**Experiment 4:**

Coulomb’s Law

**Ben Giftakis**

TA: Mario Rojas

Physics 181

7/27/20

**Purpose**: The purpose of this experiment is to experiment with the properties of charged particles and electrostatic force and its relationship with distance and charge.

**Data**:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| q1 = | -0.000003 | q2 = | 0.000003 | **N** | Ke | 8987582791 |
| r (cm) | r^2 (m^2) | 1/r^2 (1/m^2) | Fe (N) | 8 | Ka | 8.99E+09 |
| 10 | 0.01 | 100 | 8.089 | **slope** | SKe | -2.1939E-18 |
| 9 | 0.0081 | 123.4567901 | 9.986 | **(units)** | %diff | 0.02689 |
| 8 | 0.0064 | 156.25 | 12.639 | 0.080888245 |  |  |
| 7 | 0.0049 | 204.0816327 | 16.508 | **intercept** |  |  |
| 6 | 0.0036 | 277.7777778 | 22.469 | **(units)** |  |  |
| 5 | 0.0025 | 400 | 32.355 | 1.78544E-05 |  |  |
| 4 | 0.0016 | 625 | 50.555 | **R2** |  |  |
| 3 | 0.0009 | 1111.111111 | 89.876 | 1 |  |  |
|  |  |  |  | **Sy** |  |  |
|  |  |  |  | **(units)** |  |  |
|  |  |  |  | 0.000222132 |  |  |
|  |  |  |  | **Sslope** |  |  |
|  |  |  |  | **(units)** |  |  |
|  |  |  |  | 0.0000002438 |  |  |
|  |  |  |  | **Sintercept** |  |  |
|  |  |  |  | **(units)** |  |  |
|  |  |  |  | 0.000120461 |  |  |

Table 1: calculating coulomb's constant with radius and electrostatic force

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sensor Angle** | **r** | **E** | **(+) q** | **N** | **% diff (+) q** | **Sensor Angle** | **r** | **E** | **(-) q** | **N** | **% diff (-) q** |
| **(deg)** | **(m)** | **(V/m)** | **(C)** | 4 | 2.67 | **(deg)** | **(m)** | **(V/m)** | **(C)** | 4 | 2.67 |
| 0 | 0.5 | 35 | 9.73E-10 | **`x** |  | 0 | 0.5 | 35 | -9.73E-10 | **`x** |  |
| 90 | 0.5 | 35 | 9.73E-10 | **C** |  | 90 | 0.5 | 35 | -9.73E-10 | **c** |  |
| 180 | 0.5 | 35 | 9.73E-10 | 9.736E-10 |  | 180 | 0.5 | 35 | -9.73E-10 | -9.7E-10 |  |
| -90 | 0.5 | 35 | 9.73E-10 | **Sx** |  | -90 | 0.5 | 35 | -9.73E-10 | **Sx** |  |
|  |  |  |  | **C** |  |  |  |  |  | **c** |  |
|  |  |  |  | 0 |  |  |  |  |  | 0 |  |
|  |  |  |  | **S`x** |  |  |  |  |  | **S`x** |  |
|  |  |  |  | **C** |  |  |  |  |  | **c** |  |

Table 2: calculating charge using electric field

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **sensor** | **x** | **y** | **r** | **E** | **N** | **keq(3)** | **keq(1,2)** | **PFE** |
| **#** | **(m)** | **(m)** | **(m)** | **(V/m)** | 8 | **(**units**)** | **(**units**)** | 2.922251 |
| 1 | 0.25 | 0 | 0.25 | 144 | **`x** | 9.0057 | 8.750003 |  |
| 2 | 0.5 | 0.5 | 0.707107 | 18 | **(V/m)** |  |  |  |
| 3 | 0 | 1 | 1 | 9 | 22.95875 |  |  |  |
| 4 | -1 | 1 | 1.414214 | 4.5 | **Sx** |  |  |  |
| 5 | -1.5 | 0 | 1.5 | 4 | **(V/m)** |  |  |  |
| 6 | -1.5 | -1.5 | 2.12132 | 2 | 49.23274 |  |  |  |
| 7 | 0 | -2.5 | 2.5 | 1.45 | **S`x** |  |  |  |
| 8 | 2.5 | -2.5 | 3.535534 | 0.72 | **(V/m)** |  |  |  |
|  |  |  |  |  | 17.4064 |  |  |  |

Table 3: verification of the electric field formula using the inverse square law:

Figure 1: visualization of the inverse square law

Figure : Fe vs 1/r^2

Figure : r vs Fe

**Calculations**:

0.0000002438=-2.1939E-18

**Discussion**:

In the experiment the value of Coulombs constant was calculated to be +- 2.1939E-18 Nm2/C2. This value is close to the accepted value of the constant, with a %difference of merely .02%. However, the results fail the precision accuracy test hugely, this could be an error of calculating error. The constant was calculated from the measured radius and electrostatic force.

The value of the charge in part 2 was, only 2.64% different from the accepted value of 1nC. This is pretty close to the expected value, the data was quite consistent as I chose to make all my points the same radius at different angles. I did this is for both particles, so the data was the same. The charges were calculated on accurate values for radius and electric field.

The value of Keq3 was calculated to be 9.0057 and Keq1,2 were calculated to be 8.75. the PFE of these values is 2.92%. The values were derived from the coefficient of the power trendline from the relationship between radius and electric field.

**Conclusion & results**:

Ke = +- 2.1939E-18 Nm2/C2

%diff = 0.02%

Q C

%diff = 2.64%

Keq3 = 9.0057

Keq1,2 = 8.75

These calculated values were quite expected. While the Ke failed the precision accuracy test, it was still percentage wise quite close to the accepted value. All data points on the graphs were right in line with the trend lines, with R2 values very close to if not 1. I imagine that all sources of error were due to the level of precision of the displays on the meters used, except in part 2/3 where it was difficult to control the position of the sensors.

**Questions**:

1.) Based on the trendline and how well it matches the data, it is easy to see that there is an inverse square relationship between distance and electrostatic force. This is the same relationship that is demonstrated in part 3 (figure 1)

2.)

|  |  |  |
| --- | --- | --- |
| point | v/m | E |
| center | 18 | 0.035 |
| center up | 12.7 | -0.036 |
| left | 7.9 | 5.985 |
| right | 7.9 | -5.685 |

3.)

|  |  |  |
| --- | --- | --- |
| point | v/m | E |
| center | 0.18 | 18 |
| center up | 6.49 | 16 |
| left | 9.89 | 12 |
| right | 9.97 | 12.02 |
|  |  |  |