Science Experiment Manual

A collection of 167 quick and inexpensive science activities guaranteed to rocket launch your brain into a higher state of Ah-HA!

Developed by a real scientist and university educator

"Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world."

-- Albert Einstein

By Aurora Lipper

Supercharged Science

Version 1.4: January 2009

Special Note: All experiments are to be completed at your own risk. You are responsible your own safety, as well as the safety of those around you. If you are not sure about an experiment, don't do it or get help from an experienced adult (someone with a successful track record of doing whatever it is you want to do). In all seriousness, be safe, have fun, and if you run into any problems that stump both you *and* those you consult, let us know. The rest of you guys… Stay indoors when it rains!

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Chapter 1: Air Pressure & Aeronautics

There's air surrounding us everywhere, all at the same pressure of 14.7 pounds per square inch (psi). You feel the same force on your skin whether you're on the ceiling or the floor, under the bed or in the shower.

An interesting thing happens when you change a pocket of air pressure - things start to move. This difference in pressure causes movement that creates winds, tornadoes, airplanes to fly, and some of the experiments we're about to do in this chapter.

An important thing to remember is that **higher pressure always pushes** stuff around. While lower pressure does not "pull," we think of higher pressure as a "push".

Another interesting phenomenon occurs with fast-moving air particles. When air moves quickly, it doesn't have time to push on a nearby surface, such as an airplane wing. The air just zooms by, barely having time to touch the surface. These air particles are really in a rush. Think of very busy people driving fast in their cars. They are so busy doing other things and driving fast to get somewhere that they don't have time to just sit and relax.

Air pressure works the same way. When air zooms by a surface (like an airplane wing), the fast air has no time to just sit there and push on the surface, so not much air weight gets put on the surface. Less weight means less force on the area. You can think of "pressure" as force on a given area or surface. Therefore, a less or *lower* pressure region occurs wherever there is fast air movement.

There's a reason airplane wings are rounded on top and flat on the bottom. The rounded top wing surface makes the air rush by faster than if it were flat. When you put your thumb over the end of a gardening hose, the water comes out faster when you decrease the size of the opening. The same thing happens to the air above the wing: the wind rushing by the wing has less space now that the wing is curved, so it zips over the wing *faster*, and creates a lower pressure area than the air at the bottom of the wing.

Air Pressure Experiment 1. 1: Soda Can Trick

DVD: Aeronautics, track 1

CD: Aeronautics, track 2

Materials: About 25 straws, two empty soda cans (not included)

Lay a row of straws parallel to each other on a smooth tabletop. Place two empty soda cans on the straws about an inch apart. Lower your nose to the cans and blow *hard* through the space between the two cans. Clink! They should roll toward each other and touch!

Why does this happen? When air moves, the air pressure decreases. This creates a lower air pressure pocket right between the cans relative to the surrounding air. Because higher pressure *pushes*, the cans clink together. Just remember – whenever there's a difference in pressure, *the higher pressure pushes.*

Air Pressure Experiment 1.2: Fountain Bottle

DVD: Aeronautics, track 2

CD: Aeronautics, track 2

Materials: small lump of clay, water, a straw, and one empty 2-liter soda bottle (not included)

Fill a 2-liter soda water bottle full of water and seal it with a lump of clay wrapped around a long straw so that the straw is secured to the mouth of the bottle. (The straw should be partly submerged in the water.) Blow hard into the straw. Splash!

What happened? As you blow air into the bottle, the air pressure increases inside the bottle. This higher pressure pushes on the water, which gets forced up and out the straw (and up your nose!).

Air Pressure Experiment 1.3: Squished Balloon

DVD: Aeronautics, track 3

CD: Aeronautics, track 2

Materials: a balloon, one empty glass jar (not included), and scrap of paper towel (not included), matches (not included), and an adult

Blow up a balloon so that it is just a bit larger than the opening of the jar and can't be easily shoved in. With an adult, light the small wad of paper towel on fire and drop it into the jar. Place the balloon on top. When the fire goes out, lift the balloon. The jar goes with it!

What's going on? Fire eats air, or in more scientific terms, the air gets used up by the flame and lowers the air pressure inside the jar. The surrounding air outside the jar is now at a higher pressure than the air inside the jar and it pushes the balloon into the jar. Remember: *Higher pressure pushes!*

Air Pressure Experiment 1.4: Sneaky Bottles

DVD: Aeronautics, track 4

CD: Aeronautics, track 2

Materials: two balloons, one tack, and two empty water bottles (not included)

Poke a balloon into a water bottle and stretch the balloon's neck covering the mouth of the bottle from the inside. Repeat with the other bottle. Using the tack, poke several small holes in the bottom of one of the water bottles. Putting your mouth to the neck of each bottle, try to inflate the balloons.

What's going on? This experiment illustrates that air really does take up space! You can't inflate the balloon inside the bottle without the holes, because it's already full of air. When you blow into the bottle with the holes, air is allowed to leak out making room for the balloon to inflate. With the intact bottle, you run into trouble because there's nowhere for the air already inside the bottle to go when you attempt to inflate the balloon.

A cool twist on this activity is to drill a larger hole in the bottle (say, large enough to be covered up by your thumb) and inflate the balloon inside the bottle with hole open, then plug up the hole with your thumb. The balloon will remain inflated even though its neck is not tied! Where is the higher pressure region now?

Air Pressure Experiment 1.5: Streaming Water

DVD: Aeronautics, track 5

CD: Aeronautics, track 2

Materials: A tack, and a plastic water bottle with cap (not included), and bathtub (not included)

Fill the bathtub and climb in. Grab your water bottle and tack and poke several holes into the lower half the water bottle. Fill the bottle with water and cap it. Lift the bottle above the water level in the tub and untwist the cap. Water should come streaming out. Close the cap and the water streams should stop. Open the cap and when the water streams out again, can you "pinch" two streams together using your fingers?

What's happening? First, you're getting clean. Second, you're playing with pressure again. Watch the water level when you uncap the bottle. As the water streams out, the water level in the bottle moves downward. Notice how the space for air increases in the top of the bottle as the water line moves down. (The air comes in through the mouth of the bottle.) When you cap on the bottle, there's no place for air to enter the bottle. The water line wants to move down, but since there's no incoming air to equalize the pressure, the flow of water through the holes stops. Technically speaking, there's a small decrease in pressure in the air pocket in the top of the bottle and therefore the air outside the bottle has a higher pressure that keeps the water in the bottle. *Higher pressure pushes!*

Air Pressure Experiment 1.6: Magic Water Glass Trick

DVD: Aeronautics, track 6

CD: Aeronautics, track 2

Materials: a glass (not included), and an index card large enough to completely cover the mouth of the glass

Fill a glass one-third with water. Cover the mouth with an index card and over a sink invert the glass while holding the card in place. Remove your hand from the card. Voila! Because *atmospheric* air pressure is pushing on all sides of both the glass and the card, the card defies gravity and "sticks" to the bottom of the glass. Recall that higher pressure *pushes and when* you have a difference in pressure, things move. This same pressure difference causes storms, winds, and the index card to stay in place.

Where's the pressure difference in this trick? At the opening of the glass. The water inside the glass weighs a pound at best, and, depending on the size of the opening of the glass, the air pressure is exerting 15-30 pounds upward on the bottom of the card. Guess who wins? Tip, when you get good at this experiment, try doing it over a friend's head!

Air Pressure Experiment 1.7: Air Takes Space

DVD: Aeronautics, track 7

CD: Aeronautics, track 2

Materials: 12" flexible tubing, two clear plastic cups, bathtub (not included)

Part I: Fill the tub and climb in. Plunge one cup underwater so it fills completely with water. While the cup is underwater, point its mouth downward. Insert one end of the tubing into the cup and blow hard into the other end. The water is forced out of the cup!

Part II: While still in the tub, invert one cup (mouth downwards) and plunge it into the tub so that air gets trapped inside the cup. Place the second cup in the water so it fills with water. Invert the water-filled cup while underwater and position it above the first cup so when you tilt the first cup to release the air bubbles, they get trapped inside the second cup. Here you see that air takes space, because in both variations of this experiment the air forced the water out of the cups.

What's happening? You're playing with one of the first methods of underwater breathing developed for scuba divers hundreds of years ago. Back then, scientists would invert a very large clear, bell-shaped jar over a diver standing on a platform, then lower the whole thing into the water. Everyone thought this was a great idea, until the diver ran out of breathable air!

Air Pressure Experiment 1.8: Ping Pong Funnel

DVD: Aeronautics, track 8

CD: Aeronautics, track 2

Materials: A funnel and a ping pong ball

Insert a ping pong ball into a funnel. Place the stem of the funnel between your lips and tilt your head back so ball stays inside. Blow a strong, long stream of air into the funnel.

Hey! How come the ball doesn't fly out of the funnel? As you blow into the funnel, the air under the ball moves faster than the other air surrounding the ball, which generates an area of lower air pressure. The pressure under the ball is therefore lower than the surrounding air which is, by comparison, at a higher pressure. This higher pressure pushes the ball back into the funnel, no matter how hard you blow or which way you hold the funnel. The harder you blow, the more stuck the ball becomes. Cool.

Air Pressure Experiment 1.9: Hot Air Balloons

DVD: Aeronautics, track 9

CD: Aeronautics, track 2

Materials: A lightweight plastic garbage bag, duct or masking tape (not included), a hand-held hair dryer (not included)

About 400 years ago, Leonardo da Vinci wanted to fly… so he studied the only flying things around at that time: birds and insects. Then he did what any normal kid would do—he drew pictures of flying machines!

Centuries later, a toy company found his drawing for an ornithopter, a machine that flew by flapping its wings (unlike an airplane, which has non-moving wings). The problem (and secret to the toy's popularity) was that with its wing-flapping design, the ornithopter could not be steered and was unpredictable: It zoomed, dipped, rolled, and looped through the sky. Sick bags, anyone?

Hot air balloons that took people into the air first lifted off the ground in the 1780s, shortly after Leonardo da Vinci's plans for the ornithopter took flight. While limited seating and steering were still major problems to overcome, let's get a feeling for what our scientific forefathers experienced as we make a balloon that can soar high into the morning sky.

Shake out a garbage bag to its maximum capacity. Using duct or masking tape, reduce the opening until it is almost-closed leaving only a small hole the size of the hair dryer nozzle. Use the hair dryer to inflate the bag, heating the air inside, but make sure you don't melt the bag!

When the air is at its *warmest*, release your hold on the bag while at the same time you switch off the hair dryer. The bag should float upwards and stay there for a while.

Troubleshooting: This experiment works best on *cold, windless* mornings. If it's windy outside, try a cool room. The greater the temperature difference between the hot air inside the garbage bag versus the cold, still air, the faster the bag rises. The only other thing to watch for is that you've taped the mouth of the garbage bag securely so the hot air doesn't seep out. Be sure the opening you leave is only the diameter of your hair dryer's nozzle.

Air Pressure Experiment 1.10: Genie in a Bottle

DVD: Aeronautics, track 10

CD: Aeronautics, track 2

Materials (not included): Two identical tall glasses, hot water, cold water, red and blue food dye, and an index card larger enough to cover the opening of the glasses

While this isn't actually an air-pressure experiment but more of an activity in density, really, it's still a great visual demonstration of why Hot Air Balloons rise on cold mornings.

Imagine a glass of hot water and a glass of cold water sitting on a table, side by side. Now imagine you have a way to count the number of water molecules in each glass. Which glass has more water molecules?

The glass of cold water has *way* more molecules… but why? The cold water is more dense than the hot water. Warmer stuff tends to rise because it's less dense than colder stuff and that's why the hot air balloon in experiment 1.10 floated up to the sky.

Clouds form as warm air carrying moisture rises within cooler air. As the warm, wet air rises, it cools and begins to condense, releasing energy that keeps the air warmer than its surroundings. Therefore, it continues to rise. Sometimes, in places like Florida, this process continues long enough for thunderclouds to form. Let's do an experiment to better visualize this idea.

Fill two identical water glasses to the brim: one with hot water, the other with cold water. Put a few drops of blue dye in the cold water, a few drops of red dye in the hot water. Place the index card over the mouth of the *cold* water and invert the glass over the glass of hot water. Line up the openings of both glasses, and *slowly* remove the card.

Troubleshooting: Always invert the cold glass over the hot glass using an index card to hold the cold water in until you've aligned both glasses. You can also substitute soda bottles for water glasses and slide a washer between the two bottles to decrease the flow rate between the bottles so the effect lasts longer.

Air Pressure Experiment 1.11: Squished Soda Can

DVD: Aeronautics, track 11

CD: Aeronautics, track 2

Materials (not included): An empty soda can, water, a pan, a bowl, tongs, and a grown-up assistant

An average can of soda at room temperature measures 55 psi before you ever crack it open. (In comparison, most car tires run on 35 psi, so that gives you an idea how much pressure there is inside the can!)

If you heat a can of soda, you'll run the pressure over 80 psi before the can ruptures, soaking the interior of your house with its sugary contents. Still, you will have learned something worthwhile: adding energy (heat) to a system (can of soda) causes a pressure increase. It also causes a volume increase (kaboom!).

How about trying a safer variation of this experiment using water, an *open* can, and implosion instead of explosion?

Prepare an ice bath by putting about ½" of ice water in a shallow dish. With an adult, place a few tablespoons of water in an empty soda or beer can and place the can upright in a skillet on the stove. When the can emits a think trickle of steam, grab the can with tongs and quickly invert it into the ice dish. CRACK!

The air in the can was heated and expanded. When you cool it quickly by taking it off the stove and placing it in the ice water, the air cools down inside and shrinks, creating a lower pressure inside the can. Because the surrounding air outside of the can is now higher, it pushes on all sides of the can and crushes it.

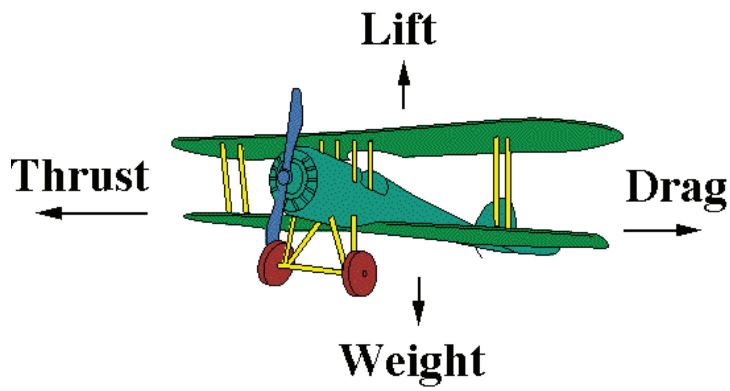
Troubleshooting: The trick to making this work is that the can needs to be full of hot *steam*, which is why you only want to use a tablespoon or two of water in the bottom of the can. It's alright if a bit of water is still at the bottom of the can when you flip it into the ice bath. In fact, there should be some water remaining or you'll superheat the steam and eventually melt the can. You want enough water in the ice bath to completely submerge the top of the can.

Always use tongs when handling the heated can and make sure you completely submerge the top of the can in the icy water. The water needs to seal the hole in the top of the can so the steam doesn't escape. Be prepared for a good, loud *CRACK!* when you get it right.

Aeronautics Experiment 1.12: Flying Paper Machines

DVD: Aeronautics, tracks 13-19 or watch the video online:
http://www.superchargedscience.com/paperairplanes.wmv

CD: Aeronautics, track 2



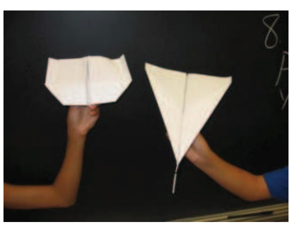
Materials: Sheet of paper, pencil (not included), and a hair dryer (not included)

Every flying thing, whether it's an airplane, spacecraft, soccer ball, or flying kid, experiences four aerodynamic forces: lift, weight, thrust, and drag. An airplane uses a propeller or jet engine to generate thrust. The wings create lift. The smooth, pencil-thin shape minimizes drag. And the molecules that make up the airplane attribute to the weight.

Think of a time when you were riding in a fast-moving car. Imagine rolling down the window and sticking out your hand, palm down. The wind slips over your hand. Suppose you turn your palm to face the horizon. In which position do you think you would feel more force against your hand?

When designing airplanes, engineers pay attention to details, such as the position of two important points: the *center of gravity* and the *center of pressure* (also called the *center of lift*). On an airplane, if the center of gravity and center of pressure points are reversed, the aircraft's flight is unstable and it will somersault into chaos. The same is true for rockets and missiles!

There are several different flying paper machine designs you can build right now. Pop in the DVD or watch the video online and start building! After you have your model, come back and we'll explore the finer details tweaking, trimming, and finding the lift points on your airplane.



Let's find the center of gravity on your airplane. Grab your flying machine and sharpened pencil. You can find the 'center of gravity' by balancing your airplane on the tip of a pencil. Label this point "CG" for Center of Gravity.

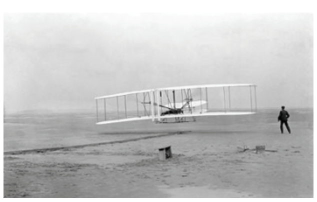
Find the Center of Pressure (CP) by doing the opposite: Using a blow-dryer set to low-heat so you don't scorch your airplane, blast a jet of air up toward the ceiling. Put your airplane in the air jet and, using a pencil tip on the top side of your plane, find the point at which the airplane balances while in the airstream. Label this point "CP" for Center of Pressure. (Which one is closest to the nose?)

Besides paying attention to the CG and CP points, aeronautical engineers need to figure out the static and dynamic stability of an airplane, which is a complicated way of determining whether it will fly straight or oscillate out of control during flight. Think of a real airplane and pretend you've got one balanced on your finger. Where does it balance? Airplanes typically balance around the wings (the CG point). Ever wonder why the engines are at the front of small airplanes? The engine is the heaviest part of the plane, and engineers use this weight for balance, because the tail (elevator) is actually an upside-down wing that pushes the tail section *down* during flight.

How does an airplane remain stable during flight? Positive stability means that the airplane is designed so that if the pilot jams on the controls during straight and level flight (in other words, pitch up hard), and then let go, the airplane will more or less return to straight and level flight.

Here's how that works: When the airplane's nose suddenly pitches up, the wind speed over the wings slows and decreases the lift on the plane. This causes the nose to tip downwards and the wind to rush over the wings again, creating more lift. This cycle eventually dampens out and soon the airplane is flying level again.

If, however, you have a negative stability (meaning that your CG is aft of or behind the CP), when the airplane suddenly pitches up, one of several things may happen, all of which require sick bags and a parachute. One of the worst cycles is this: When a tail-heavy plane noses down, the speed over the wings increases and provides more lift but only briefly, because a tail-heavy plane will keep its nose up until the wind speed slows so much that the winds stall. Lift is no longer generated by wind flowing over the wings, because there is no wind, and the airplane "falls" a distance until the air flows back over the wings. This generates a lot of lift very quickly until the tail section tilts the nose back up. The cycle continues to worsen each time with greater "fall" distances" that place huge structural forces on the fuselage or body of the plane until you jump ship.



The great news is that many of the problematic circumstances and situations related to flying were figured out a long time ago by two amazing people: the Wright brothers. The Wright brothers also took an airfoil (a fancy word for "airplane wing"), turned it sideways, and rotated it around quickly to produce the first real propeller that could generate an efficient amount of thrust to fly an aircraft. Before the Wright brothers perfected the airfoil, people had been using the same "screw" design created by Archimedes in 250 BC.

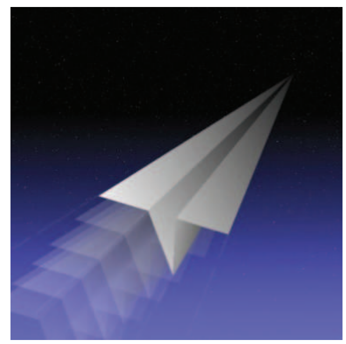
This twist in the propeller was such a superior design that modern propellers are only 5% more efficient than those created a hundred years ago by the two brilliant Wright brothers.

Aeronautics Troubleshooting Guide

DVD: Aeronautics , track 14

We've included several flying designs for you to test, including: stunt planes, fast jets, hang gliders, and a one that, mathematically-speaking, isn't even supposed to fly.

The trick to any paper airplane, be it dart, stunt, or glider, is in the *tweaking*. In order to turn a disappointing nose-diver into a stellar barrel-roller, you'll need to pay close attention to your dihedral angle (angle the wings make with the horizon) and elevator angle (pinching up or down to the tail section). Here's how we do it:



- Throw your airplane. Notice if you threw it hard, medium, or easy. Try modifying the throw to see which one works better for this particular airplane design. Stunt planes tend to work better with an easy throw and jets zoom with a fast throw.

- Now make the wing dihedral neutral (level with the horizon). Pinch up on the elevators a *tiny* bit and give it another like the throw that worked best last time.

- If the plane nose dives sharply, give it more of a pinch up on the elevators. If it nosed up first, then pitched down and crashed, you've got too much 'up elevator' in the back. What happens when you pinch one elevator up and one down?

- If the airplane still won't fly correctly, then check your symmetry. Are your wings exactly the same size and shape? When you fold your airplane, do the wings sit right on top of each other? Most airplanes don't like being asymmetrical, and it'll show up when you try to fly.

If you're crazy for airplanes, we've got several more at this link
Enjoy!

http://www.superchargedscience.com/paperairplanes.wmv

Aeronautics Experiment 1.13: Rigid Flyers

DVD: Aeronautics, track 12, or visit this link on our website:
http://www.superchargedscience.com/airplanes1.wmv

CD: Aeronautics, track 2

Materials: A small cardboard or Balsa wood flyer

Punch out the parts on the flyer, separate all the parts, and detach the metal nose-tip if included. Grab just the wing section and throw it as if you were attempting to make them fly on their own. Did you see how fast it somersaults?

Now attach the wings to the body and give it a good throw. Did the somersaults get faster or slower? The body should give the wings a bit more stability, but we need more stabilizers to keep our passengers from getting sick.

Add the elevator (horizontal tail part). Now throw it, but when you do, give it a twist to one side. Can you get it to "skid" in the air? Did the somersaults stop? Now we need to do something about that skidding problem (called 'yawing' in airplane-speak).

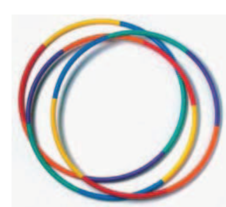
If you're using a balsa wood flyer, here are two additional variations you can test:

First, add the rudder (vertical tail piece). Throw it again, and notice what initially happens. It will probably pitch up, stall, and fall out of the sky to the ground.

NOTE: When flying, a 'stall' doesn't have anything to do with the engine, but rather it means the airflow over the wings isn't sufficient to keep the airplane flying.

Next place a fingertip on the underside of the body. Where does the plane balance now? Where is most of the weight? If you've left off the nose weight, you know now what you need to do! Add the nose-clips to balance your weight and give it a good, hard throw! Your plane should soar across the room. If not, you'll need to do a bit more tweaking with the design as described above.

Aeronautics Experiment 1.14: Ring Thing



DVD: Aeronautics, track 20 or watch the video on our website:
http://www.superchargedscience.com/airplanes2.wmv

CD: Aeronautics, track 2

Materials: Index card, straw, scissors (not included), tape (not included)

Cut an index card into thirds lengthwise. Loop one strip into a circle and tape the ends together. Place the two remaining strips together end-to-end and tape, then loop them into a large circle and tape in place. Place a piece of tape across one end of the straw and gently secure one ring to the tape. Repeat on the other end with remaining ring. Make sure the two rings are concentric (you can see through both like a telescope). Now throw it, small-end-first!

Why can this thing fly? It doesn't even LOOK like a plane! When I teach at the university, this is the plane that mathematically *isn't* supposed to be able to fly! There are endless variations to this project—you can change the number of loops and the size of loops, you can tape two of these together, or you can make a whole pyramid of them. Just be sure to have *fun!*

Aeronautics Experiment 1.15: Helicopters

DVD: Aeronautics, track 21 or watch this video online:
http://www.superchargedscience.com/airplanes4.wmv

CD: Aeronautics, track 2

Materials: A paperclip, a thin strip of paper, and scissors (not included)

The directions are a bit more complicated than usual, so watch the video online or on your DVD. This project is pretty bullet-proof—to fly the helicopters, all you need to do is drop them! Speaking of which, you can also notch the tip end and add a slingshot.

Aeronautics Experiment 1.16: Butterfly Cups

DVD: Aeronautics, track 22 or watch this video on our website:
http://www.superchargedscience.com/airplanes3.wmv

CD: Aeronautics, track 2

Materials: Two paper cups, 5 to 7 rubber bands, and tape (not included)

Tape two paper cups together, bottom-to-bottom. Chain together six rubber bands. Loop one end of the rubber band chain over your thumb and hold your arm out horizontally straight, palm up. Drape the remainder of the chain along your arm. Place the taped cups at the free end of the rubber band chain near your shoulder and slowly wind the rubber bands around the middle section of the cups. When you wind near the end, stop, stretch the chain back toward your elbow, make sure the rubber band comes from the underside of the cups. Now release the cups. The cups should rotate quickly and take air, then gracefully descend down for a light landing.

Why does THAT thing fly? The Butterflying Cups experiment is one of my favorites to use when teaching university-level fluid mechanics, because it is quite a complex task to demonstrate and analyze the aerodynamic lift. The easiest explanation is that lift is generated by the rotation of the cups. How and why the vortex generates lift is much more complex, but remember that as the air velocity increases, the pressure decreases. And remember… higher pressure regions always *push*.

You can try further experiments with your butterfly cups: Try reversing the rotation direction, spin the cups in a cloud of fog or smoke while your video-tape their flight, performing the same experiment underwater (add small particles to the water so you can see the lines of flow!), change the size of the cups, and change the number of cups.

Bonus Experiments!

We've got even MORE science for you! These experiments are not on the DVDs, CDs, and we didn't include the parts for them. They are just pure science ideas for you to test. Have fun!

Air Pressure Experiment: Diaper Wind Bag Cut an eight-foot section of the diaper genie bag and knot one of the ends. Hold the other end open, take a deep breath, and blow. How many breaths does it take for you to fill up the entire bag with air? Try this now…

After you know how many breaths it takes, do you think you can fill the bag with only ONE breath? The answer is YES! Hold the bag about eight inches from the face and blow long and steady into the bag. As soon as you run out of air, close the end of the bag and slide your hand along the length (toward the knotted end) until you have an inflated blimp.

Troubleshooting: If the bag tears open, use *packing tape* to mend it.

What's going on? When you blow air past your lips, a pocket of lower air pressure forms in front of your face. The stronger you blow, the lower the air pressure pocket. The air *surrounding* this lower pressure region is now at a *higher* pressure than the surrounding air, which causes things to shift and move. When you blow into the bag (keeping the bag a few inches from your face), you build a lower pressure area at the mouth of the bag, and the surrounding air rushes forward and into the bag.

Teaching Tip: Kids have a tendency to shove the bag right up to their face and blow, cutting off the air flow from the surrounding air into the bag. When they figure out this experiment and perform it correctly, this is one of those *oooh-ahhh* experiments that will leave your kids with eyes as big as dinner plates.

Substitution Tip: If you can't locate a diaper genie, you can string together plastic sheets from garbage bags, using lightweight tape to secure the seams. You'll need to make a 8-12" diameter by eight-foot long tube and close one end. When kids get their eight-foot bag inflated in just one breath, ask them: "Did you really have that much air in your lungs?"

Air Pressure Experiment: Plumber Magic Take two clean old-fashioned, red rubber-and-wood-stick toilet plungers and stick them together (you may need to wet the rims first). Try to separate them. Why is it so hard? When you rammed them together, air was forced out of the cavity that the insides make when pushed together, leaving you with a lower air pressure pocket inside, compared to the surrounding air pressure—14.7 (psi)—outside the plungers. Higher pressure, always pushing, keeps the plungers together.

Air Pressure Experiment: Magic Egg Trick Remove the shell from a hard-boiled egg and use a bottle with a neck large enough that the egg can be squeezed through without squashing it. Old fashioned milk bottles work great. Light a match and toss it in the empty bottle, then quickly set the egg (small-end down) on the mouth of the bottle. The air gets eaten up by the flame, thus lowering the air pressure inside the bottle. The higher pressure (now outside the bottle) pushes on the egg and pops it in. To remove the egg from the bottle, turn the bottle upside down and wiggle the egg until the small end is pointing toward the mouth of the bottle. Blow hard into the mouth of the bottle and the egg should pop right back out.

Air Pressure Experiment: Rebellious Paper Wad Take an empty water or soda bottle and lay it down horizontally on a table. Carefully set a small wadded up ball of paper towel in the mouth of the bottle—the ball should be about half the size of the opening. Can you blow hard enough to get the paper to go into the bottle? Why is this so impossible?!? HINT: You're trying to force more air into the bottle, but there's no room for the air already inside to go except back out the mouth of the bottle, taking the paper ball with it.

Air Pressure Experiment: Flying Papers Hold a regular sheet of paper to your bottom lip and blow hard across the sheet. (You may have to play a bit to find the exact location.) The paper flies up! This happens for the same reason airplanes can fly. As you blow across the top of the sheet, you lower the air pressure because the air is moving faster Therefore, the pressure on the underside of the sheet is now higher, and… Higher air pressure pushes the sheet upwards.

Air Pressure Experiment: Kissing Balloons Blow up two balloons. Attach a piece of string to each balloon. Have each hand hold one string so that the balloons are at nose-level, 6 inches apart. Blow hard between the balloons and watch them move! The air pressure is lowered as you blow between the balloons. The air surrounding the balloons is now at a higher pressure, which pushes the balloons together.

Aeronautics Experiment: Parachutes Attach a piece of dental floss or thin string to opposite corners of a tissue. Repeat for the other diagonal. Attach several different lightweight items, such as a small stick, a small pebble, etc… to the string and drop from a height. Practice dropping these from the balcony and see which falls slowest.

Aeronautics Experiment: Super-fast Parachute Grab a plastic grocery bag and tie the handles together with string. Add a weight to the string and toss the whole thing over the balcony. Instant fun!

Aeronautics Experiment: Free Form Machines

Make an obstacle course to further challenge your inventors. Design your course to include airplane banking, list and dive maneuvers, and more. By setting a goal (longest time aloft, furthest distance traveled, into the basketball hoop…), you'll encourage the kids to think about their design, test their ideas, and really zero in on which "tweak" has which effect on the airplane performance. Here are a few ideas to get you started:

- Hit a target balloon (if you're daring, you can arm the paper airplanes with toothpicks taped to the nose to pop the balloons)
- Go over and under a suspended length of string
- Make it through a hula hoop suspended vertically or horizontally
- Carry a jelly bean passenger safely across a set distance
- Dangle large paper airplanes made from 11x17-inch paper from the ceiling for a "dogfight" and earn points if you tag one. (Construction Tip: You can tape two 8.5x11-inch sheets of paper together to make an 11x17-inch sheet.)
- Shoot through a basketball hoop, and dive into a basket.

Air Pressure & Aeronautics Review

(Answer key can be found at the end of this guide.)

1. Higher pressure does which? (a) pushes (b) pulls (c) decreases temperature (d) meows (e) causes winds, storms, and airplanes to fly

2. The tips on the edge of a paper airplane wing provide more lift by: (a) flapping a lot (b) destroying wingtip vortices that kill lift (c) getting stuck in a tree more easily (d) decreasing speed

3. In the ping pong ball and funnel experiment, the ball stayed in the funnel was because: (a) you couldn't blow hard enough (b) you glued it into the funnel (c) the ball had a hole in it (d) the fast blowing caused a low-pressure region around the ball, causing the surrounding atmospheric pressure to be a higher pressure, thus pushing the ball into the funnel

4. In the sneaky bottle experiment, which of the two bottles was the balloon able to inflate in? (a) the one with a hole (b) the one with no holes (c) the one the kid fit inside

5. If your plane takes a nose dive, you should try (a) changing the elevators by pinching the edges (b) change the dihedral angle (c) change how you throw it (d) all of the above

6. What are the four forces that act on every airplane in flight?

_______________ _______________ _______________ _______________

7. Draw a quick sketch of your paper airplane when it has positive dihedral:

8. Label these parts on your sketch for Question 7: fuselage, elevators, rudder, and wings.

9. Why does the index card stay in place when you invert the cup of water in the magic water glass trick?

10. When the balloon was squished into the jam jar with the snuffed candle, where was the higher pressure?

11. Why does the water stop streaming out of the bottle when you put the cap on in the streaming water experiment? Why does the water come out if you squeeze the capped bottle?

12. How can you make the fountain bottle shoot even higher?

13. If you were designing your own “Flying Paper Machine Kit”, what would be inside the box?

14. What’s the *one thing* you need to remember about higher pressure?

"More than anything else the sensation is one of perfect peace mingled with an excitement that strains every nerve to the utmost, if you can conceive of such a combination."

Wilbur Wright
(Left)

"The exhilaration of flying is too keen,
the pleasure too great,
for it to be neglected as a sport."

Orville Wright
(Right)

