Electric Vehicles Toolkit

ALL CHARGED UP

HIGH SCHOOL PHYSICS / CHEMISTRY

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All Charged Up
How does an EV Battery work?

Lesson Overview	Career Highlight
Students will explore how a battery works, build their own battery, and then compare and contrast technologies specific to electric vehicle batteries.	Chemical Engineer

STEM Course Connections	21st Century Skills	CTE Alignment
Middle School Physical Science High School Physics High School Chemistry	Collaboration Communication	Career Readiness

Engineering Activity	
Science and Engineering Practices #2 & 8	Students will build a model of a battery using pennies and troubleshoot how to turn on an LED light.

Materials

- Supplies needed per group:
  - Five or more post-1982 U.S. pennies
  - Piece of 100-grit sandpaper
  - Matboard or thick cardboard
  - Salt
  - Vinegar
  - A red LED
  - Electrical tape
  - A voltmeter
  - Scissors
  - Cup with water
  - Paper towel
  - Optional: other LEDs of different colors, such as yellow and blue
- Student Handout

Essential Questions

1. How does a battery work?
2. How are batteries used in electric vehicles?

Background Information

Electricity is produced by the flow of electrons. In a battery cell, there is an anode and a cathode. The anode has a negative electrode while the cathode has a positive electrode. An electrode is a conductor that lets electricity enter or leave the space. Insulating material is placed between the anode and cathode to prevent them from touching each other. When the two terminals (+ and -) are connected by a wire, the electrons flow (through the wire) from the anode to the cathode. When electrons are lost, it is called oxidation which is occuring at the anode. When electrons are gained, it is called reduction, which is occuring at the cathode. If you connect one end of the battery to one end of the light bulb and the other end of the battery to the second terminal of the same light bulb, you will create a simple circuit where electrons can flow from the battery through the light bulb and back to the battery.

Mission Prep

Engage (15 mins)

- Challenge the students to complete the following brainstorm in their student handout:
  - Please list all the different battery-powered devices that you use in your daily life
- Think-Pair-Share moment
  - Have students turn to their partner, share their ideas, and add any new ideas they got from their partners to their lists
- As a whole class, share out on the whiteboard in the front of the room for all to see.
  - This can be done by the teacher as they call on partners to share or by inviting students up to add a new idea to the board that has not already been written.
- Wrap up/transition by remarking on how batteries are used in many of our devices, continue to develop, but are based on some common principles that we are going to learn about today
- Show How batteries work - Adam Jacobson and take notes using the graphic organizer in the student handout

Explore (25 mins)

Teacher Note: Materials needed for this activity are included in the Exploratorium's Penny Battery Guide

- Students will create a penny battery using the Exploratorium's Penny Battery Guide
- Students will then sketch the model that they built in their student handout
- Students can then iterate their design by adding more pennies to observe change in battery voltage.

Launch

Explain (15 mins)

- Have students read this excerpt from "How A Battery Works" and respond to questions in their student handout
- To build from prior experience, use one of the student-built penny batteries and walk through the question responses. Point to the cathode part of the battery and have students point to the cathode on their own battery. Point to the anode. Indicate the flow of electrons through the LED and back to the battery.

Elaborate (10 mins)

- Have students learn about the types of batteries specifically being used in electric vehicles from Electric Vehicle Battery Basics

Exploration

Evaluate (25 mins)

- Battery Sketchnote
    - Using the knowledge gained from the penny battery and the two readings, students can digest this content in the form of a sketchnote.
    - The sketchnote should include:
        - Content on battery components (cathode, anode, electrolyte solution, electrons), how the battery works, and types of EV batteries
        - Content should be displayed following the 50/50 rule where it is split between images and words/text
        - There should be a clear template used.
        - Color should be used effectively
        - Here is an example

Extend (Optional)

Have students check out the current research being done at Lawrence Berkeley Lab on increasing EV battery longevity. If interested in this research field, they can also read the career profile of the Associate Lab Director of the Energy Technologies Area, Mary Ann Piette, or the career profile of the principal investigator, Gao Liu.

CA NGSS Standards

- MS-PS1-6. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.
- PS1.B: Chemical Reactions § Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
- MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
- ETS1.B: Developing Possible Solutions § A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- HS - PS3.A: Definitions of Energy § “Electrical energy” may mean energy stored in a battery or energy transmitted by electric currents.
- HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

CTE Alignment

- B2.3 Present conceptual ideas, analysis, and design concepts using freehand graphic communication techniques.
- B3.0 Identify the fundamentals of the theory, measurement, control, and applications of electrical energy, including alternating and direct currents.
- B6.0 Employ the design process to solve analysis and design problems.

Resources

Chao, Julie. "How to Make Lithium-Ion Batteries Invincible by Berkeley Lab - Exposure." HOW TO MAKE LITHIUM-ION BATTERIES INVINCIBLE, 23 June 2021, photostories.lbl.gov/how-to-make-lithiumion-batteries-invincible#!

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Exploratorium. (2023, May 11). Science Snack: Penny Battery. Exploratorium. https://www.exploratorium.edu/snacks/penny-battery

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Mischa. "How A Battery Works." Curious, 11 Mar. 2022, www.science.org.au/curious/technology-future/batteries

Visser, J. (2019, November 10). *Start-up of the Month: the storage revolution in Battery Land?* IO.

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