Name________________

LAB 2: Electric Field and Potential

This is a virtual lab based on the interactive simulator ***Charges and Fields****.*

Access the simulator at
https://phet.colorado.edu/sims/html/charges-and-fields/latest/charges-and-fields_en.html .

Objectives: In this lab, you will

- Verify the formula for the electric field of the point charge
- Explore the electric field lines of various charge configurations and the superposition principle
- Explore the relationship between the electric field and electric potential

Part I: Electric field of the point charge

Procedure:

1) Click on "Grid." Place one positive charge in the center of the grid. Click on "Electric Field."

Can the arrows that the program uses to visualize the electric field be called field lines? How are they similar and different from the field lines?

2) Click on "Values". Place electric field sensors (yellow circles) on five various points on the grid. (For convenience, choose points on the intersections of the major grid lines.) Assuming the point charge is placed in the origin of the coordinate system, record the following information in the table below. Note the scale on the grid and make sure to use correct units.

Sensor #	x	y	$r=\sqrt{x^2+y^2}$	$\theta=\tan^{-1}\frac{y}{x}$	$\lvert\vec{E}\rvert$	Electric Field angle
1						
2						
3						
4						
5						

Note that the information in the columns 2 – 5 pertains to the location of the sensors and the information in the columns 6 – 7 is magnitude and direction of the electric field calculated by the simulator.

Conclusions:

a) Prove that the electric field of the point charge is radial by comparing your values in column 5 (position angle) and in column 7 (electric field angle). Explain.

b) Calculate the value of $\lvert\vec{E}\rvert \times r^2$ for all five sensors. Add another column to the table above to record your results. Do they show that the magnitude of the electric field of the point charge is inversely proportional to the distance squared? Explain. Use the values you found and the value of the point charge 1nC to find constant *k* experimentally.

Question: Suppose that you used a negative point charge instead of a positive. Look at the data you recorded in the table – which of the columns would change, and how? Use the simulator to check your answer.

Part II: Electric Field of Multiple Charges

Procedure:

1) Use the charges to create an electric dipole with a horizontal axis by placing a positive and a negative charge (equal in magnitude but opposite in sign) 1 meter away from each other. (Axis of a dipole is a line passing through both charges.) Place positive charge on the left and negative on the right.

2) Describe the field at the following locations, and explain these results using the superposition principle.

- On the horizontal axis to the right of the dipole

- On the horizontal axis between charges

- On the horizontal axis to the left of the charges

- On the vertical line bisecting the line segment connecting the charges, above the dipole

- On the vertical line bisecting the line segment connecting the charges, below the dipole

3) Is there a location where the electric field is **exactly** zero?

4) Remove the negative charge and replace it with equal in magnitude positive charge. Observe the change in electric field, and again describe the field at the following locations, explaining these results using the superposition principle.

- On the horizontal axis to the right of the charges

- On the horizontal axis between charges

- On the horizontal axis to the left of the charges

- On the vertical line bisecting the line segment connecting the charges, above the charges

- On the vertical line bisecting the line segment connecting the charges, below the charges

5) Is there a location where the electric field is **exactly** zero?

6) Remove these charges and arrange exactly four charges – two positive and two negative – on the grid in a way that the electric field in the center of the grid is zero. Insert the screenshot in this document.

7) Use as many charges as you want to create a configuration of charges that results in a uniform electric field in some region of the grid. Insert the screenshot in this document.

Part III: Electric Potential

Procedure:

1) Clear the charges and place one positive charge in the center of the grid, on the intersection of major gridlines. Grab a voltage sensor, and move it around the grid, observing how the values change. Then, do the same for one negative charge in the center of the grid.

2) Create an electric dipole by placing one positive and one negative charge on a horizontal grid line. Measure the electric field and electric potential at the point midway between the charges and at several points on the vertical line bisecting the line segment connecting the charges.

3) Create a charge configuration similar to that of a dipole but use two charges of the same sign instead. Measure the electric field and electric potential at the point midway between the charges and at several point on the vertical line bisecting the line segment connecting the charges.

4) Based on your data, what is the main difference between the superposition principle for the electric fields and electric potential?

PART IV: Relationship between field and potential

1) Place four charges, two positive and two negative, at four random points on a grid. Click on “Values.” Drag the voltage sensor in the vicinity of the charges and click on the pencil icon. A line will appear labeled by a number.

a) Move the sensor in a way such that the intersection of crosshairs remains on the line. Does the number on the sensor change? What is the physical meaning of this line?
b) Move the sensor to a different spot and click “plot” again. In this manner, create 8 to 10 lines.

c) Take an electric field sensor and move it on an equipotential line. What can you say about the way magnitude and direction of the electric field changes as the sensor travels around the line?

d) Place a few electric field sensors in a few points between the equipotential lines. Where do the electric field vectors point in terms of increase and decrease of the values on the equipotential lines?

2) Remove the charges and lace a positive charge in the center of the grid. Draw five equipotential circles with the potentials of 10 Volts, 8 Volts, 6 Volts, 4 Volts and 2 Volts. (It might be hard to get the precise values but try to get as close as you can).

Take an electric field sensor and move it in a straight line, crossing the equipotential lines. Describe the relationship between *the distance between the equipotential lines* and the *strength* of the electric field.

Conclusions:

Use the observations above and the concept of work to describe and explain

- the relative orientation between the equipotential lines and field lines

- the relationship between the direction of the electric field and increase or decrease in potential

- the relationship between the *magnitude* of the electric field and the *distance between the pairs of lines* with the equal potential difference