Performance: Report: Total:

Physics 212-1

Electrostatics

NAME: ______________________________ ☐

STUDENT ID: ______________________________ ☐

LAB PARTNER(S): ______________________________ ☐

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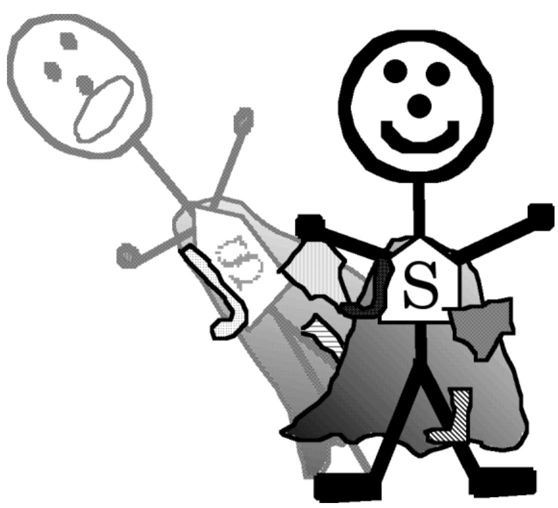
CLASS SECTION: ____________________

INSTRUCTOR: ____________________

DATE: ____________________

TABLE (GROUP NO.): ____________________

(YOU WILL BE TAKEN 3 POINTS IF TABLE IS VACANT.)



Captain Static Cling to the rescue!

Physics Lab 212-1

Equipment List

triboelectrification consisting of:
- PVC rod (gray, hollow rod)
- Glass rod
- Perspex rod
- Fur and silk and wool cloths

Electroscope
Grounding wire
Electrostatic generator
Hollow metal cylinder on an insulated stand with two pairs of suspended pith balls (one inside and one outside) on the instructor's desk
Proof plane (metal disk attached to insulating rod)
Alligator clips

Physics Lab 212-1

Electrostatics

To find out
- The qualitative behavior of charged objects brought into contact or near one another
- Some consequences of Gauss' Law

Preview
- Transfer charge
- Learn to charge by contact and by induction

WARNING: In this lab, many of the equipment items are fragile. Please handle them carefully so that everybody has a chance to do a good lab.

Activity 1 Behavior of charged objects

You certainly sometime somewhere have felt and seen the effects of the buildup of electrostatic charges caused by contact between certain dissimilar materials. In this lab, you will use dissimilar materials (like fur in contact with rubber rod and silk in contact with organic glass) in a triboelectrification setup to create buildups of electrostatic charges; you will also use a couple of devices to collect and transport charge; plus an electroscope and a hollow metal cylinder with pith balls to detect/measure charge.

Our electroscope is a simple device consisting of a thin metal strip hung side by side with a very thin metal foil inside a protective box. Both are in contact with a metal support that extends to a metal plate on the outside of the box. Yours looks like Figure 1. The foil is extremely fragile. Please always keep the box upright.

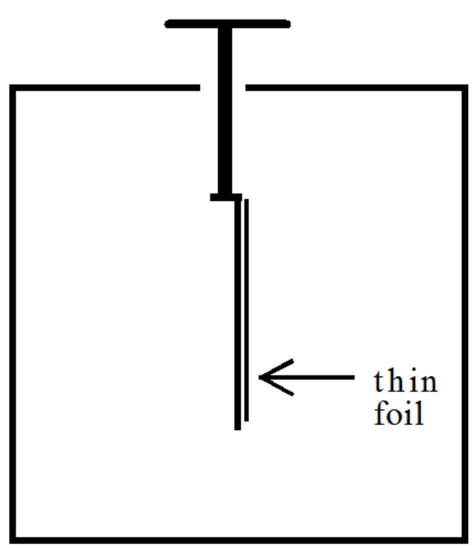


Figure 1. Your Electroscope

The charging apparatus you will use in this lab are shown below in Figure 2.

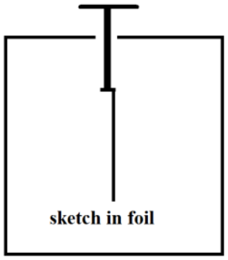
Figure 2. The triboelectrification materials. A – glass rod; B – Perspex (acrylic) rod; C – PVC rod; D – wool cloth

Rod	Rod's Charge with Silk Cloth	Rod's Charge with Fur Cloth	Rod's Charge with Wool Cloth
Glass	Positive	Positive	Positive
PVC	Negative	Negative	Negative
Perspex	Negative	Negative	Positive

Table 1. Results after rubbing each of the various types of rods with the different cloths.

Prediction

Suppose you touched the metal plate on top of the electroscope with a *positively* charged object. Sketch your expectation for the behavior of the metal foil.



Would your response look any different if you used *negative* charges instead of positive charges? If so, explain.

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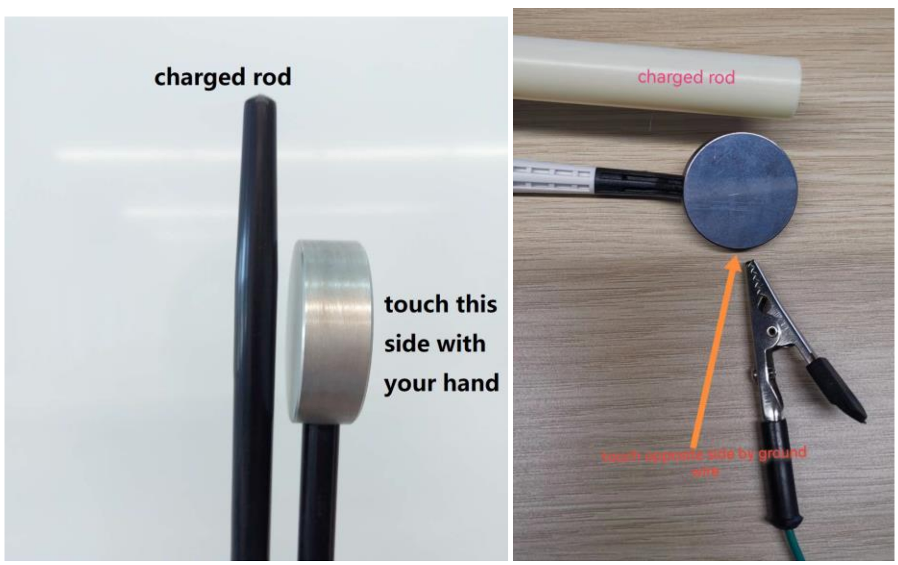
1. Generate static electricity and try the experiment.

    - Clean the transparent organic glass (Perspex) rod. Hold one end of the rod on in your hand and then rub it with the white silk. **This action 'charges'** (to be precise, it's the electrons transferred from one object to another) **the rod negative charges.**
    - keep touching the rod directly to the metal plate at the top of the electroscope. **Note: when you take the rod away after touching, the opening angle of the foil will become smaller or even zero! This is because the rod is insulating, the electrons are hard to transfer. A better way (optional) is to use a proof-plane (see the figure below): put the charged rod near (not touched) the proof plane and then touch the other side of the proof plane with your hand (or ground wire), The disk now has a net charge with a polarity opposite to that of the rod. After that, you can use the proof plane to touch the electroscope and observe the angle (and the angle keeps).**



Two examples of transferring charges by proof plane

Q1 What happened, and how did it compare to your first prediction?

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2. Discharge the electroscope.

    - If the rod is taken away form the electroscope while the metal foil still shows the angle, to discharge the electroscope, simply touch the metal plate of the electroscope with your hand or the ground wire.

Note: when one person touches the charged object one or more times, the person may also be ‘charged’, then the person is not electric neutral. Thus, let this person to neutralize the object won’t be a good idea. Don’t worry, this person will become electroneutral dozens of minutes later.

What happened when you discharged the electroscope and why?

Q2 ____

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Given that the surface of the organic glass (Perspex) rod became negatively charged when you rubbed it with the silk, explain how the disk of the proof plane became positively charged. Discuss this with your partners.

Q3 ____

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3. Now try the opposite charge. Steps are similar.

- Clean the Perspex rod. Hold one end of the rod on in your hand and then rub it with the wool. This action 'charges' the rod with positive charges. Or try any other rod and cloth (you will find the glass rod is not good).
- Touch the rod directly to the metal plate at the top of the electroscope.

Note: if you used the proof plane just now, then use the proof plane again to be consistent.

Does the result agree with your prediction for opposite charge? Was there any change in your result when using a different charging material?

Q4 ____

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4. How do you know it was an *opposite* charge?

- You and your group should come up with an experiment to determine whether the two charging experiments were in fact testing opposite charges. Then perform your experiment.

Our Plan and Experiment:

Q5 Do the two charging materials give different charges? How do you know?

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Activity 2 Charging by Induction

Here is an experiment we want you to first try, and then try to explain. Study Figure 3. Follow the steps carefully, then discuss the result with your group and provide a physical reason for what is happening.

1. Do the experiment.
    1, Touch the electroscope and the charge transfer plate with the ground wire (or your hand) to make sure they are not charged.
    2, Rub the Perspex rod with wool cloth.
    3, See Figure 3. While keeping the edge of the organic glass rod at least 1.0 cm near the metal plate of the electroscope, but *do not let it touch*. Note: If you bring the rod too close to the metal plate, a spark will jump to the plate --- you would be charging the electroscope directly rather than by induction.
    4, Have a partner *briefly* touch the metal plate of the electroscope with his/her finger precisely on the opposite side of the electroscope plate from the side that you're touching the plate.
    5, **After** the partner has pulled his/her finger away from the plate, take away the rod. Repeat the steps if nothing happens.

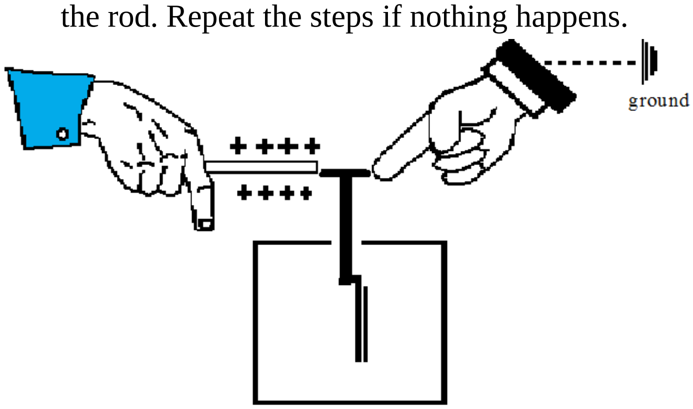

Figure 3. Charging by induction.

Prediction	Consider the setup in Figure 3. Given that the rod is *positively* charged, what effect does the electric field due to the rod have on the randomly distributed positive and negative charges in the electroscope? Sketch your prediction using positive and negative signs on the electroscope plate in Figure 3. What type of charge is on the electroscope after it is charged by induction? ____ ____ ____

2. Test the type of charge.
   - Using the method you devised in Activity 1 to test the type of charge on the electroscope, find out the type of charge you have induced.

Q6 What charge is on the electroscope after it is charged by induction? Is this what you predicted?

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Q7 Explain what is happening at each step of the procedure in step 1 of this activity. What sorts of charges flow which way? **Draw pictures** below for each of the process in step 1. (The process should remind you how the electrophorus is used to charge the proof plane or charge transfer plate.)

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Draw here:

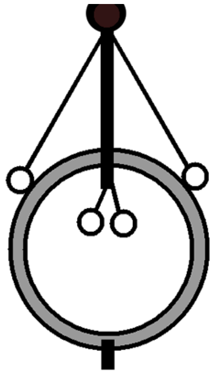
3. Discharge the electroscope.

Activity 3   How charges distribute themselves on a conductor

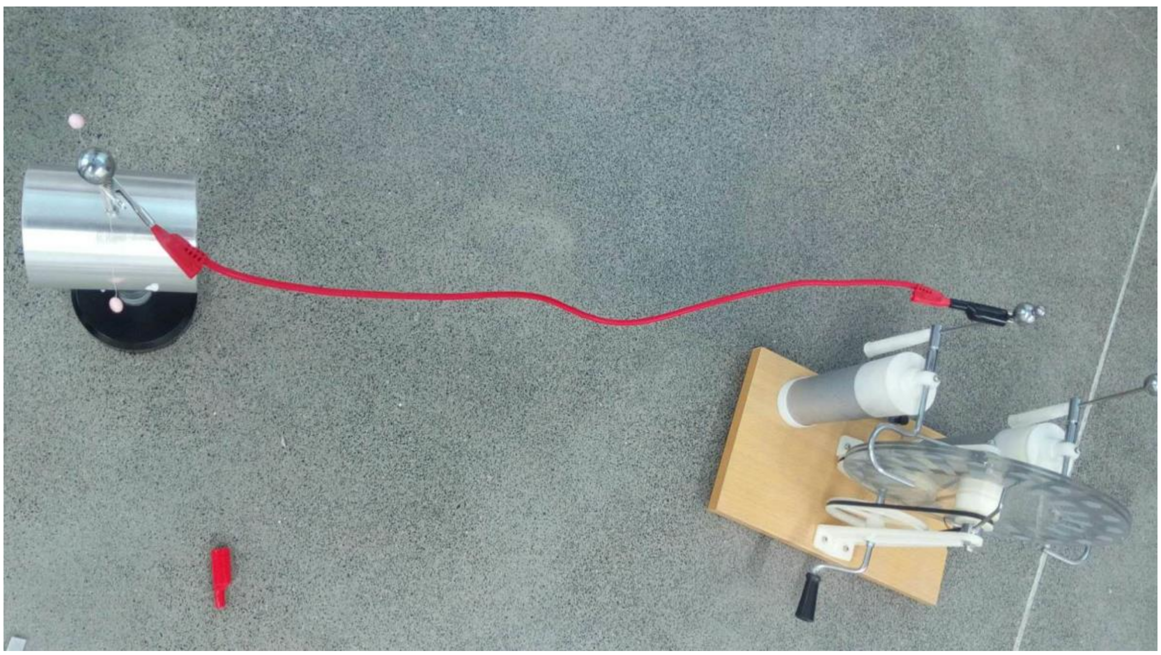
You will use a hollow metal cylinder that is mounted on an insulated pedestal as shown in Figure 4. A metal rod topped by a metal cylinder protrudes out of the top of the cylinder. From near top of this rod, two metalized pith balls hang. In a neutral position, they rest on (and therefore touch) the sides of the cylinder. Two additional metalized pith balls hang in the inside of the cylinder. All of the pith balls hang by insulating thread.

Figure 4. Hollow metal cylinder apparatus and proof plane.

1. Neutralize the cylinder.

Prediction	Suppose a large amount of charge is applied to the outside surface of your cylinder. What do you think will happen to the four pith balls? (Remember, the pith balls hang by nonconductive thread.) Describe and sketch your prediction on the cylinder end view below.  initial location shown

2. Apply charges.



- Since the number of charges in the rod is small and hardly transfer to the cylinder, we need use the electrostatic generator (figure above). Connect the metal rod in the electrostatic generator to the metal rod of the hollow cylinder. Keep rotating (**clockwise**) the handle of generator, and then you have applied a net charge to the hollow metal cylinder.

How did the experiment's result of strings (pith-balls) compare with your prediction?

Q8 ____

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Now we have applied a net charge to the hollow metal cylinder. Where exactly are these charges? Have they collected on the inner surface of the cylinder, the outside surface, or both? You can use the proof plane at your station to contact different parts of the cylinder. You can then touch the proof plane to the electroscope to see if it has picked up any charge. **In our case, you must use a pen refill whose tip is metal, instead of proof plane.**

Prediction	What will happen if you touch the proof plane to the *outside* of the cylinder, and then to the electroscope? ____ ____

3. Test your prediction.
 Touch the proof plane (or pen refill, **pen refill is much much better actually**) to the *outside* of the cylinder, and then to the electroscope. Repeat several times.

What happened? Is it what you predicted?

Q9 ____

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Prediction	What will happen this time if you touch the proof plane to the *inside* of the cylinder, and then to the electroscope? ____ ____

4. Keep the pith-ball cylinder charged. Touch the neutralized proof plane (or pen refill) to the *inside* ***<u>center</u>*** *area* of the cylinder, and then to the electroscope. Repeat several times. (If you "nick" the inside of the cylinder near the edge, discharge the proof plane and try again.)

Q10

What happened? Is it what you predicted?

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You might think that your previous results are related to the fact that the cylinder was originally charged from the <u>outside</u>. To test this hypothesis, you can try to charge the cylinder from the inside or edge of the cylinder.

5. Charge cylinder from its edge by clamping the alligator clip to the edge. Then do the same thing as step 4.

Q11 What did you find? Was there charge on the inside surface of the cylinder? How about the outside surface?

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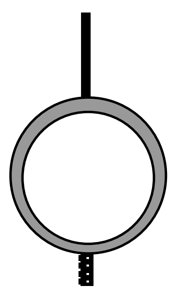
Next, you will investigate the electric field around the charged cylinder. If you charge the pith balls attached to the apparatus, you can learn something about the electric field by observing how the pith balls move in response to it. They will act as test charges and feel a force due to the electric field of the cylinder.

Prediction When the cylinder is positively charged, what are the directions and magnitudes of the electric field lines (if any) outside and inside of the cylinder? Draw your prediction on the figure below. Remember that the electric field lines start at positive charges and flow away from them (and there can never be a field inside the metal itself).



Draw the electric field lines if
the cylinder is positively charged

6. Add more charge.

- Rotating the electrostatic generator with different number of turns to charge the pith-ball electroscope. More turns, more charges (but it will saturate). The two pith balls on the *outside* should also be charged since they were in contact with the cylinder when you charged it up.

Q12. Do you see some evidence to support (or refute) your prediction for the electric field lines (if any) that you drew outside of the cylinder? Explain.

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7. Investigate the field inside the cylinder.
   - First, discharge the cylinder and pen refill using the grounding wire.
   - Charge the pen refill by electrostatic generator.
   - Now charge the pith balls *inside* the cylinder by carefully inserting the charged pen refill through the center of the opening of the cylinder and then touching it to the pith balls. Carefully pull the proof plane out through the center of the opening of the cylinder. Carefully observe the positions of the pith balls, which should now be able to act as test charges.
   - Finally, charge up the hollow cylinder again. Did the pith balls inside change their positions?

Q13 Do you see some evidence to support (or refute) your prediction for the electric field lines (if any) that you drew inside of the cylinder? Explain.

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CLEAN UP CHECKLIST

☐ Make your setup look neat for the next group.

☐ Staple everything together, make sure you have answered all the questions and done all the activities, make sure the first page is completed with lab partners' names and check boxes. Hand in your work before leaving the laboratory.