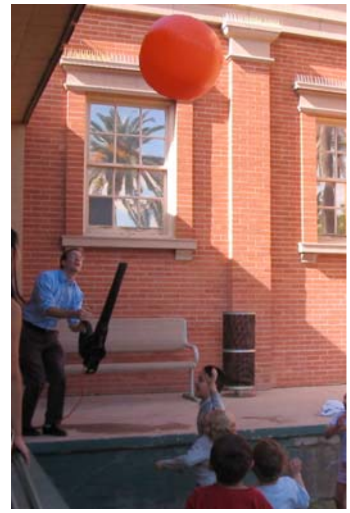
# Demonstration Explanations

## Bernoulli Ball

**AZ Strand 5: Physical Science, Concept 2: Properties and Changes of Properties in Matter, PO 2. Describe the various effects forces can have on an object (e.g., cause motion, halt motion, change direction of motion, cause deformation). PO 9. Represent the force conditions required to maintain static equilibrium.**



Most of us have no problem understanding that a powerful blast of air from a leaf blower can support the weight of a ball. What is not easy to understand is how the ball is able to balance there without falling out of this stream of air. If it isn't immediately clear how weird this is, try balancing a beach ball on the end of a broomstick. When the blower is pointing straight up, the fast moving air between the leaf blower and ball pushes the ball away, lifting it up. The rest of the air has no place to go but around the ball—this is where the weird stuff happens. At first you might think of this air as a moving tube or pipe that pushes the ball inward from all sides, but this is actually backwards. Instead, this tube of air is sucking the ball outwards from all sides, keeping it in the middle! When the blower is tilted, the air that curves around the top of the ball actually helps lift the ball perpendicular to the stream of air. The reason it's called the *Bernoulli Ball* is because Daniel Bernoulli was the one who figured out that fast moving air pulls things perpendicularly toward the flow.

## Van de Graaff

**AZ Strand 5: Physical Science, Concept 3: Energy and Magnetism, PO 2. Investigate how forces can make things move without another thing touching them (e.g., magnets, static electricity). PO 2. Investigate how forces can make things move without another thing touching them (e.g., magnets, static electricity).**

All things are made up of atoms. Atoms have three main parts, the neutrons and protons in the nucleus, and the electrons around the nucleus. It's a pretty involved process to take parts away from the nucleus, but normal people give and take electrons from atoms all the time. We know this when we get a small zap from a doorknob. This 'trading' of electrons among atoms is called electricity. Some materials have a tendency to give up their electrons like people who can't help spending money, and other materials have a tendency to collect electrons like people who save every penny. If you put two of these materials together, one will keep giving up electrons, and the other will keep collecting more and more. A good example of this is when you rub a balloon on your head; your hair looses its electrons to the balloon as the balloon collects electrons from your hair. Because electrons are negatively charged, the balloon becomes negatively charged in this process (and your head becomes positively charged!) A Van de Graaff generator has a relatively simple construction—two rollers and a belt between them. One roller gives up electrons, the other roller takes electrons, and the belt between them is basically an electron one-way superhighway. This keeps the electron-collecting process going and crowds as many of them as possible on the large dome at the top. There, the electrons wait to jump onto something less crowded, like your finger.

## Liquid Nitrogen

**AZ Strand 5: Physical Science, Concept 1: Properties of Objects and Materials, PO 3. Demonstrate that water can exist as a: gas – vapor, liquid – water, solid – ice.**

Nitrogen is a gas that makes up most of our atmosphere. Like most other elements, it has a melting point, a freezing point, and a boiling point. Liquid nitrogen is simply nitrogen that is so cold (-320°F) that it has condensed into its liquid form. When liquid nitrogen is exposed to things that are at room temperature, even the air in the room itself, it acts like water on a hot stove and it expands into a gas. This is because, compared to the liquid nitrogen, room temperature things are really, really hot! The 'smoke' you see is actually water vapor—the same stuff clouds are made of. When room temperature things are submerged in liquid nitrogen, they become really cold. When an air-filled balloon is submerged in liquid nitrogen, the molecules become so densely packed that the balloon shrivels up like a raisin! Liquid water in liquid nitrogen immediately becomes solid ice. Even solids change when they touch liquid nitrogen. Normally, solids come in various degrees of flexibility and 'springyness'; there are 'mushy' solids like pizza dough, and 'bouncy' solids like rubber bands. This is because solids have different degrees of flexibility in the bonds between their molecules. However, when submerged in liquid nitrogen for a while, racquetballs and flowers become as brittle and breakable as a wine glass!

## Master Violet Ray / Tesla coil

**AZ Strand 5: Physical Science, Concept 3: Energy of Magnetism, PO 1. Demonstrate that electricity flowing in circuits can produce light, heat, sound, and magnetic effects.**

Moving electrons make magnetic fields. If you form a loop with an electron-carrying wire, a magnetic field is created in the middle of the loop. This field acts as if an 'imaginary magnet' is in the middle of the loop. The poles of this imaginary magnet depend on the direction the electrons are flowing. If the electrons change direction, the poles of the imaginary magnet flip over. Just like moving electrons make magnets, moving magnets make electrons move. When a magnet moves through a loop of wire it makes the electrons move around the loop. The direction the electrons move depends on which pole of the magnet entered the loop. Since an electron-carrying loop of wire also acts like a magnet, electrons can be made to move with the changing magnetic field of another wire. Making electrons move with a changing magnetic field is called induction. If you keep switching the direction the electrons flow in the first loop, you will keep inducing electrons to move in the second loop, and the voltage you apply to the first loop will be identical to the voltage in the second loop. However, if the second loop has twice as many turns as the first loop, the voltage of the second loop will be double the voltage of the first loop. If the first loop has one turn and 10 volts, and the second loop has 100 turns, the second loop will have 1000 volts! Using this, you can make virtually any voltage from the plug in the wall of your house. The master violet ray 'steps' up the voltage to 10,000.

## Hovercraft

**AZ Strand 5: Physical Science, Concept 2: Motion and Forces, PO 2. Identify the conditions under which an object will continue in its state of motion (Newton's 1st Law of Motion).**

We live in a world of friction. If we push a toy car or roll a ball, they both eventually stop. Imagine you are in outer space and you throw a baseball out the window of your spaceship. The baseball will continue in the same direction, and with the same speed, for years and years (as long as it doesn't come too close to a gravitational body). The hovercraft allows us a taste of this perpetual motion, though is unfortunately not an anti-gravity device. Here's how it works. A strong blower sends air downward and the carefully designed sheet underneath allows the air to escape evenly around the entire perimeter. This creates a thin cushion of air between the hovercraft and the ground. Because of this, there is less friction between the hovercraft and the ground than there is between ice skates and ice! On a perfectly flat surface, one push on the hovercraft and you might go a few miles. Eventually you'd stop because of air resistance (one more reason we don't have perpetual motion on Earth).

## Vacuum Packing

**Strand 5: Physical Science, Concept 1: Properties of Objects and Materials, PO 4. Demonstrate that solids have a definite shape and that liquids and gases take the shape of their containers.**

If we could see air, we would see that it covers the Earth like a blanket. We would also notice that the top of the blanket was light and fluffy, and the bottom, where we are, was packed tightly. The reason for this is simple. Imagine a stack of pancakes 10 miles high. The top pancake doesn't have anything pushing on it, so it's fluffy. But the bottom pancake has150 thousand pancakes sitting on top of it, and all that weight squeezes the pancake into a tiny space. The same is true of air. The weight of Earth's blanket of air pushes down on us with a force of about 15 pounds per square inch. That's like having a 15 pound weight sitting on a space as big as your big toe! So why don't we feel the weight of all that air? First of all, we were born with all this pressure on us so we don't really notice it. But also, air not only pushes down, it pushes up, sideways and in every direction. In fact, air even pushes outward from within our body with the same force as the air pushing inward from outside our body! In this experiment, we put you in an airtight bag. Normally when you put something in a bag and seal it there is air trapped inside the bag too. This air claims a certain amount of space no matter how hard you squeeze it. When we put kids inside a bag for our demonstration, we use a vacuum cleaner to suck air out from between the bag and your body. With all the weight of the atmosphere pushing on the bag and no air molecules in the bag to push back, the bag gets pushed toward your skin.

## Rubens Tube (otherwise known as the “Flame Tube”)

**Strand 5: Physical Science, Concept 5: Interactions of Energy and Matter, PO 2. Describe the following characteristics of waves: wavelength, frequency, period, and amplitude**


If we could look inside a flute when it is playing a note we wouldn’t see anything making the sound. Sound is made of invisible waves, which travel to your ear through the air at over 750mph. The flame tube allows us to ‘see’ what we could otherwise only hear. The flames are fueled by gas that escapes through small holes in the propane filled tube. A speaker at the end of the tube produces specific notes that are sung or played on the keyboard. Hills and valleys in the flames reveal areas of high and low pressure in the tube because the height of any individual flame is controlled by how much propane flows out of that particular hole. The sound waves actually go over 1000mph in propane, but they appear to stand still. These ‘standing waves’ occur when waves that have bounced off the end of the tube interfere with oncoming waves.

### Ping Pong Ball Cannon


Have you ever tried to throw a ping pong ball so hard that it goes right through an aluminum can? You’re lucky if you can throw a ping pong ball 30 feet! Every time something moves through the air it has to push all the air molecules aside. When we’re walking we don’t even notice we’re doing this with our body, but next time you’re going down the highway in a car try holding your hand out the window flat (as if to signal “stop” to all the people in front of you.) The way your hand feels when doing this is what the ping pong ball experiences when we throw it. The ping pong ball has to push all the molecules in the air aside so it can get through. And it doesn’t have the help of a strong arm and a car to keep it going! The ping pong ball cannon gets the ping pong going at a very high rate of speed over a very short distance. At first you might think that it works much the same way the potato bazooka works, but actually it is quite the opposite! The ping pong ball cannon is a pipe that is sealed at both ends by nothing more than some common packing tape. The ping pong ball rests at one end. Most of the air is sucked out of the pipe by a vacuum pump; this means there isn’t much for the ping pong ball to push aside. When the tape is punctured, the weight of the atmosphere pushes against the ball, accelerating it until it punctures the tape at the other end and blasts right through the can!

### The Hoot Tube

**AZ Strand 5: Physical Science, Concept 3: Energy and Magnetism, PO 3. Demonstrate that vibrating objects produce sound.**

When air oscillates in a pipe that is open on both ends. During half of the oscillation it is moving in form the ends, compressing the air, and during the other half of the oscillation, the air is moving out of the ends, decompressing the air in the center. If nothing else is happing inside, then the oscillations gradually die away by radiating sound. However, if there is a screen of hot wires at the right place in the tube, then when the air is moving it extracts heat from the wires. This added heat energy makes up for the energy lost radiating sound and keeps the oscillations going.

## Potato Bazooka

The potatoes that fly from the barrel of our potato cannon have been clocked at over 375mph. This is about half the speed of sound! In a real bazooka a flammable powder is ignited and the resulting explosion pushes the projectile out, but in our bazooka there is no thing flammable. Instead we used compressed carbon dioxide from a high pressure cylinder (the same kind used to carbonate your soda). There are three basic parts to the bazooka: the air chamber, the barrel, and an electric valve between them. The air chamber holds highly compressed gas. The gas pushes on the walls of the chamber with the pressure of about 300 pounds for every square inch. The potato has about 3 square inches for the air to push on. This means that 900 pounds of force push the potato out of the barrel. The longer the barrel is, the longer the potato has this force behind it, so the longer it has to accelerate.

## Smoke Rings


The smoke ring cannon is a garbage can with a hole in the bottom and plastic fastened over the top. When the plastic is pushed toward the hole, it forces all the air in the center of the can to move out of the center of the hole very quickly. The ring of air that is *not in the center* is stopped by the bottom of the trash can. This ring, with its inside moving quickly forward and its outside moving backward, is called a "toroidal vortex". Toroidal vortices have the unique ability to glide through the air almost undisturbed by the air they travel through.

## The Whoosh Bottle

**AZ Strand 5: Physical Science. Concept 4: Chemical Reactions PO 9. Predict the products of a chemical reaction using types of reaction (e.g., synthesis, decomposition, replacement, combustion).**

The whoosh bottle has explosive gases inside it. When these gases are ignited, molecular bonds are broken which creates heat. Hot gasses take up more room and there's only so much room in the bottle. The only have one way to escape, through the neck of the bottle. This is similar to how a rocket engine works (except rocket engines are usually pointed downward!)