RESET AN AEOP EFFORT aeop | Circuits

Authors

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SUBJECT/GRADE LEVEL

Subject Areas: Chemistry
Physical Science

Grade Levels: 7-12

Optional Subject Area(s):
Mathematics
English
Computer Science

Materials

- Conductive dough: Link
- Non-Conductive (Insulating) Dough: Link
- Squishy circuits (optional): Link
- Battery pack with leads: Link
    - These battery packs will provide roughly 3V.
- LEDs (RGB): Link
- LEDs: Link
- Additional Optional Challenges
    - Fans: Link
    - If you pursue the mathematics connection:
        - Voltmeter: Link
    - May require some coding (If you pursue CSTA connection):
        - Various Parts Kit (optional): Link
        - Servo Motors: Link
- Plan for a class of 30 students.

STANDARDS

Next Generation Science Standards

- HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole).
- HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long-chained molecules, and pharmaceuticals are designed to interact with specific receptors.

Mathematics Standards | Common Core State Standards

- CCSS.MATH.CONTENT.HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (*HS-PS2-6*)
- CCSS.MATH.CONTENT.HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling. (*HS-PS2*-6)
- CCSS.MATH.CONTENT.HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (*HS-PS2-6*)

English Language Arts Standards | Common Core State

- CCSS.ELA-LITERACY.SL.11-12.1.A: Come to discussions prepared, having read and researched the material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas.
- WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (*HS-PS1-3*)
- WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (*HS-PS1-3*)
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (*HS-PS1-3*)
- RST.11-12.1 (HS-PS2-6) Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- WHST.11-12 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. (*HS-PS2-6*)

Computer Science Teachers Association | CSTA Standards for Students

- 3A-AP-16 Design and iteratively develop computational artifacts for practical intent, personal expression, or to address a societal issue by using events to initiate instructions. (*P5.2*)

LESSON OBJECTIVE(S)

Students will compare and contrast series and parallel circuits using conductive and insulating materials and be challenged to build a working electrical model for an army building.

CAREER CONNECTION(S)



Mentor Background: Dr. Erin Gawron-Hyla, Chemist

Erin earned her B.S. in chemistry and mathematics from *Rose-Hulman Institute of Technology* (Terre Haute, IN) in 1999. Upon graduating, she decided to pivot and pursue teaching as a career. She earned her M.S. in science education and her teaching. Hers at *Purdue University* (West Lafayette, IN) in 2002. Erin then took a position teaching high school science at *Heritage High School* (Conyers, GA). Erin taught honors and gifted chemistry, AP Chemistry, and AP environmental science from 2002 to 2012. She received the *Science Teacher of Promise* award from the *Georgia Science Teachers' Association*. She served as science department chair, worked with the marching band and drama club, and coached Ultimate Frisbee. Also, during her teaching tenure, she worked as a summer researcher at the *University of Georgia* through the *Georgia Intern-Fellowships for Teachers* (GIFT) program. Through this program, Erin was able to establish an extensive biofuels curriculum for her students that was also shared throughout the world with other educators. After her tenth year of teaching, Erin chose to attend graduate school full-time and earned her Ph.D. in chemistry from *Georgia Tech* (Atlanta, GA) in 2017. Her work focused on conducting polymer/noble metal composites for catalysis. She followed that with a post-doctoral appointment at the *University of Calgary* (Calgary, Alberta, Canada), researching polymer/nanoparticle composite films. While there, her team's work led to a start-up company, *SenSyn, Inc.*, which makes sensors to detect oil pipeline leaks, and Erin serves as a co-founder and Chief Technical Officer. She now works as a research chemist at the *U.S. Army Research Laboratory* (DEVCOM ARL) in Adelphi, MD, where her current work focuses on porous silicon nanoenergetic reactions, including researching new oxidizers, printable formulations, and reliability studies.

ROTC Cadet Background: Keon Brown



Keon joined the army in 2018. He served in the Middle East (between Jordan and Syria for three years. He is currently pursuing his undergraduate degree in engineering. He plans to continue his career with the Army for a few more years and would like to find a full-time job in engineering after leaving the Army. Thankfully, Cadet Keon was interning at the Army Research Laboratory while we put this lesson plan together. He gave us some great ideas and helped ensure this lesson plan was as authentic as possible.

STEM Careers: Army engineer (and other army technical fields), Electrical Engineer, Data Analyst, and computer scientist.

ENGAGEMENT

Article: *Do Birds Get Shocked when They Sit on Wires?*

Great Visuals: One & Two

“Have you ever looked up at a power line filled with perched birds and asked yourself how they can do that and not get electrocuted? We all know power lines are dangerous when touched, so how can birds sit there looking perfectly safe and content?

Birds sitting on a wire don’t touch the ground (or anything in contact with the ground), so electricity stays in the power line. But, if a bird touches a power line and equipment or other metal that is grounded, it gives electricity a path to the ground, and the bird could be shocked.

Additionally, if a bird touched two wires at once, it would create a circuit. Meaning electricity would flow through the bird and likely electrocute it.

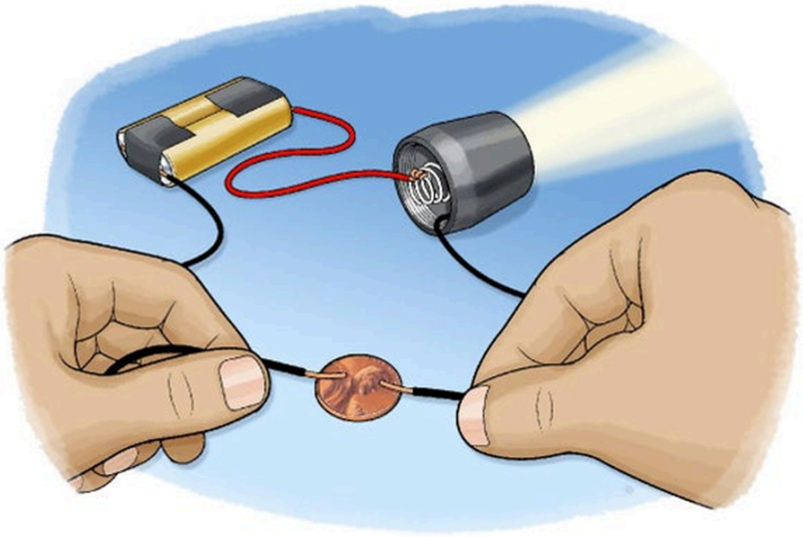
How can we tell which materials can conduct electricity and which ones cannot?

What Teachers need for each student group:

1. Teachers need conducting and nonconducting material
2. Flashlight (a flashlight you can take apart)
3. Batteries for your flashlight
4. Three pieces of wire can be cut and stripped (See Procedure for more information.)
5. Ruler with metric measurements.

Teachers need to help students:

1. Build their own circuits to explore the materials and try different ways of lighting the LED(s).
2. What arrangements worked and which didn’t? Why did some arrangements work and some not?
3. What material must each dough be (conductor or insulator)?
4. Explain how electricity can flow through materials
5. Plan and investigate evidence to compare the structure of substances to infer the strength of electrical forces between particles. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole).
6. Communicate scientific and technical information about why the molecular-level structure is essential in the functioning of designed materials and how attractive and repulsive forces determine the functioning of the material. What do materials have to have to conduct electricity?



EXPLORATION

Conductive/Nonconductive Squishy Circuits Teacher Copy
Conductive/Nonconductive Squishy Circuits Student Copy

Brief Description:
Students will be asked: "Is this dough all the same?" Students will be given two doughs, one that is conductive and one that is insulating. Students will be given time to explore the Squishy Playdough lab supplies and try to light the LED lights making a simple circuit deciding which dough is conductive and which is insulating. Students will then be instructed to make the conductive dough into different diameters and lengths. They then can compare qualitatively and quantitatively any differences in voltages in the circuits.

Procedures:

- Begin by letting students explore the materials. Ask students if they can figure out how to light an LED using the conductive dough so that the LED is not in direct contact with the battery pack. Let students play with the materials and try different ways of lighting the LED(s).
- After some exploration, start a discussion with students on what arrangements worked and which didn't.
    - Why did some arrangements work and some not?

Move the discussion towards why they think the conductive dough worked on lighting the LED.

What type of material must the Play-doh be (conductor or insulator)?
What do you think makes it a conductor?

1. Data collection for diameter:
    a. Roll the conductive playdough into different diameter snake-sized pieces, ensuring the length of each remains the same and only the diameter is different.
    b. Measure and record the diameter of each in the data table below.
    c. Attach the LED lights to the different diameter pieces of conductive dough and record what you observe.
    d. Measure the voltage across each side of the circuit and record your amount of voltage.
2. Data collection for length:

a. Roll the conductive playdough into snake-sized pieces making sure the diameter of each remains the same, and only the lengths are different.
b. Measure and record the length of each in the data table below.
c. Attach the LED lights to the different diameter pieces of conductive dough and record what you observe.
d. Measure the voltage across each side of the circuit and record your amount of voltage.

EXPLANATION

PhET Student Sheet

Brief Description:
This inquiry lab takes students through building different types of circuits in the PhET Circuit Construction Kit. Students will build series and parallel circuits and explore the differences between them. It should take one class period to complete.

Procedures:
Click here to open the PhET Virtual Lab

Choose: Intro.

Drag: Items into the middle of the screen, and begin building your circuits. If you want to compare the voltage, check the values on the right-hand side.

CIRCUIT A: "Simple closed circuit"

- Connect 1 battery and 1 bulb using just 2 wires.
- Record your observations of what you see in the space below:
    - What happens if you connect two batteries simultaneously? Why does this happen?

CIRCUIT B: "Series circuit"

- Make a circuit that lights two bulbs simultaneously, but if either bulb is cut, the other bulb goes out too. Use only one battery.
    - Which was brighter, circuit A (from above) or circuit B (this one)?
    - What do you predict would happen if you added a third bulb? How about 4?

CIRCUIT C: "Parallel circuit"

- Make a circuit that lights two bulbs simultaneously. However, make it so this time if either bulb is unscrewed, the other bulb stays lit. Use only one battery.
    - If you built this correctly, and if there is not too much resistance in the materials, the other bulb stays lit. Why do you think it stays lit?
    - Is this circuit brighter or dimmer than B? What do you think causes this?

CIRCUIT D: "Series circuit with a switch"

- Make a circuit with two bulbs and two switches. Create this circuit so that if both switches are closed, both bulbs stay on. If either switch is opened, both bulbs go out.
    - How many wires did you need to make the switch work?
    - What effect does the switch have on the electrons in the circuit?

CIRCUIT E: "Parallel circuit with a switch"

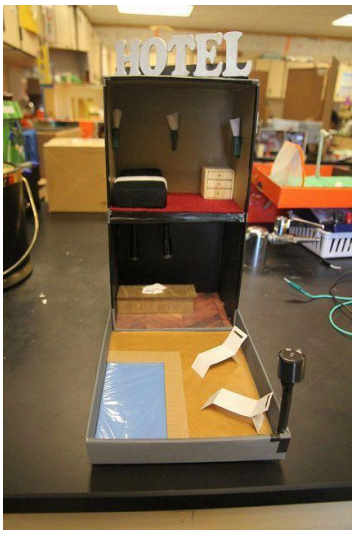
- Make a circuit with two bulbs and two switches. However, opening both switches turns off the bulbs. If either switch is closed, both of the bulbs stay on. You may only use one battery (or if you have multiple batteries, they must be connected in one location).
    - How many wires did you need to make the switch work in this parallel circuit? Is this circuit brighter or dimmer than C? What do you think causes this?
    - Why might a set-up like this be more beneficial than the one you created with Circuit D?

ELABORATION

Student activity sheet

Brief Description:
This project requires the students to build their (own) working electrical models for an army building. They should follow the guidelines provided in the student activity sheet. The rubric for this activity is included in the student's activity sheet to understand better how to be successful. Students will provide evidence of their understanding of parallel and series circuits, switches, and general knowledge of how electrical currents flow.





Procedures:
Teachers ensure that all students have access to a copy of the student activity sheet. Students should read through the activity sheet and ask appropriate questions before starting this project. You may give students two weeks (or three weeks) to work on this assignment. You may also modify the rubric and have students meet with you during their planning process to ensure all of your students are on task, have planned their work according to the rubric guidelines, and can complete their plans on time.

Furthermore, students should present their projects upon completion. Plan accordingly to ensure these presentations are given in front of an intended audience. For example, find some electrical engineers, army personnel, bankers, and other pertinent individuals who may be interested in this project and can ask the students thought-provoking questions. In addition, some students may expand upon this project and make it a science fair project. Finally, this project would also be great to showcase at a family engagement activity night.

EVALUATION

Project and Presentation Rubrics

Brief Description:
Use the rubrics (provided in the link) to ensure students have understood and provided evidence of learning about electrical circuits.

Procedures:
You may modify (or keep it the same) the presentation rubric and have the class (depending on maturity level) provide school-appropriate and mindful feedback for each of the classmates' presentations.

You may also ask students to complete the following multiple-choice link provided at the following link if you would prefer a self-scoring system. You may also have students complete this quiz if they do not do well on the project and ask for a second chance.

Self-Scoring Assessment Link

Remember to make a copy of the linked documents to use in your classroom. If you make copies and store these copies in your Google Drive, you can modify the docs and forms to best suit your classes and complement your teaching style.

REFERENCES

Introduction materials

- https://www.thetech.org/sites/default/files/simplicityelectricitylab_squishycircuits.pdf
- https://www.teacherspayteachers.com/Product/Virtual-Circuits-Inquiry-Lab-Phet-resource-6280616?st=68d060158a128861cbf22e51599d433e
- https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html

Presentation rubric

- https://www.pinterest.com/pin/260927372140402150/

Questions posed in multiple-choice survey

- https://quizlet.com/192206679/electricity-practice-flash-cards/
- https://www.toppr.com/ask/en-us/question/complete-the-given-statement-the-voltage-across-each-light-bulb-in-a-parallel-circuit/