

UNIT I - Electric Field Exploration

Run the PhET simulation *Charge and Fields*.¹

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 boxes 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 $+1\text{nC}$ 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?

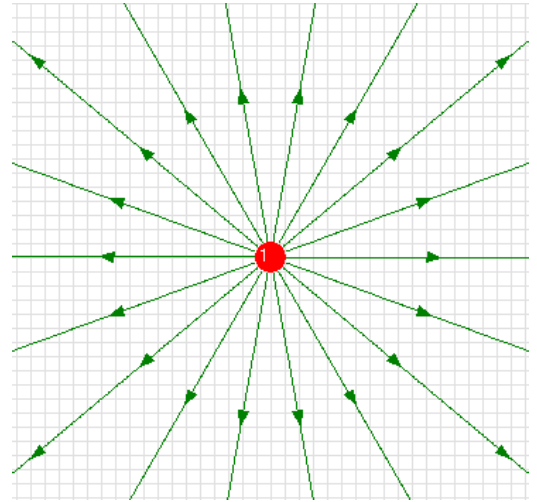
What does this arrow represent?

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 to the right of the point charge. Now, place a second vector 10 gridmarks to the left of the point 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 below the point charge, how will it compare in size to the first vector? Test your prediction.
3. Place another $+1\text{nC}$ charge on top of the first to make it a $+2\text{nC}$ charge.
 - a) What happens to the strength of the electric field at the location of each sensor? (You may not be able to use the grid at the first location.) What can you conclude about the relationship between electric field strength and the magnitude of the point charge?
 - b) Predict what will happen to the length of the electric field vectors if you place a third $+1\text{nC}$ charge at the center. Was your prediction correct?

¹ You can run the simulation directly from the PhET website <https://phet.colorado.edu/en/simulations/category/physics> or download the Java applet to your computer and run it locally.

4. In your mapping lab you found that the field around a positive charge had the appearance shown below.

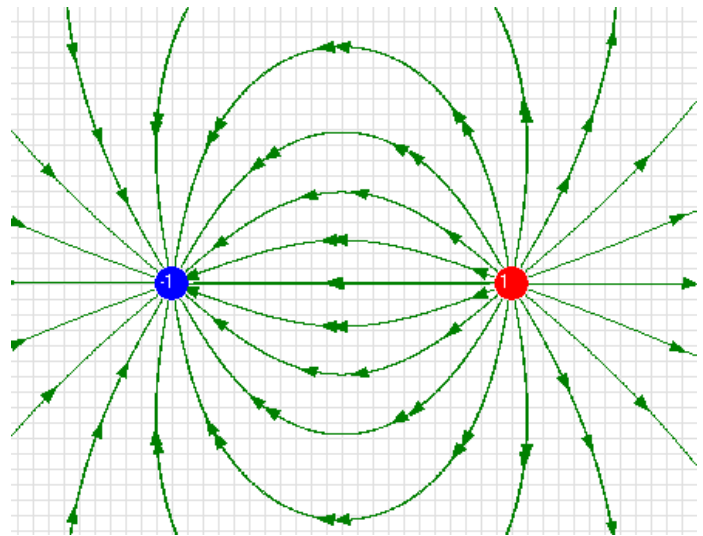
- a) What information is missing in the "field line" diagram that was given by the field vector diagram?
- b) Predict the relationship between the *field strength* and the *spacing of the field lines* at a given point in this representation



5. Erase the field lines. Place a $+1\text{nC}$ and a -1nC charge on the screen 20 gridmarks apart. (Such a configuration of charges is called a dipole)
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.

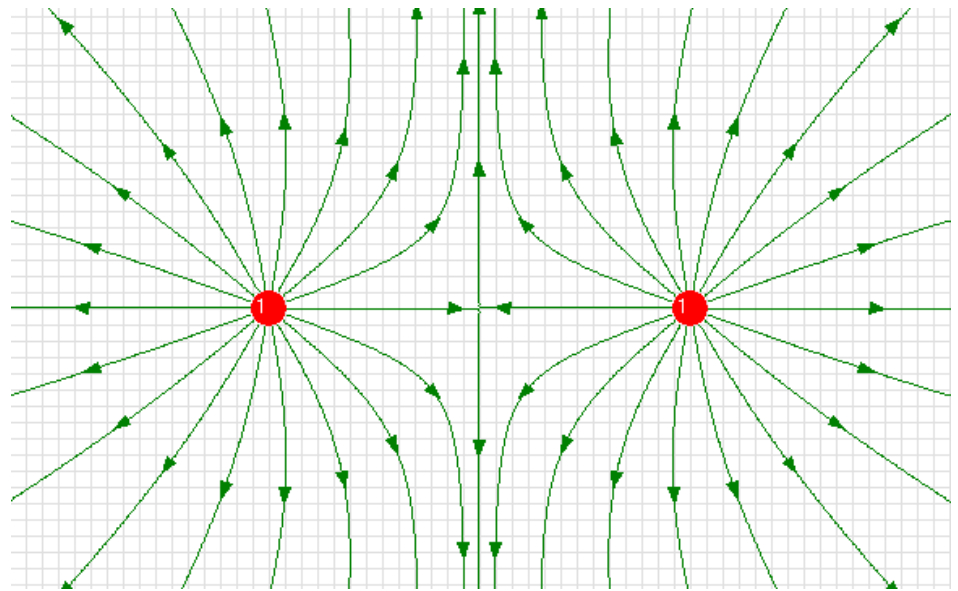
6. Clear the simulation and place two $+1\text{nC}$ charges 20 grid marks apart. Use an E-field sensor to probe the electric field around the two charges. After completing your exploration, answer the following questions:

- 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 test charge halfway between the two $+1\text{nC}$ 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? Suggest a possible "rule" about the behavior of field lines in this case.

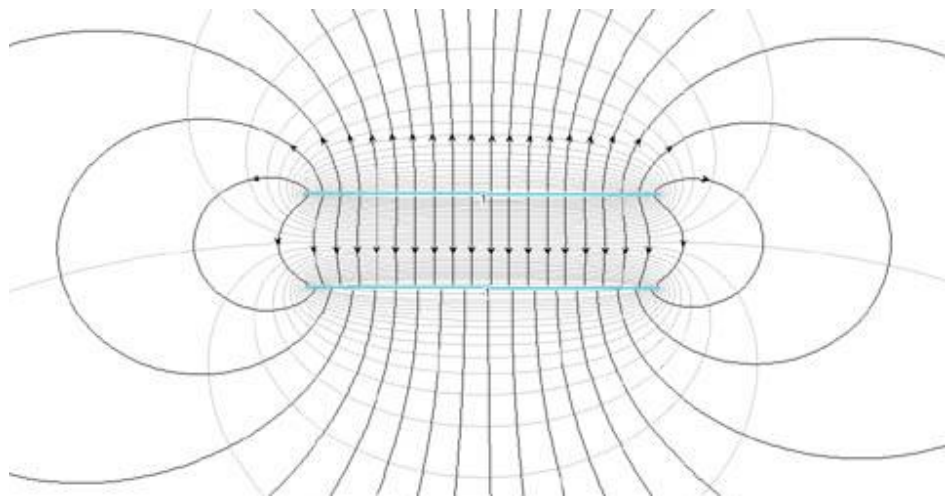


II – Exploring the field around charged parallel plates

Due to inability of the software to show the electric field for plates of charge, the diagram below has been provided for you.

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

From the direction of the field lines deduce the charge of the top and bottom plates.



2. Observe the electric field lines between the two conductive plates, in the middle third of the plates.

a) What do you observe about the density of the field lines in this region?

- 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 ends of the plates.
- a) What do you observe about the density of the field lines in these regions?
- b) What does this indicate about the nature of the field in these regions?
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”.
Note: *The shading of the electric field vectors represent the relative strength of the electric field at that location in space. White arrows indicates a strong field, bright green indicates a medium field strength and dark green is a weak field.*
- a) What can you tell about the strength (and direction) of the electric field?
- b) What happens to the field strength around the plates if the plates are brought closer together? (To do this, place the cursor on a plate, hold down the left mouse button and move the plate.)
5. Suppose you were to place a small positive charge between the two plates, close to the positive plate.
- a) Describe how you would expect the charge to move. *Be as specific as possible about the type of motion you would observe, include what happens to the speed and the acceleration.*
- b) Describe how the kinetic energy of the charge changes as it moves.