Electrostatics

Lufkin High School

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Electric Charge

- There are only two types of charge
  - **q** is the variable
    - **Positive**
    - **Negative**
  - Unit of charge is Coulomb**, C**
- *Like charges repel*, unlike charges attract.
- A neutral object has a net charge of zero.

Units of Charge

- Charge is a fundamental unit in electrostatics
  - 1 e = 1.6 x 10^{-19} C
  - A proton has a charge of +1e
  - An electron has a charge of -1e
  - 1 Coulomb = 6.25 x 10^{+18} electrons

Insulator

- Does not allow charge to move freely.
- Can be used to 'store' charge
- Glass, rubber, silk, plastic

Conductor

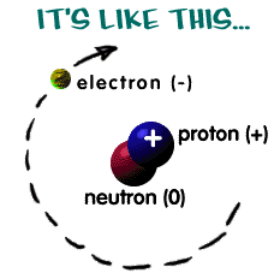
- Allows charge to move freely.
- Electrons move easily
- Most metals

Conductors and Insulators

Electrical conductor	Electrical insulator
Allows electricity to move through it easily	Does not allow electricity to move through it easily
"loose" electrons	Tightly bound electrons
Metals, copper, aluminum, plasma, graphite	Glass, dry wood, plastics, cloth, dry air

Atomic Structure (review)

- Atoms are composed of electrons (negative charge), protons (positive charge), and neutrons (no charge).
- When the atoms electrons and protons are not balanced the atom has net charge.



We now know (review):

- That charge depends on a balance of electrons and protons.
- A surplus of electrons is a negative charge
- A deficit of electrons is a positive charge.
- The total charge is always conserved. (we do not make or destroy electrons)

How to Transfer Charge

- Friction – rapidly rub two materials together. Ex. dragging your feet on carpet
- Conduction – touch a charged object to a neutral object. The neutral object gains the same charge
- Induction – bring a charged object close to a neutral object. The neutral object gains the opposite charge.

How do you charge something?

Add or remove electrons, but how does that happen?

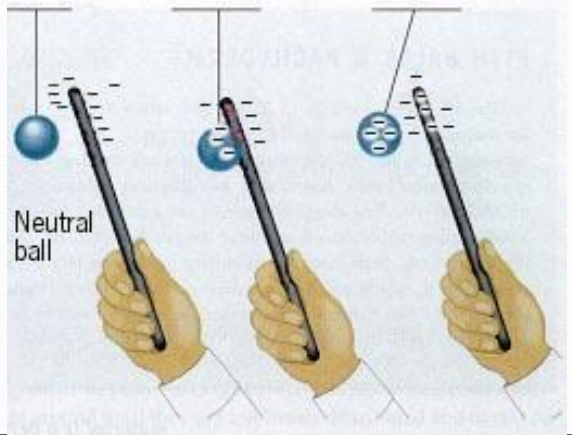
Charging by conduction

Charging by induction

Charging by friction
(aka as charging by contact)

Charging by conduction

Charging a neutral object by **direct contact** with a charged object.

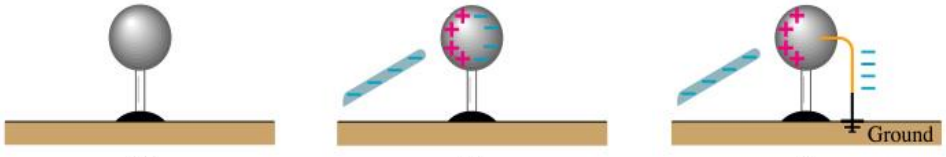


If the substance is a good conductor, the charges will spread throughout it immediately

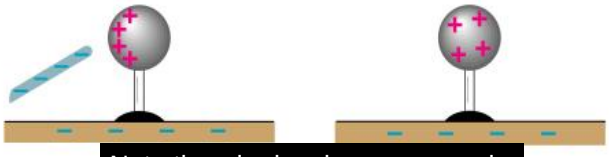
If the substance is a poor conductor, you will need to touch the object in multiple places to distribute the charge

Charging by Induction

Charging an object without actually touching it, but by forcing opposite charges apart, and then separating them.



Conductor is insulated from table.



Note the wire has been removed.

Law of Conservation of Electric Charge

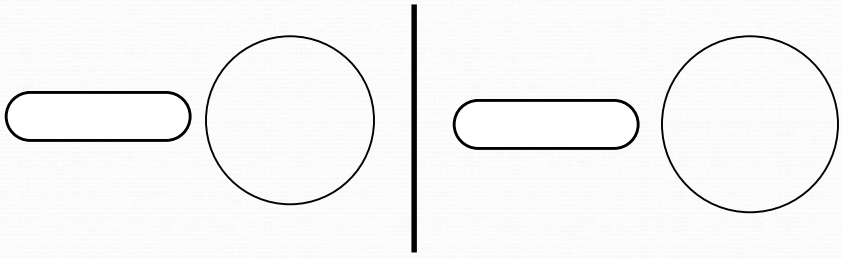
- The net amount of electric charge produced in any process is zero.

Polarization

- A surface charge can be induced on an object by polarization.
- Polarization is when the charges align themselves so that all like charges are grouped together – simulating a net charge even though the actual charges balance out
- Polar Bonds - water

Charge Polarization

Charging by induction is not limited to conductors. It is possible to cause a neutral object to become charged by simply forcing its protons and electrons to rearrange. Polarization occurs extremely rapidly. The polarized object can create a nonzero eclectic field in the surrounding space.



Coulombs Law

- In the 1780's Charles Coulomb conducted a series of experiments to determine the magnitude of the electric force between two charges. He came up with the following equation:

$$F_{Electric} = k_C\left(\frac{q_1 q_2}{r^2}\right)$$

$$k_C = 9.0\times10^9\ Nm^2/C^2$$

Coulomb's Law Variables Defined

- $F_{Electric}$ is the electrostatic force felt between two charged particles.
- $F_{Electric}$ is a repulsive force for like charges and an attractive force for opposite charges.
- k_c is Coulomb's constant from $1/(4\pi\varepsilon_o)$
  - Permittivity of free space, ε_o, in physics is called "epsilon naught" where epsilon is a Greek letter 'e' and naught means zero.
- q_1 and q_2 are the charges "feeling" the force
- r is the straight line distance between the two charges.

Coulomb's Law Examples

1 C = the charge of 6.25×10^{18} electrons

Force varies proportional to the size of the charge

$$F_{electric} = k\ (\frac{q_1 q_2}{r^2})$$

$$k = 9.0 \times 10^9\ Nm^2/C^2$$

Force varies inversely to the square of the distance

Millikan

- Robert Millikan (1886-1953) performed an experiment in 1909 at the University of Chicago.
- He balanced droplets of oil between two charged plates.
- After studying millions of drops, he discovered that charge was quantized.
- This means that the net charge was always divisible by a certain number.

End of Reading Quiz Question

- Determine the electrical force of attraction between two balloons with separate charges of $+3.5 \times 10^{-8}$ C and -2.9×10^{-8} C when separated a distance of 0.65 m.