



# SE&M Activity III - E: What Happens When You Rub Electrical Materials?

Name:

Group:

Class Period:

In the first unit you thought about static cling. When you shuffle or "rub" your feet on the carpet you will often get a shock. What is it about rubbing feet on carpet that causes a change?



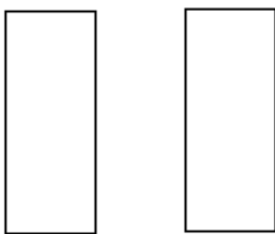
- Most of the time things do not attract or repel each other. However, certain materials do attract or repel each other after they have been rubbed with the right materials. You saw that if a foam plate was rubbed with an acrylic sheet, each had an opposite effect on a rubbed straw. Thus, rubbing certain objects seems to change their behavior. **What do you think is different about the acrylic sheet and styrofoam plate after they are rubbed together, compared to before they were rubbed? What evidence do you have from Cycle I to support your model of static electricity?** (Answer this question individually.)



- Below are drawings representing cross-sections of the foam plate and the acrylic sheet, before they are rubbed, while the rubbing is taking place, and afterwards. The black lines represent the **surfaces** of the materials. The white area inside the rectangles represent the **inside** (interior) of the foam or acrylic material. **Draw** diagrams to represent your model for what you think is going on with the two materials.

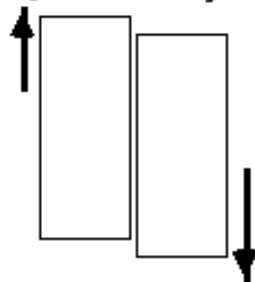
Styrofoam

Acrylic



Before rubbing

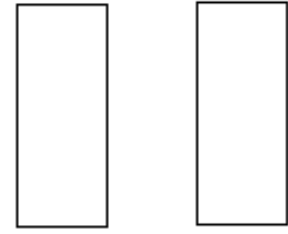
Styrofoam Acrylic



During rubbing

Styrofoam

Acrylic

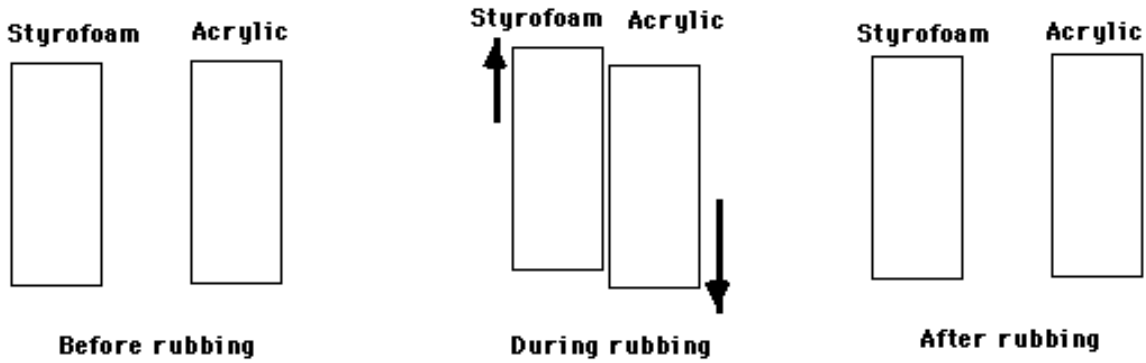


After rubbing

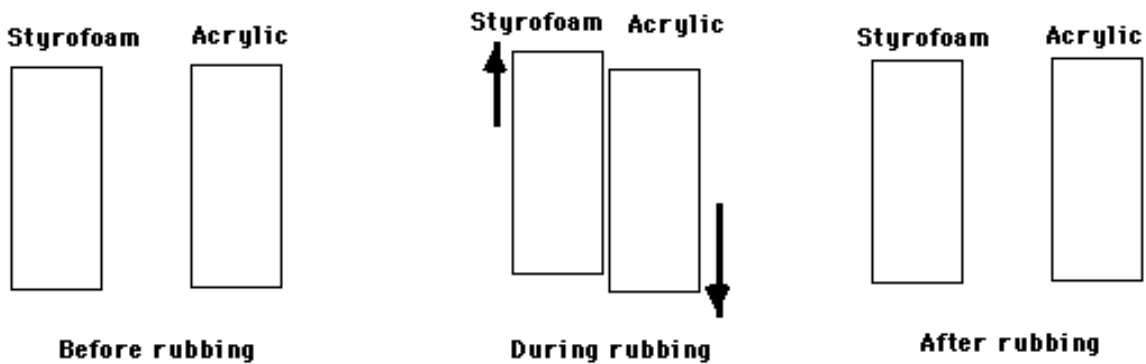


- Discuss** your models with other members in your group. Record ideas and/or sketches that differ from your own. Each group member should also discuss the evidence that he or she

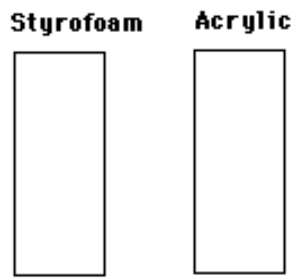
used to construct the **model of static electricity**.



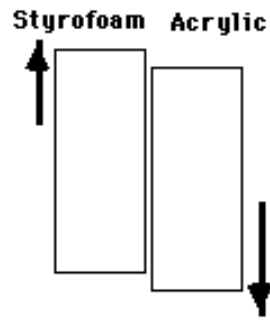
4. **Decide** as a group on a **model of static electricity** that you would like to share with the rest of the class. The model should be based on **evidence** gathered during the first cycle. One member of your group should sketch this model on the whiteboard, and summarize the main **evidence** on which the model is based. Another member of your group should be prepared to **discuss** it in front of the class.



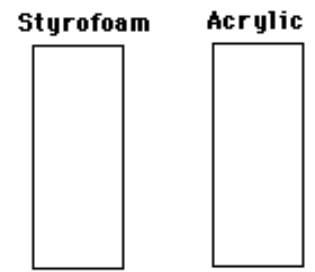
5. **Listen** to other members of your class discuss their **models** and **evidence**. **Record** any ideas or sketches that differ from your group's and that you think might be particularly useful.



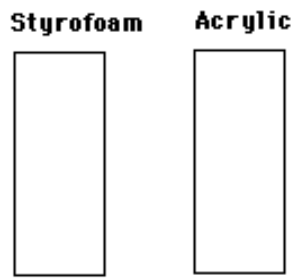
**Before rubbing**



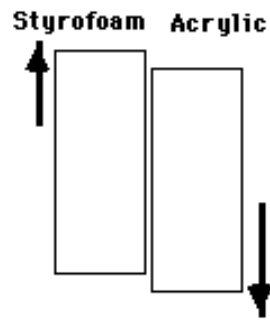
**During rubbing**



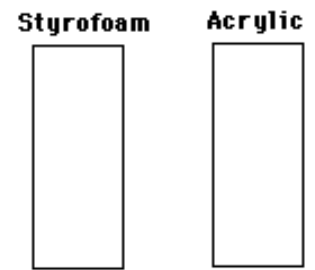
**After rubbing**



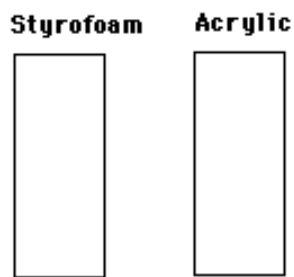
**Before rubbing**



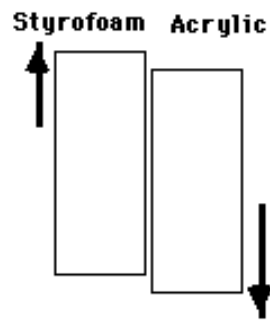
**During rubbing**



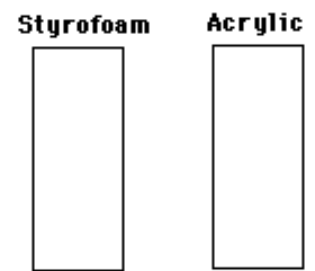
**After rubbing**



**Before rubbing**



**During rubbing**



**After rubbing**

## Notes



# Idea Journal

Name:

Group:

Class Period:

## SE&M Cycle III

Construct an idea for each of the following numbered questions.

- ❖ In the first column record the date.
- ❖ In the second column, write a complete sentence of your idea with a drawing or diagram that illustrates the idea.
- ❖ In the third column, record the evidence that supports your idea (sentences and drawings).
- ❖ The ideas are given names in this cycle; in the next cycle you will be giving ideas your own names.

When you need to modify or add to your **Idea Journal** be sure to record the date and the evidence. Even when you do not need to change an idea, date and record the additional evidence for this idea.

### 1. How does an electrical conductor differ from an electrical insulator?



Idea Name:

Date	Statement/Drawing of Idea	Evidence

## SE&M Cycle III Idea Journal

2. What seems to be happening when you rub two different objects together (what is your "model" for static electricity)?



Idea Name:

Date	Statement/Drawing of Idea	Evidence

3. Where are the electrical effects located on a rubbed object? On the surface of the object? In the interior of the object?



Idea Name:

Date	Statement/Drawing of Idea	Evidence

4. How can you cause an insulator to lose its charge? A conductor?



Idea Name:

Date	Statement/Drawing of Idea	Evidence

5. How does the direction of the electric force, attraction or repulsion, depend on what kind of charge is on the two surfaces?



Idea Name:

Date	Statement/Drawing of Idea	Evidence

### SE&M Cycle III Idea Journal

6. How does the amount and type of charge compare on two rubbed insulator surfaces? How does the amount of rubbing affect the amount of charge on the surfaces?



Idea Name:

Date	Statement/Drawing of Idea	Evidence

7. When a rubbed insulator comes into contact with a neutral conducting soda can electroscope, why does the tinsel rise and stay up after the rubbed insulator is removed?



Idea Name:

Date	Statement/Drawing of Idea	Evidence



8. What seems to be the difference between a red-charged object and a blue-charged object according to your MICROscopic data?



Idea Name:

Date	Statement/Drawing of Idea	Evidence

9. Our own question:



Idea Name:

Date	Statement/Drawing of Idea	Evidence

**Notes**



## SE&M Activity III - D1: Can Electrical Effects Transfer Through a Material?

Name:

Group:

Class Period:

**You have been studying electrical effects with several types of materials. Do you think that all objects that can be made to attract or repel other objects are electrically alike? In a lightning storm, would you prefer to be holding an aluminum baseball bat or a wooden one?**

**Materials:** two styrofoam cups, short pieces of tinsel, tape, plastic straw, wool cloth, piece of metal hanger, strips of acrylic, styrofoam, aluminum, and colored pencils

1. Stick three or four pieces of tinsel (about 5cm each) to a piece of tape. This is a "tinsel indicator." It will not look pretty, but if the tinsel "hangs loosely" (or freely points in some crazy direction) then you should be able to observe small effects.

You will be attaching this to different objects. You can prepare the tinsel to indicate an effect by brushing it lightly with your fingers before bringing a rubbed object nearby.



2. **Observe** some effects: Stick the tinsel indicator to the edge of your table so that tinsel hangs down below the edge. Gently smooth the tinsel with your fingers. Rub a straw with wool, or through dry hair, and move the rubbed end around near the tinsel. Do you see an effect? What happens?

**Note:** (on rubbing the straw) It helps to have a straw that will give a strong effect. Sometimes rubbing the straw with wool gives a strong effect, and sometimes it doesn't. If this is the case you can try rubbing a straw against dry hair. Hair does not have to be freshly washed to be more effective than a wool cloth.



3. **Imagine** taping a styrofoam strip to the top of a styrofoam cup and attaching the tinsel indicator to the end. Then you rub a straw vigorously with the wool cloth and gently rub the straw against the non-tinsel end of the strip (see the diagram below). **Predict** what, if anything, will happen to the tinsel.

**How did you decide?**



4. Suppose, instead, you did the same experiment with an **aluminum** strip taped to the cup, rather than the styrofoam strip. **Predict** whether the result will be the same or different than with the styrofoam strip? If so, in what way?

**How did you decide?**



5. **Test** your predictions. Tape the aluminum and styrofoam strips to two different cups and make a second tinsel indicator. **Make sure that part of the tinsel touches the strip that is being tested. If it does not, then you will get lame results.**

Bring the **rubbed** end of the straw to the non-tinsel end of the styrofoam strip. Rub the straw all over the end of the strip being tested. Then re-rub the straw and try it with the aluminum strip. **Describe** what happens to the tinsel while rubbing and after removing the straw.

**Styrofoam Strip:**

**Aluminum Strip:**



6. You should also have a strip of clear **acrylic** and a piece of **coat hanger wire**. **Test** these the same way you tested the styrofoam and aluminum strips. Does the tinsel react with either of these?



7. Try to develop a general statement about what types of material seem to transfer electrical effects easily (from one end of the object to the other), and what types of material do not. **Write** your statement below.

Materials that transfer electrical effects easily are called **conductors**. Those that do not transfer effects easily are called **insulators**. If you want more materials to test, consult with your instructor about appropriate ones to try. If you have additional evidence, please list it.



8. Try to think of a model for electricity that can help to explain these effects. **Describe** it below.



9. We will investigate these effects in more detail throughout the remainder of this unit. For now, go to your **Cycle III Idea Journal** and based on the evidence gathered in this activity write some ideas about conductors and insulators.

**Notes**



**SE&M Activity III - D2:**  
**What Part(s) of Insulators are Affected**  
**When Rubbed?**  
**(Instructor-led Demonstration)**

**Name:**  
**Group:**  
**Class Period:**



**In Activity III-D1 you investigated some of the different properties of insulators and conductors. We now look more closely at the properties of insulators.**

1. When an insulator material is rubbed by another insulator material to produce static electric effects, what part(s) of the insulator is (are) affected?
  - a. Just the surface that is rubbed
  - b. All the surfaces of the material
  - c. All the surfaces and the entire inside region

**What is your initial idea?**

**How did you decide?**



2. Previously you have observed that when a **rubbed** agent stirrer is brought near an **unrubbed** victim stirrer in a test stand, the two ends attract each other. **Imagine** then touching the **agent** stirrer **all over with your fingers** and then bringing it near the end of an **unrubbed victim** stirrer. **Predict** what would happen.

**How did you decide?**

## SE&M Cycle III Idea Journal



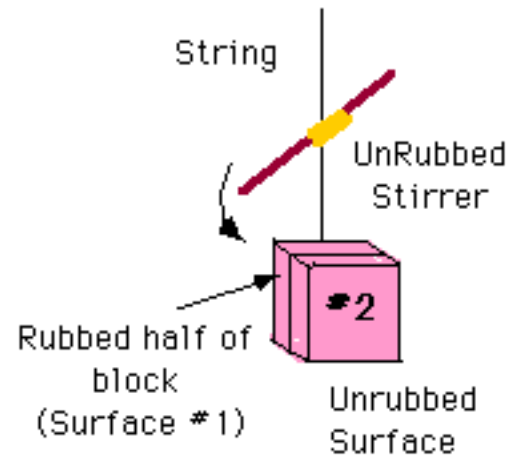
3. To help you get more evidence, your instructor will perform the experiment. **Describe** what happens.



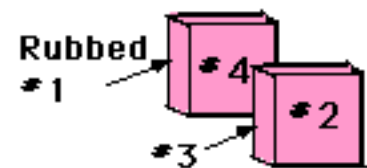
4. In terms of your model for static electricity, what do you think the act of **touching an electrified object all over with your fingers** seem to do so that the object no longer exhibits a static electric effect?



5. You will be shown a pair of styrofoam blocks, with a piece of tape holding them together. Two surfaces of the block are numbered, #1 and #2. With the two halves tightly together the **acrylic sheet** is rubbed vigorously against **surface #1**. Then surface #1 is brought near the unrubbed plastic stirrer and **you should observe an attraction**. See picture on the right.



6. **Imagine** removing the tape and separating the two pieces of the block. You will note that the two inside surfaces are numbered, #3 and #4.



**Predict** what would happen if surface #2 were to be brought near the unrubbed stirrer. Would it attract, repel or would there be no effect? What about surface #3? Surface #4? **How did you decide?**





7. After the experiment is performed, **describe** what happens for all the cases.



8. Reconsider the question posed at the beginning of this activity: **When an insulator material is rubbed to produce static electric effects, what part(s) of the insulator is (are) affected?**



9. In this activity you have focused on determining the location of electrical effects on an insulator. Go to your **Cycle III Idea Journal** and add to, or modify your ideas about:

- ❖ The location of electrical effects on rubbed insulators.

**Notes**



## SE&M Activity III-D3 Part 1: What Happens When Insulators are Rubbed?

Name:

Group:

Class Period:

**So far, you have been exploring electrical effects with different materials. In this activity, you will develop your model of what is actually happening within the materials. You will also use a simulator to help you in your explanations.**

**Materials:** test stand, 2 plastic stirrers, 2 straws, wool, acrylic sheet (with cleaner and paper towel), styrofoam plate, red and blue colored pencils.



1. **Imagine** you rub an acrylic sheet with a styrofoam plate. Do you think that the **number** of times you rub them together would make a difference in the **strength of the attraction** between the acrylic sheet and the unrubbed test stirrer? **Yes or no?**

**How did your model for static electricity help you to determine your answer?**



2. **Test** your prediction. Move your fingers all over the test stirrer to ensure that it is unrubbed. Clean the acrylic with cleaner so that when you bring the clean, unrubbed acrylic near the test stirrer you should notice **no** effect. If there is an effect, clean it again.

Rub a clean acrylic sheet **just once or twice** against the styrofoam and bring it near the end of the test stirrer. **Describe** the observed effect below.



3. Now, rub the acrylic sheet **vigorously** with the styrofoam plate **many** times, then bring it near the stirrer. Does the effect seem to be different?

## SE&M Cycle III Idea Journal

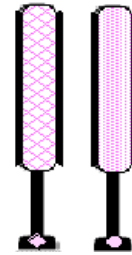


4. Do you conclude that the amount of rubbing does, or does not, make a difference? If so, in what way? Check your conclusion with other groups. **Use your model to describe why this makes sense.**
5. In the **Cycle III Elicitation** many students suggested that the acrylic and styrofoam each became "charged" differently as a result of rubbing. Some students used plus (+) and minus (-) symbols to represent two types of "charge".

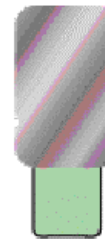
Because we have not gathered enough evidence to decide what plus and minus actually mean, we suggest a different scheme for representing "charged" and "uncharged" materials.

We will be using the scheme described below throughout this cycle.

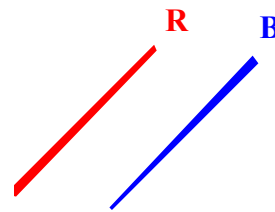
**Insulators** will be represented using different patterns of lines. On the computer simulator, these lines will be colored magenta (pink).



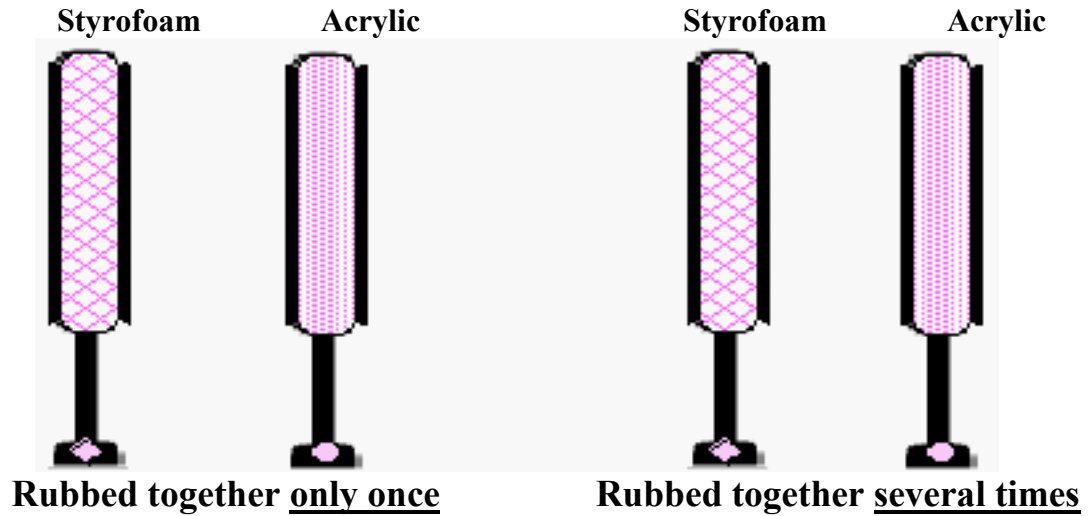
**Conductors** will be represented using a grey. In the computer simulator, there is a grey-magenta mix.



One type of charge will be represented by drawing lines in **red color (R)**. The other type of charge will be represented by drawing lines in **blue color (B)**.



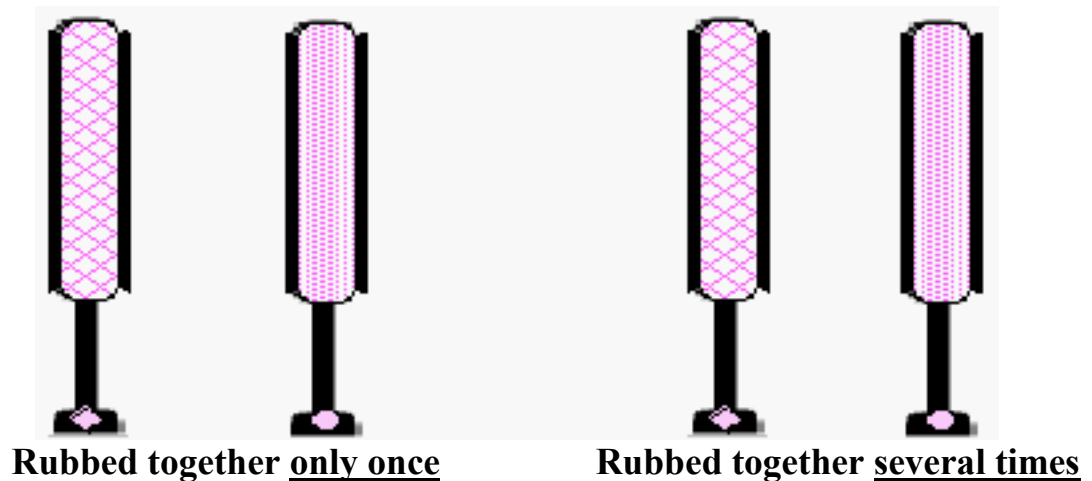
6. In the previous activity most students concluded that only the **rubbed surfaces** of two insulators are affected when rubbed. Color both sets of insulators on the following page to **predict** how the coloring scheme might be used to represent how insulators that are rubbed only once would compare to insulators that are rubbed together many times.



How did you decide?



7. To help you check your coloring scheme, your instructor will use the computer simulator. Record your observations on the picture below by coloring the objects as they appear in the simulator. Pay special attention to how the thickness of the red line in each set compares to the thickness of the blue line.



8. How does the thickness of the red line in the left set of insulators compare to the thickness of the blue line? How about in the other set of insulators?

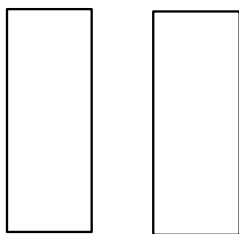
## SE&M Cycle III Idea Journal

9. What can you infer about the **amount** of charge on each insulator from this observation?
10. A previous student observed that the thickness of the red and blue lines on two rubbed surfaces seem to be equal. She inferred that in the process of rubbing, the two insulator surfaces acquire equal amounts of different types of charge -- in this case **blue** charge and **red** charge. What do you think about this idea? Does it seem to make sense to you at this time? Why or why not?



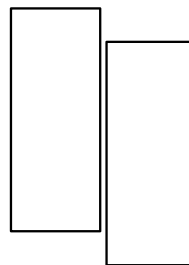
11. **Explain** how your model of static electricity can account for this observation. Also, record your ideas on the picture below. Try to consider **all** of the observations you have made during this cycle.

Styrofoam    Acrylic



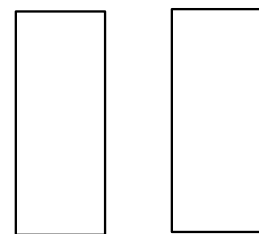
**Before Rubbing**

Styrofoam    Acrylic



**During Rubbing**

Styrofoam    Acrylic



**After Rubbing**



12. You have made several discoveries in this activity, including a new scheme for representing the charge (red, blue or neither) of an insulator. Go to your **Cycle III Idea Journal** and add to, or modify, your ideas about:

- ❖ How the amount of charge on the surface of an insulator depends on rubbing.
- ❖ How the **strength** of the electrical force (attraction or repulsion) depends on the amount of charge on the surfaces.
- ❖ Whether or not the amount of rubbing affects the amount of charge on the surfaces?
- ❖ How the amount and type of charge on a rubbed insulator compares to the amount and type of charge on the insulator with which it was rubbed.

**Try to use your model of static electricity to account for each of your ideas.**

**Notes**





## SE&M Activity III–D3 Part 2: What Happens When Insulators are Rubbed?

Name:

Group:

Class Period:

**You have been using your model for static electricity to explain what happens when insulators are rubbed together. In this activity you will have a chance to use the red and blue coloring scheme to help you represent and explain how rubbed objects interact.**

**Materials:** test stand, 2 plastic stirrers, 2 straws, wool, acrylic sheet (with cleaner and paper towel), styrofoam plate, thread, tape, scissors, ruler, colored pencils.

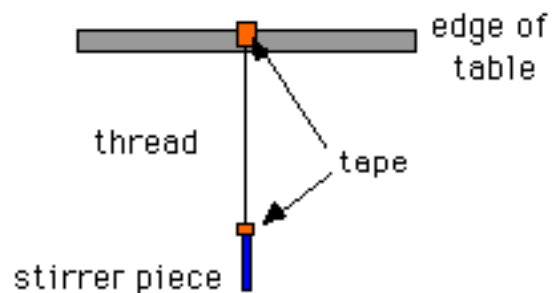
1. Cut a long piece of plastic stirrer (about the size of your pinky). Use a tiny piece of tape to attach the end of the stirrer to a long piece of thread (about as long as your forearm). Tape the other end of the thread to the edge of your table, so the plastic piece hangs straight down. See figure below.



2. Hold the stirrer piece by the taped end and rub it vigorously with the wool. Then, rub an acrylic sheet vigorously against the styrofoam plate.

Bring the rubbed styrofoam plate (with acrylic) near the hanging stirrer piece.

**Describe** what happens.

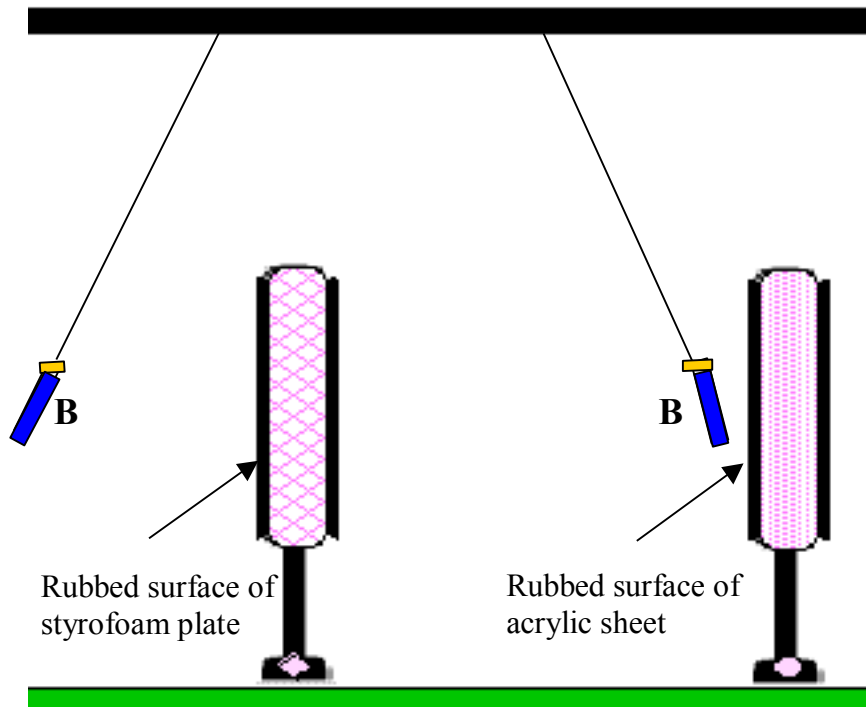


3. Bring the rubbed acrylic sheet near the hanging stirrer. **Describe** what happens.

### Activity III-D3 Part 2



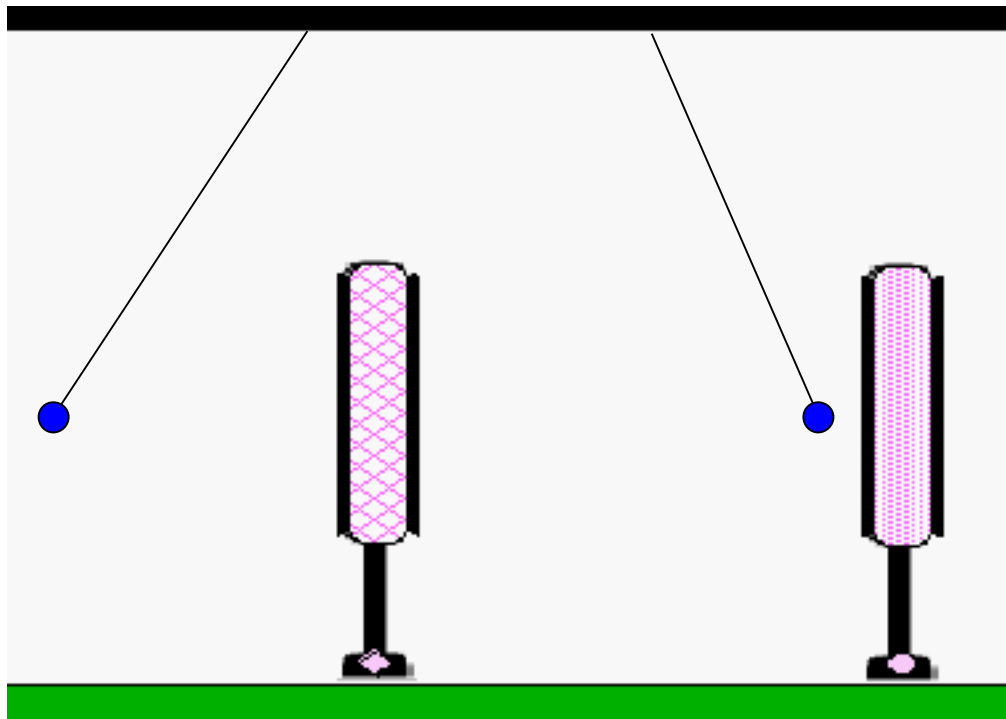
4. Use the red and blue coloring scheme to represent how the hanging plastic stirrer, the styrofoam plate, and the acrylic sheet have been affected by rubbing in the picture below. The stirrer has already been rubbed by wool so assume that it is colored blue. (Remember to use the **R** and **B** labels to identify the colors if you are not using colored pencils).



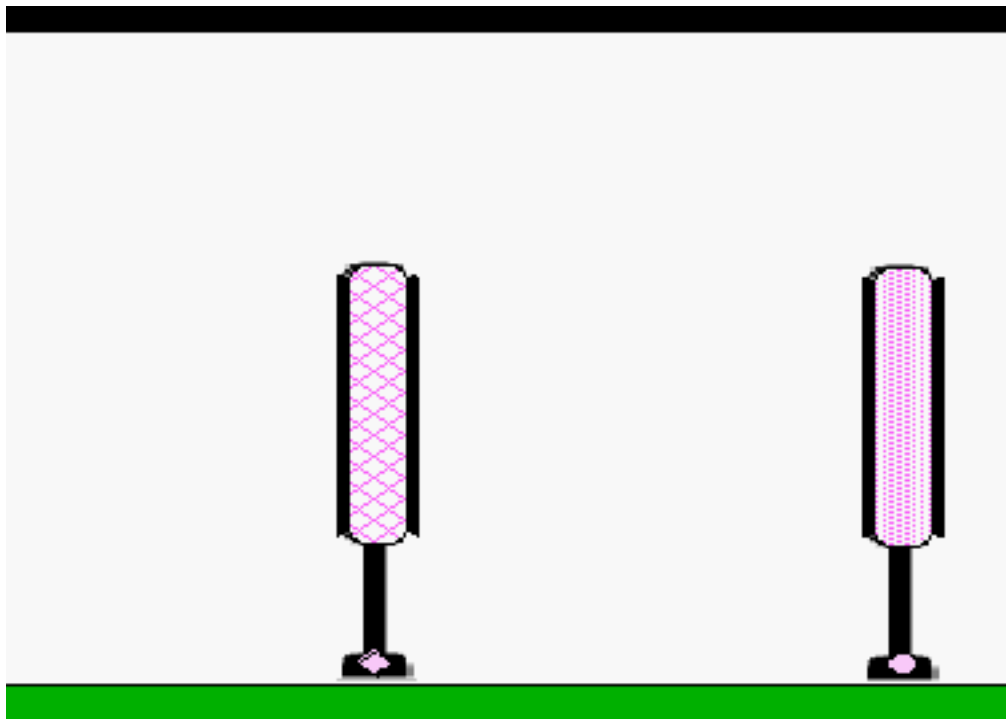
5. **Imagine** that the "charge state" of the pendulum was **red** rather than **blue**. How would it interact with the rubbed styrofoam and with the rubbed acrylic?



6. To help you test your coloring predictions, your instructor will run the simulator. The red or blue pendulum ball in the simulator represents the rubbed stirrer. Use colored pencils to record the simulator results in the diagrams below.



7. For the next experiment, **draw** in the red colored pendulum and the insulator colors in the picture below to represent the simulator results to the experiment with a red-charged stirrer.



### Activity III-D3 Part 2



8. In this activity you worked with rubbed objects and how they interact with each other. Go to your **Cycle III Idea Journal** and add to, or modify, your ideas about:
- ❖ How the **direction** of an electric force (attraction or repulsion) depends on what kind of charge is on the two surfaces and how the **strength** of the force depends on the amount of charge on the surfaces.



## SE&M Activity III - D4: Do Objects Always End up the Same When Rubbed?

Name:

Group:

Class Period:

**You have been working with many materials in rubbed and unrubbed conditions. Do you think it matters what kind of material you use to rub a plastic straw? Will it have the same charged condition no matter what you rub it with? Does rubbing a balloon on your hair have the same effect as rubbing it on other things?**

**Materials:** test stand, tape, two stirrers, wool, cellophane, foam plate and acrylic sheet, colored pencils.

1. In previous activities you rubbed a **stirrer** with **wool** and it behaved in a certain way. Is this due to properties of the stirrer? Properties of the wool? Both? **What do you think?**

**How did you decide?**



2. **Imagine** rubbing a stirrer with wool and placing it in the test stand. **Predict** what would happen when you held another wool-rubbed stirrer near it. Place your prediction by writing the letter **A** (attract), **R** (repel), or **O** (no effect) in the appropriate cell in the table below.

Prediction Table	Wool-rubbed stirrer	Foam plate	Acrylic sheet
Wool-rubbed stirrer			
Cellophane-rubbed stirrer			



3. Complete the table by **predicting** what would happen if you rubbed a foam plate with an acrylic sheet and held each one (separately) near the rubbed stirrer in the test stand. Indicate your predictions by filling in the remainder of the **first row** of the table. Use the letters **A** (attract), **R** (repel), or **O** (no effect).



4. Now, **imagine** replacing the **wool-rubbed** stirrer in the test stand with one that you rub with **cellophane** instead of wool. What would you expect when you hold each of the rubbed objects (wool-rubbed stirrer, acrylic-rubbed styrofoam, styrofoam-rubbed acrylic) near the cellophane-rubbed stirrer? Show your predictions by filling in the remainder of the table with the letters **A** (attract), **R** (repel), or **O** (no effect).

### SE&M Activity III - D4

**How did you decide?** Be specific about any differences or similarities that exist in the two rows of your table.



5. **Test your predictions.** Put a handle on one end of a plastic stirrer using tape. Hold this end and rub the other end with wool. Test it against another wool-rubbed plastic stirrer, an acrylic-rubbed styrofoam, and a styrofoam rubbed acrylic. Record your observations in the first row of the table below.

Before performing the cellophane tests make sure that your test stirrer is unrubbed (touch it all over with your hands). **Clean cellophane, folded double, may give a bigger effect.** Record your observations in the second row of the table below.

<b>Observations Table</b>	<b>Wool-rubbed stirrer</b>	<b>Foam plate</b>	<b>Acrylic sheet</b>
<b>Wool-rubbed stirrer</b>			
<b>Cellophane-rubbed stirrer</b>			



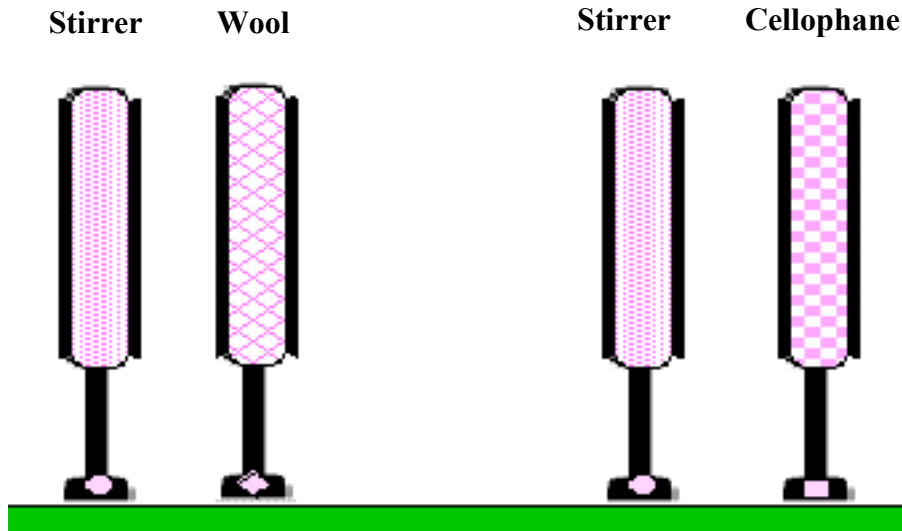
6. When you have completed the table, **post** your results on the **class observation board**. If your results are different from most others, you should repeat the experiment and talk with other groups if necessary.



**Are the results in the table what you expected? Why or why not?**



7. On the picture below, use the coloring scheme to **predict** how you think the wool and stirrer would look **after** rubbing compared to how the cellophane and stirrer would look **after** rubbing.

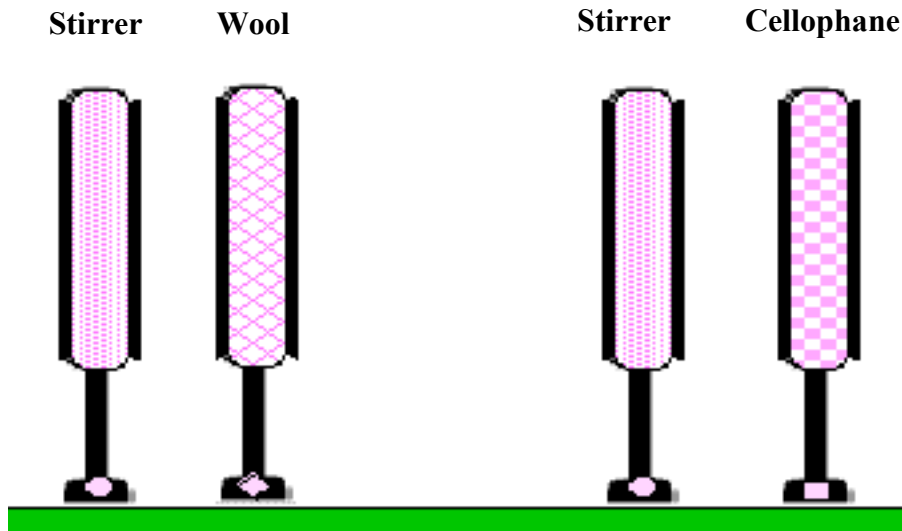


How did you decide?



8. To help get more evidence for your predictions, your instructor will run the simulator.

Record the simulator results for below. Use colored pencils or label the surfaces with "R" and "B".



### SE&M Activity III - D4



9. **Describe** how you think these objects actually acquired a charge. State any relevant evidence.



10. Go to your **Cycle III Idea Journal**. Based on the evidence gathered in this activity, modify, if necessary, your ideas about rubbing two insulators together. You may also want to add or modify other relevant ideas.





## SE&M Activity III-D5:

### What is the Charge Type?

Name:

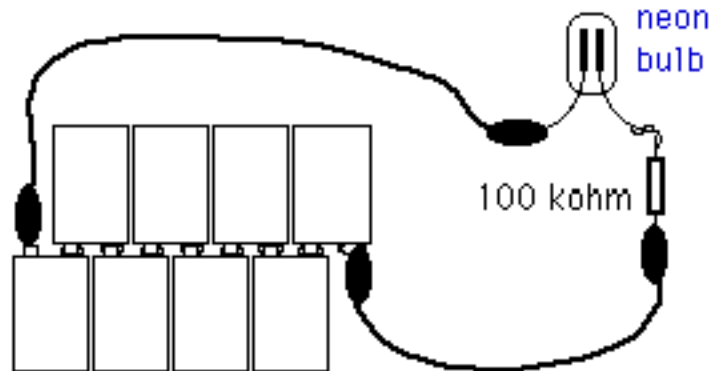
Group:

Class Period:

If you have ever looked at a battery, you have seen a + symbol on one end and a - symbol on the other end. Some students used + and - to represent charge at various stages in this unit? What do the + and - symbols mean and how do they relate to the red and blue coloring scheme?

**Materials:** Demonstration (10 9V batteries, 100 Kilohm resistor), 2 Neon bulbs, wires, foam plates and acrylic sheets, wool, white plastic bag, soda can electroscope.

1. Your instructor will demonstrate a set-up consisting of several batteries, wires, a component called a resistor, and a special bulb called a neon bulb.



2. A neon bulb consists of two wires called electrodes that are encased in a glass tube that contains neon gas. **Observe** as your instructor connects the bulb to a group of batteries. Look carefully at the bulb as the experiment is passed around the room. What is the difference between the two electrodes?



3. Trace the connections of each wire from the bulb back to the battery. Which battery terminal (positive or negative) is connected to the glowing electrode?

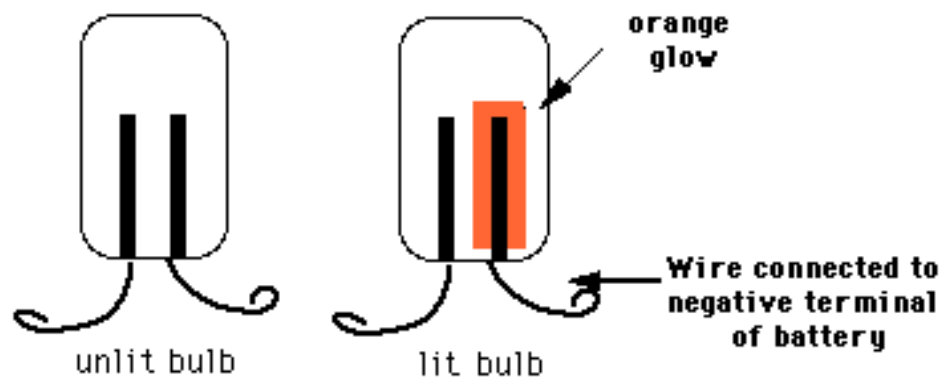
### SE&M Activity III-D5



4. **Imagine** that the instructor reverses the connections. **Predict** what you think would happen to the bulb, if anything?

**How did you decide?**

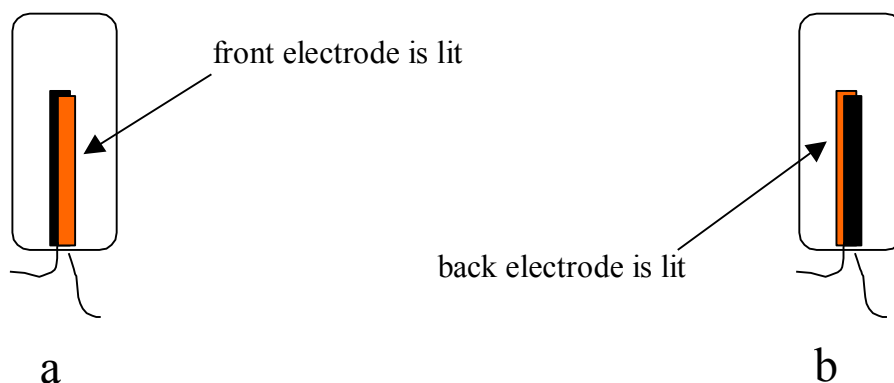
5. A neon bulb can be used to provide evidence for the charge state of an object. One side of the neon bulb will glow when the bulb is touched to a charged object.





6. Rub a styrofoam plate vigorously against an acrylic sheet. Hold the neon bulb by one of its wires and drag the other wire over the surface of the foam. Which electrode lights up? The one closest to the foam or the one farthest from the foam?

**Note:** This observation may be difficult to make since the neon effects are very short lived. In order to make it easier to determine which electrode lights up, hold the neon bulb sideways so that one electrode is directly in front of the other (see figure below). Then rub the object with the terminal connected to the electrode that is in the back. If the front electrode lights up you will see a glowing rectangle as in figure (a) below. If the back electrode lights up, you will see a dark rectangle, as in figure (b) below:



You may need to turn off the room lights to see an effect



7. What do you conclude is the sign (+ or -) of the excess charge on the rubbed styrofoam?  
**What is your evidence?**

## SE&M Activity III-D5



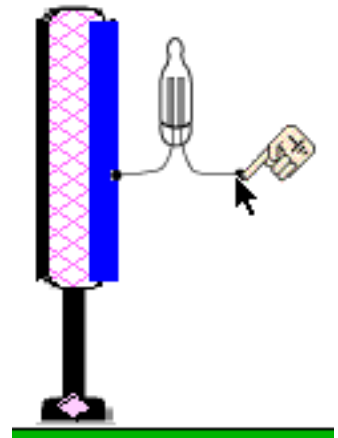
8. **Imagine** that you rubbed the styrofoam and acrylic vigorously together and this time, you rub one of the terminals of the neon bulb against the acrylic instead of the styrofoam. Which electrode do you think will light up, if any? The one nearest the acrylic or the one nearest your finger?

### How did you decide?



9. These effects are sometimes difficult to see because they come and go so quickly. Therefore, your instructor will use the computer simulator to help you check your predictions and results.

Which electrode lit up when the neon bulb was rubbed against the styrofoam, the one closest to the grounding hand or the one closest to the charged surface of the styrofoam?



10. Which electrode lit up when the neon bulb was rubbed against the acrylic, the one closest to the grounding hand or the one closest to the charged surface of the acrylic?

11. What do you conclude is the sign (+ or -) of the excess charge on the styrofoam? The acrylic?

12. To help you check your conclusions, your instructor will open the "property boxes" of the insulators to reveal the charge. How did your conclusions compare with the simulator results?

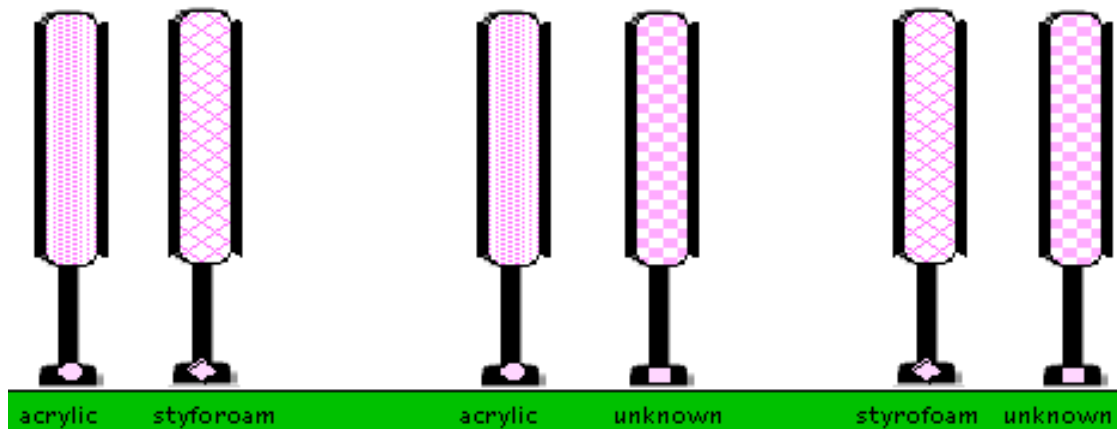


Why does this make sense?



13. **Imagine** that you had an unrubbed sheet of acrylic, an unrubbed styrofoam plate, and an unrubbed sheet of some **unknown material**. Suppose you rubbed the unknown material against the styrofoam plate and found that the styrofoam plate acquired a blue charge (as represented by the simulator). **Predict** the excess charge on the unknown object.

14. What do you think would happen if you took an unrubbed sheet of the same unknown material and rubbed it against the acrylic? Double click on the picture below and color the objects to represent your thinking.



**How did you decide?** Do you have enough evidence to construct an evidence-based prediction? Why or why not?

## SE&M Activity III-D5



15. To help you get more evidence for your prediction, your instructor will perform the experiment using the computer simulator. Record your results below.



16. Your teacher will open the property boxes for each of the insulators. On the left-hand side of the window you will notice a box that says "right side charge" and "left side charge"? In the table below, record the excess charge of each of the objects in each pair (one should be the right-side charge and the other should be the left side charge). Be sure to distinguish whether it is negative or positive.

<b>Styrofoam</b>	<b>Acrylic</b>	<b>Acrylic</b>	<b>Unknown</b>	<b>Styrofoam</b>	<b>Unknown</b>



17. According to your model of static electricity, why is the amount of excess negative charge on the styrofoam equal to the amount of excess positive charge on the acrylic (and for acrylic/unknown or styrofoam/unknown)?



18. Try to classify the acrylic, the unknown material, and the styrofoam in terms of their tendency towards obtaining blue charge.

19. In **Activity III-D4** you discovered that the sign of charge that a material acquires in rubbing depends on the properties of the material being rubbed AND the properties of the material you are rubbing it with. Below is a list of materials organized by what happens when they are brought into close contact or rubbed together. They are ranked from those that tend to accept negative charges easily to those that tend to give up negative charges easily. This is called the **TRIBOELECTRIC (or Electrostatic) SERIES**.

**Receives negative charge Easily**



**Gives up negative charge Easily**

**Saran™ Wrap**  
**hard rubber**  
**celluloid**  
**sulfur**  
**rubber balloon**  
**polyethylene**  
**polystyrene foam**  
**amber**  
**sealing wax**  
**acrylic**  
**wood**  
**cotton**  
**paper**  
**silk**  
**cat's fur**  
**wool**  
**nylon**  
**mica**  
**glass**  
**rabbit's fur**



20. Of the materials listed in the triboelectric series above, list all of the materials that could have possibly been the unknown material in the experiment above?



21. Open your **Cycle III Idea Journal** and add to or modify your ideas about rubbing two insulators together (#2), how the amount of charge compares on two insulator surfaces that were rubbed together (#6), and the difference between red and blue charged insulators (#8).

**Notes**





## SE&M Activity III – D6: Building a Microscopic Model of Static Electricity

Name:

Group:

Class Period:

**You have probably used at least a couple different symbols to represent what is happening when two insulators are rubbed together. We have also used the term "charge" to refer to an insulator that has been electrically affected by rubbing. What does the term "charge" mean and how does it relate to the red and blue coloring scheme? How can your model account for what is going on inside conductors and insulators on a microscopic level?**



1. You have made several observations in which your model of static electricity should be able to account for:

- In **Activity III-D2** you discovered that only the surface of an insulator is affected by rubbing.
- In **Activity III-D3** you discovered that these effects can be represented by red or blue lines on the surface of insulators.
- In **Activity III-D3** you also discovered that the amount of rubbing determines the strength of the electrical effect which can be represented by thicker and thinner red and blue lines.
- In **Activity III-D4** you observed that the material you rub an insulator with determines the type of effects the rubbed insulator has on other rubbed objects.



2. In the space below **explain**, in words, what happens before, during, and after a styrofoam plate is rubbed together with an acrylic sheet. Your explanation should be able to account for all of these effects you've observed. Also **color or draw** symbols on the pictures below to represent your model of charging insulators by rubbing.

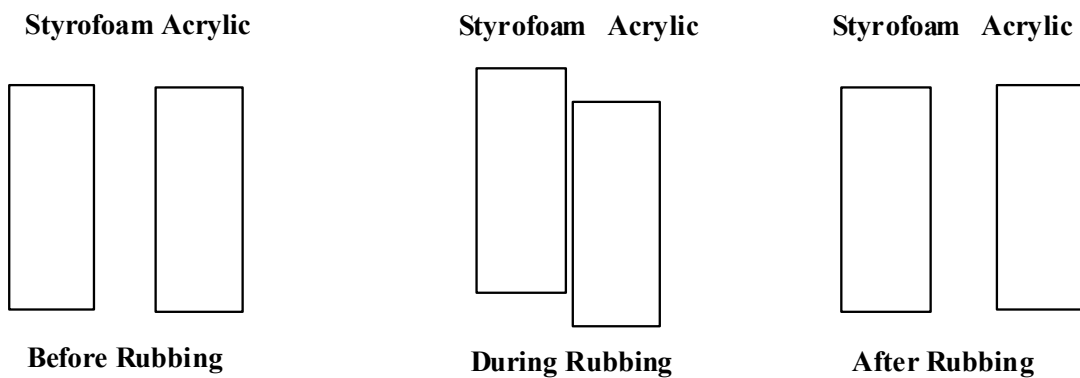
### SE&M Activity III – D6



**Before Rubbing:**

**During Rubbing:**

**After Rubbing:**



3. Consider the following conversation held by two students:

Student 1



"When styrofoam and acrylic are rubbed together, I think a certain type of "charge" moves from inside the styrofoam toward the surface of the styrofoam and the other type of charge moves from the inside of the acrylic toward the surface of the acrylic. This way they will both have opposite charge on their surface and will have opposite effects on rubbed victim objects."

Student 2



"I disagree. If a certain type of "charge" only moved **within** the styrofoam out to the rubbed surface of the styrofoam then the other side of the styrofoam would retain all of the other type of "charge". If this were the case, then we would expect for both sides (the rubbed and the unrubbed sides) to be charged opposite from each other and both sides would display static electric effects."



4. Do you agree with Student 1, Student 2, both, or neither? **Explain your reasoning and state any relevant evidence you have from previous activities.**



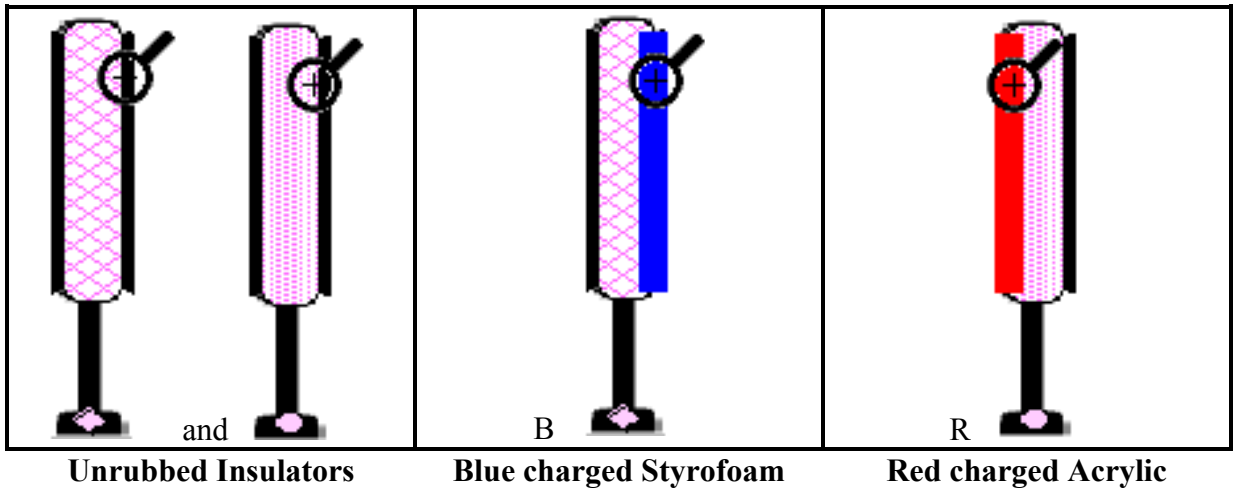
5. It is impossible for us to see exactly what is happening on the surface of insulators as they are rubbed together. However, the computer simulator contains a special tool called an **ultrascopes**. This tool provides a microscopic representation of what happens in terms of a coloring scheme. There are a variety of ways to represent charge (for example, red and blue lines or plus and minus symbols, etc.). The microscopic function of the simulator uses another representation that may be helpful.



6. To help you get more evidence of what might be going on at the surface of insulators, your instructor will use the ultrascopes tool. When your instructor clicks the little magnifying glass on the regions of interest, a window representing the charge state of that region will open up. **Draw** (or describe) the view for each situation in the spaces provided.

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SE&M Activity III – D6



7. **Compare** the three ultrascopes pictures you drew (or described) above. What do you notice about the ultrascopes view for the rubbed styrofoam (blue) versus the rubbed acrylic (red) and how does this relate to the ultrascopes view for the unrubbed objects?



8. How does this model compare to the model you described in step 2 above. **Discuss** any similarities and differences.

9. The model represented in the ultrascopes pictures can be referred to as a **MICROscopic model** and the red and blue model represented in the simulator as thick or thin red and blue lines can be referred to as a **MACROscopic model**.



10. In what ways do you think the **MICROscopic model** corresponds to the **MACROscopic model**?



11. **Explain** why both a **MICROscopic** and a **MACROscopic** model could be useful for formulating an understanding of static electricity.



12. Open your **Cycle III Idea Journal** and add to or modify appropriate ideas. If you have made any new observations or inferences that have affected your model of static electricity make sure to modify your model of what happens when two insulators are rubbed together. How might you incorporate a microscopic component to your model of rubbing insulators together?

**Notes**



## SE&M Activity III – D7: How Does a Soda can Show if it is Charged?

Name:

Group:

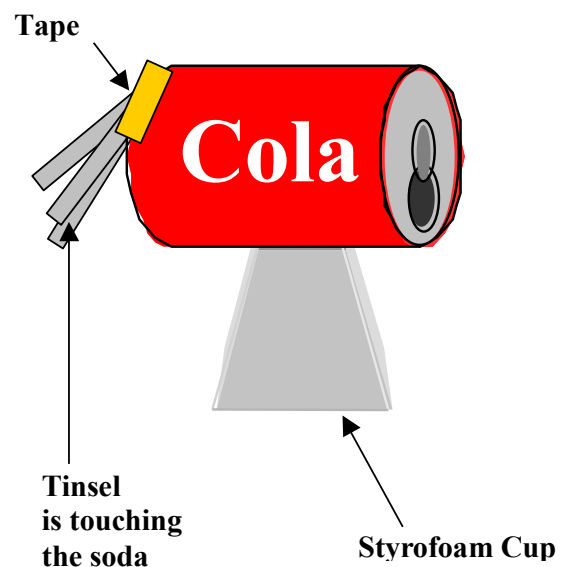
Class Period:

Earlier you discovered that charge on an insulator stays on the rubbed part of the surface. But when you shuffle ("rub") your feet on the carpet and grab a doorknob you feel the shock on your hand. How does the charge move from your feet to your hand? Do you think that you are an insulator or a conductor?

**Materials:** aluminum soda can, styrofoam cup, scotch magic tape, tinsel, acrylic sheet, styrofoam plate, colored pencils.

1. Tape the soda can to the bottom of an inverted styrofoam cup (see right). Then tape several pieces of tinsel to the end of the soda (but not to the end with the opening).

**Make sure that each piece of tinsel is in contact with the can itself.**



2. **Imagine** rubbing an acrylic sheet with the styrofoam plate, then moving the styrofoam plate up and down **against** the soda can (but not where the tinsel is hanging). **Predict** what will happen to the tinsel pieces after the styrofoam plate is removed. Will they hang down or stick out?

**How did you decide?**



3. **Test** your prediction. Make sure the acrylic sheet is clean. Rub it vigorously against the styrofoam plate and then move the rubbed side of the styrofoam plate up and down against the end of the soda can, but not the end where the tinsel hangs. Make sure there is good contact between plate and can. After doing this for a few seconds, remove the plate. What happens to the pieces of tinsel?

### SE&M Activity III - D7

**Note:** Most students find that the tinsel sticks out after the styrofoam is removed. If your tinsel does not stick out, discuss your situation with your instructor.

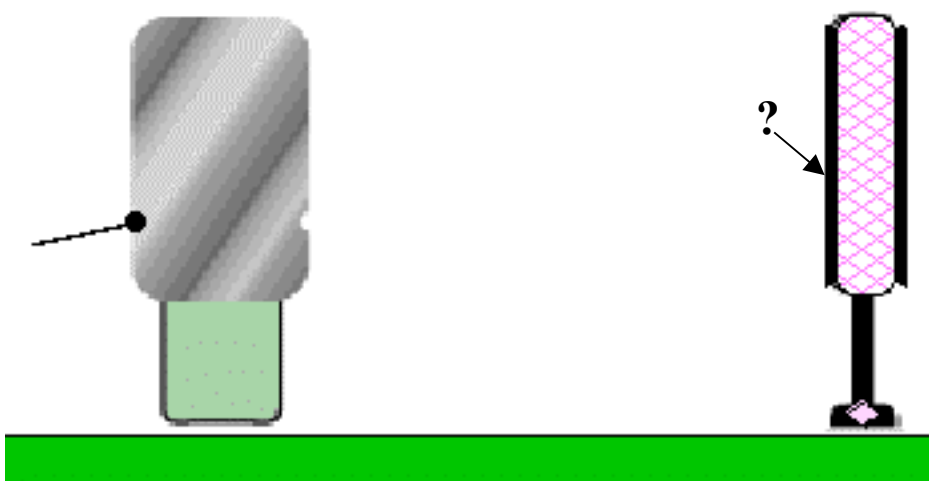
4. In the previous activity, the rubbed surface of a styrofoam plate was represented by a blue line. In the picture below the styrofoam, the soda can, and the hanging tinsel are represented **before the styrofoam is moved up and down against the can.**

Before moving rubbed styrofoam up and down against soda can.



5. **Predict** how you think the soda can, the styrofoam, and the tinsel should be colored, if at all, to represent the situation **after** the styrofoam is moved up and down against the soda can and then removed. To make your prediction color the objects in the picture below.

After moving rubbed styrofoam up and down against soda can.

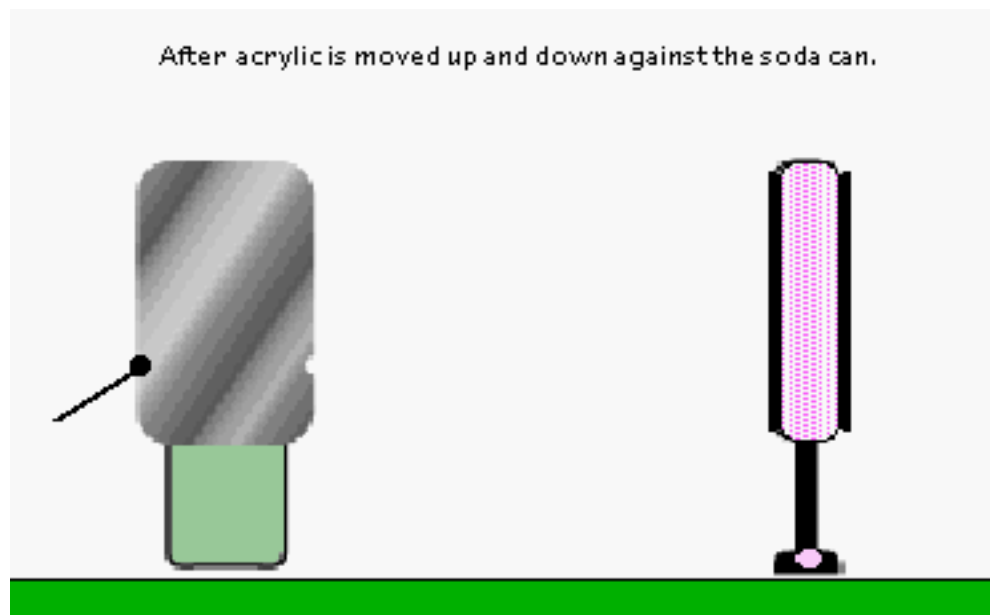
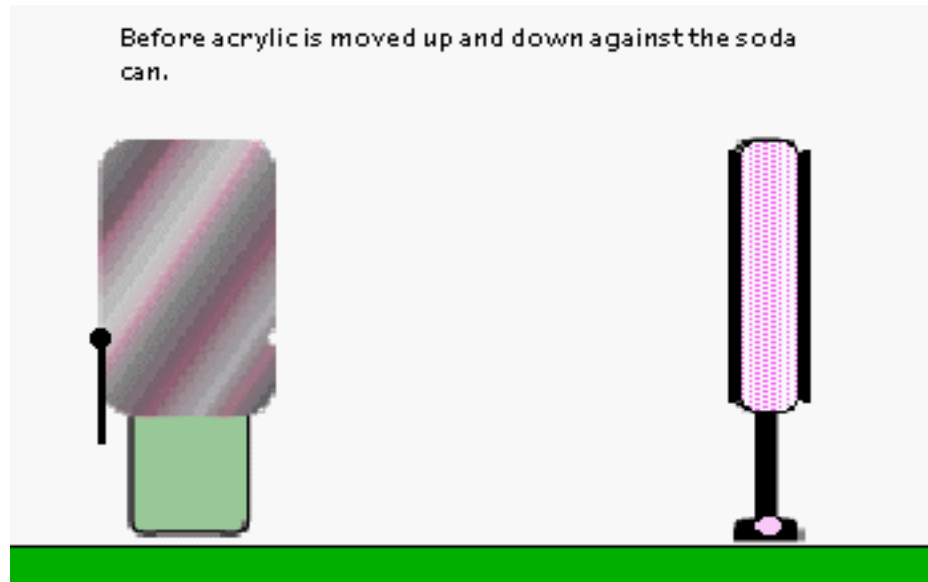


**How did you decide?**





6. **Imagine** rubbing the uncharged can with the rubbed acrylic plate instead of the styrofoam plate. **Predict** what you think would happen by coloring in all the objects below in the “before” and “after” pictures.



**How does your model support your prediction?**

## SE&M Activity III - D7



7. It is usually the case with your experimental apparatus that charge acquired by a conductor (or an insulator for that matter) doesn't remain for very long. Therefore, it is likely that your tinsel has dropped straight down by now.

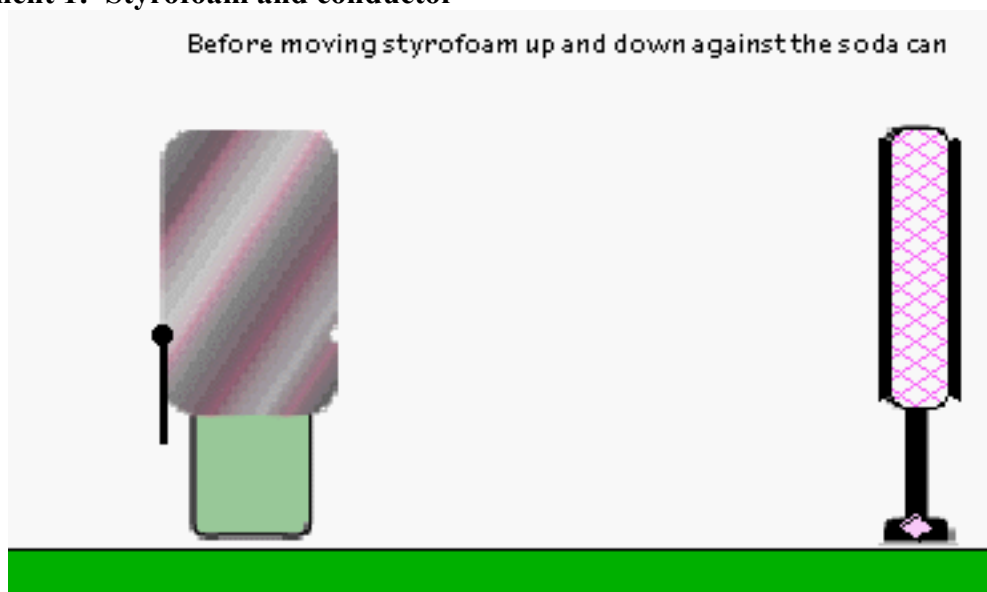
If so, make it stick out again by re-rubbing it with the acrylic-rubbed styrofoam. Then touch the can with your finger. **Describe** what happens to the tinsel below.

8. In terms of a **MICROscopic** model, what can you **infer** about the charge state of the soda can after you touched it?

9. To help you get more evidence for all of your coloring predictions, your instructor will perform these experiments using the computer simulator. Record your results below but first color the objects in the first picture below to represent the **initial** situation (before styrofoam is in contact with soda can).

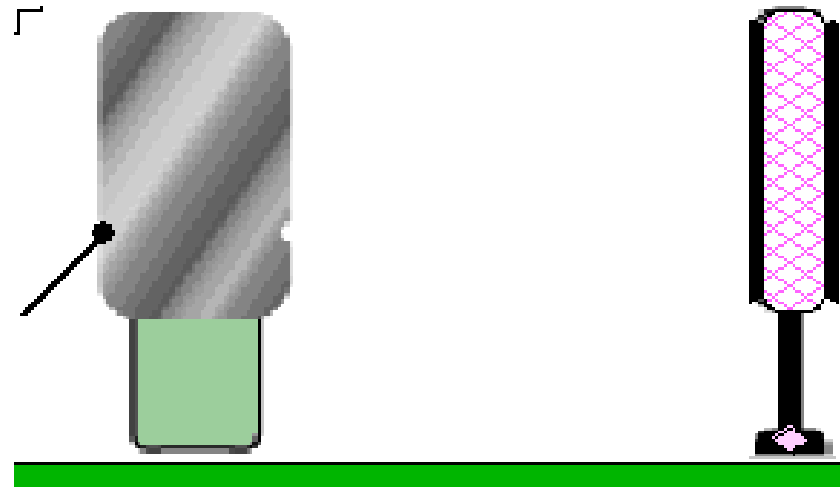
Pay close attention to the thickness of the blue line on the insulator before and after rubbing it up and down against the soda can.

### Experiment 1: Styrofoam and conductor





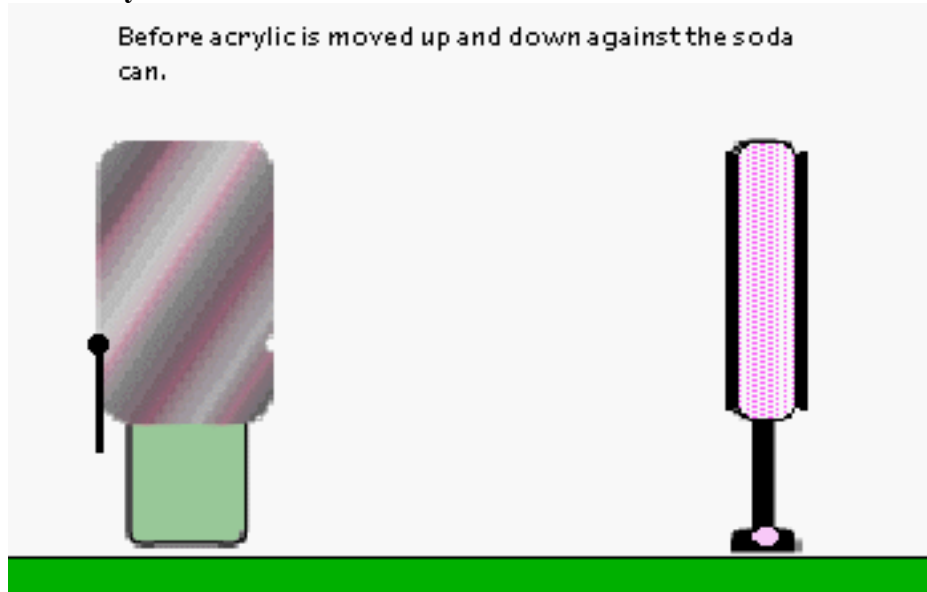
After styrofoam is rubbed against the soda can and moved away.



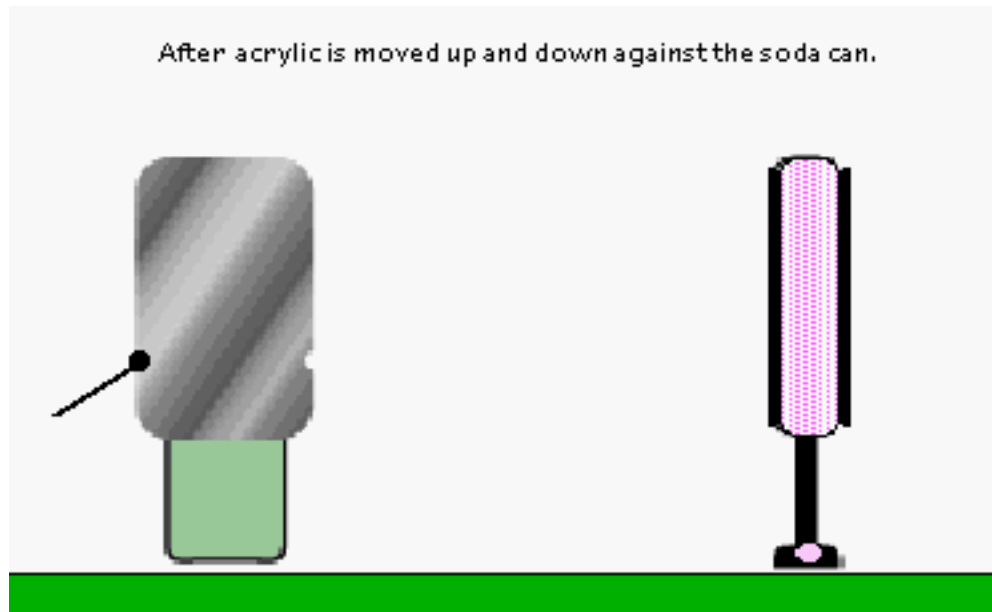
**Experiment 2: Acrylic and conductor**



Before acrylic is moved up and down against the soda can.



### SE&M Activity III - D7



10. You should have noticed a difference in the **thickness** of the colored line on the insulator before and after it made contact with the soda can. How do they compare? How does your model of static electricity account for this? If it doesn't, don't you think it should?
  
11. **Compare** coloring of the conductor and insulator with your predictions and try to resolve any differences in the coloring of the soda can or the coloring of the insulator before and after.
  
12. **Describe** what happens to the tinsel and the coloring of the soda can when a charged conductor is touched by the grounding hand.



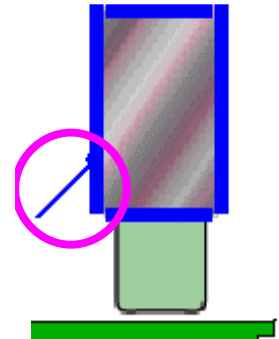


13. The process of causing the tinsel to go down by touching the conductor with your finger is called "**grounding**" the conductor. This removes all the excess charge from the conductor. In the next Cycle you will develop an explanation for why this happens. For now, just note that we can always make a charged conductor become uncharged by grounding it with our finger.



14. Look at your picture that represents after the styrofoam was in contact with the soda can. Notice that the tinsel is colored blue. According to your model of static electricity, how did the tinsel become charged blue?

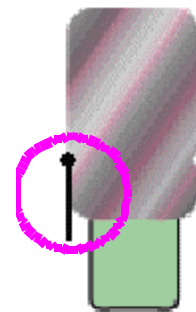
15. According to your model, and the evidence you've obtained in this cycle, what seems to be causing the tinsel stick out? Notice the picture on the left where both the tinsel and the soda can are blue-charged.



16. Since the tinsel sticks out when the soda can is charged, this apparatus can serve as a detector of charge. Such a detector is called an electroscope, in this case, a **soda can electroscope**.

Both the tinsel and the end of the aluminum can are charged blue. Therefore they will repel. Since the tinsel is so light, its end lifts up and points away from the end of the can.

When the tinsel is observed to hang straight down we can infer that neither the tinsel nor the end of the can that the tinsel hangs from is charged.



### SE&M Activity III - D7



Go to your **Cycle III Idea Journal**. Based on evidence gathered in this activity, **write** a concise statement that explains why the tinsel goes up when the soda can electroscope is touched by a charged insulator. You should also make some statements about some of the differences you have noticed between insulators and conductors with respect to charge. Also, update your **MICROscopic** model of static electricity if necessary.



## SE&M Activity III - A1: What Causes Static Cling?

Name:

Group:

Class Period:



1. In the **Elicitation** activity for **Cycle I** you were asked to explain what causes the phenomenon known as "static cling"--when articles of clothing stick together when you pull them out of the dryer.

Based on the ideas you have developed in **Cycle I** and **Cycle III**, revisit this question: **What causes static cling?** In explaining this, use your class consensus ideas and **draw** appropriate pictures.



2. There are commercial products that are supposed to reduce static cling. You just throw the product into the dryer along with your clothes. How do you think these products might work? What do you think they do to reduce the static cling? **Discuss** your suggestions with other groups, and summarize any suggestions that differ from yours.

### SE&M Activity III - A1



3. You may have noticed that sometimes two of your cotton socks stick together when you take them out of the dryer. Based on the ideas you have developed in this cycle, develop an explanation of why this might occur.



4. You may wish to open your **Cycle III Idea Journal** and modify any ideas that apply.