Tutorial Name ____________________________

Working from a model: Static electricity

You probably associate “electrostatics” with physics class, but you probably also have lots of experience with “static electricity” at home. Of course, it’s the same stuff!

I. What interacts?

Obtain a variety of materials from your TA and from your own possessions, including Styrofoam picnic plates, cloth, wax paper, plastic wrap, tin foil, rods of different materials, your clothes, stuff in your pockets, and so on.

A. Do any of these materials show signs of static electricity without you doing anything special to them?

B. What about when you rub various things together? Are there things you can cause to show signs of static electricity by rubbing them with certain other things? Try some combinations and record the ones that work.

What are the signs of static electricity you’re observing? (Sparks? Crackles? Interactions?)

C. Take a piece of paper and tear it up into little bits (maybe 5mm on a side). Take something that you identified as showing signs of static electricity and bring it close to the little pieces of paper. Does your object interact with the little bits of paper when it’s not touching them?

Things that attract little bits of paper are said to be *electrically charged.* The attraction is one kind of *electrical interaction.*

D. Use the bits of paper to test whether the following objects are electrically charged:

1. Your finger
2. A pen or pencil
3. The little bits of paper you made for part C
4. A pith ball
5. A bar magnet
6. A battery

E. Get a piece of tape (4-6 inches long) and fold over a little bit of one end. Stick the tape to a smooth plastic binder or table surface and then pull it off. Is it charged? How can you tell?

F. Make electrically charged objects and then find good ways to make them *un*charged. Try some or all of the following techniques or invent your own. Different techniques may be more effective (or appropriate) with different objects. (Please don't render the objects unchargeable for other students.)

Touch it in one place with your hand – Touch it all over with your hand –Wipe it off with your hand – Wipe it off with a cloth – Set it aside for a while – Rinse it with water – Shake it vigorously – Blow on it – Breathe on it – Put it in your pocket – Run it over the tip of your nose – Draw it across your lips – Roll it on the floor – Touch it to something else that's charged – (other)

✭ Before you go on, prove to a TA that you can charge, then uncharge, each of the following objects: (1) a Styrofoam plate and (2) a piece of tape.

II. How do things get charged?

You have probably already started to wonder how it is that objects become charged, or uncharged. To explore how something happens, it's often useful to think about when it *doesn't* happen, or when you think it might not.

A. Have you ever noticed an electric charge when you rub your hands together? How about if you rub someone else's hands? Try it if you're not sure, using your test for charge from part I. Why do you think this is the case?

B. Make a prediction for what would happen if you were to rub two uncharged Styrofoam plates together. If they had no net charge to begin with, would either one have a net charge as a result of rubbing? What do you think is going on?

Make sure your two Styrofoam plates are uncharged, then try rubbing them together and see if they get charged. Does the explanation you tried in part B fit with what you observe?

C. Think about the piece of tape that you charged by peeling it off the desk. What's your theory about how that got charged?

D. Think about some of the ways you found to uncharge your charged objects. What do you think is going on there?

✯ *Explain your ideas to a TA before you proceed.*

III. Types of charge

We'll continue investigating how things get charged by making some new charged objects.

i. Charge a piece of tape like you did in part I (stick a piece 4-6 inches long onto a smooth surface and pull it off – don't forget the folded "handle"). Hang it up somewhere where it will not be disturbed. This will be your "test tape."

ii. Stick another piece of tape (also with a handle) to the same smooth surface. Write the letter "B" (for "bottom") on the tape.

iii. Stick another piece of tape (again with a handle) directly on top of the first tape. Write the letter "T" (for "top") on that tape.

iv. Pull the tapes off the desk together, so that they are still stuck to one another all along their length. Uncharge the pair of tapes using whatever method you have found most effective and appropriate for tapes.

v. Hold the folded handles of the two tapes in your opposite hands and pull the two tapes apart.

A. Which tape is charged: the T tape, the B tape, neither, or both? Give evidence.

What's your explanation for how that happened?

B. What kind of interaction, if any, do the T and B tapes have with each other? What kind of interaction does each have with the test tape?

C. You probably already know the rule that like charges repel and opposite charges attract. But you could figure that out even if someone didn't tell you.

1. Show that the test tape is either a T tape or a B tape, not by using the rule, but by showing that it interacts with other objects the same way that a T or a B tape does. Make more T and B tapes if you need to.

2. Take uncharged objects and observe how they interact with T and B tapes (attract, repel, both, or neither?). Do uncharged objects have the same interactions as T tapes or B tapes? Or do they have their own special pattern of interactions?

3. See what happens if you take a T and B tape and stick them back together. What is the charge on the resulting object? Explain how that supports calling the charge on T and B "positive" and "negative."

   Do you have any evidence to tell you which is positive (T or B)?

4. Suppose we have two objects, labeled 1 and 2. Object 1 attracts object 2. From this observation alone, what can you say about the charge on object 1? on object 2? What additional experiments could you do to determine how objects 1 and 2 are charged?

D. Now think back to your ideas about how things get charged.

1. Explain what's happening when T and B tapes get charged.

2. Explain what's happening when a test tape gets charged.

3. Explain why Styrofoam plates don't get charged just by rubbing on one another.

4. Explain why your clothes sometimes get charged in the dryer.

5. Explain what's happening when you uncharge an object. Where does the charge go?

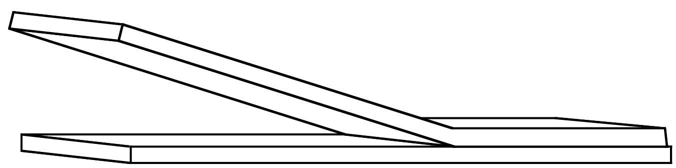
✯ *Explain your ideas to a TA before you proceed.*

IV. Representing charge

In our model of electricity, everything is loaded with positive and negative charges (protons and electrons), but in nearly identical numbers. If you wanted to represent *all* the charges around in a drawing, you could draw lots of pairs of "+" and "–" symbols everywhere, but that would get tedious. So it's customary to draw "+" and "–" symbols only to show that there's more of one or the other. (You could draw a couple of pairs to remind yourself what's going on, though.)

Also according to our model, the amount of charge can be distributed in different ways in an object: Different parts of an object may be charged differently. So we use "+" and "–" symbols to show where on the object there's an excess of which kind of charge.

A. A bottom (B) piece of tape and a top (T) piece of tape are separated halfway. Use "+" and "–" symbols on the diagram to indicate the parts of the tapes that are charged and the type of the charge.



B. Suppose you were to take one of the foam plates and rub it with a piece of cloth. Draw a diagram in the space to the right showing the charge on the plate and on the cloth. (Can you tell whether the plate is + or –? If not, just pick one!)

C. If you earn $500 and $150 is deducted in taxes, the amount of money that you take home ($350) is called your "net" income. The word "net" is used similarly to describe the relative amounts of charge on an object. (We also sometimes use the word "total.") If there is more positive charge than negative charge then the object is said to have a "net" positive charge. If an object has the same amount of both types of charge, then it is common to say that the object has a "net" zero charge. (We also sometimes say it has "no charge," but that could be misleading!)

   1. In part A, was the sign of the net charge on the pair of tapes taken together positive, negative, or zero? Explain how you know.

   2. In part B, would the net charge on the plate and cloth taken together be positive, negative, or zero? Explain how you know.

   3. Check that the drawings you made in parts A and B are consistent with your answers above.

V. Supplement: Another way to separate charge

Notice that in our model, we never *make* charge (electrons and protons); we pull pairs of charge apart from each other. Rubbing was one way to do that. In this section, you'll find another way.

You should have at your table an aluminum pie plate with the foam cup attached. This is a version of a device called an "electrophorus"—a fancy name for a simple thing. It's a device for holding charge. The following instructions will show you how to put a net charge on the electrophorus; at the end of the tutorial we'll ask you to use the model of + and – charges to explain why these instructions work.

To charge the electrophorus:

1. Rub a foam plate with cloth so that it has a net charge (and let's suppose it's negative).
2. Set the foam plate on the table, and, holding the electrophorus by its handle (the cup), bring the aluminum plate very close to the foam plate.
3. Holding the two plates close together, touch the top of the aluminum plate with your finger. If things work well, there'll be a tiny spark. (Even if there isn't, the electrophorus still might be charged.)

A. Verify that the electrophorus is charged after steps 1-3. (Later we'll ask you to explain how touching the plate can result in its being charged.)

B. Charge the electrophorus and set it on the cup as a stand. Now find the pith ball at your table. (In place of a pith ball, you might have a tiny ball of aluminum foil, also hanging from a string.)

1. Make a prediction for what will happen if you let the pith ball touch the plate. Use a diagram to explain why that's your prediction.

2. Try it: Touch the bottom of the plate to the pith ball. If it doesn't come out as you predicted, try to figure out why not. Revise your diagram if you need to.

✯ *Please check with your TA before you continue.*

(At any point during this tutorial, especially now with that pith ball, you might make your own discovery of some interesting phenomenon. As long as you can reproduce it—make it happen reliably when you do specific things—you could use it to further your thinking. We're just picking some things we know about and expect will give you reproducible results. So feel free, if you find something else that's interesting and reproducible, to go figure it out. Use the model!)

C. Charge the electrophorus again, and, holding it by the cup, touch it to the pith ball and hold it near.

1. Make a prediction for what would happen if you were now to touch the pith ball with a foil-covered straw, still holding the plate near by. Draw a diagram of the charges, to explain your prediction.

2. Try it! If something different happened, same deal: Try to figure out why not.

3. Would the same thing happen if you used a plastic straw, with no foil covering it? How about if you touched it with your finger? Explain.

D. D. Try to explain those instructions for charging the electrophorus. Draw a series of sketches showing what happens at each step, in terms of + and – charges. Check your thinking with each other and with your TA.

