Coulomb's law lab

Objective: to verify coulomb's law

Materials:

String

Wool cloth

Plastic ruler

Box

2 Graphite balls, one attached to the string

Procedures:

1. measure the mass of the graphite ball which is attached to the string
2. put the ball in the box with the string attached with the box, measure the distance from the top of the box where the string is attached, to the hanging ball, also measure the horizontal position of the ball
3. rub the ruler with the wool cloth so that it is charged
4. use the ruler to touch the other ball which is attached to a holding tool, so it gets charged
5. place the charged ball into the box, until that it touches the ball in the box
6. the balls will then repel, record the distance of the repulsion, the distance is measured from the center of the ball to the center of the other ball
7. To record the distance, one sees the scale through the transparent glass, and should not see the image of the ball in the mirror
8. repeat step6 4 more times without recharging the ball,(the charge on the ball is unchanged)

Data collection

Table 1: the distance between the two balls due to repulsion(subtracting one from the other)

trial#	position of the other ball(m)	position of the hanging ball(m)	distance between(m)
1	0.053	0.033	0.02
2	0.056	0.035	0.021

3	0.052	0.032	0.02
4	0.056	0.035	0.021
5	0.043	0.028	0.015

Hanging ball's mass: 0.11g=1.1x10^-4kg

Length of the imaginary string:21.7cm=0.217m

Equilibrium position of the hanging ball:4.3cm=0.043m

The diagram represents the hanging ball's force vector diagram. From the above diagram, it is seen that the ball is in an equilibrium position, meaning that the forces acting on it balances out. The ball experiences electric force of repulsion (fe), and the force of gravity(mg), the resultant force of these two forces(Ft), is balanced by the tension of the string, which acts in the opposite direction to it.

From the diagram, Fe is the horizontal component of Ft, thus, Fe= sin θ Ft. Mg is the vertical component, Mg/Ft=cos θ. Rearranging it gives, Ft=mg/cos θ. Combining the two equations, Fe=sin θ mg/cos θ ,=tan θ mg.

To find out the tan θ in the above equation, the formula tan θ = x/L is used where x is the distance the hanging ball moved from its original equilibrium position and L is the distance of the hanging ball from the top of the box.(since the ball is held by two strings, it is assumed that there's an imaginary string from the top of the box to the string in the middle, this imaginary string distance is thus L. As seem in the diagram, x is only an approximation of the distance the ball moved, since that the ball didn't move exactly horizontally but also moved up vertically which is ignored in the calculations.

Table 2 the distance the hanging ball moved from the equilibrium(x)(subtracting the former from the latter)

trial #	equilibrium position of the hanging ball(m)	position of the hanging ball after repulsion	the change distance(x)
1	0.043	0.033	0.01
2	0.043	0.035	0.008
3	0.043	0.032	0.011
4	0.043	0.035	0.008
5	0.043	0.028	0.015

Table 3 tan θ using =x/L

trial #	(x)the change in distance of the hanging ball(m)	(L)length of the imaginary string(m)	$\tan\theta$
1	0.01	0.217	0.046
2	0.008	0.217	0.037
3	0.011	0.217	0.051
4	0.008	0.217	0.037
5	0.015	0.217	0.069

Weight of the ball(Mg) is calculated by the hanging ball's mass multiplied by g:

=1.1x10^-4kg* 9.8

=0.001078N

Table 4 Fe on the hanging ball using the equation (fe= tan θ mg)

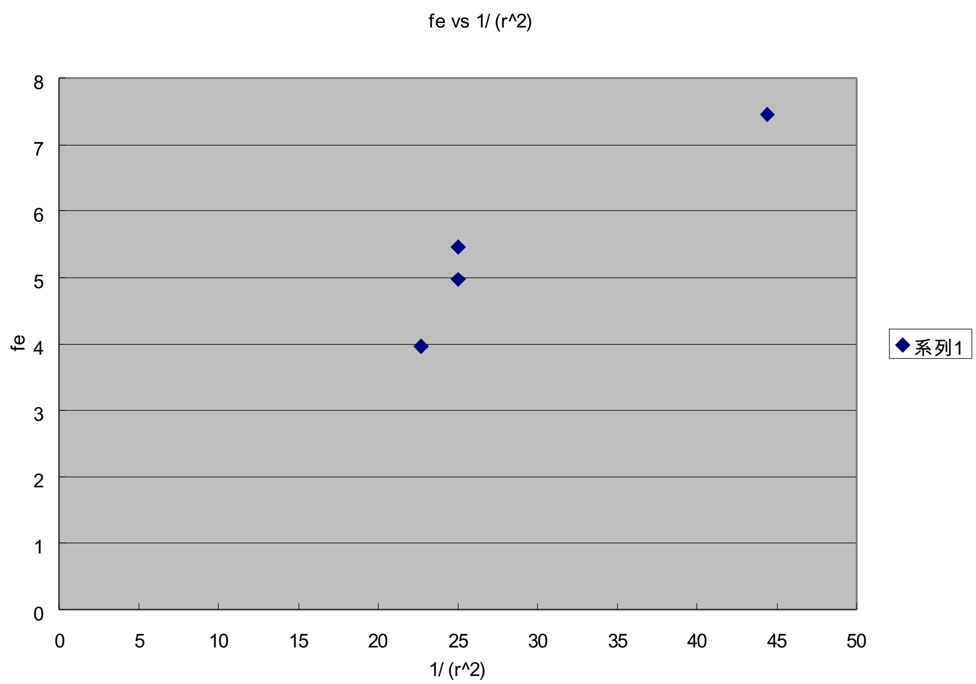
trial #	(mg)weight of the ball(N)	tanθ	fe(N) *10^-5
1	0.001078	0.046	4.97
2	0.001078	0.037	3.97
3	0.001078	0.051	5.46
4	0.001078	0.037	3.97
5	0.001078	0.069	7.45

According to coloumb's law, Fe=(kq1q2)/r^2, in this case q1=q2 because that after the balls touched, the charges distribute evenly on the balls.

(1/r^2) is calculated using r as the distance between the two balls(in table 1)

Table 5 The relationship between fe and 1/(r^2)

trial #	fe(N)*10^-5	1/(r^2)*10^2(m)
1	4.97	25
2	3.97	22.7
3	5.46	25
4	3.97	22.7
5	7.45	44.4



Evaluation

Weaknesses, limitations, errors

The main weakness and also the main limitation to the experiment was that charges on the balls were lost to the air which then created errors in the values of the distances between the two balls. The charges on the ruler after we rubbed it with fur, and also the charges on the graphite ball could have escaped into the air. The fact that it was a humid day even more made the charges to escape. The humidity would cause the negative charged electrons in the air to neutralize the positively charged rod, or if the rod is negatively charged, the extra electrons would likely to escape into the air, leaving the ball to be neutral.

However, it was difficult to measure the distance between the two balls just by viewing it by the eye. This can cause errors in the measurement and that this human error cannot be avoided without some measuring devices that doesn't require measuring by human vision.

The other major error in calculating the data that was ignored was that the hanging ball didn't repel exactly horizontally, but with also a vertical component. This means that the x (distance it moved from equilibrium) is not the distance the ball moved but the horizontal component. Therefore, x is only an approximation, and tan θ may not be exactly precise, because we are assuming x is at right angle with L.

Suggestions for improvement

The loss of charges in the experiment cannot be prevented, but a suggestion is to do it on a dry day, where the charges would not escape into the air as in a humid day would. The approximation of x can be much improved by opening the lid of the box and hang the string from the ceiling. This way, the L would be much larger, and the approximation of tan θ would be more precise because now is at a smaller angle.

Conclusion

The experiment fairly showed the columb's law, and the relationship between the variables, r, fe, q. During the process, as the charges are lost to the air, the distance as well as fe decreased. The graph of fe vs 1/(r^2) suggested a straight line, a linear relationship between the two variables, that the force between the two charges was inversely proportional to the square of the distance between them r2.