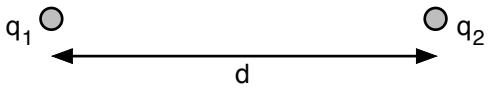
# Electric Field Part 2

*Source of Electric Field*

So far we have dealt with what happens when a charge is caught in an electric field with the equation E = F/q. Now we will figure out where the electric field comes from.

We began this unit with Coulombs Law, which gave us the force that two charges exerted on each other. The force depended on the two charges and how far apart they were, and in fact the equation was very similar to the equation that described gravitational forces.




From Coulomb's Law, we know the force acting on $q_1$ (the charge on the left) is

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

Now we can also say that the reason there is a force on $q_1$ is that it is in an electric field of

$$E = \frac{F}{q_1}$$

Notice what happens when we combine these two ideas: the electric field at the location of $q_1$ is the Coulomb force between the two charges divided by the $q_1$. In equation form:

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

Hey! The term $q_1$ canceled out! That equation tells us the strength of the electric field a distance d away from the charge $q_2$. We typically write it this way:

The electric field (E) a distance (d) away from a charge (Q) is given by

$$E = k\frac{Q}{d^2}$$

*Problems*

1. These are unrealistic numbers (because the charges and fields are way too big), but will help you get a feel for the relationship between the variables:
   a. What is the electric field 3 meters away from a charge of 15 C?

   b. What is the electric field 6 meters away from a charge of 30 C?

   c. How much charge would be needed to make a field of 100 N/C from a distance of 4 meters?

   d. How far away from a 0.003 C charge is the electric field 6000 N/C?

2. A fly accumulates $3.0 \times 10^{-10}$ C of charge as it flies through the air. What is the strength of the electric field 0.02 m away from the fly?

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3. What is the electric field 30 cm away from a 33 $\mu$C charge?

4. The electric field 75 cm away from the center of a van de Graaff generator is 50,000 N/C. What is the charge on the van de Graaff generator?

5. A balloon has a charge of $8 \times 10^{-7}$ C.
   a. What is the electric field 45 cm away from the center of the balloon?

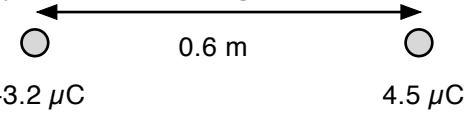
   b. Where is the electric field 8000 N/C?

6. A charged balloon has radius of 10 cm. The electric field on its surface is 4000 N/C.
   a. What is the charge of the balloon?

   b. How many electrons would this represent?

7. What is the electric field 1 Å ($10^{-10}$ m) away from a helium nucleus? (A helium nucleus has 2 protons in it.)

8. A 3.2 $\mu$C charge and a 4.5 $\mu$C charge are 60 cm apart, as shown in the diagram below. What is the net electric field half way between the charges?




*Answers:*
*1. a) 15,000,000,000 N/C b) 7,500,000,000 N/C c) 1.78 x $10^{-7}$ C d) 67.1 m 2) 6750 N/C*
*3) 3,300,000 N/C 4) 3.13 x $10^{-6}$ C 5. a) 35,600 N/C b) 0.95 m*
*6. a) 4.44 x $10^{-9}$ C b) 27,800,000,000 electrons 7) 288,000,000,000 N/C 8) 130,000 N/C*