Static Electricity

This is the outline of exercises that we want you to do in lab. This is a complement to the material in the lab manual. Please read the manual to learn about the tools and techniques; use this document to guide your experiments and calculations in the lab.

You should complete the lab through Problem 3, then proceed to the others if you have time remaining**. You must complete the last activity in the last five minutes of lab.** You should record and discuss all your observations, and include sketches of the charge arrangements when asked to explain phenomena.

Problem #0: Take Charge

For the sake of drawing, your TA will "assign" the tape and plate a charge. By the end of lab, you will determine if they were correct or not, but until then note these assumptions in your report:

- What charge are we assuming the tape gains when pulled off the roll?
- What charge are we assuming the plate will have when rubbed on your shirt?

Problem #1: The Problem With Tape

Remove about 10cm of tape, and bring it near a finger. We want to get to know it, and it will be best if it is flipped over as shown here. A quick warning:

Keep the tape away from the electrophorus! Very well away.

The tape breaks the tinsel, so keep them separated! Now, grab your piece of tape and:

- Bring it near another finger - how does this indicate the tape is charged (or not)?
  - If you flip the tape round, how does it's behavior change (or not)?
  - Explain this attraction.
- Draw out a free-body diagram of your finger, and another one of the tape. What forces are at work on each?
- On a sketch of both, indicate the charges - where are they, an indication of how much charge, etc...
  - Discuss: How well does your third sketch explain your first two?

Now, grab a second piece of tape:

- Discuss their interaction. Why might you have expected this?
  - Again, let's sketch out the charges in this situation! You should generally include sketches of some sort in your report, especially for topics that require a bit of imagination.

Take some time here to discuss with your TA how things are going. How does your writeup so far look? Are your sketches informative enough? Can your TA follow along with your reasoning? Have you adequately demonstrated how well you understand the material?

Problem #2: Charging the Electrophorus

Charge your plate by rubbing it on your shirt. If the plate sticks to you, great, if not, try another labmate. The, let's charge the electrophorus first by ***conduction***:

1. First, neutralize the electrophorus by tapping its edge with your finger.
2. Charge up a styrofoam plate by rubbing the bottom against your shirt.
3. Next, set the styrofoam plate upside-down on the corner of your yellow bin. Bring the electrophorus down to it (Note: you should hold the electrophorus by the insulating handle, so that the charge does not bleed off through you!), and rub it against the plate to pull charge off it.
4. Finally, pull the electrophorus well away from the plate, and set it on your plastic bin. Observe the results.
   - How does the tinsel bunch allow you to tell whether or not your electrophorus is charged or not?
   - Explain how this process puts charge on the electrophorus. Sketch out each step (1 through 4), indicating the charges and their motion and/or transfer, and write a brief sentence or few for each.
     - Complete the sentence: "When charging by conduction, the electrophorus is charged with the ___(same/opposite)_____ charge as the plate."

Now, let's charge your electrophorus by ***induction***. Charge your plate back up, then:

1. First, neutralize the electrophorus by tapping its edge with your finger.
2. Bring the electrophorus (again, holding it by the handle) down near to the charged plate, but do not let the two touch! You should see that the tinsel bunch reacts; this means that the tinsel is charged.
3. Next, keep the electrophorus where it is, and touch the side of the electrophorus with your finger. You might even feel a small spark; charge is being transferred through this contact! Notice what happens to the tinsel bunch when you do this.
4. Finally, pull the electrophorus away. Observe the results.
   - What happens to the tinsel bunch when you tap the edge of the tin in Step 3? Why does it react that way?

- What happens to the tinsel as you pull the electrophorus away from the plate in Step 4 ?
- Explain how this process puts charge on the electrophorus. Sketch out each step (1 through 4), indicating the charges and their motion and/or transfer, and write a brief sentence or few for each.
  - Complete the sentence: "When charging by induction, the electrophorus is charged with the ___(same/opposite)_____ charge as the plate."
- Compare and contrast these two charging methods. What are the pro's and con's of each? Which worked better for you?

Problem #3: Charge!

The questions to answer: What charge does the plate get when rubbed on your shirt? What charge does the tape get?
You have a neon lightbulb which can be used to measure charge if you examine the spark in detail - read the original lab manual for further information.

- Charge up your electrophorus in the two different methods, and use the neon lightbulb to determine how it becomes charged.
  - How should the charges gained by the two techniques compare?
- From the electrophorus results, determine the charge on your plate.
  - Note: Once you have determined the charge on your plate, place your electrophorus well away from your working area - and keep it well away from your tape!
- Bring a piece of tape near the plate, what charge must it have?

Problem #4: Current Events

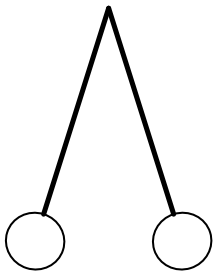
If you have time, work with the foil ball on a string. Support the ball just a millimeter or two away from the edge of your charged electrophorus, and bring a finger close to the ball.

- What do you observe as your finger gets closer and closer to the ball?
  - Explain the behavior that results when your finger gets "close enough".
  - Draw out this process: Why does the ball react to your finger? What happens to the charges on the tin/ball/finger next? Why does the ball react in that fashion? What are the charges doing at each stage of the action?
  - A Big Question: Which direction does the current flow at each of the steps in your process? Why does that make sense?

Additional Problems:

You've got the time, and we've got the equipment. Take the rest of the lab to run a cool experiment, and show your TA just how well you get this. We've got some example activities below, you are welcome to do them in any order - but encouraged to make your own!

If you have time, pull a 15-cm-long piece of tape off the roll. Your question: what is the approximate net charge? You'll need to know that a 1.0-m-long strip of tape has a mass of 1.1 g.



- Sketch out a force diagram (think back to last semester!) of two strips of tape repelling eachother - note how we are making a very simplified model here. What forces are involved? What is the net force on a single piece of tape?
- Estimate the angle at which the pieces of tape hang. With that final piece of information, calculate the approximate charge on one piece of tape. How many excess electrons (or protons) are there on your piece of tape?
- How many electrons (in excess, or missing) do you calculate are on a piece of tape?
- Do you expect that this number over- or under- estimates the charge on a piece of tape?

You've got a handy charge-identifier to work with.

- What charges do you gain when you rub your shoes on the carpet?
  - Does the type of shoe (or carpet) matter?
- Can you determine what materials build up a strong charge, and which don't?
- Can you find differences in how much things "like" or "dislike" electrons?
  - Can you rank materials in this fashion?

Final Activity: Clean Up

There's likely a bit of mess around your station, so let's tidy up:

- Check your station (floor, desk surface, bin, etc...) for any bits of tape, remove them, and throw them away in the trash bin.
- Make sure you bin has one (1) styrofoam plate, a neon bulb tool, and a foil ball on a stick .
- Make sure your electrophorus unit is sitting on the back corner of the bin, suspended off the desktop.

Report

You'll be recording your work on the whiteboard tables as you go, and so be clear when summing up your process and your conclusions. Keep your discussions short, sweet, and to the point, please. Be sure to indicate what work you did on the report (as opposed to what your lab partners did).

Remember: The point of the report is to show your TA how well each of you understand the material, how well you designed and performed experiments, how well you can discuss your results, and how much of a scientist you were - not to show them you can parrot the textbook, always get the "right" answer, or do everything. The process, your reasoning, and your improvement are the key to earning full credit.

Be sure that each of your group members submit this as an assignment on Canvas as a single pdf file, and include your own self/peer evaluation in an attached comment.

Looking Ahead: The In's and the Con's

This isn't something to calculate today, but something to think about: You charged your object by *con*duction when you made *con*tact between two objects - the plate and your shirt for example. The induction method involved two objects not touching, but still interacting using just the fields they "gave off". Back at the start of the semester, you played with magnets - which also make their own kinds of fields. Did the phenomena you explored then involve contact, or was it more of an induction experience?