

# Levitation Principles

**Pre-requisites:** understanding of atoms, electrons, protons, static electricity, charges, discharge, e-field, insulators, conductors, polarization, and induction.

**Recommended Reading:** FunFlyStick Electrostatics, by Carl Ahlers, Prof Bunsen Science

Launch a Fun-Flyer (Mylar shape) according to the instructions included with your wand. The Fun-Flyer floats by repelling electric field of the Fun-Fly-Stick.

When you turn the Fun-Fly-Stick on, it begins separating positive and negative charges. The positive charge gets accumulated on the control tube – the cardboard tube mounted on top of the wand. When the shape touches the control tube, it acquires positive charge and immediately repels from the control tube because they now have the same charge. The shape opens up because it repels within itself due to the same charge being distributed along the entire surface of the shape.

To levitate shapes you need to have two things: a statically charged object (either Fun-Fly-Stick or latex balloon, or PVC pipe) and a shape able to float on an electric field.

To float, the material has to be lightweight and conductive. For example, a shape made of the thinnest paper tissue, Christmas tree tinsel, or a metallic thread will float because it is both lightweight and conductive.

Gravity is stronger than the e-field of the charged object. The material has to be lightweight to be able to defy gravity. The more weight it has, the lower it sinks (if it even takes off the wand at all). But why do we choose conductive materials?

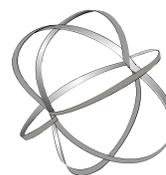
A non-conductive material (insulator) upon contact with a charged object merely gets polarized, not charged. Therefore there is little attraction between the non-conductive material and the charged object.

A conductive material gets charged almost instantly either on contact or through induction. If the e-field of the Fun-Fly-Stick is strong due to an accumulation of charge,

the small flying toys (like the butterfly) may not even touch the Fun-Fly-Stick to get charged.

The charge on a shape gets distributed on the entire surface. This causes every part of the shape to repel from every other part.

A shape consisting of strands tied together on both ends opens up into a floating orb, much like a globe with meridians. The repulsion of like charges within the shape itself causes the shape to open up and become 3-dimensional.

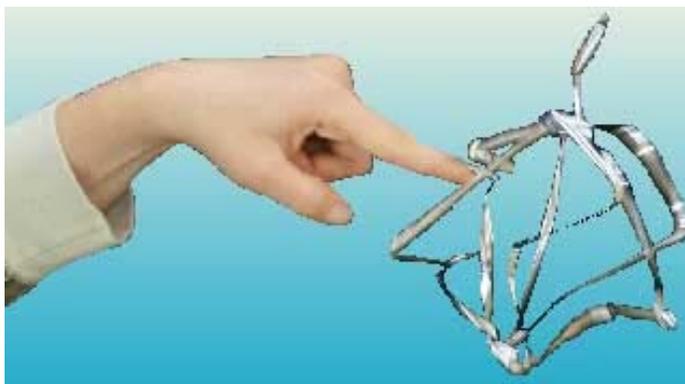


The shape, when afloat, is surrounded by an e-field of the same charge as the Fun-Fly-Stick. It repels only from the control tube of the Fun-Fly-Stick or any other object charged with the same charge. That is why floating two flyers at the same time is a challenge; they repel each other. When you press the button on the Fun-Fly-Stick you increase the charge on the control tube and thus expand the e-field. When the floating shape rises higher and higher, some people try reaching it with the charged Fun-Fly-Stick. This causes the floating shape rise even higher and escape the e-field.

All the objects surrounding us are mostly neutral. An e-field approaching a neutral object causes electrostatic induction in conductors and polarization in insulators. Thus, when the floating shape nears a wall, a person, furniture, or any other object, its e-field causes redistribution of charge in that object. The positive e-field surrounding the floating shape induces negative charge in generally neutral objects. This in turn causes the floating shape to attract to those neutral objects. If it touches the object a discharge occurs and the flyer loses its charge.

This is why instead of chasing the floating shape that has risen too high with the Fun-Fly-Stick and repelling it, the best way to get it down is simply to extend your free hand toward it. “The Beckoning Hand” magic trick when you float a shape and then make it follow your hand by approaching its e-field and moving the hand away with the same speed the shape attracts to it, makes people think that your hand has some magnetic powers. Now we know that it really gains those magnetic powers by induction!

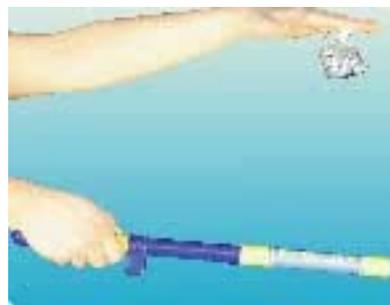
Experiment: Launch a shape and let it rise up to your eye level. Touch the floating shape with the index finger of your free hand. It collapses and drops down lifeless. “Catch” it with the control tube of your activated Fun-Fly-Stick. The shape will



expand again and spring up to life. Repeat several times.

Why does this happen? Your body is a conductor. Once your finger touches a positively charged conductive shape, the electrons from your body instantly migrate on to the flying shape, causing it to lose the charge and collapse. Touching it with the Fun-Fly-Stick charges the shape again. Once the shape has the charge, it repels within itself and repels from the wand, creating a feeling of magic.

Experiment: Launch any small shape and put the palm of your free hand above it. Trapping the shape between the control tube of the Fun-Fly-Stick and your palm causes the shape to bounce back and forth. The process repeats itself creating a vision of a “jumping” shape.



Why? Touching the control tube of the activated Fun-Fly-Stick causes the shape to charge with the same charge as the Fun-Fly-Stick and repel. On the way up the shape meets your hand, touches it, and instantly discharges because your body is a conductor and the shape is a conductor too.

The e-field of the Fun-Fly-Stick pulls the shape toward the wand where it gets recharged upon contact (or by induction) and repels again, moving up toward your hand. You can also do the same trick bouncing the shape from side to side.

Experiment: Isolate a person from the ground by having him or her stand on an insulator. As an insulator, you can use interlocking foam floor tiles, rubber-soled shoes, a plastic sheet, or another insulating material.



Have the person extend one hand with an open palm facing up. Place the Mylar

shape on the open palm. Have the person hold the control tube of the Fun-Fly-Stick with the other hand. Turn on the Fun-Fly-Stick and observe the Mylar shape slowly expand and take off.

Why? Isolating the person from the ground is the same as isolating a large conductive object from the ground. When the person holds the control tube of the activated wand, all the charge created by the Fun-Fly-Stick gets transferred onto the conductive object – the person. The contact between the wand and the isolated person drains the electrons from the person's body leaving him positively charged. This gives the charged person a power to levitate the shapes with his/her hands instead of using the Fun-Fly-Stick.

If the charged person, who is being isolated touches another person who is not charged, this will produce a spark or a zap caused by the electrons flowing from the non-charged person into the charged person through the point of contact. If the point of contact is the nose of one person and index finger of another, the spark may be very visible and will often makes students laugh.

When you charge the person isolated from the ground with the Fun-Fly-Stick, they receive a positive charge. However, you can also charge yourself with the opposite charge. To do so you have to also be isolated and hold the Fun-Fly-Stick while charging another person. Alternatively, you can isolate yourself from the ground and touch a large conductive object (a door knob, a conductive wall). The positively charged control tube attracts electrons from the conductive object it touches and transfers them onto you via the belt and the metal rim of the button.