History of Coulomb's discovery

It was known to the ancient Greeks as long ago as 600 B.C. that amber, rubbed with wool, acquired the property of attracting light objects. In describing this property today, we say that the amber is electrified, or possesses an electric charge, or is electrically CHARGED. These terms are derived from the Greek work elektron, meaning amber. It is possible to put an electic charge on any solid material by rubbing it with any other material. Thus, an automobile becomes charged when it moves through the air, a comb is electified in passing through dry hair. Actually intimate contact is all that is needed to give rise to an electric charge. Rubbing merely serves to bring may points of the surfaces nto good contact.

In the field of electricity, unitl the end of the eighteenth century, only the static form was recognized, but in 1731 it was shown, that while some bodies wold conduct electricity, others would not. Thus 'insulation' was possible. In 1747 Benjamin Franklin (1706-90) began to take an interest in electricity and soon observed that electric charges could be drawn off with piculiar faciilty by metal points. He supposed that 'electric fire is a common element' existing in all bodies. If a body had more than its normal share it was called PLUS, (+), if less MINUS, (-).

In 1767 it was suggested by Priestley, that the law of electrical attraction was the same as that of gravitational attraction, namely, the strength of electrical attraction varies as the inverse square of the distance. The first method of measurement applicable to electricity was the action of an electrified of an electrified objects on light suspended bodies such a s threads.

The first effective verification of the law of attraction was made by the French engineer Charles Augustus Coulomb (1736-1806). Using hairs and wires he constructed a torsion balance. The principle was to measure the amount of torsion required to bring a charged pith-ball within various distances of another pith-ball, equally charged with electricity of the same sign and therefore repelling it. Coulomb was the founder of the mathematical theory of electrical action.

The Formula

Coulomb's law describes the force between two charged particles.

$$F = k\frac{q_a q_b}{r^2}$$

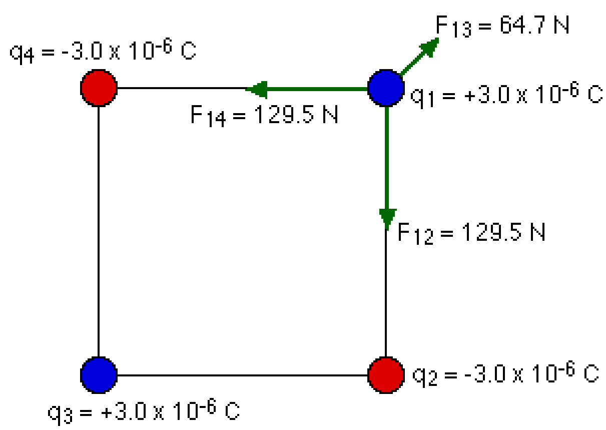
Here, *F* is the force between the particles, q_a and q_b are the charges of particles *a* and *b*. The separation between the particles is *r*, and *k* is a constant, 8.99x10^9 *(Nm^2/C^2)*. Note that the force falls off quadratically, similarly to the behavior of the gravitational force. The force is attractive, when *F* is negative, hence when the charges have opposite sign. Opposites attract - like charges repel. Of course, remember that force is a vector, which in this case points parallel to *r*. If a charge *a* is in the presence of several charges, the force that *a* feels is the sum of the forces from the remaining charges. For instance if there are three charges, *a, b,* and *c*, the net force felt by *a* is:

$$\vec{F}_a = k\frac{q_a q_b}{r_{ab}^3}\vec{r} + k\frac{q_a q_c}{r_{ac}^3}\vec{r}$$

where r_{ab} is the separation between a and b.

An example

Four charges are arranged in a square with sides of length 2.5 cm. The two charges in the top right and bottom left corners are +3.0 x 10^{-6} C. The charges in the other two corners are -3.0 x 10^{-6} C. What is the net force exerted on the charge in the top right corner by the other three charges?



To solve any problem like this, the simplest thing to do is to draw a good diagram showing the forces acting on the charge. You should also let your diagram handle your signs for you. Force is a vector, and any time you have a minus sign associated with a vector all it does is tell you about the direction of the vector. If you have the arrows giving you the direction on your diagram, you can just drop any signs that come out of the equation for Coulomb's law.

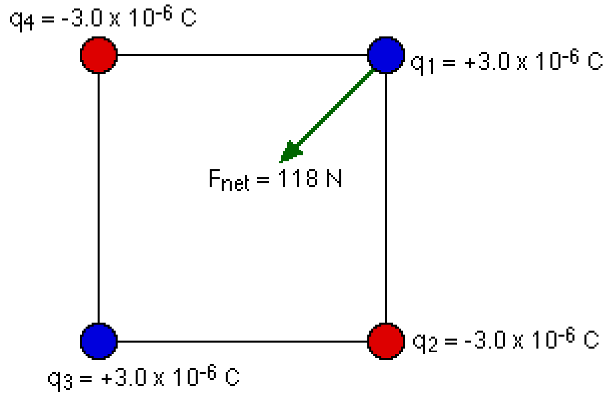
Consider the forces exerted on the charge in the top right by the other three:

from charge 2 : $F_{12} = k\, q_1 q_2 / r^2 = (8.99 \times 10^9)(+3.0 \times 10^{-6})(-3.0 \times 10^{-6}) / (0.025)^2$
$= -129.5$ N = +129.5 N in the direction shown on the diagram

from charge 3 : (note that r = 0.03536 m)
$F_{13} = k\, q_1 q_3 / r^2 = (8.99 \times 10^9)(+3.0 \times 10^{-6})(+3.0 \times 10^{-6}) / (0.03536)^2$
$= +64.7$ N = +64.7 N in the direction shown on the diagram

from charge 4 : $F_{14} = F_{12} = +129.5$ N in the direction shown on the diagram

You have to be very careful to add these forces as vectors to get the net force. In this problem we can take advantage of the symmetry, and combine the forces from charges 2 and 4 into a force along the diagonal (opposite to the force from charge 3) of magnitude 183.1 N. When this is combined with the 64.7 N force in the opposite direction, the result is a net force of 118 N pointing along the diagonal of the square.



The symmetry here makes things a little easier. If it wasn't so symmetric, all you'd have to do is split the vectors up in to x and y components, add them to find the x and y components of the net force, and then calculate the magnitude and direction of the net force from the components.