Electric Field Part 1

Action at a Distance

By the 1800s, people had discovered the mathematical rules that governed gravitational, electric and magnetic forces between objects. While the rules worked fabulously, there was an ever-present concern over what is called "Action at a Distance": exactly how do objects exert forces on each other when they are not touching? How can there be an action caused over a distance? How does one object "know" that there is a second object some distance away from it?

The answer came in the concept of the "field." The existance of an object creates a field that spreads out through space, getting smaller the further away it goes. A second object doesn't know about the first directly, it simply knows that it is in the field created by the first object (and vice versa.) Objects that have mass are affected by a gravitational field and have their own gravitional field around them. An object that has charge is affected by electric fields, and in turn creates its own own electric field that affects other charged objects.

[We have actually used this idea for most of the year when dealing with gravity; we are all in a gravitational field of 9.8 m/s^2, which is the same as 9.8 N/kg. The further away from the earth you are, the less you weigh because the gravitational field is smaller.]

Definition

If a charge (q) is experiencing an electric force (F), then the charge is in an electric field (E) defined by

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

Problems

1. What are the units for electric field?

2. These are unrealistic numbers (because the charges are way too big), but will help you get a feel for the relationship between the variables:
   a. A charge of 3 C experiences a force of 27 N because it is in an electric field. How strong is the field?

   b. A charge of 6 C experiences a force of 27 N in an electric field. How strong is the field?

   c. What is the force on a 0.2 C charge in a 300 N/C electric field?

   d. What is the force on a 2 C charge in a 300 N/C electric field?

   e. A charge experiences a force of 15 N when it is in a 5 N/C electric field. What is the charge?

   f. What charge would experience a 175 N force in an electric field of 25 N/C?

3. What is the strength of an electric field at a location where a 1.6×10^{-19} C test charge experiences a force of 3.2×10^{-16} N?

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4. An electron (1.6×10^{-19} C & 9.1×10^{-31} kg) is in an electric field of 600 N/C.
   a. What is the force acting on the electron?

   b. What is the acceleration of the electron?

5. An unknown charge experiences a force of 0.4 N when it is in an electric field of 8000 N/C.
   a. What is the charge?

   b. If the unknown charge were doubled, what would happen to the force on the charge?

   c. If the unknown charge were doubled, what would happen to the electric field?

6. It turns out rubbing a balloon in your hair creates an electric field of about 50,000 N/C near the surface of the balloon.
   a. What would be the force on an electron close to the surface of a charged balloon?

   b. What would be the force on a proton close to the surface of a charged balloon?

   c. What would be true about the accelerations of a proton and electron near the surface of a charged balloon? (Think about magntiudes and directions.)

7. An electron is accelerated at 3×10^{12} m/s^2. What is the strength of the electric field?

8. A proton (1.7×10^{-27} kg) is accelerated at 3×10^{12} m/s^2. What is the strength of the electric field?

Answers:
1) N/C 2. a) 9 N/C b) 4.5 N/C c) 60 N d) 600 N e) 3 C f) 7 C
3) 2000 N/C 4.a) (-) 9.6 x 10^{-17} N b) 1.1 x 10^{14} m/s^2 5. a) 5 x 10^{-5} C b) double (0.8 N) c) same (8000 N/C) 6. a) 8 x 10^{-15} N b)) 8 x 10^{-15} N c) opposite directions. electron bigger accleration because less mass 7) 17.1 N/C 8) 31,900 N/C