Physics C Electrostatics Lab

The purpose of this activity is to gain knowledge and experience with: positive and negative charges, charging by processes of conduction and induction, and the material types of conductors and insulators.

Electric Field Detector

The electric field detector reveals the presence of positive or negative charge by detection of the relative strength of the electric field produced by charged objects. Attach the green terminal to an appropriate ground, turn the device on, and then simply bring the object in question near the electrode that protrudes from the device. Do <u>not touch</u> the object to the device (this can transfer charge to the electrode, which is not desirable). When there is nothing near the electrode the reading should be zero and no LED's should be lit – if this is not the case then press the reset button. For this experiment, start with "high" sensitivity, which is best for detecting relatively weak electric fields. (the "low" setting is useful for stronger fields – probably not needed)

NOTE: to make a "fair comparison" of charge amounts place each object at the <u>same distance</u> and note the number of blue or red LED's that light up. This gives you a somewhat quantitative way to compare charge quantities.

Part A – Triboelectric Effect

Materials sometimes become charged due to the effect of contact and/or friction. This is the triboelectric effect. Use the electric field detector to determine and <u>rank</u> the triboelectric tendencies of the six materials/items used in the following four interactions:

1. CPVC pipe (tan) rubbed with fur
2. acrylic pipe (clear) rubbed with felt
3. glass rod rubbed with silk

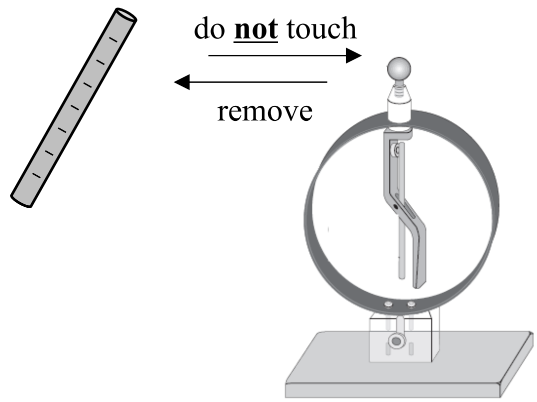
also: feel free to try other combinations such as acrylic pipe and silk, fur and glass, etc.

In the ranking, show the "tendencies" of the materials/items – from the material/item with the greatest tendency to become most negative to that with the greatest tendency to become most positive. Any materials/items that show little tendency to gain either type of charge are "in the middle" of this list – near "zero" on a "tendency number line".

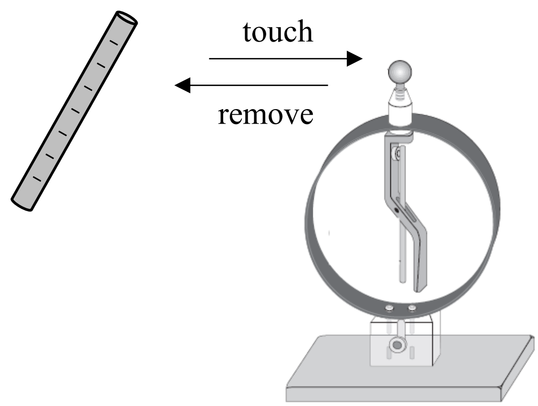
Part B – Conductors, Conduction, and Induction

The following experiments incorporate an electroscope. The "needle" of the electroscope will deflect from vertical in the presence of charge. The amount of deflection can be used to judge the relative amount of charge. If the electroscope's aluminum parts gain a net charge, then it may be necessary to "reset" by touching it with your hand or a grounding wire in order to return it to neutral.

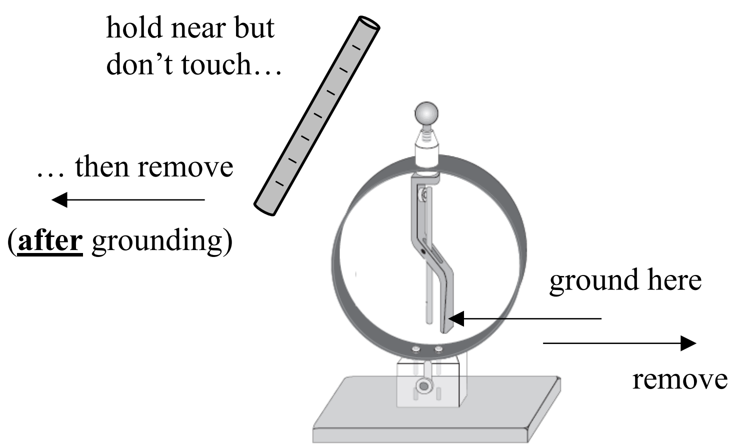
1. Use the electric field detector to confirm that the various aluminum parts of the electroscope are initially neutral. Charge the CPVC pipe and bring it near, but do not touch, the small metal sphere ("charge sampler") atop the electroscope. Observe the effect on the pivoting needle. After the charged pipe is then removed from the vicinity, use the electric field detector to observe the charge (or absence thereof) on the various aluminum parts of the electroscope. Repeat the experiment with a positively charged rod.



2. Repeat the experiments described above, but this time allow the charged pipe to actually touch the charge sampler. You can "reset" the electroscope to neutral by touching it with your finger or a grounding wire. Do this experiment with both negative and positive charged rods. As before use the field detector to observe the charge on the various parts of the electroscope before and after the process.

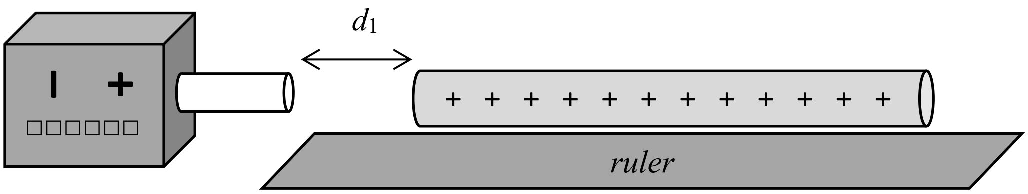


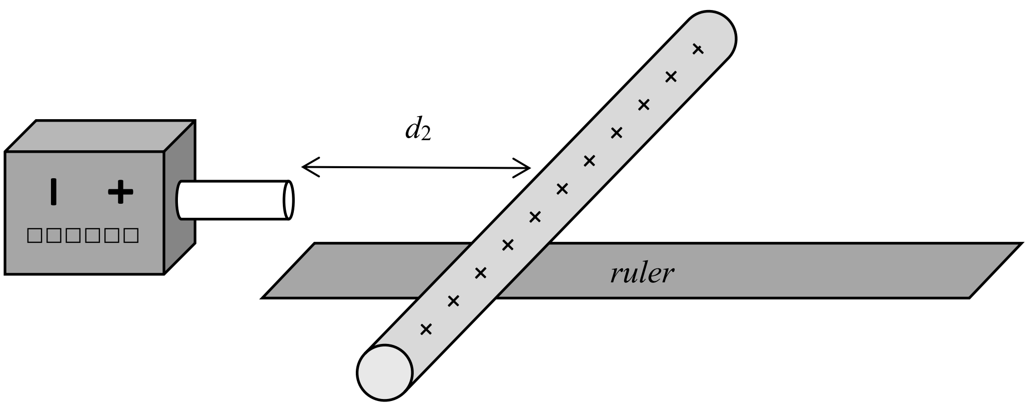
3. Discharge the electroscope. Use the charged CPVC pipe, but, as in experiment 1 above, do <u>not</u> allow it to touch or spark at any point. Bring the charged pipe about 1 or 2 cm away from the charge sampler and hold it in place without touching (or sparking). Then ground the bottom of the stationary aluminum support by touching it with your finger or a grounding wire in the location shown. Then remove the charged pipe from the vicinity of the electroscope. After the charged pipe is removed from the vicinity, use the electric field detector to observe the charge on the various aluminum parts of the electroscope.



Part C – Distribution of Charge

Place the electric field detector on its side as shown below. Take a charged rod and hold it parallel to the table and aligned with the axis of the detector. Move it toward the detector probe until a particular number of LED's are illuminated. Note and record the distance d_1 from the end of the rod to the end of the detector's metal probe. Then rotate the rod ninety degrees so that it is parallel to the table and perpendicular to the axis of the detector. Find the location at which an equal number of LED's are illuminated and note and record the distance d_2 from the center of the charge distribution to the end of the detector's probe. Repeat the process with the same rod, but different numbers of LED's. Then start over with a different rod of the opposite type of charge and repeat the entire procedure.





<u>Note:</u> during Part C it is prudent to frequently "check the zeroing" of the detector. If there is no charged object near the detector probe there should be no LED's illuminated (it should "read zero"). If this is not the case then use the Reset button on the detector.

Data/Observations (submit with report – responses may be on separate paper if desired)

Part A

Triboelectric Tendencies (ordered list of six items/materials)

most negative ◄────────────────────────► most positive

Part B

Questions for each of the three experiments performed in part B. In your responses to each question below you should refer to observations made with the field detector and also describe how electrons have been affected by the actions taken.

1. (a) Why does the needle move when the negatively charged pipe is near but not touching the charge sampler? Why does it do the same thing with the positively charged pipe?

   (b) Why does the needle return to vertical once the charged pipe is removed?

2. (a) What is the evidence that conduction has occurred? What is the evidence that aluminum is a conductor?

   (b) Why does the needle "stay stuck in place" after the charged pipe is removed?

3. (a) Is the net charge on the electroscope *after* the procedure the same or opposite of the charged rod used *during* the procedure?

   (b) Explain why and how the electroscope obtains a net charge without being touched by the charged rod.

Part C

	LED indicator (relative field strength)	Axial Distance from End of Charge, d_1 (cm)	Perpendicular Distance from Center of Charge, d_2 (cm)
positively charged rod	+2		
	+4		
	+6		
	+8		
	+10		
negatively charged rod	−2		
	−4		
	−6		
	−8		
	−10		

Analysis

Produce a high quality graph of d_2 versus d_1 for each charged rod. If you choose to put data for both rods on the same graph then use appropriate colors/symbols and include a legend to distinguish the sets. Include a line or curve of best fit.

Questions for Part C (put on separate paper):

1. The ratio of d_2/d_1 should approach 2 in the limit as each distance approaches zero. The same ratio should approach 1 in the limit as each distance approaches infinity.
   (a) Derive the limiting ratio of 2 based on the field "to one side" of an infinite line of charge versus the field "off of one end" of "half of an infinite line" of charge.
   (b) Explain why the ratio should approach 1 as the distances increase (no derivation required).
2. Discuss how well your data supports the expected properties of the electric field produced by a linear distribution of charge.

Completed Report:

- Data/Observations Parts A and B and C
- Graphs of d_2 versus d_1 for each rod, including best fits
- Responses to questions for Part C