LAB D01: *INVESTIGATIONS IN STATIC ELECTRICITY*

Revised 12/17/01

We are starting this lab on electrostatics without having done any formal reading in Cutnell & Johnson. We realize, however, that you have probably acquired some of the basic ideas about electricity just from experience (e.g., receiving mild shocks after shuffling your feet over a rug or having seen television commercials about "static cling"). You also probably know how many kinds of electric charge there are, know the laws of attraction and repulsion, and understand some basic ideas of atomic theory. In doing this lab, however, we ask you to try to put aside your preconceived ideas about electricity and electric charge and see what you can discover and deduce just from the activities contained within.

Each equipment station should contain all (or almost all) of the following:

Styrofoam cups, bar	balloons
Saran wrap	paper
rabbit or cat fur	sticky tape
Lucite	plastic strips
aluminum plates	plastic ruler
ball of aluminum foil on thread	

As you carry out your observations, keep in mind the following points; they may keep you from making incorrect conclusions and wasting time.

- In this lab, "rub" means rub vigorously, not "pet." Vigorous rubbing is required to transfer sufficient amounts of electric charge from one object to another.
- Some objects may have different charges in different areas. Be sure to test the area you rubbed.
- At several points in the lab, you will be using two strips of sticky tape, called "top" and "bottom" tape, which will generally have opposite charge. The charges of the top and bottom tape can become reversed. (Think about why as you do the lab.) It is wise to check their charges occasionally to be sure that a charge reversal has not occurred.

This lab is one in which results are sometimes inconsistent; we suggest that you try each activity twice (or each partner tries it once). Don't write a result or observation down until it is repeatable.

INVESTIGATION A

1. Suspend a Styrofoam cup with a piece of thread, and rub it vigorously with the fur. Rub the Styrofoam bar (or another cup) with fur and bring it near the suspended cup. What happens?

2. Tear a strip of sticky tape (15 - 20 cm) from a roll and stick it down firmly to the table top, leaving a short overhang to pick it up again. Strip it off the table top, being careful to hold only the end with your fingertips. Without touching the tape anywhere else, hang the strip of tape vertically over the table's edge such that the non-sticky side faces outward.

   Repeat the above procedure with another strip of tape and then bring this strip of tape near the first strip (the non-sticky sides should face each other). What do you observe when the strips are far apart? when brought close together?

   To re-charge the sticky tape, repeat the procedure above. Tape can be re-used! Also re-charge the tape strip anytime something inadvertently comes in contact with it.

3. What general principles can you formulate as a result of the above observations? Careful! Do not state any principles from experiences or studies prior to the above observations! (The terms electrons, positive, and negative are OFF LIMITS at this point, since you have no direct experience with them; do not use them!)

   Here is an example of a principle you may have formulated based on your observations above:

   A) Two objects prepared in the same manner (e.g., 2 styrofoam pieces each rubbed with fur) repel.

   List each separate principle with a separate letter; start the list on a new page that will be reserved for “principles” only.

4. Are any of your observations above not explained by your principles? If so, which ones?

INVESTIGATION B

1. Rub Saran wrap vigorously against the Lucite square. After rubbing let the plastic wrap lie on top of the Lucite, and then turn the Lucite square over. What happens?

2. Again rub the Lucite square with the Saran wrap. Now bring the Saran wrap near a tape strip prepared as in Part A2; what happens? Then bring the rubbed surface of the Lucite near the tape strip; what happens?

3. Take one of the tape strips and stick it back down to the table. Mentally label this tape strip B. Tape another strip directly on top of the one already on the table. Mentally label the top piece with a T. Now unstick both strips from the table at the same time without unsticking the strips from each other. Run them over your lips or a piece of metal. Then pull the two tape strips apart. What do you observe as you bring the T and B strips closer together?

4. Hang both the B and T tape strips vertically over the table's drop edge such that the non-sticky sides face outward. We shall refer to these as the "test strips." Prepare another pair of top and bottom strips by repeating the procedure in step 3. What do you observe as you bring the new top piece near each of the original B and T test strips? as you bring the new bottom piece near the test strips?

5. Is the tape charged as it comes off the roll? Design a method for deciding and then try it. Describe your method and your findings. Does the off-the-roll tape have the same charge as the B or the T strip?

6. Rub a Styrofoam cup with fur. Bring the rubbed cup close to the B test strip. What do you observe? What would you expect to observe if you brought the cup near the T test strip? Predict and then try it.

7. Which of the observations in Investigation B can be explained with the principles formulated in part A? Can you find any new principles that explain the observations from Investigation B? If so, state them. (Careful! Again avoid OFF LIMIT terms.)

8. Are there any observations that are not explained by your principles? If so, which ones?

INVESTIGATION C

1. Rub a Styrofoam bar (or cup) with fur. Run the bar just over the back of your hand or over your arm. What do you observe and/or feel happening?

2. Bring the bar close to another person's hair. What do you observe?

3. Tear some scrap paper into *very* tiny bits and place them on the table top. Rub a plastic collar strip with fur and bring the rubbed strip near (almost but NOT touching) the bits. Observe everything that happens carefully (at least two different things should happen) and record your observations. You have to observe really carefully here and explain in detail!

4. Rub an inflated balloon with fur. What can you make the balloon stick to? Does rubbing with fur work as well, better, or worse than rubbing the balloon against your hair instead? How does the rubbed balloon affect the paper bits?

5. After rubbing a balloon with fur, bring the balloon near (but *NOT* touching) a thin stream of water. Draw what you see. Does the same thing happen when other charged objects are brought near the water? Try some and record the results. Please do *NOT* get any fur wet!

6. Which of the observations in Investigation C 1-5 can be explained with principles formulated previously? Match up the observations to the principles clearly in your journal.

   What new general principles must you formulate as a result of observations in this section?

7. Describe an observation of repulsion in Investigation C 1-5 that can be explained with a principle formulated previously.

8. Now bring a neutralized plastic ruler (you can neutralize an object by touching it with your hand in several places; your skin will draw off any residual charge) near an electrically-charged test strip. What happens?

   Recharge the test strip and try the same thing with a neutralized piece of metal. What happens? Now try it again with the neutral plastic ruler. Which attracts the strip better, metal or ruler? Why?

   Is this a new rule, i.e., that electrically-charged objects attract neutral ones?

   Why did the attraction occur? See section 18.4 of your text for help in explaining.

9. Rub the Lucite square vigorously with the Saran wrap, remove the Saran wrap and then hold the Lucite flat. Place an aluminum pie plate (bottom down) on the Lucite. Slowly turn the Lucite over. Is the plate attracted to the Lucite? Does the plate stay attached? If yes, why? If no, try using a flat piece of aluminum foil (about 10cm square) instead of the pan and discuss in terms of forces why the foil behaves differently. Is the aluminum stuck to the Lucite charged?--explain. Gently pull the aluminum from the Lucite. Describe how you can test whether the aluminum has a net charge after removal from the Lucite. Try it and report your result.
   (Also try this activity with an initially neutral Styrofoam cup instead of the aluminum.)

10. Charge the ruler with the Saran Wrap. Can the ruler be used to pick up small bits of paper or Styrofoam? Try it. Why do you see this behavior? What new process (in addition to friction or rubbing) was used to separate different electric charges in the activities in this section?

INVESTIGATION D: INTERPRETATIONS

1. In Parts B5, B6 and C8 you tested the effect of a number of charged objects on top and bottom tape strips. If, for example, an object repels bottom strips, then you can say that the object has the same charge as the bottom strip. However, if an object attracts a bottom strip, this test alone is not enough to tell whether the charge of the object is opposite that of the strip. Explain why not.

2. Rabbit fur is one of the most electropositive objects known. This means that, when rubbed against most things, rabbit fur acquires a positive charge (i.e., it loses electrons to the other material it is rubbed against). If the rabbit fur is rubbed against the collar strip, the fur acquires a positive charge; the collar strip, negative charge. Rub the collar strip with fur, and then use the known charge of the collar strip to determine the charges of the top and bottom tape strips. Record your observations and conclusions.

3. Make a table that shows the charges of the following objects when rubbed with fur and when rubbed with Saran wrap. Use "rubbed with fur" and "rubbed with wrap" as column headings. Use + and - for the charges these objects acquire (use 0 for neutral objects).

Balloon	collar strip
plastic ruler	pie plate
Styrofoam bar	

4. Which one of these objects acts like a neutral object? Why does it act that way?

5. Now that you can officially use the terms positive and negative, draw a diagram clearly showing the signs and distributions of the charges on the ruler and the test strip when the ruler is near the test strip in part C8.

INVESTIGATION E: CONSTRUCTING AN ELECTROSTATIC SERIES

1. Examine your table in Part D3. You should notice that some objects have the same charge whether rubbed with fur or wrap. Other objects change their charge, depending on whether they are rubbed with fur or wrap. Explain, using the ideas of atomic theory -- that electrons are bound, in varying degrees to their parent nuclei, how the charge of a given object can be changed by rubbing it with different materials.

2. Consider the 4 non-neutral materials tested in Part D along with the fur and the Saran wrap. Which of these 6 materials is the most electronegative? Justify your answer.

3. Which of these 6 materials is the most electropositive? Justify your answer.

4. How could you find out whether the balloon or the bar was more electropositive? Describe your method, try it, and give your results.

5. Make any other observations that you need to determine the "electrostatic series" for the 6 materials: Saran wrap, balloon, plastic ruler, fur, Styrofoam bar, collar strip. Describe clearly the specific observations that you make and why they were necessary. List the series starting from the most electropositive. Label the endpoints.

INVESTIGATION F

This investigation is to be done after you have read about conduction, induction, and polarization (Cutnell & Johnson : Sections 18.2,3,4). Knowing about these things will help you explain what you observe. In each of the parts below, explain your observations fully and draw sequences of pictures (each should be at least one-half page) showing how the positive and negative charges are distributed over the objects as you perform the tests below.
For an idea of how your diagrams should generally look, see figures 18.8 - 18.10 of Cutnell & Johnson.

1. Suspend a small ball of aluminum foil from a piece of thread about 50cm long. Tape the loose end of the thread to an overhead support so that the ball hangs at a reachable height that is at least several inches above any surface. Neutralize the ball by touching it with your finger. Charge a plastic strip by rubbing it with fur. Then bring the charged strip close to BUT NOT TOUCHING the ball . (If the ball accidentally touches the strip, neutralize the ball and try again). Describe what you observe. Why does this happen? Use diagrams to help explain.

2. With the charged strip near to BUT NOT TOUCHING the neutral ball, gently and quickly touch the ball with your finger on the side opposite the strip. What do you observe? What does your observation mean in terms of the charge on the ball and the strip? What exactly was the purpose of touching the ball while the strip was nearby?. Remember, your diagrams should support your words! (hint: you should have more than one diagram for this part.)

Neutralize the ball. Then bring the charged strip close enough to the ball so that the ball gently and quickly touches the strip once. Describe what you observe <u>just</u> after they touch. Why does this happen? --use words and diagrams.

An After Lab Problem (to be included in your report)

Suppose you have two strips of tape that are oppositely charged. You also have two aluminum pie plates. When pie plate A is brought near each strip, each strip is attracted to the plate. However, when pie plate B is brought near each strip, one strip is repelled and one strip is attracted. How can this be? Use both words and diagrams to explain.

SUMMARY/CONCLUSION

Be sure to discuss in your conclusions the three methods by which objects were charged in this lab, and give examples (by listing lab sections' letters) of each of these methods.

ELECTROPHORUS ACTIVITY

Materials:

styrofoam square
aluminum pie plate (with 'coffee cup' insulating handle)
piece of wool or fur
neon bulb with exposed wires
tape test strips

PART A

1. Tape the open end of a Styrofoam cup to the inside center of an aluminum pie plate. In the following activities, use the Styrofoam cup as a "handle". Do not touch the aluminum plate with your hands unless specifically directed to do so.

2. Make sure that the pie plate is uncharged initially. How can you test this?

3. Place a neutral foam square flat on a table. Place the neutral pie plate 'handle up' on top of the neutral square. Now slowly lift the plate from the square, noticing if there is any detectable interaction between the plate and the square.

4. Remove the plate from the foam. Rub the top surface of the square of foam insulation vigorously with a piece of fur. Put the fur aside.

   Place the neutral pie plate 'handle up' on top of the charged square. Now slowly lift the plate from the square, noticing if there is any detectable interaction between the plate and the square. Describe what you feel.

   Test the plate to see if it is charged. Is it?

5. Replace the neutral pie plate on top of the charged square. Bring your finger near to the rim of the plate until something interesting happens. Yes! Something should happen! Describe what happens and why.

6. Now gently lift the plate from the square, noticing if there is any detectable interaction between the plate and the square. Describe what you feel. Is this any different from part 4? Why?

   Test the plate to see if it is charged. Is it? Should it be?

   Explain your observations in words and diagrams.

7. Now bring the plate near to your finger. What happens?

   Test the plate to see if it is charged. Is it? Should it be?

   Explain your observations in words and diagrams.

8. Put the plate back onto the charged square (You may have to recharge the square first). Repeat the actions in steps 5-7. See how may times you can repeat the sequence and still get sparks.

PART B

Always hold the plate by its insulating 'coffee cup' handle.

The Styrofoam square only needs to be rubbed at the beginning of these exercises. It will not lose its charge easily and may not need to be 'recharged' for the remainder of the class.

1. After 'charging' the Styrofoam square by rubbing it with the wool or fur, place the pie plate on top of it. Hold the neon bulb by its short wire and touch the long wire to the edge of the plate. Carefully watch the glass bulb while touching the pan's rim with the wire.

   Next, remove the bulb from the pan, lift the plate off of the Styrofoam, and again touch the elevated plate rim with the bulb's long wire.

Repeat the rim touching with the plate in the down position and also in the up position. Watch the bulb flash in each position.

2. Now look closely at the glass bulb that contains the neon gas. Inside the bulb you see two thin metal rods (called electrodes), each attached to one of the external wires. Note that there is no fine filament connecting these rods. (Most 'normal' light bulbs have a fine, coiled tungsten filament that glows to produce light.) These neon bulbs glow when an electron 'falls into' an incomplete electron shell, creating a neutral, noble gas atom and releasing a photon of light. The color of the emitted light is characteristic of the gas that fills the glass globe.

   Make a mental note of which electrode is attached to the short wire (held in your fingers) and which is attached to the long wire and is touched to the plate rim. (You might notice that the short wire of your neon bulb may also be attached to a small device called a resistor, which has absolutely NO effect on these exercises.)

   Watch the bulb closely while it flashes and you will be able to see that the orange glow is always closer to one of the two electrodes: one when the plate is down and the other when the plate is lifted.

   Indicate the correct choice in each case

   (A) When the plate is ON the Styrofoam the (finger / pan) electrode glows.

   (B) When the plate is LIFTED the (finger / pan) electrode glows.

   The glow always occurs near the electrode that is receiving negative charges (electrons) from the wire and delivering them to the neon gas in the bulb. Does this statement make sense in terms of the type of charge that we know is put onto the Styrofoam when it is rubbed with the fur (or wool)? Explain.