***Charges and Fields*** (PhET Simulation) Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Partner(s), if any: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Hr: \_\_\_\_ Due at beg of hr on: \_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Go to <https://phet.colorado.edu/en/simulation/charges-and-fields> . Click \_ **↓** DOWNLOAD \_ and open the simulation.

2. From the box at the bottom of the screen, drag a red +1 nC charge into the middle of the screen.

3. Glance over the entire screen. What property of the *E* field vector-arrows gives an indication of the strength of the *E* field at a particular location?

(Hint: It is NOT the density/spacing of the arrows.)

4. Based on the *E* field vector-arrows you see, draw here a (+) point

charge and show the *E* field lines around the charge. Remember,

*E* field lines are NOT discrete arrows; they are continuous lines.

5. Drag the red +1 nC charge back into the box at the bottom, and

then drag a blue –1 nC charge onto the screen. At right, draw a

(–) point charge and show the *E* field lines around this charge.

6. We haven’t mentioned this in class, but see if you can figure

out which term best applies to (+) and (–) charges. (CIRCLE)

 (+) CHARGES: SOURCE of SINK of

 *E* field lines *E* field lines

(–) CHARGES: SOURCE of SINK of

 *E* field lines *E* field lines

7. Clear your screen by dragging the blue –1 nC charge back into the box at the bottom. Alternatively, in the lower-right corner of the screen is an orange button with a white arrow on it. Clicking that button will always clear away everything from your screen so you can start from scratch.

8. On the right side of the screen, click the \_\_\_ Values and \_\_\_ Grid boxes. At the bottom of the screen, to the right of the “charges and sensors” box, note the scale, which shows how much 1 meter is.

|  |  |
| --- | --- |
| *r* (m) | *E* (V/m) |
| 1 |  |
| 2 |  |
| 3 |  |
| 4 |  |
| 5 |  |
| 6 |  |
| 7 |  |
| 8 |  |

9. Drag a +1 nC charge near the far left side of the screen. Place it so that it is at the intersection of two of the heavier gridlines. This way, you can place sensors at fairly-specific distances away from the charge. Ask your teacher for the total number of +1 nC charges you need to place at that exact spot. Write that number here: \_\_\_\_\_. Then, put that many +1 nC charges…there. ☺

10. From the box at the bottom, drag a sensor and place it 1 m to the right of your “however-many-nC” charge. This sensor measures the *E* field at the location of its placing. For now, just trust that V/m is a viable unit for *E* fields. In the table at right, record the *E* field magnitude at a distance *r* of 1 m. Ignore the degrees.

11. Drag the sensor to the other distances shown in the table, then record the *E* field measurements.

12. Drag your *E* field sensor back and replace it in the box at the bottom of the screen.

 13. On the right side of the screen is a voltmeter. With the voltmeter, repeat what you just did with the *E* field sensor, with one very important exception: Notice the button on the voltmeter that has a PENCIL. When you have the voltmeter at each distance, click this button. Doing so will record the potential *V*

|  |  |
| --- | --- |
| *r* (m) | *V* (V) |
| 1 |  |
| 2 |  |
| 3 |  |
| 4 |  |
| 5 |  |
| 6 |  |
| 7 |  |
| 8 |  |

and draw a green line

on the screen. Fill in the

table at the far right. Then

draw a simple sketch of

the charge and the green

lines. Don’t bother putting

values in; just get the

general shape of the lines.

14. Clear the screen. Make sure the \_\_\_ Values and \_\_\_ Grid boxes are checked. Place a red +1 nC charge on the left and a blue –1 nC charge on the right, 2 m apart.

15. In the space to the right, draw those charges and the *E* field lines that surround them. Be sure to include arrows on the *E* field lines to show their directionality.

16. Drag an *E* field sensor around many points of this charge configuration, observing how the value on the sensor changes, as well as what happens to the red arrow. What do you observe about…?

A. the sign (+ or –) of *E* field, as reported by the sensor?

 B. Is there any point on the screen where the *E* field is zero? \_\_\_\_\_\_\_ If so, describe the point(s).

17. Place the *E* field sensor directly in the middle of the two point charges. Carefully drag the sensor straight to the top of the screen, keeping it on the same gridline. Observe the arrow as you drag the sensor straight up and down a few times. What do you observe about the red arrow’s…?

 A. direction B. magnitude

18. Put away the *E* field sensor, then grab the voltmeter and use the pencil button on it to create a series of green lines across the screen. Compared to your Part 16A answer, what do you observe about the sign (+ or –) of the potential *V*, as reported by the voltmeter?

19. In the space at right, make a sketch of your charges/green

lines from Part 18. Don’t bother recording the numbers.

20. Now, drag an *E* field sensor around the screen. Below,

describe the direction of the red arrows (relative to the

green lines) whenever the sensor is directly atop the lines.

21. Clear the screen. Make sure the \_\_\_ Values and \_\_\_ Grid boxes are checked. Place a single red +1 nC charge in the center of the screen. Make a mental note of the direction of the *E* field vector-arrows. Now, drag in additional +1 nC charges, forming a vertical line of charges at a spacing of 0.5 m. What happens to the direction of the arrows as you add more charges in this fashion?

**ANALYSIS** Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Partner(s), if any: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Hr: \_\_\_\_ Due at beg of hr on: \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Here, you will analyze your results from the *Charges and Fields* simulation. Note that, when you took your data, the items were NUMBERED, so references here to numbered items will require that you look back at the data on your OTHER sheet. References to LETTERED items involve parts on THIS analysis sheet.

A. Slightly off-topic, but it’s a physics-related question… Based on your Q6 answer, why – would you guess – an ice bath (or, say, a lake that is adjacent to a nuclear power plant) is referred to as a heat sink? (The sketch you drew as your answer to Q5 might also be of help to you.)

B. In this class, you have worked with the equation for the *E* field magnitude

at any distance *r* away from a point charge *Q*. Write that equation here.

C. In this class, you have worked with the equation for the magnitude of the poten-

tial *V* at any distance *r* away from a point charge *Q*. Write that equation here.



D. Draw rough graphs that show the essential relationship between *E* and *r* (and between *V* and *r*) that you reported in your answers to Parts B and C. Above each graph, write a proportion that shows how *E* (or *V*) varies with *r*.

E. $\frac{N}{C}=\frac{V}{m}$ Both units shown to the left are used for electric field *E*. Show that you can modify the right

 side of this equation to yield the units on the left.



F. Use the space to the right of the table of Q9-11 to linearize that table’s *E*-*r* data. Create one or more new columns to the right of the table. Put a proper label and unit above any new columns. (Feel free to “re-unitize” the *E* column with N/C and proceed from there, if you wish.) Also, let’s “square stuff” rather than “square-root stuff.” ☺

G. Graph your linearized data. Employ all elements of how to properly graph data. As *r* is our independent variable, be sure any *r*-type quantity is the abscissa (look it up!).

H. Determine your graph’s slope, employing techniques we have previously discussed. Include the correct unit on your slope.

I. Use your Part H answer to determine an experimental value for Coulomb’s constant *k*. (Obviously, we can look up the accepted value, but let’s find out what your data have to say about it.) It is likely that you will need to employ your answer to Part B, as well as the amount of charge you used (see Q9).

J. Use the space to the right of the table of Q13 to linearize that table’s *V*-*r* data. Create one or more new columns to the right of that table. Put the proper label(s) (with correct unit) at the top of your new column(s).

K. Graph your linearized data.

L. Determine the slope of your graph.

M. Use your Part L answer to again determine

an experimental value for Coulomb’s

constant *k*. (Hopefully, it will be close to your

Part I answer, as well as to the accepted value. ☺)

You will probably need your answer from Part C, as well as the charge you used (see Q9).

N. Refer back now to the lines you drew in your sketch of Q13.

 i. In reality, those lines represent surfaces…of what shape?

 ii. Aside from sharing the same distance from the charge, each point on any given surface

has the same \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ as every other point on the same surface.

 iii. In electrostatics, what do we call all such surfaces

(regardless of whether they are real or imaginary)?

 iv. Give a concise definition of your answer to Part Niii.

v. State how *E* field lines are oriented, relative to such surfaces.

vi. Your answer to which NUMBERED question (i.e., on

the other sheet) fully supports your Part Nv answer?