Electrostatic Forces and Coulombs Law

By

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Electrostatic Forces Definition

Electrostatic forces are attractive or repulsive forces between particles that are caused by their electric charges. This force is also called the Coulomb force or Coulomb interaction and is so named for French physicist Charles-Augustin de Coulomb, who described the force in 1785.

How the Electrostatic Force Works

The electrostatic force acts over a distance of about one-tenth the diameter of an atomic nucleus or 10^{-16} m. Like charges repel one another, while unlike charges attract one another. For example, two positively charged protons repel each other as do two cations, two negatively charged electrons, or two anions. Protons and electrons are attracted to each other and so are cation and anions.

Why Protons Don't Stick to Electrons

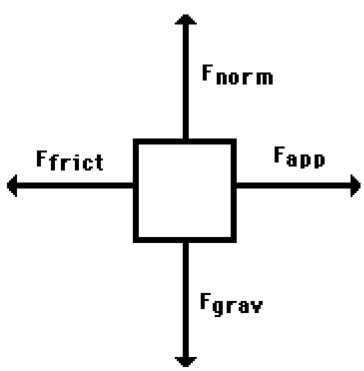
While protons and electrons are attracted by electrostatic forces, protons don't leave the nucleus to get together with electrons because they are bound to each other and to neutrons by the strong nuclear force. The strong nuclear force is much more powerful than the electromagnetic force, but it acts over a much shorter distance.

In a sense, protons and electrons are touching in an atom because electrons have properties of both particles and waves. The wavelength of an electron is comparable in size to an atom, so electrons can't get closer than they already are.

Define an electrical force

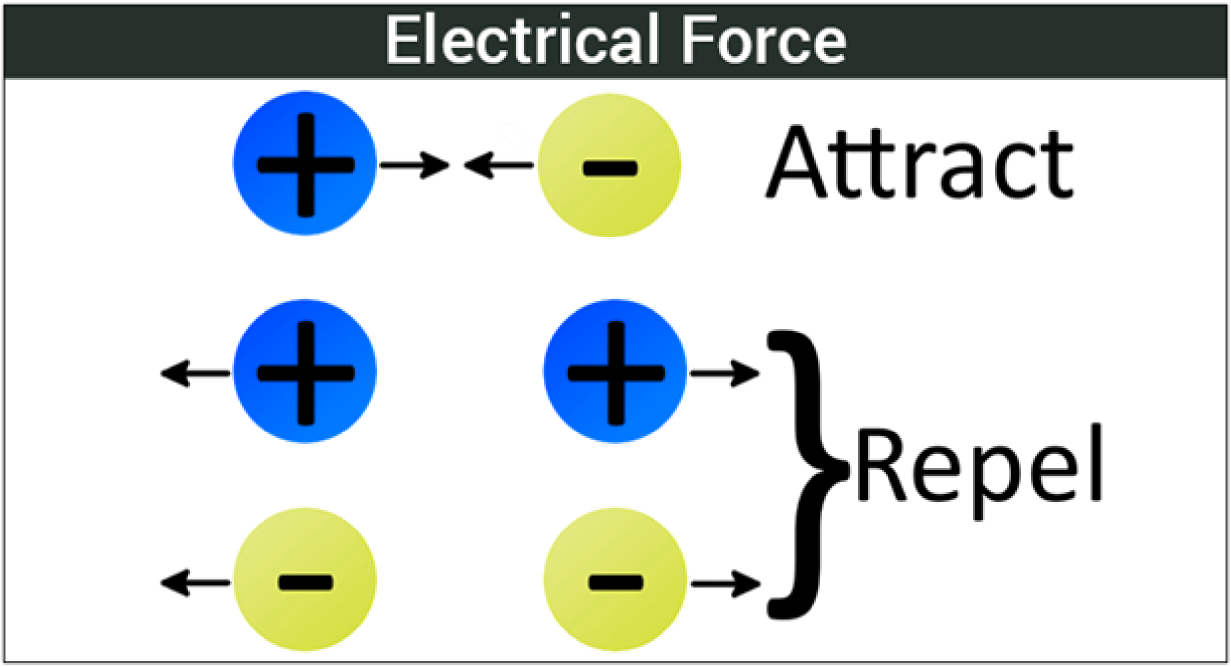
The repulsive or attractive interaction between any two charged bodies is called as an electric force. Similar to any force, its impact and effects on the given body are described by Newton's laws of motion. The electric force is among the list of other forces that exert over objects.

Newton's laws are applicable to analyze the motion under the influence of that kind of force or combination of forces. The analysis begins by the construction of a free body image wherein the direction and type of the individual forces are shown by the vector to calculate the resultant sum which is called the net force that can be applied to determine the body's acceleration.



The size of the electric force depend on

The electric force between two electrons is equal to the electric force between two protons when placed at equal distances. This describes that the electric force is not based on the mass of the object, but depends on the quantity known as the electric charge.



Coulomb’s Law

Coloumb’s law is an experimental law that quantifies the amount of force between two stationary electrically charged particles. The electric force between stationary charged body is conventionally known as the electrostatic force or Coloumb’s force. Coulomb’s law describes the amount of electrostatic force between stationary charges.

Coulomb’s law states that:

The value of the electrostatic force of interaction between two point charges is directly proportional to the scalar multiplication of the charges and inversely proportional to the square of the distance among them.

Calculating the Electrostatic Force Using Coulomb's Law

The strength or force of the attraction or repulsion between two charged bodies can be calculated using Coulomb's law:

$F = kq_1q_2/r^2$

Here, F is the force, k is proportionality factor, q_1 and q_2 are the two electric charges, and r is the distance between the centers of the two charges. In the centimeter-gram-second system of units, k is set to equal 1 in a vacuum. In the meter-kilogram-second (SI) system of units, k in a vacuum is 8.98 × 109 newton square meter per square coulomb. While protons and ions have measurable sizes, Coulomb's law treats them as point charges.

It's important to note the force between two charges is directly proportional to the magnitude of each charge and inversely proportional to the square of the distance between them.

Verifying Coulomb's Law

You can set up a very simple experiment to verify Coulomb's law. Suspend two small balls with the same mass and charge from a string of negligible mass. Three forces will act upon the balls: the weight (mg), the tension on the string (T), and the electric force (F). Because the balls carry the same charge, they will repel each other. At equilibrium:

$T \sin \theta = F$ and $T \cos \theta = mg$

If Coulomb's law is correct:

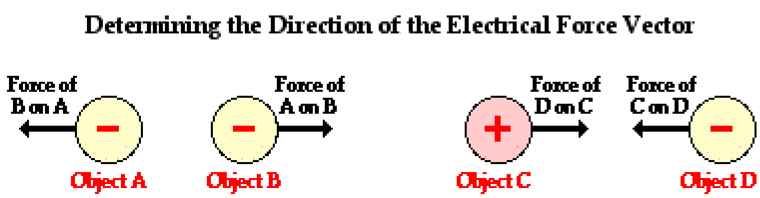
$F = mg \tan \theta$

The Importance of Coulomb's Law

Coulomb's law is extremely important in chemistry and physics because it describes the force between parts of an atom and between atoms, ions, molecules, and parts of molecules. As the distance between charged particles or ions increases, the force of attraction or repulsion between them decreases and the formation of an ionic bond becomes less favorable. When charged particles move closer to each other, energy increases and ionic bonding is more favorable.

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.



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*.