

14455 Electrostatic Materials

Purpose:

To investigate the effects and uses of electrostatic charges including: conductors, insulators, Coulomb attraction and repulsion, and induction.

Contents:

Eight (8) Vinyl strips (opaque)
Eight (8) Acetate strips (clear)
Eight (8) Polyethylene strips
Eight (8) Aluminum tubes
Eight (8) Wool cloth squares
Eight (8) Cotton cloth squares
Eight (8) Wooden holders for insulating strips
One (1) Package of graphite coated balls (24/pkg)
Nylon monofilament
Aluminum foil

Required Materials:

The materials contained in this Electrostatics Kit are used in a number of experiments, each of which require particular accessories normally available in classroom laboratories. These include:

Ringstand, clamps, and rod (or other framework for suspending materials)
Beakers (or other insulating supports)
Electroscopes
Dry paper
Toothpicks
Needle
Tape

Procedure:

Electrostatic experiments require a low relative humidity in the laboratory (50 percent or less) for best results. High humidity will cause charges to "leak" across insulators or escape into the atmosphere. To reduce leakage in high humidity, keep the materials in a heated area until just prior to use. Also when experiments require the use of aluminum tubes, use a low molecular weight polyethylene to support them.

To generate negative charges, rub an opaque vinyl strip with a dry clean paper. Positive charges can be generated by rubbing a clear acetate strip with a dry clean paper. Remember, the surfaces of the strips must be clean and dry. Dirty surfaces and excessive handling of the strips make it difficult to retain charges. These statements are especially true when working with induced charges on the aluminum tubes.

When experiments involve hanging charged strips (or other charged material) from a ring stand, be sure that they are far enough from the metal stand. This will prevent induced charges in the stand from interfering with your experiments.

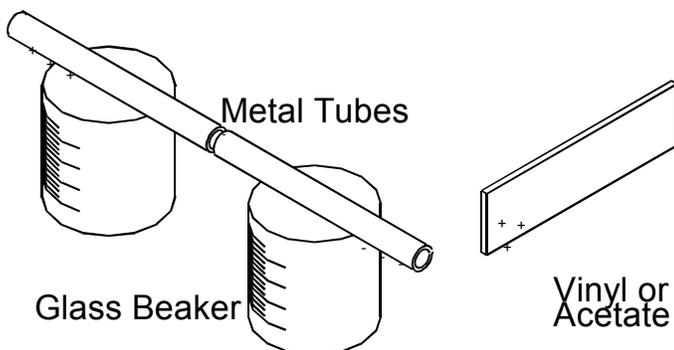
Much of the qualitative behavior of electric charges was discovered during the eighteenth century. Common materials like glass were rubbed with different kinds of cloth to produce electric charges. You can observe for yourself the behavior of electric charges by rubbing easily charged plastic strips with paper or cloth.

Hang a strip of cellulose acetate (clear) and a strip of vinyl (opaque) by short lengths of masking tape from a crossbar of a ringstand so they can swing freely without twisting. Briskly rub the vinyl strip and the acetate strip with a dry piece of paper. Do not touch the rubbed surfaces. Rub another vinyl strip with paper and bring it near each of the suspended strips. What can you conclude? Now rub another strip of acetate with paper and bring it near the hanging strips. What do you observe?

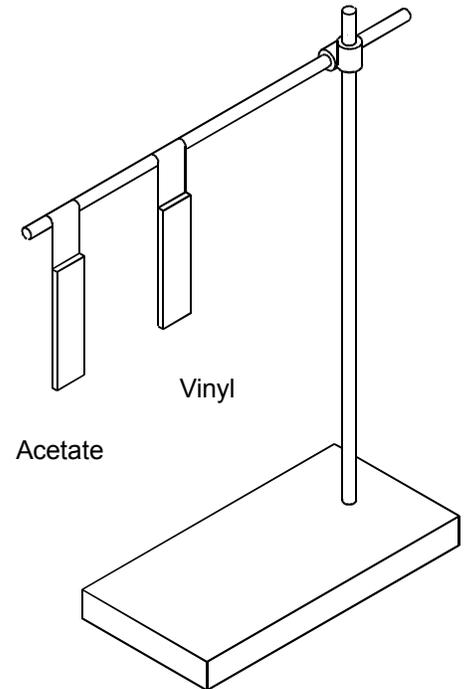
Charge one of the plastic strips. Now put some styrofoam packing peanuts out on the table. Try to pick them up with the charged plastic strip, or pour some over the charged strip. See how many different ways you can make the peanuts interact with the charged strip. Are the peanuts attracted to the strip? Why?

How can you classify different objects as conductors or insulators? To find out, charge the electroscope then touch the probe with one of a variety of hand held objects: pen, pencil, paper, metal, etc. List each object used and describe note how quickly the electroscope discharges. A conductor will discharge the electroscope quickly and completely when it touches the probe. An insulator will not discharge the electroscope. Do all of your objects fall neatly into the "conductor" or "insulator" categories? You'll find that most objects will fall somewhere between being a perfect conductor or a perfect insulator.

Charge on a conductor will try to distribute itself equally over the object's surface. We can investigate this by beginning with a charged electroscope. Hang a coin from a length of the monofilament line. Holding the monofilament line, bring the coin in contact with the probe on the electroscope. Note the relative amount the leaves of the electroscope fall when contact is made. Why did the leaves fall? Charge the electroscope again and repeat the experiment with different sized coins, and perhaps an empty soda can. The charge on the electroscope distributes itself evenly between the electroscope and the conductor touching the electroscope probe. When the conductor is removed from the probe it takes some of the electroscope's charge with it. Can you make some conclusions about the size of the conductor and the amount of charge removed from the electroscope?



We have just found that charges can move freely through conductors. We can use this fact to "induce" charges on conductors. Make a charge indicator by hanging a piece of foil or a graphite coated ball from a length of monofilament line tied to a ringstand cross bar. The graphite coating gives the ball a conductive surface. Next, place two metal rods on separate glass beakers so that they touch end to end. Bring a charged piece of plastic close to one end of the rods (do not get the plastic close enough that sparks jump between the plastic and the rod). With the charged plastic close to the rods, separate the rods (without touching them!) by moving one of the beakers.



Remove the plastic and transfer some of its charge to the hanging ball by touching it with the charged plastic. Bring the rod that was furthest from the plastic strip when it was charged near the hanging ball (remember, hold the beaker, don't touch the rod!). What do you observe. Is the charge the same on both objects or different? Bring the second rod near the ball. What happens now? Touch the two rods together. Bring them near the charged ball. How does the charged ball behave when it is near the rods?

Place the rods end to end and touching as you had done earlier. Again bring the charged plastic close to one end of the rod then touch the other end of the rod briefly with your finger. After you have removed your finger from the rod, then remove the plastic strip. Touch the plastic strip to the hanging ball then test for the presence of charge on each rod as you had done before. Is the charge on each rod the same and is this charge the same as or opposite to the charge on the plastic? The ball you have been using gives an indication of the presence and sign of a charge but is not good for measuring the quantity of charge.

When a charged object is brought near a conductor, opposite charges are attracted by the object and flow through the conductor to get themselves as close to the oppositely charged object as possible. At the same time, the like charges are repelled and try to get as far away from the charged object as possible. If you touch the conductor briefly, you provide a path for the like charges to escape to ground. When you remove your finger, the opposite sign charges are trapped on the conductor. This is charging an object by induction.

Charge the ball that is hanging by the monofilament then bring it near a conducting surface (a cookie sheet or a flat piece of aluminum foil. What happens and why? If you charge the ball with the opposite sign would you expect the ball to move in the opposite direction? (Hint: think about the induction experiment performed earlier.)

You can make a couple of simple instruments to detect the presence of charges and electric fields. A charged ball suspended from a stick by a length of monofilament line can be used as a rough indicator of fields around charged spheres, plates, and wires. Use a point source of light to project a shadow of the thread and ball. The angle between the thread and the vertical gives a rough measure of the electric forces. Use the charged ball to explore the nearly uniform field near a large, charged plate suspended by tape strips, and the $1/r$ drop off of the field near a long charged wire. (To prevent leakage of the charge from the pointed ends of a charged wire, form a small drop of solder at each end.)

A sensitive electric "compass" is easily constructed from a toothpick, a needle and a cork. An external electric field induces surface charges on the toothpick. The forces on these induced charges cause the toothpick to line up with the electric field lines. To construct an electric compass, first bend a flat toothpick into a slight arc. When it is mounted horizontally, the downward curve at the ends of the toothpick will give it stability by lowering the center of gravity below its pivot point. With a small nail, drill a hole at the balance point almost all the way through the pick. Push a needle into a cork and balance the pick on the tip of the needle. Be sure the toothpick is free to swing like a compass needle. Try bringing charged objects near it to see what happens.

Time Allocation:

To prepare this product for an experimental trial should take less than five minutes. Actual experiments will vary with needs of students and the method of instruction, but are easily concluded within one class period.

Feedback:

If you have a question, a comment, or a suggestion that would improve this product, you may call our toll free number.