

RAFT IDEAS

Topics: Static electricity,
Experimental variables

Materials List -

- ✓ Finishing nail, 5 cm -8 cm (2"-3") long (dimpled head)
- ✓ Block of foam or wood, ~2 cm (~3/4") thick
- ✓ Thin straw, 1.5 cm (1/2") long
- ✓ Sports bottle cap
- ✓ Rubber band, 3-6 mm (1/8" to 1/4") wide, that fits tightly around cap
- ✓ Mirrored Mylar, ~3 x 5 cm (1 1/4 x 2")
- ✓ Pushpin
- ✓ Foam lunch plate
- ✓ Foam cup, 180-240 ml (6-8 oz)
- ✓ Bubble wrap or thin flexible foam, about 5 cm x 15-30 cm (2" x 6"-12")
- ✓ Silk (best), wool, or plastic wrap, 10 cm x 10 cm (4" x 4")
- ✓ Hammer/scissors

This Activity can be used to teach:

CO Science Standard 1:
Physical Science

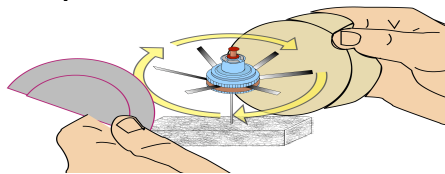
- Opposite charges attract, like charges repel

- Electricity

Grades: 4, 6, 8, HS

Static Merry-go-Round

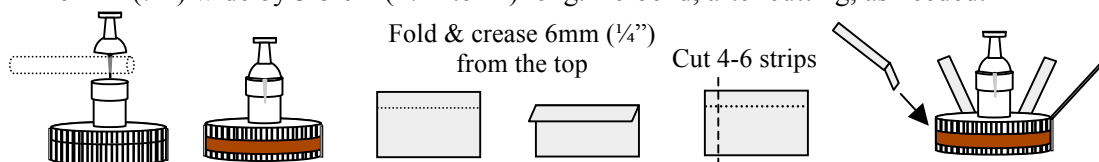
An easily made and powered version of the first electric motor!



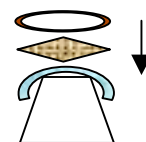
This unique adaptation of the first static motor lets students create spinning motion using only static charges. The design can be easily modified for experimentation.

Assembly (Safety Note: Wear eye protection when using a hammer!)

1. Insert the nail partway into the center of a foam block. Remove the nail and insert the nail's point into a 13 mm (1/2") piece of thin straw. Reinsert the nail into the hole in the foam block. For a wood block simply hammer the nail in partway.
2. Pry off the sports bottle cap's push/pull closure (optional, but recommended)
3. Twist the pushpin into the center of the cap. Alternately cut a 2.5 cm (1") slit in the end of a regular straw. Put the pushpin into the slit. Center over the cap, as shown, and then hammer the pushpin in with a firm but not too forceful blow.
4. Place the rubber band around the cap, covering the ridges, as shown.
5. Fold and crease the Mylar, as shown below, and then unfold. Cut 4-6 strips about 6 mm (1/4") wide by 3-5 cm (1 1/4" to 2") long. Re-bend, after cutting, as needed.



6. Insert the short bent end of a Mylar strip under the rubber band, coming in from above. To make this easier try angling a corner of the strip into one of the gaps between the cap's ridges and the rubber band. Other strips can be inserted later.
7. Place the cap over the nail so that the point of the pushpin fits into the dimple in the finishing nail. The cap will spin freely if the pushpin is positioned correctly.
8. Drape the bubble wrap, or flexible foam, over the bottom of an upside down foam cup. Longer strips could first be folded in 1/2. Cover with a square of fabric, or plastic, so 2 opposite corners are on the bubble wrap.
9. Secure the corners of the fabric with a rubber band around the cup.
10. Cut a foam plate in half (a whole plate or a 2nd cup could be used).



To Do and Notice (results will vary with temperature and, especially, humidity!)

1. Hold the cup and plate. Briskly rub the fabric and plate bottom together. Repeat while doing the activities. For some brands of foam plate, one side may work better (or neither side may work!) for generating a charge imbalance.
2. Bring the fabric or plate near the Mylar strip. How does the strip react?
3. Touch the strip briefly and then bring the other item near the strip. What happens? Lightly touch the strip to remove any charge imbalance.
4. Rub the plate with the fabric and place them on either side of the strip. Vary the positions of the fabric and plate for best effect. Repeat the rubbing as needed. Can the strip be made to rotate? (Will work better when more strips are added)
5. Repeat steps 1 and 2 but bring a finger near and on the opposite side. Does the cap keep turning? Repeat steps 1 and then 3. Same result? Add more Mylar strips, spaced evenly around the cap. Repeat the previous activities.
6. How does adding more strips affect the speed of rotation?

The Science Behind the Activity

Placing items in contact and then separating them can move electrons from one item to the other. Items vary in how strongly they “hold on” to electrons. An item that gains electrons will have a net negative (-) charge. An item that loses electrons will have a net positive (+) charge. Electrons are moved, not created! For solid materials the positive charges (protons) cannot leave or move about like the electrons. Opposite (**unlike**) charges (+/-) are equally **attracted** to each other. Same (**like**) charges (+/+ or -/-) are equally **repelled** by each other. **The force** of attraction and repelling **increases with a decrease in the distance** between the charges. The charges will, in a sense, “stay put” unless the item is a conductor (metal, etc.) that lets electrons move about easily. An item with a net charge, positive or negative, is said to be charged or to have a charge imbalance.

Touching a charged item can eliminate (neutralize) the charge imbalance at the spot touched or all over if the item is a conductor. The human body can safely give up or take on the electrons needed to neutralize small charge imbalances. Touching the Mylar strips removes any existing charge imbalance. The electrons can leap across an air gap unseen or cause a spark, if the charge imbalance is large enough. Charge imbalances can also be neutralized, over time, by charges on dust, etc. in the air. The charge imbalance will diminish more slowly if the air is cool and/or dry. Generating a large or lasting charge imbalance on a damp or humid day may be impossible.

An uncharged, **neutral**, item has an equal number of positive and negative charges. A neutral item will still be mutually attracted to any charged item! The attraction is due to the electrons in a neutral item’s atoms rearranging their orbits very slightly when near a charged item. The electrons will move slightly closer to a positively charged item or slightly away from a negatively charge item. The result is a net attraction, as the attractive force from the slightly closer opposite charges is greater than the repelling force of the slightly farther apart like charges. This is why a neutral Mylar strip, which can turn, will rotate toward a charged item that is being held in place.

When a Mylar strip moves near enough to a charged item, some electrons can bump over the gap. Some electrons will move toward the Mylar from a negatively charged item **or** from the Mylar toward a positively charged item. Either way the Mylar will now end up with the same type of charge (+ or -) as the nearby charged item. A Mylar strip, which can rotate, will be repelled from the charged item, since like (same) charges repel each other. The strip is now strongly attracted to the oppositely charged second item. When a charged strip moves near enough to the second item some electrons are again transferred. The Mylar strip now acquires the same type of charge as the second item. The strip is now repelled from this second item, but will be attracted to the first charged item. The Mylar strip continues rotating due to momentum. When a Mylar strip rotates near the first charged item the process repeats. The attractive force changes to a repelling force and the Mylar strip rotates away, repeating the cycle.

For steps 2 & 3 with only one charged item the strip(s) can all end up with the same charge. Some of the charge can be lost as a strip moves through the air. The strip may stop rotating or change direction. **In step 500** a charged strip will first be attracted to a neutral finger. Electrons going to or from the finger will at some point neutralize the charge on the approaching strip. The neutralized strip will again be attracted to a charged item and rotate around. The reflective Mylar has a thin coating of aluminum, a conductor. Electrons can move easily in a conductor. The electron movement and transfer happen so quickly that the Strips spin without stopping. Only a relatively small amount of electrons are move to or from a strip each time. The charged item(s), having a much larger net charge, can supply or take on extra electrons for many rotations of the strips.

Troubleshooting

Cool and/or dry days are better for doing static based activities; moisture of any kind can be a problem. Wrapping fabric around a foam cup and bubble wrap will prevent unseen hand moisture from entering the fabric.

Taking it Further

Experiment with changing a variable such as the position, number, and/or shape of the Mylar strips.

Web Resources (Visit www.raft.net/more for how-to videos and more ideas!)

- Basic background information on static electricity - <http://www.sciencemadesimple.com/static.html>
- Benjamin Franklin and his electric motor - <http://www.todaysengineer.org/2002/Aug/heritage.asp>
- Franklin’s experiments and adaptations - http://www.tufts.edu/as/wright_center/personal_pages/bob_m/