Electric Field Activity

In completing this activity, you are to utilize some online applications and other online resources to make some conclusions regarding electric fields.

First, follow this link http://phet.colorado.edu/en/simulations/category/physics , select and explore the indicated simulation (for the first two) and then respond to the questions listed.

Electric Field of Dreams

1. Use this applet for a couple of minutes. Add multiple charges using the "add" button. To adjust the sign or mass of a charge to be added, you must first click on the "Properties" button, make your change and click "done". The next charge you add will reflect your change. For some reason the Properties Box always appears in the far upper left corner of the screen – look here if you don't see it when you first select "properties". Use the properties option to change the sign on some of your charges. How do the sizes of the arrows at points in space relate to the proximity of each point charge that you add?

2. The arrows point toward what type of charges (positive or negative)? Explain how you know this.

3. How does arrow length at a point correspond to the magnitude(size) of nearby charges you have placed in your applet?

4. How does arrow length at a point in space correspond to the motion of charges as they move through or near that point in space on the applet? In other words, do the arrows correlate with the apparent forces acting on the moving charges?

5. The blue arrows represent the electric field present at a point in space due to the presence of one or more of the electrical charges you have inserted. Electric fields are vector quantities. The electric field is defined as:

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

$\mathbf{E}$ = The electric field (a vector quantity) at a point in space due to *other* charges besides q. Let's think of these other charges as Q, capitalized because charge that creates the dominant electric field at a point in space is generally much larger than smaller charges under the influence of these electric fields. The charges you inserted in the applet are all Q's and all contribute to the electric field that is displayed. That being said, any charge, no matter its size, produces an electric field around it. Small charges simply produce smaller electric fields. It is similar to the gravitational field of the Earth vs. the gravitational field of your backpack. The gravitational field produced by your backpack's mass is there, but it is dwarfed by the Earth's larger gravitational field. As a result, we always perceive Earth pulling on objects rather than how other objects pull on the Earth. (Units for E-fields are N/C).

$\mathbf{F}$ = The force (due to Q, also a vector quantity) that acts on q because of the electric field generated by Q.

q = A small charge acted on by electrical forces due to the electric field. In the applet, no q were shown. You must imagine that they exist, look at the electric field, and then you can predict what force that q would feel.

You can generate an external electric field (caused by some Q that is not shown on the screen) by clicking and pulling on the arrow in the box on the right labeled "External Field". Reset all values and place an external field of your choice on the screen. Next, place one or more charges. Based upon what you see, do electric fields point in the direction of forces acting on positive or negative charged q's? Fully explain your response.

6. Suggest two reasons why the concept of electric fields might be a helpful one. Why not simply always talk about the forces between charges?

Charges and Fields

This applet can be used to explore electric fields. We can use the definition of an electric field provided earlier, and Coulomb's Law as presented in class to derive a general expression for **the electric field produced by a point charge**. This would be for the case in which you might place one charge, Q within the field on the previous applet.

$$\mathbf{E} = \frac{\mathbf{F}}{q} = \frac{\text{force acting on } q \text{ due to } Q}{\text{charge impacted by E-field of } Q} = \frac{\frac{\mathrm{k}Qq}{r^2}}{q} = \frac{\mathrm{k}Q}{r^2}$$

$\mathbf{E}$ = The electric field at a point a given distance from Q (r in the equation is this distance) due to the charge Q (in N/C or V/m – these are equivalent units, we will discuss what V is later).

k **=** Coulomb's constant from Coulomb's Law: 9.0×10^9 N m^2/C^2.

Q = The point charge generating the electric field (in Coulombs).

r **=** The distance from the point charge to the point at which the electric field is being determined (in meters).

7. Turn on the "grid", "show numbers" and "tape measure" options. Place 1 nC of charge somewhere on the screen. (Note: 1 nC = 1×10^{-9} C). Calculate what the electric field is two meters from this charge. (Remember E-fields are vectors --- you need to specify a direction as well as a magnitude). Show all your calculations, and then verify your answer using the applet.

8. Pick a point somewhere on your screen to serve as an origin for a Cartesian Coordinate system. Place 3 nC of charge at (0, 3 meters). Place 2 nC of charge at (4, 0 meters). Determine the total electric field at the point (4, 3 meters). Show all your calculations, and then verify your answer using the applet.

9. Pick a point somewhere on your screen to serve as an origin for a Cartesian Coordinate system. Place 5 nC of charge at (0, 3 meters). Place -4 nC of charge at (-2, 0 meters). Determine the total electric field at the point (-2, 3 meters). Show all your calculations, and then verify your answer using the applet.

3-D Electrostatic Field Demonstration (***http://www.falstad.com/vector3de/***)

Use the applet for a couple of minutes. At minimum be sure to look at the *double point charge* and the *dipole* options under the "Field Selection" box, and be sure to display *particles (Vel*), *field vectors*, and *field* *lines* in the “display” box. You will have to do each of these options one at a time. When you have done this, fully answer the following questions:

10. What is a dipole?

11. How do *field vectors* relate to *field lines*?

12. What do you see when you set the display to show the velocity of particles? What real particles do you believe the virtual particles represent? Explain why the particles move as they do in the simulations.

13. In your own words, what do field lines represent? Explain your answer fully.

14. There are some general conclusions you can make about field lines. Please explain why each statement is true.
    a) Electric field lines never cross one another.
    b) The number of electric field lines in a given region are directly proportional to the strength of the electric field at that point.
    c) Electric field lines always originate at a positive charge, and terminate at a negative charge.