Electric Field and Superposition Principle

Name: _____

Instructor: _____

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Instructions: Follow the steps on this worksheet, using your lab manual as a guide, unless directed to do otherwise by your lab instructor. Show at least one sample calculation for each step. Box final mathematical results.

All charges in this lab have a charge of plus or minus one nanocoulomb, $\pm 1\,\text{nC}$. The unit of distance used is meter, m, and the units for electric field are volts per meter, V/m, which are equivalent to newtons per coulomb, N/C. The steps in this worksheet assume you have selected the boxes for 'Values' and 'Grid' in the PHET application.

1 Data

1.1 Single Charge

Take a charge of either sign out of the bin and drop it in the middle of the screen. Call this point $(0, 0)$. Put sensors at $(0.5, 0)$, $(-1, 0)$, $(0, 1.5)$ and $(0, -2)$, then record the magnitude of the electric field and the angle at each point in a table. Make a sketch of the situation.

1.2 Make a Dipole

1. Take a positive charge and put it in the middle of the screen at $(0.5, 0)$. Take a negative charge and put it at $(-0.5, 0)$. We will define the center of the dipole to be the point $(0, 0)$. Put a sensor at $(2, 0)$. Make a sketch of the situation. Record the magnitude of the electric field.

2. Return the negative charge to the box, then record the magnitude of the electric field due to the positive charge at the location of the sensor.

3. Place a negative charge at $(-0.5, 0)$, return the positive charge to the box, then record the magnitude of the electric field due to the negative charge at the location of the sensor.

1.3 Make a Square

1. Arrange four charges in a square of 2 m side-length. Sketch the situation. Measure and record the magnitude and direction of the electric field in the middle of the square.

2. Now leave the electric field sensor in its place, but return each charge to its bin except for the one on the upper left corner of the square. Record the magnitude and direction of the electric field due to this charge. Repeat this for the other charges and make a table of your data.

1.4 Make a Triangle

1. Choose a point as the origin. Place negative charges at $(-1, 0)$ and $(0, 1)$, a positive charge at $(1, 0)$, and a sensor at $(0, 2)$. You should have an isosceles triangle pointed in the y-direction. Sketch the situation. Measure and the magnitude and direction of the electric field at the location of the sensor.

2. Proceed as in step 2 of Section 1.3, by measuring the electric field of each individual charge at the location of the sensor. Make a table including the charge location, magnitude of the electric field, and direction of the electric field vector for each charge.

1.5 Field Lines

Click 'Electric Field'. Make a sketch of each of the following situations and draw the electric field lines.

1. **Single Charge**: Put a single charge at $(0, 0)$.

2. **Dipole**: Place positive and negative charges at $(-1, 0)$ and $(1, 0)$, respectively.

3. **Two Positive Charges**: Put a positive charge at $(-1, 0)$ and at $(1, 0)$.

4. **Quadrapole**: Place positive charges at $(-1, 1)$ and $(1, -1)$. Place negative charges at $(1, 1)$ and $(-1, -1)$.

2 Analysis

2.1 Single Charge

Calculate the electric field at the location of the sensors, and compare to your previous measurements.

2.2 Make a Dipole

Use the superposition principle to combine the results of the electric field from the negative and positive charges, then compare to the case when both charges were present.

2.3 Make a Square

1. During data collection, you found the magnitude and direction of the electric field vector for each charge in the square configuration. Decompose each of these vectors into its x-component and y-component and tabulate the results.

2. Superimpose the results from the individual charges and compare to the result when four charges were present.

2.4 Make a Triangle

1. Decompose the electric field vector for each charge into its x-component and y-component and tabulate the results.

2. Superimpose the results from the individual charges and compare to the result when all three charges were present.