

# Electrostatics

## Big Picture

All objects have positive and negative charges inside them. If the number of positive and negative charges are equal, as they most often are, then the object is neutral. Charged objects are objects with more positive charges than negative ones, or vice versa. Opposite charges attract, and similar charges repel. Electric fields are created by a net charge and point away from positive charges and towards negative charges. Many macroscopic forces can be attributed to the electrostatic forces between molecules and atoms.

## Key Terms

**Charge:** Charge is carried by protons and electrons. Charge is always conserved in a closed system. SI unit: C

**Coulomb's Law:** Coulomb's law states that the force between two charges is proportional to the value of the two charges and inversely proportional to the square of the distance between them.

**Electric Fields:** Electric fields surround electrically charged particles and affect other electrically charged particles. The field itself is a vector force field - it indicates the direction a positive charge at a given point would move. The electric field can also be thought of as the force per unit charge at a given point, similar to a gravitational field. SI units: N/C = V/m

**Conductors:** Materials where electricity can pass through easily, meaning that electrons can easily move inside the material.

**Insulators:** Materials where electricity cannot pass through easily.

**Semiconductors:** Materials with a conductivity between the conductivities of insulators and normal conductors.

**Superconductors:** Materials with exactly zero resistance below certain temperatures.

**Plasma:** A conductive state of matter, similar to gas, containing ions and/or free electrons.

**Voltage:** Potential energy measured as a difference in potential between two points in space. SI units: V

**Equipotential Lines:** Lines linking points of equal voltage around a point charge. Around point charges, equipotential lines just form circles around the charge. In more complex arrangements, equipotential lines can make all sorts of shapes. Equipotential surfaces are the same as equipotential lines, except in 3-dimensional space.

## Coulomb's Law

There are two types of charge: positive and negative.

- Electrons have negative charge.
- Protons have positive charge.
- The magnitude of the charge is the same for electrons and protons:  $e = 1.6 \times 10^{-19}C$

Coulomb's law is used to calculate the force between two charged particles:

$$F = \frac{kq_1q_2}{r^2}, \text{ where } k \text{ is a constant, } q \text{ is the charge, and } r \text{ is the distance between the charged particles.}$$

The force can be attractive or repulsive depending on the charges:

- Like charges (charges with the same sign) repel.
- Charges with opposite signs attract.

## Electric Field

Electric force can be represented by an **electric field**.

The field  $E$  due to a single point charge  $q$  is:  $E = \frac{kq}{r^2}$

The field describes the force a charged object will feel if it enters the field. If another point charge  $q_0$  is in the field, it will feel a force  $F = Eq_0$ .

A simple diagram can tell us a lot about an electric field - the density of the field lines in a region indicates the strength of the field, and parallel lines (like between two charged plates) mean that the field is constant.

Electric fields can interact with each other just like gravitational fields.

To determine the direction and magnitude of the electric fields at any point, just add the vectors from all of the different electric fields at that point. To the right is an illustration of the electric fields between a positive charge and a negative charge. The lines show the direction a positive charge placed in the fields will take.

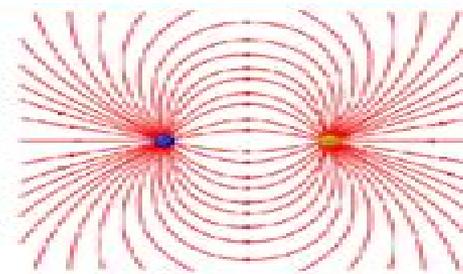


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