Course and Section_______ Names ___________________________

Date___________________ ___________________________

ELECTRIC POTENTIAL SIMULATION

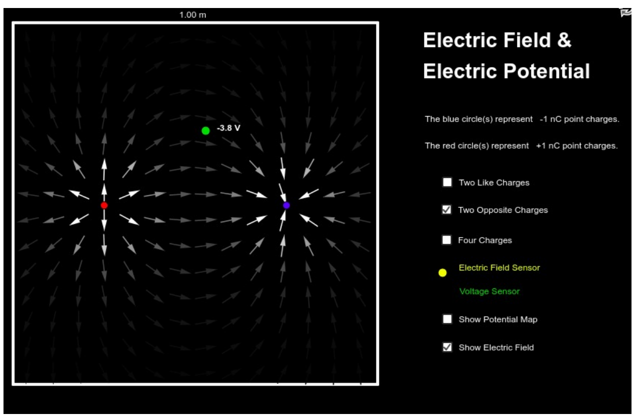
Introduction

In class we learned that the electric potential is the electrostatic potential energy per unit charge. In this online lab we will further explore the connection between the electrostatic potential, the electrostatic potential energy and the force on charged particles.

Submit your answers using Blackboard.

1 – Point charges

Open the simulation https://ophysics.com/em4.html



Select Two Opposite Charges. Click on the green dot (Voltage Sensor) and drag it over the picture. Place it directly to the left of the blue charge and move horizontally across until you hit the red charge.

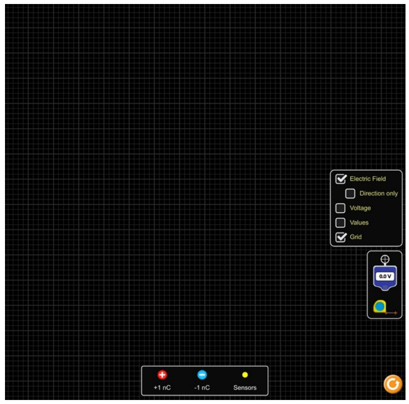
1. How does the voltage change?
2. Is there a location where the voltage is zero?

Select Two Like Charge

3. What happens to the voltage as you move towards either charge?
4. What happens to the voltage as you away from both charges?
5. Is there a location in the box where the voltage is zero?

2 – Non-uniform Electric Fields

Open the simulation below select the *grid* option.
(https://phet.colorado.edu/sims/html/charges-and-fields/latest/charges-and-fields_en.html)



You see a blank grid on which you can create charge distributions by drag and drop the positive and negative charges located at the bottom.

Place a positive charge in the region. Use the potential difference measuring device (the purple tool). If you place this device on the canvas it reads the potential at that location. If you click the pencil it will draw an equipotential line. Start at a potential of 20 V and draw an equipotential line. Now move until you hit 15 and draw another equipotential line, continue to decrease in steps of 5V and draw equipotential lines until you hit 5 volts.

6. What is the shape of the equipotential lines?

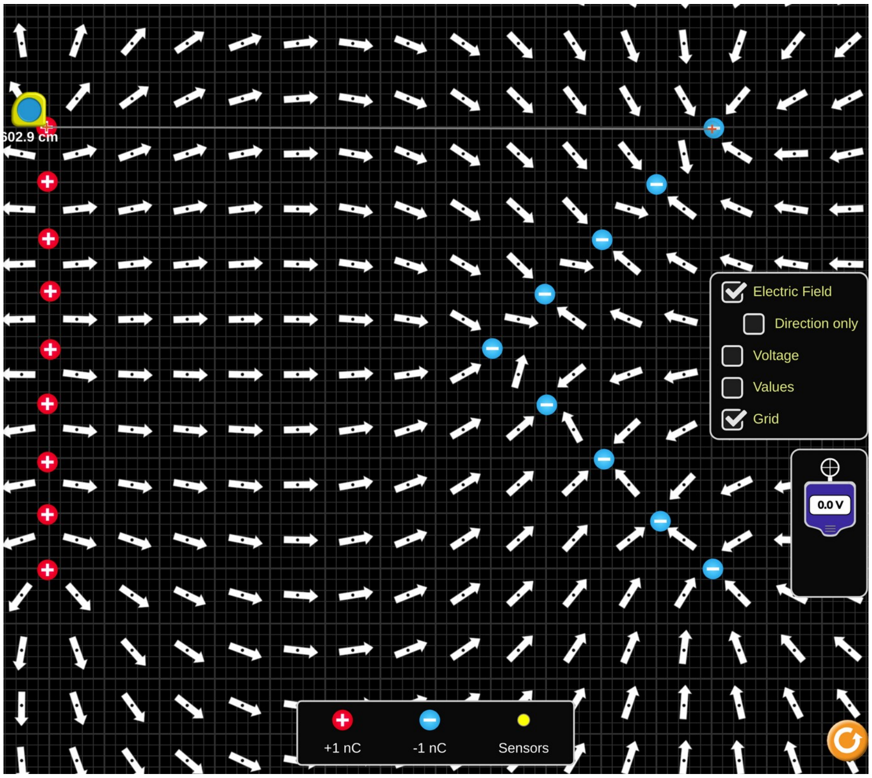
Now reset (orange reset button) and instead place a negative charge. Do the same thing only this time start at -20V and continue to **increase** in steps of 5V until you hit -5V, drawing an equipotential line every 5V.

7. What is the shape of the equipotential lines?

Now reset and place both a positive charge and negative charge into the region. Separate the charges by a distance of 100cm. Repeat the above exercise of drawing equipotential lines starting at 30 V and decreasing in steps of 5V until you reach -30V.

8. In general are the equipotential lines for this charge distribution circles?
9. If you go close to the positive or negative charge and draw an equipotential line what shape is it?
10. What is the name of this type of charge distribution? (Feel free to use google or your book to help).

The grid is created by major rulings thicker lines and minor rulings, thinner lines. Create the following charge distribution by placing a positive charge at the intersection of every major ruling of the grid on the left side of the canvas. Go to the center most charge and then place a negative charge 300 cm away from the central positive charge on the right hand side of the canvas. This negative charge will also be placed at the intersection of two major rulings. To measure the distance use the *ruler tool.* Now continue to place the negative charges along a diagonal as shown in the image. They will also be placed at the intersection of two major rulings. The uppermost and lowermost negative charges will be 500 cm away from their positive counterpart.



Use the potential difference measuring device (the purple tool). If you place this device on the canvas it reads the potential at that location. If you click the pencil it will draw an equipotential line. Start at a potential of 60 V (next to the central positive charge) and draw an equipotential line. Now move right and decrease in steps of 10V and draw another equipotential. Make sure to have placed **ALL THE CHARGES** on the grid before start to display the equipotential lines. Continue to draw an equipotential every 10 V until you hit -40V.

The electric field and the electric potential are related by

$$\left|\frac{\Delta V}{\Delta x}\right| = |E|$$

Focusing on the region between the positive and negative charges

11. At which points are the equipotential lines the closest together?
12. At which points are they the farthest apart?
13. At which points is the electric field the strongest?
14. At which points is the electric field the weakest?
15. Calculate the value of the electric field at one of the weakest locations. (N/C)
16. Calculate the value of the electric field at one of the strongest locations. (N/C)

3 – Force in a Non-Uniform Electric Field

Imagine placing a negatively charged particle q near the positive charges in the electric you have created in part 2.

17. Will it feel a force?
18. In what direction will the force be?

Suppose the particle is placed at the 40V equipotential surface along the line connecting the two central positive and negative charges.
(hint The electric field can be obtained using the 40V and 30V potential difference lines.)
19. What is the force on the charged particle if q=80μC? (mN) (m-milli 10^{-3})
20. What is the force on the charged particle if it is now located at the 0V potential difference line? (mN)
(hint: The electric field can be obtained as above using the 0V and -10V equipotential lines.)

4 – What Charge is it?

In a certain region an electric potential V is present. An unknown charge Q is moved around this region between points at potential difference ΔV. A physicist measures the change in the the potential energy ΔU as the charge is moved. The table below shows the data of the measurements. The unit for ΔV are MV (mega-Volts), the units for ΔU are kJ (kilo-joules).

ΔV	57.1	29.9	21.7	16.7	9.97	8.55	8.32	6.52	6.87
ΔU	362.8	199.5	157.6	124.3	55.3	48.8	53.9	37.9	47.3

You want to find the value of the unknown charge Q in mC. Since $\Delta U = Q\Delta V$ make the plot $y=mx$ where y=ΔU and x=ΔV. Use Excel or Libreoffice Calc or what you prefer. From the slope of the plot, calculate Q.

21. What is the unknown charge Q? (mC) (m-milli 10^{-3})