

Electrostatics I



Objective:

- To investigate how excess charge is created and transferred. To examine interactions between different charges and how an object that has a net neutral charge can experience and exert a force on a charged object. To observe the phenomena of charge polarization and electrical shielding.

Apparatus: Scotch tape, Aluminum canister or soda can, fake fur, white plastic rod, wood dowel, ring stand and clamp, foil bit on string, copper sphere on insulating stand, clear plastic gloves (to keep hand sweat from moistening the fur), styrofoam cup or plastic beaker.

You have all heard about electric charge. There are two types, like charges repel, unlike charges attract, and so forth. You may also have heard that conductors are materials in which charges are free to move and insulators are materials in which they are **not** free to move. Finally, you may know from lecture that *inside* a conductor, the force felt by an object due to other charges is zero (technically, the electric field is zero); a conductor acts to shield anything inside it from any electrical forces.

For now, forget everything else you have heard. For the rest of this lab, you are only to describe your observations and make statements that are supported by the observations

and analysis of the experiments that follow. If you do not see it, do not say it!

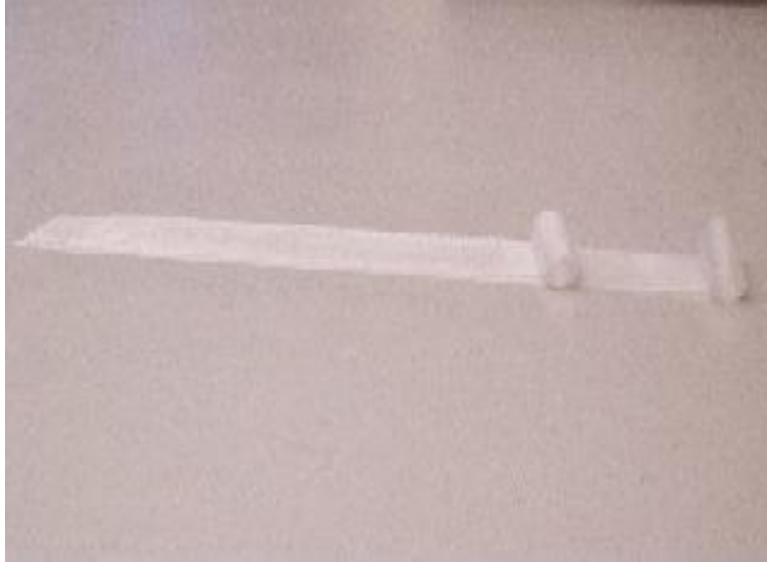
Activities

Your lab report, on which you and your lab partners will record all your data and calculations, and answer all the questions **IN RED** this write-up, will be written on Google Docs. Make sure the lab partner who creates it for the group shares it with all partners, the TA and the LA. Note that lab partners and collaborate on the document simultaneously.

Activity 1: Remove two **10-cm** long (short pieces will be much less effective) pieces of regular clear tape from a roll of tape. Curl the ends of the tape over to make handles (see the photo below). Press the sticky sides of the tape to the top of the lab table and rub them so that they make good contact with the table – use your fingernails, if necessary, until the tape is almost invisible. Then, quickly pull the strips of tape off the surface and bring the tops of the non-sticky sides of the tape near each other. **Does it matter which side (sticky, non-sticky) of the strips face each other?** (5 pts) **How does the distance between the strips affect what happens?** **Record your observations.** (5 pts)



Activity 2: Stick a new **10-cm** strip (short pieces will be much less effective) of Scotch tape with a handle to the lab table. Using a pen, label the handle of this strip with a "b" for bottom strip. Now, place a second new strip with handle on top of the first strip (see photo below); make sure it doesn't touch the table. Label the handle of this strip with a "t" for the top strip. Rub the strips so they make good contact with the table and with each other. Quickly pull the bottom strip off the table and then pull the two strips apart and bring their non-sticky sides near each other. **Does it matter which side of the strips face each other?** (5 pts) **How does the distance between the strips affect what happens?** **Record your observations.** (5 pts)



Activity 3: Attach the two pieces of tape from the previous experiment to wood dowels suspended horizontally from a ring stand. Now tape a new strip with handle to the lab bench, quickly pull it off, and then hold it first near the b-strip and next near the t-strip. **Record your observations. Then provide an explanation that is consistent with what you observed—it must be based on experimental evidence.** (5 pts)

Important notes: When performing the following experiments, extend the rubbed objects away from your body so that you do not measure the force of your body or clothes (which can carry charge) on the hanging tapes. Another confounding problem is that some objects attract both types of tape. Ignore this difficulty, as it will be discussed later. Also, in humid conditions the electric charge on the pieces of tape can “leak off” causing them to become discharged. You may have to recharge your t- and b-strips from time to time.

Activity 4: **First put on clear plastic glove on the hand with which you'll grasp the fake fur.** Pick up the fur with that hand. Hold the plastic rod with your other hand (try to hold it with your fingers rather than your palm, which could get sweaty) and rub the rod inside the fur. Hold the rod near the t-tape and the b-tape. **Record your observations. Indicate if the rod has the same electric charge as the t-tape or as the b-tape.** (5 pts)

Activity 5: While still wearing the glove, try holding the fur (which you just used to charge the rod) near the t-tape and b-tape. **Is it the same or different from the rod's charge?** (2 pts)

<p><u>Summary:</u> We say that the b-tape pulled off the lab bench has a negative electric charge (–) and the t-tape pulled off the back of the tape has the opposite positive charge (+). We could have chosen other names for the charge; Benjamin Franklin – this</p>
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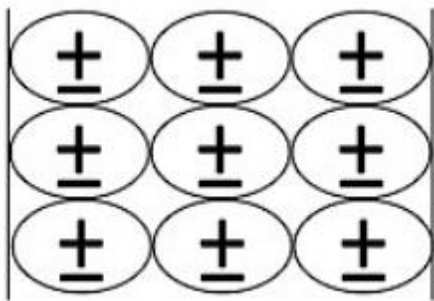
country's first physicist – chose this convention, which persists to this day. These are just words to help us describe a property of matter that produces electric force.

Activity 6: Take the Aluminum canister and hold it near the electric charge detectors (the strips of tape) one at a time. **Describe your observations and develop an explanation for them, remembering of what material the Al can is made.** (5 pts)

Activity 7: Design an experiment to determine whether the claim in the first page of this write-up is true – that a conductor acts to shield anything inside it from any electrical forces. **Detail your experimental steps and observations** in your lab report. **Are there conductors on your lab table in which you can place things to test this?** If you can prove this, **can you reinforce your claim by also proving that an insulator (like a styrofoam cup) does *not* shield from electrical forces?** (10 pts)

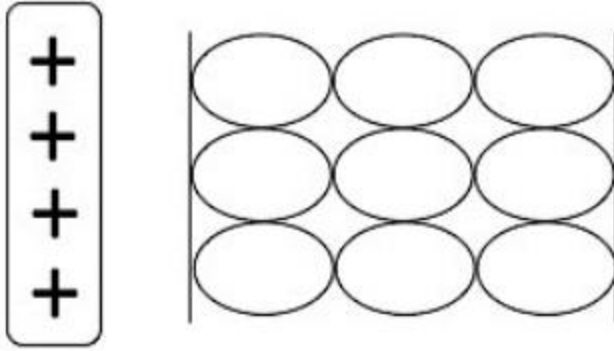
Activity 8: Cut or tear a piece of paper into many small bits and lay them on the lab bench. Rub the rod with the fake fur. Then, bring the rod near the paper but do not touch it. **What happens?** (2 pts) Try the same experiment with some object that becomes charged opposite the rod when rubbed. **What happens when this oppositely charged object is brought near the paper?** (2 pts) **Explain your observations.** (4pts)

Activity 9. Suppose that the molecules in the bits of paper are represented schematically by oblong circles (see figure below). The molecules are electrically neutral - that is, the average position of the (+) charge and of the (-) charge is at the same location. Although paper is an insulator, the electric charge within the molecules can make small shifts in position. For example, under certain conditions, it is possible for a slight excess of negative charge to move toward one side of the molecule and of positive charge to move slightly toward the other side.

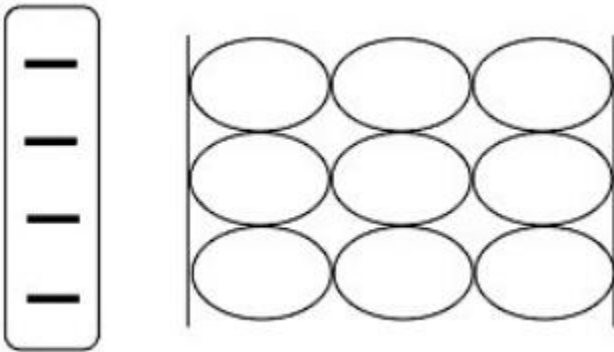


The (+) charge and of the (-) charges of each molecule above are (on average) at the same location (the illustration approximates that).

How would the electric charge on these molecules in the paper redistribute if a *positively* charged object were brought near the left side of the paper (see figure below)? **Draw how the positive and negative charges would redistribute themselves.** (5 pts)



How would the electric charge on these molecules in the paper redistribute if a *negatively* charged object were brought near the left side of the paper (see figure)? Again, **draw how the positive and negative charges would redistribute themselves.** (5 pts)



Would there be a force on the charged object in the two situations just described? **If so, would the force be attractive or repulsive? Explain.** (5 pts)

Activity 10: You should have a foil bit (crumpled aluminum foil) attached to a string on your desk. The bit is a conductor, while the string is an insulator. Hang the foil bit from the wooden dowel. Ground the foil bit by touching it with the tip of your finger. Charge up the rod as usual and move it (very slowly) towards to the bit.

- What was the net charge on the foil bit before you approached the bit? (2 pts)
- What do you observe as the rod approaches the foil bit (but doesn't touch)? (2 pts)
- What is the net charge on the bit as the rod approaches it (but doesn't touch)? (2 pts)

Now take the copper sphere with insulating stand and touch it lightly with your finger to ground it (taking any net charge away). Hold it only by its base and avoid touching the plastic stand so that it remains an effective insulator. Bring it close (but do not let them touch) to the foil bit.

- What do you observe? (2 pts)
- Is what you observed consistent with zero net charge on both copper sphere (or mass) and foil bit? (2 pts)

Keeping the foil bit and copper sphere where they are, again charge the rod and bring it close to the copper sphere, opposite the side that the foil bit is on:



What do you observe? How do you account for this? (5 pts)

Maintaining the rod close to the sphere (mass), slowly bring your finger towards the foil bit and gently make contact with it. What kind of motion do you observe? (2 pts) Based on the above, can you explain the sequence of events in terms of charge sign and charge transfer? (5 pts)

Finally, while keeping your finger where it is, move the charged rod away from the sphere (mass) quickly. Is there the motion you observed in the previous step above? (2 pts) What do you now observe, and how do you account for this? (6 pts)

PLEASE DON'T THROW THE STYROFOAM CUP AWAY; LEAVE ON THE TABLE.