§6.2 Electric Force & Field

Greeks → tried to explain the attraction/repulsion of objects that had been rubbed together.
→ proposed the idea of an electric charge.
→ positive and negative charges
→ like charges repel and unlike charges attract

Electrostatics → Study of the effect of stationary charges.

Law of Conservation of Charge

In any closed system, the algebraic sum of all the charges remains constant

Conductors

- a material that allows the flow of electric charge.
- charges must be free to move.
- metals, ionic solution, graphite.

carbon has 4 valence electrons
3 involved in bonding
1 electron is left and delocalized between the layers of atoms.

Insulators

- materials that do not have any free charges to move → they do not allow the flow of electric charge.
- nothing is a perfect insulator.
- a high enough potential difference can cause the charges to move.

Semi Conductor

- a material like Silicon in which a conduction band exists, but normally without any electrons.
- electrons can be excited (heat or light) into the conduction band and now the material is conducting.

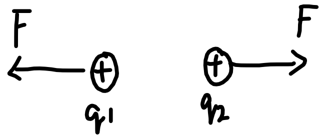
Coulomb's Law

- late 1700s
- Coulomb used a torsion balance to measure the force of attraction/repulsion between charged objects.
- Coulomb found:

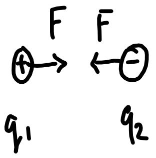
$$F \propto q_1,\quad F \propto q_2,\quad F \propto \frac{1}{r^2} \quad \Rightarrow \quad F \propto \frac{q_1 q_2}{r^2}$$

Coulomb's Law

- applies to point charges.



- the forces on each object are relate by Newton's Third Law
- the force between the two charges is a mutual force.



- the magnitude of the force between the two charges depends on the medium in which the charges are located. We will worry about air or a vacuum.

$$F \propto \frac{q_1 q_2}{r^2}$$

$$F = \frac{k q_1 q_2}{r^2}$$

Where $k = \frac{1}{4\pi \varepsilon_0}$ and ε_0 is the permitivity of free space. (vacuum)

$(k = 8.99 \times 10^9\ Nm^2C^{-2})$ $(8.85 \times 10^{-12}\ C^2N^{-1}m^{-2})$ a fundamental constant.

Example

Determine the force between a +2.5nC charge and a −5.0nC charge placed 2.5 mm apart. ← magnitude of force.

attractive → unlike charges

$$F = \frac{kq_1q_2}{r^2}$$

do not put signs on charges

$$F = \frac{(8.99\times10^{9}\,N\,m^{2}C^{-2})(2.5\times10^{-9}C)(5.0\times10^{-9}C)}{(2.5\times10^{-3}m)^{2}}$$

$$F = 1.8\times10^{-2}N$$

Example

The force between two point charges is 6.0×10^{-6} N. What is the force between them if the charge on one of is halved and the distance is doubled?

$$F = \frac{kq_1q_2}{r^2}$$

(new force) $$F' = \frac{k\left(\frac{q_1}{2}\right)q_2}{(2r)^2}$$

$$F' = \frac{\frac{1}{2}kq_1q_2}{4r^2}$$

$$F' = \frac{1}{8}\frac{kq_1q_2}{r^2}$$ ← F

$$F' = \frac{1}{8}F$$

$$F' = \frac{1}{8}(6.0\times10^{-6}N)$$

$$F' = 7.5\times10^{-7}N$$