Electric Force

The force between the charged particles is an electric force. The size of the electric force depends on 2 things:

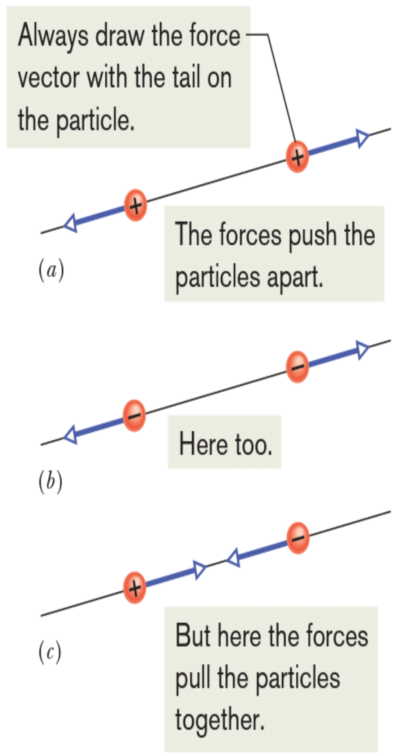
1. The amount of charge (greater the charge, the greater the force)
2. The distance between the charges (farther the distance, the less the force)

Explain with help of **Coulumb's law**

Coulumb's Law

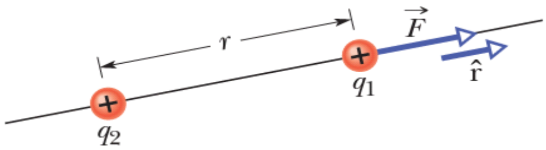
Now we come to the equation for Coulomb's law, but first a caution. This equation works for only charged particles (and a few other things that can be treated as particles). For extended objects, with charge located in many different places, we need more powerful techniques. So, here we consider just charged particles and not, say, two charged cats.

If two charged particles are brought near each other, they each exert an **electrostatic force** on the other. The direction of the force vectors depends on the signs of the charges. If the particles have the same sign of charge, they repel each other. That means that the force vector on each is directly away from the other particle (Figs. *a* and *b*). If we release the particles, they accelerate away from each other. If, instead, the particles have opposite signs of charge, they attract each other. That means that the force vector on each is directly toward the other particle (Fig. *c*). If we release the particles, they accelerate toward each other.



Two charged particles repel each other if they have the same sign of charge, either (*a*) both positive or (*b*) both negative. (*c*) They attract each other if they have opposite signs of charge.

The equation for the electrostatic forces acting on the particles is called **Coulomb's law** after Charles-Augustin de Coulomb, whose experiments in 1785 led him to it. Let's write the equation in vector form and in terms of the particles shown in Fig.,



The electrostatic force on particle 1 can be described in terms of a unit vector $\hat{r}$ along an axis through the two particles, radially away from particle 2.

where particle 1 has charge q_1 and particle 2 has charge q_2. (These symbols can represent either positive or negative charge.) Let's also focus on particle 1 and write the force acting on it in terms of a unit vector $\hat{r}$ that points along a radial axis extending through the two particles, radially away from particle 2. (As with other unit vectors, has a magnitude of exactly 1 and no unit; its purpose is to point, like a direction arrow on a street sign.) With these decisions, we write the electrostatic force as

$$F = k(q_1 q_2/r^2)r \qquad \text{(Coulomb's law)}$$

where r is the separation between the particles and k is a positive constant called the *electrostatic constant* or the *Coulomb constant*. (We'll discuss k below.)

Unit. The SI unit of charge is the **coulomb**. For practical reasons having to do with the accuracy of measurements, the coulomb unit is derived from the SI unit *ampere* for electric current i. Here let's just note that current i is the rate dq/dt at which charge moves past a point or through a region:

$$i = \frac{dq}{dt} \qquad \text{(electric current)}$$

Rearranging above equation and replacing the symbols with their units (coulombs C, amperes A, and seconds s) we see that

$$1 \text{ C} = (1 \text{ A})(1 \text{ s}).$$

Force Magnitude. For historical reasons (and because doing so simplifies many other formulas), the electrostatic constant k is often written as $1/4\pi\varepsilon_o$. Then the magnitude of the electrostatic force in Coulomb's law becomes

$$F = (1/4\pi\varepsilon_o)(q_1 q_2/r^2) \qquad \text{(Coulomb's law)}$$

The constants in above equations have the value

$$k = 1/4\pi\varepsilon_o = 8.99\times10^9 \text{ N.m}^2\text{C}^2$$

The quantity $\in_o$, called the **permittivity constant,** sometimes appears separately in equations and is

$$\varepsilon_o = 8.85\times10^{-12}\ C^2/N.m^2.$$

Applications:

1. Xerography (Photocopier)
2. Inkjet Printer
3. Vacuum Cleaner

Related Problems

1. Two identical charges -8.00×10^{-5} C, each are separated by a distance of 25.0 cm. What is the force of repulsion?

2. The force of repulsion between two identical positive charges is 0.800 N when the charges are 0.100 m apart. Find the value of each charge.

3. A charge of $+3.0\times10^{-6}$ C exerts a force of 940 N on a charge of $+6.0\times10^{-6}$ C. How far apart are the charges?

4. A charge of -3.0×10^{-8} C exerts a force of 0.045 N on a charge of $+5.0\times10^{-7}$ C. How far apart are the charges?

5. When a -9.0 μC charge is placed 0.12 cm from a charge q in a vacuum, the force between the two charges is 850 N. What is the value of q?

6. How far apart are two identical charges of $+6.00$ μC if the force between them is 25.0 N?