Department of Mathematics and Natural Sciences

Physics -112 Lab Assignment: 04

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Theory section : 02

Lab section : 02

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Objective:

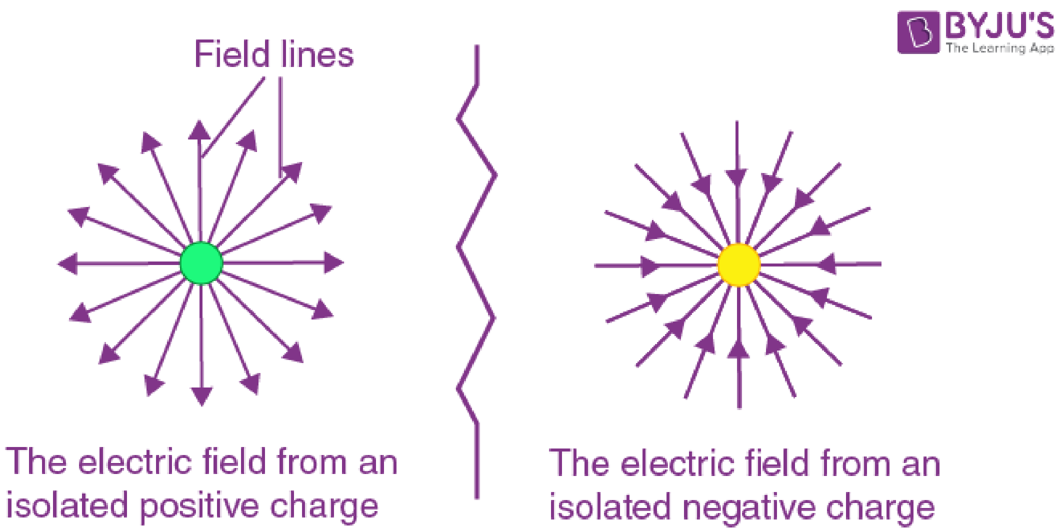
In these activities you will use the Simulation: *Charges and Fields* to develop your understanding of the relationship between electric fields and electric potential.

Theoretical Background:

The Electric field is a vector quantity that exists at every point in space. The electric field at a location indicates the force that *would* act on a unit positive test charge *if* placed at that location.
The electric field is related to the electric force that acts on an arbitrary charge by,

$$E = F/q$$

The dimension of the electric field is newtons/coulomb.



Electric potential energy is the energy that is needed to move a charge against an electric field. You need more energy to move a charge further in the electric field, but also more energy to move it through a stronger electric field. Mathematically we can say that,

$$\mathbf{E = W/Q}$$

The dimension of the electric potential is joules/coulomb.

Activity 1:

Activity 1:

Go to the following link : https://phet.colorado.edu/sims/html/charges-and-fields/latest/charges-and-fields_all.html

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

   Answer:

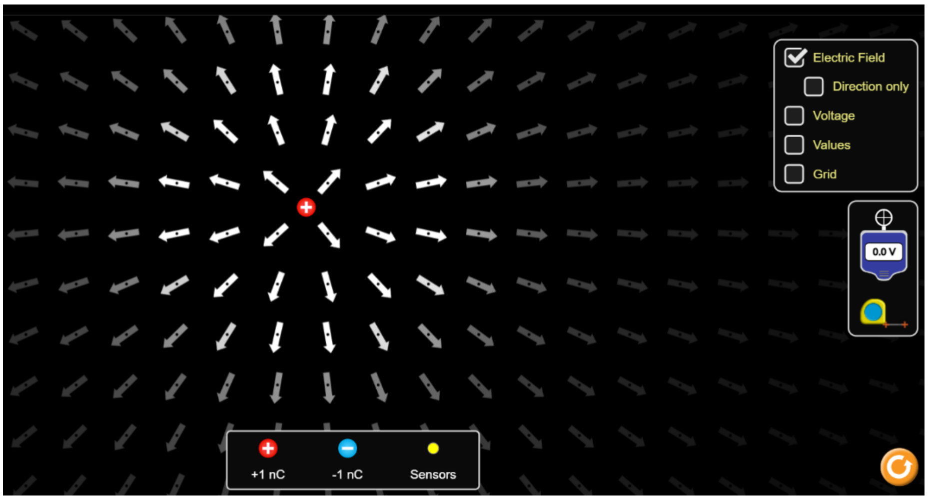


Figure-1: Electric field for +1 nC without checking "Direction"

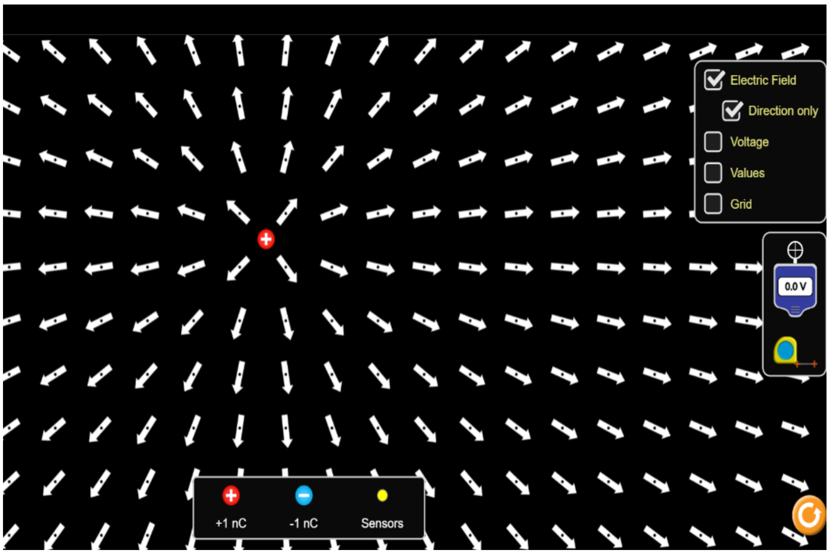


Figure-2: Electric field for +1 nC with checking "Direction"

2. If not already selected: Select ‘Electric Field’. How does the brightness of the arrow relate to the strength of the field? What happens when you check/uncheck ‘Direction only’? Which way do the arrows point for a positive charge?

Answer:

Relation to brightness: In an electric field, the arrow's brightness generally is equivalent to the field's strength. **The field is stronger when the arrow is brighter.**

check/uncheck ‘Direction only’: Arrows that point in the field's direction without taking their length or brightness into consideration.

The way do the arrows point for a positive charge : A positive test charge would be repelled away from a positive charge since the electric field arrows for positive charges point across **outward**.

3. Drag the red +1 nC charge back into the box at the bottom, and then drag a blue –1 nC charge onto the screen. Which way do the electric field arrows point for a negative charge?

Answer:

After dragging a blue –1 nC charge onto the screen,the arrowos points across **inward.**

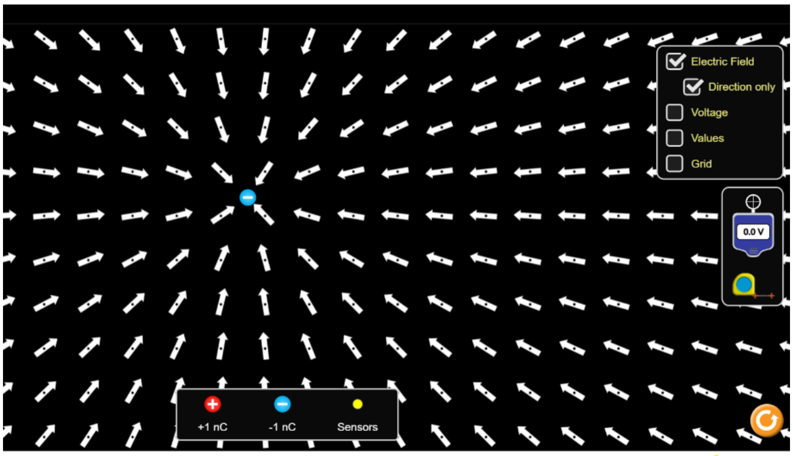


Figure-3: Electric field for -1 nC with checking “Direction

4. Click on the yellow Sensor at the bottom and drag it across the electric field. What information do the Sensors show?

Answer:

The electric field's strength and direction at the sensor's location are measured by the yellow sensor. It **displays the electric field vector**, a representation of the electric field's direction and magnitude (strength) at that particular location or point.

5.What happens to the electric field as you move further from the charges?

Answer:

As I move further from the charges, there decreases in the electric field. The reason behind this is that Coulomb's Law implies that the electric field strength is inversely proportional to the square of the distance from the charge.

6. Take the Voltage meter (labeled '0.0 V'). What information does the voltmeter give? What information is given when you click on the pencil (you should have a green circle)? What does the green circle represent? (If you're not sure, move on and come back to this later.)

Answer:

Electric potential, or the electric potential energy per unit charge, is measured by a voltmeter. To state it in another means, it measures the voltage.

When I click on the pencil, it creates a green circle which represents the specific point in the field where the voltage is being measured.

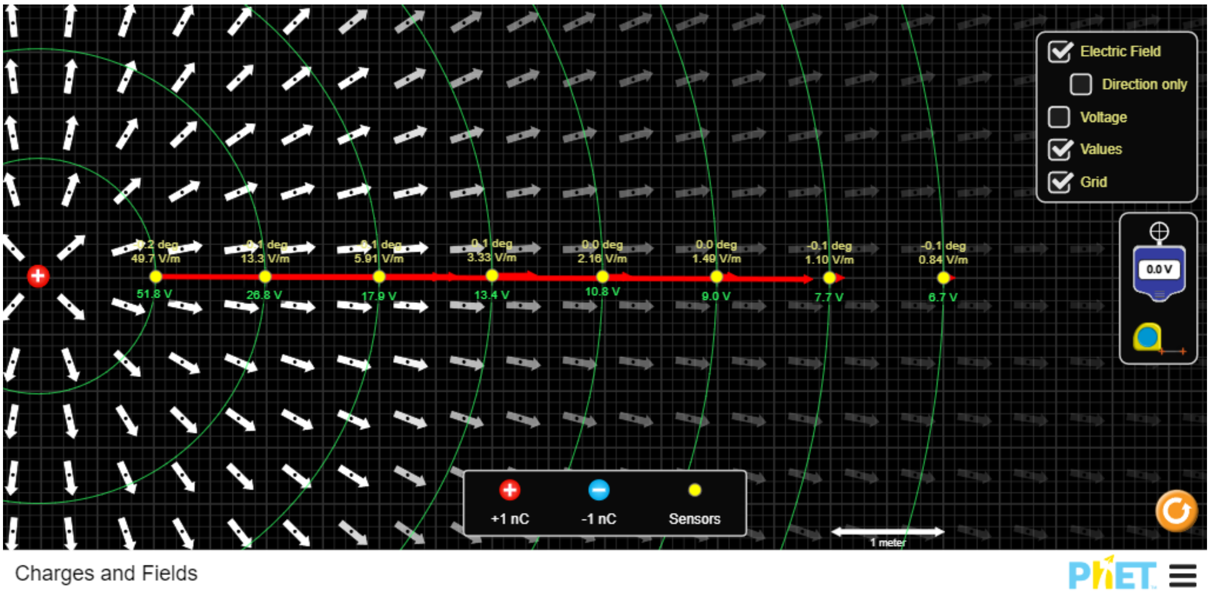
Activity 2:

1. Place six +1 nC charges on top of each other somewhere on the left side of the screen. (It can go anywhere, but there needs to be enough space to measure 8 m away.)
2. From the box at the bottom, drag a Sensor and place it 1 m to the right of your charge. This sensor measures the E field at the location of its placing. In the table at right, record the E field magnitude at a distance r of 1 m. Ignore the degrees.
3. Drag the Sensor to the other distances shown in the table, then record the E field measurements.

Distance , r (m)	Electric Field , E (V/m)
1	49.7
2	13.3
3	5.91
4	3.3
5	2.16
6	1.49
7	1.10
8	0.84

4. Drag your Sensor back and replace it in the box at the bottom of the screen.

5. Using the voltmeter, record the potential V by drawing a green line on the screen at each distance. Fill in the table at the far right. Include a screenshot with all of the green circles.



Distance , r (m)	Voltage , V (V)
1	51.8
2	26.8
3	17.9
4	13.4
5	10.8
6	9.0
7	7.7
8	6.7

6. Write the equation for the electric field at any distance *r* from a point charge *q*:

   Answer: $E = \frac{kq}{r^2}$

7. Write the equation for the potential at any distance *r* from a point charge *q*:

$$\boldsymbol{Answer}: V = \frac{kQ}{r}$$

8. Using the table above, make a graph in Excel of electric field *E* and distance *r* to determine Coulomb's constant *k* using the appropriate trendline.

   (Hint: there are 2 ways to do this. Either make a graph and then create the appropriate trendline, or figure out how to make the graph into a straight line and then use a linear trendline. Once you have a trendline, compare the equation written above to the equation of the trendline to find *k*)

Distance , r (m)	$1/r^2$	Electric Field , E (V/m)
1	1	49.7
2	0.25	13.3
3	0.11	5.91
4	0.0625	3.3
5	0.04	2.16
6	0.02778	1.49
7	0.02040	1.10
8	0.0156	0.84

9. Insert the graph below and write down the *k* value that you found. Compare this value to the known value found on the equation sheet or in class slides using percent error or percent difference (whichever is most appropriate)?

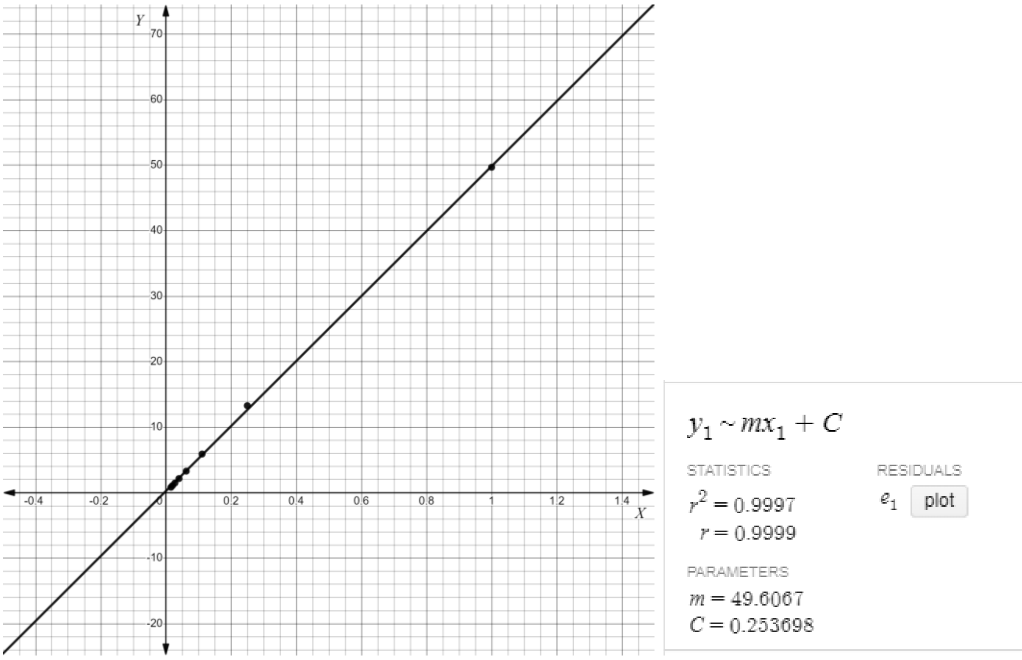


Figure : Graph of E vs 1/r²

<u>Calculation:</u>

We know,

$$E = \frac{kq}{r^2}$$

$$E = (kq).\frac{1}{r^2}$$

$m = kq$

$k = \frac{m}{q}$ [where , m = 49.6067 , q= 6×10^{-9}]

So , k = 49.6067/ 6×10^{-9} = 8.2678×10^9

Real value of k = 8.99×10^9

Hence, the Percentage Error = $((8.99\times10^9 - 8.2678\times10^9) / 8.99\times10^9)\times100$

= 8.03 %

10. Using the table above, make a graph in Excel of voltage *V* and distance *r* to determine the constant *k* again using the appropriate trendline.

Distance , r (m)	Voltage , V (V)
1	51.8
0.5	26.8
0.33	17.9
0.25	13.4
0.2	10.8
0.167	9
0.142	7.7
0.125	6.7

11. Insert the graph below and write down the *k* value that you found. Compare this value to the known value using percent error/difference?

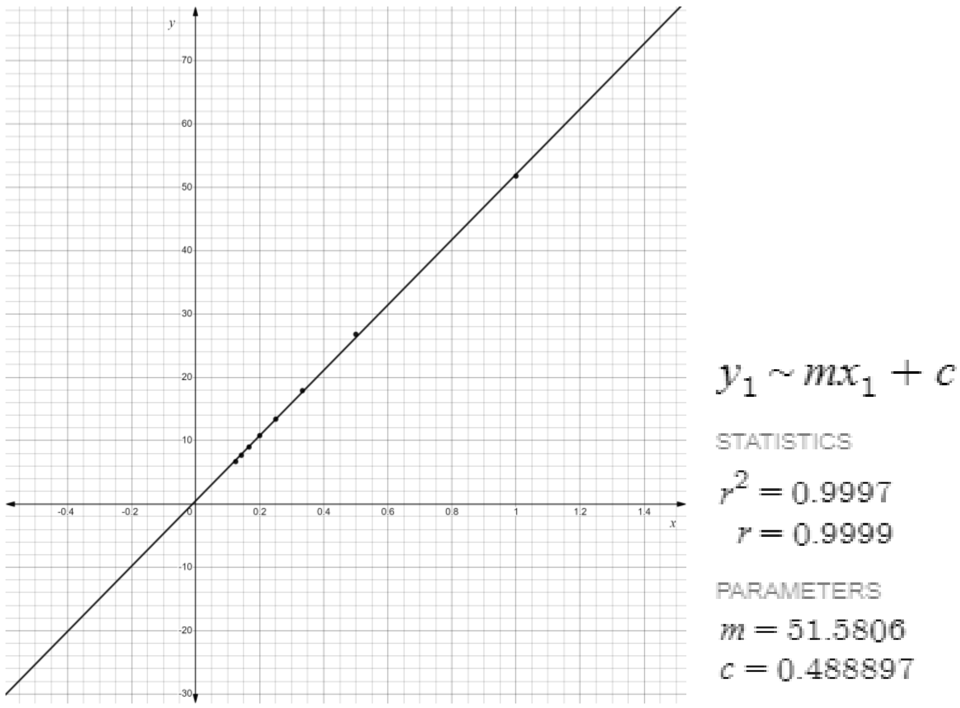


Figure : Graph of V vs 1/r

Calculation:

Here,

V vs 1/r is provided where y-axis indicates V

and x-axis indicates 1/r

we know,

$$V = \frac{kQ}{r}$$

$$V = (kQ).\frac{1}{r}$$

$m = kq$

$k = \frac{m}{q}$ [where , m = 51.5806 , q= 6×10^{-9}]

So , k = 49.6067/ 6×10^{-9} = 8.5967×10^{9}

Real value of k = 8.99×10^{9}

Hence, the Percentage Error = $((8.99\times10^{9} - 8.5967\times10^{9}) / 8.99\times10^{9})\times100$

=4.37 %