Name_____ Date_____

Electric Field Worksheet 1

Electric Field

The field that exists around any charged object. The forces exerted by electric fields can do work, transferring energy from the field to another charged object. This energy is something you use on a daily basis, whether you plug an appliance into an electric outlet or use a battery-powered, portable device.

The direction of an electric field is the direction of the force on a positive test charge. The magnitude of the electric field strength (E) is measured in newtons per coulomb, **N/C**.

Electric Field Lines

Electric Field lines provide a picture of the electric field. They are directed away from positive charges and toward negative charges. They never cross, and their density is related to the strength of the field.

The magnitude or strength of an electric field in the space surrounding a source charge is related directly to the quantity of charge on the source charge and inversely to the distance from the source charge. The direction of the electric field is always directed in the direction that a positive test charge would be pushed or pulled if placed in the space surrounding the source charge. Since electric field is a vector quantity, it can be represented by a vector arrow.

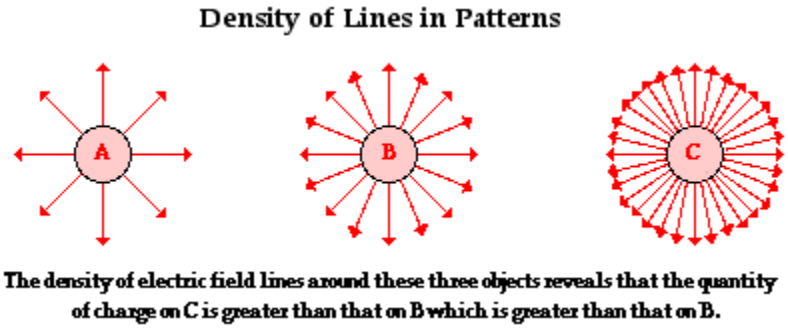
A more useful means of visually representing the vector nature of an electric field is through the use of electric field lines of force. Rather than draw countless vector arrows in the space surrounding a source charge, it is perhaps more useful to draw a pattern of several lines which extend between *infinity* and the source charge. These pattern of lines, sometimes referred to as **electric field lines**, point in the direction which a positive test charge would accelerate if placed upon the line. As such, the lines are directed away from positively charged source charges and toward negatively charged source charges. To communicate information about the direction of the field, each line must include an arrowhead which points in the appropriate direction. An electric field line pattern could include an infinite number of lines. Because drawing such large quantities of lines tends to decrease the readability of the patterns, the number of lines are usually limited. The presence of a few lines around a charge is typically sufficient to convey the nature of the electric field in the space surrounding the lines.

Electric Field Lines for Two Source Charges

Negative Source Positive Source

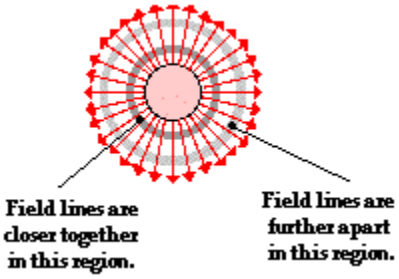
Rules for Drawing Electric Field Patterns

One common convention is to surround more charged objects by more lines. Objects with greater charge create stronger electric fields. By surrounding a highly charged object with more lines, one can communicate the strength of an electric field in the space surrounding a charged object by the line density. This convention is depicted in the diagram below.



The density of electric field lines around these three objects reveals that the quantity of charge on C is greater than that on B which is greater than that on B.

Not only does the density of lines surrounding any given object reveal information about the quantity of charge on the source charge, the density of lines at a specific location in space reveals information about the strength of the field at that location. Consider the object shown at the right. Two different circular cross-sections are drawn at different distances from the source charge. These cross-sections represent regions of space closer to and further from the source charge. The field lines are closer together in the regions of space closest to the charge; and they are spread further apart in the regions of space furthest from the charge. Based on the convention concerning line density, one would reason that the electric field is greatest at locations closest to the surface of the charge and least at locations further from the surface of the charge. Line density in an electric field line pattern reveals information about the strength or magnitude of an electric field.



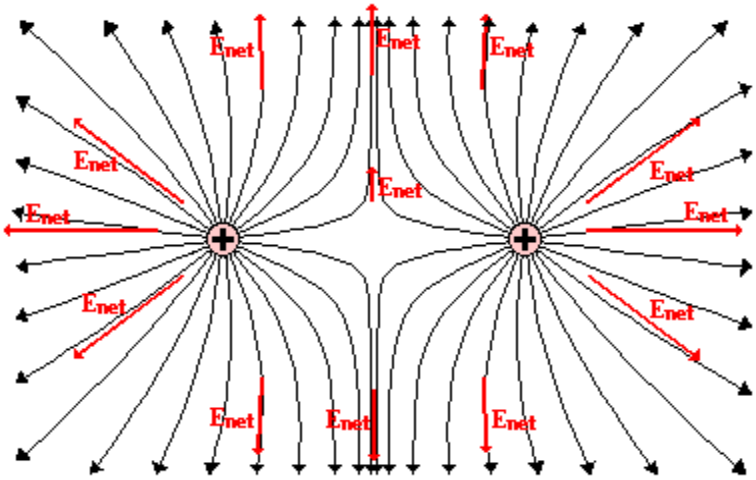
A second rule for drawing electric field lines involves drawing the lines of force perpendicular to the surfaces of objects at the locations where the lines connect to object's surfaces. At the surface of both symmetrically shaped and irregularly shaped objects, there is never a component of electric force which is directed parallel to the surface. The electric force, and thus the electric field, is always directed perpendicular to the surface of an object.

A final rule for drawing electric field lines involves the intersection of lines. Electric field lines should never cross. This is particularly important (and tempting to break) when drawing electric field lines for situations involving a configuration of charges. If electric field lines were ever allowed to cross each other at a given location, then you might be able to imagine the results. Electric field lines reveal information about the direction (and the strength) of an electric field within a region of space. If the lines cross each other at a given location, then there must be two distinctly different values of electric field with their own individual direction at that given location. This could never be the case. Every single location in space has its own electric field strength and direction associated with it. Consequently, the lines representing the field cannot cross each other at any given location in space.

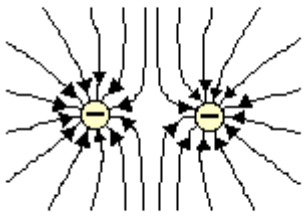
Electric Field Lines for Configurations of Two or More Charges

In the examples above, we've seen electric field lines for the space surrounding single point charges. But what if a region of space contains more than one point charge? How can the electric field in the space surrounding a configuration of two or more charges be described by electric field lines? To answer this question, we will first return to our original method of drawing electric field vectors.

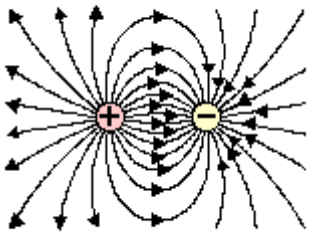
Ultimately, the electric field lines surrounding the configuration of our two charges would begin to emerge. For the limited number of points selected in this location, the beginnings of the electric field line pattern can be seen. This is depicted in the diagram below.



Other Charge Configurations



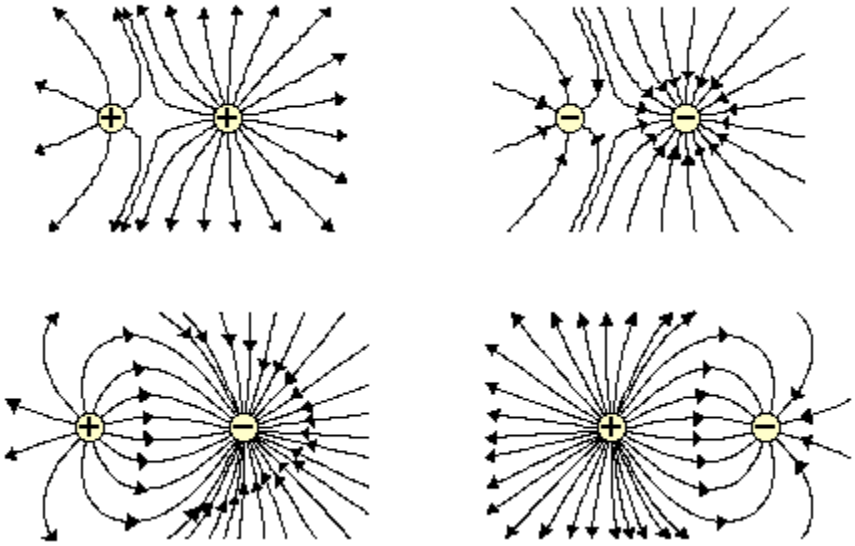
Two Negatively Charged Objects



A Positively and a Negatively Charged Object

In each of the above diagrams, the individual source charges in the configuration possess the same amount of charge. Having an identical quantity of charge, each source charge has an equal ability to alter the space surrounding it. Subsequently, the pattern is symmetrical in nature and the number of lines emanating from a source charge or extending towards a source charge are the same. This reinforces a principle discussed earlier which stated that the density of lines surrounding any given source charge is proportional to the quantity of charge on that source charge. If the quantity of charge on a source charge is not identical, the pattern will take on an asymmetric nature as one of the source charges will have a greater ability to alter the electrical nature of the surrounding space. This is depicted in the electric field line patterns below.

Electric Field Line Patterns for Objects with Unequal Amounts of Charge



After plotting the electric field line patterns for a variety of charge configurations, the general patterns for other configurations can be predicted. There are a number of principles which will assist in such predictions. These principles are described (or re-described) in the list below.

- Electric field lines always extend from a positively charged object to a negatively charged object, from a positively charged object to infinity, or from infinity to a negatively charged object.
- Electric field lines never cross each other.
- Electric field lines are most dense around objects with the greatest amount of charge.
- At locations where electric field lines meet the surface of an object, the lines are perpendicular to the surface.

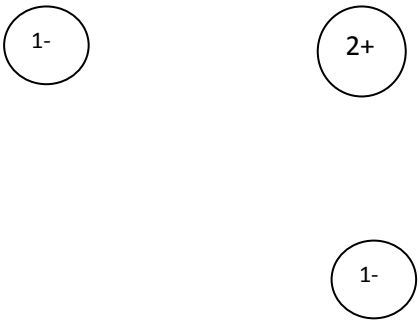
Now it's your turn! Draw Field Lines to fit the rules discussed above.

1)Draw Field Lines

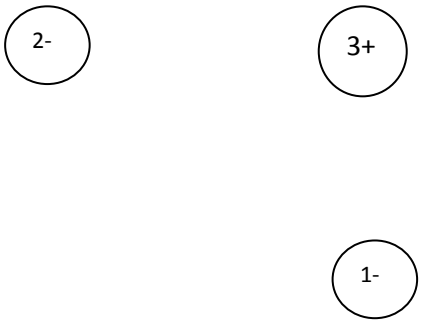
2) Draw Field Lines

3) Draw Field Lines

4)Draw Field Lines



5) Draw Field Lines



6) Draw Field Lines