SUMMER BRAIN GAMES

museum of science+industry chicago

SUMMER

BRAIN GAMES

Take off on a voyage of exploration this summer with the Museum of Science and Industry, Chicago. Summer Brain Games features eight weeks of free and fun at-home experiments for kids of all ages (with a little adult supervision). Learn about engineering, physics and other STEM subjects as you launch a glider, move a vehicle with propulsion, engineer a parachute and more.

Register with Summer Brain Games online at **msichicago.org/summerbrain** and receive a voucher for a free Museum Entry ticket! You'll also get a weekly email with tips and ideas on how to play with science all summer long, and coupons for MSI's store and restaurant.

FREE MUSEUM ENTRY VOUCHER

Register at **msichicago.org/summerbrain** and get one free ticket per household.

TOUCH THE SKY

EXPERIMENT: STOMP GLIDERS

OUTSIDE FUN

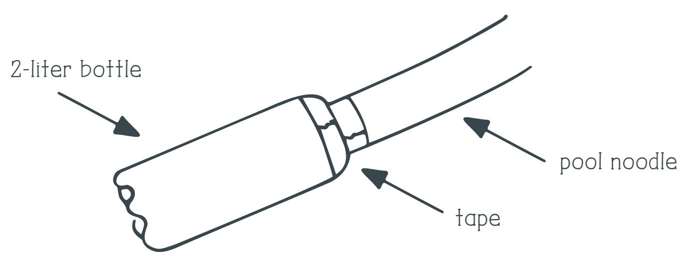
Explore the physics of flight! You'll harness the power of compression to launch a glider through the sky.

MATERIALS

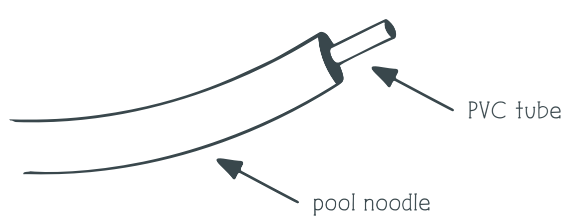
- ☐ PVC pipe (short piece that's 1 inch in diameter or less), or another tube of similar size
- ☐ Ping pong ball
- ☐ Pool noodle
- ☐ Two-liter bottle
- ☐ Markers
- ☐ Cardstock
- ☐ Scissors
- ☐ Duct and clear tape
- ☐ Paper (8.5 by 11 inches)
- ☐ Hula hoops or other rings (optional)
- ☐ Small toy figure (optional)

INSTRUCTIONS

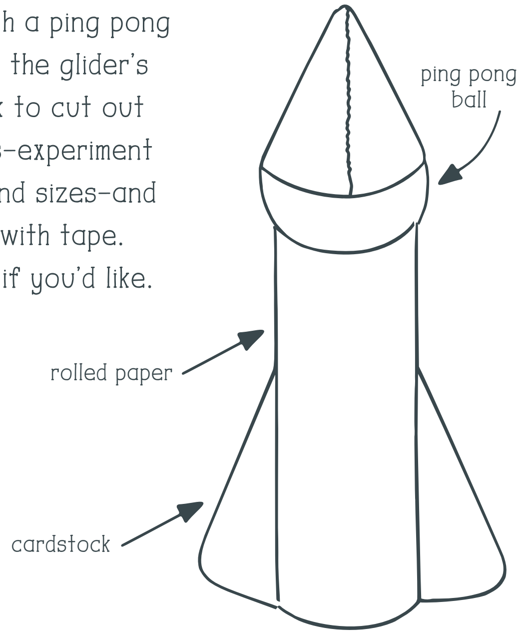
Build the stomp launcher by inserting the mouth of the two-liter bottle into one end of the pool noodle. Secure it thoroughly with duct tape, trying to make it as airtight as possible.



Insert the PVC piece or other tube into the other end. Make your glider by rolling a piece of 8.5 by 11 inch paper so that it fits around the outside of the tube. Don't make it tight, it should slide on and off. Tape the paper so it holds its shape. This is the fuselage of your glider.



Use clear tape to attach a ping pong ball to one end to make the glider's nose. Use the cardstock to cut out some wings and rudders–experiment with different shapes and sizes–and attach to the fuselage with tape. Decorate with markers if you'd like.



Load the glider onto the tube. Place the two-liter bottle on the ground and aim the launcher. It may be easier to ask a partner to hold the launcher for you. Stomp on the bottle to watch the glider fly! To launch again, just blow into the tube until the bottle re-inflates.

WHAT'S HAPPENING?

When you stomp on the bottle you compress, or squish, the air inside. This compressed air has to go somewhere, so it escapes through the easiest way out–which is the other end of the launcher. By placing the glider over the other opening, this escaping air pushes it out of the way. If the compressed air didn't have an escape route, like the launching tube, the container would burst. That's why compressed air or gas containers like pressure cookers and propane gas cylinders always have a safety valve that keeps the pressure from getting too high. The wings help the glider gently drift back to the ground.

GAME ON

Experiment with different wing shapes to see if you can make your glider fly farther. Try adjusting the launch angle, or improve your accuracy and aim your glider at a hula hoop that a friend holds at a distance. Can you design a glider that will carry a payload or even a passenger, like a small toy figure?

TIPS

The duct tape or bottle will eventually wear out from all the stomping. When that happens, just cut off the end of the pool noodle and attach a new bottle.

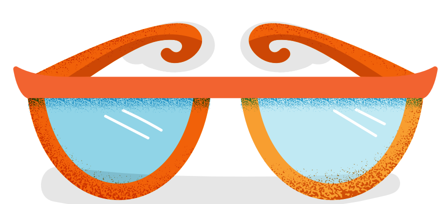
LEARN MORE

Explore how people have flown, soared, sped and chugged through the years in MSI's Transportation Gallery.

RECOMMENDED READING

Planes, Gliders and Paper Rockets: Simple Flying Things Anyone Can Make–Kites and Copters, Too! by Rick Schertle and James Floyd Kelly

Explore Flight! by Anita Yasuda, illustrated by Bryan Stone



LOOK OUT BELOW

EXPERIMENT: PARACHUTE DESIGN

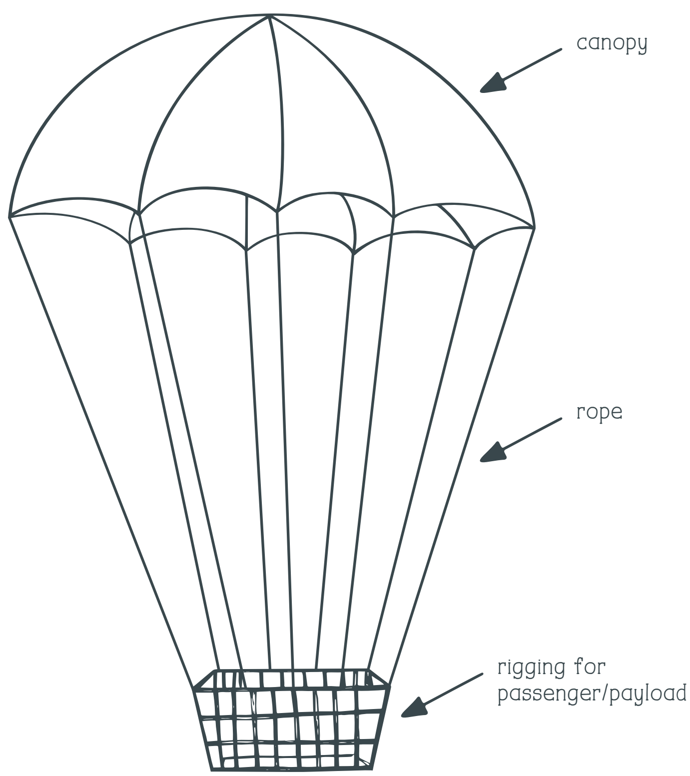
Whether they are used for safety or sport, all parachutes work essentially the same way to help a passenger land softly on the ground. Think like an engineer and design a parachute that lets you land your passenger safely on a target.

MATERIALS

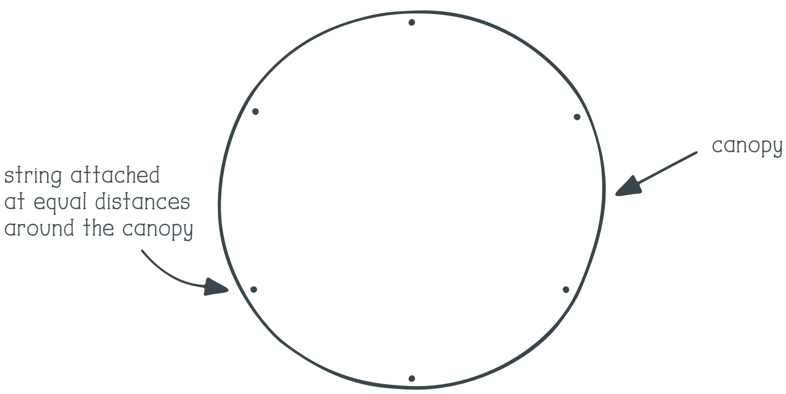
- ☐ String
- ☐ Scissors
- ☐ Tape
- ☐ Paper clip or binder clip
- ☐ Passenger, like an action figure
- ☐ Pen or pencil
- ☐ Pushpin
- ☐ Thin, lightweight materials (tissue paper, coffee filters, plastic bags, fabric, napkins, etc.)
- ☐ Landing target (download ours at msichicago.org/summerbrain)
- ☐ Lightweight container (small box, plastic cup, etc.)

INSTRUCTIONS

There are many designs and shapes of parachutes, but all have a few common elements: a canopy that catches air, rope that hangs below, and a type of rigging to attach a payload or passenger. Use our suggestions to get started, then experiment to figure out which parachute design works best.



Make a canopy by cutting a circle from a lightweight material of your choice. Cut at least six pieces of string that are the same length, and tape the string to the canopy at equal distances around the circle. Tie the strings together at the other end.



Make a rigging by using a clip, such as a binder clip or key ring, to attach a toy passenger to the end of the tied strings. Place the landing target on the ground and drop the parachute from a tall height. Did the parachute slow the fall of your passenger? Did the parachute go straight down?

Experiment to improve your parachute design. For the canopy, try different shapes, materials and sizes. Try more or fewer strings. Some parachute canopies have small holes in them. What works best for you? Try dropping the parachute from different heights and timing it as it falls to see which design is most effective.

Make a container to hold your passenger or payload, using a cup or plastic container or small box. How can you attach the container to the strings? What effect does the added weight have on your canopy design?

WHAT'S HAPPENING?

Parachutes are a lesson in air resistance. The broad surface area of the canopy catches the air and slows the parachute down. If you have ever flown a kite or tried to ride your bike into the wind, you know that air can push hard. Wind can push harder against something that has a broad, flat shape. By experimenting with the weight, shape and size of your parachute, you change how fast and how much air is pushed out of the way. The study of how wind effects the speed of object is called aerodynamics.

GAME ON

Challenge a friend and see whose parachute can land closest to the target, or which parachute can carry the same weight but take the most time to land.

TIPS

If your payload swings back and forth as it falls, try adding weight to ensure a smooth, straight drop.

LEARN MORE

Explore aerodynamics with NASA's beginner's guide at grc.nasa.gov/WWW/k-12/airplane/.

RECOMMENDED READING

Everything Goes: In the Air by Brian Biggs

Blown Away by Rob Biddulph

SEAS THE DAY

EXPERIMENT: PADDLE BOAT

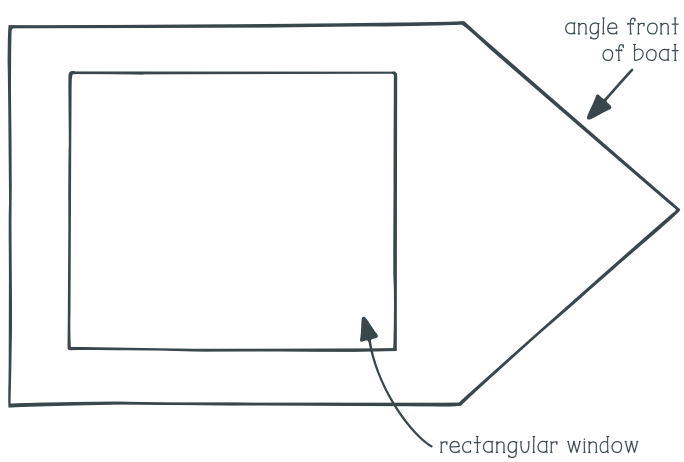
Steam-powered paddle wheel boats were common on American rivers in the 1800s, but now you're more likely to see smaller versions paddled by people. Both kinds work the same way, by pushing water with paddles mounted on wheels. Build your own boat that uses kinetic energy stored in rubber bands to move.

MATERIALS

- ☐ Cardboard
- ☐ Ruler
- ☐ Scissors
- ☐ Duct and clear tape
- ☐ Rubber bands
- ☐ Bin
- ☐ Water
- ☐ Craft sticks or straws
- ☐ Lightweight, lidded plastic bottle or container, such as one for margarine

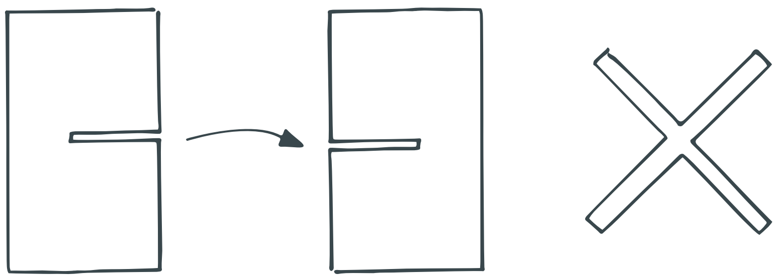
INSTRUCTIONS

Cut the cardboard into several pieces of these dimensions: one piece that is 5 inches by 10 inches, and two pieces that are 1.5 inches by 2.5 inches each. The large piece is the body of the boat. On one end of this piece, cut a rectangular window that measures 3 by 4 inches and is 1 inch from the edges. This is the back of the boat. On the front of the boat, cut the corners on an angle so the front is pointed.

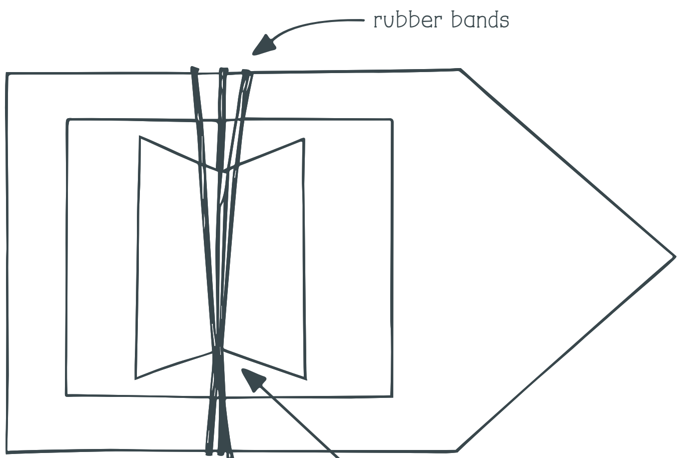


Cover the entire body of the boat with duct tape. This will help make it waterproof. The better you cover everything, especially the tricky inside corners, the longer your boat will last.

On the smaller pieces, cut a slit in the center of the long edge that goes half way through. Do the same with the other piece. Fit the two slits together in an X or "plus" shape. This is your paddle wheel. Cover the X shape with duct tape.



To attach the paddle wheel to the boat body, stretch two rubber bands across the center of the boat's back window. Place the paddle between the rubber bands, with one on each side of the X.



Wind up the boat by turning the paddle backwards. Hold on to the paddle as you place the boat in water, then let it go!

WHAT'S HAPPENING?

When you wind up the paddle, the rubber band stores energy. This is potential energy, which occurs because the twisted rubber band is not in equilibrium–you have to hold it in place or it will unwind. When you let go of the paddle, the rubber bands unwind to rotate the paddle and push the boat forward. That unwinding is the conversion of potential energy to kinetic energy, which is the energy of motion. The rubber band moving the paddle and the paddle pushing on the water and the boat moving forward are all examples of kinetic energy.

GAME ON

Change your boat design to see if you can make it move faster or travel farther. Use a lightweight plastic container, tape two craft sticks or straws on either side and attach the rubber bands and paddle to the end of the craft sticks. Try other materials that float and don't get soggy in water, such as wood or Styrofoam. Decorate your boat, and see if you can give a toy figure a ride!

RECOMMENDED READING

Things That Float and Things That Don't by David Adler, illustrated by Anna Raff

Boats Float! by George Ella Lyon

UP, UP AND AWAY

EXPERIMENT: HOT AIR BALLOON

OUTSIDE FUN

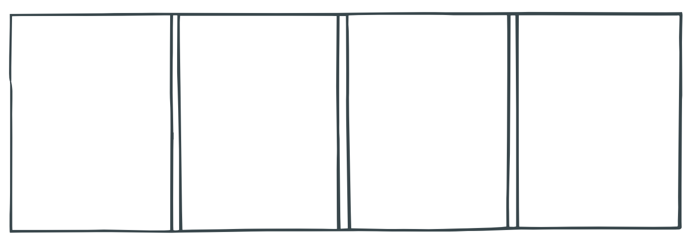
Move some molecules as you explore thermal energy. Float to your destination as you build a tissue paper balloon and then use hot air to make it soar.

MATERIALS

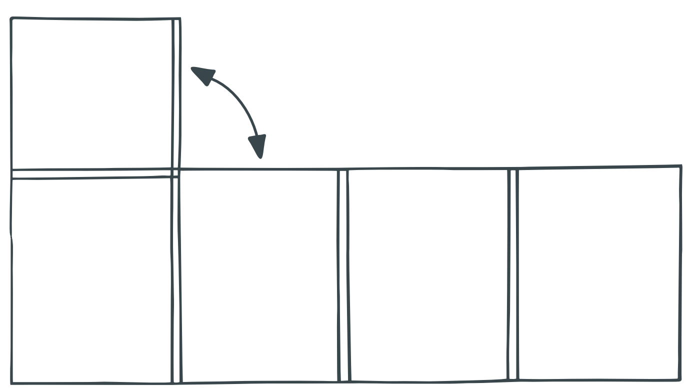
- ☐ Glue stick
- ☐ Scissors
- ☐ Meter stick
- ☐ Small toy figurine
- ☐ Paper clips
- ☐ String
- ☐ Masking tape
- ☐ Lightweight basket (optional)
- ☐ 6 sheets of tissue paper (20 inch by 26 inch)
- ☐ Heat gun (a hair dryer will work, but not as well)

INSTRUCTIONS

Glue two sheets of tissue paper together on the long edge so they overlap by about half an inch. Be careful to not tear the tissue paper as you're gluing–your balloon can't have any holes in it in order to work. Glue two more sheets along the long end of your first set so you have four tissue paper panels glued together, overlapping each sheet by half an inch.



Cut the remaining two pieces of tissue paper into squares that are 20 inches per side. Glue one edge of the square to the short, top edge of the first full-sized sheet, overlapping the paper by half an inch.

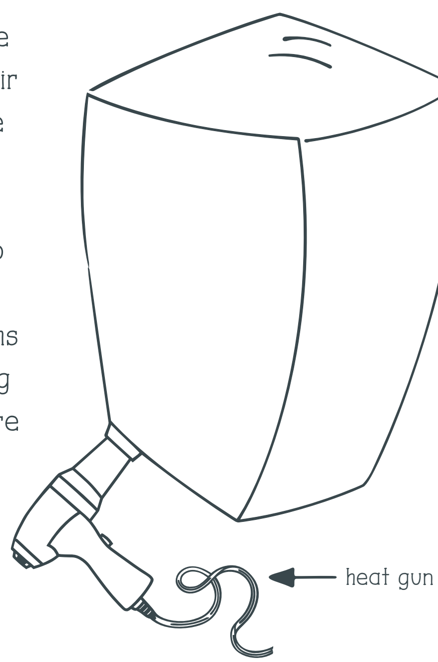


Now it gets a bit tricky because we will give the balloon three-dimensional shape instead of being flat. Glue the remaining three edges of the square to the short edges of the remaining three full-size sheets, with the tissue paper overlapping by half an inch. Glue the last two long edges together. The resulting shape should look like a rectangular box that's open on one end.

Take the second square and glue it along the remaining open edges, like you did on the top. When you are done, you should have a sealed, rectangular box with six sides. Check your seams and make sure they are sealed. If you have any rips or holes, add a patch by cutting a small piece of scrap tissue paper and gluing it over the hole.

Pick one corner of the box and cut a small hole that's big enough to fit the nozzle of the heat gun or hair dryer. Put masking tape around the edge of the hole to strengthen it.

To launch, gently flatten the balloon and fill it with hot air by putting the nozzle of the heat gun inside the hole. Be careful–the heat gun gets very hot! Have a friend help keep the balloon upright as it fills with air. Once it seems full, keep the hot air blowing for a bit longer to make sure it's thoroughly heated. Then turn off the heat gun and let go!



WHAT'S HAPPENING?

You have probably heard that hot air rises, but why does that happen? Air takes up space, which you can see when a balloon is filled up with air. But air also has weight. Air is made up of microscopic molecules, and when you heat them up, the molecules move around and fewer of them will fit in a space like your balloon. That means the air inside the balloon weighs less than the air around it (it has a lower density). Things with a lower density will float. When the air inside the balloon cools, the density of the air increases so the balloon comes back to the ground.

GAME ON

Try making hot air balloons of different shapes, like one that looks like the balloons that take passengers in the sky. Can you make one that's twice as big? How about one that's able to carry a small passenger, like your favorite LEGO® figure?

TIPS

Safety note: Use caution when using the heat gun. A hair dryer will also work, but it won't heat the air inside the balloon as much, so your balloon may not fly as high. Tissue paper is really fragile. You don't want any tears in your balloon, so glue carefully.

LEARN MORE

Explore the science of convection as you send huge hot air balloons soaring three stories high in MSI's *Science Storms* exhibition.

RECOMMENDED READING

The Hot Air Balloon Book: Build and Launch Kongming Lanterns, Solar Tetroons, and More by Clive Catterall

The Amazing Air Balloon by Jean Van Leeuwen

THE RUBBER MEETS THE ROAD

EXPERIMENT: FLUBBER AND BOUNCY BALLS

When you travel, you're often in a vehicle that uses rubber tires. Rubber is made of many different polymers, which are long chains of molecules. Link the polymers in glue together to create flubber (aka slime), then change the recipe to make a bouncy ball.

MATERIALS

- ☐ School glue (white or clear)
- ☐ Measuring cups and spoons
- ☐ Glitter, googly eyes, confetti (optional)
- ☐ Borax laundry additive
- ☐ Craft sticks or other stirrers
- ☐ Food coloring
- ☐ Bowls
- ☐ Water
- ☐ Plastic cups
- ☐ Wax paper

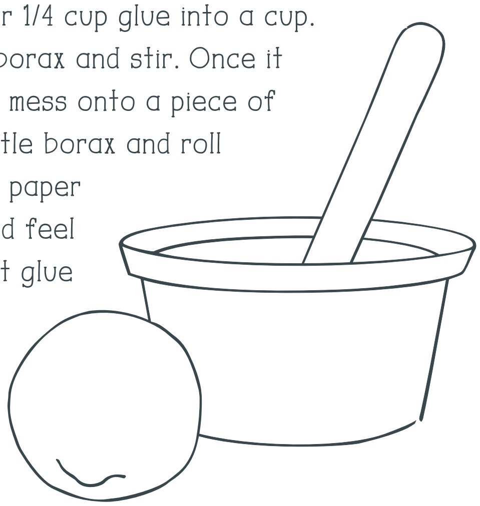
INSTRUCTIONS

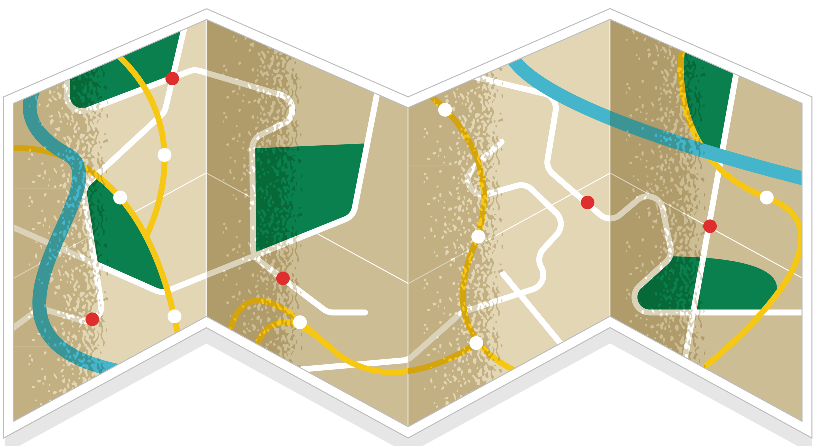
Measure 1/2 tablespoon of borax and put it in a cup or bowl. Add two tablespoons of water and stir. Not all of the borax will dissolve.

In another cup or bowl, measure two tablespoons of glue and add two tablespoons of water. Stir well. Add a few drops of food coloring.

Quickly pour the borax mixture into the glue mixture and stir rapidly. If you have a helper, one person can stir the glue while the other pours in the borax. The mix should instantly turn to flubber. If you would like, add some glitter or other small items to the flubber. Finish mixing by hand.

To make a bouncy ball, pour 1/4 cup glue into a cup. Mix in three teaspoons of borax and stir. Once it starts to solidify, dump the mess onto a piece of wax paper. Sprinkle on a little borax and roll the blob around in the wax paper to work it in. The ball should feel dense. Rinse the excess wet glue and borax off with some water, and give it a bounce.





GAME ON

Try making other flubber variations, like magnetic flubber. Add one tablespoon of iron filings to the flubber and work it into the mixture. Hold a strong neodymium magnet near the flubber and watch it move! Neodymium magnets and iron filings can be purchased online from science supply stores.

WHAT'S HAPPENING?

White glue is loaded with a type of chemical called a polymer. Polymers are long chains of molecules. Polymers are part of our everyday lives–fabrics like nylon and polyester are polymers. Proteins and fats in our bodies also are polymers. Natural rubber from trees is also a polymer. The polymers in glue just slide past each other, but adding borax causes a chemical reaction. Borax links those polymers to each other and connects them in a big network; this is called cross-linking. Now the polymers can't slide around and the mix solidifies into flubber.

TIPS

Borax is an irritant and should be kept out reach of children and pets. While safe in diluted solutions, borax can be harmful if ingested. To keep the flubber and bouncy ball from drying out, store them in zippered plastic bags.

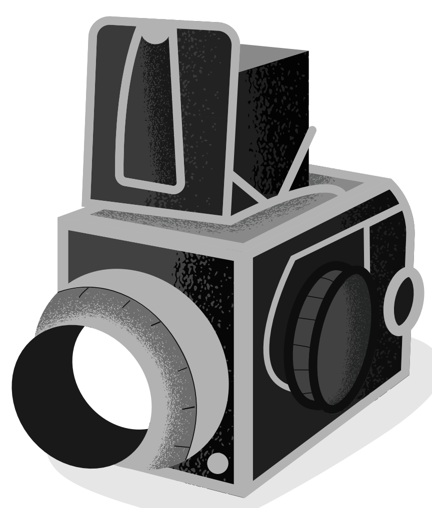
LEARN MORE

Making flubber causes a chemical reaction. Make virtual chemical reactions with MSI's goREACT game and app: msichicago.org/goreact.

RECOMMENDED READING

Henry Ford for Kids: His Life and Ideas with 21 Activities
by Ronald Reis

Cars, Trains, Ships, and Planes
by DK Publishing



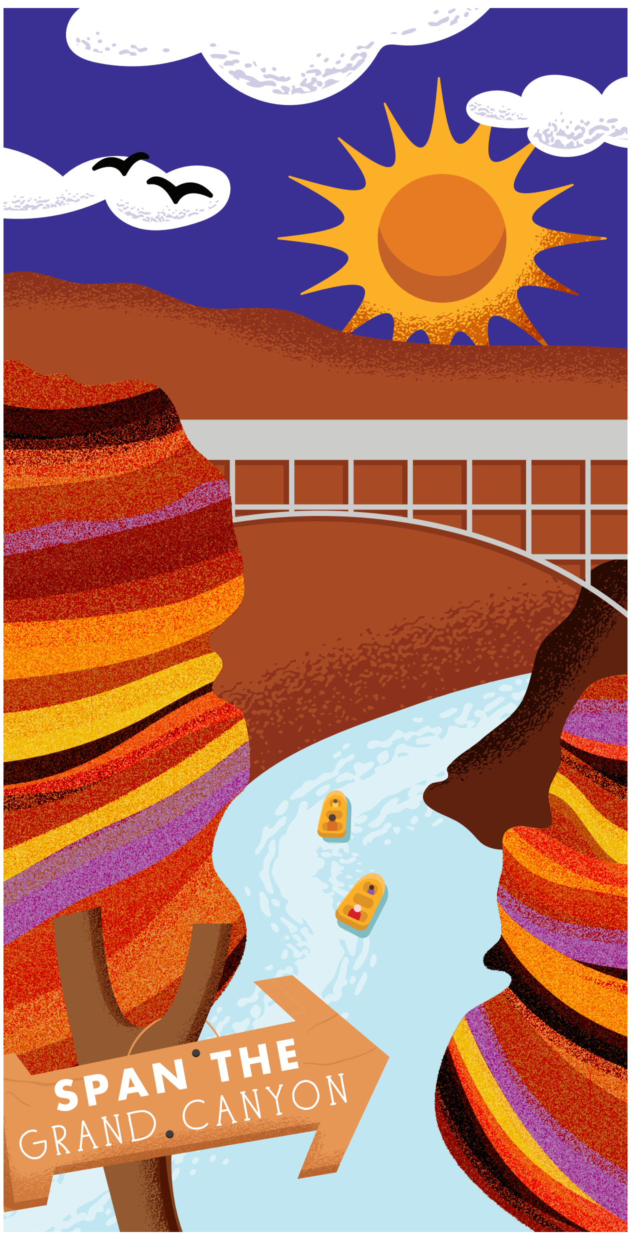
BRIDGING THE GAP

EXPERIMENT: STRAW BRIDGES

Travel is easier when you have a bridge to help you get across a rushing river or huge gorge that's in your path. There are many different bridge designs, but they all have the same function: to provide passage over an obstacle.

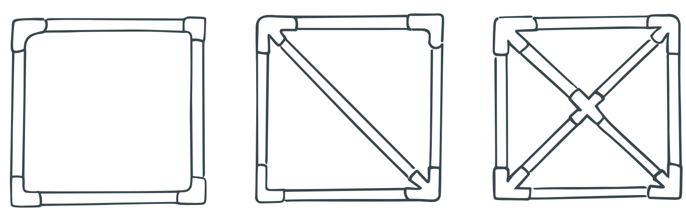
MATERIALS

- ☐ 35 non-bendy straws
- ☐ Clear tape
- ☐ Scissors
- ☐ Meter stick
- ☐ 200 to 300 pennies
- ☐ Small cup
- ☐ Pencil
- ☐ Paper
- ☐ Two chairs or tables



INSTRUCTIONS

Start with a quick activity to understand which shape is strongest. Tape together straws to make three squares like the ones below. On one square, tape a straw on the diagonal through the center. On another square, tape two straws through the center to make an X. Stand up each shape and push down gently on the top. Which shape feels strongest?



Your challenge is to build a bridge using shapes that you think will make your bridge the strongest and able to hold the most weight. It must meet these requirements:

1. Span at least 25 centimeters across two tables or chairs and not be taped or attached to them.
2. Use no more than 20 straws, but they can be cut into smaller pieces.
3. Securely hold a small cup in the middle of the bridge. This is where you place pennies to test the weight limit.

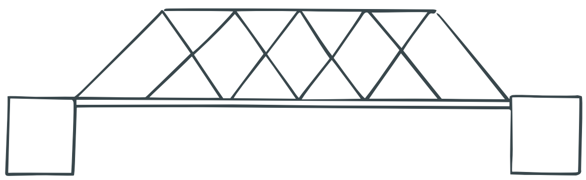
Before you build, come up with an idea of how you will design the bridge. Draw sketches if it helps you think through your ideas. Build your bridge using only straws and clear tape. When you are satisfied with your bridge place it between two tables or chairs that are 25 centimeters apart. Place the cup in the middle and add a few pennies at a time. Count the pennies and keep adding them until the bridge collapses. How many pennies did it hold? How did the bridge break? Can you change your design to make it stronger?

PRIMARY BRIDGE TYPES

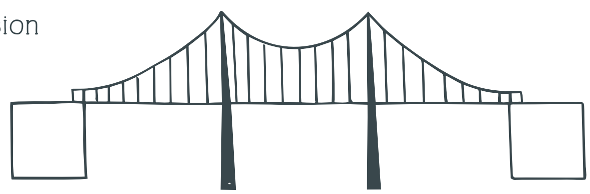
Beam

Arch

Truss



Suspension



WHAT'S HAPPENING?

Look at a steel or wooden bridge and often you will see triangle shapes making up most of the bridge's support structure. These are called truss bridges. Triangles are structurally the strongest shape because they allow weight to be evenly spread throughout a structure, allowing it to support heavy loads. Truss patterns are used in other structures as well, such as roofs, radio towers, crane arms and more. Engineers must consider loads, or the weights and forces that a structure must withstand. The dead load of a structure is the weight of the structure itself. The dead load of a bridge includes beams, cables and the deck. The live load of a structure is the weight that is added to the structure, including people, cars and wind.

GAME ON

Have a bridge-building competition with your family or friends. Give everyone the same amount of materials and try to build the strongest bridge in a specific amount of time. Or try building a bridge over a longer distance. You can also try building bridges with other materials, such as craft sticks or dry spaghetti.

LEARN MORE

Marvel at the 60-foot Golden Gate Bridge made entirely from LEGO® bricks in MSI's *Brick by Brick* exhibit, then try your hand at several building challenges.

RECOMMENDED READING

Bridges and Tunnels: Investigate Feats of Engineering by Donna Latham

FLOATING ON AIR

EXPERIMENT: HOVERCRAFT

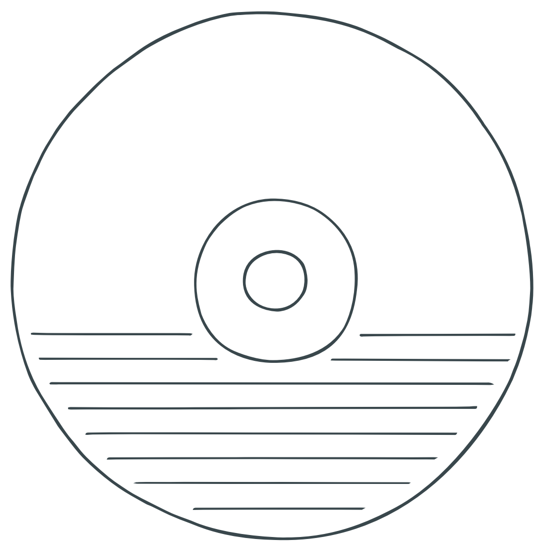
Imagine a vehicle that has no wheels but can travel over land and water. That's what a hovercraft can do! Hovercrafts float just a little bit above the ground by pushing air down really fast, creating a cushion.

MATERIALS

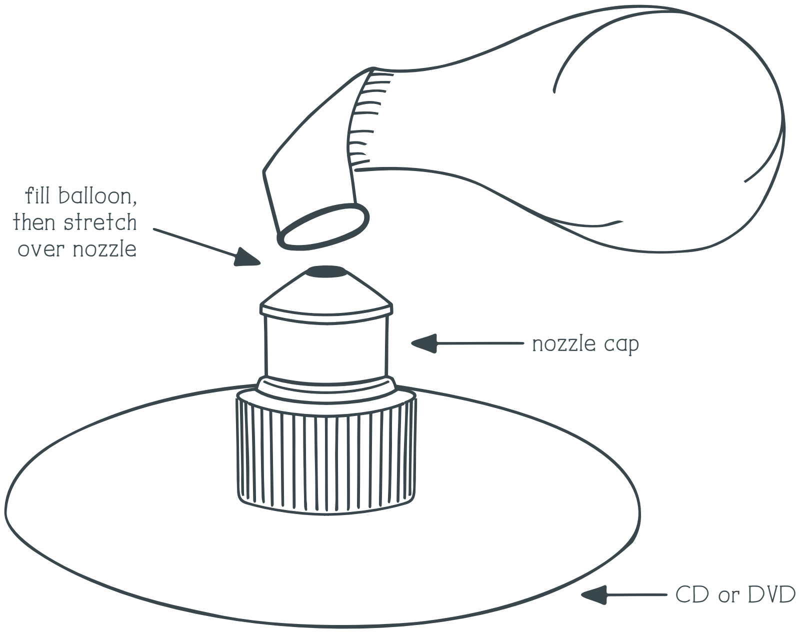
- ☐ Super glue or rubber cement
- ☐ Markers
- ☐ Plastic cups
- ☐ CD or DVD (one that it's OK to ruin)
- ☐ Balloons (try different shapes and sizes)
- ☐ Nozzle cap, like from a bottle for a sports drink or dish soap

INSTRUCTIONS

Glue the nozzle cap to the CD or DVD so it's centered over the hole in the disc. Make sure the cap is in the closed position. Let the glue dry. This can take time, so be patient! Use markers or stickers to decorate the CD.



Blow up the balloon and twist–but don't tie–the end. Stretch the end of the balloon over the nozzle. Let the balloon untwist. If the nozzle is closed, the air should stay in the balloon.



Place your hovercraft on a smooth, hard, flat surface like a table or counter. Pull up on the nozzle and give your hovercraft a gentle push. It should float smoothly over the surface like an air hockey puck. Make a game of it—create a goal at one end of the table with cups and try to make your hovercraft score. Or stack plastic cups in a pyramid and see if the hovercraft can knock them down.

GAME ON

Try different sizes and shapes of balloons, such as a large punching bag balloon or a long, thin balloon. What type of balloon works best? What can you do to make the air in the balloon escape more slowly? Challenge a friend and see who can make their hovercraft travel farthest on one balloon full of air.

WHAT'S HAPPENING?

The air coming out of the balloon is pushed underneath the disc and needs to escape. As it pushes down and out, a cushion of air is created underneath the disc and pushes the hovercraft up just a little bit. That little bit of air cushion means the disc is no longer in contact with the surface and friction is greatly reduced. Without friction, a little push can make the hovercraft go a long way.

TIPS

Regular school glue or glue sticks won't work to attach the nozzle to the disc. Super glue works best, so use safety precautions when using it. Have a parent help, and be careful to not get the glue on your skin.

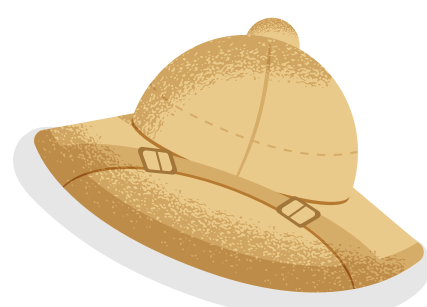
LEARN MORE

The Canadian Coast Guard uses a hovercraft called the CCGS Mamilossa in the St. Lawrence River because of the vehicle's versatility. Learn more at bit.ly/1S1neOJ, and find videos on YouTube.

RECOMMENDED READING

Kinetic Contraptions: Build A Hovercraft, Airboat, and More With A Hobby Motor by Curt Gabrielson

Forces and Motion by John Graham



DESIGNED TO MOVE

EXPERIMENT: RUBBER BAND CAR

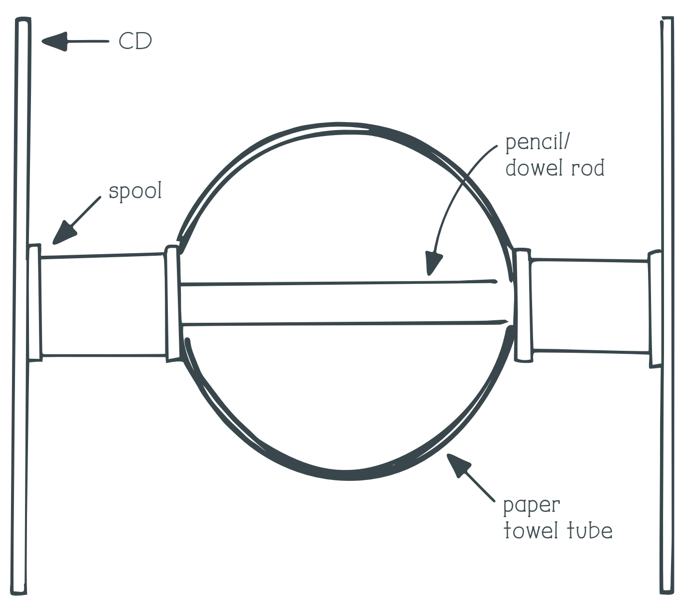
Cars move by transforming stored electrical energy to kinetic energy that pushes the vehicle. Try building a simple wheeled vehicle that uses the potential energy in a twisted rubber band to move. Use our suggestions to get you started, then use your creativity to design your own.

MATERIALS

- ☐ CDs or other round items for wheels (wide bottle caps, container lids, etc.)
- ☐ Paper clip
- ☐ Two pencils or dowel rods for the axles
- ☐ Rubber bands
- ☐ Hole punch
- ☐ Paper towel tube for the body
- ☐ Four spools
- ☐ Duct tape
- ☐ Super glue
- ☐ Four balloons
- ☐ Scissors
- ☐ Markers

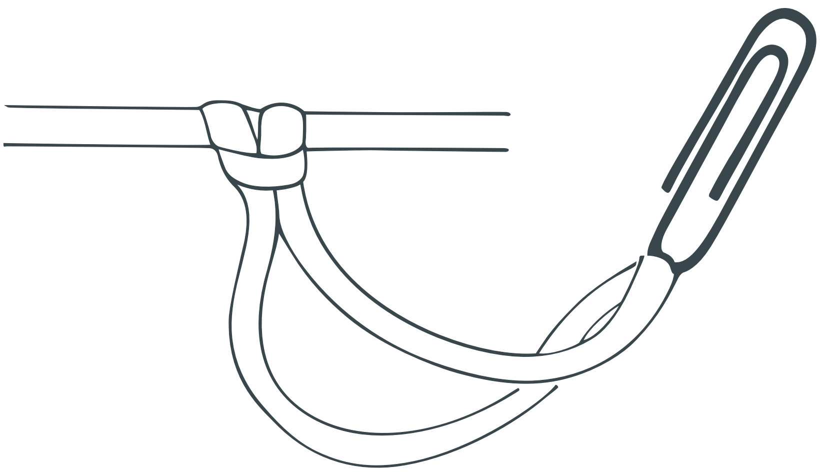
INSTRUCTIONS

Prepare the car's body by using the hole punch to make two holes opposite each other on one end of the paper towel tube. The holes should be large enough so the dowel or pencil can fit through and spin freely. Repeat with two more holes on the opposite end of the paper towel tube and insert the dowels. The dowels should be far enough away from each other so that when the wheels are attached the wheels don't touch. Decorate the body with markers or other art supplies.



Attach the wheels firmly to the axles by inserting the end of the dowel into a spool, then using super glue and duct tape to attach the CD wheel to the spool and dowel. The spool has more surface area, so there's more space to attach the CD wheel. Let the glue dry.

Use a rubber band that's almost as long as the body of the car. If you don't have one long enough, loop two or more rubber bands together. Loop one end of the rubber band around an axle and hold it in place with duct tape. Attach a paper clip to the other end of the rubber band, stretch the rubber band through the paper towel tube and clip the paper clip to the opposite end of the paper towel tube. The rubber band should not have slack, but it shouldn't be too tight, either.



Wind the rubber band around the axle by spinning the back wheels until the rubber band is tight. Place the car on the floor while holding the back wheels and let it go! To give the wheels more traction, cut the mouth off a balloon and stretch it around to cover the CD. Repeat for the other wheels. You can also try covering the wheels with tape or wrapping them with a few rubber bands.

WHAT'S HAPPENING

The rubber band stores energy when it's wound up. This stored energy is called potential energy. When you release the wheel, all the energy makes the wheels spin to push the car forward. The potential energy is transformed into kinetic energy, which is the energy of motion. The more you wind the rubber band around the axle, the more energy is sent to the wheels which makes it move faster and farther.

GAME ON

Challenge a friend to a race! Be an engineer and alter your car design - what other materials can you use for the body or the wheels? Try fewer or more wheels, or a different body shape, or more rubber bands. Can your car overcome obstacles, like ramps or debris?

TIPS

The wheels need to be larger than the car body.

LEARN MORE

The wheel and axle is one of six simple machines, which are machines designed to help make work easier. Find out about the others by playing MSI's online Simple Machines game at msichicago.org/simple-machines.

RECOMMENDED READING

Poem-Mobiles: Crazy Car Poems by Patrick J. Lewis, illustrated by Jeremy Holmes

Are We There Yet? by Dan Santat

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

The Museum of Science and Industry, Chicago (MSI), one of the largest science museums in the world, offers world-class and uniquely interactive experiences that inspire inventive genius and foster curiosity. From groundbreaking and award-winning exhibits that can't be found anywhere else, to hands-on opportunities that make you the scientist–a visit to MSI is where fun and learning mix. Through its Center for the Advancement of Science Education (CASE), the Museum offers a variety of student, teacher and family programs that make a difference in communities and contribute to MSI's larger vision: to inspire and motivate children to achieve their full potential in science, technology, medicine and engineering. Come visit and find your inspiration! MSI is open 9:30-4 p.m. every day except Thanksgiving and Christmas day. Extended hours, until 5:30 p.m., are offered during peak periods. The Museum is grateful for the support of its donors and guests, who make its work possible. MSI is also supported in part by the people of Chicago through the Chicago Park District. For more information, visit msichicago.org or call (773) 684-1414.

museum of
science+industry
chicago

5700 S. Lake Shore Drive | Chicago, IL 60637 | **msichicago.org**

Travel poster illustrations by Jillian Marsala. Technical drawings by Alison Neidt Toonen.