Lab #3: ELECTRIC FIELD: APPLET INVESTIGATION

Physics 204, February 6, 2007

Objective:

In the following exercises, we will use an applet (sometimes referred to as physlet) or simulation to investigate experimentally how the electric field varies with position for various charge distributions.

Background:

Again the lab is slightly ahead of the class. We will be addressing electric fields in quite a bit of detail in tomorrows lecture.

Yesterday we introduced Coulombs law which states that there is a force between any two objects that carry a net charge (q_1 and q_2). The magnitude of this force depends on the magnitude of the charges and the distance that separates them according to the formula

$$F_e = k_e \frac{|q_1||q_2|}{r^2}$$

In this formula, k_e is an empirical constant (k_e = 8.99 x 10^9 N m^2 / C^2). The direction of the force is repulsive if the charges are alike and attractive if they are not alike.

An alternate way to understand this force is to imagine that the presence of q_1 creates an *Electric field* in the space around it and it is this field that exerts a force on q_2. This field could be determined from the force that is exerted on q_2.

$$\vec{E} = \vec{F}_e \ / q_2$$

The magnitude of the electric field created by the chare q_1 would then be given by

$$E = k_e \frac{|q_1|}{r^2}$$

The direction of the field is toward negative charges and away from positive charges. When there are multiple charges the total electric field is the VECTOR SUM of the electric field produced by the individual charges. In this experiment you will examine the total electric field produced by a variety of charge distributions.

Applet:
Open Internet Explorer and proceed to the following URL.
http://www.vjc.moe.edu.sg/academics/dept/science_dept/files/physics/applet/efield/efield_demo.htmWith a few changes to the default settings, this applet will allow you to look at the electric field associated with any number of point charges.

1) In the bar at the top, delete *sin(x)*cos(y)* and click the *U(x,y)* button.
2) Deselect the *Contour* box.
3) Charges may be added to the box by clicking the + or **–** buttons and the corresponding electric field is represented by a field of vector arrows. The color of the arrows will represent the strength of the electric field and the direction of the arrow will represent the direction of the field
4) To determine the electric field at any point in the space, simply click and hold with the left mouse button and the coordinates of that location and the magnitude of the electric field are displayed in the yellow box at the bottom of the frame. For this exercise, we will assume that the coordinates are measured in meters and the electric field is in N/C

Exercise 1, Point Charge:
Starting with a blank frame, click the + button to add a positive charge to the frame. Move the positive charge so that it is near the center of the frame (which is the origin). **Record the electric field at some location in the space around the charge. Use the electric field measurement to determine the magnitude of the positive charge.** (Recall that the magnitude of the electric field produced by a "point charge" is given by the formula $E = k q / r^2$ and that r is the distance between the source charge and the point where you want to know the field $r = ((x-x_s)^2 + (y-y_s)^2)^{1/2}$.) **Describe what happens to the electric field when the magnitude of the charge is increased** (you can increase the charge by adding another positive charge to the frame and moving it so that it is directly on top of the first charge). You can observe what this electric field would do to a positive charge by clicking the "test" button. Move the test charge to the location you desire and click the forward button. The blue arrow represents the force on the charge and the black arrow represents the velocity of the charge. **Describe what happens to the "test" charge. What would happen to the "test" charge if the source charge were negative?**

Make five measurements of the electric field at five different distances from the source charge and record these values in a table.

Using these data, make a plot of E versus $1/r^2$. Is the line straight? Determine the value of the charge from the slope of this line (include an explanation of how you did this).

Exercise 2, The Dipole:

Starting with a blank frame (use the "clear" button), place a positive charge at about (-0.2,0.0) and a positive charge at about (0.2,0.0). **Calculate the electric field that these two charges should produce at about (0.6,0.0) and compare it to the value that the applet calculates for that location (clearly show your calculation)**.

Measure the electric field at about (0.0,0), (0.0,.4), (0.0,.8), (0.0,1.2), (0.0,1.6), (0.0,2.0), (0.0,2.2) and record these values in a table. **Plot the electric field as a function of the y coordinate (y represents the perpendicular distance from the dipole axis). Does the magnitude of the electric field for the dipole exhibit $1/r^2$ behavior? (Hint try plotting E versus 1/y, $1/y^2$, etc. and see which gives you a strait line.) Discuss.**

Place a "test" charge at various locations within the dipole electric field and observe its motion under the influence of this field. **Do the force on the "test" and the velocity of the "test" charge always coincide? Discuss why they might be different.**

Exercise 3:

Using the + button add 24 positive charges to the frame. Move the charges so that they are evenly distributed along a line from (-3.0, 0.0) to (3.0,0.0). You have now created a "line" charge. **Discuss how the resulting electric field pattern differs from the pattern from the electric filed of the point charge and the dipole.**

Measure the electric field at (0.0,0.4), (0.0,0.8), (0.0,1.2), (0.0,1.6), (0.0,2.0), (0.0,2.2) and record the values and locations in a table. **Make a graph of the electric field versus perpendicular distance from the line charge (y). Does the magnitude of the electric field for the line charge exhibit $1/r^2$ behavior? (Hint try plotting E versus 1/y, $1/y^2$, etc. and see which gives you a strait line.) Discuss.**

Measure the electric field at (0,1) and compare this value to the field calculated using the formula $E = 2k\left(\frac{Q}{L}\right)\frac{1}{y}$, where y is the perpendicular distance to the line and L is the length of the line.

Extra Exercise:

Add a charge of –Q to location (-1,0) and a charge +2Q to location (1,0). Using Coulomb's Law and the Component Method of Vector Addition, determine the magnitude and direction of the electric field at (-1,1). Compare your magnitude and direction to that determined by the applet.