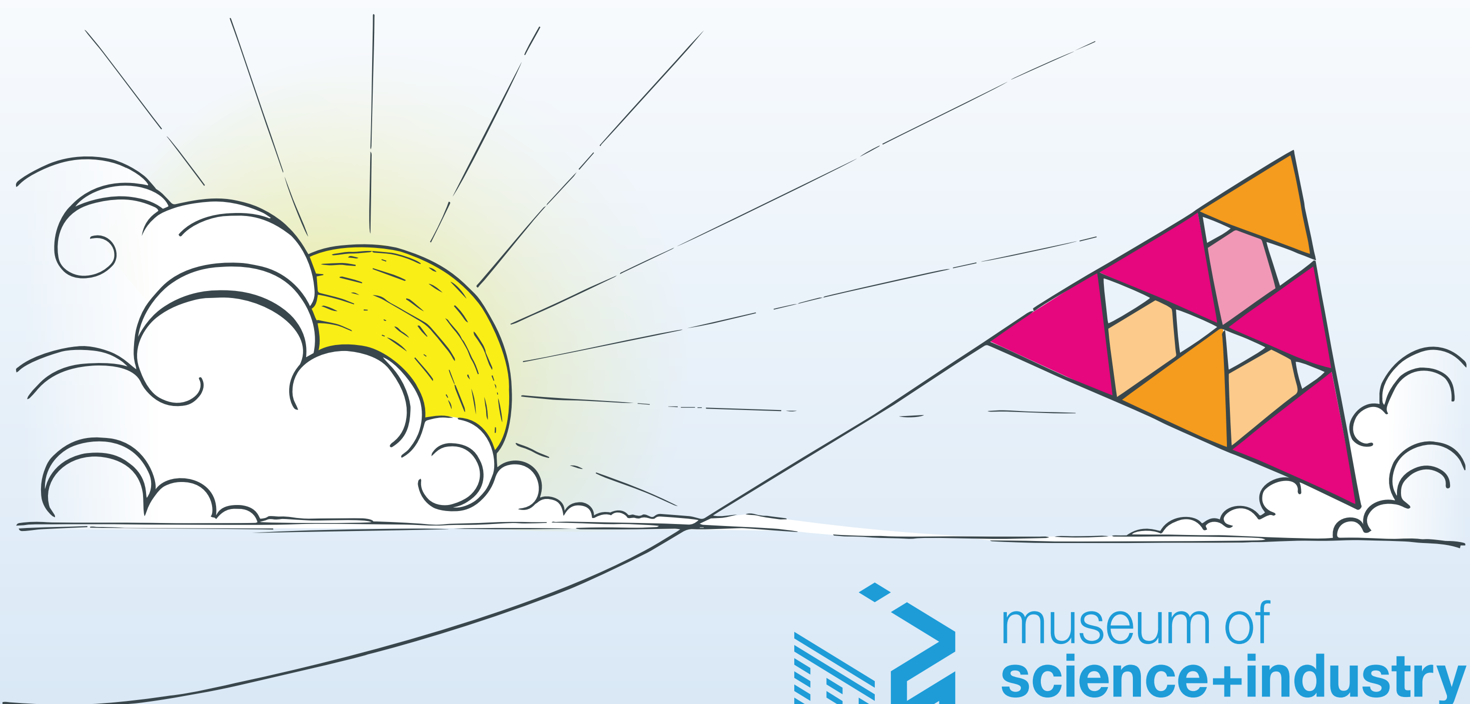
summer BRAIN GAMES



museum of
science+industry
chicago

Play along at **msichicago.org/summerbrain**

Get ready to grow some summer fun!

summer BRAIN GAMES

Summer Brain Games is back at the Museum of Science and Industry, Chicago. Join us for eight weeks of free and fun at-home experiments that can easily be done by kids of all ages (with a little adult supervision).

Personalize your creations and even document your findings all summer long. We'd also love to see how you GO BIG with these activities. How large of a tetrahedron kite can you build? How many steps are in your Rube Goldberg machine? How many plants are in your hydroponic garden?

Register with Summer Brain Games online at msichicago.org/summerbrain and you'll get a weekly email with tips and resources. You'll also receive a pass for one free Museum Entry and will be entered into a weekly drawing for a Household membership so you can visit for free all year long!

Enter our Summer Brain Games contest by sharing what you've learned and you could win a family tech prize package with an iPad, notebook and digital camera!

So grab your friends, family or neighbors and dive into science this summer!

Register for a free Museum Entry ticket and the chance to win a membership at msichicago.org/summerbrain

Week 1: On Your Mark, Get Set, Blow!

Make your own breeze on a hot day and learn about Newton's third law of motion at the same time. Build balloon racers and explore the idea that for every action, there is an equal and opposite reaction. Challenge someone to a race, experiment with different types of balloons, even make your racer into a Chicago "L" car!

Experiment

BALLOON RACERS

Materials

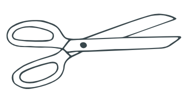
String

Balloons
(long, skinny ones work best)

Straw

Tape

Binder clip



Scissors

Chicago "L" car template (available at msichicago.org/summerbrain)

Crayons or markers

Popsicle stick

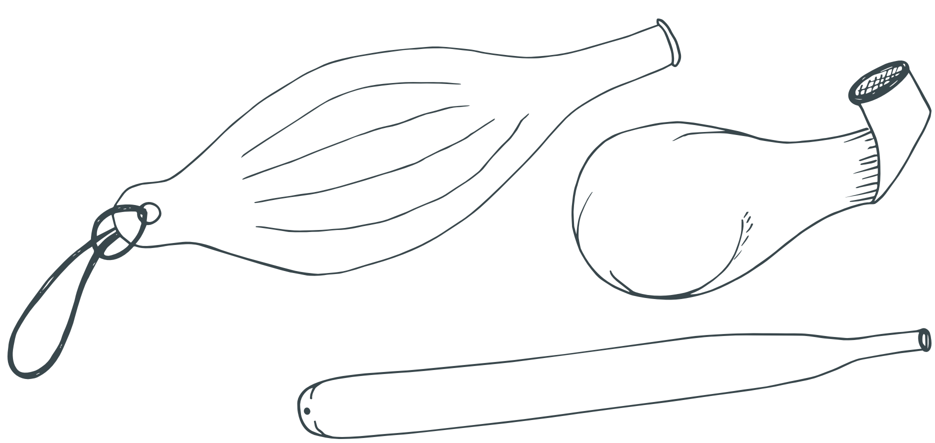
Lightweight basket, like for cherry tomatoes or berries (optional)

Small toys or figurines (optional)

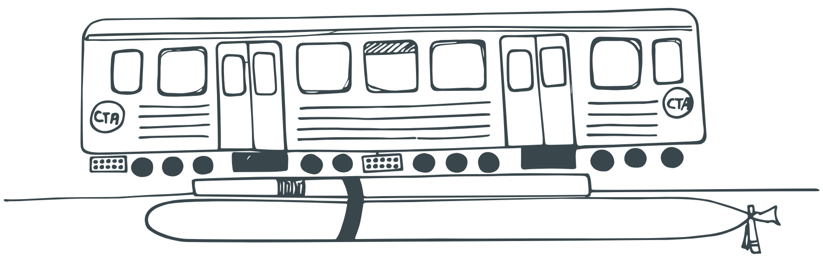
Instructions

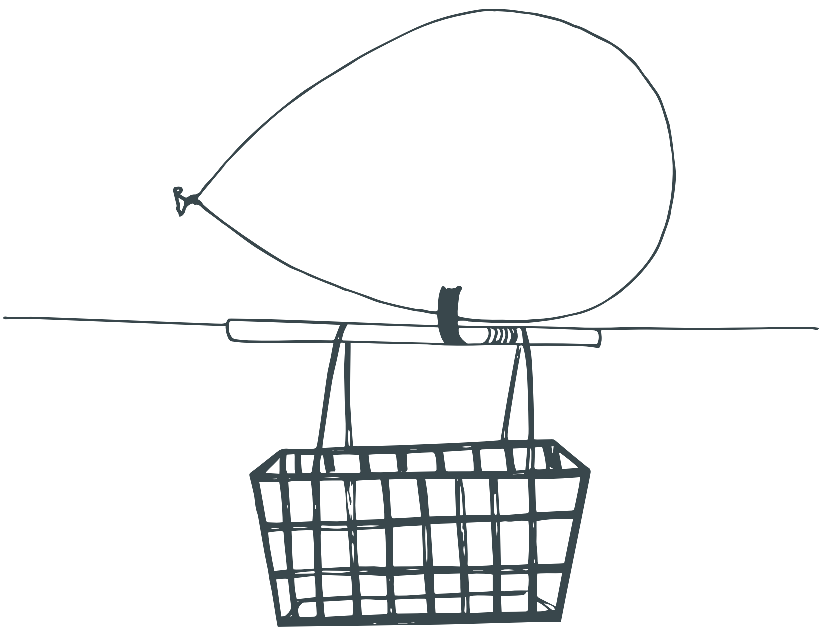
Cut a long piece of string (at least 8 feet), tape one end to a wall and thread a straw on the string.

Blow up a balloon, close the end with a binder clip or clothespin, and tape it to the straw so that the neck of the balloon points in the opposite direction the balloon will travel. Hold the string so it's parallel to the floor, or even tape the other end to another wall. Position the balloon racer at the end, remove the clip and watch it go!



Turn your racer into a Chicago "L" car by downloading our template, cutting it out and decorating it. Print it on cardstock or tape it together with a popsicle stick in the middle for support, then tape it to the straw above the balloon. Set up two string "racetracks" next to each other and challenge someone to a race! Experiment with different balloons, or try making the racer go up a steep incline.





What's happening?

As air rushes backwards out of the balloon, it pushes the racer in the opposite direction with the same amount of force. This is Newton's third law of motion at work—for every action, there is an equal and opposite reaction.

Game on!

Turn your racer into a blimp by hanging a lightweight basket, like one used for cherry tomatoes or berries, from the straw so that the balloon is positioned on top. Add some passengers to your basket and take them for a ride!

Tips

Tape the balloon onto the straw in just one place. The balloon shrinks as it loses air, which can pull off the tape.

More Ways to Play With Racers

See some of the fastest vehicles in history at MSI, including the Spirit of America, a land vehicle that traveled more than 539 miles per hour!

Like this activity? You could be a ...

- Mechanical Engineer
- Aerospace Engineer
- Rail Engineer
- Materials Scientist

Week 2: "Water" Your Plants

Did you know that plants don't need soil to grow? All that's needed is a way for nutrients to get directly to a plant's roots. Build a simple hydroponic garden system where water takes the place of the soil and see if your plants grow faster and better. Try growing herbs or sprouting some beans for a yummy summer meal!

Experiment

HYDROPONIC GARDEN

Materials

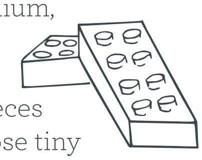
Yogurt cup

Small cup or can slightly larger than the yogurt cup

Plant (like ivy, pothos, herbs or seeds)

Cotton wick, like a strip of t-shirt, yarn or rope

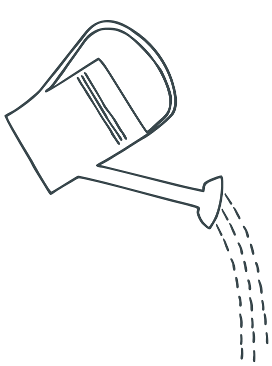
Growing medium, like marbles, LEGO bricks, cardboard pieces or perlite (those tiny white pellets found in potting soil)



Scissors

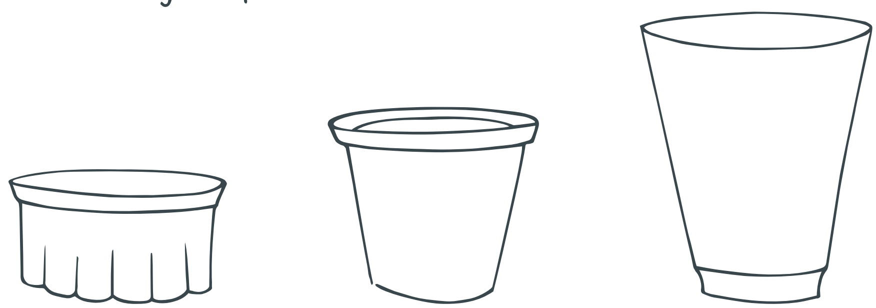
Water

Water-soluble plant food (optional)



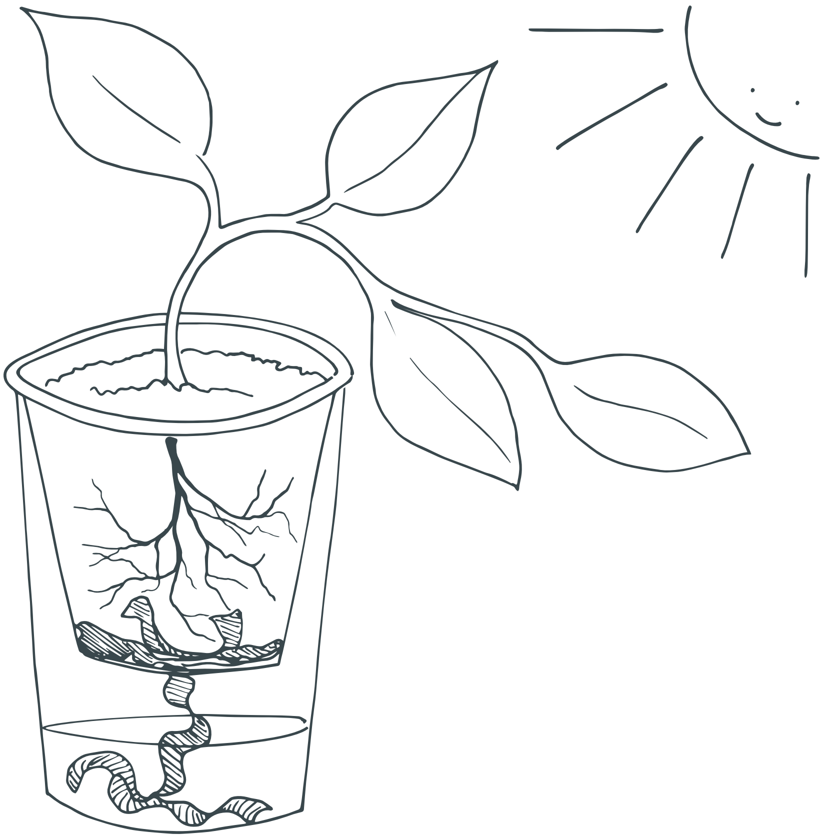
Instructions

Poke a small hole in the bottom of a yogurt cup with scissors. Thoroughly wet a cotton wick in water and thread it through the hole, leaving several inches inside the cup. Add water to your larger cup or can—keeping the water level below the bottom of the yogurt cup—and submerge the bottom of the wick. Nestle the yogurt cup inside the larger cup or can.



Coil the wick throughout a growing medium in the yogurt cup so water will spread throughout. If you're using a plant, gently clear the dirt from its roots and place it in the yogurt cup, adjusting the growing medium to hold it upright. You can get seeds to sprout by burying them in perlite, which is found at gardening stores. If your cups are clear, cover the outside with paper; roots like to be in the dark. Place your hydroponic garden in a sunny spot and add water to the larger cup when the level looks low.

Some plants, like ivy, pothos and spider plants, will grow in just water. Others, like lettuce and herbs, may wilt even though they're getting enough water from the wick. For a healthier plant, add nutrients to the water, like water-soluble plant food or nutrient solution made for hydroponic gardens.



What's happening?

Plants don't need soil as long as there's a way for nutrients to go directly to the roots. In hydroponics, water takes the place of soil. Plants will often grow faster and better in hydroponic systems because the nutrients are delivered more efficiently. It also eliminates soil pests and many diseases. In this system, water travels up the wick to provide nutrients to the roots. NASA is experimenting with hydroponics as a way to provide food on long-term space missions.

Game on!

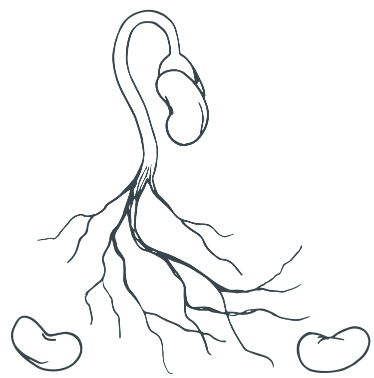
Design your own hydroponic garden system. Try making a vertical "window" setup that links several bottles together, on top of each other, so that water dripping from the top bottle drains down into the one below until it reaches the bottom bottle. Add tubing and a pump at the bottom reservoir to bring the water back up to the top.

Tips

Make sure the wick is wet all the way up, to make sure water is reaching the plant roots.

Using torn pieces of cardboard as a growing medium provides extra moisture to the roots. Clay pellets and perlite also expand and hold moisture.

Try growing plants from seeds by nestling the seeds in perlite.



More Ways to Play With Hydroponics

Experiment with different types of plants to see which ones grow best. Keep track of how your plants are doing and make observations all summer long in a science journal.

Learn about vertical farms in MSI's *Fast Forward ... Inventing the Future* exhibit and the latest in farming crops in *Farm Tech*.

Like this activity? You could be a ...

- Agricultural Researcher
- Chemist
- Environmental Scientist
- Horticulturalist

Week 3: Go Fly a Kite

Warm breezes make summer the perfect time to fly a kite. A tetrahedral kite is made up of triangles connected together to make pyramids. Connect several pyramids together and watch this unique kite soar as you learn about the forces of flight.

Week 3

Experiment

TETRAHEDRAL KITE

Materials

24 bendable drinking straws

Pipe cleaners

Tissue paper

Clear tape

String

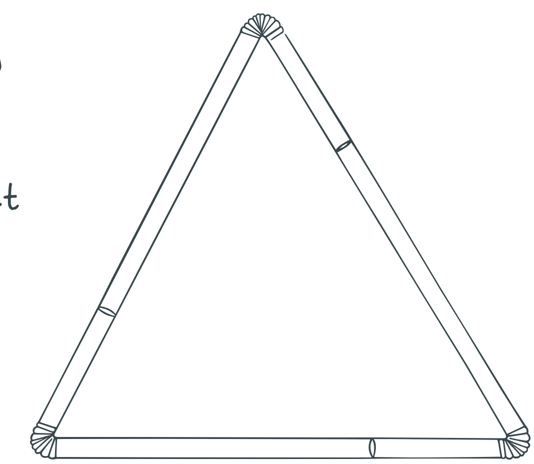
Kite cell template (available at msichicago.org/summerbrain)

Are you a summer brainiac?

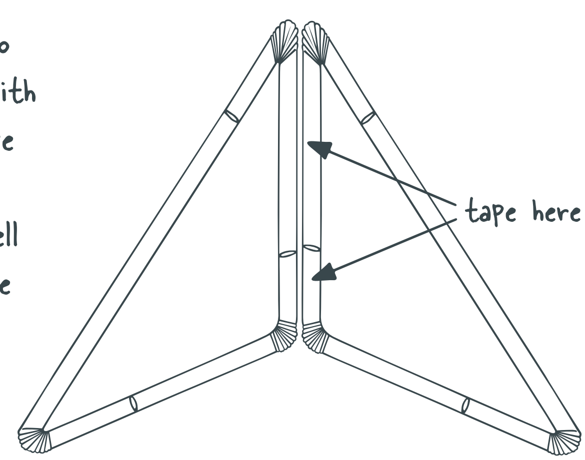
Send us your Summer Brain Games photos and you can win a family tech package! Visit msichicago.org/summerbrain to enter.

Instructions

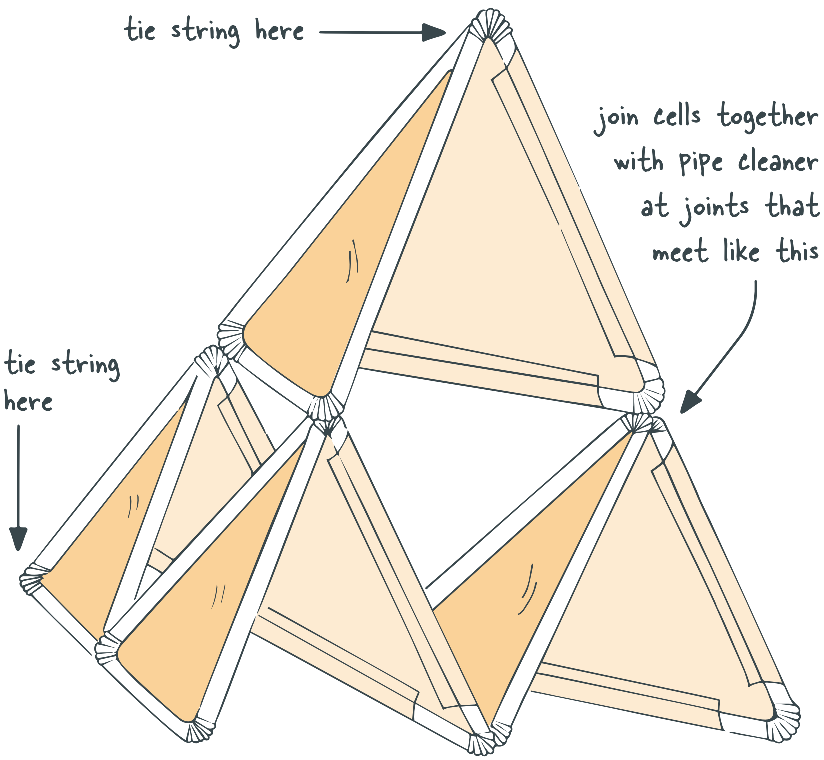
Make a triangle by flattening the long end of a straw and inserting it into the shorter end of another straw. Connect three straws to make a triangle, and repeat until you have eight triangles.



Make a cell by joining two triangles along one edge with tape, so the pyramid shape opens outward. Cover the back two sides of each cell with thin paper, like tissue paper or plastic grocery bags. Use our template for an easy pattern for the cell covering. Repeat to make four cells.



Attach the four cells together with pieces of pipe cleaner at the corners to make a larger pyramid. Place three cells on the bottom in the shape of a triangle, and one on top attached to the tops of the other three cells. Make sure the open sides of each cell are facing the same way.



Turn the kite around and tie the string to the back, attaching it at the top and bottom of the back edge of the pyramid. Leave plenty of string to let your kite soar. Now go for a test flight!

What's happening?

A kite flies when all forces – lift (up), weight (down), thrust (forward) and drag (backward) – are balanced. The lifting force in a tetrahedral kite comes from catching and deflecting air. Air can't pass through the kite, so it gets blown down at an angle through the tetrahedral cells. Because of Newton's third law of motion – for every action there is an equal and opposite reaction – this downward movement of air causes an upward force on the kite, causing it to lift.

Game on!

Try building a bigger tetrahedral kite by connecting four of the four-celled pyramids in a larger pyramid shape, with three on the bottom and one on top. Add extra support by attaching straws across open diamond-shaped areas. Tetrahedral kites with more cells provide more lift for their weight and tend to fly better, especially in light winds. What different shapes can you make, and do they all fly successfully? Some people have flown tetrahedral kites with 100 cells!

Tips

Add additional supports by attaching straws across the open diamond shapes on the front and bottom of your four-celled kite.

Do a web search for ideas on making unique tetrahedral kites (try www.my-best-kite.com/tetrahedron-kite.html)

More Ways to Play With Flight

Explore the history of flight at MSI, from the Piccard Gondola to a United 727.

Like this activity? You could be a ...

- Aerospace Engineer
- Aircraft Mechanic
- Avionics Technician
- Pilot

Week 4: Weather the Summer

Don't let summer storms dampen your fun. Instead, assemble your own weather station to understand how meteorologists study and predict the weather. Make a rain gauge to track rainfall amounts, a wind vane to see which way the wind blows, an anemometer to calculate wind speed and barometer to measure air pressure. Then collect and compare data and even make your own weather forecasts.

Experiment

WEATHER STATION

Materials

Paper ruler and protractor (available at msichicago.org/summerbrain)

Plastic, 2-liter bottle

Gravel

Two index cards

Two straws

Pencil

Pushpin

Paper clip

Modeling clay

String

Ping pong ball

Small jar or cup, such as a yogurt cup or juice glass

Balloon

Rubber band

Thermometer

Scissors

Tape

Glue

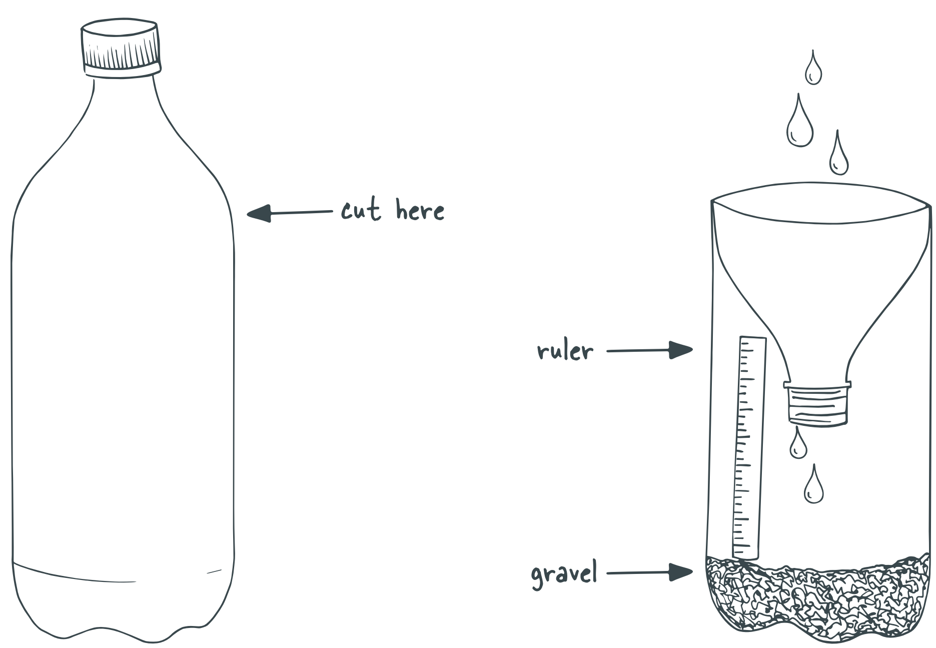
Paper

Weather log (available at msichicago.org/summerbrain)

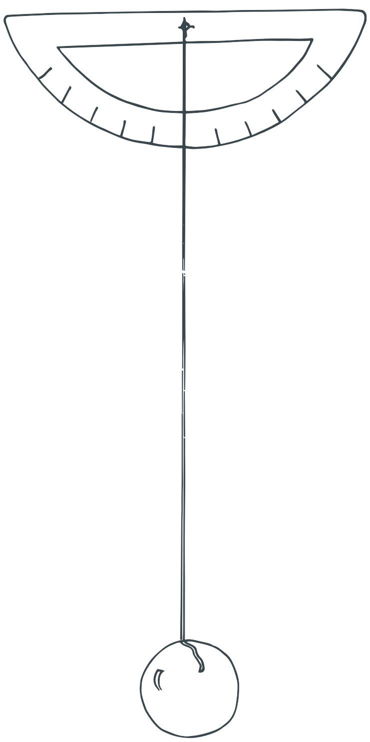
Instructions

Assemble your instruments, then put them all together on a base (like a tray or a box) to make an all-in-one weather station. Add a thermometer so you can track the temperature. Put your weather station outside and collect your data.

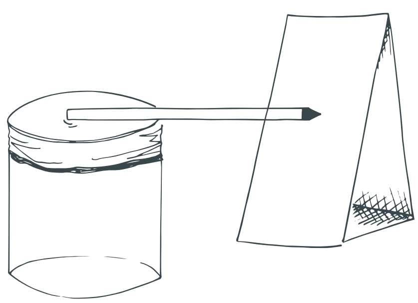
Rain Gauge: Cut off the top fourth of a two-liter bottle. Add gravel to the base of the bottle and tape a paper ruler outside with the "0" mark at the top of the gravel. Add water until it reaches the top of the gravel. Invert the top of the bottle, place it inside the base and cover the cut edges with tape. Decorate the outside of the bottle. Measure each rainfall on the ruler.



Wind Vane: Cut two identical triangles from index cards. Poke a hole through a straw with a pushpin and insert one end of a straightened paper clip into the hole and through the straw. Tape the triangles to the straw so that one side of the triangle is parallel to the straw; cut the ends of the straw so they remain inside the triangle. Poke a hole in the eraser on top of a pencil and insert the paper clip. Use clay at the base of the pencil to hold the wind vane in place. The narrow tip should point in the direction the wind blows.



Anemometer: Tape one end of a piece of string to a ping pong ball and the other to the center of the straight edge of a protractor. Hold the anemometer with the straight edge parallel to the floor. Note the angle of the string when the wind blows, then use it to calculate the wind speed; check the chart on our protractor template.



Barometer: Cut the neck off a balloon, stretch the balloon over the top of a jar or small cup and secure it with a rubber band. Cut a straw in half and trim at an angle to make a point; glue the opposite end to the center of the balloon. Make a gauge by cutting a strip of paper and folding it in half so that it stands next to the straw (the paper should be about twice as tall as the jar). Mark on the gauge where the straw points each day.

What's happening?

Weather describes the temperature, humidity, atmospheric pressure, wind, rainfall and other meteorological characteristics of the atmosphere in a specific place at a specific moment in time. Instruments help measure the weather. A rain gauge measures how much rain falls at a time.
A wind vane shows which direction the air blows and an anemometer measures the speed of the wind.
A barometer measures air pressure; low or falling pressure (when the straw points downward) means a storm is approaching, while high or raising pressure (when the straw points up) means sunny weather.

Game on!

Collect data all summer on a weather log, including the temperature and observations on what you see (sun, clouds, etc.). Guess what tomorrow's weather will be – even make a video forecast like a TV meteorologist!— then check the next day to see if you're right.

More Ways to Play With Weather

Explore the physics behind weather in MSI's *Science Storms* exhibit, which features large-scale natural phenomena like tornados, avalanches and tsunamis.

Like this activity? You could be a ...

- Meteorologist
- Atmospheric Scientist
- Data Analyst
- Climate Scientist

Week 5: Reach for the Skyscrapers

Half the fun of a backyard fort is figuring out how to build it. For inspiration, take a look at skyscrapers. Chicago is home to some of the tallest buildings in the world. In addition to their soaring height, skyscrapers need to be strong and able to withstand forces like wind. See what shapes make a structure stronger by building and testing a model of your favorite skyscraper.

Experiment

SUPER-STABLE STRUCTURE

Materials

Suggested building supplies:

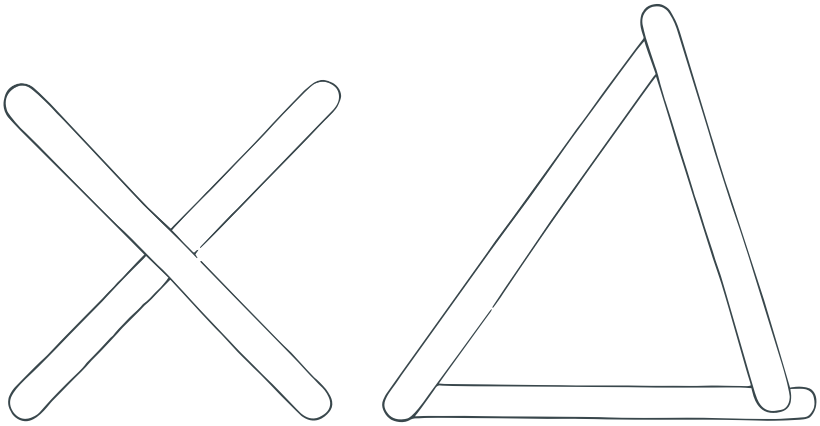
Newspaper
Tape
Pencils
Plastic cups
Popsicle sticks
Pipe cleaners
Straws
Glue
Cardstock
Rulers

Instructions

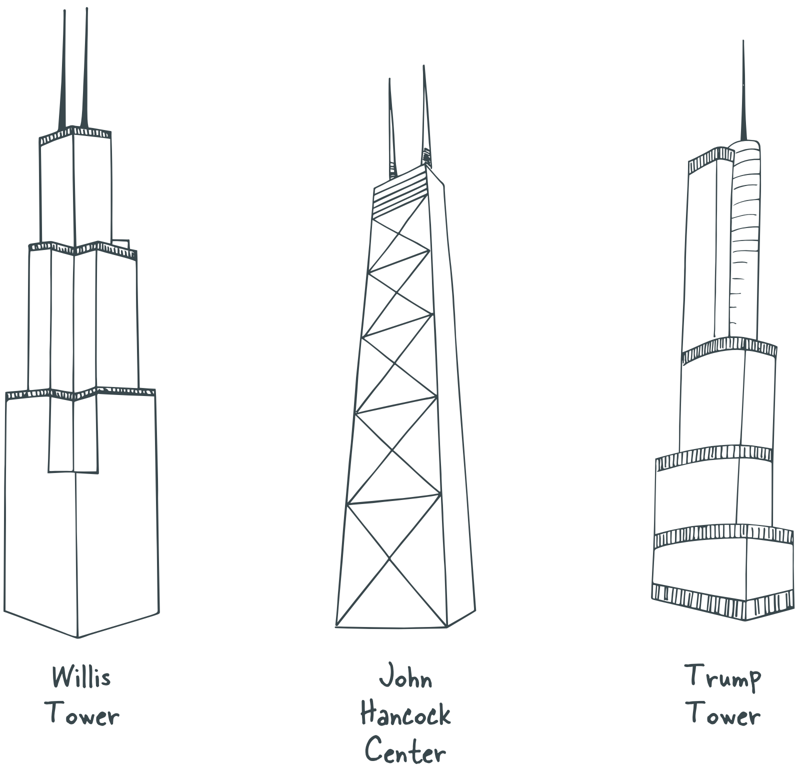
When designing a building, engineers must consider the effect of forces that can change quickly; these are called "dynamic loads". Earthquakes and wind are two examples of dynamic loads. Buildings must be flexible enough to absorb the force of wind, but not so flexible that they sway on the top floors. Earthquakes create a sudden, severe change in force, so buildings must be constructed soundly to avoid collapsing.

Your challenge is to design and build a model of your favorite skyscraper that's at least 61 centimeters tall and able to withstand winds and earthquakes. Think about what shapes will help make your building strong.

When you're done, run a couple of tests. Aim a hair dryer or fan at the building for a wind test. Gently shake the table to simulate an earthquake. And see how much weight it can hold by stacking some small objects on top, like metal washers or wooden blocks, to see what it can take.



Chicago's Architectural Inspiration



What's happening?

Buildings with a heavier base or more weight at the bottom than at the top will withstand both wind and earthquakes better. Wind speeds increase with height, so wind blows faster at the top of a skyscraper than the bottom. A heavier base makes a sturdier, more balanced building. Triangles, arches and domes are the strongest shapes used in architecture, as they can withstand forces of tension and compression.

Game on!

Challenge someone to see who can build the tallest building that passes all three tests (wind, earthquake and weight). Or make a city of skyscrapers by building several models and using them as a play scene for your toy cars, dolls or action figures.

Tips

Triangles provide great support to tall buildings.

Don't go overboard with tape! Be creative with other items that can provide support, like small sticks or straws.

More Ways to Play With Structures

Check out a mini version of downtown Chicago at MSI's *The Great Train Story* exhibit.

Explore large structures and what it takes to build them from PBS at www.pbs.org/wgbh/buildingbig/

Like this activity? You could be a ...

- Architect
- Building Inspector
- Construction Manager
- Urban Planner

Week 6: A Simply Complicated Sip

Hot summer days make us feel lazy. That's why we love simple machines … they make work easier. Perform the easy task of pouring your favorite summer drink into a cup by using at least three simple machines to build a deliberately complicated invention called a Rube Goldberg machine.

Experiment

RUBE GOLDBERG MACHINE

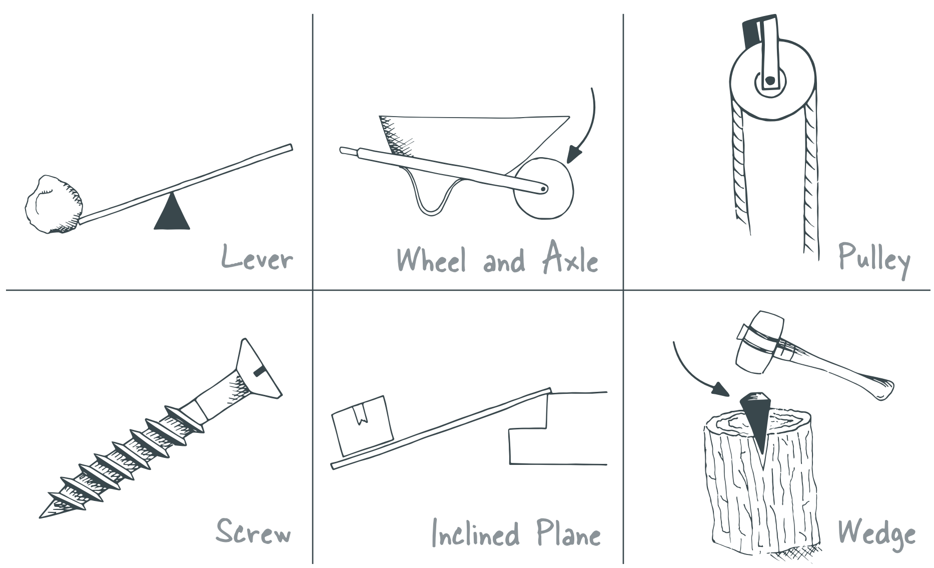
Materials

Suggested items include:

- Bottles
- Cups
- Cardboard tubes or boxes
- Tape
- Aluminum foil
- Books
- Balls
- Cans
- String
- Pencils
- Rulers

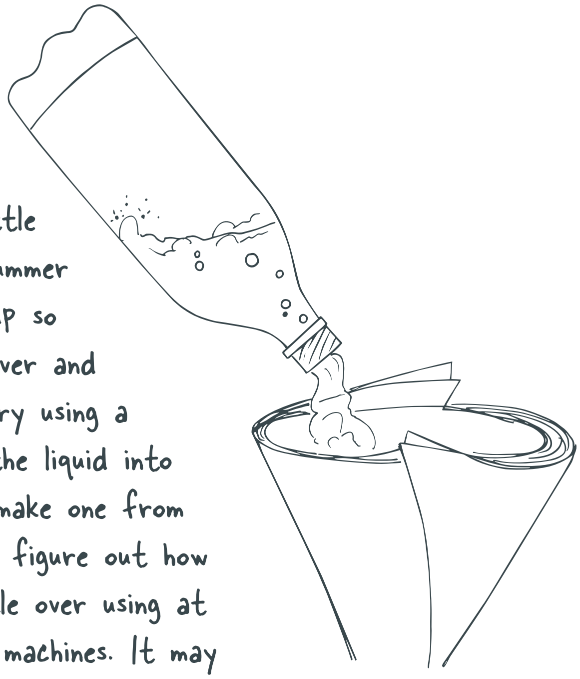
Instructions

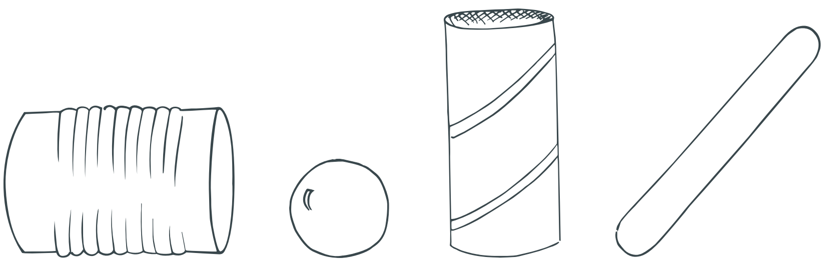
There's no "right" way to build a Rube Goldberg machine, it's all based on your imagination. Start by learning about the six types of simple machines before deciding which three to use: inclined plane, wheel and axle, lever, pulley, screw and wedge.



Find a location for your machine; it may be helpful to have a spot that lets you use several heights, like a table and chair, or a stack of books on a table.

Set up your final step first by securing your cup and positioning a small plastic bottle filled with your summer drink above the cup so that it can fall over and pour the liquid. Try using a funnel to direct the liquid into the cup—you can make one from aluminum foil. Now figure out how to knock the bottle over using at least three simple machines. It may take several tries to get each step to work right, but that's part of the fun!





What's happening?

Rube Goldberg was an engineer and artist who drew cartoons of overly complicated inventions. His drawings showed a long, difficult process that ended in a simple task. Complex machines are made up of simple machines connected together in a chain reaction. Simple machines make work easier by providing a tradeoff between force and distance, meaning you'll need to exert less force if you use a simple machine to move an object a longer distance.

Game on!

Try making your invention even more complicated by using all six simple machines. Challenge your friends to see who can build a machine with the most steps. Dream up another invention, like one that can turn your lights off while you're lying in bed, and draw how it will work.

Tips

Use a funnel to direct the liquid into the cup. You can make one from aluminum foil.

It takes some weight to knock over your bottle … falling books and rolling cans can be helpful.

If pouring a drink is too difficult, try building a machine that gets a ball into a cup instead.

More Ways to Play With Machines

Understand how simple machines work by playing MSI's Simple Machines online game at msichicago.org/simple-machines.

Play the board game Mouse Trap, a classic example of a Rube Goldberg machine.

Check out *Swiss Jolly Ball* at MSI, a giant pinball machine that's 7 feet high and 15 feet wide.

Like this activity? You could be a …

- Robotics Technician
- Inventor
- Electrical Engineer
- Industrial Designer

Send us your Summer Brain Games photos!

Visit msichicago.org/summerbrain and enter a contest to win a family tech package!

Week 7: Topsy Turvy World

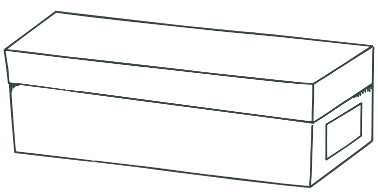
Don't just shield your eyes from the bright summer sun. Instead, explore the properties of light and understand how your eye works. Make a pinhole viewer to see the world in a new way … upside down!

Experiment

PINHOLE VIEWER

Materials

Box, like a tissue box or shoebox



Aluminum foil

Wax paper

Tape

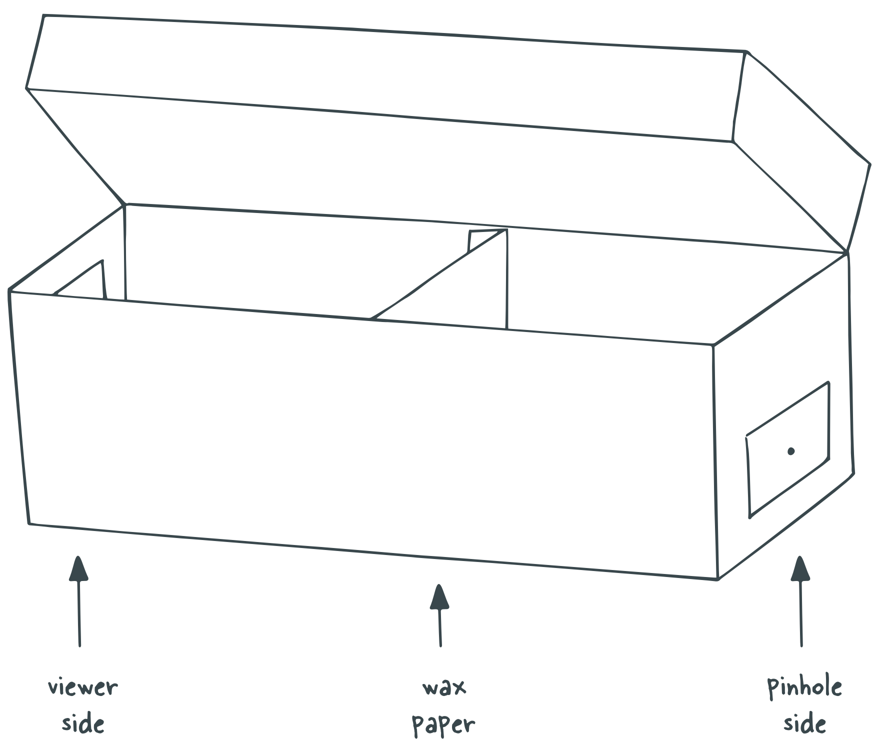
Scissors or box cutter

Pushpin

Large box (optional)

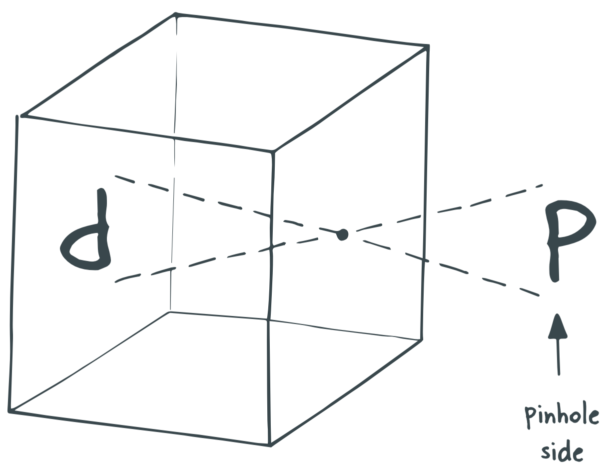
Instructions

Cut two square holes on opposite ends of a square or rectangular box. Cover one hole with aluminum foil and the other with wax paper, taping down the edges. Make sure light doesn't get inside the box by taping off any gaps or edges. Poke a small hole in the aluminum foil square with a pin. Head outside or look out the window on a sunny day. Hold the viewer with the wax paper side facing you and look around. You'll see images reflected on the wax paper, but they're upside down!



If your box is long, like a shoebox, attach the wax paper inside in the middle of the box by taping a wax paper flap on either side. Get the wax paper as flat as possible. Hold the open side against your eye and block the sunlight with your hands as you look inside.

Make a wearable pinhole viewer out of a large box (one that fits over your head). Cut a small square on one side near the bottom of the box. Cover it with aluminum foil and poke a pinhole in the middle. Tape a piece of white paper on the inside of the box, opposite the pinhole. Block out all light by taping off gaps and holes. Decorate the outside of the box. Put the box over your head with the pinhole at the back, and look at the white paper to see what's behind you. Bring a digital camera inside the box with you and try taking a picture of what you see! Don't use a flash, and hold the camera very still to get the best shot.



What's happening?

The pinhole in the viewer acts like a camera lens, forcing light through to create an image on the opposite side. Light only travels in straight lines. When forced through a pinhole, only light from the top of the object you're seeing reaches the bottom of the paper in the viewer and only light from the bottom of the object reaches the top of the paper. The result is an inverted picture of what you're seeing. Your eye works like this, too. Light travels through the lens and is reflected on the retina, the back of the inside of your eye. The image on the retina is also upside down ... your brain just flips it right side up so you can tell what you're seeing.

Game on!

Turn your bedroom into a huge pinhole camera, also called a camera obscura. Darken the window with a blanket or curtains, and tape a piece of aluminum foil with a dime-sized hole in the center of the window. On the opposite wall, you should see an upside-down image of whatever is outside your window!

Tips

Experiment with different shapes of boxes to see what works best. Boxes where the pinhole and wax paper are only a couple inches apart result in smaller images.

More Ways to Play With Light

Learn about vision by dissecting a cow's eyeball in our Dissect an Eye at MSI program.

Make rainbows with giant prisms in *Science Storms*.

Like this activity? You could be a ...

- Ophthalmologist
- Photographer
- Optometrist
- Surveyor

Week 8: Let it Flow

There's nothing better than cooling off in water on a hot summer day, like running through a sprinkler or playing in a fountain. Learn how water moves by experimenting with pressure, then get creative and make water move—even uphill!—by building a water wall.

Experiment

outside fun!

WATER WALL

Materials

Two pails

Three or more 20-ounce plastic bottles

25 feet of clear aquarium airline flexible tubing (available at pet stores)

Food coloring (optional)

Duct tape

Scissors

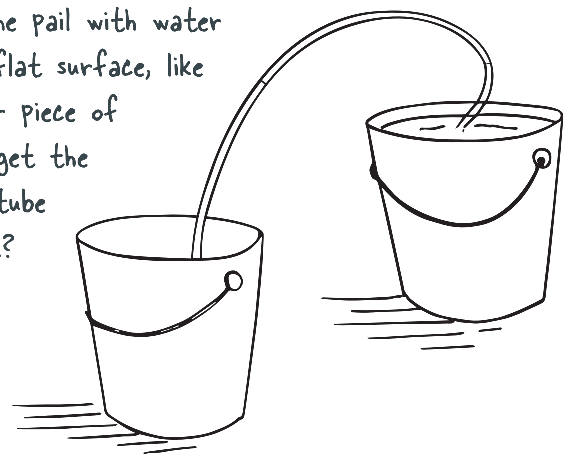
Pipe cleaners

Zip ties

Pegboard

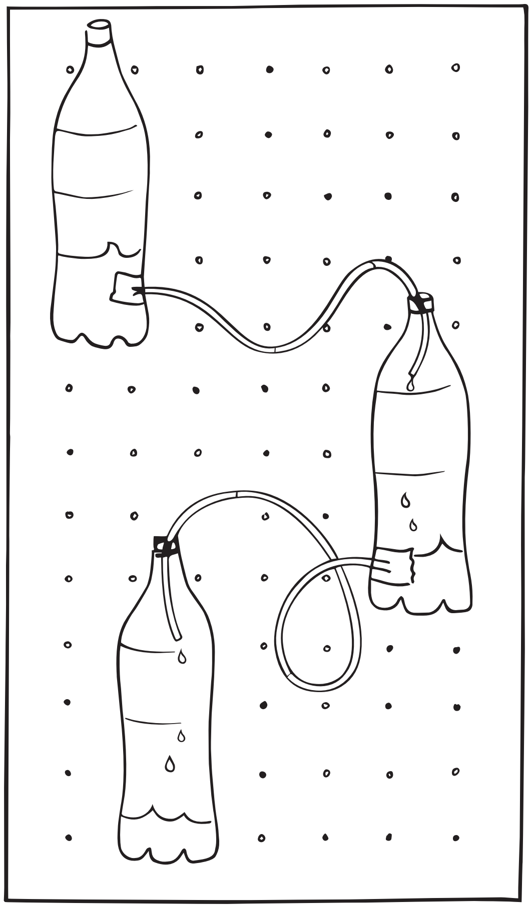
Instructions

First, understand how pressure helps water move with a quick challenge. Fill one pail with water and set the two pails on a flat surface, like a table. Cut a 61-centimeter piece of aquarium tubing and try to get the water to move through the tube into the empty pail. Stumped? Make a siphon—submerge the tubing in the pail of water so that no air is left in the tube, put your finger over one end of the tube and place that end of the tube into the empty pail. Get the water flowing by moving the empty pail to a lower spot, creating a longer slope in the tube. The water will flow through the tubing into the empty pail as long as the "receiving" pail is lower than the "source" pail. See what happens to the water flow as you change the position of the pails.



Now get creative, making water move by building a water wall. Use what you've learned about height and pressure to design a system where water moves through three (or more!) plastic bottles connected by tubing. Use scissors to poke a small hole about the diameter of the tubing in the side of a plastic bottle, very close to the bottom. Insert one end of the tubing and tape all around the opening with duct tape, trying to stop water from dripping out. Repeat with the other bottles so they all have a length of tubing coming from the bottom.

Attach the plastic bottles to a peg-board with zip ties. Place the first bottle at the top of the board and drape the tubing so that the other end is inside the open top of the next bottle. Position each bottle at a lower level than the one before. Experiment with the position of the tubing; try making hills or loops, holding the tubing in place with pipe cleaners.



Test your design by pouring water into the first bottle; pressure will build up and push the water through the tubing into the next bottle. It may not work the first time, so just adjust the placement of your bottles and tubes until the water starts flowing!

What's happening?

Siphons are often used to move a liquid over an obstruction without pumping, like directing water from a canal over a dike to irrigate a field. Siphons operate by atmospheric pressure. When the tube is filled with water, atmospheric pressure on the source container will force water through the tube and into the receiving container. A liquid always flows from an area of higher pressure to one with lower pressure. Elevating the source container creates a difference in pressure (called a pressure gradient), with a higher pressure in the source container and a lower pressure in the receiving container. Once the flow of water has started, it will continue as long as the end of the tube is below the surface of the water.

Game on!

Get a better view of the moving water—and learn about color mixing—by adding a few drops of food coloring in each bottle. Or try one of these design challenges:

- Use at least five bottles.
- Add a water wheel (or similar water toy).
- Make water flow uphill.

Tips

Add tape anywhere you see water dripping.

Instead of a pegboard, tape the bottles to a piece of wood or a wall, set them on stairs, or ask people to hold them at different levels.

More Ways to Play With Water

Visit a fountain or water playground to cool off in a big siphon system.

Play with moving water in MSI's *Idea Factory*.

Tackle water-moving challenges in the Where's My Water? app or online game at http://disney.go.com/wheresMyWater/

Like this activity? You could be a ...

- Civil Engineer
- Water Park Designer
- Hydrologist
- Water Filtration Technician

Inspiring the Inventive Genius in Everyone

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Through its Center for the Advancement of Science Education, MSI also aspires to a larger vision: to inspire and motivate children to achieve their full potential in science, technology, medicine and engineering. The Center's programs are designed to extend the content of Museum exhibits through strategies that empower teachers, engage the community and excite students and Museum guests. Learn more at msichicago.org/CASE.

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The Museum of Science and Industry gratefully acknowledges the support of the Chicago Park District on behalf of the citizens of Chicago.