



UNIT 1

ENERGY AND

ELECTRICITY



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The Energy and Electricity Unit provides members with hands-on experiences with common applications of energy in the world around them. From exploring how to use electricity with electromagnets, motors and speakers to using energy to power robots and light bulbs, participants will formulate hypotheses about energy and electricity, collect data about their experiments, and verify and interpret their results.

Additionally, members will be encouraged throughout the modules to record their data and observations in their scientific notebooks and observe safety practices in their laboratory experiments. Each activity and module is aligned with the NGSS to help members and Club facilitators determine how the activities will prepare them to be successful. Moreover, the practical nature of the experiments will engage and connect members with their understanding of how science plays a major role in their daily lives. The approximate cost range for the materials can be found in Appendix A: Materials List with Estimated Costs.

UNIT 1 - ENERGY AND ELECTRICITY		
Activity	Goals	Recommended Time Allotment
Don't Stop the Music	Create electromagnets, then create a motor using electricity, magnets, wires and a paper clip. Use principles of electricity and magnetism to create homemade speakers.	60-90 min.
Art Bot: A Robot that Creates Art	Build robots that create art using electricity and magnets	80 min.
A Bright Idea!	Create a homemade light bulb by constructing a circuit	45-60 min.

DON'T STOP THE MUSIC

(60-90 MINUTES)

Introduction: This activity features three mini-activities that build upon prior content knowledge. Members will learn the fundamentals of electricity, magnetism and circuits to construct a speaker from commonly used household materials.

Objective: Members will learn about magnetism through the use of hands-on activities that will connect them with materials that enable signals to travel between poles using circuits.

NGSS Alignment: MS-PS2-3: Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

MS-PS4-2: Structures can be designed to serve particular functions by taking into account properties of different materials and how materials can be shaped and used.

MS-PS4-3: Structures can be designed to serve particular functions.

MS-PS2-5: Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time or cost.

3-5-ETS1-3: Plan and carry out fair tests by considering controlled variables and failure points to identify aspects of a model or prototype that can be improved.

4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat and electric currents.

4-PS3-4: Apply scientific ideas to design, test and refine a device that converts energy from one form to another.

4-PS3-4: Most scientists and engineers work in teams.

4-PS3-4: Science affects everyday life.

MATERIALS

- Large iron nail (about 3 inches)
- Small iron nail
- D battery
- Paper clips or other magnetic objects
- Insulated copper wire
- Black permanent marker
- Scissors
- Neodymium (disc) magnets
- Sticky tack or modeling clay
- Large paper clips
- Pen or pencil
- Foam bowl
- Paper plate
- Button magnets
- Magnet wire
- Stereo with amplifier
- Large rubber bands
- Paper plates

FACILITATOR'S TIP BLOCK

Monitor and pay close attention to members as they use glue guns - these can get very hot and cause burns.

DON'T STOP THE MUSIC A: ELECTROMAGNETS (20 MINUTES)

Objective: The purpose of this activity is for members to create electromagnets.

Facilitator should make a sample electromagnet from the following instructions in advance of the session and test that it works:

1. Wrap the copper wire around the nail, leaving about 8-12 inches of wire loose at each end. Make sure the wire doesn't overlap.
2. Tape the ends of the wire to each terminal of the battery. Point the nail toward the paper clips.
3. You have an electromagnet! Electricity is traveling through your nail in a current, which changes the arrangement of the molecules so they align with polarity.

Instruct Members To:

1. Get in small groups.
2. Show them an example of an electromagnet you've made and how it behaves like a magnet when constructed.
3. Provide members with materials, but no instructions.
4. Give them 10 minutes to create and construct their electromagnets.

Extension Activity Questions: Give members 10 minutes to construct and tinker, then ask:

1 What happens if you increase or decrease the amount of coils you wrap around the nail?

2 What happens if you change the power source (the type of battery)?

KEY VOCABULARY

Magnetism - The properties of attraction possessed by magnets

Circuits - The complete path that an electric current travels along

Armature - The part of an electric motor or generator that produces an electric current when it turns in a magnetic field

Electromagnets - A piece of metal that becomes magnetic when an electric current is passed through or near it

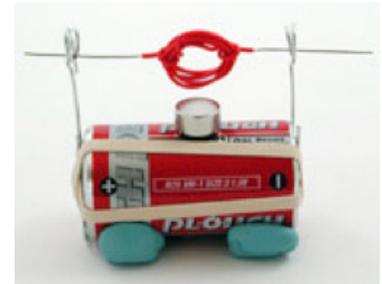
Polarity - The direction of a magnetic or electrical field

DON'T STOP THE MUSIC B: MOTORS (30 MINUTES)

Objective: The purpose of this activity is to have members create a motor.

Instruct Members To:

1. Cut a 12-inch piece of wire.
2. Starting in the center of the wire, wrap both ends around the permanent marker to make 4 1/2 loops.
3. Then carefully remove the wire, holding the loops together.
4. To make a bundle, wrap each end of wire several times around the loops to hold them in place. Position the ends so they are directly across from each other and extend out in a straight line on either side of the bundle to form an axle. What you just made is called the armature.
5. Hold the wire bundle you have made so it would be flat against a wall. Color the top side of each wire end with the marker. Leave the bottom side of each wire bare.
6. Carefully bend each paperclip to form a small loop by wrapping one end around a small object, such as a pencil or pen. If you prefer, use thick wire and pliers instead of a paper clip. Be sure to use caution when using the pliers.



If you are using a battery holder, attach a paper clip to either side and insert the battery. If you don't have a battery holder, wrap the rubber band tightly around the length of the battery. Insert the paper clips so each one is touching one of the terminals, securely held by the rubber band. Use the clay or sticky tack to attach the curved side of the battery firmly to a table or other flat surface.

7. Set one neodymium (disc) magnet on top of the battery at its center. Position the armature in the paper clip loops with the shiny, uncolored side touching the paper clips. Make sure it doesn't touch the magnet. If your motor doesn't start immediately, try starting it by spinning the wire bundle. Since the motor will only spin in one direction, try spinning it both ways.
8. If your motor is still not working, make sure the paper clips are securely attached to the battery terminals. You may also need to adjust the insulated wire so both ends are straight and the bundle you have made is neat, with the wire ends directly opposite of each other.

Extension Activity Questions:**1**

Hold the other magnet above the armature with the motor spinning. What happens when you move it closer?

2

What happens when you turn the magnet over and try the activity again?

DON'T STOP THE MUSIC C: SPEAKERS (25 MINUTES)

Introduction: The purpose of this activity is to allow members to continue to explore the relationship of electricity and magnetism as they create homemade speakers.

Objective: To create homemade speakers using magnets.

Instruct Members To:

1. Stack button magnets to form a 1- to 2-inch cylinder.
2. Cut a strip of paper and roll it around the stack of magnets. Then tape the paper to seal the cylinder.
3. Roll another strip of paper over the first and tape it to itself.
4. Firmly wrap the wire 50 times around the tube.
5. Glue the coil in place with a hot glue gun.
6. Pull the inner core of paper (containing the magnets) from the outer paper that the wire is glued to. This is your voice coil.
7. Cut the voice coil to a length that will slide over the stack of magnets.
8. Glue your voice coil to the bottom side of a paper plate.
9. Cut out your speaker from the paper plate while the glue dries.
10. Tape the magnet stack to the bottom of the foam bowl.
11. Place the paper plate with the voice coil over the top of the magnets, and glue the plate in place (along the edge of the bowl).
12. Paint or decorate your speaker.
13. Use sandpaper or an open flame to remove the wire coating at the end of each wire.
14. Hook your speaker up to a stereo with a built-in amplifier and press play.

**Extension Activity Questions:****1**

Can you create the same effect when you complete this task with batteries of different strengths?

2

Do the number of batteries used affect the light produced by your light bulb?

ART BOT: A ROBOT THAT CREATES ART

(60 MINUTES)

Introduction: Members will use robots to create art. Members will need some prior knowledge about robots and their role in society. You can spend approximately 10-15 minutes discussing their role in society before the activity. Have members brainstorm how to use the materials to make a robot before the activity. You could also discuss some of the basic tasks they would like their robot to complete related to art.

Objective: To build a robot that creates art and determine how changes in the design of the robot affect the art produced.

NGSS Alignment: 3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time and cost.

3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

KEY VOCABULARY

DC - Stands for direct current and is a one directional flow of electric charge produced by sources such as batteries and power supplies

Battery pack - A set of any number of identical batteries or individual battery cells

FACILITATOR'S TIP BLOCK

Adult supervision is required. Glue guns get very hot and cause burns. The robot's motor and attachments can spin very fast. Facilitators should be available to assist while the motor is spinning to remind participants to keep hands and fingers away from the attachments.

MATERIALS

- Toy DC motor that will operate at three volts (V). Important: Make sure you buy a motor with leads attached - this will enable you to connect it to your battery pack
- Battery holders - AA with a built-in power switch (which makes it easy to turn your robot on and off)
- AA batteries
- 16-ounce plastic cup
- Popsicle sticks
- Cork or Styrofoam® ball (cork will work better, but can be harder to find at craft stores)
- Thin-size washable markers
- 22 x 28-inch white poster board (at least three pieces)
- Electrical tape
- Scotch tape
- Glue gun (make sure an adult supervises if you use a normal hot glue gun, otherwise use a low-temperature child-safe glue gun)
- Craft materials: googly eyes, pipe cleaners for decoration

Instruct Members To:

1. Use the plastic cup for the robot's body.
2. Apply a small amount of glue to the tip of the motor's shaft. Before the glue dries, press the cork or Styrofoam ball onto the motor's shaft.
3. Use the hot glue gun to attach one end of a single Popsicle stick to the top of the cork or Styrofoam ball.
4. Use double-sided tape, electrical tape and/or glue as needed to firmly attach the motor to the top of the robot (you must flip the cup upside down, so the base of the cup acts as the top of the robot). How well the motor attaches will depend on its exact shape and if it has a flat bottom.
5. Put the two AA batteries in the battery pack. Make sure the switch on the battery pack is in the off position.

6. Use electrical tape to strap the battery pack to the side of the cup.

Note: If you did not purchase a battery pack with a built-in on/off switch, then wait until the end of the project to complete the instructions in the next bullet. Do not twist both pairs of wires together yet.

7. Twist the exposed metal ends of the motor wires and battery pack wires together (red to red, and black to black). This lets electrical current flow from the batteries to the motor when the switch is on.
8. Using electrical tape, attach the three markers – with their lids left on – to the sides of the cup with their points facing downward. Make sure the markers are spaced equally around the cup to create a stable tripod – the cup should not fall over when it is standing.
9. If you have arts and crafts supplies, be creative and use these to decorate your robot.
10. Place one sheet of poster board flat on the floor and put your robot in the middle. (You can do this on a table or counter, but be careful so your robot does not fall off the edge.)
11. Remove the lids from the markers, and turn the battery pack switch on.
12. After you create your first Art Bot, turn it off – either with the on/off switch or by untwisting one pair of wires.
13. Be inventive to change the position of the objects attached to the motor.
14. Use glue (assist younger members with the hot glue gun) to attach objects securely - you don't want objects flying off robots as they are spinning!
15. Take a new piece of poster board (or use the back of your first piece, if you want to save paper) and turn off your robot either by untwisting one pair of wires or with the on/off switch and design again! Do this as many times as you wish.

Extension Activity Questions:**1**

Do you notice any patterns emerging?

2

What happens if you use a different number of Popsicle sticks (or other objects of your choice) but keep them all centered?

3

What happens if you use a different number of off-center Popsicle sticks?

4

Does the robot tend to move around faster in some cases more than in others?

FACILITATOR'S TIP BLOCK

Be sure to keep your hands and fingers clear of the spinning Popsicle sticks, which can give a painful whack.

A BRIGHT IDEA

(45-60 MINUTES)

Introduction: Many household items contain circuits and switches that allow a free flow of electricity. For example, light bulbs contain a simple circuit of electricity that burns so bright that they make light. In devices like cellular phones, tablets and computers, circuits are more complex and help to flow charge from a battery to areas within the devices where data can be stored, sent and even analyzed! All of these complicated things happen in such small devices!

Objective: The purpose of this activity is to use household items to construct a simple circuit that results in a homemade light bulb.

NGSS Alignment: 3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-1: Defining and Delimiting Engineering Problems. Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

4-PS3-4: Apply scientific ideas to design, test and refine a device that converts energy from one form to another.

Instruct Members To:

1. Ask members to get in to groups of two to four and give each group one set of materials from the materials list.
2. Give them 10-15 minutes to tinker, explore and create the homemade light bulbs.
3. After 15 minutes, lead a demonstration with members. Instruct members to follow your lead as you construct the light bulb.

MATERIALS

- D-size batteries (8-10)
- Mason jar or other clear glass container
- Electrical tape
- Pie pan
- Scissors
- Toilet paper tube
- Mechanical pencil refills
- Alligator clips

KEY VOCABULARY

Circuits - The complete path that an electric current travels along

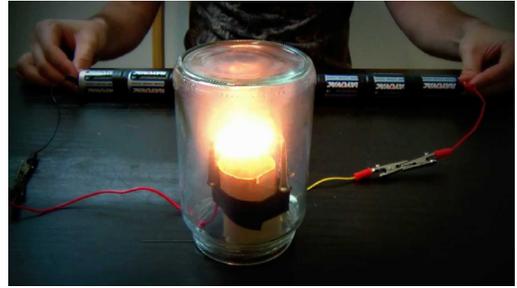
Pole - Either of the two terminals of an electric cell, battery, generator or motor

FACILITATOR'S TIP BLOCK

Give groups 5-10 minutes to brainstorm and share solutions before going through the instructions of creating a light bulb. This will engage participants in the activity.

Instruct Members To:

1. Make a super-charged battery using 8-10 D-size batteries. Tape the batteries together, positive to negative poles, using electrical tape.
2. Cut a toilet paper tube to a height that will fit inside of a mason jar or other clear glass, leaving plenty of room at the top.
3. Tape alligator clips (one positive and one negative) to the end of the tube. Make sure clips are facing up and away from the tube.
4. Tape the tube to the inside of the pie pan, with tubes still facing up.
5. Place a mechanical pencil refill (carefully!) between the alligator clips. The refill must remain in one piece.
6. Place the clear glass jar over the toilet paper tube.
7. Attach one alligator clip to either end of the super battery.



You've created a closed circuit, which will generate electricity! As the energy flows through the system, the pencil refill should provide a soft glow, acting as the filament in your DIY light bulb!