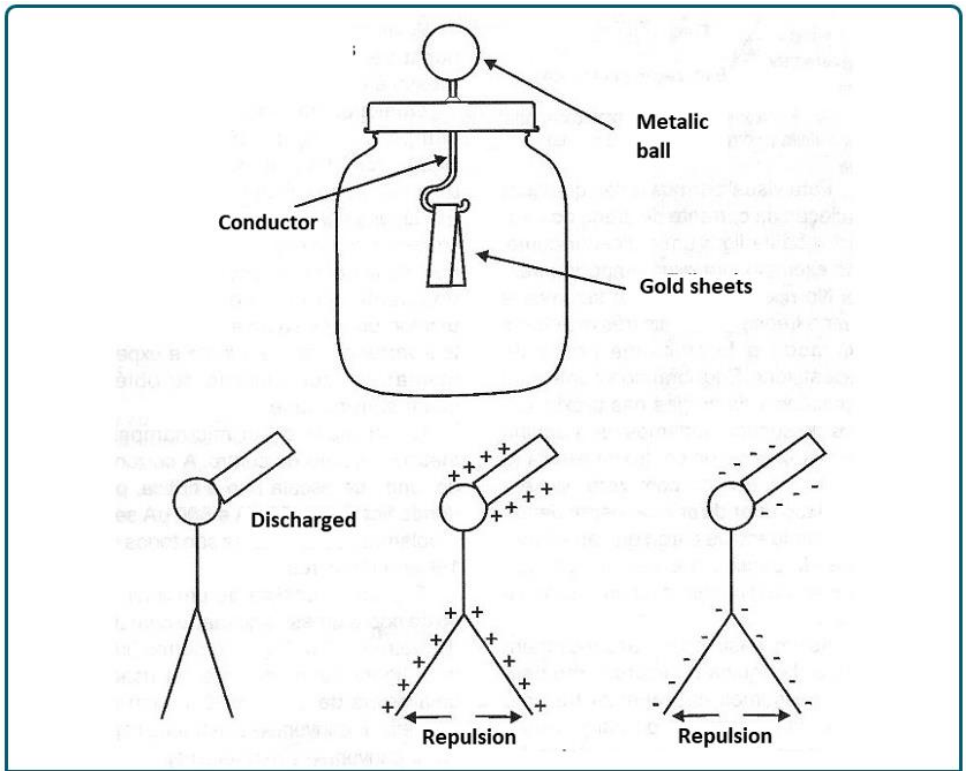
The Electroscope

The **electroscope** is a measuring device used to determine the charge of an object.
Description: The typical electroscope has one or two lightweight strips of metal that bend easily. These metal strips, called leaves, are attached to a central metal rod that has a metal sphere at the top. Sometimes, the leaves and metal rod are enclosed in glass or plastic so that air movement does not affect the device.

To operate, the material is brought close enough (conduction or induction) to pass some charge (if any) onto the metallic ball. The charge travels down a conducting metal to the leaves, which will become charged if the starting object is charged. This will cause them to repel each other based on the amount of charge.



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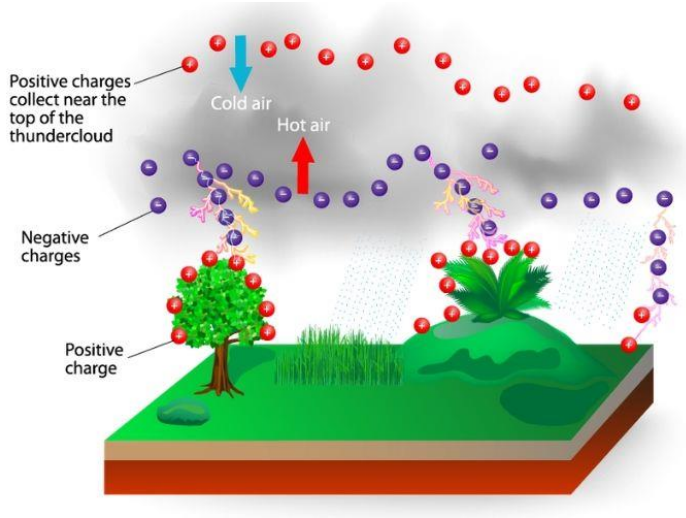
Some electroscopes can give you the charge as an amount. Charges are measured in **Coulombs** (C), a unit of static charge. We will not be going into the math or true meaning behind the Coulomb, but for those who care, it is the charge delivered by an electric current of one ampere in one second.

Lightning:

In thunder clouds, large amounts of negative charges gather at the bottom of the cloud (and positive charges are at the top) because of two air masses with different temperatures meeting. The ground has an overall neutral charge, but the positive charges in the ground attract the negative charges in the clouds.

When the build-up of negative charge is big enough, the electrons will move through atoms in air to reach the ground. They will take the easiest, shortest path to the ground, often moving down satellite dishes, trees, buildings, and, rarely, people.

Some of the energy is given off on the way down, converted to light (lightning) and sound (thunder) energy.



To avoid being struck by lightning in open areas, humans can use objects that act as Faraday cages. A **Faraday cage** is a conductive, cage-like structure that surrounds a less conductive object. This causes the electrical charge to travel through the easier path, which protects the less conductive object. An example of this is a car. Note: car tires do nothing to protect anyone!