Physics Laboratory Report

Lab Number and Title: Lab 200: Electrostatics - Electric Charge and Force

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Course & section number: Physics 121A-010 **Instructor's Name:** Kai Qian

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Introduction

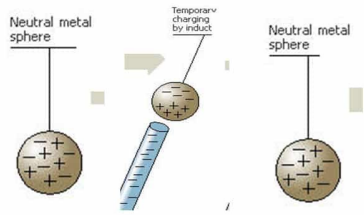
There are two types of charges, positive and negative. All materials consist of protons, neutrons and electrons. A body is electrically neutral when it possesses an equal number of protons and neutrons. A body with more protons than neutrons are electron deficient and electrically positive. However, a body with more electrons is proton deficient and electrically negative.

Materials in which electrons are loosely bound are called conductors (metals). As a glass rod is rubbed against a silk cloth, the rod is positively charged and the silk negatively. The electrons from the cloth transfer to the cloth. Friction helps transfer the charge from one body to the next, it does not create charge.

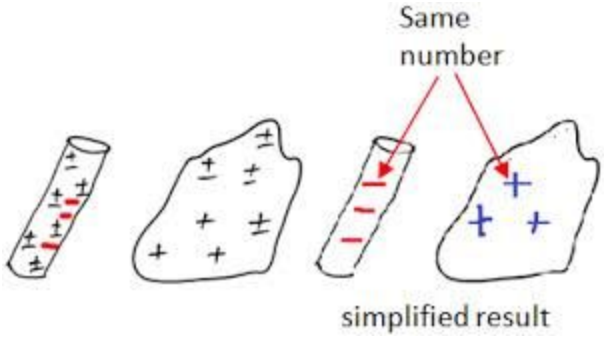
Case	Material A	Material B	Positively Charged	Negatively Charged
1	Glass	Silk	Glass	Silk
2	PVC	Wool	Wool	PVC
3	Silicon	Human Hair	Human Hair	Silicon

<u>The methods to electrically charge an object are:</u>

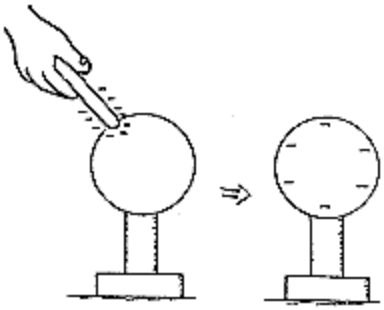
Induction:Objects are charged without contact with a charged source. Works with metal conductors to separate the charges.



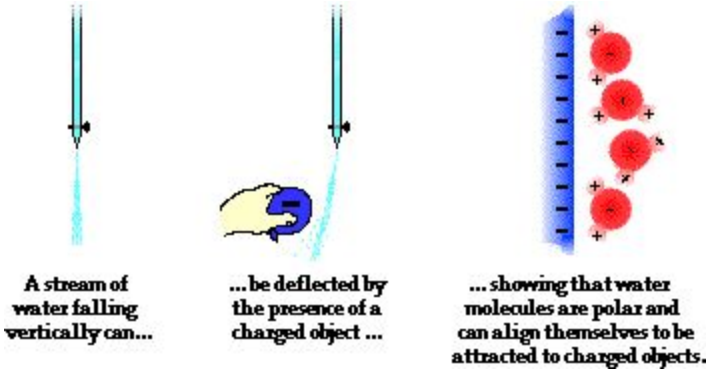
Friction : Materials can be charged by making contact with one another charged material.



Conduction**:** Negatively charged object is brought close to a neutral metal object.



Electric Polarization: Insulators hold onto electrons very tightly. Charge redistribution happens on a much smaller scale.



Coulomb's Law:

Same charges repel and opposite charges attract.

(1) $F_e == \frac{K_e|q_s||q_L|}{r^2}$

where :

$K = 9 * 10^9$

r is the distance between the charges squared

q_L *and* q_S *are the electric charges in the system*

(2) $F_{st} = \frac{k_e q_s q_t}{r^2} * r$

where r is the unit vector directed from the source charge s towards the test charge t.

(3)$T cos\theta = mg \; - \; - \; -> T = mg/cos\theta$

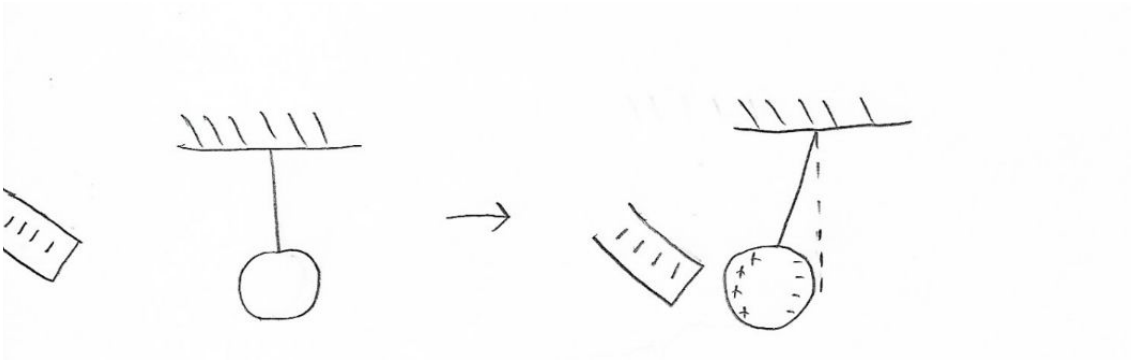
The horizontal component of the tension force becomes equal to the electrostatic force:

(4)$T \; sin \; \theta = \; F_e = kQq/ \; r^2$

(5) $F_e = (K \; Qq/r^2) = mg \; tan \; \theta$

Handheld Van de Graaff Generator (Fun-Fly Stick): produces a static positive charge simply by running a rubber belt over two rollers. As the positive charge is generated the electrons are pushed to the upper comb and onto the rubber belt.

Experimental Procedure:



This image represents the induction portion of experiment 4. As the negatively charged PVC rod is brought close to the pitch ball, it attracts the pitch ball, which is neutral through the process of electrical polarization. As seen in the drawing, the free moving protons move towards the end which is farthest away from the negatively charged PVC rod. As a result, the part of the pitch ball closest to the rod becomes positively charged.

Overall, the procedure of the lab was very similar to the lab manual except for a couple changes mandated by the instructor. For one, we had to switch some materials in table 1 of Experiment 3.

Additionally, we were instructed to cross out the first row, titled “Glass”, of the table in Experiment 3. Throughout the experiment, there were not too many experimental variables since the lab was straight forward, but one possible variable could have been that some of our materials, such as the wool, were a little worn out from previous uses and that could have possibly caused a minimal error in the experiment.

Results

Experiment 2: Table 1

	Uncharged Plastic Straw (insulator)	Uncharged metal (conductor)	Plastic Straw rubbed with wool	PVC rod rubbed with wool
Uncharged Plastic Straw	No interaction	No interaction	Attracting interaction	Attracting interaction
Plastic Straw rubbed with silk	Attracting interaction	Attracting interaction	Repelling interaction	Repelling interaction
Acrylic rod rubbed with silk	Attracting interaction	Attracting interaction	Attracting interaction	Attracting interaction

Experiment 3:

	Fur	Silk	Wool
PVC	Negative	Negative	Negative
Acrylic	Negative	Positive	Positive

Analysis and Discussion

In experiment 1 of the lab, we demonstrated that we can electrically charge an object by rubbing (friction) it with other kinds of materials. This is apparent when we rubbed the end of a rod with the cloth and brought it close to the pieces of paper and aluminum. The paper and/or the aluminum would be attracted to the rod because rubbing the cloth on the rod moves electrons further from the end of the rod. This creates a polarity at the end of the rod, therefore causing an attraction to the paper and/or aluminum.

In experiment 2 of the lab, we demonstrated that there is an interaction between charged objects: repelling or attracting each other, depending on the polarity of the charges. Table 1, shows the type of interaction between the specified rods. One rod having a negative polarity and the other rod having a positive polarity, causes an attracting interaction. For example, when the plastic straw was rubbed with wool (negative charge) and the acrylic rod was rubbed with silk (positive charge), the two rods attracted each other. However when both rods have the same polarity, the rods have a repelling interaction. When the rods are uncharged, there is no interaction. However, when an uncharged rod is near a polar rod, could be either positive or negative charged, there is attraction due to polarization. This is because when the positive or negative rod is brought near the neutral rod, it polarizes the neutral rod's molecules.

In experiment 3 of the lab, we identified the polarity (positive or negative) of a charged object based on what we learned about charge interaction. Based on the previous experiment, we knew which rods created a negative or positive charge when rubbed with specific cloths. This was useful to see if the rod rubbed with the cloth in Table 3, was negatively or positively charged due to its interaction with the known charged rod. For example, if the known rod was negatively charged and the tested rod repels the known rod, then we could conclude that the tested rod has a negative charge.

In experiment 4 of the lab, we demonstrated that a conductor can be charged by methods of conduction and induction. Conduction is when a negatively charged object comes in contact with a neutral object. The electrons of the negatively charged object are then directly transmitted through the neutral object, charging the neutral object. Induction is when a charged object is brought near a neutral object but never comes into contact with the neutral object. The presence of the charged particles near the neutral conductor object causes the electron in the neutral conductor object to move. This causes a slight polarity in the previously neutral conductor object.

The objective of the lab was met. Our results are reasonable due to the methods to electrically charge a material (friction, conduction, and induction).

Experiment 1:

Charging:

5. The attraction between the acrylic rod and aluminum is stronger than the attraction between the acrylic rod and the pieces of paper. Both the rod and cloth are charged.

6. Rubbing the rod with a cloth for a longer time won't create more charge. It will just move more electrons further from the end of the rod.

7. You cannot tell what the charge is.

Discharging:

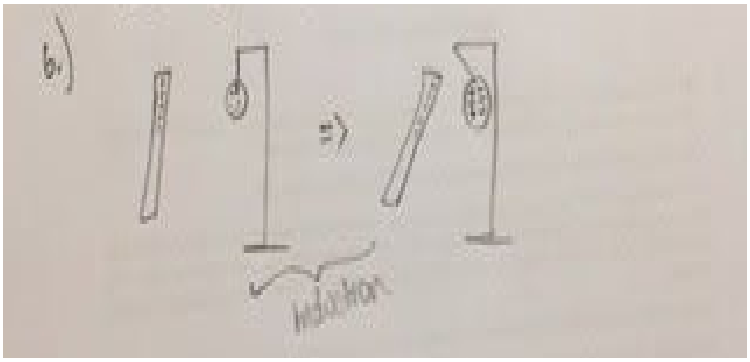
4. There are no interactions because once the tip touches a surface (finger/metal surface), the surface acts as a conductor neutralizing the rod.

Experiment 4:

Charging by induction:

3. The pith ball is partly positively charged for it was attracted to the negatively charged PVC rod. The part of the ball closest to the PVC rod is more positively charged and the part of the ball furthest from the PVC rod is more negatively charged.

5. The pith ball moved away from the Fun-Fly stick (positively charged). After the induction process, we could conclude that the pith ball is positively charged.

6. 

Conclusion

By completing this lab, we were able to visualize how charges were produced through various materials and how each was mostly unique. We experimented by means of induction where the objects were brought near each other but did not touch. We noticed that if both materials were uncharged, there was usually no interaction between them but if at least one was, then there was some sort of interaction whether that be a repelling or attracting interaction. The data for this lab was qualitative as we only had to determine the types of interactions that occurred on each trial and take note. This experiment only raised the question concerning what would happen with other materials and how much of a difference conduction would have on the outcomes. Some changes in experimental design that could possibly incite additional questions and improve results could be to measure just how powerful the charges were and how far the objects repelled or attracted. If there were any possible sources of error in this experiment, it would only be human error in failing to get the desired charges on materials. Overall, this lab was quite straightforward and was based purely on observations of interactions between materials.