

In **Charges and Fields** students explore electrostatics as they arrange positive and negative charges space and observe the resulting electric field, voltage, and equipotential lines.

OBSERVE the electric field

DRAG charges and sensors out of the toolbox

VIEW the direction of the electric field

MEASURE the distance

Charges And Fields

The screenshot shows a simulation interface with a central area containing two charges: a red '+' charge and a blue '-' charge. White arrows represent the electric field lines, pointing from the positive charge towards the negative charge. On the right side, there is a control panel with checkboxes for 'Electric Field', 'Direction only', 'Voltage', 'Values', and 'Grid'. Below this is a sensor icon showing '0.0 V'. At the bottom, there is a toolbox with '+1 nC', '-1 nC', and 'Sensors' options. A callout box on the right shows a zoomed-in view of the electric field arrows.

MEASURE the electric field at a precise location

PLOT equipotential lines

VIEW the electric potential

CHANGE the background color of the sim to white for projection

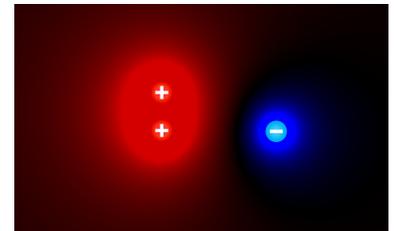
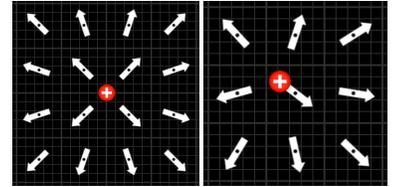
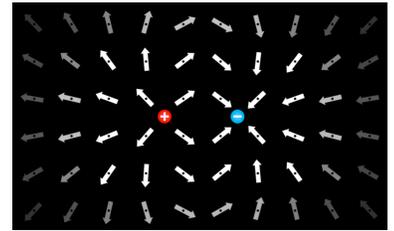
Options...
 PhET Website...
 Report a Problem...
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 Screenshot
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 About...

Charges And Fields

The screenshot shows the same simulation but with a dark blue background. It displays equipotential lines as concentric green circles around the charges. A red arrow points to a specific location where the electric field is measured, showing a value of '152.9 deg' and '22.1 V/m'. Another red arrow points to a location where the electric potential is measured, showing a value of '-110.4 deg' and '8.17 V/m'. The control panel on the right has 'Voltage' and 'Values' checked. A sensor icon shows '3.907 V'. The toolbox at the bottom remains the same. A callout box on the right shows a zoomed-in view of the equipotential lines.

Model Simplifications

- The charges are assumed to be pinned wherever they are placed.
- The electric field is displayed using an array of arrows fixed to a grid. The brightness of the arrows indicates the magnitude of the field. This representation allows for discussion about the direction and magnitude of the electric field.
- The grid is arranged so that if a single charge is placed on a major intersection, the electric field will look like a classic textbook picture (left), whereas a charge placed off the grid may look odd (though still correct) at first glance (right).
- The “Direction only” option removes the brightness gradient from the E-field arrows to allow the direction of the E-field to be explored separately from its magnitude.
- The sensors can be used to detect the precise magnitude and direction of the E-field at any location.
- Charges can be placed on top of one other. If a +/- pair is overlapped, the electric field will become zero. If three or more +/- pairs are overlapped, the sim may experience buggy behavior.
- The electrostatic potential can be displayed using the “Voltage” checkbox. The brighter the color, the larger the magnitude of the voltage. Positive voltages are red, and negative voltages are blue, black represents 0 V (though voltages that are relatively small may also appear black).



Suggestions for Use

Challenge Prompts

- Create a +2 nC (or +3 nC, -2 nC, - 3 nC) charge.
- Predict the direction and size of an E-field sensor before it is placed.
- Determine where the electric field is the greatest for two opposite charges in a line. Is there a point where the electric field is zero?
- Design an experiment to determine the relationship between distance, the magnitude of charge, and the strength of the electric field around a single charge.
- Choose a charge configuration with at least two charges, and predict how the electric field around the charges will look at four different points. Verify the prediction using vector addition.
- Construct a parallel-plate capacitor and examine the electric field between the plates.
- Identify the factors that contribute to a large electric potential (voltage).
- Explore the behavior of the electric field along an equipotential line.

See all published activities for Charges and Fields [here](#).

For more tips on using PhET sims with your students, see [Tips for Using PhET](#).