

Static Electricity

Equipment Needed	Qty	Equipment Needed	Qty
Glass Rod	2	Plastic Rod	2
Fur	1	Silk Cloth	1
Pith Ball	1	Rotating Support	1
Electroscope	1	Paper towel	1

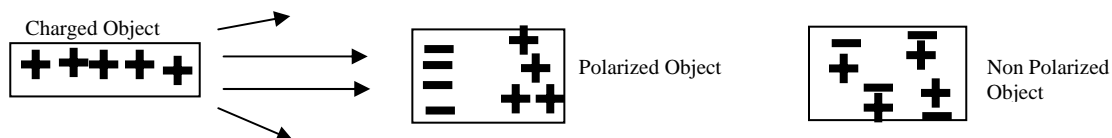
Background

Static electricity, a natural phenomenon, has been known since at least as early as the 6th century B.C., as discussed by Thales of Miletus, a pre-Socratic Greek philosopher and one of the Seven Sages of Greece. The name electron comes from the Greek word amber, a fossilized tree resin. When rubbed with fur, a piece of amber can attract small objects like tiny pieces of paper. When rubbed many materials exhibit this same behavior, ability to attract small objects. Today we know that the source of this attraction is due to the presence of static electric charge.

Electric charge comes in two forms: positive and negative. Electrons carry negative charge and protons carry positive charge. Normally materials are electrically neutral; that is, they have an equal number of positive and negative charges (equal number of protons and electrons). From a microscopic point-of-view, a material is comprised of atoms. An atom is composed of electron(s), proton(s) and neutron(s). Electrons are relatively light, mobile and easily removed from the core nucleus that is comprised of relatively massive proton(s) and neutron(s) that are strongly bound together.

Static electricity occurs whenever there is an accumulation of one type of charge and may be produced two dissimilar insulating materials are rubbed together; for example, plastic and fur. A static charge is produced when electrons are transferred or removed from one object and placed on the other. The material losing electrons has fewer electrons than normal and becomes positively charged. The material gaining electrons now has more electrons and becomes negative.

Surrounding a charge is an electric field that becomes weaker as the distance from the charge increases. For positive charge, the field lines are directed outward from the charge. For negative charge, the field lines are directed inward towards the charge. When a second charge is placed in proximity to a first charge, a force is imposed on the second charge through the electric field of the first charge and a force is imposed on the first charge through the electric field of the second charge with these two forces being equal in magnitude but opposite direction. For similar charges, both of them being positive or negative, the charges repel one another. For opposing charges, one negative and the other positive, the charges will be attracted to one another.



If a neutral material is placed inside a weak, negligible, electric field, it will not experience a net force because the material contains an equal number of positive and negative charges. However, if a neutral material is placed inside a strong electric field the material may become polarized and experience a net force. A material may become polarized because the dissimilar charges will be attracted toward the charge(s) while similar charges will be repelled away from the charge(s) producing the

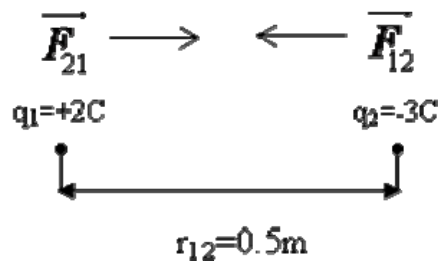
electric field; thereby, the material becomes polarized whereby the charges in the material are no longer randomly distributed and are slightly separated (positive on one side, negative on the other side). Since the strong electric field surrounding a charged object becomes weaker with distance from the charge object, the object experiences a net attractive force due to the from the closest charges of opposite sign as compared with the weaker repulsive forces on like charges that are further away. As an example of such polarization effects, a balloon may become charged by rubbing it in your hair. If the balloon is then placed against a neutral wall, it may then stick to the wall and defy the forces of gravity.

In a conductor, metal, a charge and may move freely and will remain on the surface of the conductor. In an insulator, a charge cannot move freely and may reside in the same location on the insulator for long periods of time.

The magnitude of the force, F , that one charge exerts on another may be expressed as

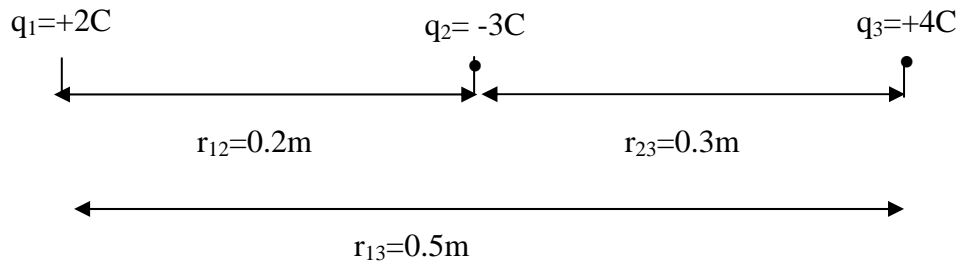
$$F_{12} = k \frac{q_1 q_2}{r_{12}^2}$$

where q_1 is the charge on object 1, q_2 is the charge on object 2, r_{12} is the distance between object 1 and 2, k is a proportionality constant, $9 \times 10^9 \text{ (N}\cdot\text{m}^2/\text{C}^2)$, and the direction of the force is along the line between the two charges. Note that a negative sign indicates that the force is attractive and a positive sign means that the force is repulsive between the two charges. Using the picture below, calculate the force on the +2C charge.



$$\vec{F}_{12} = 9 \cdot 10^9 \left(\frac{\text{N} \cdot \text{m}^2}{\text{C}^2} \right) \frac{2\text{C} \cdot (-3\text{C})}{(0.5\text{m})^2} \hat{r} = -2.11 \cdot 10^{11} \text{N} \hat{r} = -\vec{F}_{21}$$

The force on charge one (+2C), \vec{F}_{21} , is to the right and the force on charge 2 (-3C), \vec{F}_{12} , is to the left with the minus sign indicating attraction between the two charges. The arrow is drawn to the right because the +2C charge is attracted to the -3C charge. When two or more charges act upon one another, the total electric force on each charge is from the superposition principle the sum of the individual forces acting upon the charge under consideration.



$$\vec{F}_{21} = -\vec{F}_{12} = -9 \cdot 10^9 \left(\frac{N \cdot m^2}{C^2} \right) \frac{(+2C) \cdot (-3C)}{(0.2m)^2} \hat{r} = +1.35 \cdot 10^{12} N \hat{r}$$

$$\vec{F}_{31} = -\vec{F}_{13} = -9 \cdot 10^9 \left(\frac{N \cdot m^2}{C^2} \right) \frac{(+4C) \cdot (+2C)}{(0.5m)^2} \hat{r} = -2.88 \cdot 10^{11} N \hat{r}$$

and

$$\vec{F}_T = \vec{F}_{21} + \vec{F}_{31} = (1.35 \cdot 10^{12} - 2.88 \cdot 10^{11}) N \hat{r} \approx 1.06 \cdot 10^{12} N \hat{r}$$

with the positive sign meaning the force is to the right.

SAFETY REMINDER

- Follow the directions for using the equipment.

THINK SAFETY
ACT SAFELY
BE SAFE!

Purpose

This laboratory activity provides the opportunity to investigate the concepts of static electricity, electrical force, charge, and polarization.

PART I: Equipment Setup and Data Collection

I. Accumulation of Charge

Read the laboratory section **Accumulation of Charge**, perform the instructions, and answer the questions. Be sure to utilize the glass rod with a piece of silk and plastic rod with a piece of fur while briskly rubbing the objects against each other to accumulate enough charge to observe the effects of static electricity.

II. Force Between Charged Objects

1. For the cases below, in the laboratory report section II, indicate whether there is attraction or repulsion and which charge, positive or negative, resides of each rod.
 - A. Charge a glass rod with a piece of silk and then put it on the rotating support. Next, rub a second glass rod with a piece of silk. Bring this second rod near the rod on the support.
 - B. Charge a glass rod and put it on the rotating support. Bring a charged plastic rod near the charged glass rod on the support and record your observations.

- C. Charge a plastic rod and then put it on the rotating support. Bring a second charged plastic rod near the plastic rod on the support and record your observations.
- D. Charge a plastic rod and put it on the rotating support. Bring a charged glass rod near the charged plastic rod on the support and record your observations.

III. Polarization

A. Small Paper Pieces

1. Paper is neutral. Tear a paper towel into small pieces (the smaller the better).
2. Briskly rub a glass rod with a piece of silk and then bring the glass rod near the pieces of paper and record what happens in the laboratory report section, III-A.
3. This time, using an plastic rod and fur, perform the same procedure (2) above and record what happens in the laboratory report section, III-A.

B. Pith Ball

1. Neutralize the pith ball by holding it few seconds with your hand before performing the tasks below.
 - A. Bring a charged glass rod near the pith ball. (Make sure not to touch the pith ball with the rod.) Describe what happens and mark the corresponding type of charge (+ or -) in the figure in the laboratory report section, III-B.
 - B. Bring a charged plastic rod near the pith ball. (Make sure not to touch the pith ball with the rod.) Describe what happens and mark the corresponding type of charge (+ or -) in the figure in the laboratory report section, III-B.

C. Electroscope

1. Record your observations and draw charges in the figure, laboratory section III-C, for each of the following cases.
 - A. Briskly rub a glass rod with a piece of silk and bring it near, but not touching, the electroscope terminal.
 - B. Briskly rub a plastic rod with a piece of fur and bring it near, but not touching, the electroscope terminal.
 - C. Briskly rub a plastic rod with a piece of fur and touch it to the electroscope terminal.

IV. Problems

In the examples find the magnitude of the electric force acting on point charge (1) and draw an arrow showing the direction of the electric force.

Record your results in the Lab Report section.

Lab Report – Static Electricity

List at least three ways we can encounter static electricity.

I. Accumulation of Charge

1. Glass Rod

Briskly rub a glass rod with a piece of silk and charge the rod. Given that electrons are transferred from the rod to the silk cloth; then, after charging the

Net Charge (+ or -)

Glass Rod is charged _____

Silk is charged _____

2. Plastic Rod

Briskly rub the plastic rod with a piece of fur and charge the rod. Given that electrons are transferred from the fur to the rod; then, after charging the

Net Charge (+ or -)

Plastic Rod is charged _____

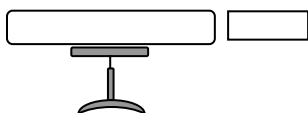
Fur is charged _____

3. What is the net charge, positive (+) or negative (-), of an object that loses electrons after being rubbed?

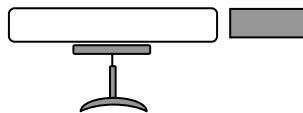
II. Force Between Charged Objects

1. For the below figures, the white glass rods represent glass rods while the gray rods represent the plastic rods from the laboratory section, Accumulation of Charge, above. For each of the cases below, indicate if there is attraction or repulsion and the charge of each rod as determined from the laboratory report section, Accumulation of Charge, above.

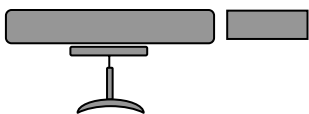
A. _____



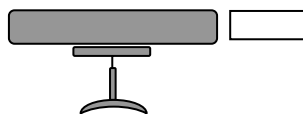
B. _____



C. _____



D. _____



2. Generalize your observations.

Two rods with the same charge: _____

Two rods with opposite charge: _____

III. Polarization

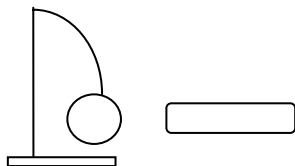
A. Small Paper Pieces

1. What happens if you briskly rub a glass rod with a piece of silk and then bring it near the pieces of paper?
2. What happens if you briskly rub a plastic rod with a piece of fur and then bring it near the pieces of paper?

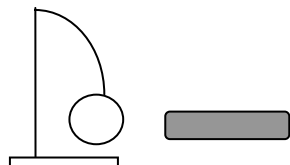
B. Pith Ball

Utilizing the pith ball apparatus and the appropriately charged rod, for each figure below, describe what happens and mark the corresponding object(s) with the corresponding type of charge(s). You may need to recharge each of the rods by briskly rubbing the each rod with the appropriate cloth before performing the instructions above. Remember do not touch the rod to the pith ball or apparatus. If you have touched the rod to the pith ball apparatus, you may discharge or neutralize the apparatus by physically touching it (the metal ball) with your hand.

A.



B.



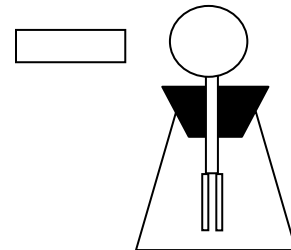
1. For each figure above, was the pith ball attracted toward the rod? In each case above, if the pith ball is attracted to the rod, is this attraction due to the pith ball having a net charge or due to polarization effects?

C. Electroscope

A. What happens when the charged glass rod is brought near the terminal? Be sure not to touch the charged rod to the electroscop. If you do, you may discharge it by physically touching with your bare hand.

What happens when glass the rod is removed?

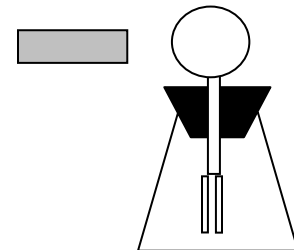
What is the net charge of the electroscop?



A. What happens when the charged plastic rod is brought near the terminal? Be sure not to touch the charged rod to the electroscop. If you do, you may discharge it by physically touching with your bare hand.

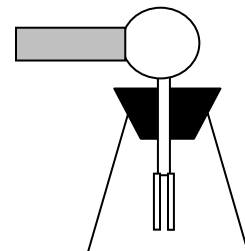
B. What happens when the plastic rod is removed?

What is the net charge of the electroscop?



C. Now touch the plastic rod to the electroscop. What happens when the plastic rod touches the terminal?

What happens when the plastic rod is removed?

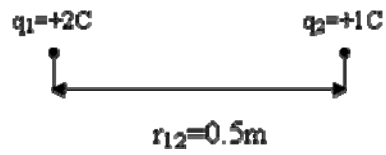


What is the net charge of the electroscop?

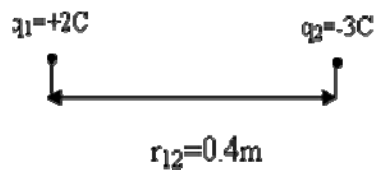
IV. Problems

Find the force on charge one.

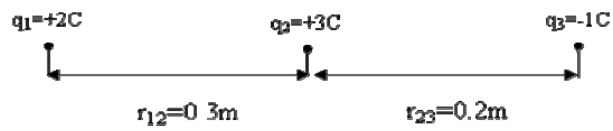
1.



2.



3.



4.

