

# Online Games on Equipotential

## Purpose:

Practice calculating electric potential and get an impression for the shape of the equipotential surfaces in configurations with multiple charges. The relation between potential and electric field will also be studied.

## Procedure:

### *Charges and Fields*

1. Google “PhET” and click on the first search result. This should take you to the homepage of the Physics Education Technology. Alternatively you can enter the following address to the web browser directly:  
<http://www.colorado.edu/physics/phet/web-pages/index.html>
2. Click on “Simulations” and then choose from the tabs on the left “Electricity & Circuits”. Scroll down to the “Charges and Fields” simulation, double click it to start the program. You should see something similar to the screenshot in Figure 1.
3. Choose the same options in the lower right green box as the screenshot below. You can drag and place more charges or sensors in the region. They can be removed by dragging them back to their cages. Play with the program a little bit to get a feel for its operation.

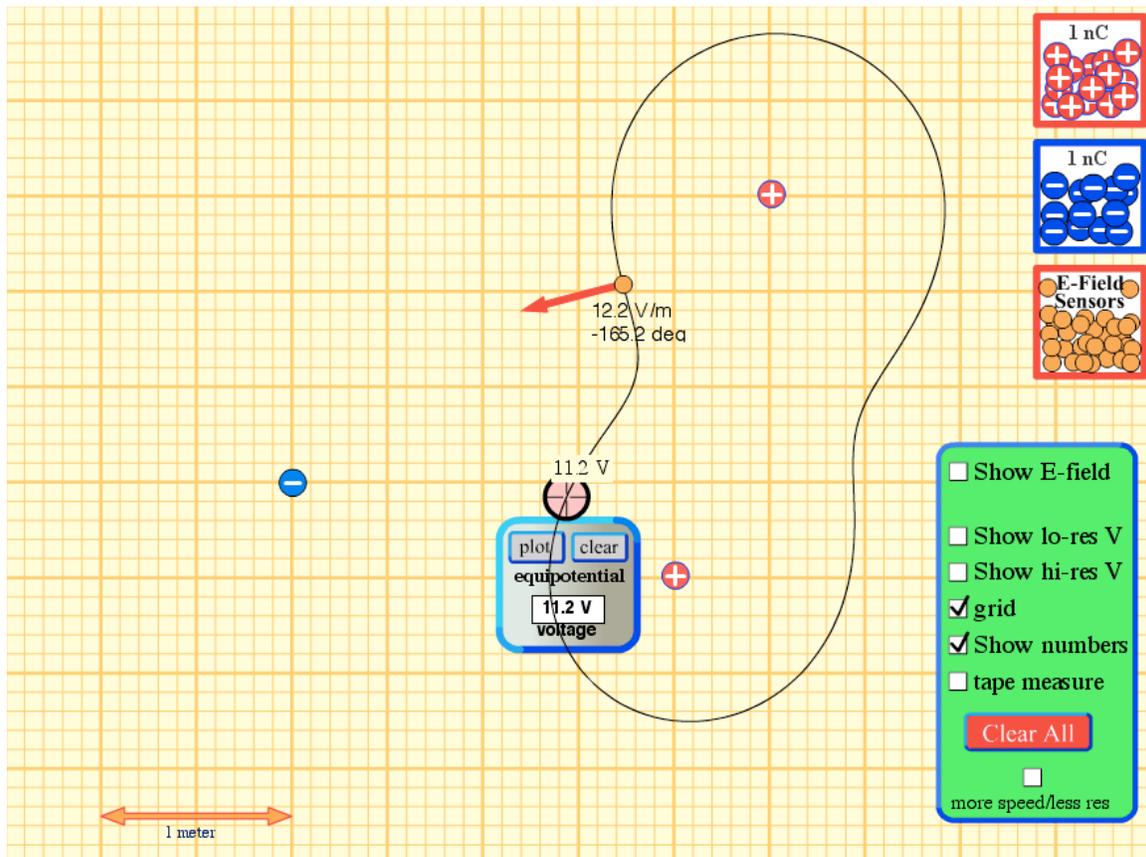


Figure 1

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- Click “Clear All” to clean up the screen. Put a negative charge ( $q = -1nC$ ) in the middle and two sensors (we will refer to these two sensors as A and B below) at different places of your choosing. You can place the charges and sensors at the cross-points of the grid to help you find the distances instead of using the tape measure.
- We will not use the electric field readings on the sensors, rather they will simply serve to mark the points A and B. The potential is measured by the equipotential plotter which you can drag around. You can also move the plotter by pressing the arrow keys for fine adjustments. *Calculate* the potential at A and B and confirm they are the same values given by the potential plotter.
- Press the “plot” button on the plotter to plot a number of equipotentials on the diagram and sketch the diagram. You should plot enough equipotentials to see the overall pattern. Make sure you have one equipotential passing through each sensor. What angle does the electric field vector at the sensor make with the equipotential?
- Repeat steps 5 and 6 for all the charge configurations in Table 1. Calculate (except for the first case) the potential energy of the charge configurations. Sketch (not print!) a diagram for each case, do not forget to write down the distances in the diagram. You can choose where to place the charges and sensors in each case.

**Table 1**

| Charge   |          | Potential at A | Potential at B | Potential Energy |
|----------|----------|----------------|----------------|------------------|
| Positive | Negative |                |                |                  |
| 0        | 1        |                |                | <i>N/A</i>       |
| 2        | 0        |                |                |                  |
| 1        | 1        |                |                |                  |
| 1        | 2        |                |                |                  |

## *Two Parallel Plates*

- Set up your charges as Figure 2 below. Put a sensor in the middle and record the electric field reading.
- Move the potential plotter to where the potential is 0V, plot the equipotentials. Plot another one at  $\pm 10V$ ,  $\pm 20V$ ...etc, so that you have many equipotentials 10V apart. You can stop plotting when you get reasonable close to the plates, where the equipotentials will begin to be packed very close together.
- In the region in the middle, you should see that the equipotential are more or less the same distance apart. Record the separation between the 0V and 10V equipotentials in the middle as  $\Delta x$ .
- Recall that  $\vec{E} = -\vec{\nabla}V \Rightarrow E_x = -\frac{dV}{dx} \approx -\frac{\Delta V}{\Delta x}$ , calculate the electric field by dividing  $\Delta V = 10V$  by  $\Delta x$ . Compare the result with the reading you took in step 1 using the sensor. Are these values close? What is the percentage difference?

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5. Sketch the equipotentials.

6. Use the fact that the electric field is always perpendicular to the equipotentials, draw the electric field lines.

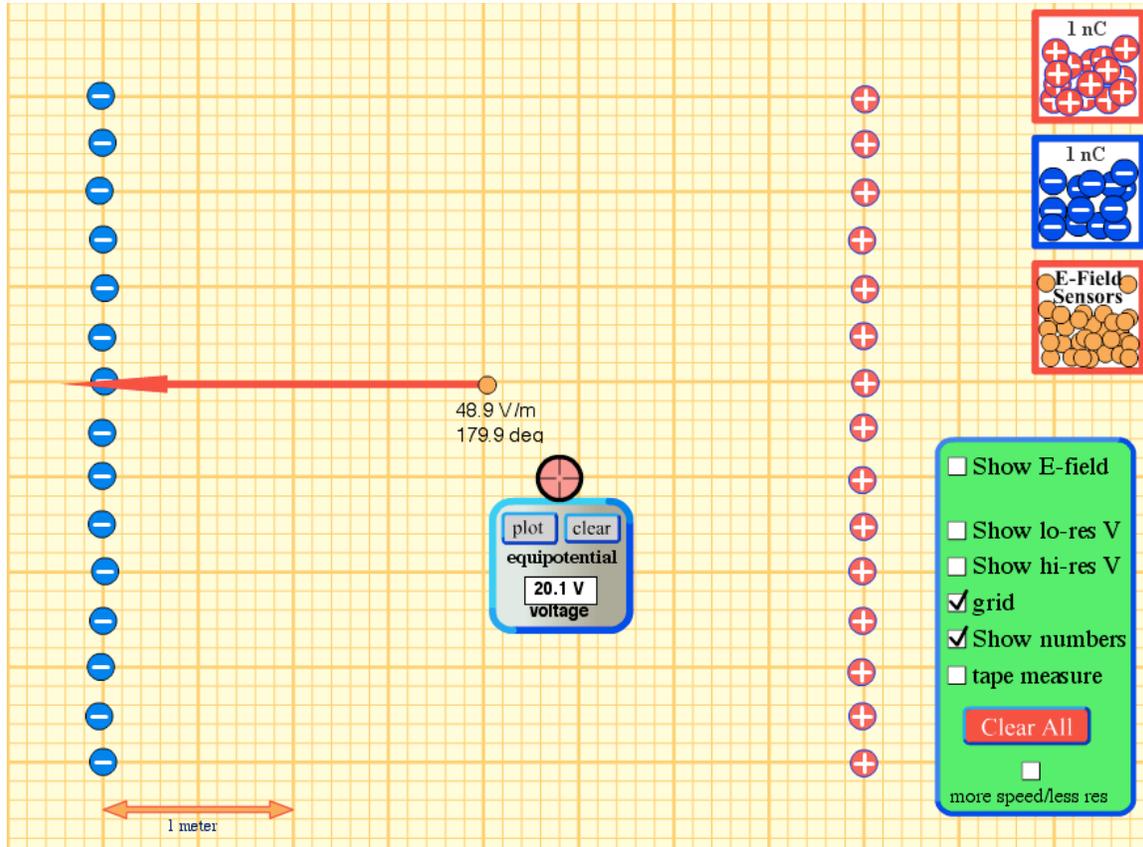


Figure 2