# Sticky Electrostatics

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Topic: Static Electricity

## Purpose

To investigate the nature of static electricity.

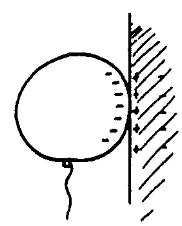
## Equipment and Supplies

3/4" tape, Scotch brand Magic™ tape (no substitutes)
fresh balloons
digital voltmeter (DVM), with 10 mega-ohm input impedance or greater

## Discussion

When discussing static electricity, many people focus on the need to rub materials together in order to generate separations of charge. Some state that friction creates the separation of charge. Is this statement always true—or only some of the time? What *is* the nature of electrostatic charge?

Forget rubbing for now and consider two objects simply touched together. Their surfaces adhere slightly. Chemical bonds form at the regions of contact between the molecules of both surfaces. If the surfaces are not of the same material, the bonds will probably be *polarized*, with the shared bonding electrons staying with one surface more than with the other. When the two objects are pulled apart again, the bonds rupture and one surface may end up with electrons from the other surface. Now the surfaces are no longer neutral. One surface has extra electrons (electron *surplus*) while the other surface has fewer electrons (electron *deficient*) compared to the number of protons in each substance. These charges are then separated as the surfaces are pulled apart. As the objects are separated the charges move with them.

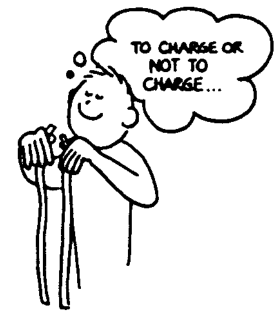


If the surfaces involved are rough or fibrous, friction *does* play a part in surface charging. If you touch a balloon to a head of hair, the hair really only touches the balloon in tiny spots, and the total area of contact is extremely small. However, if the balloon is *dragged* across the hair, then the successive areas of contact add up. Rubbing a balloon on your head increases the total area of contact, so it increases the amount of charge that is separated. However, the friction does not *cause* the charging. You can rub two balloons together as much as you like, and you will never create any "static electricity." Contact between *dissimilar* materials is required.

## Procedure

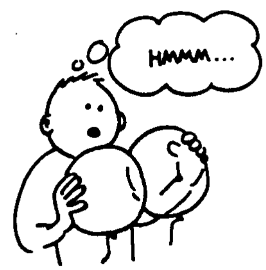
**Step 1:** Pull a couple of strips of plastic adhesive tape from a roll. Each one should be about 12-20 cm long. Hold them up by their ends, then slowly bring them side by side. What happens? Notice that they repel each other. If you try to get the dangling lengths of tape to touch each other, the tape will swerve and gyrate to frustrate your efforts. Obviously the tape has become electrically charged. But how? No friction was involved.

**Step 2:** One at a time, pass each of the strips of tape lightly between your fingers so as to discharge or neutralize them, then hold the two strips near each other again. Now how do the strips behave? If discharged, they will not repel each other. You've managed to discharge the strips by touching them.




**Step 3:** Fold over a couple of centimeters of the end of each strip. This gives you a non-sticky handle to work with. Carefully stick the two strips to each other so the sticky side of one strip adheres to the "dry" side of the other. You should end up with a double-thick layer of tape which is sticky on one side, and which has two tabs at the end. Now grasp the tabs and rapidly peel the strips apart. Keep them distantly separated, then slowly bring them together again. How do the strips behave this time?

**Step 4:** Blow-up two fresh balloons. Do not rub them against your hair or clothing. See if you can "create" static electricity by rubbing two electrically neutral balloons together. What is your result?




**Step 5:** Discharge your two strips of tape by running each one between your fingers. Hold them near each other to verify that they neither attract nor repel one another. Now stick the two strips together, but this time do it with the adhesive sides facing one another. Peel the strips apart again, then bring them near each other. Are the strips now neutral, or do they attract one another?

**Step 6:** Finally, peel four separate strips from a roll and neutralize them with your fingers. Then stick them together in pairs with the sticky side of one stuck to the dry side of the other. Now peel each pair apart so you have four charged strips.

Hold pairs of these strips together in different combinations. What do you discover? You can determine the polarity of the four strips by rubbing a balloon on your hair (rubber always acquires a negative charge when touched to hair), then holding it near the strip being investigated. If the balloon and the tape strip repel, the strip is negatively charged.

## Summing Up

1. *How* did the strips of tape become charged in Step 3?

2. How do you explain why the strips of tape are *not* charged when peeled apart in Step 5 while they *are* in Step 4?

3. Paper is a reasonably good conductor compared to plastic tape. Explain why masking tape does not work well for this activity.

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## Going Further

A digital voltmeter (DVM) can be used to detect the sign of the charge that accumulates on an object. Turn the "DC Volts" scale of the meter to maximum sensitivity (some newer models are auto-ranging and only require being set to "DC Volts". When brought near a charged object, the digital display not only indicates a small voltage, but the *sign* of the charge on the object as well. Place the common, or ground probe, off to one side out of the way. The meter may give a small positive or negative readout—depending on its environment. Allow the meter to stabilize. Use the positive probe to investigate the sign of the charge on objects. When a positively charged object is brought near the probe, the positive charge on the object "pushes" on positive charges on the probe through the meter, causing the reading on the meter to *increase*. When a negatively charged object is brought near the probe, the negative charge on the object "pushes" on negative charges on the probe, causing the reading on the meter to *decrease*. Therefore, the sign of the charge on the object is related to the *change* of the reading on the meter—regardless of the sign of the original readout. As you investigate the sign of the charge of objects, you will note that the change in the readout "decays". The reason the readout of the meter decays is due to the transient nature of how the meter works—not because the charge on the object is dissipating. The decay rate depends on the input impedance of your particular meter. The greater the input impedance is, the slower the decay. The lower the input impedance is, the faster the decay.

Pull a 12-20 cm strip of tape from a roll. Being careful not to neutralize the tape, use a DVM to determine the sign of the charge on the strip of tape. Repeat for several strips. Record your results below.

sign of the charge on the strip ________________

Use the DVM to probe the roll of tape after pulling a strip of tape from the roll. What do you find?

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