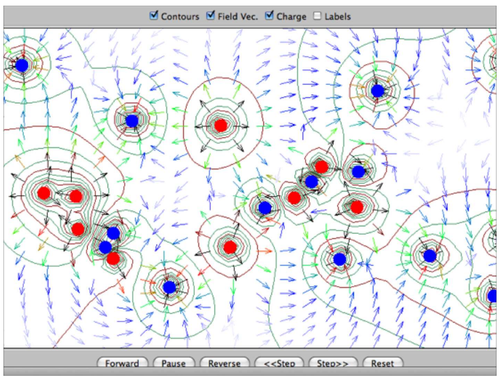
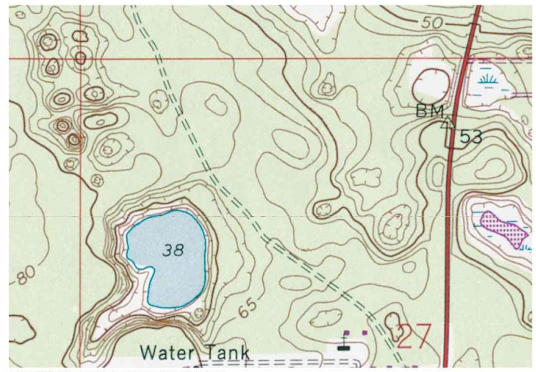
University of Calgary

Department of Physics and Astronomy

PHYS 259, Winter 2021

Lab 4: Electric Potential





The figure on the left shows equipotential lines (i.e., lines of constant electric potential) for a distribution of charges that was created with the applet charges_generator that you have used before. The figure on the right shows contour lines (i.e. lines of constant elevation) for a landscape. Both figures give you, for example, information about the direction of steepest descent. Both physical situations can be described using the same mathematical tools.

Learning Goals:

To understand the relationship between the electric potential and the electric field. To understand and be able to draw different graphical representations of the electric potential. To understand equipotentials.

Preparation:

Halliday, Resnick, and Walker, "Fundamentals of Physics" 10th edition, Wiley: 24.1-7. Complete the pre-lab assignment before coming to the lab.

Equipment:

PhET Simulation "Charges and Fields"

https://phet.colorado.edu/sims/html/charges-and-fields/latest/charges-and-fields_en.html

Pre-Lab Assignment

In this pre-lab assignment, you will answer some preliminary questions related to the preparatory textbook reading (sections 24.1–24.7). There is no at-home experiment to do and no equipment needed to complete it. Part of the pre-lab assignment involves watching the introductory video posted to D2L before attending your lab section, but you should be able to answer the following questions without having first watched the video. This video will be available on D2L by the latest on the afternoon of Friday February 12.

Question 1: Assume that the electric field between two charged parallel plates has a magnitude of 200 V/m. Find the change in the electric potential from one point to another in the electric field, for the following three cases:

a) 20 cm in the direction of the electric field

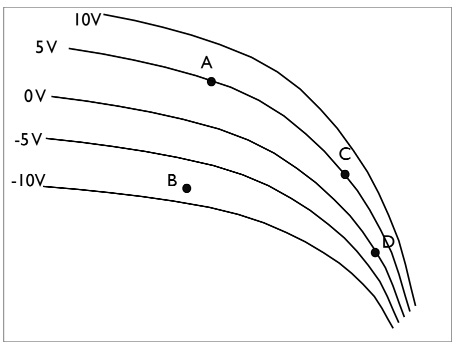
b) 20 cm in a direction perpendicular to the electric field.

c) 3 cm in the direction of the electric field, then 4 cm perpendicular to the field, and then 5 cm back to the original position.

Question 2: a) Since the electric field component in a certain direction is proportional to the change in potential, ΔV, in that direction, what is the magnitude of the electric field component in the direction of an equipotential line? Explain.

b) Based on your answer to part (a), what is the direction of the electric field, relative to the equipotential lines? Explain.

Question 3: What can you say about the electric field strength in a region where the equipotential lines are close together, as opposed to a region where they are far apart? Explain your answer using the mathematical relation between the electric field and the electric potential, $E_x = -\frac{dV}{dx}$.



Question 4: The figure to the left shows some equipotential lines in a region of space.

a) Indicate the direction of the electric field at the four points A, B, C, and D in the figure by drawing the electric field vectors. Explain why you drew them that way.

b) Is the magnitude of the electric field constant along each of the equipotential lines? Explain.

c) Rank the electric field strengths at the points A, B, C, and D.

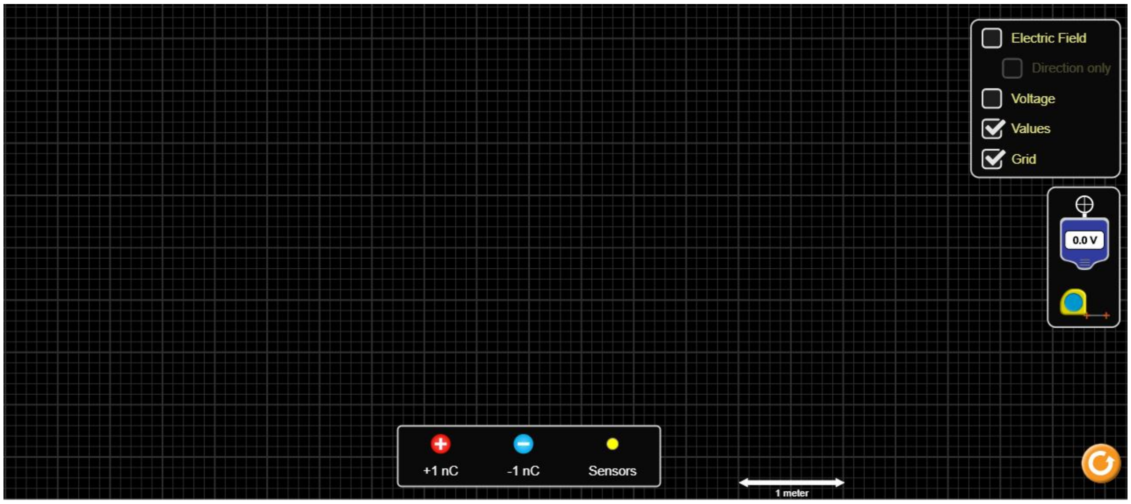
End of Pre-Lab Assignment

Submit your pre-lab assignment to the appropriate dropbox for your lab section on D2L by 5:00 PM **the day before your scheduled lab section.** Please see the instructions posted to D2L about submitting pre-lab assignments.

1 Finding equipotential lines

You will use the applet “Charges and Fields” to map the potential of two configuration of charges: an electric dipole and two parallel plates. Open the application and uncheck all the boxes except “Grid” and “Values” (see the figure below).

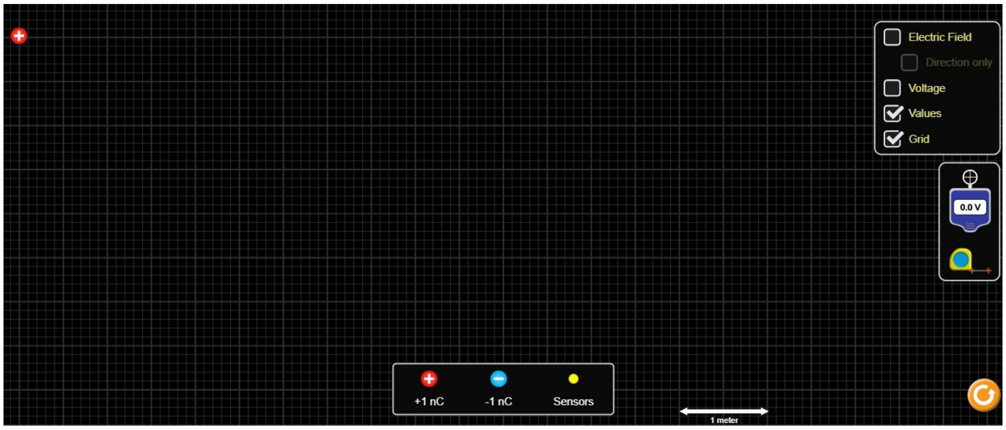
https://phet.colorado.edu/sims/html/charges-and-fields/latest/charges-and-fields_en.html



Question 5: When you check the “Values” box, an arrow and its label is displayed in the bottom-right corner. Based on the information provided in the simulation, what is the length of the edge of a large (thicker gridline) box in the grid?

Question 6: On the right side of the simulation screen, in the bottom square there is a potentiometer and a meter tool. Use the meter tool to verify your answer to the previous question. What is the length of the edge of a small (thinner gridline) box in the grid?

Question 7: Place a positive charge in the top left corner of the large grid located closest to the left top corner of the screen, as shown in the diagram below. Will all the points on the simulation screen be at the same electric potential, or at different values? Explain your answer.



Question 8: Knowing that the charge is +1.0 nC, calculate the distance from the positive charge to where the potential is equal to 1.0 V.

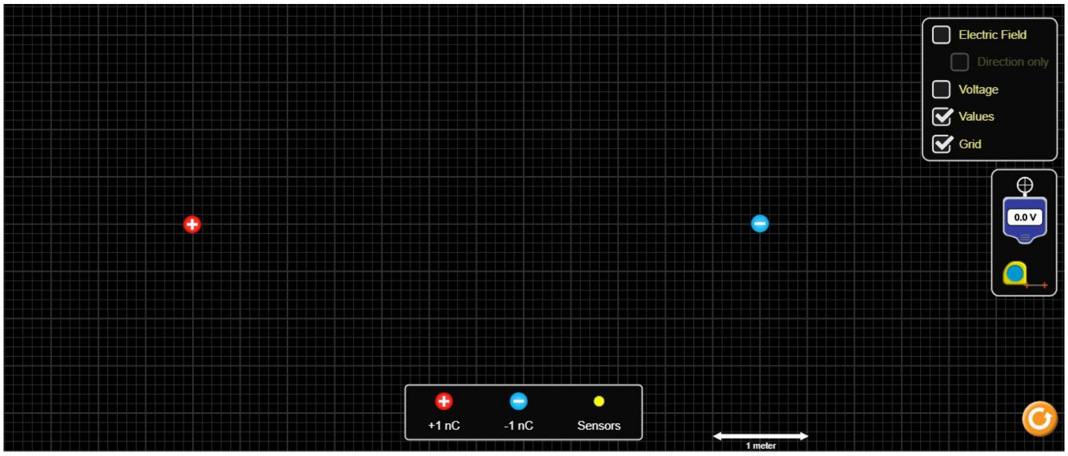
Question 9: Using the potentiometer in the applet, find the distance from the positive charge to where the potential is equal to 1.0 V. Use the grid or the meter tool to measure it. How does your answer to this question compare with the answer to the previous one?

B:
A:

STOP

CHECKPOINT 1: Before moving on to the next part, discuss your results as a group, then have your TA evaluate your answers.

Question 10: Place a positive and a negative charge 6.0 meters apart in a straight line, in the centre of the screen, as shown in the diagram below. Knowing that the charges are equal to +1.0 nC and -1.0 nC respectively, calculate the distance from the positive charge (on the line connecting the two charges) where the net potential is equal to 0.0 V. Hint: use the corners of the large boxes in the centre of the screen to place the charges.

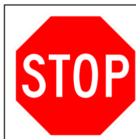


Question 11: Using the potentiometer in the applet, find the distance from the positive charge (on the line connecting the two charges) where the net potential is equal to 0.0 V. How does your answer to this question compare with the answer to the previous one?

Question 12: Using the drawing option (pencil icon) in potentiometer in the applet to draw the equipotentail line for V= 0.0 V. Decribe the shape of the line.

B:

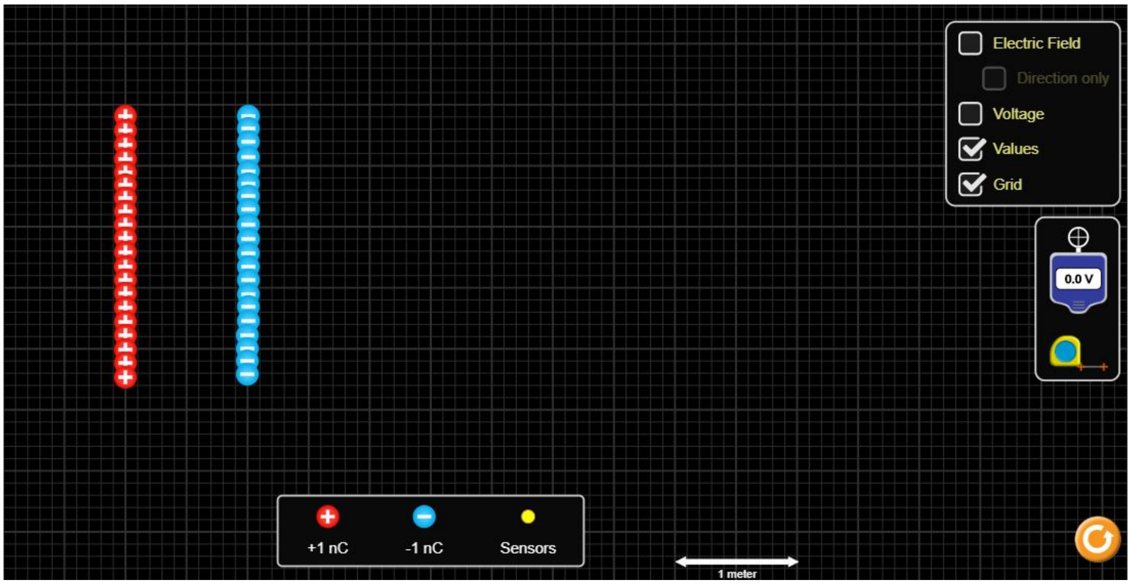
A:



CHECKPOINT 2: Before moving on to the next part, discuss your results as a group, then have your TA evaluate your answers.

2 Finding equipotential lines for the parallel plate field plate

You will now simulate the configuration of the parallel plate capacitor using point charges. Place a line of 20 positive charges and another line of 20 negative charges 1.0 meter apart. Try to align the charges in each line vertically to the best of your abilities, you can overlap the charges; see the configuration of charges shown on the figure below.



Question 13: Using the potentiometer, find the value of the electric potential for the following distances from the positive charge on an axis perpendicular to the two plates connecting the two plates (in the region between the two plates): 0.1 m, 0.2 m, 0.3 m, 0.4 m, 0.5 m, 0.6 m, 0.7 m, 0.8 m, 0.9 m. Record your values in the table below. Make sure to note the value before moving to the next point (lines will be close together).

x (in meters)	electric potential (in Volts)

For each point, use the drawing option (pencil icon) in potentiometer in the applet to draw the equipotential line.

Question 14: Based on your data, what is the direction of the electric field on a perpendicular line connecting the two plates?

Question 15: Check the "Electric Field" box in the applet. How does the electric field direction indicated compare with your answer to the previous question?

You will now use the collected data to study equipotential lines for the parallel plates quantitatively.

Question 16: How do you find the direction of the electric field between the plates from your data for the potential?

Question 17: Using Excel, enter your data to produce a plot of V vs. x and fit an equation to your graph. What does the plot represent? Write down the equation for the fit. What is the magnitude of the electric field that you obtain from your fit?

B:

A:

STOP

Last Checkpoint! Before being dismissed from the lab, discuss your results as a group, then have your TA evaluate your answers.