

## Triboelectric Series (The Pith Ball Experiment)

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If you rub a glass rod with a silk cloth or if you rub a piece of amber with wool, the glass and amber will develop a static charge that can attract small bits of paper or plastic.

To understand what is happening when your body or a glass rod develops a static charge, you need to think about the atoms that make up everything we can see. All matter is made up of atoms, which are themselves made up of charged particles. Atoms have a nucleus consisting of neutrons and protons. They also have a surrounding "shell" that is made up of electrons. Typically, matter is neutrally charged, meaning that the number of electrons and protons are the same. If an atom has more electrons than protons, it is negatively charged. If it has more protons than electrons, it is positively charged.

Some atoms hold on to their electrons more tightly than others do. How strongly matter holds on to its electrons determines its place in the **triboelectric series**. If a material is more apt to give up electrons when in contact with another material, it is more positive in the triboelectric series. If a material is more apt to "capture" electrons when in contact with another material, it is more negative in the triboelectric series.

The following table shows you the triboelectric series for many materials you find around the house. Positive items in the series are at the top, and negative items are at the bottom:

- Human hands (usually too moist, though) *Very positive*
- Rabbit Fur
- **Glass**
- Human hair
- Nylon
- **Wool**
- **Fur**
- Lead
- **Silk**
- Aluminum
- Paper
- Cotton
- Steel *Neutral*
- Wood
- Amber
- **Hard rubber**
- Nickel, Copper
- Brass, Silver
- Gold, Platinum
- Polyester
- Styrene (Styrofoam)
- Saran Wrap
- Polyurethane
- Polyethylene (like Scotch Tape)
- Polypropylene
- Vinyl (PVC)
- Silicon
- Teflon *Very negative*

(The above list is adapted from Nature's Electricity, by Charles K. Adams.)

The **relative position** of two substances in the triboelectric series tells you how they will act when brought into contact. Glass rubbed by silk causes a charge separation because they are several positions apart in the table. The same applies for amber and wool. The farther the separation in the table, the greater the effect.

**Objective:** The student will determine the relative net charge (+ or –) on each material listed below after being rubbed by various objects.

**Apparatus:** various pelts, silk cloth, wool cloth, plastic sheets, friction rods, wooden dowels, ring stands.

**Background Information:**

When two dissimilar materials are rubbed together, electrons can be transferred from one material to another. This creates a "free" static charge on each surface through a process known as **triboelectrification**.

The suffix *tribo* means *to rub* in Greek, thus **triboelectrification** simply means to electrify (or charge) by rubbing, or by contact. Interestingly, it is **not** friction that results in the charging process, but rather a chemical reaction called **adhesion** that occurs between the two dissimilar materials. By rubbing the two materials together a larger surface area is contacted, resulting in a greater **exchange** in charge.

**Procedure:**

1. Ground out your strips and your pith ball by holding each in your hand for 20 seconds.
2. Place the each of the rods next to the pith ball and notice that nothing happens.
3. Take blue strip and rub it 20 times with the wool
4. Touch the blue rod to the pith ball for 20 seconds. Your pith ball is now negatively charged.
5. Again rub the blue rod with the wool 20 times.
6. Place it near the pith ball (DO NOT TOUCH IT TO THE PITH BALL). Note what happens.
  - a. If the pith ball is attracted to a rod, the rod is oppositely charged; if it is repelled, it has the same charge. Student will place a + or – sign in the table accordingly representing the charge on the strip after rubbed with the material.
  - b. Estimate based on the amount of attraction or repulsion which rod has the most charge on it.
7. Repeat Steps 5 & 6 with the other 3 strips.
8. Ground out each of your strips by touching the side of the strip you rubbed for 20 seconds.
9. Repeat Steps 5-8 with the silk.
10. Repeat Steps 5-8 with the plastic.
11. Repeat Steps 5-8 with the fur.

**Data Table 1: Charge on Different Materials**

<b><u>Charge on material when rubbed with:</u></b>				
<b><u>Material</u></b>	<b><u>fur</u></b>	<b><u>wool</u></b>	<b><u>silk</u></b>	<b><u>plastic</u></b>
<b>Blue Acetate Strip</b>				
<b>Clear Strip 1 (long)</b>				
<b>Clear Strip 2 (short)</b>				
<b>Vinyl Plastic</b>				
<b>White Strip</b>				