Introduction to Electrostatics

The interaction between charged objects is a non-contact force that acts over some distance of separation.

Charge, charge and distance

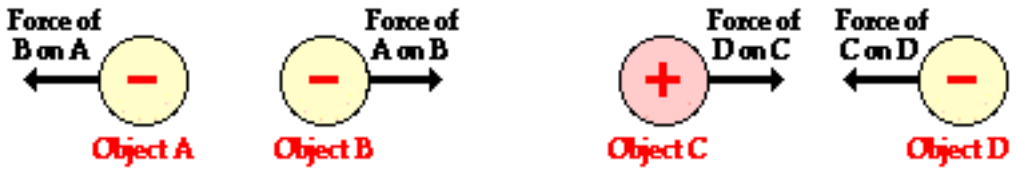
Every electrical interaction involves a force that highlights the importance of these three variables. Whether it is a plastic golf tube attracting paper bits, two like-charged balloons repelling or a charged Styrofoam plate interacting with electrons in a piece of aluminum, there is always two charges and a distance between them as the three critical variables that influence the strength of the interaction.

Force as a Vector Quantity

- The electrical force, like all forces, is typically expressed using the unit Newton.
- Being a force, the strength of the electrical interaction is a vector quantity that has both magnitude and direction.
- The direction of the electrical force is dependent upon whether the charged objects are charged with like charge or opposite charge and upon their spatial orientation.
- By knowing the type of charge on the two objects, the direction of the force on either one of them can be determined with a little reasoning.
- In the diagram below, objects A and B have like charge causing them to repel each other. Thus, the force on object A is directed leftward (away from B) and the force on object B is directed rightward (away from A). On the other hand, objects C and D have opposite charge causing them to attract each other. Thus, the force on object C is directed rightward (toward object D) and the force on object D is directed leftward (toward object C).

When it comes to the electrical force vector, perhaps the best way to determine the direction of it is to apply the fundamental rules of charge interaction (opposites attract and likes repel) using a little reasoning.

Determining the Direction of the Electrical Force Vector



Electrical force also has a magnitude or strength.

Like most types of forces, there are a variety of factors that influence the magnitude of the electrical force.

Two like-charged balloons will repel each other and the strength of their repulsive force can be altered by changing three variables.

- First, the quantity of charge on one of the balloons will affect the strength of the

repulsive force. The more charged a balloon is, the greater the repulsive force.

- Second, the quantity of charge on the second balloon will affect the strength of the repulsive force. Gently rub two balloons with animal fur and they repel a little. Rub the two balloons vigorously to impart more charge to both of them, and they repel a lot.
- Finally, the distance between the two balloons will have a significant and noticeable effect upon the repulsive force. The electrical force is strongest when the balloons are closest together. Decreasing the separation distance increases the force. The magnitude of the force and the distance between the two balloons is said to be *inversely related*.

There are two types of electric charge. Protons carry a positive charge and electrons carry a negative charge.
The fundamental unit of charge is the charge of a single electron or proton is $1.6x10^{-19}$ Coulombs. The symbol for charge is **q**.

Charge is **quantized**. Objects can only carry a charge that is an integral multiple of the fundamental unit of charge. (ie: An object can have a charge of $4X10^{3}C$ this doesn't represent the number of electrons)

Conductors are materials containing free electrons that can carry an electrical impulse. (They conduct electricity.) Typically, metals are conductors.

Insulators are materials with few or no free electrons. They do not conduct electricity well. Typically, plastic and wood are insulators.

Charge is conserved. Charge cannot be created or destroyed, but it can be transferred from one object to another. If one loses charge, the other must gain an equal amount. Example: rubbing a balloon on your hair

A neutral object can become charged if **electrons** are added or removed from it. A gain of electrons produces a net negative charge; a loss of electrons yields a net positive charge.

There are several methods for charging neutral objects:
1. charging by friction: When 2 neutral objects are rubbed together, the rubbing force strips outer electrons from atoms of one object & transfers them to the other object.
2. charging by conduction: when objects with different amounts of charge contact each other, the charge equalizes.
3. charging by induction: a charged object influences the distribution of electrons in two neutral objects. The charged object never touches the uncharged objects.

Polarization occurs when the charges in a neutral object are influenced by the electric field of a nearby charged object. ***A polarized object has no net charge, but rather a positive end and a negative end***. Example: a positively charged balloon attracts opposite charges in a neutral wall and repels like charges. The wall remains neutral, but it has a negative area that attracts the balloon. The balloon to sticks to the wall.