

Exploring Models of Electromagnetism

Purpose and Expected Outcome

In this activity you will examine your ideas about electric charges. You will also try to form a simple model that explains the behavior of charged objects as they interact with each other.

Prior Experience / Knowledge Needed

The only prior knowledge needed is that, for the most part, objects seem to interact only when they are in contact, that is, only when they are touching. Almost all of the forces you have studied so far are so-called *contact* forces. The most obvious exception to this is the gravitational force, which acts at a distance. In other words, the gravitational interaction occurs even when two objects are not touching, such as when an airplane is flying over the Earth or when the Earth is orbiting the Sun.

ELECTRICAL PHENOMENA AND ELECTRIC CHARGE

Have you ever noticed any of the following phenomena?

- A plastic comb rubbed against clean, dry hair will attract small bits of paper.
- A balloon rubbed on hair will remain fixed when placed against a wall.
- Two balloons rubbed on hair will repel each other when close to each other.

These are all examples of *electrical* phenomena. The property responsible for the electric interaction is called *electric charge* (or sometimes simply *charge*).

CLASSIFYING OBJECTS BY ELECTRICAL PROPERTIES

Consider the following observations:

- Some rubbed objects interact with nearby objects without touching, such as a rubbed comb and pieces of paper, or two rubbed balloons. This occurs for many different kinds of materials, but not all. For example, a soda can rubbed using hair or wool will not interact with small bits of hair or paper.
- Some rubbed objects repel each other (e.g., two balloons rubbed with wool). Some rubbed objects are attracted to each other (when a piece of wool is used to rub a balloon, the wool and the balloon will attract each other). Some rubbed objects show no observable interactions (two soda cans rubbed with wool do not interact with each other).
- Most unrubbed objects do not seem to interact with each other, but they are attracted to some rubbed objects (bits of paper are attracted to a comb that has been rubbed with hair, wool, or fur) but not all rubbed objects (bits of paper do not interact with a soda can that has been rubbed with wool).

Despite the seeming complexity of the interactions, a simple pattern emerges when objects are grouped together. In the table below, **R** indicates repulsion, **A** indicates attraction, and **X** indicates no interaction. Also, the material used to rub each object beforehand is shown in square brackets. For instance, a soda can that was rubbed with fur is attracted to Styrofoam* that was rubbed with fur.

		Group 1		Group 2		Group 3	
		STYROFOAM [Fur]	Balloon [Fur]	Fur [Balloon]	Glass [Silk]	Soda Can [Fur]	Spoon [Silk]
Group 3	Soda Can [Fur]	A		A		X	
	Spoon [Silk]						
Group 2	Fur [Balloon]	A		R		A	
	Glass [Silk]						
Group 1	STYROFOAM [Fur]	R		A		A	
	Balloon [Fur]						

* Styrofoam is a registered Trademark of Dow Chemical Company. Hereafter we will write simply “STYROFOAM” when referring to this product.

It appears that all rubbed objects fall into one of three groups:

Groups 1 & 2: Objects in either of these groups repel each other, but are attracted to objects in other groups.

Group 3: Objects in this group do not interact with each other but are attracted to rubbed objects from groups 1 and 2. These objects behave exactly like objects that have not been rubbed.

Explanation of Activity

There are two parts in this activity. In the first part, you will use the previous table of observations to begin to form a model of electrical phenomena. In the second part, you will offer your own explanations of electrical phenomena.

PART A: Interpreting and Modeling Electrical Properties

Use the table and discussion above, as well as your own experiences, to answer the following questions.

- A1.** (a) What happens when a spoon that was rubbed with silk is brought close to STYROFOAM that was rubbed with fur?
(b) What happens when glass that was rubbed with silk is brought close to STYROFOAM that was rubbed with fur?
- A2.** What do you suppose would happen when a balloon and a piece of fur are rubbed together, pulled far apart from each other, then brought near each other again? Explain why you think so.
- A3.** (a) After glass has been rubbed with silk, which group do you suppose the silk is in? Explain why you think so.
(b) After STYROFOAM has been rubbed with wool (instead of fur), which group do you suppose the STYROFOAM is in? Explain why you think so.



- A4.** You are presented with four unknown objects: *W*, *X*, *Y*, and *Z*. You need to know which group each object is in. All that you are able to determine about the objects is:
- *W* is attracted to *X*.
 - *X* is repelled by *Y*.
 - *Z* is attracted to *Y*.
 - *Z* is attracted to *W*.
 - *W* is attracted to STYROFOAM rubbed with fur.
 - *X* is attracted to a balloon rubbed with fur.

Use this information and the data in the table above to determine the groups of all four objects.

- A5.** Someone claims that after STYROFOAM is rubbed by a balloon, the STYROFOAM is attracted to a balloon that was rubbed by fur. Do you think this is possible? If so, what can you say about the group (1, 2, or 3) that STYROFOAM is in after it is rubbed with a balloon? If you do not think the STYROFOAM could be attracted to the balloon, explain why not.
- A6.** During the winter some pieces of clothing, taken immediately out of a clothes drier, will stick together (a phenomenon known as “static cling”). In fact different parts of the same piece of clothing sometimes attract each other. Is static cling an electrical phenomenon? Give arguments in favor of your position. What would you need to do to determine whether static cling results from electric interactions?
- A7.** A television (or computer) monitor that is on, or was recently turned off, will attract bits of material, such as paper, hair, and STYROFOAM. Determine whether the phenomenon is electrical. If it is electrical, determine the group the monitor is in.
- A8.** Magnets can attract or repel each other without making contact. Make an argument in favor of the hypothesis that magnetic interactions are in fact electrical. Then suggest an experiment to determine whether or not this hypothesis is correct.

Summary (of part A)

Objects in groups 1 and 2 are charged, and the types of charges on objects in the two groups are different. By convention, the type of charge on group 1 objects is called *negative*, and the type on group 2 objects is called *positive*. When two objects have the same type of charge on them, they are repelled from each other; when two objects have different types of charge on them, they are attracted.

Objects in group 3 have no charge; they are called *neutral*. Charged objects are attracted to neutral objects (and vice versa), but neutral objects are not attracted to each other.

PART B: Exploring Your Own Ideas About Electrical Phenomena

In the following you will be presented with descriptions of electrical phenomena. For each item, offer two or more explanations of the phenomena. Think about whether your explanations are consistent with other things you know. Look for patterns between the items. Since we have not yet stated any principles of electric interactions do not be concerned about whether your explanations are right or wrong.

- B1.** If wool is put into contact with a sheet of STYROFOAM, even for an extended period of time, the STYROFOAM does not appear to become charged very much, if at all. Rubbing the STYROFOAM with the wool seems to greatly increase the amount of charge on the STYROFOAM. The same is true for other objects that exhibit electrical phenomena.

- B2.** The strength of electric interactions between objects tends to decrease over time. The amount of time an object remains charged varies from one material to the next. Some materials lose their charge quickly while others remain charged for many days.

- B3.** If a small area of a large STYROFOAM board (or large balloon) is rubbed with wool, then only the region near the rubbed portion seems to interact significantly with other objects.

- B4.** If a charged piece of STYROFOAM board is touched all over by someone's hand, the STYROFOAM may become uncharged, or at the very least, it interacts less strongly with other objects.

- B5.** When two uncharged objects are rubbed together and one of the objects gets charged, sometimes the other object is observed to be charged, but not always. When both objects become charged they are always oppositely charged.

Reflection

- R1.** (a) Which group (1, 2, or 3) do you suppose a balloon is in before it is rubbed with fur? Explain why you think so.
- (b) Which group (1, 2, or 3) do you suppose fur is in before it is rubbed on something else? Explain why you think so.
- R2.** Explain what you believe causes the electrical properties of two objects to change when they are rubbed together.
- R3.** (a) Does the energy of two objects increase or decrease while they are being rubbed together? Explain why you think so.
- (b) Does this explain why rubbing two objects together allows them to interact electrically? Why or why not?
- R4.** (a) Does the temperature of two objects increase or decrease while they are being rubbed together? Explain why you think so.
- (b) Does this explain why rubbing two objects together allows them to interact electrically? Why or why not?
- R5.** If you rub a balloon on your hair, do you become charged? How? If you are charged, are you positively or negatively charged? Explain.
- R6.** You might think that a television monitor is charged because it attracts bits of neutral matter, such as hair and paper. How would you determine if it is charged? Assuming it is charged, how do you think the monitor becomes charged? What type of charge, positive or negative, do you think is on the monitor? How would you test this prediction?