

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 a positive charge (+1 nC, red) and a negative charge (-1 nC, blue). White arrows represent the electric field lines, pointing away from the positive charge and towards the negative charge. A control panel on the right includes checkboxes for 'Electric Field', 'Direction only', 'Voltage', 'Values', and 'Grid'. Below this is a sensor icon showing '0.0 V'. At the bottom, a toolbox contains '+1 nC', '-1 nC', and 'Sensors' buttons. A callout box on the right shows a zoomed-in view of the 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

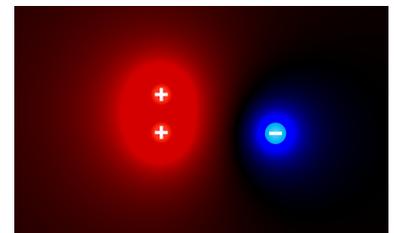
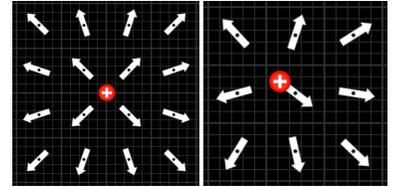
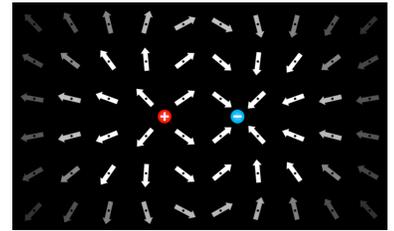
Options...  
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 Report a Problem...  
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 Screenshot  
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Charges And Fields

The screenshot shows the same simulation but with equipotential lines (green) overlaid on the electric field. The positive charge is surrounded by red equipotential lines with values like 15.3 V, 5.6 V, and 3.9 V. The negative charge is surrounded by blue equipotential lines with values like -8.5 V, -19.5 V, and -6.0 V. A red arrow points to a specific location where the electric field is measured as 22.1 V/m at 152.9 degrees. Another red arrow points to a location where the electric field is measured as 8.17 V/m at -110.4 degrees. A sensor icon shows '3.907 V'. The background is dark blue. A callout box on the right shows a zoomed-in view of the field and potential 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](#).