Coulomb's Law

Name: Rebecca Proni Date: ____________

Instructor: ____________

Teammates

1.- ____________ 2.- ____________

3.- ____________ 4.- ____________

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. Do not forget the units.

Follow the instruction in the lab manual to collect your data.

Electric Force and Distance

In this experiment, we control the distance between charges and observe the force between them. For each distance, record the torsion angle required to realign the marks on the vane and the index arm of the balance. Organize your data in a table with headings and units.

Data

Seperation distance d (m)	Angle θ	$x = 1/d^2$(m^{-2})
0.20	12	2.50E+01
0.14	14	5.10E+01
0.10	25	1.00E+02
0.08	42	1.56E+02
0.06	63	2.78E+02

Analysis

1. Use graph paper to Plot θ as a function of the separation distance d. Call this Figure 1.
2. Add a third column to your data table to record the inverse square of the separation distance. Call this variable x; x should have units of m^{-2}.
3. Make another graph of θ, but this time as a function of the x variable. Call this Figure 2.
4. If the data on Figure 2 looks like a straight line, use a straight edge to determine the line that best fit your data; draw this best-fit line on top of your data in Figure 2.
5. Determine the best-fit line slope, which is a good estimate for the constant in equation (5) of your lab manual.

   The best-fit line equation is $y = 0.2116x + 5.3803$ with a slope $m = 0.2116$ degrees $\cdot$ m^2

   Equation 5 is $\theta = C\dfrac{1}{d^2}$ where $C = \dfrac{kq_1q_2}{c}$

6. Use the value of the best fit line's slope to determine the value of Q. Assume that the spheres get the same amount of charge, Q, every time you charged them. Take the accepted value for the Coulomb's constant in equation (1) as $k = 8.99 \times 10^9$ $\mathrm{Nm^2C^{-2}}$, and the value of the proportionality constant in equation (3) as $c = 1.448574 \times 10^{-6}$ $\mathrm{N(degree)^{-1}}$.

   $q_1 = q_2 = q$ so we write

   $$C = \frac{kq^2}{c} \rightarrow q = \sqrt{\frac{Cc}{k}} = \sqrt{\frac{(0.2116\text{degrees}\cdot\text{m}^2)(1.448574\times10^{-6}\text{N/degree})}{8.99\times10^9\text{Nm}^2/\text{C}^2}} = 5.84\times10^{-9}\text{C}$$

1 Questions

1. Some times the Coulomb's law is written as

   $$F = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{d^2}, \tag{1}$$

   where ϵ_0 is the permittivity of free space. What are the SI units for ϵ_0.

   $$F = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{d^2} \rightarrow \epsilon_0 = \frac{1}{4\pi F}\frac{q_1q_2}{d^2}$$

   $\epsilon_0 = \dfrac{1}{N}\dfrac{C^2}{m^2}$ which makes sense since the units of k are $\dfrac{Nm^2}{C^2}$ and $k = \dfrac{1}{4\pi\epsilon_0}$

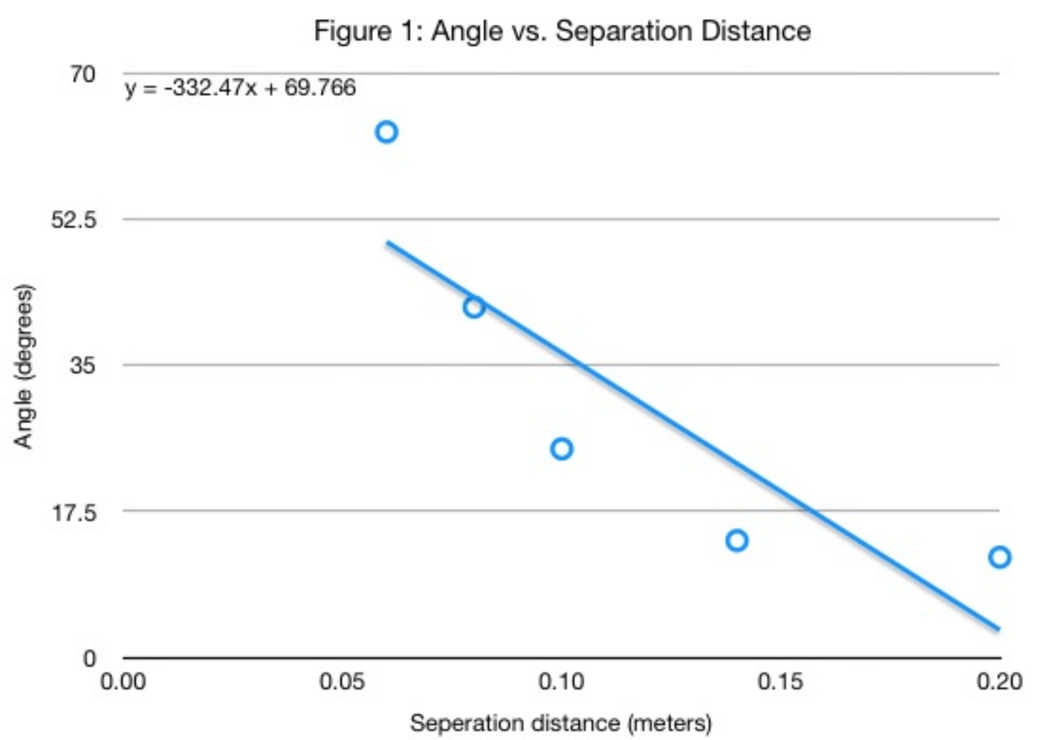
Figure 1: Angle vs. Separation Distance
y = -332.47x + 69.766
70
52.5
35
17.5
0
Angle (degrees)
0.00
0.05
0.10
0.15
0.20
Seperation distance (meters)

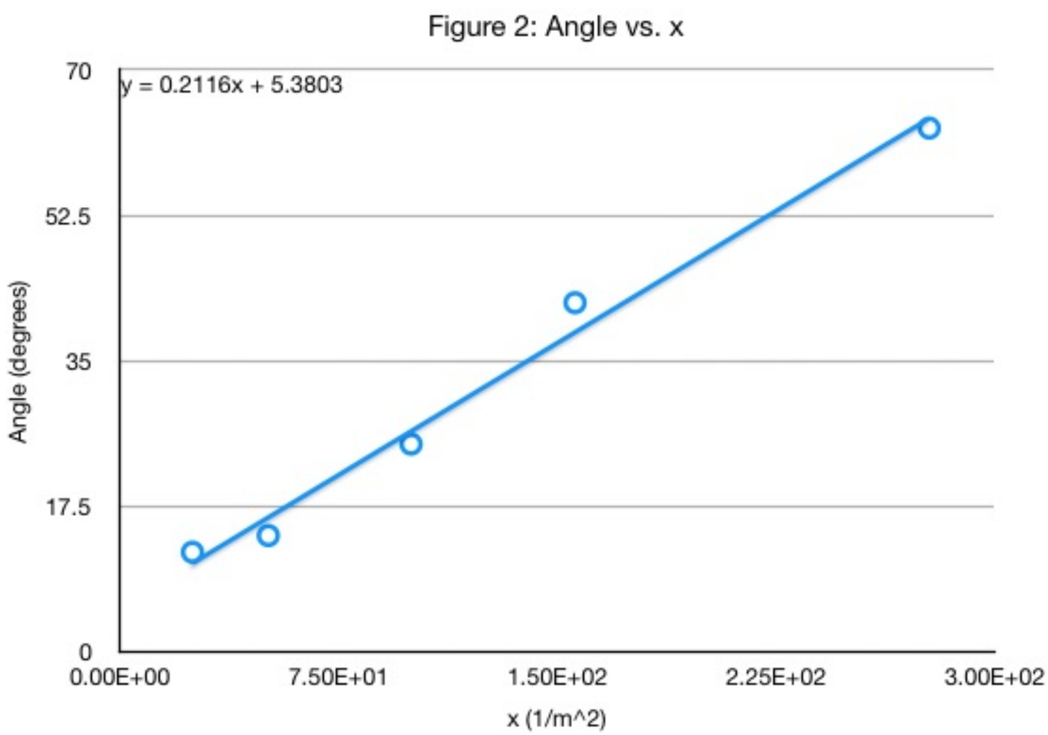
Figure 2: Angle vs. x
y = 0.2116x + 5.3803
70
52.5
35
17.5
0
Angle (degrees)
0.00E+00
7.50E+01
1.50E+02
2.25E+02
3.00E+02
x (1/m^2)