Physics 305
name________________________

Lab E02--Electric Fields Activity block ______
date _______

1/28/03

EMfield Instructions

EMfield is an interactive program that lets you select charges and currents, arrange them how you want, and then view the electric fields (and magnetic fields) around them. To download EMField to your computer, go to T:\Software\Physics\EMField. Just double click on the Setup.exe icon and accept the defaults. EMField is also available on the hard drives in lab 2, Physics floor.

Electric Fields

1. **Getting used to the software**. Go to *Sources,* then *3D point charges*. You'll see a line of red circles with numbers in them at the bottom of the screen; these are the point charges, and the numbers are their charge magnitudes (with no units … a real shame). Drag one of the charges onto the screen. What do you think the field will be like? Click somewhere around the charge; notice that the bottom of the screen changes to show the length of a field vector of magnitude one; click on more places around the charge (near, far). Also notice that you can click and drag the charge to change its position, and click and drag around the charge to see the field vector at different points. If your screen gets messy, clear it by going to *Display* and then *Clean up screen*. Also, you can display a grid by going to *Display … Show grid*.

A. Clear the screen, show the grid, and click at a gridpoint close to the charge. Notice the length of the field vector at that location. How big should the field be at one horizontal or vertical gridpoint away from your original click? Why? Try it; were you right? (hint: this is a ratio problem). Show below your calculation of the length of the field vector at the new location. Call the instructor or a lab assistant over to check your work once you have made and tested your prediction.

B. According to Coulomb's Law, the magnitude of the electric field of a point charge Q is given by

$E = k\,Q/d^2$. The software assumes that the distance d is measured in units of grid boxes, and that the charge Q does not have any units (it is just a number). Now look at the length of the field vector at one of your locations. Using the values of Q and d for your point charge, and the length you measure for the field vector, determine the value of the constant k used by the software. Show your work below.

2) Drawing field lines

Do parts II A,B and C (on the following pages) using these basic instructions.....

First, clear the screen, and go to *Field and Potential … Field lines*.

Place one or more charges as directed on the screen.

Try clicking around in different areas to see the field as a whole (15-20 clicks around each charge will be enough). How would you find the direction of the force on a positive test charge placed at any point in the diagram? Use your answer to add the arrowheads to the field lines in your report.

Part II: A. Dipole Field (two equal but opposite point charges) Place two equal but opposite point charges a distance apart on the screen. Create the field lines. Sketch the field shape and direction in the space provided.

Describe how you know where the field is strongest. Where is this in this field?

Describe how you know where the field is weakest. Where is this in this field?

Print out your computer screen with the field line pattern for the dipole. Then do the following on your printed version:

1. Locate a point on the diagram that is equidistant from the two charges, but ***not*** along the line connecting the charges. Label that point P.

2. Calculate the magnitude of the electric field of ***one*** of the point charges, at the location P. Assume that the units for the magnitude of the charge are micro-Coulombs. You will need to use a ruler to measure the distance to point P from the charge. Show your measurement and calculation (including units for all numbers) on your printout, below the field line pattern. We are using real metric units for all numbers here, not the software's units.

3. On your printout, draw the two electric field vectors (one for each charge) at point P. You will need to choose a scale (for example, a vector 1 cm long might correspond to a magnitude of 1000 N/C). Choose your scale so that the vectors you draw are large (at least 3 or 4 cm long). Indicate next to your diagram what scale you chose.

4. Use the graphical (tip-to-tail, or parallelogram) method of vector addition to add the two electric field vectors and thereby obtain the net electric field vector at point P. Show your method clearly on the diagram.

5. Answer this question on your printout: What relation should there be between the net electric field vector at any point on the diagram, and the electric field line at that same point ? Does that relation seem to be true at point P ?

6. If you have time, repeat steps 1-5 for a different point on the diagram (point R) that is a different distance (but still equidistant) from the two charges. How should the magnitude of the net electric field at point R compare to the magnitude at point P ? How should the difference in those magnitudes be noticeable in the electric field line pattern ?

B. **Two opposite but unequal point charges** Place two opposite point charges, one with four times the magnitude of the other, a distance apart on the screen. Create the field lines. Sketch the field shape and direction in the space provided.

Describe how you know where the field is strongest. Where is this in this field? Hint: It may be easier to tell if you try moving the two charges closer to one another (or farther apart).

Describe how you know where the field is weakest. Where exactly is this in this field? (hint: is there any location where the net electric field should be ***zero*** ?). Show below any calculations you used to find the location. Be sure to include a vector diagram showing the electric fields of the individual charges at the location in question.

What would be the force on a positive charge placed at the location you identified in the last question ?

How is the dipole field when the charges are not equal in magnitude different from the field when the charges had the same magnitude ?

C. Two identical positive point charges Place two equal positive point charges a distance apart on the screen. Create the field lines. Sketch the field shape and direction in the space provided.

Where is the field strongest?

Where is the field weakest? If you think the field is zero at some location, prove this below using a vector diagram and calculation.

3) Playing the Challenge game

Now go to *Option … Challenge game*, and click on *Find 1 hidden point charge*. Notice that you can't choose field lines from the *Display* menu anymore … why? Click around until you think you've found the charge, then drag the marker at the bottom to the point where the charge is. (Hint: What should happen to the field vectors far away from a charge? What about close to a charge?) If you make a mistake, you can go to *Challenge … Remove marker*. Clean up the screen. What sign does the charge have to be? How do you know? Try to estimate the magnitude of the charge. (Hint: the grid tells you the distance from a charge … and a grid distance of 1 is the same as the length of the unit field vector … so you can measure the magnitude of a field vector). When you think you have the charge's sign and magnitude, go to *Challenge … Estimate amount of charge*, and click on the charge. Enter your estimated value. Go to *Challenge … Judge* to see if you were right.

Analysis.....

Part I: A. Dipole Field (two equal but opposite point charges) Place two equal but opposite point charges a distance apart on the screen. Create the field lines. Sketch the field shape and direction in the space provided.

Picture:

Sign of charges indicated

Enough lines but not too many

Arrows on all lines

should have up-down and left-right symmetry

same # of lines touching each charge

Describe how you know where the field is strongest. Where is this in this field?

Strongest where lines are most closely spaced.

Strongest where positive test charge feels largest net electrical force.

Near either charge, along the line joining them.

Describe how you know where the field is weakest. Where is this in this field?

Weakest where lines are most spaced.

Weakest where positive test charge feels smallest net electrical force.

Far from either charge

B. Two opposite but unequal point charges Place two unequal but opposite point charges a distance apart on the screen. Create the field lines. Sketch the field shape and direction in the space provided.

Picture:

Sign of charges indicated

Magnitude of charges indicated

Enough lines but not too many

Arrows on all lines

should have up-down symmetry

more lines touching larger charge

Describe how you know where the field is strongest. Where is this in this field? Hint: It may be easier to tell if you try moving the two charges closer to one another (or farther apart).

Strongest where lines are most closely spaced.

Strongest where positive test charge feels largest net electrical force.

Close to larger of the two charges along the line joining them.

Describe how you know where the field is weakest. Where is this in this field? (hint: is there any location where the net electric field should be zero ?)

weakest where lines are most spaced.

weakest where positive test charge feels smallest net electrical force, in this case zero net force.

To the outside of the smaller charge where there is an obvious gap in field lines

Show below any calculations you used to find the location. Be sure to include a vector diagram showing the electric fields of the individual charges at the location in question.

What would be the force on a positive charge placed at the location you identified in the last question ?

How is the dipole field changed when the charges are not equal in magnitude?

Part of the symmetry is lost, though the BASIC shape is rather the same as before

C. Two identical positive point charges Place two equal positive point charges a distance apart on the screen. Create the field lines. Sketch the field shape and direction in the space provided.

Pictures:

Enough lines but not too many

Arrows on all lines

should have up-down and left-right symmetry

same # of lines touching each charge

Where is the field is strongest?

Strongest where lines are most closely spaced.

Strongest where positive test charge feels largest net electrical force.

Near either charge, "outside", along the line joining them.

Where is the field weakest?

Weakest where lines are most spaced or non-existent.

Weakest where positive test charge feels smallest net electrical force, in this case zero net force.

Exactly halfway between the two charges.

If you think the field is zero at some location, prove this below using a vector diagram and calculation.