Summer STEM from your Library

A Toolkit of STEM Activities for Libraries

The contents of this toolkit were created by Charlene Beach for use by the Idaho Commission for Libraries' *Summer STEM from Your Library Program.*

Funding provided in part by the Idaho STEM Action Center, the U.S. Institute of Museum and Library Services under the provision of the Library Services and Technology Act, and the Idaho Commission for Libraries.

IDAHO STEM ACTION CENTER

ICfL Idaho Commission for Libraries

INSTITUTE of Museum and Library SERVICES

Idaho Commission for Libraries
325 W. State Street
Boise, ID 83702

Visit us at: https://libraries.idaho.gov

TABLE OF CONTENTS

How to Use This Toolkit

Engaging Kids and Families with STEM

This part of the toolkit contains helpful instructions about how children engage with STEM concepts and how we can support their learning. Many STEM concepts and thinking processes help kids build literacy and reasoning skills. You should keep these concepts in mind as you plan your program.

Activities

How does it work? Each of the activities in this toolkit contains a section called "How does it work?" You can use this section to help explain the activities to kids before you begin your program. This is also a great place to start learning about the activity's primary STEM focus.

Objectives. This section helps you focus on what the learning outcome should be for each activity.

Let's Try It! This section explains how to do each activity. Plus, the "Additional Resources" section at the end of this toolkit contains links to videos for each activity. Some of the activities require materials to be prepped in advance, and since some supplies may not be available locally, make sure you plan ahead. If you can, try to do each activity on your own before you do it for a program.

Learning Tips. Each activity contains one science tip for adults to use in helping children build literacy skills. **[All of these tips are in brackets and bolded.]** Share the tips during your program.

Supplies. You should be able to purchase supplies for all of these activities using the grant funds from the Summer STEM program. For supplies that are harder to find or not readily available at most stores, the "supplies" section of the activity includes a link to a website from which the items may be purchased. Also, the needed supplies can often be found on amazon.com.

Knowledge Check. At the end of each activity, there are a couple of questions for you to ask the kids to see if they understood the STEM lesson and to help you determine if it was a meaningful learning experience for them.

Additional Resources

Each activity has a series of additional online resources that can help you better understand its STEM concept and visualize how it should work. For some activities, a picture book recommendation is also included, in case you would like to start your program with a storytime.

Vocabulary

Each activity has a series of additional online resources that can help you better understand its STEM concept and visualize how it should work. For some activities, a picture book recommendation is also included, in case you would like to start your program with a storytime.

Scale it Up/Scale it Down

The activities in this toolkit can be scaled -- up or down -- to accommodate just a few kids or a large easel or some other display device can help you demonstrate the activity to a larger audience. You may also want to bring a table for the materials.

Helpful Hints for This Activity

Notes about considerations that may make each activity go more smoothly are included at the end of the activity.

General Helpful Hints & Connections

Idaho can be very hot in the summer. If you are doing these activities outside, remember to bring a chair, water, sunscreen, and an umbrella or pop-up awning, if there is no shade.

Be mindful of children who may have allergies. Although none of the activities involve food, one of them does include the use of rubber bands, which might be problematic for children with latex allergies.

To save time in handing out materials, especially for larger or younger groups, have materials pre-punched and in individual sets.

Check for a STEM lending library in your area. The i-STEM Libraries are a collection of STEM tools, kits, equipment, and other resources available for Idaho educators to check out and use in their classrooms for free. There is an Online Catalog to search and browse items available at their nearest library location, make a check-out request, and access curriculum and other resources. Visit: https://stem.idaho.gov/i-stem-library/. There are currently six locations around the state.

A regional Idaho STEM ecosystem may provide you with experts who can assist you or provide materials for you to use in your programs.

Consider joining your regional STEM EcosySTEM. https://stem.idaho.gov/idaho-stem-ecosystem/

Where are the kids who are not coming to your traditional library programs? Reach out and establish partnerships with the entities in your community that are serving the kids who are not able to come to the library in the summer:

- Day camps
- Summer school programs
- Day care facilities
- Parks Department & YMCA programs
- Meal & food distribution sites
- Family community centers
- Festivals

Engaging Kids & Families with STEM

Involving parents and caregivers in library programs amplifies the benefit of kids' participation because parents, as kids' first teachers, now share the common experience and vocabulary to continue the learning beyond the program time.

STEM teaching is an interdisciplinary approach to learning where children learn and apply concepts in science, technology, engineering, and mathematics and computational thinking. Many early literacy skills overlap with early STEM concepts. We can design our programs to support STEM learning. Consider the definitions of each discipline:

Science: a way of knowing. The process of finding out about the world and how it works by exploring, gathering data, looking for relationships and patterns, and generating explanations and ideas using evidence.

Technology: A way of doing. The tools that have been designed to meet human needs such as balance scales to compare weights, lenses to look closely at living things, and digital tools like computers and tablets. Technology is the way we apply scientific knowledge for practical purposes. Technology is neither inherently helpful nor harmful. It is simply a tool. The real effects of technology depend upon how it is used. It can be used to inspire and catalyze change just as easily as it can be used in ways that are detrimental to society.

Engineering: A process of designing tools, systems, and structures that help humans meet their needs or solve problems using a variety of materials and creating things that work. Engineering tasks typically involve some constraint: time, materials, minimum strength of final product, etc.)

Mathematics: The study of quantities (how many or how much), structures (shapes), space (angles and distances), and change. Early math skills include sequencing (1, 2, 3, 4…), patterning (1, 2, 1, 2, 1, 2…), and exploring shapes (triangle, square, circle), volume (holds more or less), and size (bigger, less than).

Computational Thinking: the thought processes involved in solving problems, specifically problems that can be expressed as steps or **algorithms** that can be carried out by a computer. We don't need a computer to use computational thinking, but we do need computational thinking to program a computer! Computational thinking helps one define the steps to solve the problem (the algorithm) and, if possible, build a model to simulate, test, and debug the solution.

Computational thinking is generally understood to be a combination of four skill categories:

- Pattern recognition is the process of identifying, defining, extending, and creating patterns
- Creating and using algorithms - everyday tasks like sewing a button on a shirt or baking a pie also involve creating and using algorithms in the form of step by step instructions.
- Decomposition - an analytical process that involves breaking something down into smaller parts or smaller steps.
- Understanding abstractions. An abstraction is something that exists only as an idea. Understanding abstractions requires us to make generalizations, draw conclusions, and use other problem-solving thought processes to imagine something that we can't see or touch. Understanding abstractions is a particularly high level thinking skill that most young children are not able to master.

Methods for Engaging Children

As children explore with their minds and with their senses, they are observing, asking questions, designing, building, testing, and solving problems.

We can develop children's abstract thinking, the basis for STEAM concepts, and language skills by:

- **Following the child's lead and interests.**
- **Giving children time to figure things out** - say less, "go slow and **show.**"
- **Putting words to what they are looking at or playing with** while adding descriptions: expand what the child is saying or label with a variety of words.
- **Encouraging persistence and problem solving**: talk about feelings, take a break and come back to it, or encourage them to try it another way.
- **Using words for science concepts** - help children learn the real vocabulary words.

- **Using open-ended questions.** Open-ended questions cannot be responded to with one word answers such as yes or no. Open-ended questions encourage children to:
  - develop their language by using different words and a wider range of vocabulary to answer the question
  - provide more information and details
  - express their thoughts, ideas, and opinions
  - be creative
  - develop positive relationships by engaging in meaningful conversations
  - think about how they approach, plan, carry out, and extend upon their own ideas.

Vary the complexity of the questions you ask based on a child's age and experience. Here are some examples of open-ended questions that can be asked:

- **Concrete (knowledge) level :** What's this? What happened?
- **Understanding level:** Tell me about what you're doing? Show me how you…? How do you know…?
- **Application level:** What does it feel like?
- **Analysis level:** What else feels like this? What do you think comes next? How are these the same? What else can you do? Is there another way to….? How are these different?
- **Evaluation level:** What are some reasons this would /would not be a good approach? What do you think would happen if? (lead a child to a discovery rather that providing an explanation) What do you think would work? What will happen next? What can you do about it?
- **Creativity level:** Can you create something to do another way? Design an animal that can survive in that environment.

Make Literacy Part of STEM Explorations

- Read fiction and nonfiction picture books on STEM-related topics.
- Have children collect data by drawing or writing.
- Record ideas, opinions, estimations, and predictions on group charts.
- Encourage children to share ideas verbally with others (such as when they describe the structures they've built).
- Have kids use blocks or manipulatives to explain through oral language.

STEM Activities

Anemometer

Earth Science: Measuring the Wind

An **anemometer** is a device used to measure wind speeds. Anemometers are essential for predicting weather changes, for research purposes, and for determining good locations for wind farms.

How Does It Work?

The cups of the **anemometer** catch the wind and the force from the wind moves the cups. The cups rotate around the center point; the stronger the wind, the faster the anemometer spins. An anemometer is **calibrated** (adjusted to measure data accurately) to convert the speed of the rotating cups into a measure of wind speed. In this case, the anemometers are calibrated in such a way that a known number of rotations correlates to a known wind speed. We can approximate the actual speed by comparing it with the protractor anemometer.

Objective

After doing this activity, kids will learn:

- How to measure wind speed using an anemometer.

Supplies

Each person will need:

- 5 paper cups, 5 oz. size (optional: one cup in a different color)
- 2 straws
- 1-inch piece of brightly colored tape
- 1 pushpin
- Blob of clay, enough to support an upright pencil
- 1 unsharpened pencil with eraser

Shared materials:

- 1 hole punch
- Stopwatch (or phone with stopwatch app) or timer
- Fan - for everyone to use
- Ruler

Make the following protractor anemometer to calibrate the speed with these materials:

- 12 inches of string
- Ping-pong ball
- Tape
- Wind speed chart

1. Tape one end of the string to a ping-pong ball and the other to the center of the straight edge of a protractor.
2. Hold the anemometer with the straight edge on top, parallel to the floor.
3. Note the angle of the string on the protractor when the wind blows, and then use it to calculate the wind speed from the chart below. (Do you see a pattern? Can you extend the chart for greater angles?)

Wind Speed Chart

Angle	Wind Speed (km/hr)
90	0
95	9
100	13
105	16
110	19
115	21
120	24
125	26
130	29
135	31
140	34

Let's Try It!

Discuss with the group how tools are used to help predict the weather. Talk about wind and how it can be measured. Introduce the word "anemometer" and talk about how anemometers are used in various applications.

Making the Anemometer

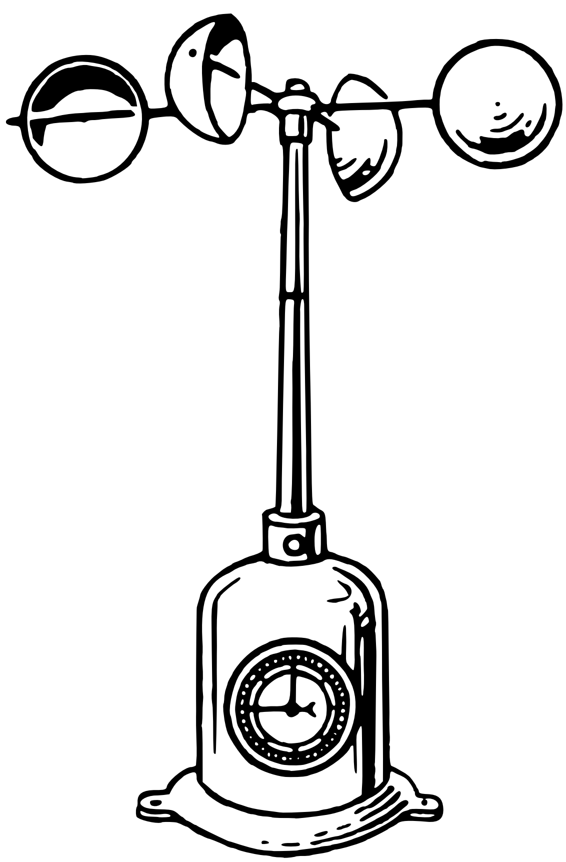
- Use a hole punch to punch out four holes (evenly spaced) just under the lip of one of the paper cups. This will be your center cup. (Note: If you have one cup in a different color, save it for use later.)
- Using one end of the pencil, punch a hole in the center of the bottom of the center cup.
- On each of the remaining four cups (including the cup in a different color), punch out two holes just under the lip, approximately 1 inch apart.
- Thread one of the straws through two opposite holes in the center cup. Then thread the other straw so it lies crosswise on the first straw.
- Attach the four cups to each of the four ends of the straws by threading a straw end through both holes. Make sure the top of each cup is facing toward the bottom of the next cup.

- Attach the colored tape to the bottom lip of one of the cups; if you used one cup in a different color, attach the tape to this cup. The tape and the different color make it easier to measure the rate at which the anemometer spins.
- Insert the pencil, eraser end first, through the hole in the bottom of the center cup until it reaches the straws. Stick the pushpin gently through the 2 straws and into the eraser. Hold the pencil in one hand and push one of the cups to spin them. If the cups spin easily, you're ready for your experiment. If not, loosen the pushpin a little.
- Stick the end of the pencil into the clay so your anemometer can be freestanding.

Make predictions

If you hold your anemometer in front of a fan, what do you think will happen? What happens if you move your anemometer farther away from the fan? How can you measure how fast your anemometer is spinning?

Making predictions is a huge part of process thinking, which is important for subjects like science and math. Making predictions also develops narrative literacy skills. When you are reading a book aloud, ask kids to predict what will come next.



Observe
Position the anemometer a few inches away from the fan and turn on the fan. What happens? What if you move the anemometer farther away from the fan?
Measure the rate (how many times the cups spin in a certain amount of time) of the anemometer. Place your anemometer approximately 12 inches away from the fan. Position your finger under your anemometer so that the tape lightly touches your finger. Keep your finger here and set the timer for 15 seconds (you can do this for the whole group at once, or if you have multiple timers, kids can help each other in small groups). Count how many times the anemometer spins in 15 seconds by counting how many times the tape touches your finger. You can also count how many times you see the different-color cup pass in front of you. Record your results in your journal.

Leaving the fan speed the same, choose two other distances from the fan and measure the rate at which your anemometer spins for each one. Record your results.

Try taking your anemometers outside to conduct some experiments. What conclusions can you make about where the wind speed is highest and lowest?

Knowledge Check

- How does your anemometer measure the wind speed?
- Why do we need to calibrate the anemometer?

Scale It Up/Down

- Simplify for younger kids by having kids make only the protractor version of the anemometer.
- Have a large crowd? Have the kids work in groups to build and test their anemometers.

Additional Resources

Anemometer

Vocabulary:

Anemometer - an instrument used to measure how fast the wind is blowing.
Calibrated - adjusted to measure data accurately.
Kinetic Energy - the energy in an object due to its movement.

Books:

The Wind Blew by Pat Hutchins
Like a Windy Day by Frank Asch
I Feel the Wind by Arthur Dorros
I Face the Wind by Vicy Cobb

Poems:

Who has seen the wind? By Christina Rosetti
Action Poem:

(walk in step to rhythm of this rhyme and turn when it says; go through the rhyme several times, speeding up each time)

There was an old man in our town
Who went for a walk one day
The wind it blew so ver-y hard
It turned him 'round the other way!

Videos:

Windy Day - Exercise Song for pre-K and kindergarten

Websites:

Preschool Express - Wind Songs and Rhymes
National Geographic - Anemometer

NOTES:

Balloon Car

Simple Machines and Physical Forces

Newton's Third Law of Motion states that "for every action, there is an equal and opposite reaction." Air being forced out of a balloon will cause the balloon to be pushed rapidly backwards. A **wheel and axle** is a simple machine with two parts. The wheel connects to the axle. The two parts spin together around the same center point. Having wheels and axles to move an object reduces friction, allowing the object to move more easily - faster and farther.

How Does It Work?

Because the air from the balloon is pushed out rapidly backwards, there is a reaction force that pushes the car forward. Balloons are elastic and store **potential energy** when they are filled with air. When the air is released, the potential energy is converted into the energy of motion, which is also known as **kinetic energy**. This is the energy you see when the car is propelled forward.

Supplies

- Toilet paper tube
- Paint (optional) or stickers
- Ruler
- Scissors
- 2 drinking straws
- Hot glue gun & glue sticks (low temperature glue guns are available)
- Bamboo skewers
- 4 plastic bottle caps (start saving them!)
- Balloon
- Small rubber band (consider there may be latex allergies)

Objective

After doing this activity, kids will be able to:

- Explain potential and kinetic energy.
- Understand the basic idea of Newton's 3rd Law of Motion.

Let's Try It!

1. Use a manual inflator (much easier and cleaner than using your mouth) to blow up a balloon and pinch off the opening, but do not tie it off. Ask the kids to predict what will happen when you let go of the neck of the balloon.
2. Ask kids why they think that will happen. Talk about **potential** and **kinetic** energy.
3. Let go and confirm or change predictions.

When we use science vocabulary words and explain them instead of replacing those words with simpler words, we expand children's vocabulary so that they will later understand what they read.

Begin the car

- (Optional) Paint a toilet paper tube and let dry while you read a story.

Make the Wheels and Axles

1. Cut two 2-inch pieces of one of the straws. These are the axles. Put dot of hot glue on the middle of each. Set the tube on the straws - (this will keep the axles parallel to the surface they will drive on). The straws should be near the ends of the tubes. Make sure the tube rests on the straws evenly.
2. Cut two 3-inch pieces of bamboo skewers. Put dots of hot glue in the center of 2 bottle caps. Stand one skewer piece in each dot of glue. You don't want to attach the other bottle caps to the opposite ends yet.
3. Stick the skewers through the straws on the tubes. Put a dot of glue on the other two bottle caps and then stick them to the ends of the skewers to complete the wheel and axles.

Attach the long straw

1. Put a dot of hot glue inside each end of the toilet paper tube opposite the wheels (on the "top" inside of the car). Press the long, uncut straw to attach it to the inside of the tube.
2. Use the rubber band to attach the balloon to one end of the long straw.

Set the car in motion:

- Blow through the other end of the straw to inflate the balloon. Cover the end of the straw as you set the car down.
- Then let go and watch it zoom!
- Try different shaped balloons. Before each trial, have kids predict what will happen.
- Can kids improve on their car design in any way? Try different balloons.

Knowledge Check

- What makes the car/balloon move?
- At what point does the balloon have the most potential energy? When does it change to kinetic energy?

Scale It Up/Down

For younger kids or larger crowds:

- Skip making the cars and stretch a length of yarn across the room.
- Thread a straw onto each before securing the second end.
- Blow up the balloon and close the end with a binder clip or clothespin.
- Tape the balloon to the straw… release the end of the balloon and watch it zip along the string.
- You can have several strings and have balloon races.
- Try different types of balloons.
- Have kids predict what will happen with different types of balloons.

Helpful Hints for This Activity

- Use a manual balloon inflator.
- Inflate the balloons a few times (kids can also do this) to stretch them before the kids attach them to their cars. It will make it easier for them to inflate the balloon through the straws.
- If you don’t want to use hot glue or have no electrical outlet, another option for attaching wheels is to make a small hole in each bottle cap in advance of the activity. You can use a push pin and wiggle it about to make the hole just big enough for the skewer to fit snugly inside. Use tape to attach the straw pieces to the toilet tube.
- To save time, pre-cut the bamboo skewers and straws to length.

Additional Resources
Balloon Car

Vocabulary:
Wheel & Axle - a simple machine consisting of a wheel attached to a smaller axle so that these two parts rotate together in which a force is transferred from one to the other.
Friction - the rubbing of one object or surface against another.
Energy - the ability to do work.
Potential Energy - stored energy in an object.
Kinetic Energy - energy in an object due to its movement.
Newtons 3rd Law of Motion - action and reaction are always equal but opposite in direction. Common examples of Newton's third law of motion are: A horse pulls a cart, a person walks on the ground, a hammer pushes a nail, magnets attract a paper clip.

Books:
What Do Wheels Do All Day? by April Jones Prince
Motion: Push and Pull, Fast and Slow (Amazing Science) by Darlene Ruth Stille
Newton and Me by Lynne Mayer
Air Is All Around You (Let's-Read-and-Find-Out Science 1) by Dr. Franklyn M. Branley

Video:
Make a Balloon Car (uses a plastic bottle instead of a cardboard tube)

NOTES:

Code Your Name

Computational Thinking: Binary Code ASCII

Any code that uses just two symbols to represent information is considered **binary code**. Different versions of binary code have been around for centuries and have been used in a variety of contexts. For example, braille uses raised and un-raised bumps to convey information to the blind, and Morse code uses long and short signals (“dots” and “dashes”) to transmit information. Perhaps the most common use for binary nowadays is in computers: binary code is the way that most computers and computerized devices ultimately send, receive, and store information. A "binary digit" is called a "bit" for short. A grouping of eight bits is called a byte. Fun fact: A grouping of four bits is called a nibble!

How Does It Work?

The 0s and 1s of binary code are somewhat arbitrary. Any symbol, color, or physical object that can exist in two different forms or states—such as a coin (heads and tails), a switch (on and off), color (blue and green), shapes (circle and square)—can be used as a binary code.

Objectives

After doing this activity, kids will be able to:

- Encode letters into binary and decode binary back to letters.
- Understand how storing initials on a bracelet or string is similar to the idea of storing information in a computer.

Supplies

- Pictures of the inside of a computer or an old computer that has been opened up so they can see the insides.
- Chart with binary code translations for letters (here is a worksheet from Code.org https://code.org/curriculum/course2/14/Activity14-BinaryBracelets.pdf) OR the simplified chart in the Additional Resources: Code Your Name section below.
- Chenille stems, thin wire, or yarn - chenille stems work best because they prevent beads from slipping off too easily and can be joined easily to make more length if needed.
- Lots of pony beads - each child chooses 3 colors (to represent 0, 1, and space).

Let's Try It!

Write a short message on a board in binary - such as “Hi” - and ask if anyone knows what it is or what it means. Put the message aside and move on to prepping for the activity.

Start by asking the kids if they have ever seen inside a computer.

- What's in there?
- Show them the inside of a computer (or pictures of the inside of a computer).
- Wires carry information through the machine in the form of electricity.
    - The two options that a computer uses with respect to this electrical information are "off" and "on."
- When computers represent information using only two options, it's called "binary."
- Computers also store information using binary, but not in “on” or “off” circuits. Hard disk drives store information using magnetic positive and magnetic negative - that is why we keep magnets away from computers!! (And DVDs store information as either reflective or non-reflective - which is why we don’t want them to get scratched!)

“Today we are going to convert letters to binary code and use them to make a bracelet or necklace.”

- Show the kids the chart of binary conversions for letters.
- Go over a few examples of converting letters into binary, then back.
- Afterward, write an encoded letter and give them a few seconds to figure out what it is.
- When they can figure out your encoded letters on their own, you can move on to the activity.

When we do activities that follow a sequence or pattern, we are reinforcing and introducing children to several early skills, literacy, writing, math, and coding.

Knowledge Check

- Write an encoded letter of the alphabet and give the kids a few moments to figure out what it is.
- Ask, "Can you read the message I showed you at the beginning?"

Scale It Up/Down

- For younger children, have them make just the first letter of their name.
- For a large audience, break up into groups and have kids help each other or assign tasks - one person manages the beads, one person puts them on the stem, etc. Also consider using shorter words or initials of a name.
- Binary is visually hard to track, so some younger children will need more assistance. Try using "reading tracker" bookmarks (see Amazon or Oriental Trading for examples)
- **Adaptations:** If manual dexterity is an issue, use colored shapes or dot stickers to be glued down on paper instead of beads and chenille stems.

Helpful Hints for This Activity

Since each letter is very long, it helps to have kids use their (shorter) nick name or a secret word of no more than four or five letters (love, joy, smile, code).

Additional Resources

Code Your Name

Vocabulary:

Binary Code - Any code that uses just two symbols to represent information.

Books:

Hello Ruby by Linda Liukas
How to Code a Sandcastle by Josh Funk
Coding Concepts for Kids: Learn to Code Without a Computer by Randy Lynn

Songs:

Songs that have a repeated pattern (code) to follow or are cumulative. Share songs that have repetitive patterns, like “Old McDonald Had a Farm,” “Juanito Cuando Baila,” and “Un Elefante Se Balanceaba.” Try rhymes with hand movement patterns, like “Head, Shoulders, Knees and Toes” or “Chicken Dance.”

Websites:

Getting Loopy iteration dance (PDF - Code.org)
Name Games and Songs for Circle Time
Code Your Name in Binary

Notes:

Additional Resources

Code Your Name

Binary Symbol Table

A	□■□□ □□□■	a	□■■□ □□□■	0	□□■■ □□□□
B	□■□□ □□■□	b	□■■□ □□■□	1	□□■■ □□□■
C	□■□□ □□■■	c	□■■□ □□■■	2	□□■■ □□■□
D	□■□□ □■□□	d	□■■□ □■□□	3	□□■■ □□■■
E	□■□□ □■□■	e	□■■□ □■□■	4	□□■■ □■□□
F	□■□□ □■■□	f	□■■□ □■■□	5	□□■■ □■□■
G	□■□□ □■■■	g	□■■□ □■■■	6	□□■■ □■■□
H	□■□□ ■□□□	h	□■■□ ■□□□	7	□□■■ □■■■
I	□■□□ ■□□■	i	□■■□ ■□□■	8	□□■■ ■□□□
J	□■□□ ■□■□	j	□■■□ ■□■□	9	□□■■ ■□□■
K	□■□□ ■□■■	k	□■■□ ■□■■	.	□□■□ ■■■□
L	□■□□ ■■□□	l	□■■□ ■■□□	,	□□■□ ■■□□
M	□■□□ ■■□■	m	□■■□ ■■□■	:	□□■■ ■□■□
N	□■□□ ■■■□	n	□■■□ ■■■□	;	□□■■ ■□■■
O	□■□□ ■■■■	o	□■■□ ■■■■	?	□□■■ ■■■■
V	□■□■ □□□□	p	□■■■ □□□□	!	□□■□ □□□■
Q	□■□■ □□□■	q	□■■■ □□□■	#	□□■□ □□■■
R	□■□■ □□■□	r	□■■■ □□■□	&	□□■□ □■■□
S	□■□■ □□■■	s	□■■■ □□■■	‘	□□■□ □■■■
T	□■□■ □■□□	t	□■■■ □■□□	“	□□■□ □□■□
U	□■□■ □■□■	u	□■■■ □■□■	-	□□■□ ■■□■
V	□■□■ □■■□	v	□■■■ □■■□		
W	□■□■ □■■■	w	□■■■ □■■■		
X	□■□■ ■□□□	x	□■■■ ■□□□		
Y	□■□■ ■□□■	y	□■■■ ■□□■		
Z	□■□■ ■□■□	z	□■■■ ■□■□		

Homopolar Motor

The Science of Electrical Motors

A ***homopolar motor*** is a type of electric motor, specifically one that uses direct current to power rotational movement, such as that generated by a battery. It was the first type ever built and demonstrated by Michael Faraday in 1821. Although not the configuration Faraday used, homopolar motors can be made out of a single AA or C battery, a single neodymium magnet, and a piece of copper wire.

How Does It Work?

Magnets are surrounded by an invisible magnetic field. This is what allows them to push and pull on other magnets or metal objects from a distance. In this case, the magnetic field allows the magnet to snap onto the battery. When the wire touches the top of the battery and the magnet (which is touching the bottom of the battery) at the same time, electrical current flows through the wire. This electrical current passes through the magnetic field created by the magnet. This results in a force that pushes on the wire, causing it to spin around the battery. This spinning motion means it is a simple **electric motor**, a device that converts electrical energy into mechanical energy. Bigger electric motors are used in things like toys, appliances, and electric cars. This motor is called a homopolar motor because the polarity (direction) of the electrical current and magnetic field does not change.

Objectives

After doing this activity, kids will:

- Understand how electrical energy can be used make a device work.

Supplies

- Copper wire (16 gauge)
- AA battery (one per motor)
- Neodymium magnet - an ideal magnet to use is a 12 mm diameter x 6 mm thick, or two 12 mm x 3 mm, neodymium disc magnets.
- Pliers - pointed tip may be easier to use.
- Various other craft supplies to add to copper wire designs (glue guns and sticks, fabric, mini pipe cleaners, etc.)

Let's Try It!

- Place a battery on a neodymium magnet with the negative (flat side of the battery) touching the magnet. If you cannot find 6 mm thick magnets, stack two 12 x 3 magnets.
- Bend wire into a shape that will balance on top of the battery and be long enough to touch the magnet underneath the battery.
- The wire can be bent to form any shape, but one end must be touching the positive terminal of the battery and the other must be in contact with the neodymium magnet. The key is to make a shape with the wire that allows it to balance properly; if it is unbalanced, it will soon fall off the battery as it begins to spin. **See examples of different shapes that work in the Additional Resources: Homopolar Motors section below.**
- Please be careful in making a homopolar motor as the wire and battery can become very hot.

Neodymium magnets are the strongest in the world, which is why you will often see a neodymium disc magnet used in this configuration. The stronger the magnet, the quicker the wire will spin (see precautions in helpful hints section).

Knowledge Check

- Check to see if kids understand that the wire must touch both the battery and the magnet to complete the circuit.

Scale It Up/Down

- Pre-bend the wire for young kids and let them choose a shape. It has to be balanced, so young kids will find it frustrating. Older kids may be up to the challenge.
- Let younger kids spend their time creating a figure to attach to the wire that can spin around.
- For larger audiences, make this a station and include additional magnet-related activities at other stations.

Helpful Hints for This Activity

- Start the kids with a BASIC homopolar motor to get the hang of how the motor actually works, then let them try making a tiny dancer or other style.
- **The wire and the battery can get very hot**. Please use caution. Wrapping electrical tape around the parts of the wire that do not need to make contact with either the battery or magnet may provide some heat protection.
- Stacking two or three magnets will make the motor spin faster.
- Neodymium magnets are extremely strong and MUST BE KEPT OUT OF REACH OF SMALL CHILDREN! Do not give them to any child who might put them in their mouth. The magnets are dangerous if swallowed and must be surgically removed! **This is a project for older children who can understand the precautions and ADULT SUPERVISION required!**
- Additionally neodymium magnets can interfere with electronic devices, so please keep them away from phones!

Additional Resources

Homopolar Motor

Vocabulary:

Electric Motor - a device that converts electrical energy into mechanical energy.
Homopolar Motor - a type of electric motor, specifically one that uses direct current to power rotational movement, such as that generated by a battery.

Books:

How Do Electric Motors Work? Physics Books for Kids by Baby Professor
The Magic School Bus and the Electric Field Trip by Joanna Cole
See Inside Energy by Alice James - lift-the-flap book (but not for babies!) - maybe chose one or two pages to read aloud

Videos:

How to Make a Simple Homopolar Motor

Websites:

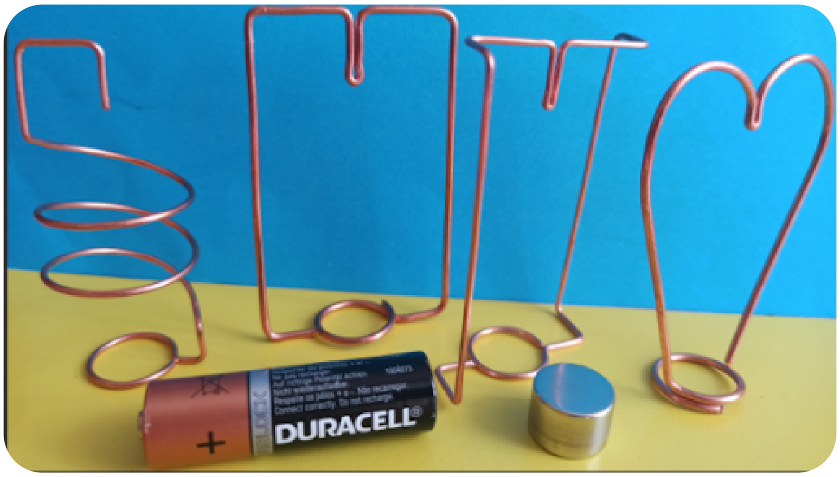
Homopolar-Motor (PDF)

NOTES:

Additional Resources

Homopolar Motor

Shapes to Use for Homopolar Motors



Human Sorting Network

Demonstrating Parallel Algorithms in Computer Science

As we use computers more and more, and the amount of data we use increases, we want them to process information as quickly as possible. One way to increase the speed of a computer is to have several computers work on different parts of the same task at the same time, which is what this activity explores.

How Does It Work?

Sorting networks are used to sort values into ascending order by comparing pairs of values. A s**orting network** can have more than one comparison happening at the same time. Think of it like a situation where you might need to set four tables for dinner; if you have four people each setting a table at the same time, then you can probably get the job done four times faster than if one person did all the work.

Objectives

After doing this activity, kids will:

- Break a problem down into small, logical steps.
- Use steps to create a process (algorithm) that solves the problem.
- Compare values and determine greater/lesser.

Supplies

- Printed cards for kids (initially digits 1-6 - you may be using other options, depending on the age and experience of your group)
- Sorting Network Template (**See Additional Resources - Human Sorting Network below**)
- Chalk - use the Sorting Network template to draw a six-person sorting network on a paved surface outside using sidewalk chalk. Other alternatives:
    - Masking/painters' tape on a carpet or wooden floor
    - Tape on a tarpaulin
    - Line-marking paint on grass
- Use different colors or line thicknesses to help kids remember which way to go. It should be large enough that two kids can comfortably stand in the rectangles; the more spread out it is, the more effective the activity is.

Let's Try It!

Set the stage:

Ask kids:

- “What are examples of tasks that get finished sooner if more people help with them?”
- “What are examples of tasks that don't get finished sooner if more people help with them?” (Potential answers may include: tasks such as cleaning up a room after an activity, picking up trash, or re-shelving library books may come up as ones that benefit from multiple helpers. Things that don't go faster might include delivering a letter to a mailbox - 10 people delivering the letter won't get it there 10 times faster, or washing dishes if there is only one sink - two people are faster than one, but more people probably won't speed it up).

Show the students the sorting network drawn on the ground, and tell them "This chalk computer can do some things very fast. Let’s investigate what it does."

Doing the activity:

- Organize students into groups of six. Only one team will use the network at a time, and other teams can observe until it is their turn.
- The current team should stand on the circles at the "input" end of the sorting network.
- Give each of the six students a card to hold (initially use a set of cards containing the numbers from 1 to 6; the cards should be given to the students out of order). These cards are the inputs into this cool chalk computer (this is a special kind of computer that can process several operations at the same time).
- Get the first two students to follow the lines from their circles until they meet at a box (the others should pay attention).
- When the two have entered the box, they should say hello to each other (this is to make sure that they stop and both engage in this step), and then compare cards to decide who has the lower number and who has the higher number.
- The student with the lower number should follow the line out to the left and go to the next box, while the person with the higher number follows the line leaving to the right to go to the next box.

When we do comparing and contrasting activities such as this, we help children develop an essential skill that will aid them with reading comprehension.

- Now get the next pair of students to do the same, meeting at a box and leaving it with the smaller to the left and the larger to the right.
- You can now get the remaining pair of students to do this (remind them to say hello when they meet).
- Once they have the idea, tell them to repeat this process until they get to the end of the network. If someone gets left behind, have the students go back to the beginning; they will need to pay attention when they meet at a square, and ensure that both people who have met know the outcome.
- When they have all reached the circles at the other end of the network, have them turn and face the starting circles and read what's on their card, from left to right. They should be in the correct order from smallest to largest; if not, they may need to try again and work more carefully.
- When each group has been through the sorting network, introduce a sorting network race to see which group can successfully complete the task in the shortest amount of time (either with two sorting network racing teams at the same time or one network with the times measured using a stopwatch).

Knowledge Check

- How does using this sorting grid help us put things in order?

Scale It Up/Down

- With a group less than six, or in a very confined situation, this activity could be done on a desktop using game counters and cards, or having kids write in the spaces of the sorting network instead of moving around.
- For younger children, use single digit numbers or objects by size (i.e., six boxes or balls of increasing size). Depending on the age and sophistication of your group, you can use two-digit numbers, multi-digit numbers, decimals, fractions, etc.

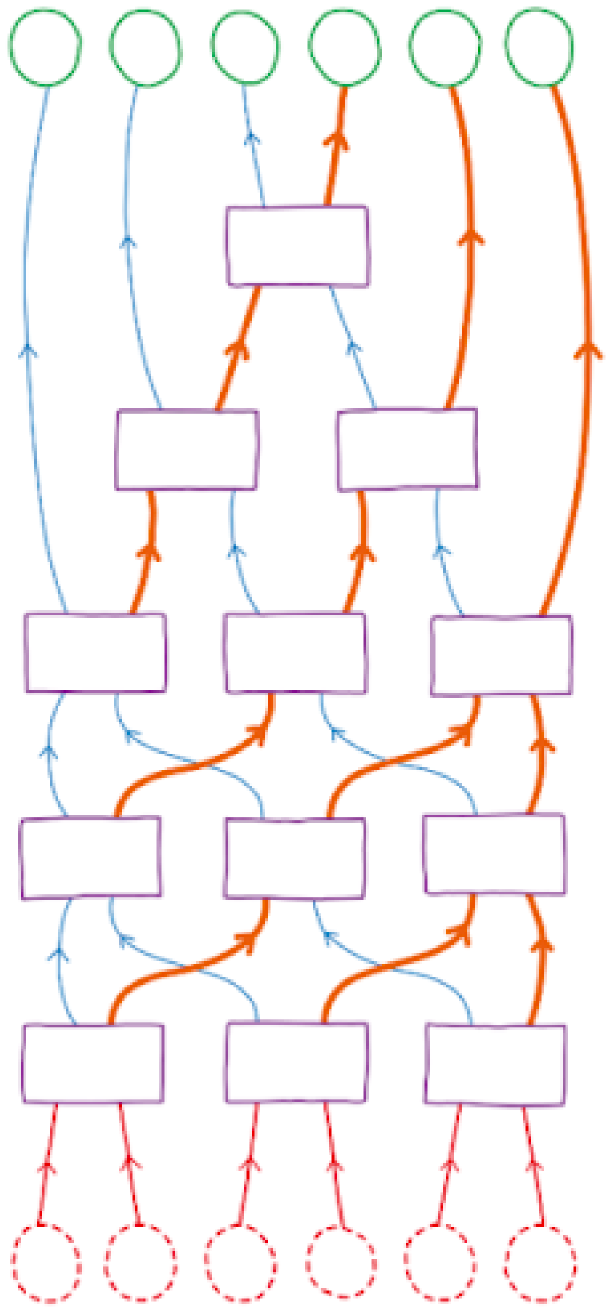
Other ideas:

- Sort colors by shade (have cards in six distinct shades of the same color or try color paint chips from the hardware store).
- Use hand bells and sort by higher and lower tone.
- Use texture and sort from smooth to rough.
- Use shapes - numbers of sides or corners.
- Use pictures of animals with number of legs (e.g. snake, bird, dog, insect, arachnid, centipede).

Additional Resources

Human Sorting Network

Human Sorting Network Template



Additional Resources

Human Sorting Network

Vocabulary:

Sorting Network - a group of hubs (stations) used to order data in an increasing or decreasing fashion according to some relationship among the data items.

Books:

Look Inside a Computer by Emily Sollinger
Look Inside How Computers Work by Alex Frith

Videos:

See this activity in action: https://vimeo.com/437722996

NOTES:

Kaleidoscope

The Science of Light, Color, and Symmetry

The kaleidoscope was invented by Sir David Brewster in 1816 and patented in 1817. The term "kaleidoscope" is derived from the ancient Greek words known as 'kalos," which means beauty, "eidos," meaning something that is seen, and "skopeo," which means to look. It has served as a toy for children, parlor entertainment for adults, and a design palette for artists, jewelers, and architects. A **kaleidoscope** contains two or more reflecting surfaces tilted toward each other at a certain angle for obtaining a symmetrical pattern when viewed from the other end.

How Does It Work?

A **kaleidoscope** works by **reflecting** light. Light travels in a straight line. When light bumps into something, it changes direction. When you point the kaleidoscope toward light, the light enters the kaleidoscope and reflects back and forth between the shiny surfaces inside the kaleidoscope. A symmetrical pattern is created due to the phenomenon of repeated **reflection**. The tube, which has reflecting surfaces, contains colored pieces of glass or beads. When the tube is rotated, symmetrical images appear and change with the rotation.

Objectives

After doing this activity, kids will be able:

- Identify images that are symmetrical and those which are not symmetrical.

Supplies

- Reflective sheet (metallic card stock , diffraction paper, or Mylar sheets)
- Clear, stiff plastic (as from a to-go container)
- Colorful beads (translucent are best)
- Cardboard tube
- Ruler
- Scissors
- Markers, stickers, fancy paper or paint to decorate outside of the tube
- Clear tape
- Washi tape (optional)

Let's Try It!

1. Decorate the outside of the cardboard tube with markers, stickers, fancy paper, or paint (optional).
2. Draw an 8-by-4-inch rectangle on a metallic, Mylar, or diffraction paper sheet. This is going to be the base of your kaleidoscope. Cut it out using scissors. Draw three horizontal lines across the rectangle, splitting it into three $1\frac{1}{4}$-inch pieces and one $\frac{1}{4}$-inch piece. (You'll need to make it this size to fit a paper towel roll. If you use a different type of tube, adjust accordingly.)
3. Fold the plastic along the lines to form a triangular shape. Press the folds well with the edge of a ruler or some other object. The $\frac{1}{4}$-inch strip should stay on the outside and act as a flap. Tape the strip along the edge using transparent tape, so the triangle holds its shape.
4. Cut a paper towel roll down to about an inch longer than your triangle. Slide the plastic triangle into the paper towel roll. (At this point, you have a simple kaleidoscope with which you can look at patterns in the room. Turn the kaleidoscope to watch the patterns change.)
5. Trace two circles out of the clear plastic using the end of the paper towel roll as a guide. Trim the first one carefully so that it just fits inside the tube. Put it into the kaleidoscope, making sure it lays flat.
6. Cut off a piece of another cardboard tube that is about 1-inch wide.
7. Make a second cut to sever the circle. Overlap the edges about ½ an inch to create a ring that fits securely inside the paper towel tube while still being able to rotate. Tape it to shape. This is your end cap. Remove it from the kaleidoscope temporarily to finish it.
8. Take the second plastic circle and place it on top of your end cap. Tape it in place with clear tape. You can cover the outside of this end cap with washi tape to make it look nice.
9. Fill the end cap with beads and place it into the end of the kaleidoscope so that the beads are captured between the plastic discs.
10. Fill the pouch with beads, sequins, and confetti. Anything small and shiny will do the trick, but translucent objects are best. You also want different shapes and sizes.
11. Place a 4-inch square of waxed paper over the pouch and around the cardboard tube, sealing in the beads and sequins. Stretch a rubber band over both the waxed paper and the plastic wrap. Make sure it’s on tight so nothing spills out!
12. Trim the corners of the squares to make the kaleidoscope look neater. (You can replace the rubber band with tape).

Using the kaleidoscope.
Hold the tube up to one eye, facing the light, and look through it. Rotate the end cap. What happens? Just how different is what you're seeing? What do you notice about the images in the kaleidoscope?

This activity can be a great way to get artistic children to be interested in science. The combination of the magical patterns of the kaleidoscope and learning the science behind what makes it happen is a great way to spark an interest in science.

Knowledge Check

- What causes you to see a symmetrical pattern when you look into the kaleidoscope?

Scale It Up/Down

For very young children, pre-cut and pre-fold Mylar, and pre-cut plastic and tubing pieces. You can stop after step 4 if you are short of time or have a very young group. Just have them point their tube at something that has a pattern, and they will be able to see the symmetrical reflections.

Additional Resources
Kaleidoscope

Vocabulary:

Kaleidoscope - a tube containing mirrors and pieces of colored glass or paper, whose reflections produce changing patterns that are visible through an eyehole when the tube is rotated.
Reflection - a sending back of light or something else without absorbing it.
Symmetry/symmetrical - when an image looks identical to the original image after the shape has been turned or flipped, then it is called symmetry.

Books:

Seeing Symmetry by Loren Leedy
What is Symmetry in Nature? by Bobby Kalman
Kaleidoscope by Salina Yoon

Videos:

DIY How to Make a REAL Kaleidoscope
Color Song for Kids - I See Colors Everywhere

Websites:

This DIY Kaleidoscope Craft for Kids Makes Upcycling Fun
10 Preschool Songs About Colors

NOTES:

Spectroscope

Science of Light and Color

Light travels in waves of **electromagnetic radiation**. It can travel through a vacuum and moves so fast we cannot detect the movement with our eyes. Most of the light that streams to our eyes appears white or yellowish. However, light, part of the electromagnetic spectrum, actually contains several wavelengths, which the human eye sees as different colors. Violet has the shortest **wavelength** that people can see, while red has the longest. At both ends of the **visible spectrum**, there are wavelengths that people cannot see, such as ultraviolet and infrared radiation.

A **spectroscope**, or spectrometer, splits light into the wavelengths that make it up. Early spectroscopes used prisms that split the light by refraction — bending the light waves as they passed through the glass. A good example of refraction is a rainbow, in which sunlight passes through raindrops and is split into its different colors. Modern spectroscopes often replace the prism with narrow slits called diffraction grating. The slits spread the light into different wavelengths by different amounts, which makes it possible to measure the wavelengths. In the 1860s, William Huggins discovered what the stars were made of by viewing them through a spectroscope.

How Does It Work?

All light is made up of waves of electromagnetic radiation. A spectroscope spreads each different wavelength to a different position within a spectrum of light. A CD has a mirrored surface with spiral tracks or pits. These circular tracks are so close together that they can act as a diffraction grating for light. When the light enters the tube, it is spread into a spectrum perpendicular to the CD tracks. This is why the slit and the viewing hole are located at right angles. Each color bends at a particular angle. For you to see the spectrum, the light must diffract off the CD and reflect into your eye. Because the CD's surface is like a mirror, the light is reflected to your eye. Adjusting the tilt of the CD allows you to properly bounce the spectrum into your eye.

Objectives

After doing this activity, kids will be able to:

- Understand that "white" light is composed of wavelengths of different colors blended together.
- Describe different color patterns of different types of light sources.

Supplies

- Empty paper towel roll
- Craft knife and/or scissors - for use by an adult
- Blank or old CD - save them when your library discards them or find them at thrift stores
- Pencil
- Small piece of cardboard or cardstock
- Masking tape
- Marker, crayons, stickers, etc. (optional)

Asking children to speak about science findings and encouraging their own experiments helps them think critically and enhances their enjoyment of science activities.

Let's Try It!

The first two steps to be done in advance by an adult:

1. Use a craft knife to pre-cut a thin slit at a 45° angle toward the bottom of each cardboard tube.
2. Directly across from the slit, make a small peephole or viewing hole using your craft knife.
3. Let kids color and decorate the paper towel roll with markers, crayons, and stickers.
4. Kids trace one end of the paper towel roll onto a small scrap of cardboard or cardstock. Cut it out.
5. Kids cut a straight slit (less than 1 mm wide) right across the center of the cardboard circle - (or an adult can do it with a craft knife).
6. Kids tape the circle to the top of their paper towel roll (end opposite the slit), making sure the slit is perpendicular to the eye hole at the other end.
7. Insert the CD into the 45° angled slit with the shiny side facing up.

Using the spectroscope:

- Hold the tube upright and point the top slit at a fluorescent light.
- Press your eye to the viewing hole.
- On the CD, look for a clear, solid line of light broken up into colored bands: this is the spectrum of light reflected from fluorescent light onto the CD.
- Adjust the angle at which you look through the viewing hole at the CD to find the best view of the light spectrum.
- Have kids go outside and point the spectroscope at the sky. Impress upon the kids that they should NEVER LOOK DIRECTLY AT THE SUN THROUGH YOUR SPECTROSCOPE. Instead, aim the scope at the light bouncing off of a white wall.
- What do they see? They should see a rainbow.
- Have them experiment with other types of light (fluorescent, LED, incandescent, etc.) and compare. Look for specific colors and notice the spacing between the colored lines.
- An incandescent light bulb produces a continuous spectrum because it is a heated solid – a tungsten filament. A fluorescent bulb produces distinct colored lines because it contains mercury vapor.
- Some other light sources to examine are a candle flame, a flashlight, yellow street lights, blue street lights, the flame from a Bunsen burner, a camping lantern, and neon signs.

Knowledge Check

- Why do we see different patterns of color when we look at different light sources?

Scale It Up/Down

Having the slits and holes pre-cut for kids will eliminate the need for a lot of adult helpers. You can adjust the size to be made with toilet paper tubes, as they may be more readily available for larger groups.

Additional Resources

Spectroscope

Vocabulary:

Visible light spectrum - the range of wavelengths of electromagnetic radiation which our eyes are sensitive to.
Spectroscope - an instrument used for splitting light, or other electromagnetic radiation, into its component wavelengths – a spectrum – for visual observation.
Refraction - the bending of light. Light bends whenever it travels from one transparent material to another. One example of this is light traveling through a glass.
Electromagnetic radiation - commonly referred to as "light." The waves travel through a vacuum (space) at the speed of light.
Wavelength - the distance from the top of a wave to the top of the next wave.

Books:

Rainbow by Marion Dane Bauer
Light Is All Around Us (Let's-Read-and-Find-Out Science 2) by Wendy Pfeffer
A Ray of Light by Walter Wick (not a read-aloud but excellent photos to show and give background information)
A Rainbow of My Own by Don Freeman
Mouse Paint by Ellen Stoll Walsh
Mix it Up by Herve Tullet
Any book about colors could be a good springboard for this activity.

Website:

See a version of the spectroscope here: https://www.exploratorium.edu/snacks/cd-spectroscope

Video:

Five-minute video explaining light and color

NOTES:

Stretchy Hair Gel

Another Non-Newtonian Fluid

The everyday materials around us generally fit into one of three categories: **solid**, **liquid**, or **gas**. Along with plasma, these three categories represent the different possible states of matter. A table is solid, while the air we breathe is a gas. Some materials can even transition between the different states. For example, water can exist as a solid (ice), a liquid (water), or a gas (steam or vapor).

Many centuries ago, Sir Isaac Newton proposed that fluids should flow at a predictable, constant rate. Many fluids do indeed behave this way and are called **"Newtonian" fluids**. Water is a perfect example of a Newtonian fluid: when you are in a swimming pool, water flows around you whether you are moving around quickly or slowly. **Viscosity** is the physical property that characterizes the flow resistance of simple liquids. You can think of it as the "thickness" of the fluid for simplicity's sake. Newtonian fluids have a constant viscosity that doesn't change, no matter the pressure being applied to the fluid. This also means they don't compress.

Non-Newtonian fluids are just the opposite — if enough force is applied to these fluids, their viscosity will change. This hair gel slime will get thicker when force is applied, and you can break it into chunks. Leave it alone, or apply pressure slowly, and it will flow. There are many examples of non-Newtonian fluids and understanding the behavior of non-Newtonian fluids is important for many areas of scientific research. For example, the food industry deals with many non-Newtonian fluids including ketchup, mayonnaise, jelly, and cranberry sauce. Understanding how these materials behave helps food scientists make more tasty food products. Biologists studying cells are also interested in non-Newtonian fluids because the goopy insides of cells behave as non-Newtonian fluids and this influences many cellular processes. Engineers are even finding ways of putting non-Newtonian fluids to good use in our everyday lives by using them to fill potholes!

How Does It Work?

This hair gel slime isn't your typical liquid - or solid. The mixture creates a fluid that acts more like quicksand than water: applying force (squeezing or tapping it) causes it to become thicker. Push your finger in slowly, and what happens? Moving slowly allows the particles time to get out of the way. Bonus: it is less messy than other slimes or Oobleck!

Objectives

After doing this activity, kids will:

- Understand qualitatively what distinguishes solids and liquids.
- Observe non-Newtonian characteristics first hand.
- Be able to make simple predictions about the behavior of non-Newtonian fluids.

Supplies

- Corn starch (about 1 cup per person)
- Hair gel (the cheaper the better) (1/2 cup per person)
- Sturdy bowl - 1 for each person
- Rubber spatula for mixing - one per person - you can use a spoon, but a spatula works best because it can scrape the sides of the bowl better
- Measuring cups - can be shared among groups of kids

Let's Try It!

As a group, brainstorm the different properties of liquids and solids. Write down your ideas. Some examples: liquids flow, splash, take the shape of the container they are in; solids hold their shape and resist forces like pushing or hitting.

Making the slime

1. Put ½ cup hair gel in the bowl.
2. Mix it by itself for I minute - to break down the viscosity.
3. Add ½ cup of corn starch to the gel.
4. Mix two to three minutes. How does it feel?
5. Now add another ½ cup of corn starch to the mixing bowl and keep mixing. Does the texture feel different? How so? Once it is mixed up well, empty the mixture onto the table and knead it like bread dough.
6. Try iterating on the process. How does changing up the recipe affect the slime? When you are done playing with it, store in a sealed container or bag.

Talking with your children about what they are doing and observing, along with giving them time to respond, is extremely valuable. This helps your children clarify their ideas and develop conversation skills. Remember that it can take young children from five to 12 seconds to process a question and formulate a response, so it's really important to give them that extra time to express themselves.

Use the list you made in step one to systematically test whether the hair gel slime behaves like a solid or a liquid. It may be helpful to also test a bowl of pure water for comparison with a "true" liquid.
Ask children to explain the difference to a partner, then solicit a few responses to the whole group.

Knowledge Check

- If you fell into a giant vat of this slime, what would be the best way to free yourself? Why?

Scale It Up/Down

If you have a very large group:

- Demonstrate first before turning them loose with their own set of materials.
- Have sets of materials either out at stations or ready to pick up in "kits."

If you have younger kids:

- Make sure an adult is on hand to help each child or group of children - have them explore the textures and take turns stirring the ingredients.

Additional Resources
Stretchy Hair Gel

Vocabulary:
Viscosity - the resistance to flow exerted by a fluid.
Liquid - one of the states of matter. The particles in a liquid are free to flow, so while a liquid has a definite volume, it does not have a definite shape.
Solid - one of the states of matter. The particles in a solid are tightly packed so that it has fixed shape and volume.
Newtonian/non-Newtonian fluids - the key difference between Newtonian and non-Newtonian fluids is that the Newtonian fluids have a constant viscosity, whereas the non-Newtonian fluids have a variable viscosity.

Books:
Bartholomew and the Oobleck by Dr. Seuss

Videos:
Beauty Edu: Strange Hair Gel Trick
Cade Museum: Stretching Hair Gel

NOTES:

Water Clock

Use Physics and Math to Measure Time

Time is one of the fundamental units of measurement. A water clock is a timepiece used to measure time by allowing water to flow out of a container through a tiny opening. Believed to have been invented in ancient Egypt, water clocks are one of the oldest time-measuring instruments. As water dripped out of a hole from one container to another, marks on one of them would measure how much time had gone by.

More than 3,000 years ago, the ancient Greeks called it a **clepsydra**, which is often translated as "water thief." According to some sources, the Chinese version of the water clock may be even older. Some versions used floating figures in the water to point to the time. Early water clocks were calibrated with a sundial. While never reaching a level of accuracy comparable to today's standards of timekeeping, the water clock was the most accurate and commonly used timekeeping device for millennia, until it was replaced by more accurate pendulum clocks in 17th-century Europe.

How Does It Work?

All timing devices, from the water clock to the digital watch, operate because of the fundamental principle that a regular pattern or cycle operates at a constant rate. A water clock is a timepiece used to measure time by allowing water to flow out of a container through a tiny opening. Scientists use multiple trials to see if they get the same results each time. Multiple trials are important when **calibrating** the water clock, as well.

Objectives

After doing this activity, kids will:

- Understand how long a minute is.
- Understand the size of the hole affects the rate of flow.
- Explain why a measuring device such as a clock needs to be calibrated.

Supplies

- A clean, dry, clear, plastic water bottle or drink container - label removed (one without ridges will be easier to see into)
- A pair of scissors
- Masking tape
- Permanent marker
- Timer or stopwatch
- Push pin or tack to poke a hole in the cap
- Food coloring (optional) - makes it easier to see
- Pitcher to pour water

Let's Try It!

1. Adults: use scissors to cut the bottle into two parts. The cut should be a little above the half-way mark. For a 9-inch bottle, cut it at the 5 1/2-inch mark. The top section needs to be shorter than the bottom section.
2. Cut a strip of masking tape and attach it vertically to the bottom part of the bottle, from the very bottom to the top. You will use this to mark the bottle at one-minute intervals.
3. Remove the cap from the bottle and use a push pin or tack to make a hole in the cap from the inside (this will make it easier for the water to drip through from the inside). If you poke the hole from the outside in, it will leave a small ridge that the water will have to get over to go through.Try to get it as close to the center of the cap as possible. **REMEMBER**: The size of the hole you make will determine how fast the water will flow through your water clock. Start small - you can always make it bigger.
4. Put the cap back on the top of the bottle tightly, so it won't leak anywhere but the hole you made.
5. Set the top half over the button with the cap side down.
6. Get ready to start your timer or stopwatch at the same time as you pour water into the top of your timer. It helps to work with a partner (add food coloring to the water to make it easier to see).
7. As the water drips, from the top to the bottom, watch your watch or timer. When the timer reaches 1 minute, make a mark with the permanent marker on the masking tape. Try it again and see if you get the same results.
8. Mark 2 minutes if you can.
9. If you aren't happy with the speed your water clock runs, you can change the size of the hole in the cap and re-calibrate. If it's too slow, enlarge the hole by twisting the scissors in the hole. If it's too fast, take a cap from another bottle and make a hole in it that is smaller than your first one.
10. This would be a good time to demonstrate how the size of the hole affects the rate of flow.

When we change the variables in an experiment, we encourage children to observe closely and inspire them to test their own ideas.

Young kids have a very limited concept of time. By doing activities like this, we can help them develop a sense of how long a minute actually is. Now that your clock is made, you can use it as timer for a game, such as “minute to win it.”

Image: Water Clock

Knowledge Check

- What would happen if the hole in the cap is very tiny? Very large? If we leave the cap off completely?

Scale It Up/Down

- Older kids can try a more complex version of the water clock that involves displacement of two liquids. Find more here: https://teachbesideme.com/homemade-water-clock/
- Have a lot of kids? Divide them into groups to work on this project.
- Have some younger kids? Have them sing a song to pass the time - like the ABC's or Twinkle, Twinkle, Little Star.

Helpful Hints for This Activity

- Adults should pre-cut the plastic bottle for safety.
- Have kids work with a partner for timing their water clocks.
- Allow kids to manipulate or be in control of as many of the steps as they are capable of.

Additional Resources

Water Clock

Vocabulary:

Calibration/calibrate -The process of comparison of a device with unknown accuracy to a device with a known, accurate standard to eliminate any variation of the device being checked.

Books:

A Second is a Hiccup: A Child's Book of Time by Hazel Hutchins , Kady Macdonald Denton
It's about Time! (MathStart 1 Series)
Stuart J. Murphy by John Speirs
A Second, a Minute, a Week with Days in It: A Book about Time by Brian P. Cleary and Brian Gable
The Clock Struck One: A Time-Telling Tale by Trudy Harris and Carrie Hartman
What Time Is It, Mr. Crocodile? by Judy Sierra , Doug Cushman
Bats Around the Clock by Kathi Appelt and Melissa Sweet

Video:

Water Timer Model Video

Websites:

Instructables: Liquid Hourglass
Teach Beside Me: Homemade Water Clock
Oh My Clock: What is a Water Clock

NOTES:

Waterwheel

The Physics of Renewable Energy

This activity provides an illustration of **hydropower**, a renewable energy resource. Hydro means water, so hydropower is something that gets power from water. Hydropower captures energy from the movement of water.

Many machines have a motor or an engine to produce the force it needs to make it move. The first kind of engine was the **waterwheel**. A waterwheel is a machine that uses and produces hydropower. Waterwheels were used to power farm equipment, drive pumps, trip hammers, saw timber, grind grains into flour, make iron products, and power textile mills. Before the development of steam power, waterwheels were the only sources of power (besides human or animal power). Often, towns were built close to a river so waterwheels could be built nearby. Waterwheels are still used today.

How Does It Work?

A waterwheel spins around as a stream of water, which is being pulled down by gravity, hits its paddles or blades. Waterwheels use the energy of moving water to perform many types of mechanical work.

Objectives

After participating in this activity, kids will be able to:

- Explain how falling water can create energy that can be used to do many useful kinds of work.

Supplies

For each waterwheel:

- Funnel
- Plastic tubing (approximately 24 inches long) that will fit on the small end of the funnel (does not have to be a perfect fit, either inside or outside the funnel tip)
- Cork
- Modeling clay
- Stiff plastic - old mini blinds are ideal, but can be cut from milk cartons or plastic bottles **Adult**: pre-cut four pieces the same length as the cork - in rectangles twice as long as wide
- Plastic soda bottle with bottom cut out by an **adult**. The 1-liter size is good, but you can use any bottle that can fit your cork inside.
- Duct tape or other water-resistant tape
- 2 toothpicks
- Dish, shallow bucket or bowl - large enough to collect water poured through. Or, if you are outside, you can let water pour through to the ground.
- Water source and pitcher to pour water

Other Supplies:

- Scissors - to cut the bottom off of bottle and to cut plastic strips
- Knife to slice slits in the cork - do ahead of time so kids don't need to use knives
- Nail to punch small holes in the sides of the bottle

Let's Try It!

Adult prepare in advance:

1. Use a knife or box cutter to cut four length-wise slits in the cork - spaced evenly.
2. Cut four pieces of stiff plastic. Make them the same length as the cork and about half as wide as they are long.
3. Cut the bottom off the plastic bottle.
4. Use a nail to pierce two holes in opposite sides of the bottle about midway down the bottle. Try to make them level with each other.

When children engage in an engineering project, they follow a sequence to complete the task. Sequencing is one of many skills that contribute to children's ability to comprehend what they read.

To make the waterwheel:

1. Fit the pieces of plastic in the slits in the cork.
2. Push a toothpick into one round end of the cork.
3. Fit the toothpick into one of the holes in the plastic bottle so that the cork will be inside the bottle.
4. Push the other toothpick through the opposite hole and into the other side of the cork. The cork is now suspended by the toothpicks inside the bottle.
5. Put a small bit of modeling clay on each outer end of the toothpicks to keep the cork from slipping out of the holes. Do not put the clay tightly up against the edge of the bottle. The cork must be able to spin freely.
6. Push one end of the plastic tubing onto the small end of the funnel. Wind tape around the funnel and tube to hold them tightly together.
7. Place the bottle in the dish or bucket.
8. Fit the tube into the neck of the bottle.
9. Work with a partner. Hold one end of the tube inside the bottle and hold the funnel in your other hand. Have your partner pour water into the funnel. The waterwheel will spin around. Direct the stream of water to hit the plastic blades of the wheel.
10. Raise the funnel higher and have your partner pour the water. What happens to the speed of the wheel when the funnel is raised?

Knowledge Check

- What happened to the waterwheel as you poured water on it?
- What happens to the waterwheel if the funnel is raised? Lowered?

Scale It Up/Down

- For large groups, have all pieces ready to go in “kits” for each person or work in groups.
- For young kids, pre-assemble the cork and plastic fin part of the wheel.

EXTENSION: Tie a string to one of the toothpicks and attach a weight, such as a paper clip, to the end. As water is poured through the waterwheel, the string will wind around the tooth pick and raise the paper clip. Are there other types of work that the waterwheel can do (spin a fan, etc.)?

Additional Resources

Water Wheel

Vocabulary:
Waterwheel - a type of device that takes advantage of flowing or falling water to generate power by using a set of paddles mounted around a wheel. The falling force of the water pushes the paddles, rotating a wheel.
Hydro power - work done by the force of water

Books:
The Boy Who Harnessed the Wind by Bryan Mealer and William Kamkwamba
The Boy Who Harnessed the Wind (Picture Book Edition) by William Kamkwamba & Bryan Mealer
Mill by David McCaulay
Hydropower: Making a Splash! (Powering Our World) by Amy S. Hansen
Finding Out about Hydropower (Searchlight Books ™ — What Are Energy Sources?) by Matt Doeden
101 Science Experiments: A Step-by-Step Guide by Neil Ardly

Website:
Water Wheel: Energy Education

NOTES:

Summer STEM From Your Library

Idaho Commission for Libraries
325 W State Street
Boise, ID 83702
208-344-2150
Visit us at http://libraries.idaho.gov