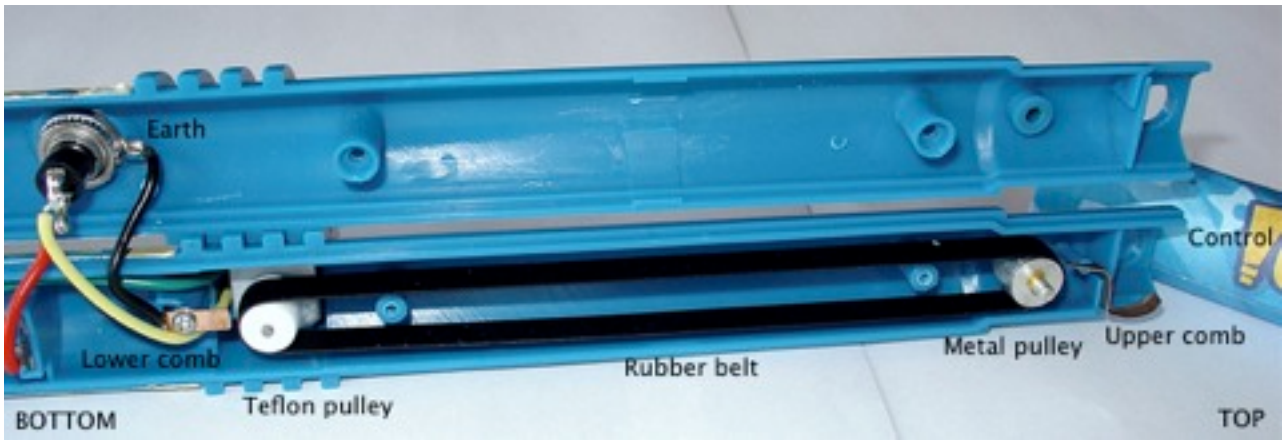
Fun Fly Stick™ Electrostatics

The Fun Fly Stick is a portable electrostatics generator that makes tinsel objects float, but there is much more to this ingenious piece of apparatus that makes it indispensable to all science teachers.

The Fun Fly Stick is simply a clever portable version of the well-known Van de Graaff Electrostatics Generator. Below you can see a 'dissected' Fun Fly Stick with the rubber belt, metal & teflon pulleys and metal combs exposed.



This is **How the Fun Fly Stick works**:

Electrical charges are separated at the point where the **rubber belt** and **teflon** pulley's paths separate. The belt then carries an excess **positive** charge and the teflon pulley a net **negative** charge. The lower comb "sweeps" the excess electrons from the pulley and these flow to ground via the operator. As the positive belt passes over the top metal pulley, free electrons from the accumulator (control tube) are sucked in via the upper comb and onto the electron-deficient belt. The electrons are carried down to the lower pulley where the cycle is repeated. The lower comb is connected to the operator's finger (Earth) through the metal rim of the button.

The one obvious part that is 'missing' from the Fun Fly Stick is the typical spherical metal dome of the Van de Graaff generator. The inventor, Boris Kriman, wanted a **charge accumulator** without the 'electrical shock' discharge, so he came up with the idea of a cardboard tube. Cardboard has a high electrical resistivity but acts as a conductor for high voltage electricity. Furthermore it discharges much slower than metal so the 'spark' discharge sensation is eliminated. Result: A safe toy! Clever!

Let's quickly refresh some **electrostatics basics**:

Tribo-electric series

Positive
glass
hair
nylon
wool
fur
silk
paper
cotton
rubber
copper
polyester
polystyrene
PVC
Teflon
Negative

★ All matter is made up of **atoms**. Atoms consist of **electrons** orbiting the **positive** nucleus. Some atoms hold on very tightly to their electrons and others easily let go of them.

★ When two dissimilar insulators (non-conductors) are in contact and then simply **separated**, one will lose electrons to the other. (There is a general misconception that "friction" causes static charges). The insulator that gains electrons have a surplus of electrons and becomes electrically negatively charged. The other have lost electrons and is labeled "positive" as it has an electron deficiency. These charges are **static** because they do not move on their own.

★ The "**tribo-electric series**" indicates which materials easily gain (become negative) or easily lose electrons (become positive) when separated after being in contact. Rubbing a PVC pipe with a woolen cloth would therefore leave the pipe with a net negative charge and the cloth with a net positive charge.

★ The fact that every movement we make generates charges are not well known as we seldom experience the discharges. We all know that getting into a car seat on a dry day causes some uncomfortable discharges but we are unaware that we generate around 12000 to 39000 V on our bodies when crossing a woolen carpet or 4000 to 13000 V when crossing a vinyl floor!

★ According to the Tribo-electric series, the Fun Fly Stick should generate a **positive** charge: Rubber vs Teflon. Confirm this in Activity 1 below.

★ Electrical charges can also be **induced** on a neighbouring insulator or conductor. If objects do **not make contact** then the charge will be of an **opposite** nature. If they do **make contact** - as with the Fun Fly Stick and tinsel - then they both carry the **same charge**!

Please Note
Electrostatic charges and water never go together, therefore:

- ✦ A humid, wet day would not be the best to try these activities;
- ✦ A hair dryer might be handy to dry the environment and objects before you start;
- ✦ Evaporative cooling systems are deadly to electrostatics experiments as these produce water vapour.
- ✦ When students gather, they breath water vapour, so keep the area well ventilated.

Great Static Electricity Activities for your Classroom using the Fun Fly Stick™.

All of these can be easily converted to student centered activities.

1. Determine the type of Charge on the Fun Fly Stick

★ Find a piece of PVC pipe or PVC conduit and a woolen cloth. From the Tribo-electric Series above we conclude that the PVC pipe will carry a net negative charge when rubbed with the cloth.
★ Pull a piece of transparent sticky tape from its dispenser and affix to a table so that most of the tape hangs freely in the air. The tape carries an unknown charge.
★ Rub the pipe with the cloth and bring the pipe close to the suspended tape. The movement of the tape will help you determine **the charge on the tape**. Deductive science! Oh yes, you still recall that like charges repel and opposite charges attract?
★ Now, start the Fun Fly Stick and approach the tape. Once again the movement will give away the type of charge on the Fun Fly Stick. Cool!
This can also be done without the PVC and cloth using a classroom electroscope.
(*Original idea by R Perkins, Educational Innovations*)

2. Determine the charge on the Fun Fly Stick with an Electronic Electroscope.

We have constructed an Electronic Electroscope using a field effect transistor (FET) and an LED. The LED glows brightly when the device is subjected to a positive electric field. This can be used to easily demonstrate the nature of the charge on the Fun Fly Stick and the PVC and cloth. The product is available as "Electroscope & Human Powered Lamp" at www.profbunsen.com.au

3. **Bend a thin stream of water**

★ Cover the control tube of the Fun Fly Stick with a plastic zip lock bag. DO NOT get the control tube wet!
★ Have a thin stream of water flow from a faucet. The thinner the better.
★ Approach the stream with the activated protected control tube. The bending of the stream should show the attraction of the water to the charges on the Stick.

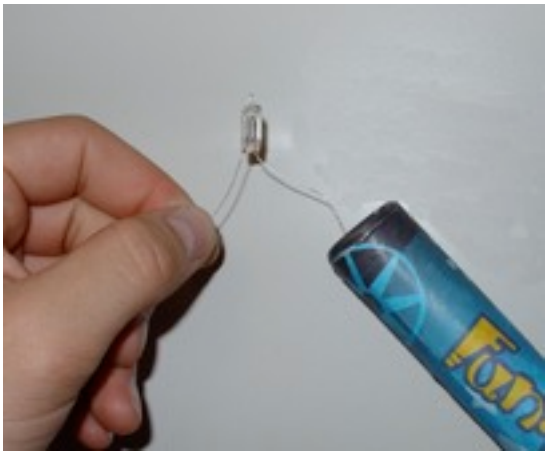
Why? Water molecules are **polar** and arrange themselves in an electric field so they act jointly as tiny 'magnets'. The negative poles of these polar molecules are attracted by the positive charge of the Stick.

4. **Move an empty Soft Drink Can**

★ Find an empty soft drink can and place it on its side on a level surface.
★ Start the Fun Fly Stick (positive charge) and hold the control tube **parallel** to the can.
★ The can should roll toward the Stick. See how fast you can get it rolling without touching the Stick.
★ Now - charge an inflated balloon (negative charge) by rubbing on dry hair. Bring the balloon close to the can. Note that both positive and negative charges attract the can. Induction!

Why? The Stick and balloon both induce opposite charges on the soft drink can's side closest to them and opposite charges will attract!

5. **Power a lamp with the Fun Fly Stick . . . Really??**



- ★ Locate a high voltage neon lamp from an electronics supplier. We have used a 100V NE2 neon lamp.
- ★ Darken the room, hold one lead of the lamp with your fingers and bring the activated Fun Fly Stick close the the other lead. Watch for the orange / red glow gas discharge.
- ★ You may also want to clamp one lead to a grounded metal clip and then approach the lamp with the Stick.

6. **Make an opposing Static Stick**

- ★ Find a piece of fur (rabbit skin) or woolen cloth and any piece of PVC tube. (A standard type of plumbers' down pipe works well.)
- ★ Rub the cloth up and down on the tube. The PVC tube will build up a nett negative charge (see series above).
- ★ Have someone fly a tinsel toy with the Fun Fly Stick (positive charge) and try to intercept the toy. The tinsel should speed to your wand as it carries a positive charge. On touching it will gain a net negative charge and speed off to the Fun Fly Stick. Rub the tube again to regain the charge.
- ★ You may also want to **drop** a neutral tinsel toy onto the charged wand to see it come alive. Do not touch the wand else you will neutralize the wand.

7. **Float some Touchable Bubbles**

★ Buy a tube of touch-a-bubble mix and blow a few bubbles.

★ Approach one bubble with the activated Fun Fly Stick. As the bubble touch the Stick, it acquires a like charge and speeds off. Try to charge another bubble and see the interaction amongst the two: "Like bubbles repel!"
★ Additional idea: Fill a balloon with a little bit of hydrogen or helium gas so it barely floats. Now charge it and move it about the room with the Stick.

8. **Glue a sheet of paper to a wall**

★ Hold a sheet of paper against a white board or wall.
★ Activate the Fun Fly Stick and stroke the paper with the control tube. Let go of the paper and 'glue' it onto the surface further by moving the Stick up and down on the paper.
★ Check how long it will stick. Compare metal surfaces with other surfaces.

Why? The sheet of paper touches the Stick and carries a slight positive charge and it gets stuck to the neutral wall through induction. As with paper, the wall is a poor conductor too and the paper only drops after ionized air particles and electrons in the wall neutralize it.

9. **Feel the "electric wind"**

- ★ Position a large needle or thin metal axle on the end of the Fun Fly Stick control tube using some sticky stuff or a cork stopper.
- ★ Lick the palm of your (clean!) hand and bring the needle close to the palm while activating the Fun Fly Stick. You should feel the coldness of moving ionized air particles, producing an 'electric wind'.
- ★ You may want to push your luck a bit with the following: Place a burning candle close the tip of the needle. Make sure there are no drafts in the room. If you're lucky you'll see a slight movement of the flame. (This can be that intense on a Van de Graaff generator that the flame can be snuffed!)

Why? Electrostatic charges are not distributed evenly on the surface of a needle. The charge concentration at the tip of the needle is so intense that it ionizes the air in its neighbourhood. Negative air ions will rush toward the needle tip and positive ions will move away due to repulsion. The movement of these ions create the 'electric wind'.

10. **Fly rice bubbles or polystyrene spheres**

- ★ You will need an empty metal Berocca™ effervescent tablet tin (or similar).
- ★ Fill the tin with Rice Bubbles (breakfast cereal) so it protrudes above the tin. Place the tin on a polystyrene cup for insulation.

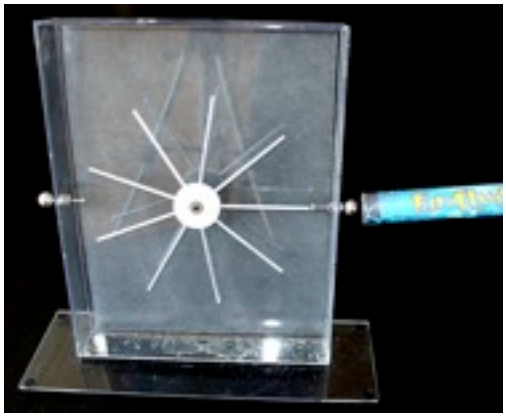
★ Now, activate the Fun Fly Stick and "energize" the tin by bringing the control tube close to it. You may try to touch it too. The top layers of Bubbles will fly off.
★ When the 'eruption' stops, lower your (neutral) hand and see what happens.
★ Small polystyrene spheres will do the same.

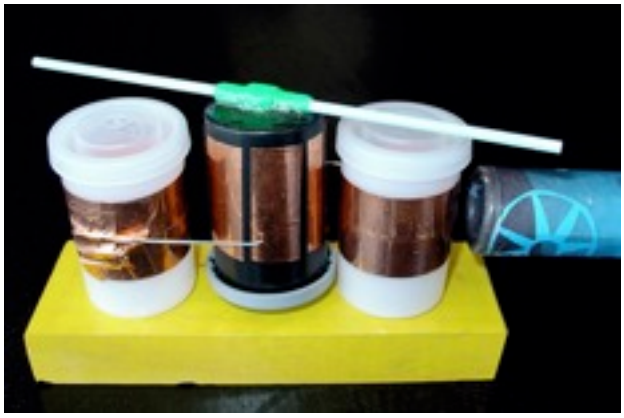
11. **Fly Flying Saucers**

This demonstration will really challenge the output of the Fun Fly Stick.

★ Find a pack of the smallest aluminium pie pans you can get.
★ Stack a number of them upside down on top of each other on a polystyrene cup.
★ Activate the Fun Fly Stick and 'energize' the pans.
★ It might take a few seconds but in a dry environment the pans should take off one after the other. You may lower your neutral hand to the pans to accelerate the process.

12. **Run an Electrostatic Motor**





★ Electrostatic motors are simply low friction electric motors based on the attraction and repulsion of electric charges.
★ The motor on the left is a high precision electrostatics motor from an American supplier. It is easily powered by the Fun Fly Stick. (See our video online)
★ The motor on the right is our DIY Film Canister Motor based on the Soft Drink Bottle electrostatics motor design by William J Beaty (http://amasci.com/emotor/emot1.html).

- ★ An empty film canister balances and rotates around a sharp axle. We have used an aquarium tube T-piece as a bearing for the metal axle. The two white tubes connected to the T-piece has no function but to indicate the movement. The outer surface of the canister has a number of vertical copper foil adhesive strips stuck to it. You may use aluminium foil strips glued on with contact adhesive. Copper or aluminium foil rolls with adhesive backing are found at craft supply stores.
- ★ Two static film canisters flank the rotating canister. They are attached to the wooden base with screws. Each has metal foil wrapped around it with a wire extending toward the rotating canister ("brush wire"). Simply tape the wire to the metal foil.
- ★ To operate: Position the brush wires as close as possible to the rotating canister. Touch one static canister with your finger and the activated Fun Fly Stick with the other. (You may replace your finger with a wire touching the metal rim of the button on the Fun Fly Stick and the static canister (Earthed wire)).

Why?
The static canister closes to the Fun Fly Stick acquires a positive charge imbalance due to the contact from the Fun Fly Stick. The other static canister acquires a negative nett charge due to your finger. Tiny sparks jump from the brush wires to the foil sectors closest to the brushes on the rotor canister. The sector under the positive brush becomes positive, the one under the negative brush becomes negative. The rotor's foil sectors are then repelled from the alike-charged static canister and attracted to the unlike charged static canister. This sideway electrostatic force causes the center canister to rotate, which brings new foil sectors under the brushes and the process repeats.
(*Source: W J Beaty*)

13. **Make an Electrostatic Drummer**

- ★ Locate a light-weight ball and glue a piece of yarn to it. Wrap the ball in thin aluminium foil.
- ★ Suspend the ball from a bar or retort stand so that it is positioned mid-way between the bottom ends of two metal cans. The cans are best insulated from the work surface using polystyrene cups or a piece of polystyrene.
- ★ Hold your finger to the one can and start the Fun Fly Stick. Approach the other can with the Stick.
- ★ The suspended ball should run to and throw between the two cans as it transfers charges, causing a drumming sound.
- ★ Now - remove your hand. The periodical motion should stop. Why? Bring it back again.

Why? This is a great demonstration incorporation, induction, charge attraction & repulsion. The neutral ball is attracted to the positive can due to induction. Once it touches the can it

acquires the same charge and is repelled away. It is attracted to the other can carrying the opposite charge, touches the can, is neutralized and acquires a net negative charge and speeds off in the other direction. And the process repeats itself . . .

References

- Homemade Lightning, R A Ford, McGraw-Hill, 1996
- Email from Fun Fly Stick inventor, Boris Kriman, November 2008
- Other sources as indicated in the text