STATIC MERRY-GO-ROUND
The expanded science behind the activity
Background information on electrons, protons, and neutrons

(**Bold** words in parentheses are the scientific terms.)

Through experimentation, scientists have learned that all the different stuff (**matter**) that makes up our world is composed of over 100 different basic building blocks (**elements)**. Each element, such as gold and aluminum, has a unique combination of properties including how much a set amount weighs (which is related to the element's **mass**) and how readily the element will combine with other elements. The smallest piece of an element that still possesses an element's key properties (an **atom**) is made up of just 3 types of smaller particles (**electrons, protons, and neutrons**).

Two or more atoms can combine to form the smallest pieces (**molecules**) of more complex types of matter.

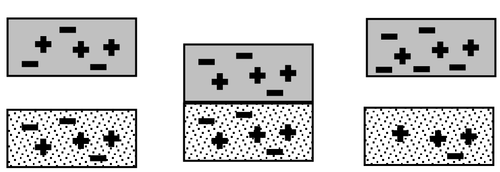
Electrons and protons have an electrical property called "**charge**". An atom usually has no overall charge (is **neutral,** has no **net charge**) since the atom contains an equal number of electrons, each with a single negative (-) charge, and protons, each with a single positive (+)charge. The equal number of positive and negative charges balance ("cancel") each other out.

How materials become charged

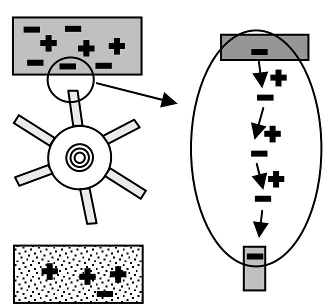
Touching items together and then separating them can move electrons from one item to the other. Items vary in how strongly they can "hold on" to electrons. The item that gains electrons will have a net negative (-) charge if the item has more electrons than protons. The item that loses electrons will have a net positive (+) charge if the item has fewer electrons than protons. An item with a net charge, positive or negative, is said to be **charged**, to have a **charge imbalance** or to have a **net charge imbalance**.

*Teaching tip: A material's varying attraction for electrons can be modeled by imagining that each material contains a different strength of glue for electrons. A material with stronger glue (has a greater attraction) can pull electrons from a material with weaker glue. The same material could in turn lose electrons to another material that possessed even stronger glue. Common materials have been arranged in a list with the weakest attracting at the top to the strongest at the bottom (called the **Triboelectric Series** - see **Charge It -** http://www.raft.net/ideas/Charge It.pdf).*

A material can lose or gain electrons because electrons can move through or between materials. The electrons are not created nor destroyed. For most materials, the positively charged protons do not leave the material or move about freely. The negatively charged electrons do move about, but will "stay put", in a sense, unless the material allows for the very easy movement of electrons (is a **conductor**). Aluminum and copper are examples of conductors. The reflective Mylar® has a thin coating of aluminum. For relatively long distances, electrons tend to travel by "bumping" along, bumping other electrons out of position like a row of bumper cars, not like a car driving down a road.



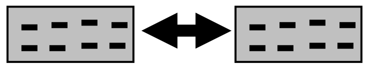
Two different materials, both neutral (equal numbers of plus and minus charges), put into contact, and then separated. The top item is now negatively charged (has more electrons than protons), while the bottom one is positively charged (has more protons than electrons).



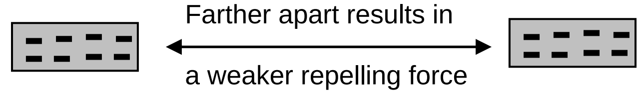
An extra electron bumps an electron out of position from an atom in the air, which bumps another electron in turn until a different electron enters the Mylar® vane.

Two items with opposite net charges (**unlike** charges), one positively charged (**+**) and the other negatively charged (**-**), will be equally **attracted** to each other. Two items with the same net charges (both positively or both negatively charged) (**like** charges) are equally **repelled** by each other. The forces of attraction and repulsion **become greater when the distance between the charged items becomes smaller**.

Closer together results in a stronger repelling force



Farther apart results in a weaker repelling force



Touching a charged item with a finger 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 the **small** charge imbalances generated by rubbing fabric and a foam plate together. Touching the Mylar® strips removes any existing charge imbalance. With a high enough charge imbalance the electrons can be push/pulled into the air, bumping other electrons out of place, which causes other electrons to do the same in turn across the air gap between charged items. The bumping process is usually unseen. It can be seen if a spark is generated. Charge imbalances can also be neutralized, over time, by opposite charges on dust and moisture 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 in a damp or humid environment can be difficult.

A neutral item (having no net charge) has an equal number of positive and negative charges. Surprisingly a neutral item will be mutually attracted to any charged item! The attraction is due to the neutral item's electrons rearranging their orbits very slightly when placed near a charged item (becoming **polarized**). The electrons will move slightly closer to a positively charged item or slightly away from a negatively charged 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 Mylar® strip that is initially neutral will move toward a charged item.

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. See the illustration on page 1.

The electron movement and transfer happen so quickly that the strips spin without stopping. Only a relatively small number of electrons are moved 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 conducting strips.

For steps 3 & 4 of **To do and notice** with only one charged item, the strip will have the same charge. Some of the charge may be lost as a strip moves through the air. The strip may stop rotating or change direction. **In step 6,** 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 Static Merry-go-Round is a very low power motor and requires 2 key features to enable easy and stable rotation. The first is a low friction turning point (**pivot**) so that very little energy is required to start and to keep the cap turning. The tiny pointed metal tip of the pushpin sitting in the dented metal head of the nail provides the required low friction pivot. The turning cap must be balanced in such a way so that the cap remains upright and does not tip over when spinning. The cap will remain upright if more than half the weight (~mass) of the cap is located below the pivot point (tip of the pushpin). The material of the cap that is above the point of the pushpin (spout and push pull top) is less than what is below the pivot point when the tamperproof ring is included. That is why the tamperproof ring needs to remain attached to the cap and not be broken off when inserting the pushpin and vanes.

