ELECTROSTATICS ACTIVITIES

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This set of activities is intended to give students experience with electrostatic phenomena while building understanding of electrical charges and their interaction in conductors and insulators. The materials used are so inexpensive that each student can have a complete set of materials to work with. Every attempt has been made to choose equipment and activities that will work in most conditions and will clearly show the phenomena. However, when working with electrostatics, it is always advisable to have the materials clean and as dry as possible and to avoid excessive humidity.

MATERIALS

paper
flexible plastic drinking straws
fur or wool
Styrofoam coffee cups
Scotch Magic tape
Masking tape
Styrofoam picnic plates or styrofoam pad
polyester sewing thread
aluminum foil
paper clip
empty aluminum soft drink can
disposable aluminum pie plates
NE-2 neon bulbs (available from Radio Shack, or in bulk from Mouser Electronics, 800-346-6873)

INTRODUCTION

In these investigations, you will be using the laboratory to learn what makes things behave the way they do. This material will help you to understand the behavior of the electrical interactions of matter, and to seek some pleasure in pitting your wits against nature to build a model for the understanding some aspects of this behavior, much in the way William Gilbert, Benjamin Franklin and other experimenters did in their attempts to understand nature. The essential element of laboratory work is honest, perceptive and accurate observation. Any preconceptions you may possess should be ignored in making these observations.

You should keep a record of this investigation in a notebook, carefully recording your experiments, observations and answers to questions in a manner you can expect to understand two months later. You should also record any questions or ideas you may wish to study later. Be careful to record your observations clearly. The apparatus used in these experiments is quite simple, but don't be fooled by the apparent simplicity. The phenomena are not necessarily simple, and are certainly not trivial.

There is an old saying in science that the easiest things to observe are the hardest to understand. Care, patience, and persistence are often required to distinguish that which is reproducible from that which is accidental. Experiments should be repeated to be sure that what you think you observed is in fact what happened. Keen eyes, skilled hands, open minds, and judicious, accurate observations are the hallmarks of good investigations.

SECTION 1. ELECTRICAL INTERACTIONS

Materials: plastic straw, paper bits, styrofoam coffee cup, wool or fur.

1.1

Tear part of a piece of paper into small bits. Take a plastic drinking straw and bring it close to the bits of paper. Can you lift the bits of paper by touching them with the straw?

Now rub the straw briskly with fur or wool or against your hair and try to lift the bits of paper from the table.

Can the scraps of paper be lifted even if you do not allow the rubbed straw to touch them first? Repeat this using the styrofoam coffee cup, trying to lift the paper bits before and after rubbing the cup on wool, fur or your hair.

1.2

Apparently, after the straw has been rubbed there is an interaction between the straw and paper which is capable of lifting the scraps of paper. What can you say about the size of this interaction compared to that of the earth's gravitational interaction with the scraps of paper?

The force involved in this interaction is called an electrical force, and was first observed by the Greeks, who found that pieces of amber (in Greek, elektron) attracted other things after being rubbed with fur. The materials which are capable of attracting the bits of paper are said to be electrically charged.

1.3

Can you conclude at this time that the bits of paper are charged? Why might you think so?

Are they charged according to the defintion in section 1.2? How could you test for this? What do you find?

SECTION 2. CHARGED STATES OF MATTER

I. Interaction between charged objects and uncharged objects.

materials: Scotch magic tape, paper bits, sheet of paper.

2.1

Take about a 15 cm (6 inch) piece of the Scotch tape and make tabs by folding the first few centimeters of tape on each end sticky side together. Stick the tape to the table-top and press and rub it down well with your finger. Now peel the tape carefully but briskly from the table top.

Will either or both sides of the tape attract the scraps of paper?

Does the tape meet the definition of being charged?

Roll a piece of paper into a tube and bring it near the tape. Is there an interaction between the paper tube and the tape?

Does the paper tube meet your definition of being charged? Why or why not?

II. Interaction between two charged objects

materials: Scotch magic tape, styrofoam coffee cup, flexible plastic straw.

2.2

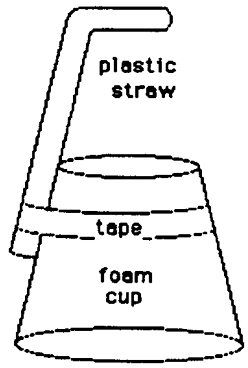
Make a second tape strip like the first one. Press them both down on the table separately, and then peel them loose from the table. Try bringing the tapes near each other and see what effect they have on each other. Does it matter which sides of the tape face each other?

Make a third strip of tape, charge it and try bringing it close to each of the other two. (You could compare one of yours with that of another student, or stick their ends to something so that you have enough hands.) What do you observe?

Can you extend the definition of when an object is electrically charged? Check your reasoning with your teacher.

2.3

A. Make a stand by taping the long end of a flexible straw to an upside down foam cup with scotch or duct tape. Bend the top of the straw horizontal and stick one of your pieces of charged tape to the straw so it hangs down. (You may have to shorten the tape a little.) We will call this the test tape.



B. Discard your other two pieces of tape, and make two new tape strips in the following manner. Label the first one A and press it down on the table. Label the second one B and press it firmly down on top of A. Peel the stuck-together tapes off the table. Bring them near the test tape. What do you observe?

Bring the combination near some paper bits. What do you observe? Is the combination tape charged under either or both parts of your definition?

C. Now run the non-sticky side of the tape combination across your lips or across a water pipe. Test the combination tape again against your test tape and against the paper bits. What do you observe?

Does the combination tape now seem to be charged according to your definition?

D. Carefully peel apart the two tapes. Hold one in each hand and bring them slowly towards each other. What do you observe?

E. Bring first A and then B towards the test tape. What do you observe?
Can you tell with certainty from this experiment that both A and B are charged according to your defintion? Why or why not?

F. Can you devise any additional experiment that will show convincingly that both A and B are charged according to your definition? Try it.

How do your observations in this experiment allow you to extend or refine your definition of an object being charged?

How do tests for attractive and repulsive interactions compare in effectiveness as a test for objects being charged? Would either test alone be sufficient? If so which one and why? If not, why not? Explain your reasoning to your teacher.

2.4

A. Make another test stand with a cup and straw and hang tape A from one stand and tape B from the other. Try rubbing various objects including your straw and a foam cup against various materials and test them against strips A and B.

Do all objects that repel A also attract B?

Do all objects that repel B also attract A?

Do any objects repel both A and B?

Do any objects attract both A and B? Do these objects meet your definition of being charged? How do you know?

B. On the basis of your experiment, describe how many different ways charged objects may behave when tested with A and B. Check your reasoning with your teacher.

III. Charges and charged states

Materials: blue styrofoam pad or styrofoam picnic plate, fur or wool, tape combination.

If two charged objects behave the same in their interactions with all other objects, we may describe them as being in the same charged condition or in the same charged state. We will suppose that a charged state depends on the presence of something called charge. With this hypothesis, we need to account for the charged states of A tapes, B tapes and unrubbed paper in terms of the kind or kinds of charges present.

2.5

A. How do two A tapes interact?

How do two B tapes interact?

Based on your experiences in 2.4 would you say that the two A tapes have the same or different charges?

Would you say that the two B tapes have the same or different charges?

On the basis of these observations we now assume that A tapes have one kind of charge and B tapes have another. What is the interaction between two objects with the same kind of charge?

How does an A tape interact with a B tape? What is the interaction between two objects with different kinds of charge?

B. Now consider the paper. How do two bits of unrubbed paper interact?

If we were to assume that the behavior of unrubbed paper is due to the presence of a third kind of charge, would the behavior of this third type of charge be consistent with the behavior of A and B charges?

C. How does an A tape interact with a B tape?

How does an A tape interact with paper bits?

How does a B tape interact with paper bits?

Based on these observations can you conclusively say that paper bits have absolutely no kind of charge?

D. Suppose we assume that there are only two kinds of charge, one associated with tape A and the other with tape B. Using only this assumption and your observations so far, could you explain the charged states and the interactions of A tapes, B tapes and paper bits and the preparation of A and B tapes in terms of the amount of each or of both kinds of charge present? Check your reasoning with your teacher.

2.6

Prepare another set of A and B test tapes. Briskly rub the foam pad or foam plate with the wool or fur. Bring the rubbed surface near the A and B test tapes. Is the foam charged like the A tape, the B tape or the paper bits? How do you know?

For the moment we will consider charged objects that behave like tapes A and B to have either styrofoam type charge (foam for short) or non-foam charge. How can you tell if an object has foam charge or non-foam charge?

In the next section we will consider the electrical interactions involving the paper bits.

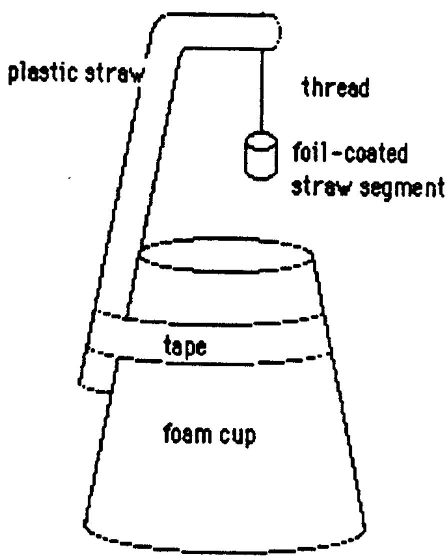
SECTION 3. BUILDING ELECTROSCOPES

Materials: straight and flexible plastic straws, aluminum foil, polyester sewing thread, empty soft drink can with a pull tab, plastic coffee cup, glue stick and tape, styrofoam picnic plate or 30 cm square blue styrofoam pad.

3.1

A. A good quick substitute for the traditional pith ball on a string used in electrostatic experiments may be made from small pieces of foil covered plastic drinking straws. Apply glue (I use a glue stick) to a strip of aluminum foil and roll a single layer of foil around a plastic drinking straw. Before the glue is dry, cut the foil covered straw into pieces about one and a half or two centimeters long with scissors. Partially unroll the foil on each bit of straw and lay one end of a 10 cm (or longer) length of polyester sewing thread under the foil, pressing it down against the glue to secure it. Keep the thread as clean and dry as possible. In the rest of this module "pith ball" will refer to these suspended aluminum foil covered pieces of drinking straw.

B. Make a stand to hold the pith ball by taping a flexible drinking straw to an upside down foam coffee cup with masking or duct tape. (You may modify one of the stands you made to hold the A and B test tapes.) Bend the top of the straw horizontal and cut slits in the top end of the straw. Slip the suspension string of one or more "pith balls" into the slit and adjust their lengths to suit your needs.

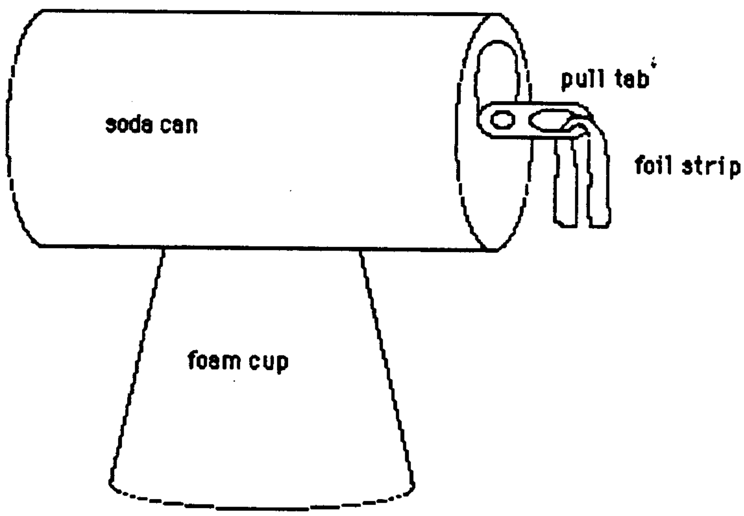


C. Set up your stand with a pith ball hanging from it on about 10 cm of thread. Rub a plastic drinking straw with wool or fur and bring it near some paper bits. Is the straw charged? Now bring the straw near the pith ball. What happens? How can you use the pith ball to test for a charged object?

The next tool you will build is a more sensitive electroscope.

3.2

A. The leaf electroscope. This is a very inexpensive version of the gold leaf electroscope. Take an empty aluminum soda can and bend the pull tab so the tab is perpendicular to the top of the can. Take a styrofoam coffee cup and set it upside down on the table and set the can on its side on top of the cup so that the loop in the end of the pull tab lies in a horizontal plane. Tape the can onto the cup. Now cut a thin strip of aluminum foil about a half a centimeter wide by five centimeters long and smooth it with your fingernail. Bend the top of the strip loosely around the horizontal bar at the end of the pull tab, so that the strip swings freely from the bar.



B. Take a plastic drinking straw and rub it with wool or fur. Touch the pith ball with the straw. Is the straw charged? Touch the straw to the top of the can on the electroscope. What happens to the foil leaf? How can you tell if an object is charged using the foil leaf electroscope?

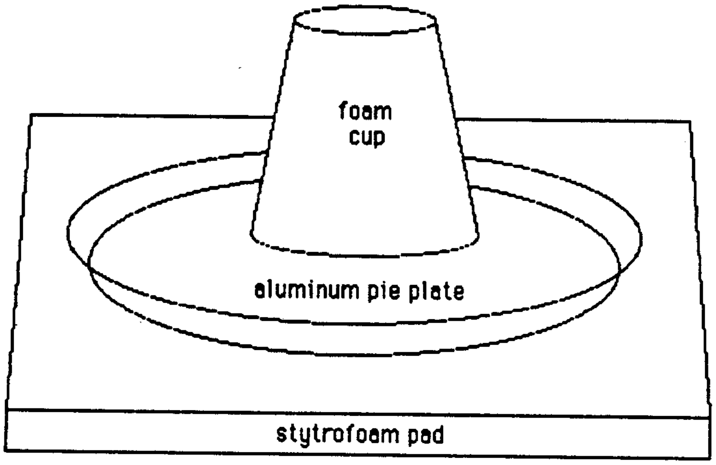
In the next section you will build a reliable charging device which you will use with the electroscopes to find out more about the behavior of charged objects.

SECTION 4. THE ELECTROPHORUS: A DEVICE FOR GENERATING STATIC ELECTRICITY

Materials: Dow blue styrofoam insulation or styrofoam picnic plate, 8 or 9 inch disposable aluminum pie plate, foam coffee cup, plastic drinking straw, wool or fur, and tape.

4.1

A. To make an electrophorus, take a 30 cm (one foot) square of foam for the base, or use a disposable styrofoam picnic plate. Take a disposable aluminum pie plate (8" or 9") and fasten an insulating handle to it by taping a styrofoam cup upside down in the center of the pie plate. You will also need to make a second pie plate with a foam cup handle for some of the experiments, or you may share equipment with a partner.



B. Rub the top surface of the foam with fur to charge it. Slowly lower the electrophorus pie plate (henceforth called the electrophorus plate) to a height of a few millimeters above the foam while holding it by the cup handle. Be careful not to touch the pie plate with your hand or arm unless instructed to do so.

Still holding the electrophorus plate by the cup, raise it away from the foam. Touch the electrophorus plate to your leaf electroscope. Is the electrophorus plate charged?

C. Again lower the electrophorus plate to a point just above the foam, and this time touch the electrophorus plate briefly with your finger while it is on or just above the foam. What happens?

Slowly lift the electrophorus plate by the handle. Do you feel any interaction between the electrophorus plate and the foam pad as you lift? Is it attractive or repulsive?

Touch the electrophorus plate to your leaf electroscope. Is the electrophorus plate charged?

Touch the electrophorus plate to your pith ball. What does the pith ball do? What can you say about the charge on the pith ball and the charge on the electrophorus plate.

Now bring the foam pad near the pith ball. What can you say about the charges on the pith ball and the foam pad?

Clearly the electrophorus is an effective, interesting and slightly puzzling charging device. Temporarily you will use it to supply charges for other experiments before trying to develop a better understanding of how it works.

<u>4.2</u>

A. Take a plastic straw and glue aluminum foil to it so that it is covered with foil. Take another straw without a foil covering. Use a bit of duct or masking tape and tape one end of each straw to the rim of the electrophorus plate at separate places so that they stick out horizontally. Set up the pith ball electroscope and briefly touch the pith ball with your finger. Rub the foam pad or the foam plate with the wool or fur, then pick up the electrophorus plate by its handle, set it on the foam pad and touch it briefly with your finger. Lift the electrophorus plate by its handle, being careful not to touch the plate or the straws. Move the plate so that first the outer end of the plain straw touches the pith ball and then the outer end of the foil straw touches the pith ball. What happens in each case?

Does the plain straw charge the pith ball?

Does the foil straw charge the pith ball?

Is the end of the plain straw charged?

Is the end of the foil straw charged?

How could you find out if the charged state of the pith ball is the same as or different from that of the styrofoam? Devise an experiment and find out.

B. Repeat the experiment in 4.2 A, this time using the foil leaf electroscope. Does it move when touched with the plain straw? With the foil straw?

C. How did the foil covered straw get charged? How did the pith ball get charged? How is this different from the way that the tapes and foam got charged?

4.3

Rub the foam pad with the fur or wool again, then pick up the electrophorus plate by its handle, set it on the foam pad and touch it briefly with your finger. Lift the electrophorus plate by its handle, being careful not to touch the plate or the straws. Now touch the end of the plastic straw with your finger and then bring the electrophorus plate near the hanging pith ball. Is the plate still charged? Did touching the end of the plastic straw change the charge on the plate?

Now touch the end of the foil covered straw briefly with your finger. Bring the electrophorus plate near the pith ball. Is the plate still charged? Did touching the end of the foil covered straw change the charge on the plate?

Objects that behave like the plastic straw, the foam and the tape are called insulators. Objects that behave like the foil covered straw and the pith balls are called conductors. We will continue to look at the differences in their behavior and try to account for it in developing a model of electric charge. In a conductor we may imagine that one or both types of charge are free to move, whereas in an insulator neither type of charge can move very much or very readily. You may now use the electroscope and electrophorous to investigate a variety of materials and see if they behave like conductors or insulators. You will probably find that some materials have a behavior in between those of the foil covered straw and the plastic straw, and that there is a range of behavior of materials.

4.4

Can you explain the results of experiments 4.1, 4.2 and 4.3 using this model? Sketch a sequence of diagrams showing what might be happening to the charges in these experiments. Check your description with your teacher.

SECTION 5: THE BEHAVIOR OF THE ELECTROPHORUS

5.1

A. Rub the top surface of the foam with fur to charge it.
Touch the electrophorus plate with your finger while it is in the air. What happens?
Slowly lower the electrophorus plate to a height of a few millimeters above the foam while holding it by the cup handle. Be careful not to touch the pie plate with your hand or arm unless instructed to do so.

Still holding the electrophorus plate by the cup, raise it away from the foam. Touch the electrophorus plate to your leaf electroscope. Is the electrophorus plate charged?

B. Again lower the electrophorus plate to a point just above the surface of the foam, and this time touch the electrophorus plate with your finger while the electrophorus plate is on or just above the foam. What happens?

Take your finger away and lift the electrophorus plate by the handle. Do you feel any interaction between the electrophorus plate and the foam pad as you lift?

Touch the electrophorus plate to your leaf electroscope. Is the electrophorus plate charged? Is the charge on the electrophorus plate"foam" or "non-foam"? How can you tell?

5.2

Touch the electrophorus plate briefly with your finger while it is in the air. What happens when you do this? Is the plate still charged? Again lower the electrophorus plate this time letting it rest on the foam, and touch the electrophorus plate with your finger while it is on the foam. What happens?

Take your finger away and lift the electrophorus plate by the handle. Is the interaction between the electrophorus plate and the foam pad as you lift it the same as before?

Touch the electrophorus plate to your leaf electroscope. Is the electrophorus plate charged?

Is the charge on the electrophorus plate"foam" or "non-foam"?

Did it matter if the electrophorus plate was in contact with the foam?

SECTION 6. FORCE AND DISTANCE

6.1

To better understand what is happening in section 5 we need to know qualitatively the way the electrical interaction or force between charged objects depends on distance. We have several ways to see this. The first way is to "feel" the interaction. Take the electrophorus plate by the handle, touch the plate briefly with your finger, then lower it onto the foam and touch it briefly with your finger. Now raise the electrophorus plate from the foam. Do you feel an interaction or force between the electrophorus plate and the foam?

Repeat the above procedure using a foam picnic plate instead of the blue foam pad. What happens to the picnic plate?

What happens to this force as you move the electrophorus plate farther from the foam? What does this tell you about the way the interaction changes with distance?

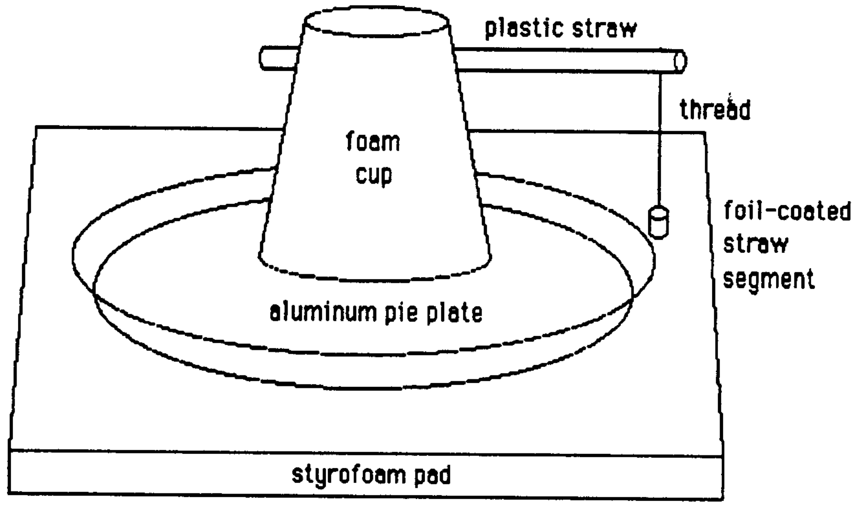
6.2

Take your stand with one pith ball hanging from it. Touch the pith ball briefly with your finger. Take the electrophorus plate by the handle, touch the electrophorus plate briefly with your finger, set the electrophorus plate down on the foam, touch it briefly with your finger, then lift the plate from the foam and touch it to the hanging pith ball. What happens to the pith ball as you move the electrophorus plate closer and farther from it? Does this agree with your conclusion in the previous experiment?

SECTION 7. THE INDICATING ELECTROPHORUS

7.1

A. Take a plastic straw and tape it horizontally to the top of the cup that serves as the handle of the electrophorus so that it extends over the edge of the pie plate. (You could instead poke holes in the cup with a pencil and slide the straw into the holes.) Cut slits in the end of the straw and suspend a pith ball so that it is just touching the rim of the electrophorus plate as in the diagram.



B. Now, touch the electrophorus plate briefly with your finger to discharge it, and lower the electrophorus plate onto the foam. What happens to the pith ball? Move the electrophorus plate up and down above the foam. What happens to the pith ball? What does this tell you about charges on the rim of the electrophorus plate and the pith ball as you move the electrophorus plate closer to the foam?

C. Again, discharge the electrophorus plate with your finger while it is in the air, lower the electrophorus plate onto the foam and bring a second pie plate with a cup handle near the pith ball. What happens?

Move the second plate closer to the first until nothing more happens. Based on your observations and your model of charge, make a cartoon strip showing what might be happening to the charges and the pith ball.

D. Discharge both plates with your finger and repeat the procedure above. This time move the second plate away, being careful not to touch it and raise the electrophorus plate, and observe the position of the pith ball as you move the electrophorus plate up and down above the foam. Does the behavior of the pith ball correlate with any interaction you feel between the electrophorus plate and the foam?

What can you infer about the amount of charge on the rim of the electrophorus plate as you move it away from the foam?

Where must the charge on the rim come from?

Is the charge on the electrophorus plate the same type as the charge on the pith ball?

Now bring the second plate near the pith ball being careful not to let them touch. What happens? Is the second plate charged? Test this by touching it to the leaf electroscope.

E. Is the charge on the second plate the same as that on the electrophorus plate or the same as that on the foam pad? Test this by charging your pith ball electroscope from the second plate and bringing the foam pad near the pith ball electroscope. Make any other tests you care to and draw a conclusion regarding the charged states of the foam pad, the electrophorus plate and the second plate. Explain your reasoning to your teacher.

7.2

Set down the plate and the foam and refresh the charge on the foam with the wool or fur. Then hold the electrophorus plate by its handle and discharge it by briefly touching it with your finger. Now carefully lower the pie plate down onto the foam. Watch the behavior of the pith ball. Bring the second pie plate near the pith ball as before while the electrophorus plate is sitting on the foam.

When electric charge flows from one place to another, we say that there is an electric current. Is there an electric current between the two plates? How do you know?

Does the behavior of the pith ball tell you anything about how fast the charge is transferred? What does this tell you about the size of the current that is flowing? Explain using your model of charge.

7.3

A. Once again take the pie plates away from the foam and discharge them with your finger, then lower the electrophorus pie plate onto the foam. Watch the behavior of the pith ball. Bring the second pie plate near the pith ball as before while the electrophorus plate is sitting on the foam, moving it closer as needed until the pith ball has stopped. Lift the electrophorus plate, watching the behavior of the pith ball, and while it is in the air bring the second plate near the pith ball. What happens? Does a current flow?

B. When nothing more is happening, test the plates for charge by touching each of them in turn to the leaf electroscope. Is there any charge on either plate?

Test the foam for charge by bringing it near the electroscope. Does the foam still have a charge?

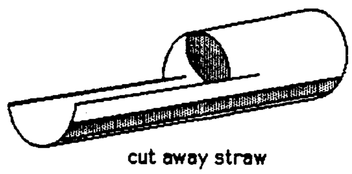
C. You may be able to account for the behavior of the electrophorus by using the model developed so far. Try this, and check your ideas with your teacher.
To confirm your idea it would be useful to have a little more information, which we can obtain by introducing another device.

SECTION 8. THE NEON BULB AND A CONVENTION FOR CHARGE

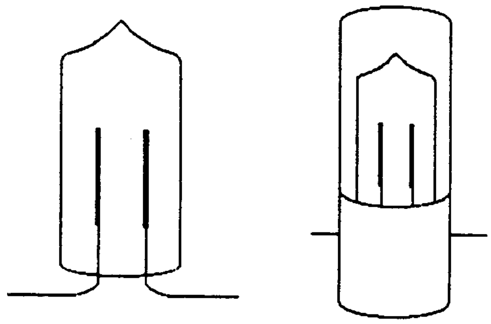
Materials: plastic straw, black marking pen, scissors, neon bulb

8.1

A. Cut about a four centimeter length of straw, and cut away half of it for about one centimeter. Use the marker to color the inside of the remaining half black. Cut slits about a half centimeter up the straw. Bend the leads of the neon bulb out at right angles and slide the neon bulb into the cut away part of the straw, leads first, so that you can see both electrodes of the bulb and the leads stick out from the slits on the sides of the straw. The black backing may make it easier to see what is happening inside the bulb.



cut away straw



neon bulb bulb in holder

B. To use the neon bulb, hold one lead in your hand and touch the other lead to a charged object while watching the electrodes. Try the following sequence. Refresh the charge on the foam pad. Hold the electrophorus plate by its handle and discharge it. Lower it onto the foam pad and touch the electrophorus plate with one lead of the neon bulb while holding the other lead. Do you see a flash? Did it flash at the electrode coming from the plate or your hand? Repeat the experiment until you are sure.

Now turn the bulb around and repeat the experiment holding the bulb by the other lead. Does the flash occur at the plate electrode or the hand electrode? Is this the same as before?

8.2

Now try the following sequence. Refresh the charge on the foam pad. Discharge the electrophorus plate. Lower the plate onto the foam and touch the plate with one lead of the neon bulb while holding the other lead. Watch for the flash. Remove the bulb, and then lift the electrophorus plate from the pad. Now touch the electrophorus plate again with the lead from the neon bulb. Did it flash at the same electrode as before? Repeat the experiment until you are sure of your results.

When the neon bulb flashes, it tells us that a current flows through it. The electrode at which the flash occurs indicates the relative DIRECTION of current flow. We now define the sign of charges by the convention that the flash occurs at the electrode that is LOSING negative charge or GAINING positive charge.[1] This definition turns out to be in complete agreement with Benjamin Franklin's arbitrary decision to call the charge on a glass rod rubbed with silk positive charge. We can now use the neon bulb to determine whether the charge we have been calling "foam" charge is positive or negative.

1. Layman, "Neon Lamps and Static Electricity, The Physics Teacher, vol 10, p 49.

8.3

You could try doing this by refreshing the charge on the foam pad, taking the neon bulb by one lead and bringing the other near the surface of the foam. You may or may be able to see a flash depending on how highly charged the foam surface is. Try it and see what happens. If you saw a flash, which electrode was it at? What is the charge on the foam?

8.4

You can also use the electrophorus to investigate the sign of the charge. Refresh the charge on the foam pad by rubbing it, then charge the electrophorus plate by the usual procedure, discharging it with your finger, lowering it to the foam pad, touching it again briefly with your finger, and lifting it off the foam pad. You know that the electrophorus plate now has the opposite charge to that of the pad. Take the neon bulb by one lead and touch the other lead to the plate. Which electrode lights?

What is the sign of the charge on the plate?

What is the sign of the charge on the foam pad?

8.5

You have now seen that you can use the neon bulb not only to indicate that charge has moved through the bulb, but to distinguish which direction the charges have travelled. Suppose that the right hand electrode of the bulb lights. Which direction would negative charges have travelled? Which direction would positive charges have travelled?

8.6

A. You are now ready to make a final investigation of the behavior of the electrophorus. To do this, take a bit of duct tape and tape one electrode of the neon bulb to the rim of the second pie plate so that the bulb and the other lead stick out horizontally perpendicular to the rim. You may now use this bulb to investigate the direction of charge transfer in the charging and discharging of the pie plates.

B. Refresh the charge on the foam pad, and once again take the pie plates , discharge them, then lower the electrophorus pie plate onto the foam. Watch carefully while your bring the second pie plate near the first so that the untaped lead of the neon bulb touches the electrophorus plate while the electrophorus plate is sitting on the foam. Observe which electrode flashes. Move the second plate away, lift the electrophorus plate, and while they are in the air bring the plates together so that the untaped lead of the neon bulb again touches the electrophorus plate. Observe which electrode flashes. When did currents flow? In which direction did they flow? What was the state of charge of the electrophorus plate at each stage of the experiment? Of the second plate at each stage?

8.7 At this point you have investigated the effect of distance on the electrical interaction, the difference between the behavior of charged conductors and insulators, and accounted for three charged states of objects with two kinds of charge. Use the features of this model to account for the behavior of the electrophorus plate and the second plate. Consider especially the type of charge you found on each plate, the direction of the charge flows and the changes that occur in the charged state of the plates as you carried out the procedure of charging and discharging the electrophorus. Make a diagram that shows the sequence of charging and discharging and the charge state of the foam pad, the electrophorus plate and the second plate at each stage. Check your explanation with your teacher.

At the beginning of these activities, we used the attraction between neutral bits of paper and a charged object as part of our intial test for an object being charged. Carry out the following experiments and then try to use your model of the behavior of the electrophorus, the change in electrical attraction with distance, and the difference between conductors and insulators to explain how a charged object can attract a neutral object.

Materials: plastic straw, paper bits, aluminum foil bits, leaf electroscope.

8.8 Charge the plastic straw with wool or fur. Bring it near the paper bits. Bring it near the foil bits. Bring it near the uncharged pith ball electroscope. Bring it near the leaf electroscope. Record your observations and account for them using the model. Check your description with your teacher.

FOIL ON AL PLATE