Electrical Conductivity

Vanderbilt Student Volunteers for Science

2018-2019 VINSE/VSVS Rural

Why is the science in this lesson important?

- Efficient and cost-effective alternatives to conventional conducting materials are being explored. One material that is currently being investigated is made from carbon nanotubes. These microscopic fibers are made entirely of carbons and have been discovered to have high electrical conductivity.

I. Introduction

Learning Goals: Students define static and current electricity and provide examples of conductors, insulators, and semi-conductors

- Ask students if they know what the two types of electricity are:

- 1. **Static Electricity:** The build up of electrical charge; it does not flow. Lightening is an example of static electricity being "discharged" after having been built up.
  2. **Current Electricity**: Moving electrical charge, usually electrons. Current electricity flows through a completed circuit.

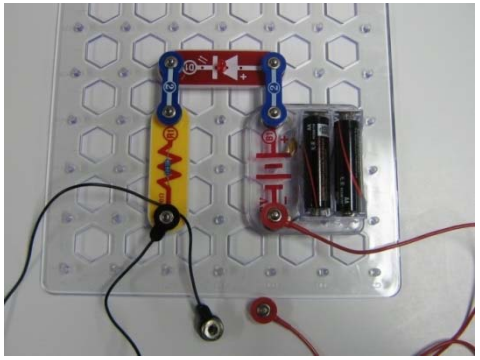
- Electricity flows through some materials better than others:
  1. **Conductors:** Materials that freely allow the movement of electrons through them.
  2. **Nonconductors:** Materials that resist the flow of electricity
  3. **Semiconductors:** Materials that allow small currents to flow.

I. Introduction

- Metals have many free electrons that can easily move and are therefore good conductors. This is why wires are made of metals like copper.
- Nonconductors are also called insulators. Materials like Styrofoam and plastic are nonconductors. Electrons do not readily flow through these materials.
- Semiconductors sometimes conduct electricity and sometimes don’t. Silicon is the most common material used in semiconductors.

I. Introduction

Learning Goals: Students define static and current electricity and provide examples of conductors, insulators, and semi-conductors

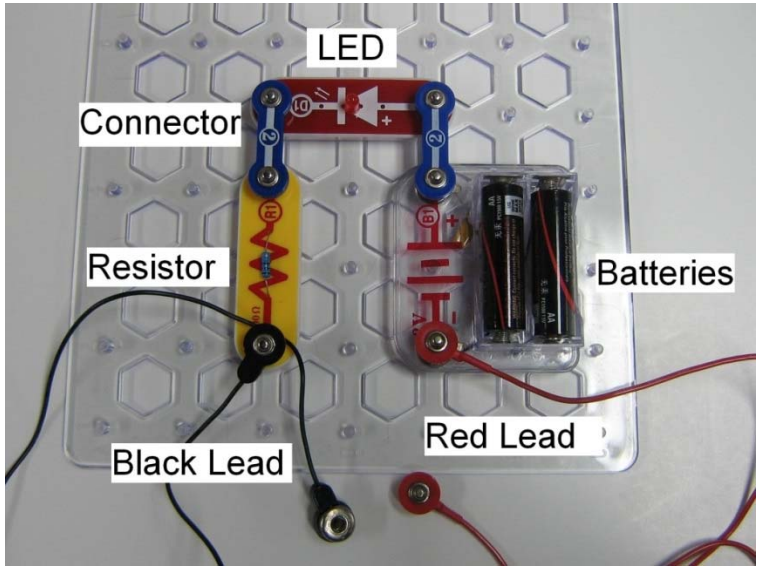


- Tell the students that the snap circuits that will be used contain flattened wires.
- Remove the #2 connector and hold it up so the students can see the metal on the underside.
- Remind students that metal is a good conductor of electricity.

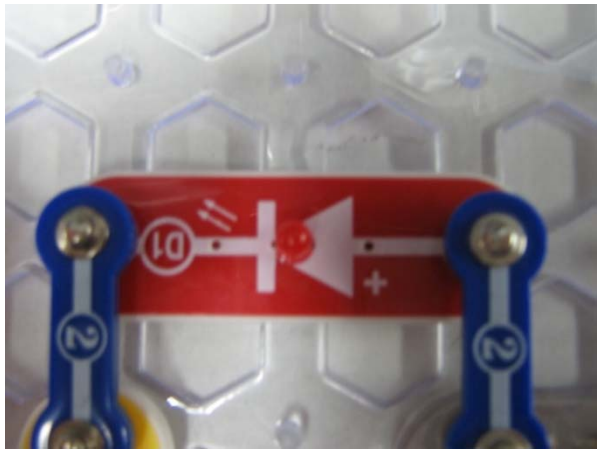
II. Explaining the Circuit - Demonstration

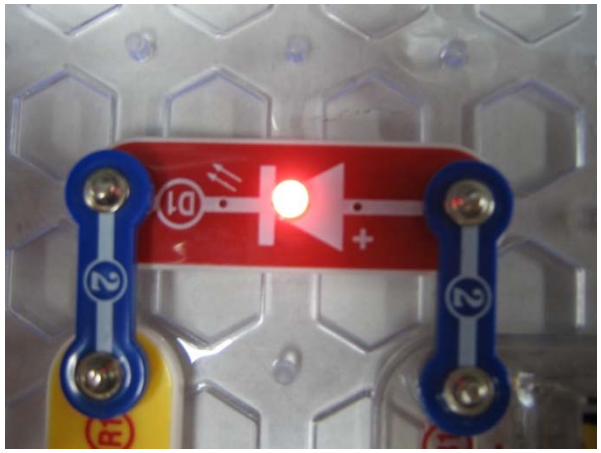
Learning Goals: Students learn what an LED is, and understand how it is used to show that a circuit is complete.

- VSVS members should hold up the demo circuit to show the students.
- Have them look at Diagram 1 and explain that it is a picture of the circuit.
- Make sure to point out the different parts (batteries, connectors, etc.)



II. Demonstration

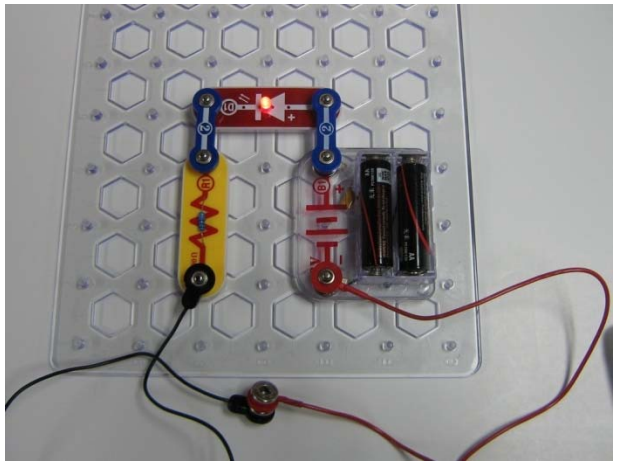


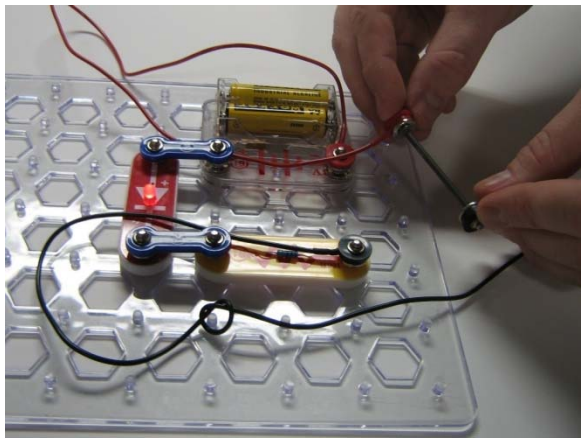


- Explain to the students what LED's are:
  Light Emitting Diodes
- They are more sensitive than light bulbs and glow brightly with even small currents.
- LED's are made from semiconductors.
- They can be damaged by high currents so **DO NOT ALLOW THE STUDENTS TO REMOVE THE RESISTORS.**

II. Demonstration

- Ask students how to make the light glow; *touch the black and red leads together.*
  - Show the students this and tell them that the **circuit is now closed**.
- Now take the **nail** and touch one lead to the head of the nail and the other lead to the tip.
  - The metal is a good conductor of electricity and the circuit is complete. The LED glows.
- Repeat this with the bottle cap;
  - the LED will not light up. This indicates that the plastic is not a conductor.

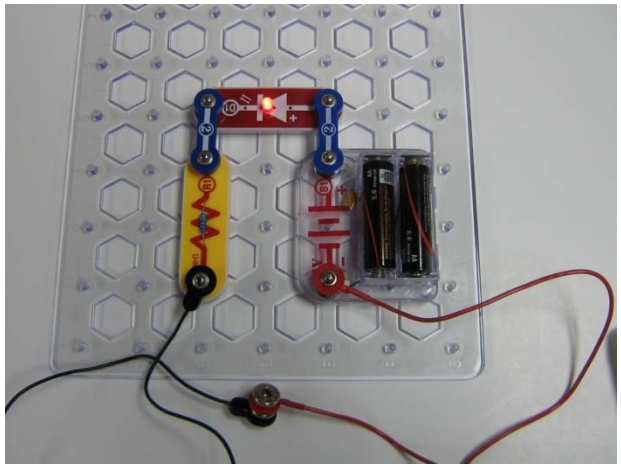




III. Conductivity Tests of Solids

Learning Goals: Students understand how conducting and nonconducting solids affect circuit pathways.

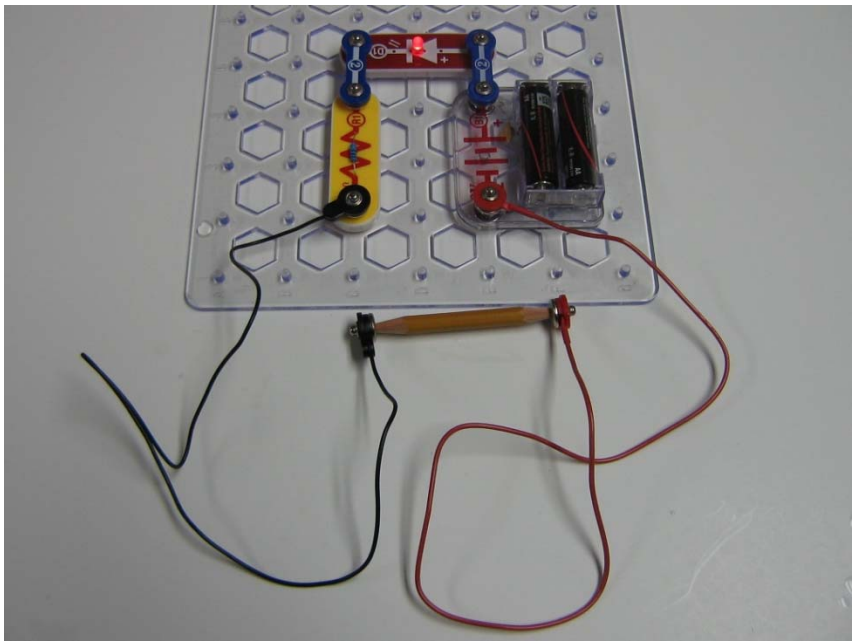
- Students will do this activity in pairs.
- Hand out one grid and one bag of solid conductivity materials to each pair of students.
- Tell the students they will be testing several materials to see if they are conductors:
  -A **conductor** will complete the circuit and cause the LED to glow brightly.
  -An **nonconductor** will not complete the circuit and the LED will not glow at all.
  - A **poor conductor** will make the LED glow dimly



- Make sure all groups have a correctly assembled circuit and have them test it by touching the two leads together (the LED should light up).

III. Conductivity of Solids (con't)

- Have the students follow the Instruction Sheet, test the solids in order, and record their results.



Explain why pencils are referred to as lead pencils, even though the core is actually graphite. (See last page of lesson.)

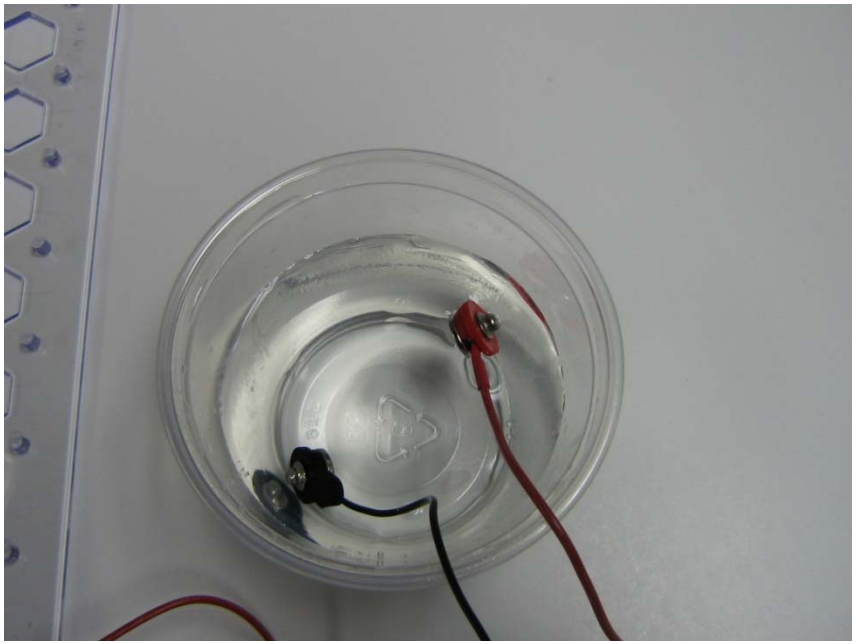
IV. Conductivity of Solutions

Learning Goals: Students understand how conducting and nonconducting solutions affect circuit pathways.

- **<u>Preparation:</u>** One VSVS member should fill 6oz. cups 1/2 full of distilled water (students will use this to rinse the leads between tests.)
- Another VSVS member should introduce background information:
  - Some liquids are conductors while others are not.
- Hand out the 6 jars of solutions, a bag of salt and sugar bottles, and the 6 oz cup of water to each pair of students.

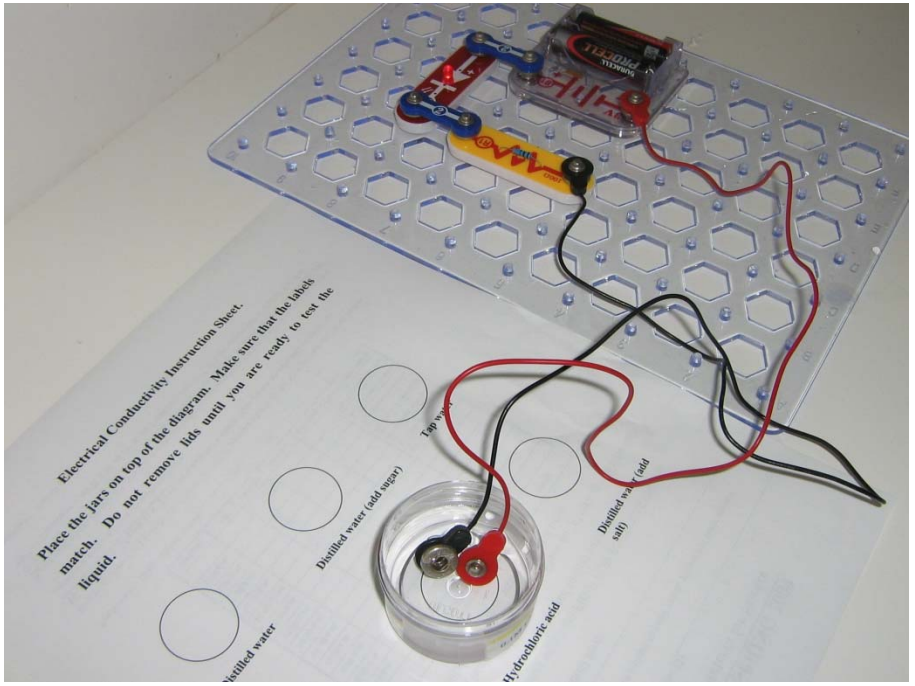
IV. Conductivity of Solutions

- Tell the students to rinse the black and red lead wires by dipping them in the cup of distilled water.
- Make sure the students know to repeat this between each test, to avoid contamination.



IV. Conductivity of Solutions

- Place the jar on top of the diagram on the Instruction Sheet. **Students must test the solutions in the given order** (nonconductors are tested first, followed by conducting solutions.)
- Tell the students that to test each solution, they will simply dip the leads into the jar. Keep **the two leads as far apart as possible. They must not touch.**



IV. Conductivity of Solutions

- The testing order is as follows (**students will make these solutions one at a time**):
  -Jar 1(distilled water): half filled with distilled water.
  -Jar 2 (sugar water): half filled with distilled water with a small amount of sugar stirred in with a toothpick.
  -Jar 3 (tap water): half filled with tap water.
  -Jar 4 (vinegar): half filled with vinegar.
  -Jar 5 (hydrochloric acid): half filled with the acid solution.
  -Jar 6 (salt water): half filled with distilled water with a small amount of salt stirred in with a toothpick.

IV. Conductivity of Solutions

- Be sure the students rinse the leads in the distilled water after each test.
- Have the students record their observations (whether the LED lit up and how bright it was) on the Observation Sheet.
- Create a table on the board displaying the results and explain the results to the students (see page 5 of the lesson for detailed explanations).

V. Optional Activity 1

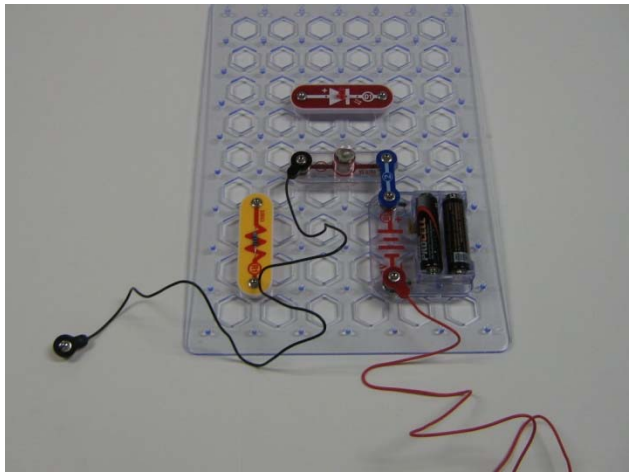
Learning Goals: Students understand how conducting and nonconducting solutions affect circuit pathways.

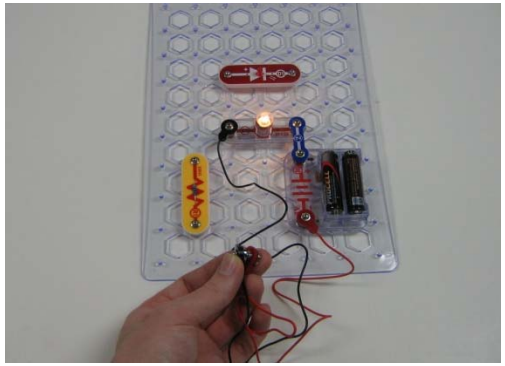
- These activities may be done if extra time remains.
- Show the students the different extra solutions (Gatorade, Sprite, etc.) and ask them to make predictions about their conductivities.
- Tell the pairs to choose one liquid and test its conductivity by simply placing the leads into the bottle.
- Compare their results with their predictions and discuss why the liquid was or was not a conductor.

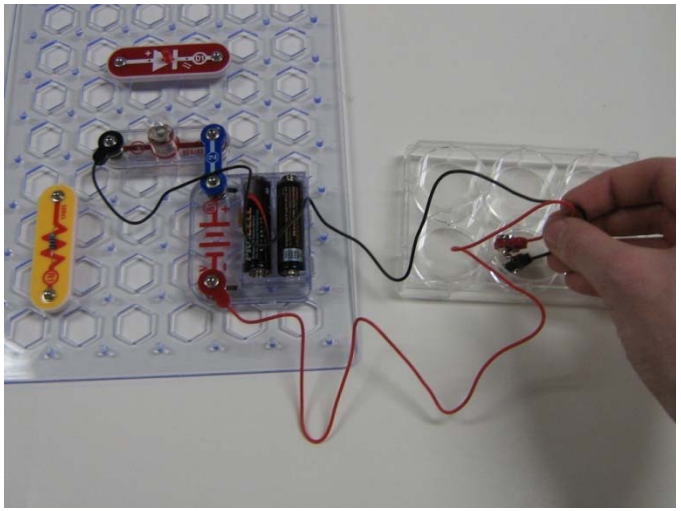
V. Optional Activity 2a

In light bulbs, electrical energy is converted into light energy. **Regular bulbs** need a high current to be bright.

- Remove the LED and resistor from the circuit and connect a regular light bulb
- Demonstrate that the low current through the electrolyte solutions is insufficient to light the regular bulb







VI. Optional Activitiy 2b

Activity 3:

- LED's are more sensitive than light bulbs and glow with much lower current. But the current can only flow in one direction.
- Ask the students which way the electricity is flowing (from the negative, or flat end of the battery to the positive, or knob end)
- Demonstration only: remove the LED unit from the circuit, turn it around, and snap it back into place.
- What happens: the LED does not light up.

VII. Summary and Clean-up

- Go over the results with the students.
- Empty the distilled water from the cups into the sink, rinse with tap water, screw lids on jars, and replace in plastic container.
  -If there is no sink, place the covers on the well plates and return them to the VSVS lab. Dump the used distilled water into a drinking fountain.
- **Double check that all circuits are complete when they are collected from the students.**
- **Make sure that the leads are NOT connected, but are snapped onto the board.**