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Electric Fields and Equipotentials

AP Physics C E&M

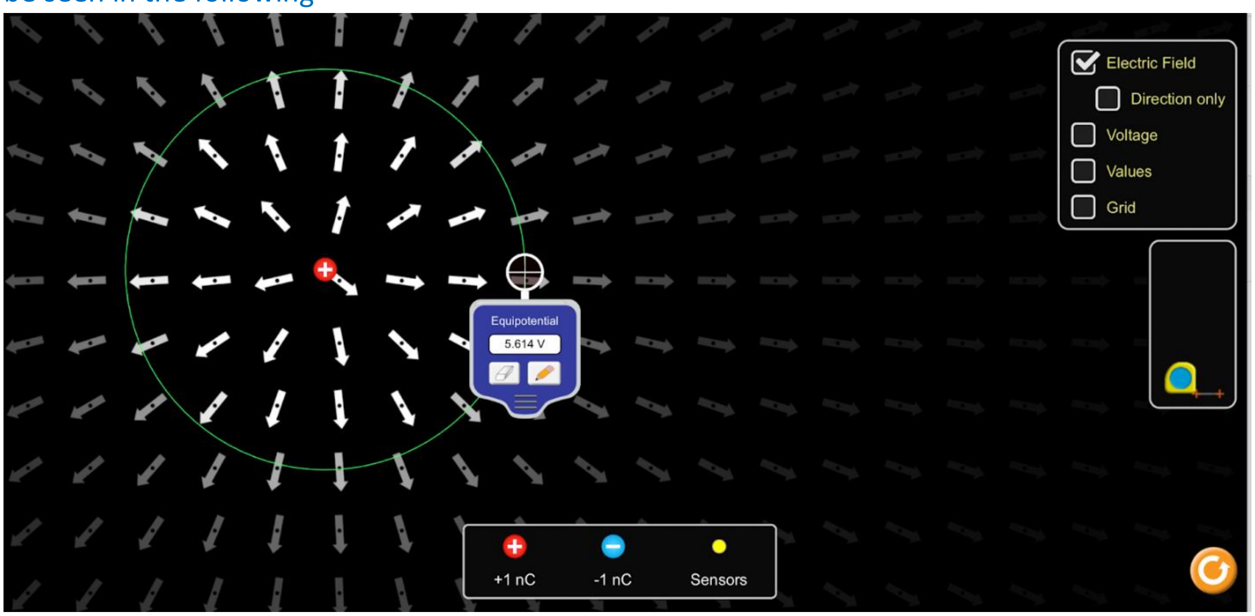
Objective: To describe the electric field of various charge configurations and to determine the motion of a charged particle placed in a uniform electric field. I will also learn how to explain and interpret electric field diagrams by creating electric fields using a computer simulation at https://phet.colorado.edu/sims/html/charges-and-fields/latest/charges-and-fields_en.html .

Procedure/Tasks

This lab is mostly investigative with some comparisons to simple charge configurations. You should start off by adding one point charge to the system (I recommend starting with 1 positive charge) and then gradually create a more complex charge distribution to help you answer the questions below. Please include your answers to the questions below and include screenshots of the charge configurations (including equipotential surfaces) you use in this lab.

The questions you are to answer are as follows:

1. How does the direction of the electric field relate to the equipotential curves? Can you describe a general direction for **E** relative to the surfaces?
   Electric field is perpendicular to equipotential curves -> E is perpendicular to surface. It also points "inside" the surface, toward the side with the negative charges. This can be seen in the following



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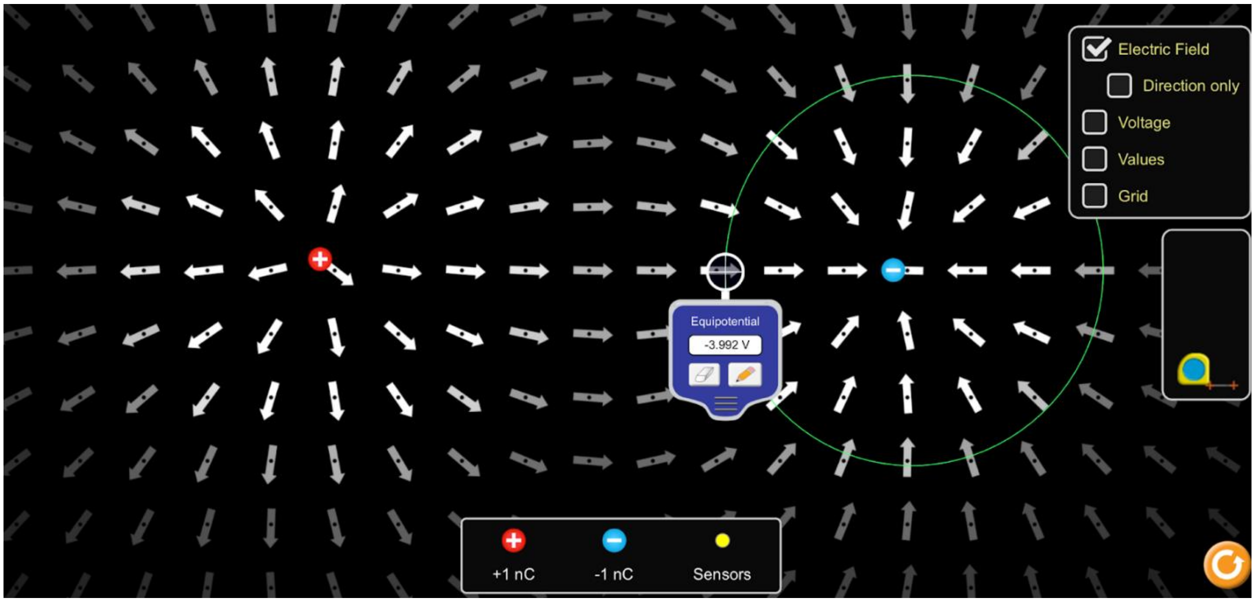
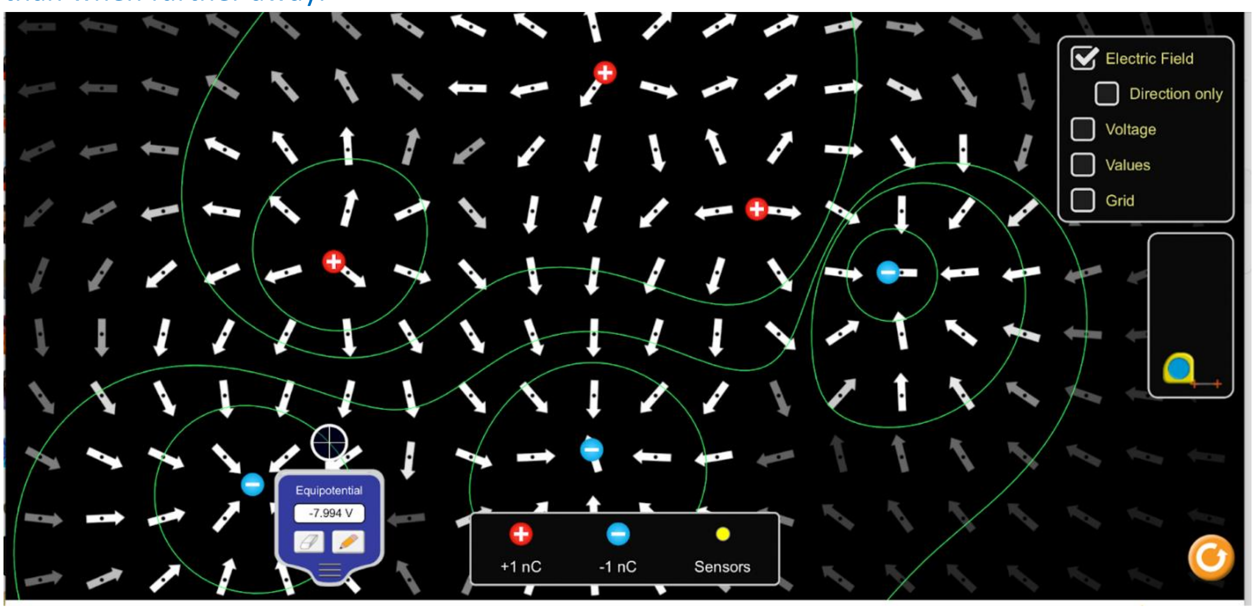


2. Does the magnitude of the electric field stay constant across an equipotential?
   No. The magnitude of electric field is the gradient of the potential. So, with multiple charges, it will not be constant across an equipotential. As seen in the figure below, a single equipotential line between positive and negative charge has higher electric field than when further away.



3. How does the magnitude of the electric field vary with the magnitude of the potential at points, if at all?
   Magnitude of electric field is equal to magnitude of electric potential divided by distance from the point to the source charge when it is a single point charge. When there are multiple charges, the magnitude of the electric field is the gradient of the potential, so it depends on how the potential is distributed across the space. All figures show this is true.

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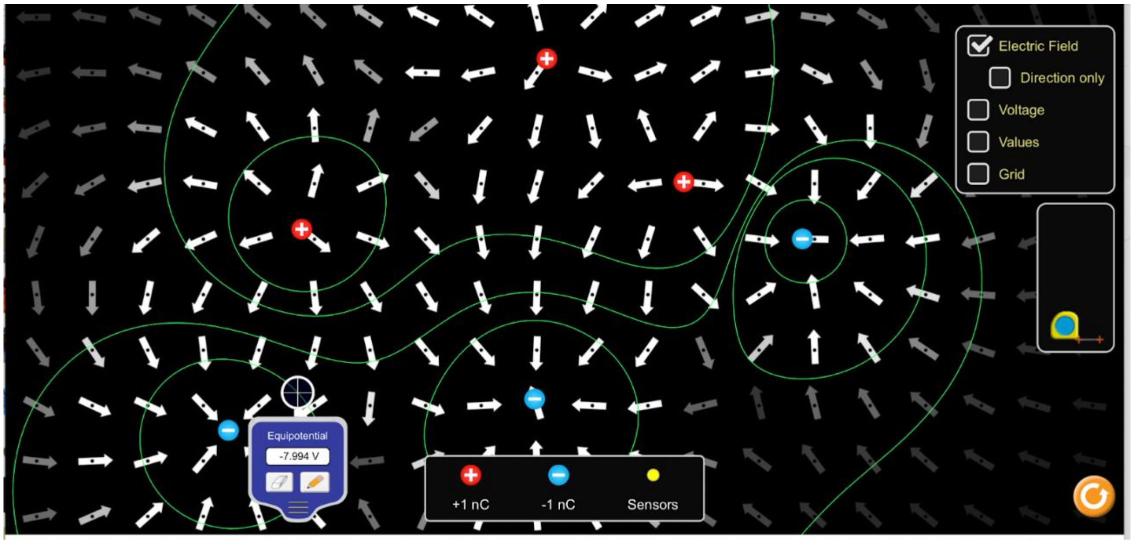
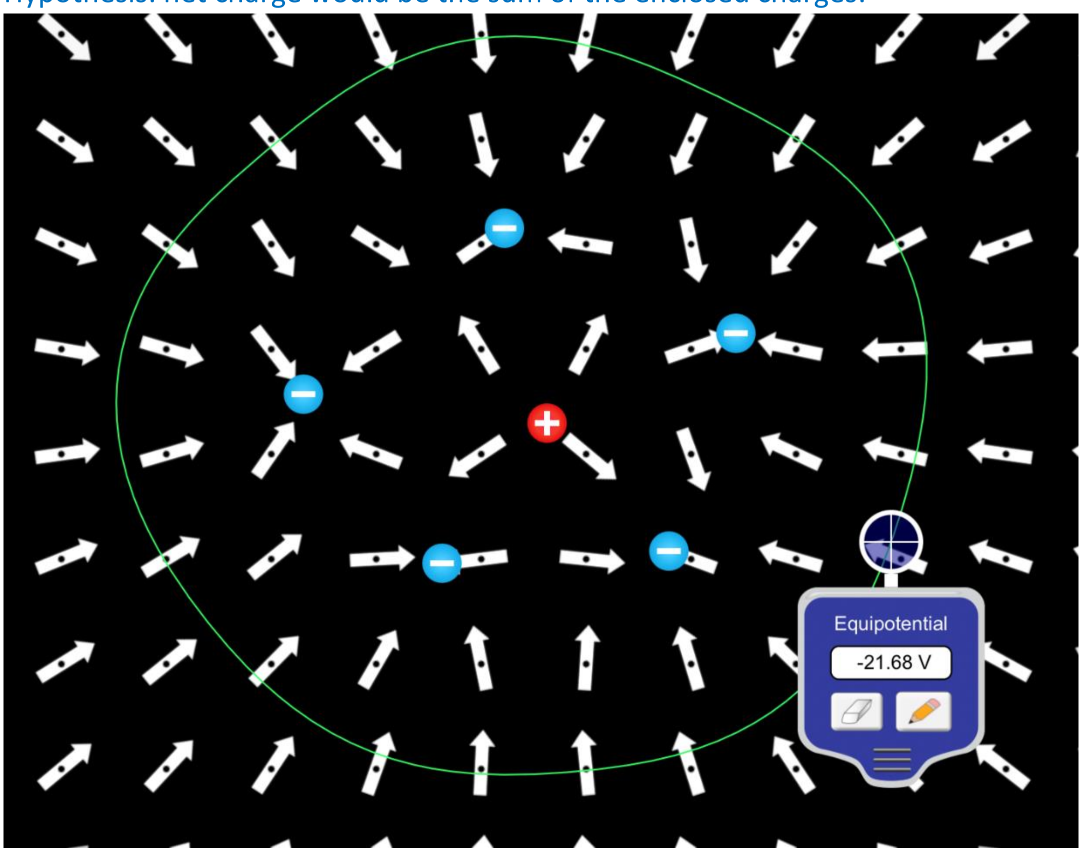


4. Can a closed equipotential surface enclose both positive and negative charges in it, or must it enclose charges of only one sign? Create a hypothesis on what the net charge must be for a surface if it can contain charges of both signs, or describe WHY an equipotential cannot enclose charges of opposite signs in it.
   A closed equipotential surface can enclose both positive and negative charges when the potential for both are the same value, just direction of increase in potential would be opposite.
   Hypothesis: net charge would be the sum of the enclosed charges.



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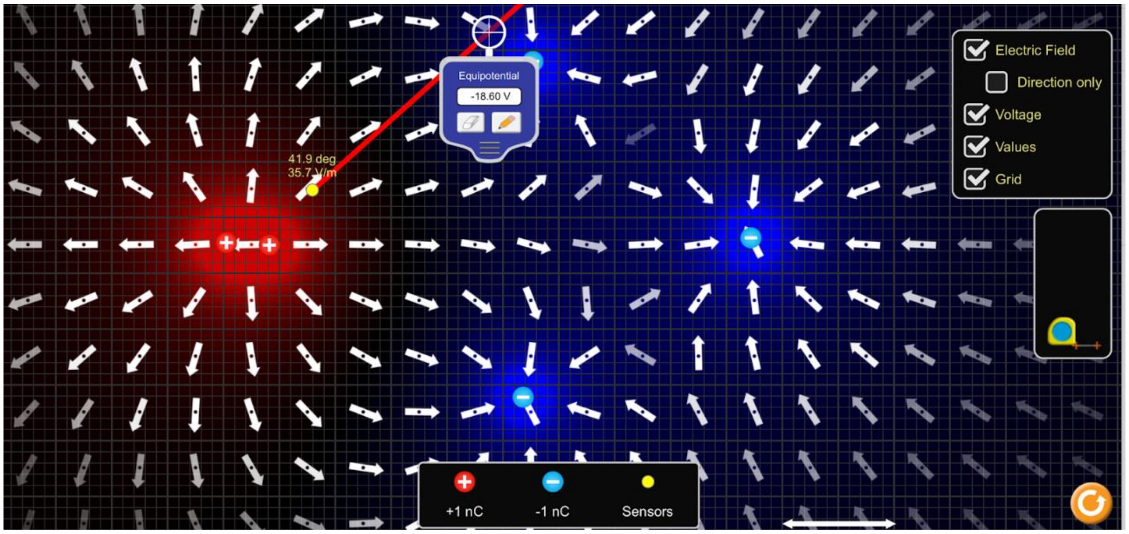
5. Based on the E-field vectors, to what values of potential will a positive charge want to accelerate toward (higher, lower, or 0)? Justify your answer.
   Higher potential to lower potential because the electric field points in the direction of decreasing potential, as shown in the diagram below.



Postlab Questions

1. If you were to draw both equipotential surfaces and electric field vectors on the same diagram, use your findings to summarize how the drawing would look, including directions and how the lines/vectors would be oriented relative to each other.
   Equipotential surfaces would wrap around the charges in a closed surface or spread to infinity in some cases and the electric field vectors would point away from the charge perpendicularly through the equipotential surfaces if the charge is positive or inward if negative.
2. Can 2 equipotential surfaces overlap? Why or why not?
   No because the two equipotential surfaces will have differing electric potential. This will result in two different values at the overlapped part with two different directions of their electric fields, which is impossible. If and only if the 2 surfaces are identical, then they can overlap.