SIEMENS STEM DAY | Science Technology Engineering Math

SIEMENS STEM DAY ACTIVITY

IT'S ELECTRONIC: COIN BATTERIES

OBJECTIVES

Students will be able to:

- **Construct** a coin battery with enough voltage to light an LED bulb.
- **Measure** voltage output using a voltmeter or multimeter.
- **Explore** different types of batteries and their practical applications.

STEM LESSON FOCUS

Engineering Design Cycle

- Creating or Protoyping

21st Century Skills

- Collaboration

STEM CATEGORY

Science

TOPIC

Chemical and Electrical Energy

OVERVIEW

Students will construct a coin battery and measure its voltage output. They will compare their battery's voltage to that of traditional AA/AAA batteries and consider modifications to their battery so it produces enough power to light up an LED bulb. Then, students will explore practical applications of concepts learned in this experiment.

MATERIALS (PER GROUP OF STUDENTS)

- Copies of "Student Resource Sheet: It's Electric–Coin Batteries"
- Small cups/beakers
- Salt
- Spoon
- Water
- Paper towels or filter paper
- Tweezers
- Scissors
- Sets of different coins (pennies, nickels, dimes, quarters)
- Sand paper or steel wool
- Voltmeter or multimeter (capable of reading at least tenths of a volt)
- LED with attached wires (or other low voltage small bulb; red color preferred)
- Extra alligator clip wires
- AA or AAA batteries.
- Computers connected to the Internet (for extension activity)

HAVE YOU EVER WONDERED...

How can we use household materials to make batteries? Or what makes batteries work?

MAKE CONNECTIONS!

How does this connect to students?	How does this connect to careers?	How does this connect to our world?
Batteries are in almost everything you use. Even though they are all around us, they are often taken for granted. Can you imagine having to continuously keep all devices plugged in to get them to work?	**Electrochemical Engineers** design and develop new electrical equipment, solve problems, and test equipment. They work with different kinds of electronic devices, ranging from small pocket devices to large supercomputers. **Materials Scientists** study the structures and chemical properties of various materials to develop new products or enhance existing ones. For example, materials scientists are involved in battery research for electric vehicles. **Chemists** investigate the properties, composition, and structure of matter, and the laws that govern chemical reactions. For instance, they investigate new chemicals for use in batteries or explore ways to make existing batteries work better.	Advancements in batteries will help deliver more power to the technology we use, including smartphones, wearable devices, and electric vehicles. This has important consequences for the electronics, transportation, and medical industries.

BLUEPRINT FOR DISCOVERY

1. Pass out copies of the "Student Resource Sheet: It's Electric—Coin Batteries" to each student. Start the lesson by engaging students in a Think-Pair-Share warm-up activity. Ask individual students to write down the components of a battery and then share what they wrote with a partner. Call on students to share what they wrote using equitable calling strategies.

Then, lead a discussion of the three main components of a battery using the following resource and have students complete **Part A** of the Student Resource Sheet: http://www.qrg.northwestern.edu/projects/vss/docs/power/2-how-do-batteries-work.html.

Key Points to Emphasize Include:

- Batteries have three parts, an anode (-), a cathode (+), and the electrolyte.
- The cathode and anode (the positive and negative sides at either end of a traditional battery) are hooked up to an electrical circuit.
- The chemical reactions in the battery cause a build-up of electrons at the anode resulting in an electrical difference between the anode and the cathode.
- Electrons repel each other and try to go to a place with fewer electrons. The electrons go through the wire, lighting the light bulb along the way.
- Electrical potential causes electrons to flow through the circuit. However, these electrochemical processes change the chemicals in the anode and cathode to make them stop supplying electrons; therefore, there is a limited amount of power available in a battery.

2. Have students complete **Part A** of the Student Resource Sheet.
3. Next, hold up a AA or AAA battery and ask students, "How we can determine the voltage output of this battery or how "fresh" this battery is?" Allow students to brainstorm ideas before showing them how to do a test with the voltmeter or multimeter.
   Show students how to use the voltmeter or multimeter with the test leads (red is positive, black is negative) to obtain positive voltage readings. Inform students that they will be using the 20V setting on the multimeter for this experiment.
4. Tell students that a fresh AA or AAA battery is around 1.5 volts and this is enough to light up a small red LED bulb. Dim the lights. Ask for a student volunteer who can demonstrate how to make the LED light up using the battery. If the wires on the LED do not reach the two terminals, have students attach alligator wires to lengthen each end. (Note: Attachment methods will vary depending upon the type of LED bulb you use. If it is not working, switch the leads and re-attempt.) Have students draw a simple circuit diagram of the set-up that worked (include the battery terminals, wires, and LED bulb) in **Part B** of the Student Resource Sheet. Their circuit diagram should look like the one on the website you showed previously, and it should show the flow of electrons using arrows (out of the anode and into the cathode).
5. Break the class into small groups (of 3 or 4) and instruct them to pick up the materials and follow the instructions in **Part C** of the Student Resource Sheet. Inform students that, in this experiment, coins will be used as the anode and cathode and filter paper soaked in salt solution will act as the electrolyte. The goal is to produce enough voltage to light up the LED bulb.
   - 60 mL of water and a saturated solution of salt work best as the electrolyte. Students can experiment with different concentrations, but they should dissolve enough salt so that a few grains no longer dissolve after stirring.
   - Filter paper should be cut into 8–10 round disks and then soaked in the salt water solution for at least 3–4 minutes.
     Note: If the disks are cut too big, they will drape over the coin and short the battery. The filter paper disks should cover the entire coin surface without draping over.

- Unit cells can be made by stacking nickel/paper/penny cells (or other combinations of dissimilar coins) on top of each other and measuring the voltage output along the way. The coins should be sanded lightly with small pieces of sand paper or steel wool to remove any oxidation from the surface.
- After stacking each new cell, the voltmeter leads will be placed on the bottom nickel and the top penny to obtain a voltage reading. Other combinations of dissimilar coins also may be used.
- With each new added cell, students should see the voltage output increase as integral multiples of the individual unit cell value. After 5 or 6 cells, they should obtain a reading of at least 1.5–2.5 volts. Have students complete the data table in Part D of the Student Resource Sheet.
  The chemical reactions in the battery cause a build-up of electrons at the anode resulting in an electrical difference between the anode and the cathode.

6. If students are not getting sufficient voltage readings, have them troubleshoot using the following guidelines and then make any necessary modifications to their batteries:
   - Check that there are no two of the same coins right next to each other.
   - Sand the surfaces of the coins to remove oxidation. Double check that the pennies are not sanded too much because the newer ones (post-1982) have a zinc core that can get exposed and change the electric potential of that electrode.
   - Make sure that the filter paper does not drape over the edge of the coin because this can cause a short circuit in the battery.
   - Ensure that the filter paper disks have soaked in the salt solution for at least several minutes (longer is better). Removing them one at a time using the tweezers works best.
7. Ask students what voltage output they obtained. Then walk around to different groups and have students show you that they can light up the LED using their coin batteries.
8. After cleaning up and returning the materials, lead a class discussion using the following questions. For this part, students will answer the questions in **Part E** of the Student Resource Sheet.
   - Was the goal achieved? If not, what contributed to errors?
   - Why is it necessary to use dissimilar coins? What would happen if all pennies or all nickels were used instead?
   - What effect does the salt concentration have on the voltage reading in this experiment?
   - Why were you instructed to not put paper between the individual cells? Why should the paper not drape over the side of the coin?
   - What are two different types of batteries and their practical applications in everyday life? Useful information related to this question can be found at: https://www.brighthubengineering.com/power-generation-distribution/123909- types-of-batteries-and-their-applications/

TAKE ACTION!

Students will research other household materials (besides coins) that can be used to make simple batteries. In addition, they will explore how lithium-ion batteries work through the following link: https://www.energy.gov/eere/articles/how-does-lithium-ion-battery-work

NATIONAL STANDARDS

Science Next Generation Science Standards	HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
Technology Education International Technology and Engineering Educators Association	Standard 16: Energy and Power Technologies In order to select, use, and understand energy and power technologies, students in Grades 9–12 should learn that: J. Energy cannot be created nor destroyed; however, it can be converted from one form to another. K. Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.

Name_______________________________________ Date__________ **STUDENT RESOURCE SHEET**

IT'S ELECTRIC—COIN BATTERIES

Directions: Complete sections A through E of the resource sheet as you complete the activity.

Part A: Think—Pair—Share

List the Primary Components of a Battery

1.

2.

3.

Part B: Draw a Circuit Diagram (Light the LED bulb).

Show the Flow of Electrons with Arrows.

Part C: Draw a Circuit Diagram (Light the LED bulb).

Show the Flow of Electrons with Arrows.

1. Form groups of 3–4 and pick up the following materials:
    - Small cups/beakers
    - Salt
    - Spoon
    - Water
    - Paper towels or filter paper
    - Tweezers
    - Scissors
    - Sets of different coins (pennies, nickels, dimes, quarters)
    - Sand paper or steel wool
    - Voltmeter or multimeter (capable of reading at least tenths of a volt)
    - LED with attached wires (or other low voltage small bulb; red color preferred)
    - Extra alligator clip wires

2. Add approximately 50 mL of water to the cup or beaker and dissolve enough salt so that a few grains remain at the bottom (undissolved) after stirring.
3. Choose sets of two different coins and use them to trace and cut out filter paper disks. Make sure that the disks are the exact size of the coin (the diameter should not be too big or too small).
4. Soak the filter paper disks in the beaker of saltwater solution for several minutes.
5. Lightly sand the surface of six of the same type of coin (e.g., nickels) and place a pre- soaked filter paper disk on top of each coin using the tweezers. Then sand the other coins (e.g. pennies) and lay the coins on top of pre-soaked filter paper disks. Make sure that the penny only touches the filter paper. Do not drape any of the filter paper disks over the side of the coins.
6. Each of the penny-paper-nickel becomes an individual coin battery cell.
7. Turn the voltmeter/multimeter to the 20V setting and check the voltage of the first cell by placing one lead on the first coin and the other lead on the second coin. The voltage reading should range between 0.25–0.50 V. Record the data in first row of the data table in Part D. Use the coin battery to light the LED by touching the wires to either end of the battery. Try switching the wires. Does the LED light up?
8. After each coin battery cell is tested, stack it on top of the previous cell and measure a new voltage using the voltmeter (place one lead on the bottom coin and the other lead on the top coin). Do not put paper between the individual cells and do not drape any of the filter paper disks over the side of the coins.
9. With each new added cell, you should see the voltage output increase as integral multiples of the individual unit cell value. Try to light the LED after adding a new battery cell to the stack and record the results in the data table in Part D. After 5 or 6 cells, you should obtain a reading of at least 1.5–2.5 volts. **Record all your data/results in the data table in Part D.**
10. If time permits, try adding additional battery cells and testing the LED to see if you can make it light brighter. Also try different combinations of coins (e.g., pennies and dimes, quarters and pennies, nickels and dimes, quarters and dimes, etc.)
11. **Clean up and then answer the follow-up questions in Part E.**

Part D: Data Table

Number of Battery Cells (Individual Stacks)	Types of Coins Used	Voltage Output (Volts)	Does LED bulb Light Up? (Yes or No?)
1			
2			
3			
4			
5			
6			

Part E: Follow-Up Questions

After completing the experiment, answer the following questions:

1. Was the goal achieved? If not, what contributed to errors?

2. Why is it necessary to use dissimilar coins? What would happen if all pennies or all nickels were used instead?

3. What effect does the salt concentration have on the voltage reading in this experiment?

4. Why were you instructed to not put paper between the individual cells? Why should the paper not drape over the side of the coin?

5. What are two different types of batteries and their practical applications in everyday life? Useful information related to this question can be found at: https://www.brighthubengineering.com/power-generation-distribution/123909-types-of- batteries-and-their-applications/