UNIT I - Electric Field Exploration

Launch the "Charge and Fields" program from the PhET simulation website. From the homepage of the website, click on the *Electricity, Magnets, and Circuits* simulations on the left. Click on the *Charge and Fields* simulation and select "Run Now!"
If the screen begins to get too crowded with E-field sensors or charges, simply drag the unwanted sensors or charges back to their corresponding box in the upper right hand corner of the screen or click the red button "Clear All" to delete everything on the screen.
You can improve your estimation of distances on the screen and magnitude of the field by adding a background grid. Do this by selecting the box next to "grid" on the right.

I - Exploring field around a point charge

Place a +1nC charge *centered on a grid dot* in the middle of your screen.

1. Drag an "E-Field Sensor" out onto the grid and while holding the mouse button down, drag your sensor around the charge. What do you notice about:
    a) the direction of the arrow at all times?

    b) the magnitude of the vector (the length of the arrow) as you move farther away from the charge?

    What does this arrow represent?

2. When you release the mouse button, the field vector will remain on the screen.

    a) Place three more electric field sensors so that they create 3 more vectors of identical length. What do the four points have in common?

    b) Place a vector 5 gridmarks from the point charge. Now, place a second vector 10 gridmarks from the charge. Compare the length of the two vectors. What can you conclude about the relationship between electric field strength and distance?

    c) If you place a vector 15 gridmarks from the point charge, how will it compare in size to the first vector? Test your prediction.

3. The diagram to the right shows the electric field lines generated by a <u>positive point charge</u>.
   a) What information is missing in the "field line" diagram that was given by the field vector diagram?

   b) Predict the relationship between the *field strength* and the *spacing of the field lines* at a given point in this representation
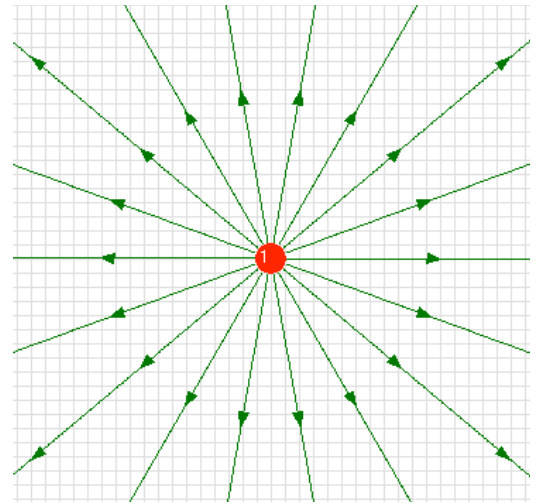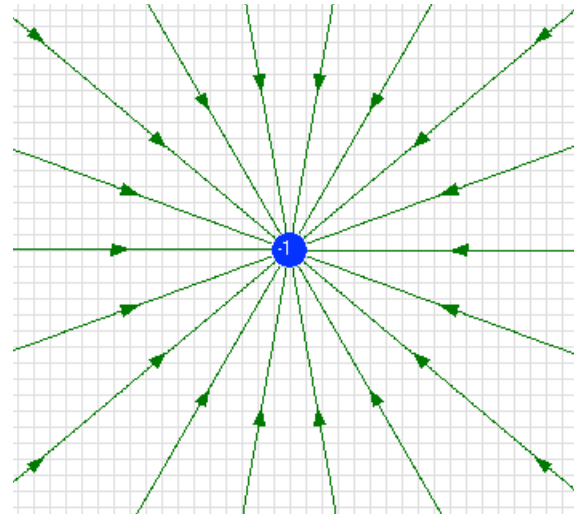
4. Back in the Charges and Fields simulation, clear the screen and place a -1nC charge in the center of the screen.
   Repeat the investigations in steps 1 – 3. Record your observations.
   Step 1

   Step 2

   Step 3 (see the diagram to the right)
   In what ways are the field vectors and field lines the same? How are they different?

5. Erase the field lines. Place a +1nC and a −1nC charge on the screen 20 gridmarks apart. Use the E-field sensors to probe the electric field around the two charges. After completing your exploration, answer the following questions:
   a) In what place or places is the field the strongest?

   b) In what place or places is the field the weakest?

c) The diagram to the right shows the electric field lines produced by this dipole configuration of charges. (negative on the left and positive on the right)
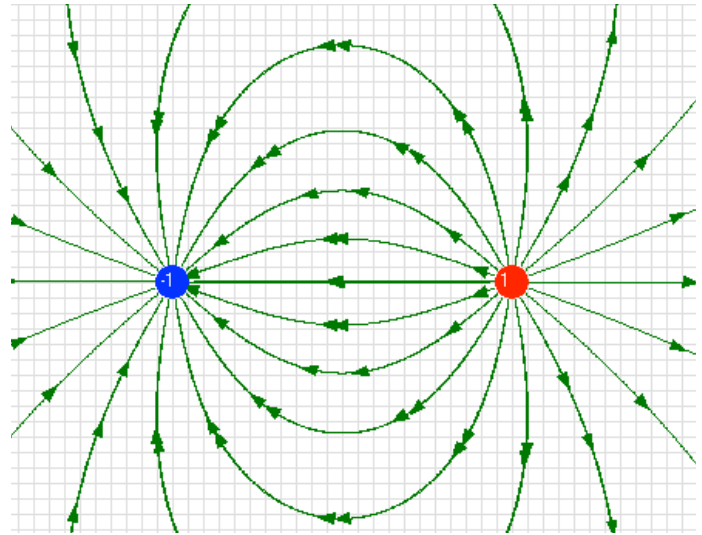
d) Use the E-field sensor to trace along one of the electric field line from + to - charge. *You will have to picture the field lines in the simulation and trace along the imaginary path.* Describe how the direction of the field vector changes as you move from one charge to the other. Describe how the magnitude of the field vector changes.

6. Clear the simulation and place two +1nC charges 20 grid marks apart. Use an E-field sensor to probe the electric field around the two charges. After completing your exploration, answer the following questions:

a) You will find the field is weak far from the positive charges. Where else is the field very weak (even zero) in strength?

b) If you placed a small positive charge halfway between the two +1nC charges, how would it move?

c) Describe as best you can the general direction of the field.
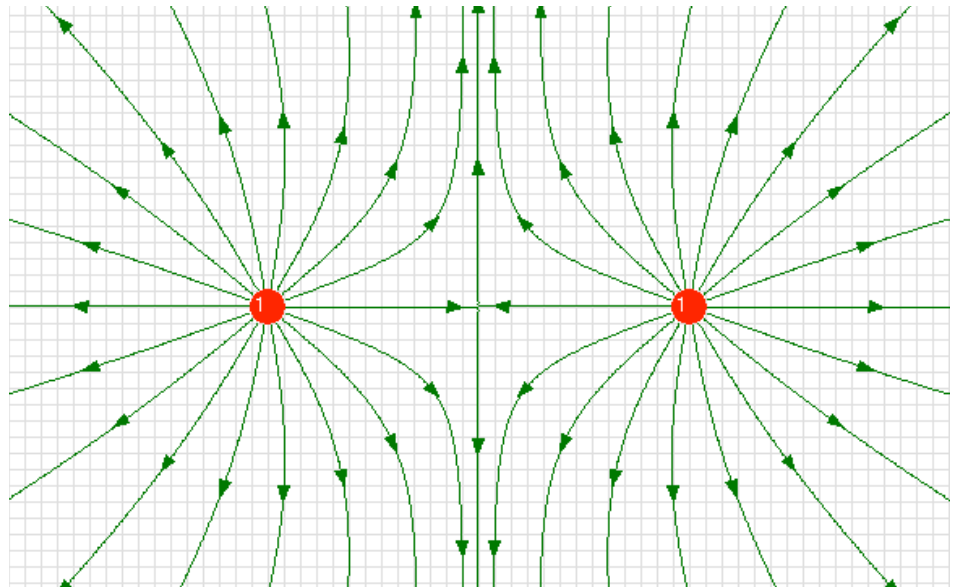
d) The field lines around a single charge are always straight. Why do the lines curve in this case?

II – Exploring the field around charged parallel plates

> While the software does not create plates, we can approximate a plate by lining up a number of rods of charge. To save time this has been created for you.

1. The diagram below shows two charged parallel conductive plates and the resulting electric field lines.

    a. What is the charge on the top plate?

    b. What is the charge on the bottom plate?
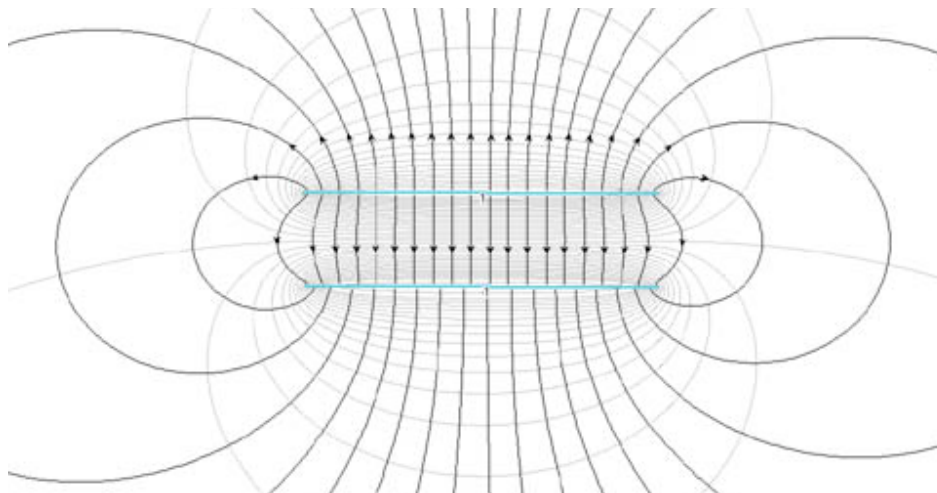
2. Observe the electric field lines between the two conductive plates, near the center of the plates.
    a) What is true about the density of the field lines in this area?

    b) What does this indicate about the nature of the field in this area? *Hint: this was explored in 3b.*

3. Now observe the regions between the plates that are closer to the edges of the plates.
    a) What is true about the density of the field lines in these areas?

    b) What does this indicate about the nature of the field in these areas?

4. Go to the following simulation of two charged parallel plates
    (**http://www.falstad.com/emstatic/**). Under the setup menu select "Charged Planes" and uncheck the box next to "Draw Equipotentials". *The shading of the electric field vectors represent the relative strength of the electric field at that location in space.*
    a) What can you tell about the strength (and direction) of the electric field?

5. Suppose you were to place a small positive charge close to the positive line of charge
    a) Describe the motion of the charge. *Be as specific as possible about the type of motion you would observe.*

    b) Describe the energy changes of the charge as it moves.