LAB 16. CHARGE

Problem

- How can an object become electrically charged?
- How do electric charges behave?
- How do charges behave differently in conductors and insulators?

Equipment

1. Two balloons, one suspended by a thread, fur
2. Electric field visualizer bottle, stand, glass and plastic rods, balloons
3. Glass or plastic rod, fur, bubble soap, stream of water, empty aluminum can
4. Tape, marker, table top.

Acknowledgement

The "Sticky tape" section of this lab is copied and lightly adapted from a Harvard University Physics 1b laboratory.

Activities

This lab consists of four stations. You may do them in any order.

1. Charge-Charge Forces

1.1. Charge a balloon suspended by a thread by rubbing it with fur. Hold another balloon in your hand and charge it in the same manner. Slowly bring the balloon in your hand toward the suspended balloon. What happens?

1.2. Re-charge the suspended balloon by rubbing it with fur. Remove the fur piece and then slowly bring it toward the balloon. What happens?

1.3. Rub a balloon in your hair. Slowly pull the balloon away from your head. What happens?

2. Electric Field Visualizer

Place the visualizer bottle on a stand to isolate it. Charge a balloon by rubbing it with fur. Hold it next to the electric field visualizer bottle. In a little while, the fibers suspended in the oil in the bottle will align with the electric field surrounding the charge.

2.1. Sketch the pattern of the fibers in the bottle, also indicating the position of the charged object.

2.2. Generate a different field around the visualizer bottle. You may do this by placing two balloons in different positions around the bottle, placing opposite charges in different positions around the bottle, placing an uncharged piece of metal under the bottle as a charged rod is held near the bottle, and so on. Sketch the pattern of the fibers in the bottle, also identifying and indicating the positions of the other objects.

3. Electric Charge Polarization

Charge a balloon by rubbing it with fur.

3.1. Hold the charged object near a thin stream of falling water. What happens?

3.2. Blow soap bubbles in air. Bring the charged balloon near the bubbles. (Try to avoid letting the bubbles touch the balloon.) What happens?

3.3. Place an empty aluminum can on its side on a level surface, so that it can roll freely. Bring the charged balloon near the side of the can. What happens?

4. Sticky Tape

Background

Most modern applications of electricity involve moving electric charges or current electricity. Historically, however, the first studies of electricity involved static charges, or electrostatics. You certainly feel the effects of electrostatic charges every time you touch a doorknob in the wintertime and get zapped. When two surfaces touch (like your socks on a carpet) chemical bonds can temporarily form between surfaces, as neighboring atoms share electrons. When the surfaces are made of two different materials, the atoms in one surface often exert a stronger pull on the electrons than does the other surface. As a result, when the surfaces pull apart, electrons are stripped out of the weaker atoms by the stronger. These stolen electrons create a negative charge on one material, leaving positive charge on the other surface. It is strictly the act of one surface touching and then not touching another surface that causes the charge transfer.

Most Positive (readily lose electrons)

Rabbit fur
Lucite
Bakelite
Acetate
Glass
Quartz
Mica
Wool
Cat's fur
Silk
Paper
Cotton
Wood
Sealing wax
Amber
Resins
Hard rubber
Metals
Polyester
Polystyrene (Styrofoam)
Orlon
Saran Wrap
Polyurethane
Polyethylene
Polypropylene
Sulfur
Celluloid
Vinyl (PVC)
Teflon

Most Negative (readily steal electrons)

Experimenters have established lists, called **triboelectric ser**ies, of the relative tendencies materials have for gaining and losing electrons. By studying these lists, you can learn that rubbing wool on Styrofoam leads to negatively charged Styrofoam (and positively charged wool). Materials with similar properties (e.g. hair, wool, fur) clump together on the list and don't interact strongly. The author of the above list notes that the series is exactly reproducible only in rare circumstances. Cleanliness, humidity, and manufacturing differences affect ordering. Adapted from *Electrostatics and its Applications*, A.D. Moore, Ed., Wiley & Sons, NY, 1973.

1. Stick a piece of plastic adhesive tape (Scotch Magic tape works well) about 40 cm long onto a table top. This is your **base tape**.
2. Cut two 12–20 cm long pieces of tape. Create a non-sticky handle on the end of each piece by folding over a couple cm section. These are your **working strips**.
3. Stick your working strips firmly to your base tape. Make sure they are in full contact with the base tape by pressing them down firmly with your fingers.
4. Grasping their handles, briskly pull your working stripes off of the base tape (imagine you are removing a band-aid). Letting the strips dangle freely, slowly bring the strips

together. Experiment with bringing the tape together with the like sides facing each other (non-sticky to non-sticky) and the opposite sides facing each (non-sticky to sticky). What happens? How does the orientation of the tape affect what you see? What do you think is causing this effect?

5. One at a time, pass each of the working strips lightly between your fingers. Try bringing the tape back together again. Is the behavior of the tape different?

6. Carefully stick the two strips of tape together (sticky to non-sticky) so that you have a double thick piece of tape, and run your fingers down the length of the working strips.
7. Grasping one tape tab in each hand, quickly pull the strips of tape apart, repeating step 4 from this new starting configuration. Do the strips behave differently this time? Is the behavior the same or different from step 4?

8. Create four new working strips that are all about 10 cm long.
9. Create two double thick pieces of tape using your 4 new working strips. Use a pen to mark the tabs of the top and bottom stripes in each pair so you can track which strips started on the top and bottom. (The piece with the non-sticky side exposed is the top.)
10. Quickly pull the two pairs of tape apart and test all possible combinations of bottom and top strips as you tested the strips in step 4. What do you discover?

11. At this point you do not know which strips are positive and which are negative. Using two objects from the triboelectric series (like hair and Styrofoam), create a negatively charged object.

12. Test a top and bottom piece of tape with the negatively charged object. How are the top and bottom pieces of tape charged?

Lab Report

Write a brief report including the standard sections. Submit it as hard copy or through Canvas as text entry, a file upload, or a link. Please do not send an email attachment without prior approval (unlikely to be granted); if you share a file, provide the link to Canvas. If you wish to refer to data or sketches that you entered on the hardcopy instructions sheet, please submit that to me as well.

Abstract: Briefly summarize what you studied.

Purpose: What physical phenomena did I hope these activities would illuminate?

Theory: This is the first lab of the Electricity and Magnetism semester of the course. Identify and explain the principles demonstrated in these activities.

Experimental: In a few sentences, report what you did and what you examined in each activity. If you wish, you may combine this section with the Observations and Data section.

Observations and Data: In brief narrative form, report what you did and what you observed.

Analysis and Discussion: Propose explanations for what you observed, and note any findings that defy explanation. Reminder: "human error" does not explain anything—suggest what in particular might have gone wrong (contaminating a specimen, accidentally delivering a static charge, reading a scale improperly, etc.).

Conclusion: Is what you observed explained by what we've learned about electric charges?