**Introduction:**

In this workshop, we will conduct experiment to verify Coulomb’s Law. As in the previous lab, we will be using a simulator to verify. We will also study electrical filed and look into the directions and combined effects when multiple charges are present.

<https://phet.colorado.edu/sims/html/coulombs-law/latest/coulombs-law_en.html>

**Theory:**

Coulomb’s Law states that the electric force between two charges with distance *r* between them is:

*K* is called coulomb’s constant and depends on the permittivity of the media between the two charges. In air or vacuum, it is:

and: = = 8.99 x 109

The strength of the electrical filed at distance *r* away from a static change is:

In air or vacuum, = 8.99 x 109

**Methodology:**

**Part 1: Coulomb’s Law**

* 1. Click on <https://phet.colorado.edu/sims/html/coulombs-law/latest/coulombs-law_en.html>
  2. Click on Macro Scale and wait for a while for the simulator to run
  3. Keep Charge 1 and Charge 2 unchanged, adjust the distance of the charges, and record at least 6 readings in the following table:

|  |  |  |  |
| --- | --- | --- | --- |
| Q1 | Q2 | r | F |
| -4 | 8 | 2 |  |
| -4 | 8 | 3 |  |
| -4 | 8 | 3.4 |  |
| -4 | 8 | 4 |  |
| -4 | 8 | 5 |  |
| -4 | 8 | 9 |  |

* 1. In Excel, draw the graph to show the relationship between *r* and *F*. Copy and paste the Excel table and graph below. Comment on the result.

(Note: To draw the graph, in an Excel workbook, copy your data of *r* and *F*, select the data, then go to the menu *Insert*, in the *Charts ribbon*, choose *Scatter*).

* 1. In Excel, create a table with columns *1*/ and *F*. Draw another graph to show the relationship between (*1*/and *F*). Copy and paste the Excel table and graph below. Comment on the result.
  2. Now keep the distance *r* unchanged, change the magnitude of Q1 and Q2, record the

results in the following table:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| r | Q1 | Q2 | Q1\*Q2 | F |
| 3 | -4 | 8 |  |  |
| 3 | -5 | 8 |  |  |
| 3 | -5 | 10 |  |  |
| 3 | +6 | 10 |  |  |
| 3 | +8 | 10 |  |  |
| 3 | +10 | 10 |  |  |

* 1. In Excel, draw a graph to show the relationship between *(Q1\*Q2*and *F*). Copy and paste the Excel table and graph below. Comment on the result.
  2. From the previous exercise, calculate the coulomb’s constant *K* in air.

**Part 2: Electrical Field and Distance**

**1**: Go to the site: <https://phet.colorado.edu/en/simulations/charges-and-fields>, click run

**2**: In the right control box tick *grid* and *Values*

3: Drag one positive and one negative charges onto the grid. Carefully place them EXACTLY 1.0 m apart horizontally (see scale at bottom left). Place a sensor exactly in-between them. Read and record filed. Repeat for other spacings:

|  |  |
| --- | --- |
| Distance Apart | Field V/m |
| 1.0 m |  |
| 2.0 m |  |
| 3.0 m |  |
| 4.0 m |  |
| 5.0 m |  |

4: Calculate the RATIO of the fields when the distance is doubled and get the average:

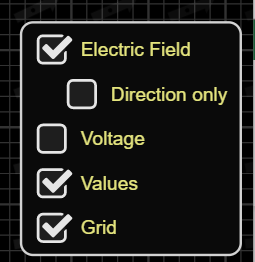
|  |  |  |  |
| --- | --- | --- | --- |
| Distances | 1m to 2m | 2m to 4m | Average |
| Field ratio |  |  |  |

5: Calculate the RATIO of the fields when the distance is tripled:

|  |  |
| --- | --- |
| Distance | 1m to 3m |
| Field ratio |  |

**6**: Based on Step 4 and Step 5, summarise the relationship between the Electrical Field and Distance:

**Part 3: Direction of Electrical Field**

**1**: Use the reset button  to clear out screen. Tick the Gird, Values boxes

**2**: Place a single positive charge on the grid. Which way are the E field arrows going? Explain the reason below:

**3**: Place a sensor in the following 4 positions 1m away from the positive charge: due north, due south, due east and due west. Draw the E-fields that the test sensor experiences in the above 4 different positions respectively:

**4**: Place another positive charge 2m away from the first one. Move the sensor to the following 3 positions: middle of the two charges, 1m below the middle of the two charges, and 1m below the first positive charge. Screenshot the E-fields at the three positions shown by the simulator below:

**5**: In the third position (i.e. 1m below the first positive charge), remove the second charge, screenshot the E-field at the sensor position. Put the second charge back, and remove the first change, screenshot the E-field at the sensor position. This step is to show the individual effect of each of the two charges on the sensor. The overall E-field that the sensor experience shown in step 4 should be the combination of the two separate ones shown in this step.

**6**: Calculate the E-fields of the three positions in step 4. Show your working below.

Position 1(in the middle of two charges):

Position 2 (1m below the middle of the two charges):

Position 3 (1m below the first positive charge):

**7**: For the third position, compare your calculation with what the simulator gave in Step 4 and Step 5. Comment on your comparison results below:

8. Optional: if you have finished all the above, there is an interesting game below. You will need to have good estimation of the electrical forces to score goals and move to the next difficulty level:

<https://phet.colorado.edu/sims/cheerpj/electric-hockey/latest/electric-hockey.html?simulation=electric-hockey>