

Science Fun with **PHYSICS**



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FOR SUMMER 2020

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THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,
AND ENVIRONMENTAL SCIENCES



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This project book demonstrates adherence to the highest educational standards within 4-H.

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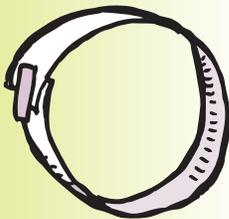
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Note to the Project Helper

Congratulations! A 4-H member has asked you to serve as a project helper. You may be a parent, relative, project leader, friend, club advisor or another individual important in the 4-H member's life. Your duties begin with helping the youth create and carry out a project plan, as outlined in the Member Project Guide. This is followed by helping the youth focus on each activity, providing support and feedback, and determining what was done well, what could have been done differently, and where to go next.

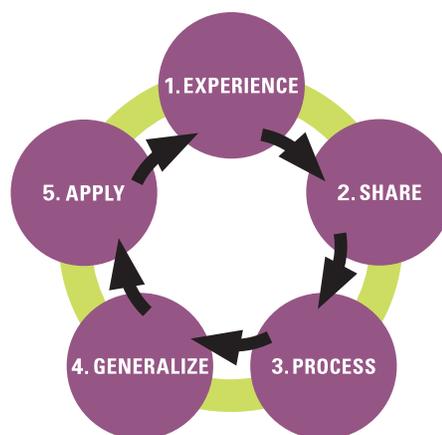
As a project helper, it is up to you to encourage, guide and assist the 4-H member. How you choose to be involved helps to shape the 4-H member's life skills and knowledge of the importance of physics.

Your Role as Project Helper

- Guide the youth and provide support in setting goals and completing this project.
- Encourage the youth to apply knowledge from this project book.
- Serve as a resource person.
- Encourage the youth to go beyond the scope of this 4-H project book to learn more about physics.

What You Should Know About Experiential Learning

The information and activities in this book are arranged in a unique, experiential fashion (see model). In this way, youth are introduced to a particular practice, idea, or piece of information through an opening (1) **experience**. The results of the activity are then recorded in the accompanying pages. Youth then take the opportunity to (2) **share** what they did with their project helper, (3) **process** the experience through a series of questions that allow the learner to (4) **generalize** and (5) **apply** the new knowledge and skill.



Pfeiffer, J.W., & Jones, J.E., Reference Guide to Handbooks and Annuals. © 1983 John Wiley & Sons, Inc. Reprinted with permission of John Wiley & Sons, Inc.

What You Can Do

- Review the Learning Outcomes (project skill, life skill, educational standard, and success indicator) for each activity to understand the learning taking place. See the inside back cover for a summary of the learning outcomes.
- Become familiar with each activity and the related background information. Stay ahead of the learner by trying out activities beforehand.
- Begin the project by helping the learner establish a plan for the project. This is accomplished by reviewing the Member Project Guide.
- After each activity, conduct a debriefing session that allows the learner to answer the review questions and share results. This important step improves understanding from an experiential learning perspective.
- Help the learner celebrate what was done well, and see what could be done differently. Allow the learner to become better at assessing his or her own work.
- In the Member Project Guide, date and initial the activities that have been completed.



Member Project Guide

Welcome to *Science Fun with Physics*! This project is designed for 4-H members with beginning-level skills with science experiments. After completing this project, you are encouraged to explore other science, technology, engineering and math (STEM) project books.

Check your county's project guidelines (if any) for completion requirements in addition to the ones below, especially if you plan to participate in county project judging or plan to prepare an exhibit for the fair.

Project Guidelines

Step 1: Complete **all 12** experiments.

Step 2: Take part in **at least two** learning experiences.

Step 3: Become involved in **at least two** leadership/citizenship activities.

Step 4: Complete a project review.

Step 1: Experiments

Complete **all 12** magical experiments. The More Magic activities are optional but help enhance your magical training and understanding of physics. Take good notes and record your experiment results. When you begin an activity, jot down the date you start it. When you finish an activity, review your work with your helper. Then ask your helper to initial and date your findings.

Magical Experiments	Date Started	Date Completed	Project Helper Initials
Beginner Level: Magic for the New Magician			
1. Drops on a Penny			
2. Parachute Away!			
3. Create a Rainbow			
4. Lincoln High Dive			
Conclusions			
Apprentice Level: More Magic that Moves			
5. Now We Mix, Now We Don't			
6. The Loopy Plane			
7. Move It with Magnets			
8. Comeback Can			
Conclusions			
Master Level: You Are Audience-Ready			
9. Egg in a Bottle			
10. Balloon Rocket Dragster			
11. Surface Surfer			
12. Bottle Levitation			
Conclusions			

Step 2: Learning Experiences

Magical learning experiences are meant to complement your training, providing you with a chance to explore the wonders of physics. What are some learning experiences you could do to show the interesting things you are discovering about physics? Here are some ideas:

- Attend a clinic, workshop, demonstration or speech related to physics.
- Help organize a club meeting based on one of the experiments.
- Go on a related field trip or tour a business that uses magnets, electricity or temperature changes to make a product.
- Write a paper about a famous physicist.
- Prepare your own demonstration, illustrated talk or project exhibit.
- Participate in county judging.

Once you have a few ideas, record them here. Complete **at least two** learning experiences. Then, describe what you did in more detail. Ask your project helper to date and initial in the appropriate spaces below.

Plan to Do	What I Did	Date Completed	Project Helper Initials
<i>Demonstration</i>	<i>Separated the colors of a rainbow on a piece of paper.</i>	<i>4/15/YR</i>	<i>K.B.</i>

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Step 3: Leadership and Citizenship Activities

Choose **at least two** leadership/citizenship activities from the list below (or create your own) and write them in the table below. Record your progress by asking your project helper to initial next to the date each one is completed. You may add to or change these activities at any time. Here are some examples of leadership/citizenship activities:

- Teach someone how physics and magic work together.
- Help another member prepare for his or her project judging.
- Organize a club field trip to a local science center.
- Encourage someone to enroll in *Science Fun with Physics*.
- Arrange for a speaker to visit your club.
- Plan your own leadership/citizenship activity.

Leadership/Citizenship Activity	Date Completed	Project Helper Initials
<i>Organized a club magic demonstration using physics.</i>	<i>5/5/YR</i>	<i>K.B.</i>

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The Magic of Matter



March 20, 1924

I, Franco Newtoni, the most amazing magician ever known, will share the secret of magic with the whole world! No longer hiding in the shadows or tricking audiences. Now, everyone will learn what I have known for years. The secret to magic is ...



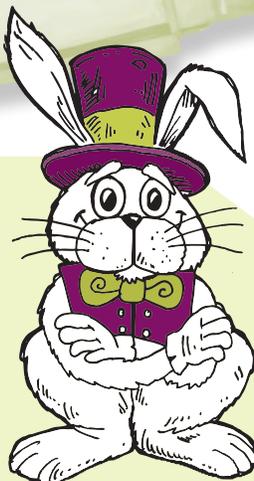
Ninety years ago, The Amazing Newtoni mysteriously *disappeared!* A leading magician of his time, Newtoni was working on this powerful book when he vanished. It was never finished. The Illusionist Guild wasn't pleased he was going to break the magician's code of honor by revealing the secret behind his tricks. Thankfully, this book fell into our hands before someone outside our Magical History Agency could decode it.

As junior researcher for our agency, it is your job to determine the secret Newtoni was going to share. This diary is filled with magical experiments designed for new magicians. We can only assume that by testing each experiment you will get closer to the truth behind Newtoni's magic. Use your observation skills, superior knowledge and logic as you explore each level of this guide.

Ready? Look for these helpful guides along the way:



Magic Assistant: Every magician has a helper. The magical assistant in our guide helps you with important tips and safety information about each trick.



White Rabbit: The white rabbit explains how science and magic work together to create illusions.

More Magic:

Included in each level are a few extra experiments you can try performing in front of an audience, such as your family, friends or club. Practice before you perform so you know exactly what happens in each trick.



Beginner Level: Magic for the New Magician

To be an outstanding magician, you need to start with the basics. **Matter** surrounds us. It's in the furniture in your house, in the food you eat, and in the air, earth and water. When you learn how to control the elements, you will amaze and astound your audience. I have collected these four experiments to teach you about water, light and an amazing force called **gravity**.

Senior Researcher Notes

Newton's book states that matter is magic. But there's a little more to it. From what we have learned, there are very specific rules to explain why matter acts the way it does. These rules were discovered after years of studying matter. Try each experiment and see if you can figure out what Newton was trying to teach.

Experiment 1: Drops on a Penny

Learning Outcomes

Project skill: *Discovering the force of surface tension*

Life skill: *Processing information*

Educational standard:
NGSS 3-PS2.B, *Objects in contact exert forces on each other*

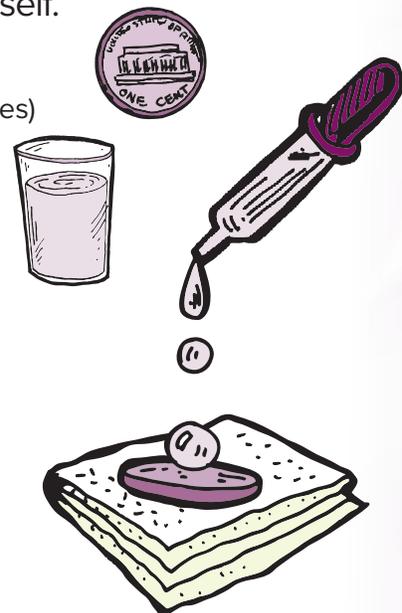
Success indicator: *Records the number of drops that fit on a penny*

Take a good look at raindrops on a leaf or water droplets from your faucet. The smallest droplets are almost perfect spheres. How do we explain how water “beads” on a surface? And how big can the sphere of water become before it breaks apart? Gather the following materials and test it for yourself.

Supplies

- eye dropper (available at drug stores)
- cup of water
- penny
- paper towel, folded in quarters

Time needed:  5 minutes



Words in **bold** throughout this book are defined in the glossary.

Magic Assistant Tip

Make sure the penny is in the middle of the paper towel square.

What to Do

Place the penny on the paper towel. Write down your guess of how many drops of water you can fit on the penny. Now, using the eye dropper, place one drop at a time on the penny, keeping track of the total. Observe the shape of the water accumulating on the penny. Once the water overflows onto the towel, dry the penny and try again. Do this a total of three times, recording your results each time.



Try It Again

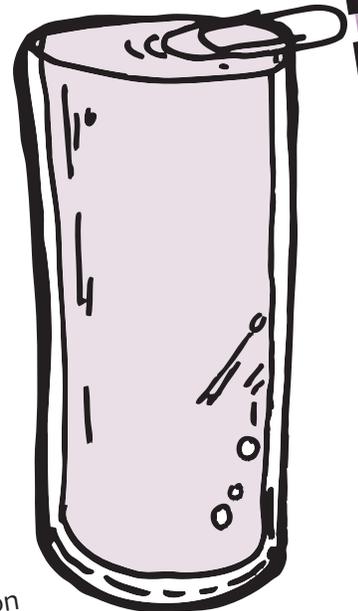
See if using different liquids makes a difference. Estimate how many drops you think will fit on top of the penny. Record each liquid and the number of drops. Were you correct? Will the penny hold the same number of drops for different liquids? Why or why not?

Record your observations:

Explanation

The force of surface tension attracts the molecules in a liquid to each other. This makes the water look as if there is a thin elastic “skin” over the surface. This skin is strong—have you ever seen insects “walk” on water? They are supported by the surface tension of the water and by spreading out their weight over the water using their long legs. How does this skin form? Molecules of water attract and are attracted by all of the other water molecules around them. Stronger **bonds** exist on the surface of a liquid because those molecules have no other molecules above them, making the surface bonds even stronger. These stronger bonds provide the effect of surface tension.

Source: This experiment is cited in numerous science books and online science resources.



More Magic

Fill a cup to the rim with water. Tell your audience you are going to make a paper clip float on the water. Challenge an audience member to try it. Most people will drop the clip straight in so it sinks to the bottom. Now, carefully balance the paper clip on the edge of the cup and slowly push it onto the surface of the water, without dipping your finger into the water. Surface tension supports the paper clip, just like magic!

What's the Trick? Surface tension helps the paper clip float, just like in the Drops on a Penny experiment. When the paper clip is flat, the water molecules have more **surface area** to support, allowing the clip to stay on top of the water.

Source: coolscience.org/CoolScience/KidScientists/FloatDivePaperClip.htm

Experiment 2: Parachute Away!

Learning Outcomes

Project skill: Testing the pull of gravity and the power of air resistance

Life skill: Keeping records

Educational standard: NGSS 3-PS2.A—Each force acts on one particular object and has both strength and direction

Success indicator: Determines which size parachute most effectively slows the egg

If you throw an egg up into the air, it will come back down and make a big mess on the floor—there's no magic in that! Discover a safe way to deliver your egg to the ground. In this experiment, you will design several types of parachutes to slow down your egg payload to keep it from cracking.

Supplies

- three, 7- or 9-ounce plastic or foam cups
- facial tissues
- large plastic garbage bag
- lightweight string
- three raw eggs, possibly more
- masking tape
- scissors
- hole punch
- yard stick



Time needed:  **30** minutes

What to Do

1. Prepare the egg cradle. Use a hole punch to make four holes in the top of each cup, as shown on the next page. Take a few tissues and wad them up before putting them in the bottom of each cup.
2. Now make three different parachutes to test. Out of the plastic garbage bag, cut one of each of the following size squares: 10" x 10", 20" x 20", and 30" x 30". For each parachute cut four 20-inch lengths of string (you will need 12 total). Tie a piece of string to each corner of the plastic garbage bag square, then attach the four loose ends of the strings to each cup, matching the parachute corners to the same corner on the cup. Mark each cup with an A (10" x 10"), B (20" x 20"), or C (30" x 30").
3. Place one egg in each cup, on top of the balled up tissues, using masking tape to keep the egg in place. Then add a few more crumpled tissues and put masking tape across the top of each cup.
4. Predict which egg has the best chance of surviving a fall from 10–12 feet. Write your prediction below. After making your prediction, test each parachute by dropping it (unfurled) as you hold it from the top center of the parachute. Time each flight. Record your test results on the next page.

Your prediction: _____

Magic Assistant Tip

If any eggs broke upon landing, see if you can make adjustments to prevent any breaks the next time you try.



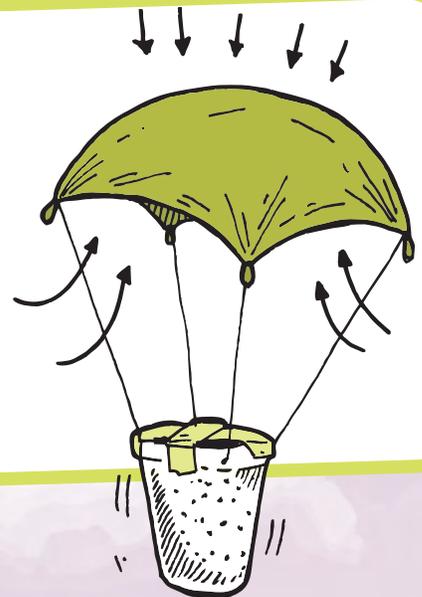


Record your observations:

Explanation

The natural force of gravity pulls objects toward Earth. When a parachute falls to Earth, or is pulled down by gravity, **air resistance** below the parachute pushes against it, slowing it down. When unfurled, the parachute has a lot of surface area. This means the larger the parachute, the slower it falls. Each parachute accelerates toward the ground until the amount of force from air resistance is equal to the pulling force of gravity.

Source: school.discoveryeducation.com/lessonplans/programs/forcesandmotion/



Experiment 3: Create a Rainbow

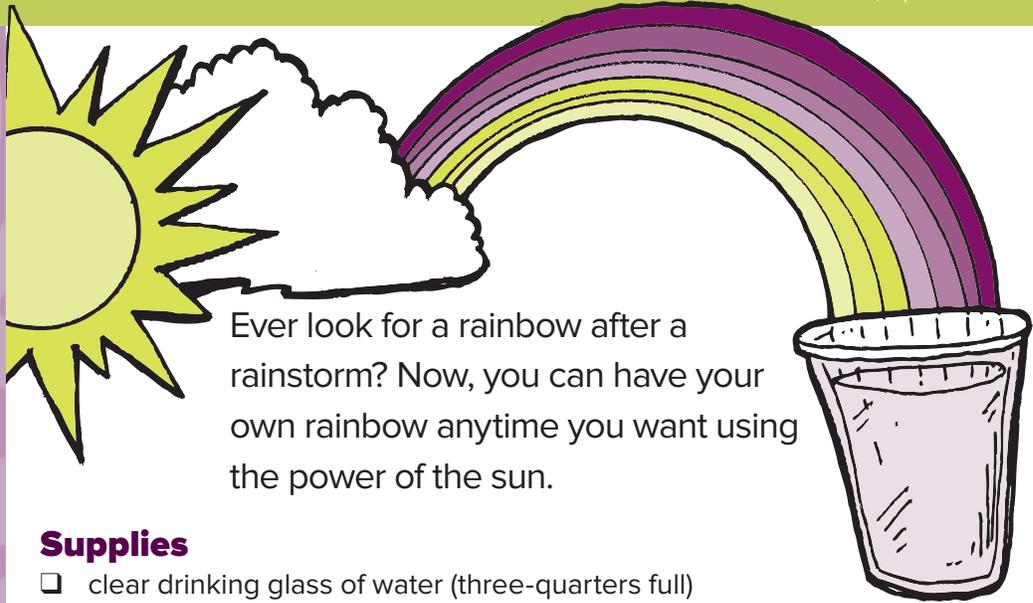
Learning Outcomes

Project skill: Bending light rays to explore the properties of light

Life skill: Navigating your environment

Educational standard: NGSS PS4.B—An object can be seen when light reflected from its surface enters the eyes

Success indicator: Splits a beam of light into the colors of a rainbow



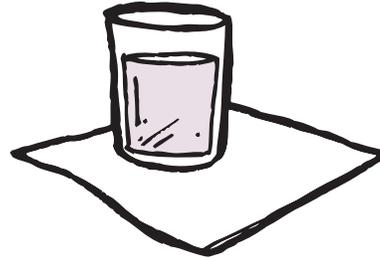
Ever look for a rainbow after a rainstorm? Now, you can have your own rainbow anytime you want using the power of the sun.

Supplies

- clear drinking glass of water (three-quarters full)
- white piece of paper
- a sunny day

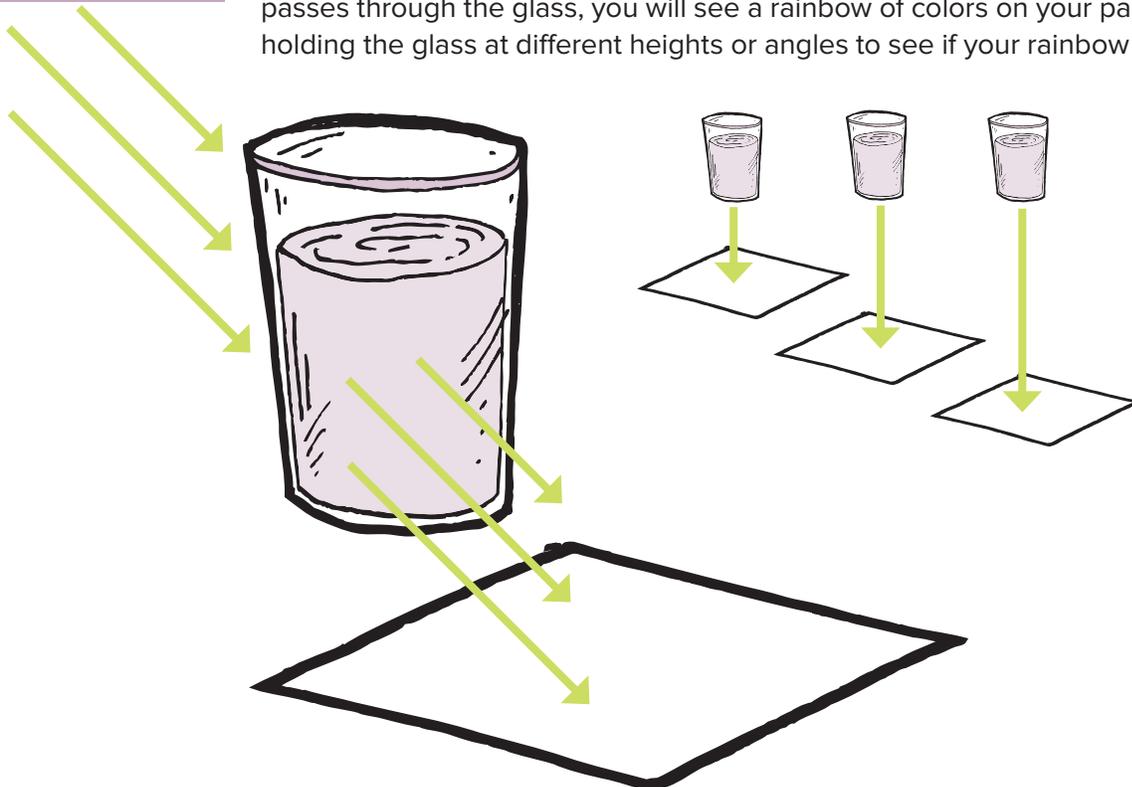


Time needed: **5** minutes



What to Do

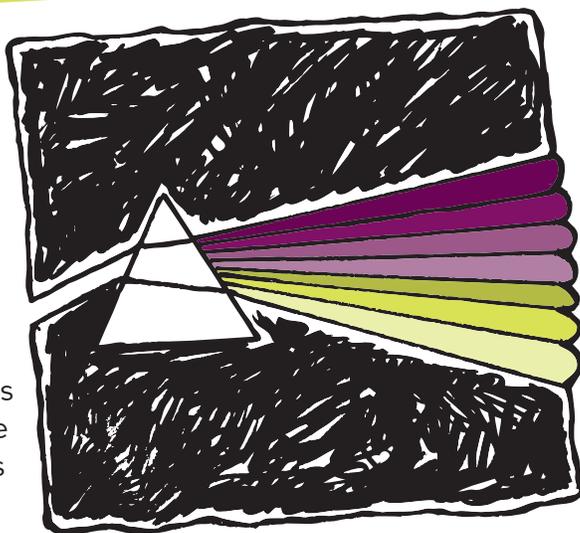
Fill the glass with water until it is three-quarters full. Bring the glass of water and the paper to a room where the sun is coming in, or go outside to a sunny spot. Hold the glass of water above the paper. Be careful not to spill it! As the sunlight passes through the glass, you will see a rainbow of colors on your paper. Try holding the glass at different heights or angles to see if your rainbow changes.



Record your observations:

Explanation

This experiment is all about **refraction**. Sir Isaac Newton was a famous **physicist** who discovered that what appears to the human eye to be “white” light is actually made up of several colors. As light passes through a glass **prism**, at an angle, it creates a band of colors: red, orange, yellow, green, blue, indigo and violet (remember the colors using this trick: ROY G. BIV). The colors in light travel at different speeds, causing them to refract (bend) at different angles. This allows the colors to separate from each other into the seven colors you see in a rainbow. Your glass acts as the prism, and separates the colors onto the white sheet of paper. Instant rainbow!



White Rabbit Wisdom

Magic is often about **illusions** and a **sleight of hand**. One way a magician creates a **misdirection** is by keeping the audience busy watching something else (an assistant or a big hand gesture) while the magician sets up the magic trick with the other hand. **Optical illusions** are visual tricks that fool your brain. Using color, light and patterns, optical illusions create confusing pictures. As your brain tries to make sense of the image, you end up seeing something that isn't really there. Follow this link for some fun optical illusions: kids.niehs.nih.gov/games/illusions

Source: sciencekids.co.nz/experiments/makearainbow.html



Experiment 4: Lincoln High Dive

Learning Outcomes

Project skill: Applying Newton's first law of motion

Life skill: Processing information

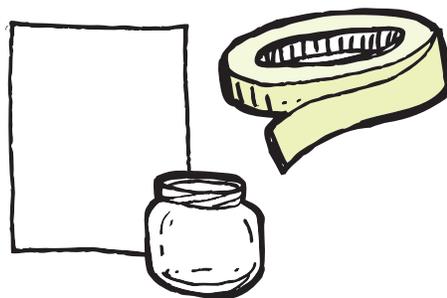
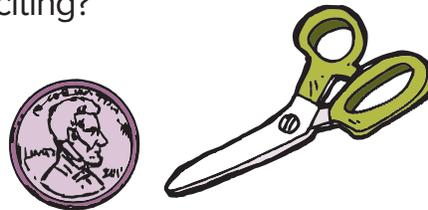
Educational standard: NGSS 5-PS2.B—The gravitational force of Earth acting on an object near Earth's surface pulls that object down toward the planet's center

Success indicator: Discovers how inertia works

Your audience won't believe this is possible. Keep your eye on the penny. Who knew **inertia**, which is an object's resistance to changing its motion, could be so exciting?

Supplies

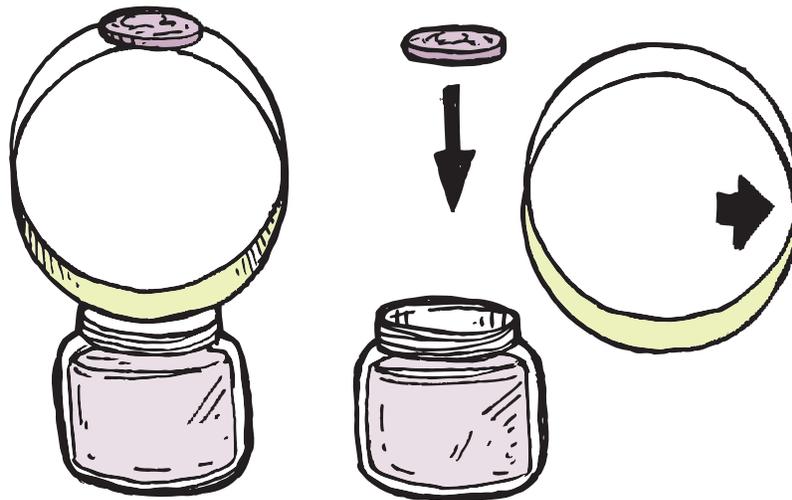
- penny or other small coin
- 8" x 11" cardstock or stiff paper
- baby food jar or small drinking glass
- scissors
- Scotch tape



Time needed: **5** minutes

What to Do

Cut the cardstock into a strip about 3/4" wide and 11" long. Form the paper into a loop and tape the overlapped ends. Place the hoop on the mouth of the jar, with taped side down. Balance the penny on the top of the hoop. Carefully place your index finger into the hoop close to one side without disturbing the penny and quickly fling the hoop off to the side. What happened?



Record your observations:

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Magic Assistant Tip

To make a splash with this experiment, fill the jar or canister with water.



Try It Again

Does the size of the hoop make a difference in this experiment? Try again with different sized hoops. How about the speed of pulling the hoop out of the way? Is the trick affected if you go slower? Try different size coins or objects to see if the results change.

Explanation

Force, motion and gravity work together to create an illusion. Sir Isaac Newton studied motion so much, he figured out certain rules—also known as laws—to explain his observations about the world around him. His first law of motion states that an object in motion will stay in motion and an object at rest will stay at rest, unless acted upon by an outside force. The penny is at rest. The hoop is in motion. When you pulled the hoop out from under the penny, you created force. However, the penny is not affected by any force except gravity when the hoop moves, so it just stays put. This is inertia in action. Without the hoop to hold up the penny, gravity pulls the inert penny down into the container.

Source: sciencebob.com/experiments/the_lincoln_dive.php

Background

Why is the sky blue? Why does the water ripple? Why is the sunlight warm? When we want to understand how the world works, we turn to **physics**. Physics is the science of matter, energy, motion and force. People who study physics have learned there are rules to explain how matter behaves in the natural world. The rules of physics can be discovered in magnets, simple machines, sound and light, electricity, and space.

Force is a form of energy that causes objects to move. Trees blow around by the force of wind. On a microscopic level, force holds the molecules of water together. Forces can push *and* pull. You use force to jump up in the air, but the force of gravity pulls you right back to Earth.

Motion is just a change in position. The penny moved from being above the loop to dropping in the jar thanks to the force of gravity. The ball you kick to a friend moves thanks to the force from your foot pushing it through the air. These same forces and motions can be found everywhere around us, from forces holding the moon in an orbit around the Earth to magnets clinging to your fridge.



Conclusions

SHARE Describe the shape of the water on the penny in the first experiment. If you tried other liquids, did they all look the same?

REFLECT Is a bigger parachute always better in Parachute Away? Why or why not?

GENERALIZE Light travels in waves. What else travels in waves?

APPLY Can you think of an example of inertia in everyday life?



Apprentice Level: More Magic that Moves

Now you must learn to control natural forces as you move objects through the air and across the room. Use the energy around you, and the power of your mind, as we journey through the next few experiments to test your magical strength.

Senior Researcher Notes

It is obvious Newtoni was not just a magician, but something else, too. These experiments seem like magic tricks, but he was using the natural qualities of objects to make his magic. You are close to discovering the big secret he wanted to share. Keep experimenting!

Experiment 5: Now We Mix, Now We Don't

Learning Outcomes

Project skill: *Mixing water with different temperatures*

Life skill: *Using scientific methods*

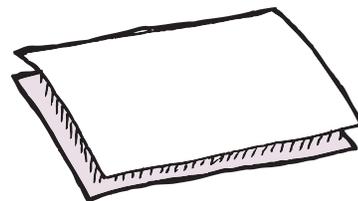
Educational standard: *NGSS 5-PS1-3—Make observations and measurements to identify materials based on their properties*

Success indicator: *Understands properties of water density at different temperatures*

You already know that mixing the colors red and blue makes purple. In this experiment you can fool your friends by using the principles of molecular motion.

Supplies

- four jars with identical mouth openings (baby food jars work well for this)
- two index cards, each large enough to cover the jar opening completely
- red and blue food coloring
- hot tap water and cold tap water
- kitchen sink or large, rimmed baking pan to catch any spills



Time needed: **20** minutes

What to Do

Fill two of the jars with hot tap water and two with cold tap water. The hotter the water, the better, but don't make it hot enough to burn you. Put a few drops of red food coloring in the jars with hot water and a few drops of blue food coloring in the cold water jars. Stir the water so the color is evenly mixed in. Fill the jars so the water bulges over the rim.

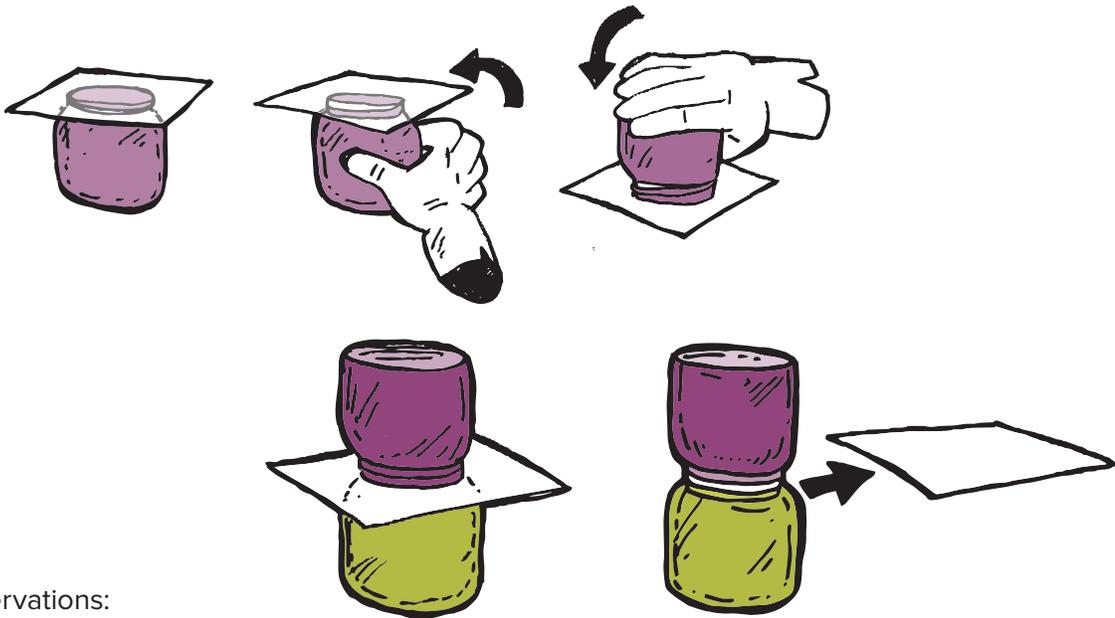
Place one of the index cards on top of a red jar of water. Now quickly pick up the jar and flip it over. (If you don't do this quickly enough, or if the card does not form a good seal, things could get wet.) Place the jar directly over a jar of blue water, with the openings together. Align jars so their openings match. Carefully pull out the card, keeping the jar openings lined up so no water leaks. Once the card is removed, the top jar should balance on the bottom jar. Observe what happens to the water.

Now take the other index card and place it on the remaining *blue* jar of water. Flip it just as you did the other jar, this time placing it on the remaining red jar of water. Pull out the index card and watch what happens. Remember surface tension from Experiment 1!



Magic Assistant Tip

As long as you have a good seal on the index card, you won't have to flip the jar too quickly.



Record your observations:

Explanation

When combining liquids that do not naturally mix (such as oil and water), the liquid that is less **dense** floats on top of the denser liquid. The molecules in hot water have more space between them because they are moving faster and farther apart. Cold water molecules move slowly and stay together. So, hot water is less dense than cold water. Since there is more space between the molecules, hot water has fewer molecules in it, weighing a little bit less than the same **volume** of cold water.

When you put the two jars together with the hot water on the top, the less dense water is already above the denser, cold water, so it does not move much. Over time the two will mix because of the continuous movement of water molecules. When you put the hot water on the bottom, it rises to the top right away, mixing with the cold water quickly and creating purple water.



Source: This experiment is cited in numerous science books and online science resources.

More Magic

Ask your audience if they believe in zero-gravity water. Explain that you will defy the laws of gravity with water. Fill a glass with water to the rim, making sure the water is bulging but not overflowing. Now press onto the rim an index card large enough to cover the **diameter** of the glass. Carefully lift the glass by the bottom and flip it over quickly so the index card is on the bottom. All the water stays in the glass. Ta-da!

What's the Trick? When you turn the glass upside down, the water is pulled down by gravity. The index card feels force from the water. At the same time, air molecules in the room apply a force to the card, pushing it up. As long as the two forces (pushing down and up) are equal, the index card will not move!



Magic Assistant Tip

Try this over a sink or outside until you get really good at it!



Experiment 6: The Loopy Plane

Learning Outcomes

Project skill: Exploring air resistance by making an airplane model

Life skill: Understanding systems

Educational standard:
NextGen Science 3-PS2.A—
Forces that do not sum to zero can cause changes in the object's speed or direction of motion

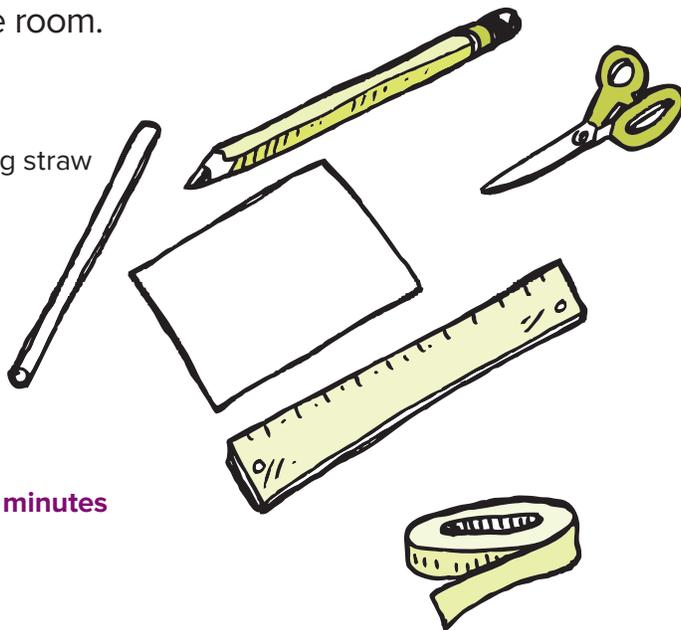
Success indicator: Flies a model airplane model using air resistance

Paper planes are easy to make. Just about everyone has made one using a piece of paper. Astound your friends with a new kind of plane, made with a straw and loops. Watch in amazement as it takes flight across the room.

Supplies

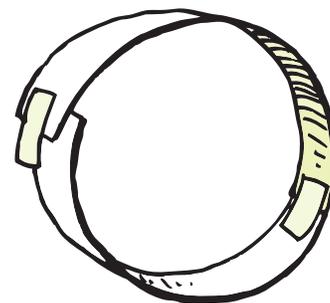
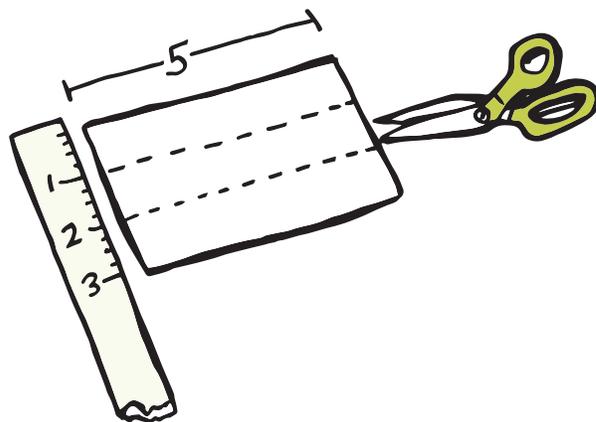
- straight plastic drinking straw
- 3" x 5" index card
- Scotch tape
- scissors
- ruler
- pencil

Time needed: **15** minutes

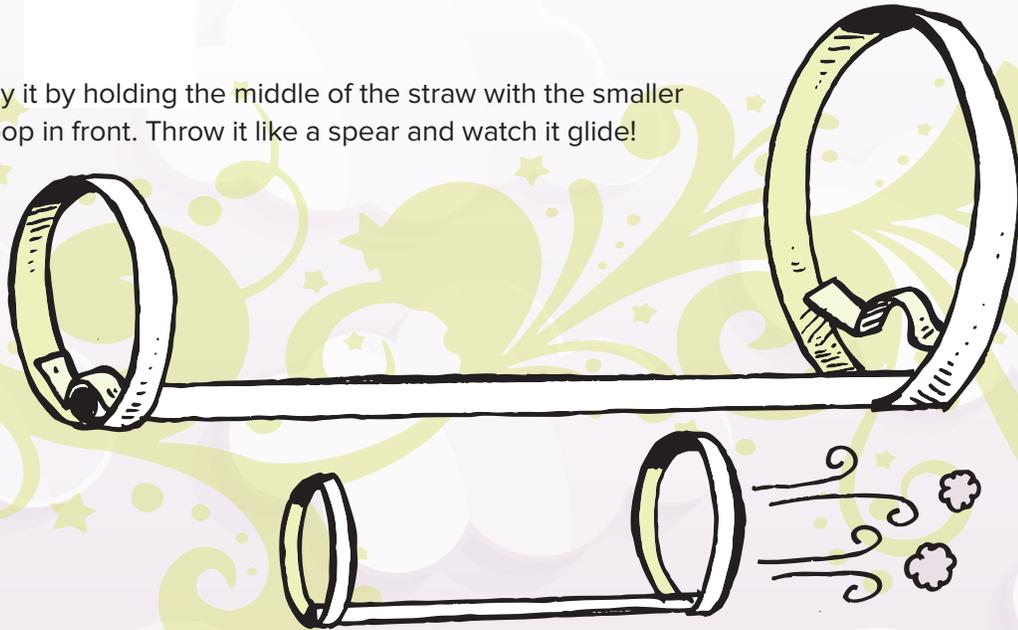


What to Do

Use the ruler and pencil to mark off three equal (1" x 5") strips on the index card. Cut the card into three identical strips. Take one strip and tape the two ends together carefully to form a loop. Try not to crease the loop or get it out-of-round. Tape the loop to one end of the straw as shown in the diagram on the next page. Next, take the remaining two strips of card and tape the ends together to form a large loop. Put this loop on the other end of the straw. Make sure the two loops are aligned evenly on the straw.



Fly it by holding the middle of the straw with the smaller loop in front. Throw it like a spear and watch it glide!



Try It Again

Try adding another loop in the middle of the plane. How does it fly now? What happens to the flight of the plane if you move one of the loops so it hangs down (opposite the direction of the other loop)? Or, try building a super long plane, using two straws and added loops. What does increasing the length of the plane do to the flight?



Record your observations:

Explanation

The two different sizes of hoops help to keep the straw balanced as it flies through the air. The big hoop helps keep the straw level by providing air resistance (drag), and the smaller hoop at the front helps keep the straw on a straight course. This type of plane tends to fly straight and very slowly as compared to paper airplanes. Airplane designers have to think about all the forces (gravity, drag, lift and thrust) pushing and pulling on a plane when it flies. If it isn't balanced well, the plane won't fly properly.

Source: sciencebob.com/experiments/straw_hoop_plane.php

Experiment 7: Move It with Magnets

Learning Outcomes

Project skill: Understanding how a compass works

Life skill: Understanding systems

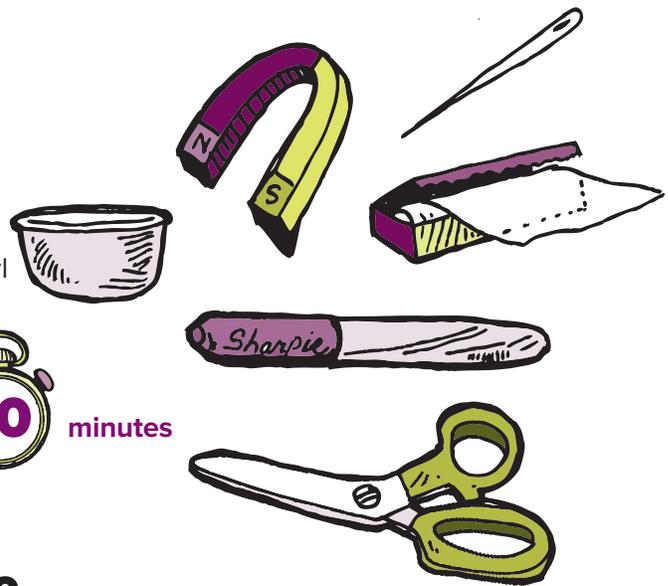
Educational standard: NGSS 3-PS2.B—Electrical and magnetic forces between a pair of objects do not require that the objects be in contact

Success indicator: Builds a rudimentary compass

Here's a great trick to use when you want to impress your audience with the power of your mind. While some people say this is simply a homemade compass, I call it magnetic magic.

Supplies

- magnet, bar or U-shaped
- water
- wax paper
- metal sewing needle
- red Sharpie marker
- scissors
- medium glass mixing bowl



Time needed: **10** minutes

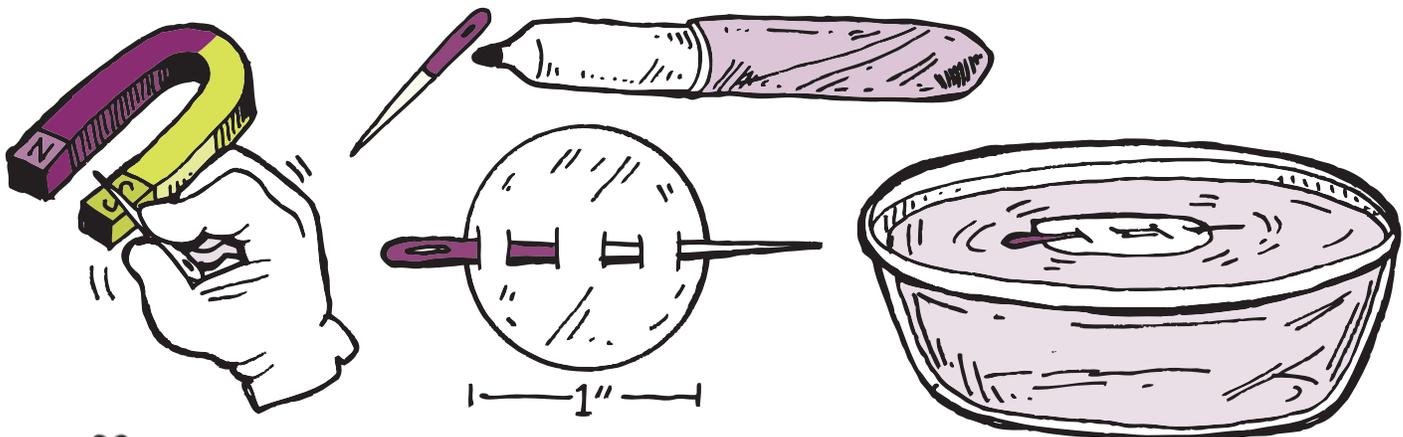
Magic Assistant Tip

Check [YouTube.com](https://www.youtube.com) to learn how to find the north and south ends of your magnet.

What to Do

Fill the bowl with water, but not to the rim. To magnetize your needle rub one end of your needle on the south end of the magnet about 50 times in one direction. Do the same with the other end of the needle and the north end of the magnet. Mark the north end of your needle with red Sharpie.

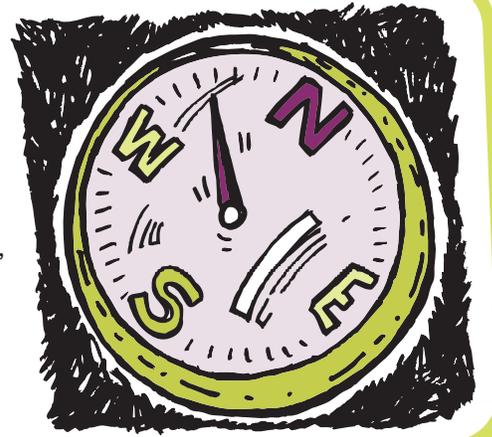
Use your scissors to cut a circle out of the wax paper, about 1" in diameter. (The diameter is the measurement across the circle's middle.) Carefully "thread" the needle into your wax paper close to the middle, leaving the needle in the wax paper. Now comes the amazing part! Float the wax paper/needle combo on the water with the needle on top and the wax paper touching the water. Pretend to control the needle with your mind. What happens next?



Record your observations:

Explanation

Rubbing the needle on the magnet helps align the atoms in the needle to form a magnet. The Earth has a **magnetic field**, thanks to all the nickel and iron in its core, with a north pole and a south pole just like your magnet. When the needle floats on the water, the Earth's magnetic field pulls on its ends, making it point north. Travelers use this magnetic field and a compass to help them find their way when there are no signs to guide them. A magnetic compass has a "needle" too, and it always points north as it balances on a tiny pin.



White Rabbit Wisdom

Telekinesis is the magical power to move objects with your mind. However, Newton's first law of motion states no object will move unless acted upon by force. *Illusionology: The Secret Science of Magic* (2012) tells us the science of physics proves telekinesis is just not possible in the natural world. It's all an illusion.

Source: stevespanglerscience.com/

Experiment 8: Comeback Can

Learning Outcomes

Project skill: Uses potential and kinetic energy to power a can

Life skill: Solving problems

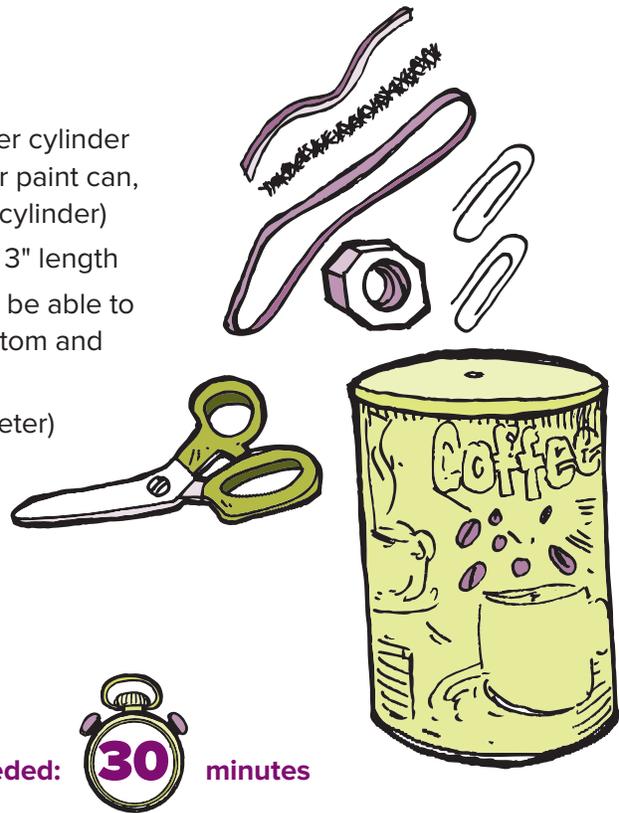
Educational standard:
NGSS 4-PS3.A—Energy can be moved from place to place by moving objects

Success indicator:
Demonstrates how energy can change from one form to another

You will use the power of different forms of energy to help you with this next experiment. The audience will think you can control the can. Can you?

Supplies

- empty metal can or paper cylinder with a lid (like a coffee or paint can, or a cardboard oatmeal cylinder)
- twist tie or pipe cleaner, 3" length
- large rubber band (must be able to stretch between the bottom and the lid of the can)
- hex nut, $\frac{3}{4}$ " (inside diameter)
- two paper clips
- scissors



Time needed: **30** minutes

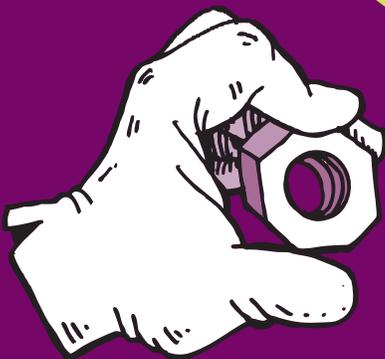
What to Do

With the help of an adult, use your scissors to punch one hole in the lid and one hole in the bottom of the can from the inside of the can. Thread one loop of the rubber band into the hole on the bottom of the can. Secure a paper clip to the band on the outside of the can to prevent the elastic from slipping through the hole.

Thread the pipe cleaner through the hex nut and twist once. Now, attach the pipe cleaner to both sides of the rubber band inside the can, with the hex nut hanging down from the middle of the rubber band. Then, pull the other end of the rubber band through the lid and place another paper clip between the band and the lid. Your rubber band should stretch between the holes tightly. If it does not, cut the rubber band loop and tie it over the paper clip so it's tight.

Place the lid on the can and find a long smooth area, free of obstacles. With a gentle push, roll the can away from you then use your "magical powers" to bring the can back to you. Did it work?

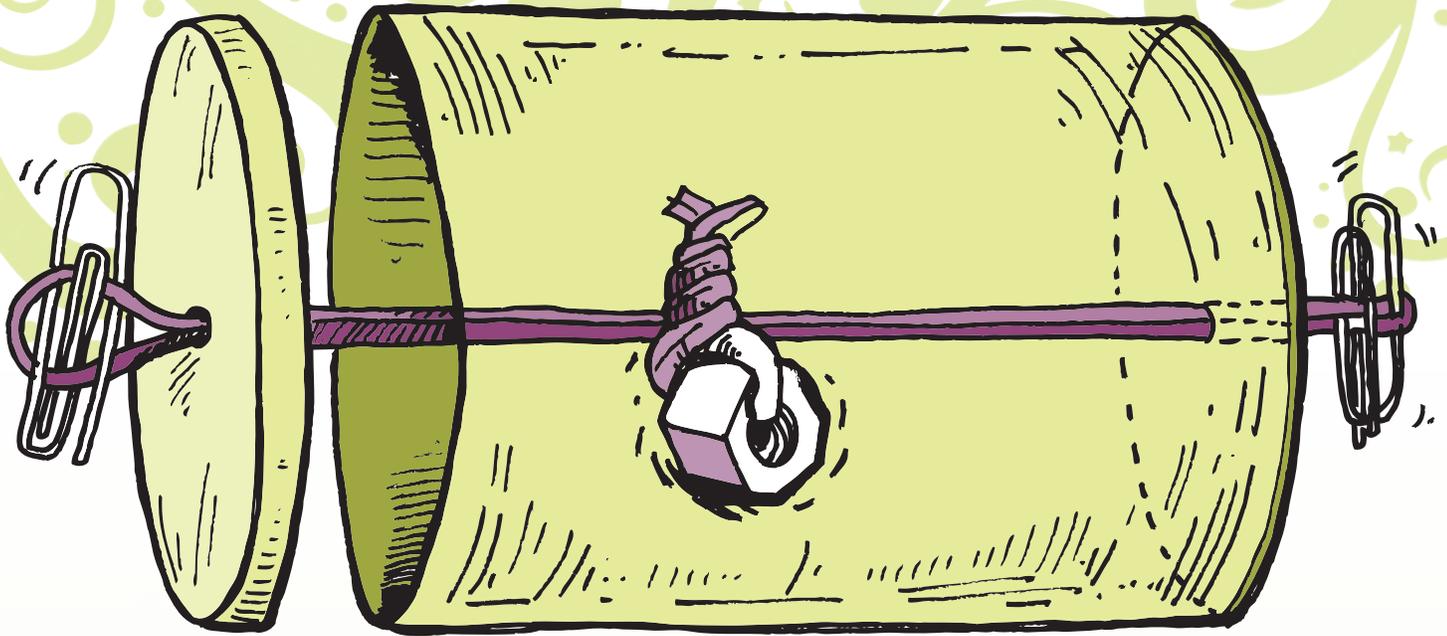
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Magic Assistant Tip

If the can doesn't roll back to you, you might need a bigger hex nut for your can size.

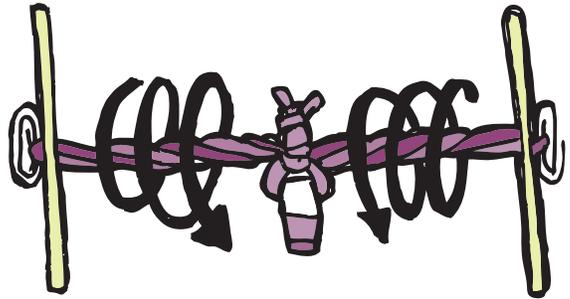




Record your observations:

Explanation

The comeback can uses two forms of energy—**kinetic** and potential. As you push the can, you are using kinetic energy to move it away from you. The hex nut inside the can twists around the rubber band until it is completely twisted. At this point, the can pauses. The energy stored in the rubber band is called **potential energy**. The can is not moving, but it has the *potential* to move. As the can moves back to you, the potential energy is released and becomes kinetic energy once again.





White Rabbit Wisdom

Here's another interesting tidbit from *Illusionology: The Secret Science of Magic* (2012). Before electricity—a form of energy—was widely used by people to power their homes, the idea of electricity was considered magical as were many modern inventions. Nikola Tesla, a rival of Thomas Edison, was an inventor and electrical engineer. Tesla presented his ideas like a showman, wowing audiences as he demonstrated his wireless light tubes. Maybe someday, wireless energy will be used in your home!

Sources:

msichicago.org/online-science/activities/activity-detail/activities/make-a-comeback-can/browseactivities/6/
resources.scienceworld.ca/

Background

All matter has **properties**—a table is hard, a cotton ball is soft, water flows in its liquid form. These characteristics help scientists understand how matter behaves. For example, the hot and cold water in Experiment 5 had different densities, which explained why one set of jars mixed colors quickly and the other happened much more slowly. Another example is that matter has atoms, which can have a positive or a negative **charge**. Atoms can either pull another object toward themselves or push it away. This is called a positive or a negative charge. Positive charges attract negative charges.

Physicists study the effects and behaviors of matter. Everything in the universe has an effect on everything else, so physics can be found in every scientific field of study. Engineers use physics to build machines and buildings. Chemists need to understand how different chemicals will behave—physics explains why some minerals are hard and why certain metals can **conduct** electricity. Astronomers use physics to explain how planets move in the solar system. Meteorologists couldn't predict the weather and cloud movement without the rules found in physics.

Physics rules can explain how we use energy every day for everything we do. Energy comes in many forms: from natural sources like gas and the sun, from motion, and from electricity. Even sound and light have energy. Energy can change forms, move from one source to another, or be stored until a force releases it. The stored energy in fuels is released when that matter is burned or heated, creating light and heat energy. A machine like a roller coaster has mechanical energy. The motion of a rollercoaster is a combination of kinetic and potential energy and can even create heat energy from the friction of the wheels on the track. The energy from food after your body digests it gives you the power to run and play.



Conclusions

SHARE How long did it take for the water in the first set of jars to mix completely and turn purple in the Now We Mix, Now We Don't experiment?

REFLECT How is the loopy plane's flight different from a paper airplane's flight?

GENERALIZE The motion of the Comeback Can is called kinetic energy. Can you think of other types of energy?

APPLY What are ways magnets are used in everyday items?

Master Level: You Are Audience-Ready

I have saved the best tricks for last. It took years of experimenting and practicing to perform these illusions flawlessly. It is my hope you will find the magic in your life, using the power in nature. There is magic all around us, if you know the secret...

Senior Researcher Notes

This is where Newtoni's book ends. It is clear Newtoni was talking about science as much as he was magic. But what is the connection? Explore these last four experiments using changes in temperature, motion and pressure to finally understand the secret Newtoni knew about magic.

Experiment 9: Egg in a Bottle

Learning Outcomes

Project skill: Heating the air inside the bottle to create suction

Life skill: Using scientific methods

Educational standard: NGSS 5-PS1.A—A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the effects of air on larger particles or objects

Success indicator: Lowers air pressure in a bottle forcing an egg through a small opening

How can you magically move an egg into a bottle when the bottle opening is smaller than the egg? Perform this experiment, with a little help from air pressure.

Supplies

- peeled, hardboiled eggs (you may want to try this more than once, so cook several)
- bottle with an opening slightly smaller than the diameter of an egg
- strip of paper (approximately 1" x 8")
- matches



Time needed:  10 minutes (not including time for eggs to boil)

What to Do

Carefully light one end of the strip of paper on fire with a match and quickly drop the lit paper into the bottle. While the paper is burning, place the egg, small end down, on the bottle opening. Observe what happens.

Magic Assistant Tip

Have an adult help with striking a match to light the paper strip!





Record your observations:

Explanation

When the egg sits on top of the bottle, it is too large to fall down inside using just the pull of gravity. The air pressure in and out of the bottle is the same, so nothing happens. However, when the air inside the bottle is heated, the pressure inside increases. At first, this causes the peeled hardboiled egg to jump a little on the opening of the bottle as some molecules escape. The oxygen in the bottle eventually runs out and the flame burns out. The air inside begins to cool and as it does, the pressure drops and the egg stops jumping on the rim and seals off the air in the bottle. Usually the air outside would rush into the bottle to fill it but the egg is in the way. The now higher air pressure outside the bottle pushes the egg through the opening.

More Magic

Air pressure can be a powerful force. For this trick, show the audience a regular potato and a drinking straw (use a straight straw rather than a straw with a bendable top). Ask a volunteer to put the straw through the potato. When they can't do it, wave your hand over the potato, say the magic word "Shazam," and place your thumb over the opening as you hold the straw. Stab it straight into and through the potato.

What's the Trick? When you place your thumb over the straw opening, you are trapping the air inside the straw to create pressure, which makes the straw strong enough to go through the potato.

Source: science-sparks.com



Experiment 10: Balloon Rocket Dragster

Learning Outcomes

Project skill: *Creating a vehicle powered by a balloon*

Life skill: *Working with numbers*

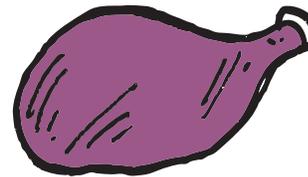
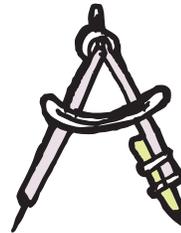
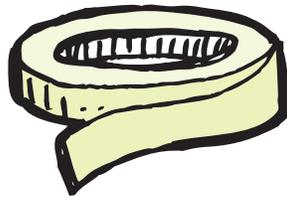
Educational standard:
NGSS 3-PS2.A—The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it

Success indicator: *Uses the force from the expelled air to propel an object*

Discover the magic of action and reaction as you create an air-powered vehicle. This car doesn't need gas to go. Harness the power of energy from air and watch it zoom across the room.

Supplies

- Styrofoam meat tray
- ruler
- scissors
- pen
- compass (the instrument used to draw circles)
- four straight pins
- bendable drinking straw
- Scotch tape
- 7" balloon



Time needed: **20** minutes

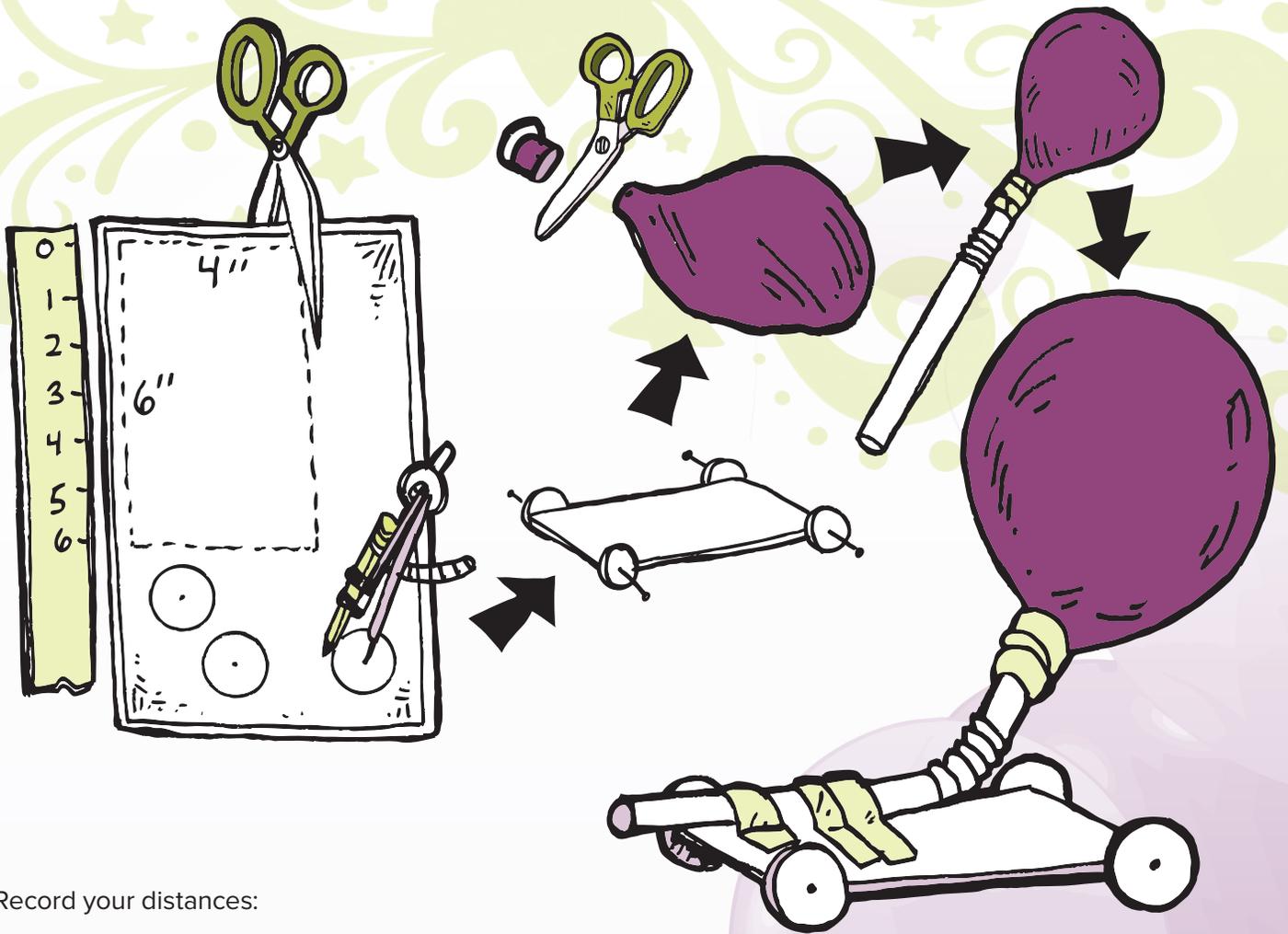
What to Do

To assemble your balloon racer, measure and cut a 4" x 6" rectangle from the Styrofoam tray. Then, use your compass to make four 1½"-diameter wheels. Fasten the wheels to the racer body using the straight pins. Make sure you put the pin through the hole made by the compass—this guarantees the wheels are perfectly centered.

Blow up the balloon to stretch it. Cut off the rolled edge and tape the balloon securely to the bendable end of the straw, making a tight seal so no air leaks out. On the top of the racer body, tape the straw with the bendable part and balloon facing upward. The other end of the straw should hang over the edge of the racer. Blow through the straw to inflate the balloon. Block the end of the straw with your finger to keep the balloon inflated until you are ready to launch the racer.

Once assembled, test your racer and measure the distance it travels when powered by the air-filled balloon. Try blowing more or less air into the balloon to see how it affects your car's distance.





Record your distances:

Explanation

This balloon-powered racer is a great example of Newton’s third law of motion: for every action there is an equal and opposite reaction. Releasing the air in the balloon propels the racer in the opposite direction of the air flow. The force of friction also plays a part in the performance of your racer. It will travel faster and farther on smooth surfaces.

Sources:

stevespanglerscience.com
 sciencekids.co.nz/experiments/stabapotato.html

Experiment 11: Surface Surfer

Learning Outcomes

Project skill: Exploring changes in surface tension and friction

Life skill: Using scientific methods

Educational standard: NGSS 6-PS1—In a liquid, the molecules are constantly in contact with others. The change of state that occurs with variations in temperature or pressure can be described and predicted using these models of matter

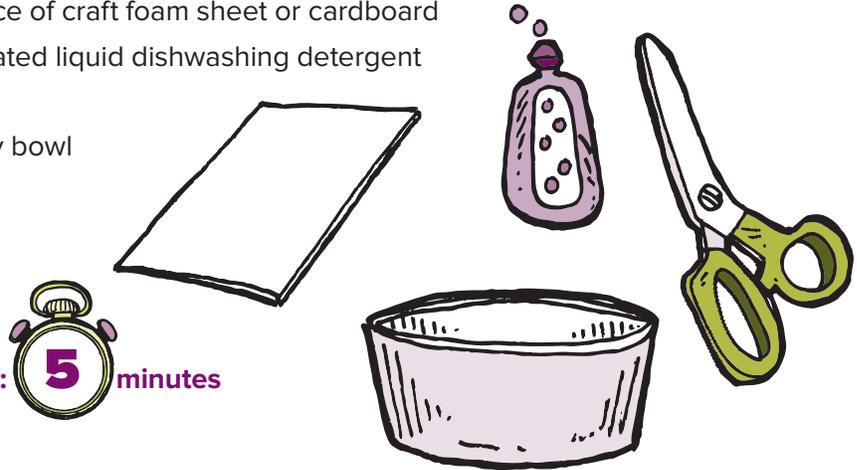
Success indicator: Lowers the surface tension enough to move the boat forward

Keep the audience guessing as to what is in the magic potion that powers your boat! You'll use the differences in surface tension to push your boat through the soapy seas.

Supplies

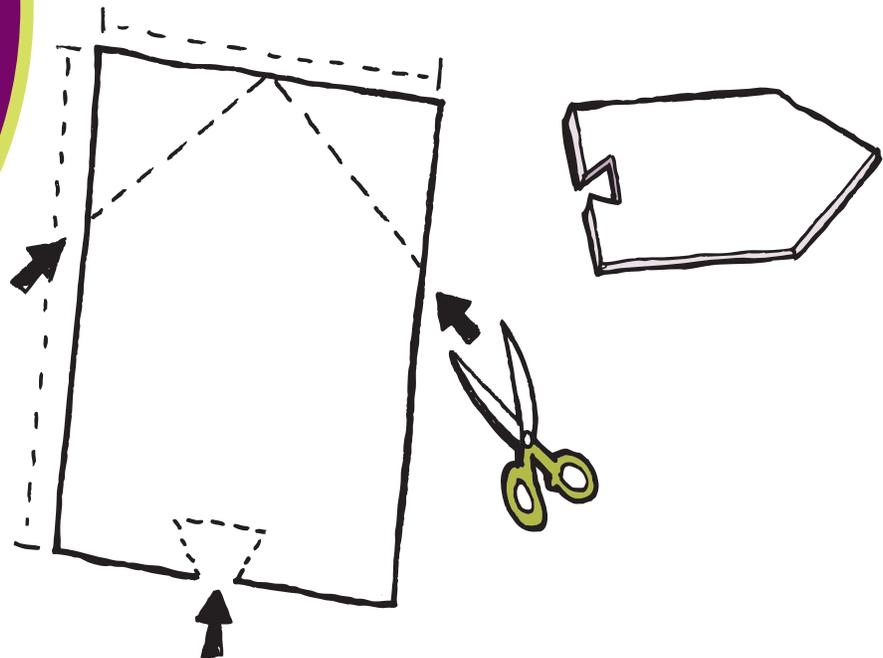
- small piece of craft foam sheet or cardboard
- concentrated liquid dishwashing detergent
- scissors
- clean, dry bowl
- water

Time needed: **5** minutes



What to Do

Cut out a small boat shape from the foam or cardboard. Using foam will make a better boat because cardboard will eventually soak up the water and fall apart. Cut a small triangular-shaped notch in the back of the boat, pointed end facing away from the boat's body. Fill the bowl with water. Carefully add a small drop of dishwashing detergent to the tip of the notch at the back of the boat, and place it in the water. Watch what happens.



Magic Assistant Tip

Once the surface tension is broken in a dish of water, it won't return. You need to use a clean, dry bowl each time you try this experiment.



Draw a picture of your boat and explain the boat's movement below.



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Try It Again

Does it make a difference where your notch is located on the boat? What happens when the notch is off to one side of the back of the boat? In which direction does your boat go now?

Record your observations:

Explanation

Water molecules pull toward each other in every direction. The attraction is strongest at the surface because the molecules have nothing to be attracted to above them. This makes for a harder pull to the sides. Detergent reduces the surface tension. When the drop of detergent is placed at the back of the boat the surface tension is reduced at that point. The water at the front of the boat still has a high surface tension and actually pulls the boat forward. Once the detergent is spread around the bowl of water by the boat, the surface tension is lowered over the entire area and the boat stops moving. Try this in a larger body of water such as a tub or pond to see what happens.



More Magic

You'll need a balloon and a faucet for this fun trick. Tell your audience you have the power to bend water with your mind. Blow up the balloon and tie the end closed. While standing by the faucet, rub the balloon **vigorously** on your head. Turn the faucet on low and slow to create a thin stream. Now, make a big production of focusing your eyes on the running water, reach toward the stream with your balloon, and amaze everyone as the water bends around the balloon.

What's the Trick? Using friction, you created static electricity when rubbing the balloon against your hair. The negative charge in the balloon attracted the positive charge in the water, pulling the stream around the balloon. This activity works best on a day with low humidity.

Sources:

planet-science.com/categories/experiments/messy/2011/02/power-a-boat-with-soap.aspx
exploratorium.edu/science_explorer/roller.html



Experiment 12: **Bottle Levitation**

Learning Outcomes

Project skill: *Creating force and friction using rice*

Life skill: *Processing information*

Educational standard:
NGSS 3-PS2.B—Objects in contact exert forces on each other

Success indicator: *Lifts a bottle of rice off table using a single chopstick*

And for our grand finale, surprise your audience with the unbelievable bottle levitation trick. Using the power of your mind, and a little bit of knowledge about friction, you will lift a full bottle of rice using a single chopstick.

Supplies

- two matching empty water bottles (16.9 ounces is a good size)
- dry, uncooked rice (Enough to fill both bottles, plus a bit extra; about 2 pounds. Regular rice works better than instant rice.)
- two wooden chopsticks, same size and shape
- marker
- tray or bowl



Time needed: **15** minutes

What to Do

Fill both bottles with rice. Tap one bottle on the table until the rice settles and the bottle can hold more rice. Jab the chopstick into the rice so it is tightly packed. Keep tapping and adding more rice until you can't fill the bottle anymore, then remove the chopstick. Label this bottle "Light Rice" and label the other bottle "Regular Rice."

Tell your audience you have created a new product called "Light Rice" that is so light it practically floats. Place both bottles on the table and invite someone to participate in your trick. Give the regular rice bottle to your volunteer. Ask him or her to push a chopstick into the rice as you do the same into the Light Rice. Now, ask your volunteer to lift the bottle straight up with the chopstick. The bottle does not rise. Then, lift the chopstick in the Light Rice and watch as both the bottle and the rice rise together.

Offer to exchange chopsticks with your volunteer. Try the trick again. Did this change the results?

Now, to prove you weren't hiding anything in the "Light Rice" bottle, pour both bottles of rice into the bowl or tray. Take a bow! You earned it.



Record your observations:

Explanation

Friction steals the show in this trick. In the “Light Rice” bottle, the grains of rice are so tightly packed that they have nowhere to go when the chopstick is stuck in the bottle, so they press against the sides, and friction helps the chopstick stay stuck in the bottle as you lift. All the air pockets left between the grains of rice in the “Regular Rice” bottle leave plenty of space for the rice grains to shift around, making room for the chopstick. Without the grip of friction, the second chopstick just slides back out of the bottle.





White Rabbit Wisdom

Magicians defy gravity as they **levitate**, or suspend, objects or people in the air. According to the rules of physics, what goes up, must come down. The force of gravity pulls all matter toward Earth. This is why we don't float up into space. Simply put, levitation is only a trick. Many illusionists use carefully hidden platforms or fine wires to make their magic, according to Albert D. Schafer, author of *Illusionology: The Secret Science of Magic* (2012).

Background

Friction forces work against motion. There are three types of friction—*sliding friction* when you ice skate, *fluid friction* when you swim in a pool, and *rolling friction* demonstrated by bowling. To overcome friction, a stronger force has to act on an object. Your muscles provide that force when swimming or skating.

All surfaces, whether smooth or rough, have tiny bumps that catch as two objects move against each other. If you look at rice under a microscope, you would see how bumpy it is even though it appears smooth. The same is true of the wooden chopsticks. As the chopstick and rice rub against each other in this experiment, the bumpy edges get stuck together and help lift the bottle. The greater the amount of surface area in contact with another object, the greater the friction between the two. The wheels on your balloon dragster are thin, so there isn't much area available to provide friction. Without the wheels, your dragster has a larger surface area in contact with the floor and it would go much slower.

Difference in pressure helped move your racer along the surface of the water. Think of detergent molecules as having a “positive” and a “negative” end. The positive end likes the water, and the negative end wants to get away because it likes only greasy molecules. (This makes detergent helpful when washing dirty dishes.) As the negative ends of the detergent molecules force their way between the water molecules in an effort to get away, the tight “skin” on the water's surface (created by the molecular bonds) is broken, lowering the resistance and pushing your racer forward.

Source: stevespanglerscience.com



Conclusions

SHARE How far did your dragster go in Balloon Rocket Dragster? Did your results change when you raced on different surfaces?

REFLECT What is another way you could do the Egg in a Bottle experiment without using a flame to heat the air in the bottle?

GENERALIZE Why did you put the detergent at the back of the boat to make it go forward in the Surface Surfer experiment?

APPLY Friction makes the Light Rice easy to pick up as the rice presses against the side of the bottle. Explain how friction works when pressing the brakes on your bicycle.



Finale

Abacadabra, you've done it! After testing each experiment from the Amazing Newtoni, you have discovered the secret behind many of his tricks: magic is really about physics and the rules of matter. Using the forces in nature, the energy in motion, and the power of physics, you levitated, moved, mixed and powered your way to the truth. That was some amazing research!

And Newtoni? Maybe he finally found some magic that can't be explained by physics. We may never know.



Glossary

air resistance. The opposing or slowing force of air molecules.

bonds. Binding forces; means by which atoms or groups of atoms are held together in a molecule.

charge. The property of particles that causes forces of attraction and repulsion between them.

conduct. The transfer of electrical energy through a metallic substance.

dense. Having parts that are close together; having a high mass per unit volume.

diameter. The length of a straight line that passes through the center of a circle from edge to edge.

gravity. The force of attraction between objects. Gravity pulls objects to Earth.

illusions. Misleading images presented as visual stimuli.

inertia. The tendency of an object to resist any change in motion.

kinetic. The energy of movement.

levitate. To rise in the air or float.

magnetic field. A space in which a magnetic force can be found based on its effect on iron-containing bodies.

matter. What a thing is made of; the substance of any physical object.

misdirection. Incorrect guidance or instruction.

optical illusions. Deceptions resulting from certain visual effects making the viewer unable to understand what is actually there.

physicist. An expert in the science of physics.

physics. The science of matter, energy, motion and force.

potential energy. A type of stored energy.

prism. A triangular piece of glass used to bend rays of light and to split white light into different colors.

refraction. The change in direction of electromagnetic radiation, such as light, on passing from one medium to another.

sleight of hand. A quick or cleverly performed trick or deception.

surface area. The total area of a three-dimensional object.

telekinesis. The use of thought or willpower, not physical force, to move an object.

vigorously. Done with great force and energy.

volume. The amount of space that a substance occupies.

Research Tools

The following books were used to conduct research for this project. Check with your local library for copies of them. You may want to purchase some for your own collection.

Bryson Gore. *Amazing Science Discoveries PHYSICS*. Mankato, Minn.: Aladdin Books, 2009.

Learning Playground: Learning About Energy, Forces and Motion. Chicago, Ill.: World Book, 2012.

Nathan Lepora. *Falling for Fun: Gravity in Action*. Pleasantville, N.Y.: Gareth Stevens Publishing, 2008.

Physics: An Illustrated Guide to Science. New York, N.Y.: Chelsea House, Infobase Publishing, 2006.

Albert D. Schafer. *Illusionology: The Secret Science of Magic*. Somerville, Mass.: Candlewick Press, 2012.

Patrice Sherman. *The Secret, Mystifying, Unusual History of Magic*. Mankato, Minn.: Capstone Press, 2011.

Shopping List

Beginner Level

- eye dropper
- three, 7- or 9-ounce plastic or foam cups
- large plastic garbage bag
- lightweight string
- eggs*
- masking tape
- hole punch
- 8" X 11" cardstock or stiff paper
- Scotch tape*

Apprentice Level

- index cards*
- red and blue food coloring
- straight plastic drinking straw
- magnet, bar or U-shaped**
- wax paper
- red Sharpie marker
- empty metal can or paper cylinder with a lid (like a coffee or paint can, or a cardboard oatmeal cylinder)
- twist tie or pipe cleaner
- hex nut, $\frac{3}{4}$ " (inside diameter)

Master Level

- Styrofoam meat tray
- compass
- bendable drinking straw
- 7" balloon
- small piece of craft foam sheet or cardboard
- two matching empty water bottles (16.9 ounces is a good size)
- dry, uncooked rice; 2-pound bag
- two wooden chopsticks, same size and shape

*Item is used in more than one experiment, in more than one level.

**Find U-shaped magnets at the hardware store for under \$5.

Household Supplies

Beginner Level

- cup
- water*
- penny*
- paper towel
- facial tissues
- scissors*
- yard stick
- clear drinking glass
- paper*
- baby food jar or small drinking glass

Apprentice Level

- four jars with identical mouth openings (such as baby food jars)
- large, rimmed baking pan
- ruler*
- pencil
- metal sewing needle
- medium glass mixing bowl
- large rubber band
- paper clips

Master Level

- bottle with an opening slightly smaller than the diameter of an egg
- matches
- pen
- straight pins
- concentrated liquid dishwashing detergent
- clean, dry bowl
- marker

Summary of Learning Outcomes

Activity	Project Skill	Life Skill	Educational Standard*	Success Indicator
1. Drops on a Penny	Discovering the force of surface tension	Processing information	NGSS 3-PS2.B—Objects in contact exert forces on each other	Records the number of drops that fit on a penny
2. Parachute Away!	Testing the pull of gravity and the power of air resistance	Keeping records	NGSS 3-PS2.A—Each force acts on one particular object and has both strength and direction	Determines which size parachute most effectively slows the egg
3. Create a Rainbow	Bending light rays to explore the properties of light	Navigating your environment	NGSS PS4.B—An object can be seen when light reflected from its surface enters the eyes	Splits a beam of light into the colors of a rainbow
4. Lincoln High Dive	Applying Newton's first law of motion	Processing information	NGSS 5-PS2.B—The gravitational force of Earth acting on an object near Earth's surface pulls that object down toward the planet's center	Discovers how inertia works
5. Now We Mix, Now We Don't	Mixing water with different temperatures	Using scientific methods	NGSS 5-PS1-3—Make observations and measurements to identify materials based on their properties	Understands properties of water density at different temperatures
6. The Loopy Plane	Exploring air resistance by making an airplane model	Understanding systems	NGSS 3-PS2.A—Forces that do not sum to zero can cause changes in the object's speed or direction of motion	Flies a model airplane model using air resistance
7. Move It with Magnets	Understanding how a compass works	Understanding systems	NGSS 3-PS2.B—Electrical and magnetic forces between a pair of objects do not require that the objects be in contact	Builds a rudimentary compass
8. Comeback Can	Uses potential and kinetic energy to power a can	Solving problems	NGSS 4-PS3.A—Energy can be moved from place to place by moving objects	Demonstrates how energy can change from one form to another
9. Egg in a Bottle	Heating the air inside the bottle to create suction	Using scientific methods	NGSS 5-PS1.A—A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the effects of air on larger particles or objects	Lowers air pressure in a bottle forcing an egg through a small opening
10. Balloon Rocket Dragster	Creating a vehicle powered by a balloon	Working with numbers	NGSS 3-PS2.A—The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it	Uses the force from the expelled air to propel an object
11. Surface Surfer	Exploring changes in surface tension and friction	Using scientific methods	NGSS 6-PS1—In a liquid, the molecules are constantly in contact with others. The change of state that occurs with variations in temperature or pressure can be described and predicted using these models of matter	Lowers the surface tension enough to move the boat forward
12. Bottle Levitation	Creating force and friction using rice	Processing information	NGSS 3-PS2.B—Objects in contact exert forces on each other	Lifts a bottle off table using a single chopstick

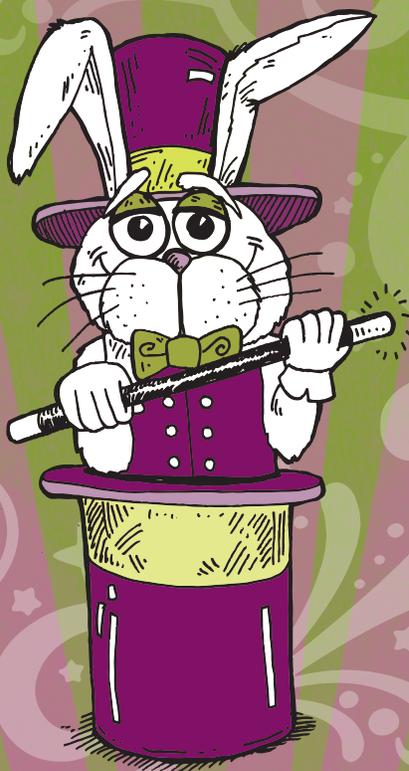
*The educational standards cited here are from the Next Generation Science Standards. These are available in their entirety at nextgenscience.org.



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I pledge

My head to clearer thinking,
My heart to greater loyalty,
My hands to larger service, and
My health to better living,
For my club, my community, my
country, and my world.



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