Electrostatics

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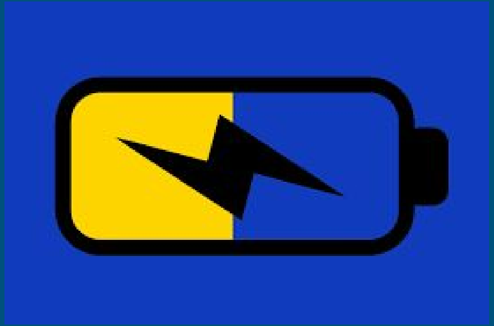
Electrostatics VS Electricity

The study of stationary electric charges or fields as opposed to electric currents.

Electrostatic deals with magnets and the distribution of charge.

Charge (C)



Coulombs-C

e-= -1.6x10^-19

p+=1.6x10^-19

Q=ne

- Q=total charge
- n=# of protons and electrons
- e=1.6x10^-19

e= the elementary charge

- The smallest charge a particle can have

n=(number of protons)-(number of electrons)

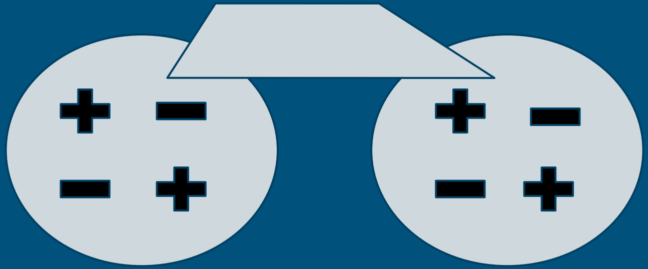
Quantization of Charge(Q)- How much charge you can have in a discrete quantity.

- Measured in Coulombs(C)

Insulators and Conductors

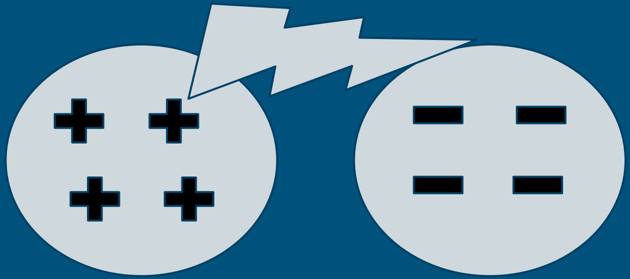
Insulators resist the motion of electric charge

Ex: paper, rubber, water, cloth



Conductors allow for the motion of electric charge

Ex: most metals



How to Move Charges

1. Conduction: where charges move between objects when they touch.
2. Induction: separation of charge within an object because of the close approach on another charged object without touching.
3. Friction: when electrons are physically stripped from one material and transferred to another.

The Law Of Conservation of Charge

Electric charge cannot be created or destroyed. The net amount of electric charge produced in any process is **always** zero.

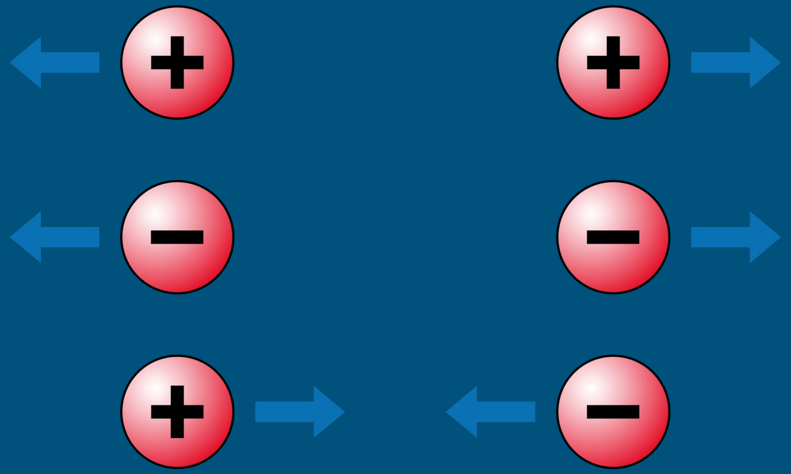
- *The Law of Conservation of Matter: Matter cannot be created or destroyed.*

Electrons distribute themselves evenly across a conductive object

Formalizing Electric Charge

The electric force between two objects is dependent upon three quantities:

1. The size of the first charge q_1
2. The size of the second charge q_2
3. The distance between the two charges



Coulomb's Law

- **$F_e = kq_1q_2/r^2$**
  - $k = 9.0 \times 10^9\ Nm^2/C^2$
- If F_e is positive, then force is *repulsive*
  - Because $q_1 = +$ and $q_2 = +$, so positive x positive = positive
  - Same with negative-- $q_1 = -$ and $q_2 = -$, so negative x negative= positive
  - Like charges repel
- If F_e is negative, then force is attractive
  - Because $q_1 = -$ and $q_2 = +$, so negative x positive = negative
  - Opposite charges attract

Electric Fields

-created by Michael Faraday to help model the behavior of electrical forces.

-$E=F/q$

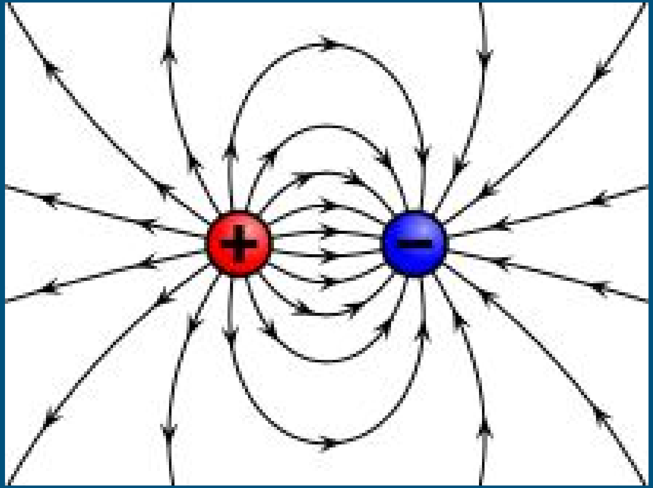
- measured in N/C

-$E=kQ/r^2$

- q is the charge feeling the field and Q is the charge creating the field.

Electric Field Lines

-drawn to indicate the direction of the force due to the given field on a positive test charge.
-always point from positive to negative
-never cross because a force can only point in one direction at a time.
-perpendicular to the surface of the charged conductors.
-density of the field line is proportional to the magnitude of the electric field.



Electric Fields Continued

-The electric field is constant between two oppositely charged, parallel plates.

-The field lines between them will be drawn parallel and equally spaced.

-The electric field inside a good conductor is zero. Any net charge on a good conductor distributes itself on the surface.

Electric Potential Energy and Electric Potential

Important equation to know for Electric Potential Energy:

1. This is used to measure the potential energy between two charges at a given distance apart
   a. **PE = (kQq)/r**

Important equation to know for Electric Potential:

1. This is used to measure potential energy per charge
   b. **V = (kQ)/r**
   c. **ΔV = (ΔPE)/q**
   d. Measured in Volts
   e. Called electric potential, potential difference, voltage (all mean the same thing)

Capacitance

Capacitance is measured in farads (F)

Batteries are different

-It is the quality of a capacitor, a device meant to store charge

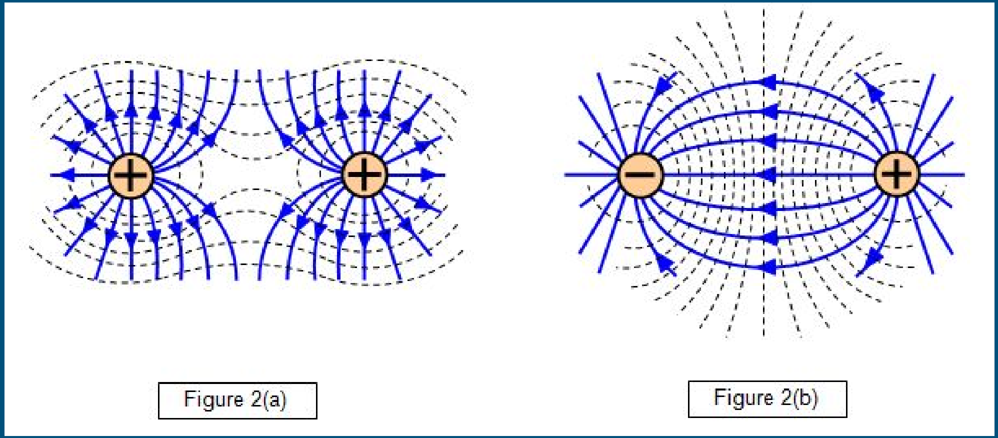
-The ability of a capacitor is dependent on how it's built

Capacitance= ε_o x Area / distance

($\varepsilon_o = 8.85 \times 10^{-12}\ C^2/Nm^2$)

Equipotential Lines

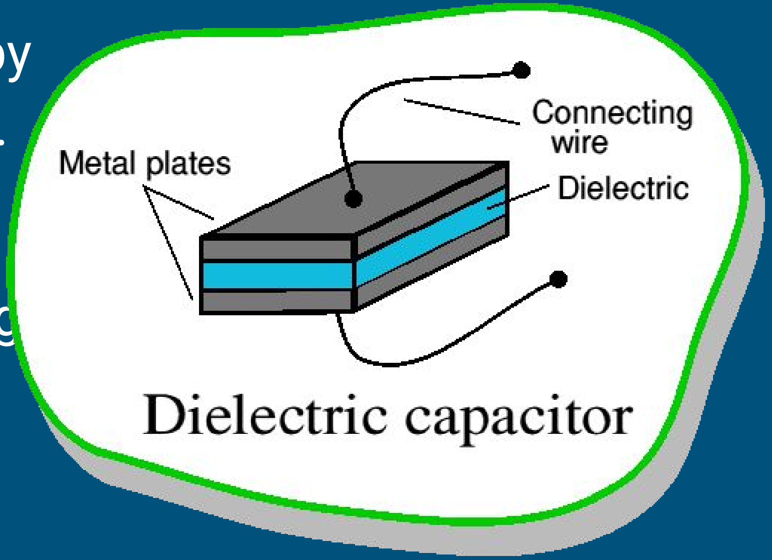
- Lines draw in a diagram representing the electrical potential
  - For 3D diagrams, they are called **equipotential surfaces**
  - They are the lines and surfaces where the voltage is the same
- **Equipotential surfaces must be perpendicular to the electric field at all times**



Dielectrics

-The capacitance can be raised further by inserting a dielectric between the plates.

-A dielectric is an insulating sheet sandwiched between the two conducting capacitor plates.



Storing Electrical Energy

-a charged capacitor stores electric energy.

-electric stored= work done charging

-$U=\frac{1}{2} QV = \frac{1}{2} CV^2 = \frac{1}{2} Q^2/C$

Common Misconceptions

- Batteries do not store or create charge. They simply push charge.
- Electric Potential Energy is not the same as Electric Potential. Electric PE is the energy associated between two charges while electric potential is the PE for one charge
- For Coulomb's Law, if the F_e is positive it means the force is *repulsive*. If F_e is negative it means the force is *attractive*.
- q is the charge feeling the field and Q is the charge creating the field
- Negative signs mean direction
- Watch out for units! Make sure distance is in meters.

Electrostatics Question 1

What is the electric force on an *electron* in an oxygen particle if the radius is 6x10^-11?

a. -6.5×10^{12} N
b. 7.5×10^{-12} N
c. -6.4×10^{-12} N
d. 6.4×10^{-12} N

Answer to Question 1

C. F= -6.4×10^{-12} N

Question 2

A charge (q_1) has a magnitude of 3.0 x 10^{-6} C. A second charge (q_2) has a magnitude of -1.5 x 10^{-6} C and is located 12 cm from the first charge. Determine the electrostatic force each charge exerts on each other. (HINT: Coulomb's Law)

a. 3.20 attractive
b. 2.81 repulsive
c. 2.81 attractive
d. 3.20 repulsive

Answer

$F_e = kq_1q_2/r^2$

B. -2.81 (answer in calculator) $\Longrightarrow$ *remember the negative only tells us the direction, so it is written as 2.81, attractive

Question 3

Capacitor plates are separated by an insulator known as:

a. non-metal
b. dielectric
c. paper
d. wood

Answer to Question 3

B. dielectric

Question 4

If 5 C of charge is moved through +5 V potential difference, determine the change in electric potential energy.

a. 15 J
b. 25 J
c. 5 J
d. 10 J

Answer Question 4

$\Delta v = \Delta U/q$

B. 25 J

Question 5

If a plate separation for a capacitor is 0.2 cm, determine the area of the plates if the capacitance is exactly 1 F.

a. 2.3×10^{10} m^2
b. 2.3×10^{8} m^2
c. 5.6×10^{8} m^2
d. 5.6×10^{10} m^2

Answer Question 5

B. $2.3 \times 10^8\ m^2$