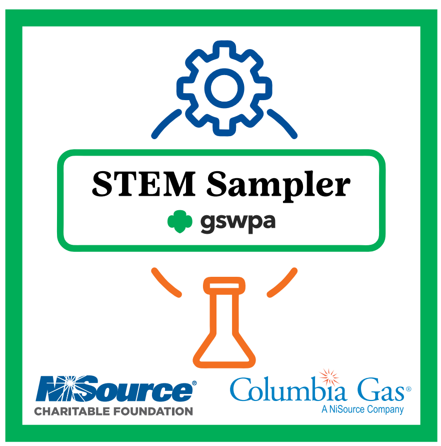
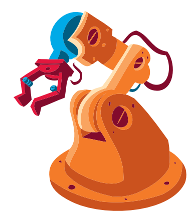
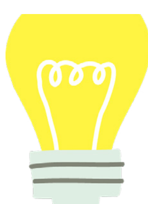
girl scouts western pennsylvania

# S.T.E.M. Sampler



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# STEM Sampler—Magnets and Slime

Let's ***DISCOVER*** more about magnets and slime!

You studied all week for that big science test and NAILED it! You proudly rush home with your A+WESOME grade to share your happiness with your closest adult. Together, you excitedly hang your "A+" test front and center on the refrigerator using a **magnet**.

You probably don't think twice about how that magnet makes the paper stick to your refrigerator or all the interesting and amazing ways that magnets and **magnetic forces** play a role in our everyday lives. Let's take a little bit of time exploring how magnets work.

## Natural Magnets

Natural magnets are made of iron, nickel, or cobalt that can attract other materials. Steel can also be made into a magnet because it is an **alloy** that contains iron and carbon. Only metals are attracted to magnets, but not all metals are naturally magnets.

All magnets have two poles—a north pole and a south pole. These opposite poles are naturally attracted and move toward each other when the north pole of one magnet faces the south pole of another magnet. However, if you put the south poles or north poles of two magnets together, they'll repel each other and push away from one another. Magnets strongly attract objects that contain iron, nickel, cobalt, or steel.

## See for yourself!

Take two of the magnets provided and try to connect them by turning them different ways and check out how they pull towards each other when their poles are opposite and repel each other when they are the same poles. The magnetic forces between the two poles of a magnet create a **magnetic field** that surrounds all magnets.

## Uses of Magnets

Because of how magnets attract and repulse, they are very useful. A pair of magnets can help keep things close together or keep them apart. For example, that same refrigerator door where your A+ test is being displayed on the outside using a magnet is also held tightly shut using magnets so that cold air doesn't escape from the inside.

Combining magnets and electricity makes for an even more powerful magnet known as an **electromagnet**. Have you ever seen a huge crane in a junkyard lifting an old car high into the air by its roof? It was probably powered by a magnet. Electromagnets can lift thousands of pounds and make it easier for junkyards to move cars around.

Magnets are also found in televisions, speakers, and even computers—where they help store data.

## The Earth and Its Magnetic Fields

The Earth itself is one big magnet that produces its own magnetic field because Earth's core is mainly made up of iron, which is one of the best materials for making magnets. Part of the Earth's core continuously spins super-fast, creating a magnetic field. This is why the Earth has a North Pole and a South Pole—the same as that magnet on your refrigerator.

One of the earliest uses of magnets was in compasses. A **compass** is a needle-shaped magnet that is free to turn around. Because the south pole of a compass is attracted to the north pole of Earth, the compass needle always points north.

**Fun Fact:** Did you know you can make your own compass using a magnet and a sewing needle? TOTALLY TRUE! And we're going to give it a try.

But first, we're going to create some super-cool magnetic slime!

Slime is a weird kind of matter that doesn't fit neatly into the three common types (or states) of matter we know about thanks to Sir Isaac Newton: solids, liquids, and gases.

It is runny, like a liquid. But when you ball it up in your hands it becomes denser, like a solid.

So, what exactly is it? Because slime's composition doesn't exactly fall into Newton's definitions of the three states of matter, we call slime **non-Newtonian matter**. Any type of matter that doesn't quite fit as a solid, liquid, or gas, falls into this broad group. Other examples of strange non-Newtonian matter are jelly, blood, toothpaste, ink, and glue.

Let's get curious and ***CONNECT*** with some terms about magnets:

**ALLOY:** Mixture of two or more elements, usually metals, where the components are melted and physically mixed together without forming chemical bonds. Some examples of alloys include steel, brass, and bronze. Alloys can be separated back into their original elements.

**COMPASS:** A tool for finding direction. Composed of a magnetic needle mounted on a pivot, or short pin, that can spin freely and always points north. The pivot is attached to a compass card marked with directions (north, south, east, and west). A compass works because the Earth is one big magnet.

**ELECTROMAGNET:** Magnets powered using electricity, most commonly consisting of an iron core wrapped in copper wire and then magnetized, or made to attract other metals, using an electric current.

**MAGNET:** A rock or a piece of metal that can pull certain types of metal toward itself.

**MAGNETISM (MAGNETIC FORCES):** A basic force of nature, like electricity and gravity, that can attract (pull closer) or repel (push away) objects that have a magnetic material (like iron) inside them. This invisible force works over a distance, meaning that a magnet does not have to be touching an object to pull it closer.

**MAGNETIC FIELD:** The area around a magnet that has a magnetic force. If a magnetic object enters a magnetic field, it is pulled toward the magnet—even underwater or through a tabletop.

**NON-NEWTONIAN MATTER:** A fluid whose viscosity (how thick or thin it is), changes when force is applied to it.

## 1 Activity #1

Let's ***TAKE ACTION*** and make our own magnetic slime and compasses.

**Supplies for 1-3 Girl Scouts:**

- 3/4 cup PVA Glue
- 3/4 cup liquid starch (borax solution could also be used)
- 6 tablespoons of iron filings or iron oxide powder
- mixing bowl and spoon
- paper towels
- magnets
- disposable gloves
- small plastic bag or container to take slime home

https://www.sciencebuddies.org/stem-activities/magnetic-slime-recipe

**Directions for Magical Magnetic Slime:**

Each batch would be split three ways.

1. Pour 3/4 cup of liquid starch into a bowl.
2. Add 6 tablespoons of iron powder or filings and stir until well mixed.
3. Add 3/4 cup of PVA glue.
4. Mix, mix, and keep on mixing until the slime thickens and gets to a point where you can mix by hand!
5. Take the slime out of the bowl and mix it with your hands. Pat the slime mixture dry with a paper towel.
6. Allow the slime mixture to dry a little longer before playing with it. Try stretching it, bouncing it, and, most of all, check out its magnetic force using the magnets provided.

## 2 Activity #2

Let's take it a step further and create our own compass.

**Supplies for 1-3 Girl Scouts:**

- sewing needle
- 1 magnet
- piece of foam
- scissors
- small bowl of water
- real compass (***Hint:*** Most cell phones have a compass on them.)

**Directions for a Cool Compass Creation:**

1. Lay the needle flat against the magnet and rub the magnet one way against the needle 50 times, making sure to always run the magnet in the same direction. Make sure that you lift the magnet off of the needle with every pass and don't simply rub back and forth. This will make your needle magnetic.
2. Stick the needle all the way through your piece of foam.
3. Place the foam with the needle through it in your bowl of water. Make sure there is enough water in your bowl for the foam to float and the needle lies parallel to the surface of the water.
4. Set your compass next to the bowl to see which direction is north on your needle.
5. Then use your magnet to see how your compass reacts to placing the magnet in different areas around the outside of your bowl.
6. Try placing your magnetic slime near your homemade compass and see what happens when you move it around to different areas outside the bowl.

# Catapults

Let's ***DISCOVER*** what a catapult is and the science behind it.

Have you ever seen a slingshot shoot a pebble across a yard (hopefully not through a window!) and asked yourself, "How can such a small device fling that pebble so far?"

A slingshot is just one example of a **catapult**. Often used as a weapon, it launches projectiles at great distances without the aid of gunpowder or other **propellants**.

Catapults use the sudden release of stored potential energy to propel their load and launch projectiles, like pebbles or stones, to a longer targeted distance without the aid of any kind of additional propellants that would push the load forward. Once the projectiles are launched, they have their own **kinetic energy** because they are in motion.

A catapult works because **energy** can be converted from one type to another and transferred from one object to another. When you prepare the catapult to launch, you add energy to it. This energy is stored in the launching device as potential (or stored) energy. When you let go, this potential energy is released, converted into energy of motion, and transferred to the launched object, which then flies through the air.

## Catapults in History

In ancient times, catapults were used during wars to launch projectiles without gunpowder. In modern times, the term "catapult" applies to devices ranging from something as simple as a hand-held slingshot to a mechanism for launching aircraft from a ship!

Let's get curious and ***CONNECT*** with some terms about magnets:

**CATAPULT:** A catapult is a device used to launch a projectile a great distance without the help of stimulants. There are three basic components to every type of catapult:

1. **The Arm:** This includes the holder or bucket where objects that the catapult will launch are placed. The human arm and an arm in a catapult both act as simple machine levers that help propel an item into the air. Think of a pitcher in a softball game winding up and pulling their arm back before whipping it forward to throw a pitch.
2. **An Elastic Force:** This is the stretching force that helps store the potential energy that will be used to launch projectiles from the arm, giving them kinetic energy. Energy is stored as elastic force in the form of a stretch (tension) band, a bend, or a twist. The material stretched, bent, or twisted must be elastic in nature, such as rope, rubber, wood, or steel. For example, the rubber band used in a slingshot is the elastic force for that type of catapult.
3. **The Fulcrum:** This is the leverage point for the launching beam of the catapult. When combined with the amount of force that's used, the fulcrum determines how far an object will fly. By changing the position of the fulcrum, you alter the length of the lever and change the distance and trajectory of the projectile.

**ENERGY:** Energy is the ability to do work. Energy makes things move. It makes machines go.

1. **Potential/Stored Energy (in relation to catapults):** The energy that is stored in your unmoving object as you prepare to launch it. For example, when you pull back on a rubber band of a slingshot with a pebble in it to launch, the pebble has potential energy based on how much force (or how far back) you pull on the rubber band.
2. **Kinetic Energy (in relation to catapults):** The energy of an object when it's in motion. When you let go of the rubber band to release the pebble in your slingshot, all the potential energy built up from you pulling back on the band is transferred to the pebble, causing it to launch into the air.

**PROPELLENTS (of a catapult):** Any gas, liquid, or solid force or substance that drives something else forward. For example, a rocket uses fuel to launch it into the air.

## 1 Activity #1

Let's ***TAKE ACTION*** and build a catapult to see the potential energy being turned into kinetic energy to thrust its projectile through the air!

**Supplies for 1-3 Girl Scouts:**

- 14 popsicle sticks
- 3 plastic spoons
- 8 rubber bands
- 1 medium size binder clip
- 2 clothespins
- masking tape
- low-temperature glue gun
- ping-pong balls
- paper or plastic cups (optional)
- bowl or cup (optional)

Allow Girl Scouts to try different designs using the materials provided to build a catapult. Some versions of catapults include:

**Design #1: The Rubber Band Catapult:**

- 7 popsicle sticks
- 3 plastic spoons
- 8 rubber bands

1. Stack 6 popsicle sticks on top of each other and secure them with a rubber band near one end.
2. Slide another popsicle stick going in the opposite direction between the last bottom popsicle stick and the rest on top.
3. After sliding in the popsicle stick, wrap the original 6 popsicle sticks together on the other side with a rubber band.
4. Take the spoon and place it on top of the original 6 popsicle sticks going in the opposite direction like the popsicle stick in step 2.
5. Wrap a rubber band around the ends of the spoon and the opposite-facing popsicle stick.

**Design #2: The Binder Clip Catapult:**

- 4 popsicle sticks
- 1 binder clip
- 1 plastic spoon
- 2 rubber bands
- hot glue

1. Take two popsicle sticks, lay them on top of one another, and hot glue one end of them together up to the halfway point of the popsicle sticks. Repeat the process for the other two popsicle sticks.
2. Wedge one of the metal arms of the binder clip in between the open end of one set of popsicle sticks and wedge the other metal arm of the binder clip in between the open end of the other set of popsicle sticks.
3. Using the rubber bands, secure the open ends of the popsicle sticks around each of the metal arms of the binder clip.
4. Hot glue a plastic spoon to the outside of one set of popsicle sticks to use as your launching basket.

**Design #3: The Clothespin Catapult:**

- 3 popsicle sticks
- 1 plastic spoon
- 2 clothespins
- hot glue
- 3 rubber bands

1. Using hot glue, glue together the two clothespins, one on top of the other, both facing the same direction.
2. Using rubber bands, secure a popsicle stick to the bottom of the clothespins (with one end of the popsicle stick extending from the mouths of the clothespins) and a plastic spoon to the top of the clothespins (with the top of the spoon extending from the part of the clothespins that you would pinch together with your fingers.) The top of the spoon will serve as your "launching pad."

## Test the Catapults

Once the catapults have been built, test them out! To test the catapults, you can build a wall with paper or plastic cups, create a target on the wall with tape, or place a bowl or cup to aim the ping-pong balls at.

*Helpful hint for any of these catapult designs:* Girls can play around and use any number of popsicle sticks and/or rubber bands. The amount they use will determine the catapults' stability and possible launch span. Encourage them to also play around with the designs to make them more stable. For example, gluing popsicle sticks together in a triangle base.

## Add to the fun:

- Set a time limit per design—a few minutes would suffice.
- Have a "no talking" challenge where girls must assemble their catapult without speaking to others.
- Add a supply fairy or a supply thief to add or remove supplies during the design process.

# Robotic Hands

Let's ***DISCOVER*** the science behind robotic hands.

## Human hands are amazing!

Hold your hands out in front of you like jazz hands and wave them around. Now, clench your fingers into fists and look at them. What do you see?

Pick up some objects around the room with your hands. Make sure to pick up bigger objects (like a ball), as well as small objects (like paper clips or a pencil). What did you notice picking up the different size objects?

Your hands are amazing. With them, you can play the piano, cook a meal with your family, play basketball, write a letter, or even design a robot! Each of your hands is made up of bones, muscles, joints, and tendons.

Do you know anyone who ever injured their hand in an accident and was unable to use it? How difficult would it be for them to pick up those same objects you just did?

## The Magic of Robotic Hands

Imagine how cool it would be to build a robot hand that could grasp a ball or pick up a paper clip or pencil like you just did. In this robotics engineering project, a few simple materials such as drinking straws, thread, and a little clay make a remarkably lifelike and useful robotic hand. What will you design your robot hand to do? Pick up a can? Move around a ping pong ball? It's up to you!

The science of developing robotic hands, along with other artificial limbs, is called **prosthetics**. Scientists, **robotic engineers**, and doctors work together to develop artificial body parts as replacements for people who were born without limbs or lost limbs due to accidents or disease. Try searching online for other types of prosthetic limbs (and even organs) that have been developed. You might be amazed at what you find!

**Bones** provide a stiff structure for the hand (much like the straws we're going to use in this project). Between the 27 different bones in your hand, there are **joints** that provide places for the fingers to bend (like the notches we will cut into our straws). The **tendons** pull on the joints to make the different segments of our fingers and thumb bend (just like the string we'll be using). The **muscles** in your robot hand are still provided by you since you are the one pulling the strings. Real robotic hands have electric motors in them that act like muscles.

The straw-hand design in this project mirrors how tendons bend your fingers even though the muscles that control the action are in your forearm. To make your finger bend, a muscle in your arm pulls on a long tendon connecting the muscle to the bone in your finger. When the muscle pulls, the finger bends at the joint.

**Fun Fact:** When engineers design robots, one of the parts they spend the most time developing is the hand—or whatever other "grabber" the robot might have. Robots do useful and important work, and unless they can grab and move things, they often cannot get the job done.

Let's ***CONNECT*** with some neat vocabulary related to a robotic hand and human hands:

**BONES:** These support our bodies and help form our shape. They are very lightweight but strong enough to support our entire weight. They also protect our body's organs, and our skull protects our brain and forms the shape of the face. There are a whopping 206 bones in our bodies!

**JOINTS:** These are the places in our bodies where our bones meet. They are places that bend—like the way our fingers or knees bend.

**MUSCLES:** Tissues in the body of animals and humans that are made up of bundles of fibers that move parts of the body by tightening and relaxing.

**PROSTHETICS:** A manmade body part. For example, if someone loses an arm or a leg, or is born without an arm or leg or another part of the body, they might get a prosthesis to replace what's missing.

**ROBOTIC ENGINEERS:** Scientists who think of ways that people can use robots and then design and build those robots.

**TENDONS:** Special band-like ropes of tissue that connect muscles to bone. When the muscles tighten, the tendons pull the bones and cause the joints to move, like the way your fingers bend on your hand.

1

## Activity #1

Let's **TAKE ACTION** and be robotic engineers designing and building a robotic hand!

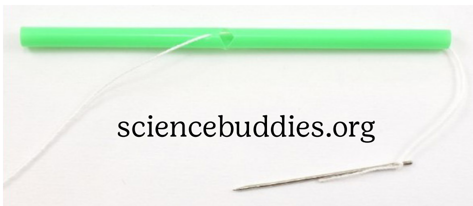
**Supplies for 1-3 Girl Scouts:**

- disposable drinking straws (dependent on how many fingers you want your robotic hand to have)
- embroidery thread
- sewing needle (the eye of the needle should be as small as possible while still accommodating the embroidery thread/dental floss; longer needles work better)
- modeling clay
- small rubber bands
- paper clips
- cardboard tubes (one per Girl Scout)
- sharp scissors
- cotton balls
- tweezers (optional)

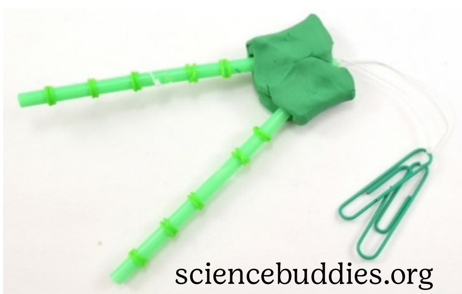
**Directions for building your Robotic Hand:**
Each finger of your robot hand will be made up of a drinking straw with one or more notches cut in it to make joints. The string will be threaded through the finger, knotted at the notches (which will act like joints), and then attached to a paper clip (which will be like your tendons). Tugging on the paper clips will pull on the strings and cause the straws to bend at the joints, making the fingers of our robotic hand flex.

1. Cut a small triangular notch in a straw, about halfway along its length. The straw will be a finger and the notch will be a joint. You should now be able to kink the straw and bend it at the joint.
2. Use a needle to poke a hole just above the notch, and thread some string through the straw. It may help to use tweezers to pull the needle through the straw.
3. Tie off the string above the hole in the straw and tie a paper clip to the other end. Hold the base of the straw with one hand and the paper clip with your other hand. When you pull on the paper clip, the straw should bend.

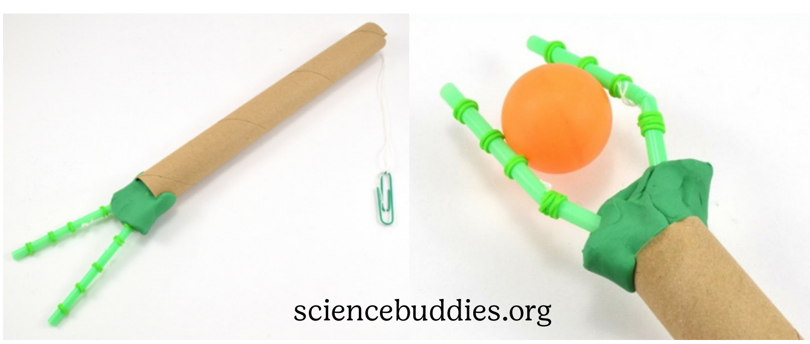
   ***Take it one step further:*** Look at how your index finger has three sections when you bend it. Try making a more complicated robotic hand finger by cutting more triangular notches in the straw and repeating the same process of threading string, tying a knot at the hole, and tying the other end to another paper clip. This will create a finger with three joints, each controlled independently by a different string.

4. Build a second finger (and even a third) finger just like the first one.
5. Form a palm for your hand around the base of both straws with modeling clay. Make sure the notches in the straws face toward each other and the clay doesn't cover the bottom of the straws where your strings come out.
6. Hold the modeling clay with one hand and the paper clips with one hand.
7. When you pull on the paper clips, the fingers should bend.
8. Wrap rubber bands around straws. This can help improve their grip.

9. Attach the modeling clay to the end of a cardboard tube to form an arm. You may need to tie longer strings and thread them through the tube. You can also connect the strings to a single paper clip to control all the fingers at once.
10. Now, hold the cardboard tube, and pull on the paper clip(s) to try and use your robot hand to pick up small, lightweight objects, like the cotton balls.

**Testing Your Robotic Hand**

Part of engineering is testing your creation to see if it works as well as you want it to. See if your robotic hand will pick up those same objects that you picked up earlier with your own hands.

# Electricity

Let's ***DISCOVER*** the electrifying science behind electricity!

Imagine you and your sister Girl Scouts are at Camp Redwing for a weekend of fun and exciting events and activities. It's dark and you need to go to the bathroom, so you grab your camping buddy and your trusty flashlight to head out.

You probably never think twice about simply flipping the switch on your flashlight to turn the light on, unless you flip the switch and it doesn't come on, at which point you change the batteries.

But have you ever asked yourself how exactly that flashlight works? What happens inside that flashlight when you flip the switch to turn on the light? And why do those batteries need to be inserted into the flashlight in a special way—with the "+" on one end and the "-" on the other?

You probably already know that a flashlight is powered by **electricity**. Electricity is energy that either builds up in one place or energy that moves from one place to another.

Electricity that gathers in one place is called **static electricity**. Electricity that moves from one place to another is called **current electricity**.

## Static Electricity

Let's take a moment and create some of our own static electricity using the balloons provided in your kit (one balloon per girl). Blow up a balloon, rub it on top of your head really fast, then pull it away slowly.

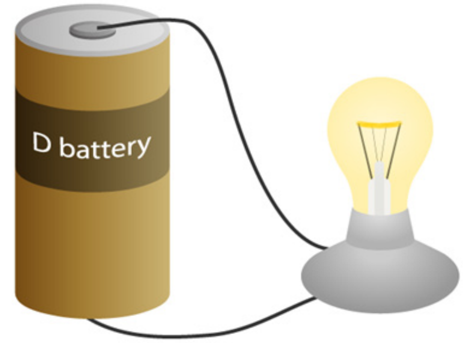
What happened? Did your hair attach itself to the balloon as you were pulling it away?

This is an example of static electricity. Your hair sticks to the balloon because you build up electricity by rubbing the balloon on your head and creating an electrical charge. However, that electricity has nowhere to go, which is why the balloon sticks to your hair when you pull it away.

## Current Electricity

Unlike your hair and the balloon, your flashlight works because of current electricity. This is when electricity is transferred from a power source (in this instance the batteries inside your flashlight) to the device it's powering (the light bulb in your flashlight). This is known as an **electric circuit**, and it allows an electric current to travel through an **electrical conductor** and power your flashlight.

## Understanding Electric Circuits




Electric circuits have three main components:

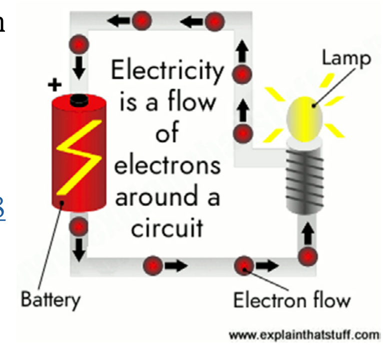
- wires that carry the current through the circuit;
- a device such as a lamp (like your flashlight) or motor that uses the current to do some type of work; and
- a power source, such as a battery or generator.

All the parts of a circuit must be connected for the circuit to work. When all the parts are connected, the circuit is closed and the current moves freely. In the case of your flashlight, this is why the batteries need to go in a certain way. This allows the electrical current to flow in the same direction, much like a circle.

When a part is not connected (or the batteries are placed in the flashlight in the wrong direction), the circuit is open, and the current stops. A switch can be used to turn the current in a circuit on and off. Flipping the switch on your flashlight closes its circuit, which allows the electrical current to flow freely and the flashlight to light up. Turning off the switch breaks, or opens, the circuit—which stops the flow of electrical current and shuts off the light.

This is just the tip of the iceberg when it comes to all the cool information out there about electricity and its uses in our world today. Do a little digging and find out more information on your own after we create our own electric circuit bugs! Here are a few websites to get you started:

- https://kids.kiddle.co/Electrical_circuit
- https://kids.britannica.com/students/article/electric-circuit/599858
- https://www.explainthatstuff.com/electricity.html
- https://kids.britannica.com/kids/article/electricity/353091
- https://www.ducksters.com/science/electricity_101.php




Let's ***CONNECT*** with some neat vocabulary related to electricity and how it powers our circuit bugs:

**CURRENT ELECTRICITY (ELECTRIC CURRENT):** When electrons move between atoms and carry electrical energy from one place to another. The flow of charged particles, such as electrons or ions, moving through an electrical conductor or space.

**ELECTRICITY:** A form of energy that can give things the ability to move and work. Everything in the world around us is made of atoms, which we can't see with just our eyes. All atoms are comprised of three even smaller particles called protons, neutrons, and electrons. Electrons create electricity when they move between atoms.

**ELECTRIC CIRCUIT:** Path for the transmission of an electric current. When an electric current moves through a circuit, electrical energy in the current is transferred to devices that change it into other forms of energy that can do work, such as providing power to lights, appliances, and other devices.

**STATIC ELECTRICITY:** The build-up of an electrical charge on the surface of an object that remains in one area rather than moving or "flowing" to another area. Formed when two surfaces touch each other and the electrons become charged, like when you rub a balloon on your hair and it attaches to the balloon when you pull it away.

**ELECTRICAL CONDUCTOR:** Materials that allow electricity to pass through them easily, including many metals, such as iron, steel, copper, and aluminum. Objects that run off electricity use metal parts to conduct the flow of electricity, such as the copper wires inside electrical leads, the metal pins in plugs, and the metal wire filaments in lightbulbs.

# Activity #1

1

Let's **TAKE ACTION** and build some circuit bugs of our own!

Have you ever seen fireflies during warm summer nights? Now you can design your own bug that glows! To find out more about how this works and a tutorial video, visit https://www.steampoweredfamily.com/circuit-bugs/.

**Supplies for 1-3 Girl Scouts:**

- 1 clothespin per girl
- 1 coin battery (CR2032 3V) per girl
- electrical tape
- 2 pre-wired LED lights per girl
- popsicle sticks (optional, depending on your design)
- pipe cleaners
- scissors or wire strippers—Adult supervision is needed to strip wires.

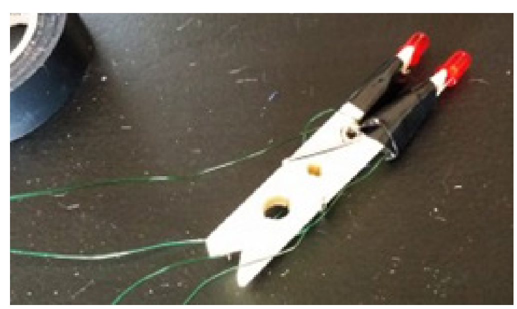
**Test the Wires:**

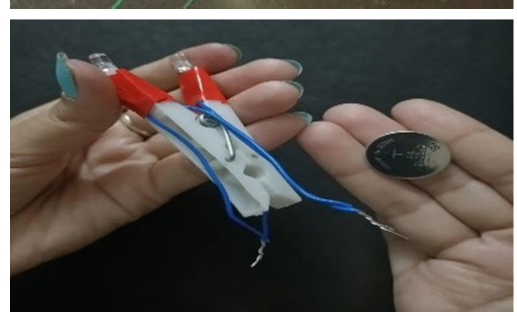
1. Before we start assembling our "homemade" lightning bugs, let's test the wires. You will want to test your LED lights and battery to make sure they work.
2. The LEDs should light up when you insert the battery between their legs/pins. If not, try turning the battery around. If the LEDs still won't light up, try a different battery. You may also have to try a new LED. You need to be sure everything works before creating your circuit bug!

**Cut and Attach Your Wires**

3. After you make sure your LEDs work, take two pieces of wire and strip 2-3" off both ends of each wire. (Remember: the longer leg of the LED is the positive leg.)
4. Take one wire and wrap it around the positive leg of one of the LEDs.
5. Then take the second wire and wrap it around the positive leg of the other LED. (The stripped part of the wires must be touching the positive legs of the LEDs.) Then twist the 2 wires together.
6. Repeat Steps 3-5 with two more pieces of wire and the negative legs (the shorter legs) on both LEDs.

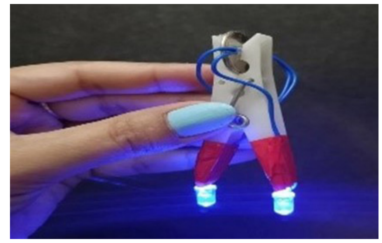
**Test and Mount Your Circuits**





7. Take your two sets of twisted wires (one set of positive wires and one set of negative wires) and test them on the battery to be sure your circuit is working. If the LEDs don't light up, try rewrapping the wires on the positive and negative legs.
8. Attach the LEDs to the legs of the clothespin by positioning each leg of the LED on either side of the wood. This prevents the positive and negative wires from touching, which could cause a short circuit (a disruption to the circuit). Wrap the LED legs onto the clothespin with electrical tape.
9. Run the wires from the LEDs down the sides of the clothespin and tape them to the clothespin with electrical tape. There should be extra wire dangling from the end of the clothespin.
10. Before creating your bug design, check that the circuit is working by touching the wires to the battery. This creates a closed circuit that will make the LEDs light up if the circuit is okay!

**Create Your Circuit Bug**



11. Create a design for your bug using pipe cleaners. You can wrap them around the clothespin to make wings, legs, and a body. Make any creature of your choice (bee, butterfly, etc.). Be creative!

**Retest the Wires with Your Battery**

12. When you've created your bug design, once again, touch the wires to the battery to make sure your circuit is still working.
13. When you have finished your design, wrap the negative wire around one half/side of the clothespin clamp (the part that closes tightly shut) and then wrap the other half/side of the clothespin clamp with the positive wire.
14. Make sure the stripped part of the wire is on the inside of the clamp! If your wires are too long and bulky, you can trim them before wrapping them around the clamp of the clothespin. If you do trim the wires, you will have to strip the ends again. The stripped part of the wires needs to get tucked into the clamping part of the clothespin because that's where the battery will go. The stripped wires need to touch the battery to complete the circuit that will light the LED.

**Bring Your Circuit Bug to Life**

15. Place the battery in the clamp of the clothespin to bring your circuit bug to life! The positive wire should be touching the positive side of the battery, and the negative wire should be touching the negative side of the battery.
16. If your bug is not working, try turning the battery around. If this doesn't fix the problem, you will need to disassemble your bug to find what is interrupting your circuit. To turn your bug off, simply remove the battery & start over.

# Mobiles

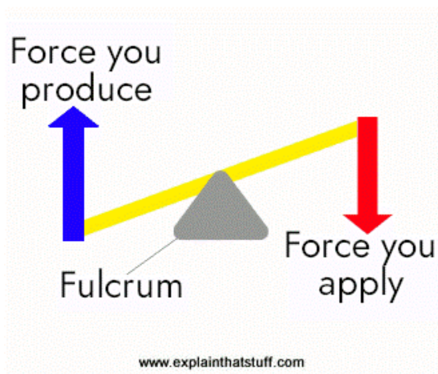
Let's ***DISCOVER*** the science behind mobiles.
No, not your cell phones—but hanging art **balanced** by rods and weight.

Have you ever played on a seesaw? Or watched a windchime blowing in the breeze? Or saw a hanging sculpture above a crib in a baby's nursery? Did you ever wonder how it is that everything stays balanced?

## The Science Behind a Mobile

In this activity, we are going to create our own hanging art sculptures—known as mobiles! **Mobiles** are free-hanging sculptures that are usually made up of many layers of rods (or **levers**) to which objects are attached with strings. These super cool pieces of art demonstrate **balanced forces**.

Each rod/lever in a mobile acts like a seesaw, and the objects hanging from the rod need to be balanced so that the rod stays horizontal. The weight of the objects and their location on the rod are both important factors in balancing the mobile. You might wonder how it remains equally balanced even when it sways or moves with the forces in the air.




Let's pretend the rod that we will use in this activity is a seesaw that you play on at the playground. If two people get on the seesaw, one on each side, what will happen to the person who weighs more?

If you said the person who weighs more will pull their side of the seesaw to the ground due to **gravity**, then you are correct! But if both people are the same weight, then both ends of the seesaw will be balanced and the plank that both people are seated on will be straight across.

That's because the **fulcrum** (or pivot point) in the center of the seesaw doesn't move and balances the weight on either side of the seesaw plank—which moves on the fulcrum. This is an example of a lever.

This is the same concept as a hanging mobile. When building a mobile, it is important to keep each rod's objects balanced so that the rod stays horizontal and is not pulled down in any one direction.

Mobiles move randomly and can be propelled by wind or air currents. When you blow on a shape in a mobile, the whole mobile moves because all its parts are connected.

Today, many artists create amazing mobiles and **kinetic sculptures** that are moved by the forces of the wind.

## History of Mobiles

Did you know that hanging art mobiles were created by a man born right here in Pennsylvania? Alexander Calder studied to be a mechanical engineer in college but later became an artist. He used his knowledge of engineering principles to create beautiful works of moving art that are now known as mobiles.

Let's ***CONNECT*** with some neat vocabulary related to mobiles:

**BALANCE:** A condition in which different elements are equal or in the correct proportions.

**BALANCED FORCES:** A set of forces (in this activity, the card designs) acting on an object (our wooden rod) in such a way that they do not affect its motion (meaning the mobile stays still and does not tilt one way or the other).

**FORCE:** A push or a pull that acts on an object due to the interaction with another object.

**FULCRUM:** The point on which a lever rests or is supported when lifting something. For example, in a seesaw, the fulcrum is the midpoint of the plank that you sit on.

**GRAVITY:** An invisible force that pulls objects towards each other, essentially keeping us on the ground by attracting us to the Earth's center; the heavier an object, the stronger its gravitational pull.

**MOBILES:** Sculptures with parts that can be set in motion by air currents.

**LEVERS:** A simple machine that uses a rigid bar or board, such as the plank on a seesaw, to increase the force applied to an object, called the load (the people at either end of the seesaw). The lever allows a small force to lift a heavy weight by transferring and increasing the force downward at one end of the lever to an upward force at the other end.

**KINETIC SCULPTURES:** Sculptures that move, either mechanically or naturally, such as in wind.

## 1 Activity #1

Let's **TAKE ACTION** and make our hanging mobile!

**Supplies for 1-3 Girl Scouts:**
- dowel rod
- string
- construction paper
- scissors
- hole punch
- form or felt

**Designing your mobile:**

1. Draw different shapes that you want to attach to your mobile on the construction paper. Ideally, the shapes should vary in shape and size.
2. Cut out the different shapes with your scissors. If you like, you can decorate each of them. Make them as intricate as you want!
3. Punch a hole into the top center of each of the cut-out shapes.
4. Attach a piece of string to each of the shapes by threading it through the punched hole and tying a knot. Try to vary the length of string attached to each shape so that they are not all the same.

**Building Your Mobile**

5. Start with one layer of your mobile. Attach a piece of string to the center of your rod. Hold the rod by the string so it is hanging freely in the air. Is the rod hanging horizontally? If not, what do you have to do to make it hang horizontally?
6. Once the rod is balanced, tie your first shape to one end of it. Again, hold the rod up in the air by its string. What do you notice happens to the rod?
7. Tie a second shape to the other end of the rod, then hold it up in the air again. Is it balanced? Why or why not?
8. Balance the rod by moving one of the shapes along it. Can you find a position on the rod where both shapes are balanced?
9. Repeat the previous step until you have used up all your cut-out shapes.

**Helpful hint:** Use different lengths of string so the shapes do not bump into each other.
Were you able to balance all the forces within your mobile?

It might have been trickier than you thought. Even balancing a rod string can be challenging. You might have noticed that if you did not attach the string to the very center of the dowel rod, it was pulled down on one side more than on the other.

To ensure that the dowel rod hangs perfectly horizontal, the weight pulling down must be the same on either side of where the center string is tied. However, this is only true if the string is in the center of the dowel rod. When you attached one shape to the rod, the weight of the shape should have pulled the rod down on the side it was attached to.

Attaching another shape to the other side of the rod most likely did not fully balance out the rod either. This was because both attached shapes were probably not the same. The shape that was heavier pulled down on the rod more than the lighter shape.

**Take it one step further:** Try sliding the hanging shapes along your dowel rod or using longer pieces of string to hang the shapes to see how those changes affect the balancing forces.

Try adding different weights of shapes by using foam or felt cutouts. See how the different weights move impact the balance of the mobile.

# Jelly Soap

Let's ***DISCOVER*** what makes jelly soap so jiggly, wiggly, and cool!

Jelly soap, or soap jelly, is a wiggly, gelatinous form of soap that cleans like traditional soap or body wash but comes in the fun form of gelatin—like the gelatin dessert you might find in your refrigerator.

Jelly soap is made by dissolving a **gelling agent** in a soap base and then adding various colors and scents that you choose! This twist on traditional soap is especially popular for its uniqueness (like every Girl Scout) because it can be customized in endless ways. Imagine the playful texture of your favorite gelatin dessert combined with the cleansing power of soap.

Did you ever hold a Jell-O Jiggler or shake a bowl of Jell-O after it has set in the fridge? Jelly soap feels and looks much the same way (just don't try to eat it because, unlike Jell-O, it won't taste nearly as good)!

So what makes jelly soap wiggle and wobble?

## The Science Behind Jelly Soap

This super fun soap is also a **polymer**, which is a larger molecule that is made when a bunch of smaller molecules, called **monomers**, bond together to form a new substance.

The word "polymer" can be broken down to "poly" (which is Greek for "many") and "mer" (which means "unit"). So, when you put it all together, a polymer is many smaller units that are bonded together into a larger molecule through polymerization. Polymerization is the chemical reaction that bonds monomers together to make a polymer.

This unique consistency of jelly soap comes from the gelling agent—the gelatin. The gelatin traps water, which then makes your "liquid" soap a semi-solid structure after it's had time to set—the same as when you make your favorite gelatin dessert. This means the soap will wiggle while still holding the shape of the mold (just like Jell-O).

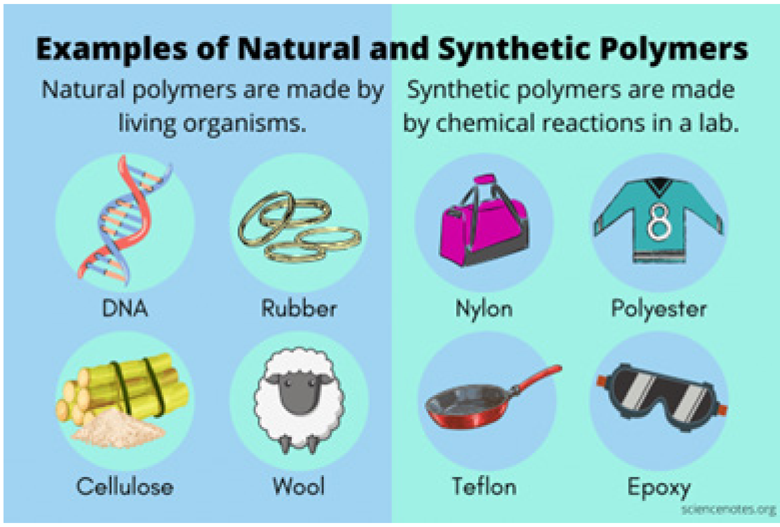
Although jelly soaps do not necessarily have to be refrigerated, keeping them in a very cool place helps maintain their shape and prolongs their shelf life immensely; refrigerating your jelly soap keeps it firmer. Think of an ice cube—it starts as a liquid, but when you put the liquid water into ice cube trays in the very cold freezer, they turn to ice.

Let's ***CONNECT*** with some neat vocabulary related to jelly soap:

**GELLING AGENTS:** Substances used to thicken or gel a liquid or food. Common gelling agents include gelatin, pectin, agar, and carrageenan. Gelling agents are used in a variety of food and non-food products—from jellies and jams to paints and glues.

**MONOMERS:** A single atom or molecule that is able to join with other monomers to make new substances called polymers.

**POLYMERS:** Large molecules made of small, repeating molecular building blocks called monomers. The process by which monomers link together to form a molecule of a relatively high molecular mass is known as polymerization. Some polymers occur naturally, while others are man-made, also known as synthetic.




## 1 Activity #1

Let's **TAKE ACTION** and make our own jelly soap!

This activity will take 2.5-3 hours to complete and requires access to a fridge.

**Supplies for 1-3 Girl Scouts:**

- 1 package of unflavored gelatin
- 3/4 cup very warm water
- 1 tsp salt
- 3/4 cup gel body wash
- cosmetic glitter or food coloring (optional)
- spray bottle with rubbing alcohol (optional, but highly suggested)
- portion cup (one per girl)
- access to a refrigerator
- whisk and mixing bowl
- tray or cookie tray (optional, but highly suggested if refrigerating as a group)
-

**Making Wiggly, Jiggly, Jelly Soap:**

1. Add gelatin and water to a bowl and whisk until dissolved.
2. Add salt and body wash. If opting to use:
   a. Add food coloring.
   b. Add glitter.
3. Whisk to blend all ingredients.
4. ***Optional:*** Spray the portion cup with rubbing alcohol.
5. Place portion cups on the sturdy tray, and gently pour the mixture equally into three cups.
   a. If the intent is to send the jelly soap home with your Girl Scouts the same day and there is not enough time refrigerate them, add the lid the portion cup and remind them refrigerate the jelly soap for 2-3 hours allow it to set.

6. Place cups into the refrigerator for at least 2 hours or until the mixture has solidified.
7. Gently remove the jelly soap from the cup and scrub away!

# Science of Sound

Let's ***DISCOVER*** the science of sound!

Ever wonder how you can HEAR all your favorite songs on the radio? Or recognize your best friend's voice on a crowded playground even before you see them? Let's learn a little more about all the amazing **sounds** we hear and how we hear them.

Place you fingers on your throat and recite the Girl Scout Promise. What did you notice? Did you feel the vibrations on your fingertips? When we speak or make any kind of noise, our **larynx** (also known as our voice box) vibrates, moving air around it in your throat and mouth. Those air vibrations you feel on your fingertips are called **sound waves**. These sound waves travel through the air and into your ear, where they send signals to your brain so you can hear.

All sounds are the result of something vibrating or moving. Sound vibrations move through matter like water, air, plastic, or metal. This bouncing around sets off a chain reaction of molecules hitting molecules, moving them from one place to the next.

## Try it!

Try this—turn on some music and listen for a few minutes. Do you hear how the singer hits low notes, high notes, and everything in between? Individual musical notes that a singer hits with their voice (or a musician plays on an instrument) make vibrations that travel through the air to our ears.

Different sounds have different properties that come from the vibrations, thus, sounding different from each other. These patterns of vibrations create sound waves. The sound wave's **frequency**—how often it vibrates per second—defines how low or high a sound you hear. Low notes have low frequencies, meaning the vibrations occur fewer times per second than a high note which has a higher frequency of vibrations per second.

But you may ask, can we SEE sound waves/vibrations the same way we might see waves in the ocean? Believe it not, the answer is yes!

## The Tonoscope

A **tonoscope** is a device that allows you to see sound vibrations. The study of these vibration patterns is called **cymatics**, and the patterns themselves are called **Chladni Patterns**, after a German physicist and musician named Ernst Chladni, who is considered the father of **acoustics**. He used a metal plate with sand to observe the vibrating patterns created by sound waves/vibrations. For this sound experiment, you'll be building a tonoscope out of recyclables and a balloon.

Let's ***CONNECT*** with some cool vocabulary related to sound.

**ACOUSTICS:** The science that deals with the production, control, transmission, reception, and effects of sound. German physicist and musician Ernst Chladni is known as the father of acoustics.

**CHLADNI PATTERNS:** Geometric designs/patterns that form on the surface of a vibrating plate, membrane (like the balloon we will use), or other surface to give a visual representation of sound.

**CYMATICS:** The field of study that focuses on visible vibrations of sounds that we can actually see with our eyes—like the Chladni Patterns.

**LARYNX:** This is a fancy word for your voice box, which works with air from your lungs to let you talk, whisper, sing, and yell.

**MOLECULES:** The smallest unit of a substance that has all the properties of that substance. You can't see a molecule with your eyes or even under a microscope

**PITCH/FREQUENCY:** The number of times per second a sound wave repeats itself. The higher the frequency, the more quickly air particles vibrate and the higher the pitch. A high pitch means a high note and a low pitch is a low note.

**SOUND:** Anything that can be heard! Whether it's music, a barking dog, or your best friend's voice.

**SOUND WAVES/VIBRATIONS:** Sound waves are vibrating energy that look like waves and are made by molecules. Sound waves travel back and forth through solids, liquids, and gases to get to another location. That's how you can hear sounds close to you, outside, or underwater.

**TONOSCOPE:** A device that allows you to see sound vibrations.

## 1 Activity #1

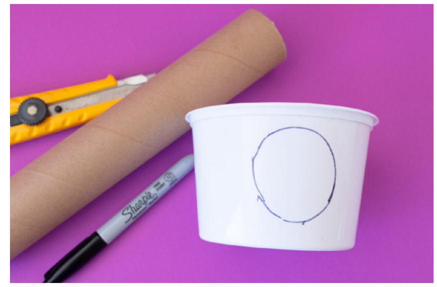
Let's **TAKE ACTION** and build a tonoscope to see some sound waves.

**Helpful hint for troops:** Girls will be blowing into the tonoscope. Give each girl a piece of plastic wrap, a plastic bag, or a breathing barrier to place around the end of the tonoscope. This will keep the tonoscope cleaner and make it so that it can be used by multiple girls.

**Supplies for 1-3 Girl Scouts:**
- 1 round plastic food container
- 2 paper towel rolls
- marker or pen
- 12" or larger balloon
- rubber bands
- masking tape
- *Tonoscope Observation Sheet*
- scissors
- table salt or granulated sugar (using grains like white rice will also work well)
- box cutter/utility knife (adult use only)
- plastic wrap, plastic bag, breathing barrier (optional, one per girl)

**Building the Tonoscope:**

1. Trace the end of the paper towel roll on the side of the plastic food container.



2. Using the box cutter/utility knife, cut the circle out from the container.

3. Cut a 1” wide half-circle into the end of one of the paper towel rolls using scissors.

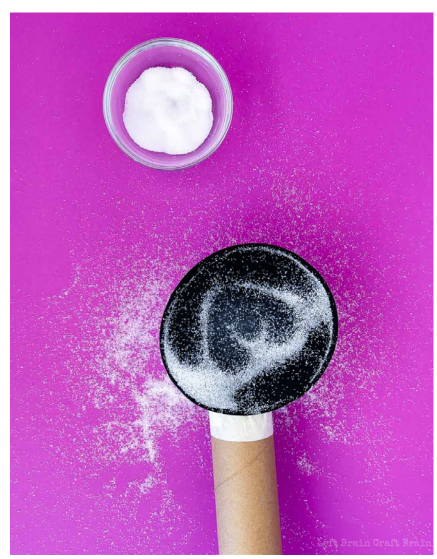
4. Insert the non-cut end of the paper towel roll approximately 1.5” into the hole in the food container with the cut part facing up. Secure the paper towel roll to the food container with masking tape.

5. Insert the second paper towel roll into the cut end of the first paper towel roll. Angle the second paper towel roll so that it points upwards and tape it into place with masking tape.

6. Cut the neck of the balloon off and stretch the balloon around the open top of the food container. Secure the balloon tightly to the container with a rubber band.

**Test the Tonoscope**

1. Place approximately one teaspoon of salt onto the top of the balloon.
2. Try making different sounds, pitches, and levels of noise into the paper towel roll as you observe the salt/sugar/rice on the balloon. Troops may give each girl a piece of plastic wrap, a plastic bag, or a breathing barrier to place around the paper towel roll.
    a. The louder the noise, the bigger the vibration produced. When you make a loud noise, the salt/sugar/rice will jump higher when it vibrates. If you make a quieter sound, it will jump lower.
    b. The higher pitched the noise, the faster the vibration produced. If you make a high-pitched noise, the salt/sugar/rice will move faster, and a lower-pitched noise will make it move slower.
3. Use the included *Tonoscope Observation Sheet* to record what you see.



Images and more information can be found at https://leftbraincraftbrain.com/tonoscope-sound-science-experiment/.