Computational Thinking

4th Grade Science

Lemon Batteries

Overview

In this module, students will write a set of rules for identification of conductors and insulators of electricity. Students will apply their conductivity rules to build a working battery from available materials.

Grade Level

4th grade

Cyber Connections

- **Computational Thinking**
- **Hardware and Software**

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Teacher Notes:

Teacher Overview

The Problem: When life gives you lemons, make electricity!

You invited your friends over to watch movies. Just as you start the first movie a fast-moving thunderstorm caused a power outage at your house. Until power is restored, you must find a way keep your friends entertained. Suddenly, you remember reading about a professor that set a record by making a fruit battery from 1,013 lemons that drew 1,275 volts of electricity!

You and your friends decide to build your own battery from materials around your home. Your goal is to generate three volts of electricity (enough to light up a colored LED).

In order to build a battery, you will conduct tests to find the best available conductors of electricity. Based on these tests, you will build a working battery.

4 Pillars of Computational Thinking

Decomposition:
Students will decompose (break down) the problem into manageable components in order to design a solution to the problem. [Test solid materials for conductivity, Test liquid materials for conductivity, Build a 3V battery]

Pattern Recognition:
Students will look for patterns in the conductivity tests to determine which of the available materials will make the best battery.

Abstraction:
Students will use abstraction to filter out the available materials that would not be conductors for the battery.

Algorithm Design:
Students will write a set of rules for identification of conductors and insulators of electricity. What are the properties of conductors? What are the properties of insulators? Using these conductivity rules, students will select available materials to build a battery. Students will then write step-by-step instructions detailing how the battery was constructed.

Teacher Notes:

Materials

Per group:

Conductivity Test:

- 9V battery
- 9V battery clip
- Two to four alligator clips
- Small light bulb socket
- Small light bulb

Battery Build:

- 4 Pickles
- 4 No. 2 Pencil
- 4 squares of Aluminum Foil
- color LED

  OR
- 4 Lemons
- 4 Galvanized nails
- 4 -8 Gauge Copper Wire cut in 2-inch pieces
- Color LED
- Voltage Output: Multimeter

Optional

- Voltage Output: Micro:bit
- Device with internet connection

Assemble the following materials and place in a large plastic bag. Students will test each of these materials for conductivity using a closed circuit.

Conductors	Insulators
Aluminium Foil	Cardboard
No. 2 Pencil (test the graphite, metal)	No. 2 Pencil (test the wood, eraser)
Galvanized Nail	Glass Marble
Penny	Rubber Band
Nickel	Foam Packing Peanut
8 Gauge Copper Wire (cut into 2-inch pieces)	Plastic Drinking Straw

Teacher Notes:

Per Class

Provide the following materials for the class. Students will test the liquids for conductivity using a closed circuit.

Conductors	Insulators
Salt Water	Bottled Water
Vinegar	Small Styrofoam Bowl

Pacing Guide

Day 1: Solid Conductors and Insulators - Test solid conductors and insulators using a closed electrical circuit. Develop conductivity rules for solids.

Day 2: Liquid Conductors and Insulators - Test liquid conductor and insulators using a closed electrical circuit. Develop conductivity rules for liquids.

Day 3: Closed Electric Circuit - Demonstrate a closed electrical circuit by building a battery.

Learning Goals

- Students will identify the properties of conductors and insulators of electricity by testing materials with a closed electric circuit.
- Students will apply this knowledge to build a battery from available materials.

Vocabulary:

- *Conductor*
- *Insulator*
- *Electricity*
- *Closed Circuit*
- *Electrons*
- *Ions*
- *Voltage*

TEKS

(6) Force, motion, and energy. The student knows that energy exists in many forms and can be observed in cycles, patterns, and systems. The student is expected to:

(B) differentiate between conductors and insulators of thermal and electrical energy;

(C) demonstrate that electricity travels in a closed path, creating an electrical circuit

Teacher Notes:

Listed below are suggested articles to use for the research. Feel free to find other articles or let the students search for themselves. When the students are recalling what they read, guide the discussion toward the flow of electrons.

- http://www.electricityforum.com/how-electricity-works.html
- http://en.wikipedia.org/wiki/Electric_current
- http://science.howstuffworks.com/electricity.htm
- http://www.qrg.northwestern.edu/projects/vss/docs/power/2-whats-electron-flow.html

Lesson Outline

Decomposition

First, let's research how electricity works, things that use electricity, and the path that electricity follows to power things.
Read the articles provided by your teacher. Write down three facts that give you a better understanding of electricity. Then, share with the class.

1. _____

_____

_____

2. _____

_____

_____

3. _____

_____

_____

Learn from your classmates! Use the space below to list any additional information your classmates learned about electricity from the articles.

_____

_____

_____

_____

_____

You may have read that electricity is actually electrons moving from atom to atom, but what are atoms and electrons?

In your own words, describe an atom

._____

_____

_____

Teacher Notes:

Check the following links for more information on conductors and insulators:

- http://www.physicsclassroom.com/Class/estatics/u8l1d.cfm
- http://www.physics4kids.com/files/elec_conduct.html

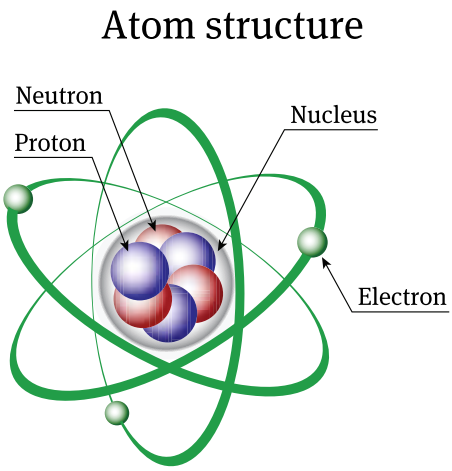
In your own words, describe an electron.

_____

_____

_____

Atoms are the basic units of matter. This means that everything is made up of atoms. Atoms consist of a nucleus and negatively charged electrons in a cloud around the nucleus. The nucleus consists of protons and neutrons, but for this lesson we will focus on the electrons that are floating around the nucleus. Electrons are negatively charged particles that provide us with electricity.



Some atoms easily give up or share their electrons with other atoms. Atoms that can easily share their electrons with neighboring atoms are called conductors. Atoms that hold on tightly to their electrons and do not share them are called insulators.

Now let's go online and research the types of materials that are conductors and insulators. In the space below, list three examples of each from your home or classroom. After you have created your list, trade with a classmate to see if you both agree on conductors and insulators.

Conductors

1. _____
2. _____
3. _____

Insulators

1. _____
2. _____
3. _____

Teacher Notes:

The following demonstration will help you learn more about conductors and insulators. Your teacher will attempt to light up a small light bulb using various objects in the classroom as a conductor. If the object is a good conductor, it should illuminate the bulb. However, if the object is actually an insulator, the bulb will not illuminate. Use the table below to make your predictions on whether the object is a conductor or an insulator and record the actual outcome. As a class, determine at least five objects for your teacher to test.

Object	Prediction (Insulator/Conductor)	Result (Insulator/Conductor)

How many of your predictions were correct?_____

How many of your predictions were incorrect?_____

Did you notice any similarities in the objects that are conductors? If so, what are the similarities?

_____

_____

_____

Did you notice any similarities in the objects that are insulators? If so, what are the similarities?

_____

_____

_____

This demonstration will further emphasize the concept of conductors and insulators. Use a 9V battery, small light bulb, alligator clips, and different objects from the classroom to complete the circuit. The bulb will light up if the object is a conductor and will not light up if the object is an insulator. Below are some suggested objects for you to test:

- Plastic ink pen
- Metal ink pen
- Water bottle
- Desk leg
- Penny, nickel, and quarter
- Notebook
- Salt water*

**Salt water is particularly good to demonstrate. Begin by showing the students that water alone does not light up the bulb. Then, add ¼ teaspoon of salt. The light will illuminate, but it will be very dim. Gradually add more salt, and the light will get brighter.*

Five steps for the setup of this demonstration are included below and continue on the next two pages.

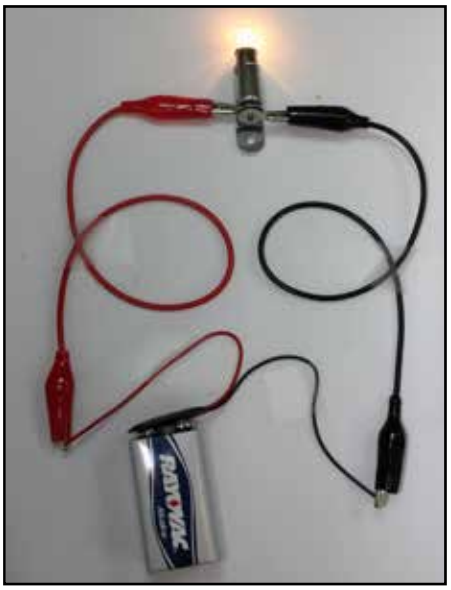
Step 1: Collect all parts.

(1) 9V battery, (2) 9V battery clip, (3) two to four alligator clips, (4) small light bulb socket, and (5) small light bulb.

Switch will not be used in this module

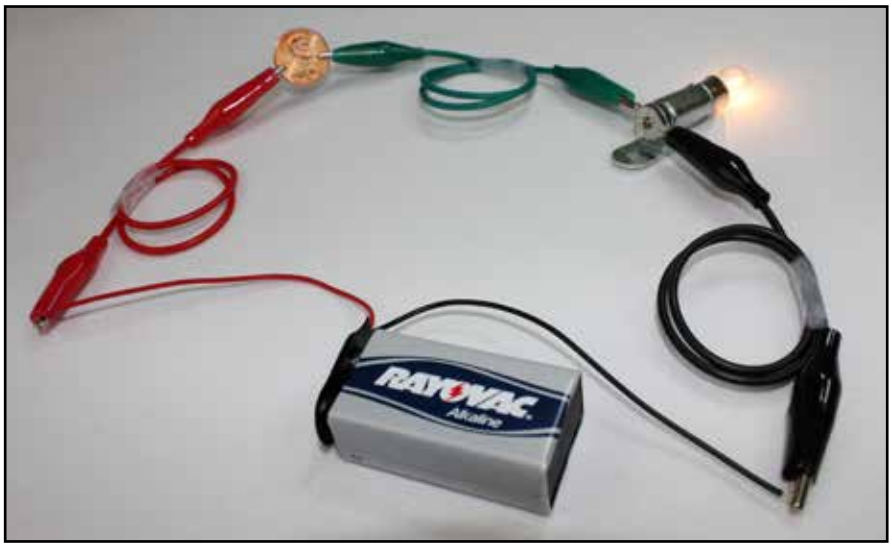
Step 2: Assemble light bulb.

Step 3: Assemble 9V battery and battery clip. Connect alligator clips to the 9V battery clip wires.



Step 4: Connect alligator clips to the light bulb as shown above, and watch it light up!

Step 5 is continued on the next page.



Step 5: Now add a conductor. Pictured above is a penny used as a conductor in the circuit. Allow the students to suggest objects for you to test as conductors. To test if something is a conductor, touch the alligator clip to the object and the wire of the battery clip to another location on the object. If it is a conductor, the bulb will light up. Do not worry about being shocked. The 9V battery is not strong enough to hurt you.

WARNING: Discuss the importance of safety and let students know that incorrect wire attachments can create dangerous situations. The red and black wires of the 9V battery clip should never be connected directly to each other. An item like a light bulb should always be connected between the wires to prevent the battery from overheating and becoming dangerous to touch.

Teacher Notes:

Use your current knowledge to decide if each object listed below is a conductor or an insulator. Write your answer as either C to indicate conductor or I to indicate insulator. If you do not know the answer to any of the materials listed below, you may need to do additional research on conductors and insulators.

1.	Gold Necklace	C	6.	Paper Airplane	I
2.	Silverware	C	7.	Window Pane	I
3.	Wood	I	8.	T-Shirt	I
4.	Keys	C	9.	Ocean Water	C
5.	Aluminum Foil	C	10.	Human Body	C

Pattern Recognition

What do the tested conductors have in common? What do the tested insulators have in common? As a group, students will test the solids and liquids provided by the teacher. Students will record the results in a chart. Based on these results, students will identify patterns in conductors and insulators.

Abstraction

From the tested materials, students will determine which available materials can be used to build a battery. [Conductors]

Build a 3V Lemon Battery (Guinness Book of World Record Challenge):
https://www.youtube.com/watch?v=uUDuTQrejYQ

Build a Pickle Battery:
https://www.exploratorium.edu/cooking/pickles/activity-kosher_dill.html

Micro bit battery test:
https://makecode.microbit.org/courses/ucp-science/electricity/setup-procedure