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| **Name: Aaron Debbink** | **Contact Info:** [**akdebbink@gmail.com**](mailto:akdebbink@gmail.com) | **Date: 11/15/2018** |

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| **Lesson Title : Battery Basics** | **Unit #: 1** | **Lesson #:**  **1** | **Activity #:**  **1** |
| **Activity Title: Introduction to Batteries Using CBL** |

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| **Estimated Lesson Duration:** | **3 days** |
| **Estimated Activity Duration:** | **2 days** |

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| **Setting:** | **Indian Hill High School, Room 118** |

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| **Activity Objectives:** |

* The students will be able to identify different internal features of a laptop or power tool battery pack.
* The students will be able to identify the Big Idea about energy storage and utilization.
* The students will be able to generate a list of Essential Questions based on the Big Idea and Hook.
* The students will be able to generate a list of Challenges based on the Essential Questions.
* The students will be able to generate a list of Guiding Questions based on the given Challenge.

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| **Activity Guiding Questions:** |

* What is inside of an individual cell in a laptop battery?
* Given an opened battery pack and a video on batteries, what is the Big Idea?
* Given a Topic and Big Idea, what are some good Essential Questions?
* What would be a good Challenge considering the Essential Questions selected?
* Given the selected Challenge, what are some good Guiding Questions?

| **Next Generation Science Standards (NGSS)** | |
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| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| Asking questions (for science) and defining problems (for engineering) | Patterns |
| Developing and using models | Cause and effect |
| Planning and carrying out investigations | Scale, proportion, and quantity |
| Analyzing and interpreting data | Systems and system models |
| Using mathematics and computational thinking | Energy and matter: Flows, cycles, and conservation |
| Constructing explanations (for science) and designing solutions (for engineering) | Structure and function. |
| Engaging in argument from evidence | Stability and change. |
| Obtaining, evaluating, and communicating information |  |

| **Ohio’s Learning Standards for Science (OLS)** |
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| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| Demonstrating Science Knowledge **(D)** |
| Interpreting and Communicating Science Concepts **(C)** |
| Recalling Accurate Science **(R)** |

| **Ohio’s Learning Standards for Math (OLS) and/or**  **Common Core State Standards -- Mathematics (CCSS)** | |
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| **Standards for Mathematical Practice (Check all that apply)** | |
| Make sense of problems and persevere in solving them | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto precision |
| Construct viable arguments and critique the reasoning of others | Look for and make use of structure |
| Model with mathematics | Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, OLS and/or CCSS):** |

* This particular activity does not address specific academics standards for AP Physics 2.

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

* YouTube Video: [The Fixers Using Recycled Laptop Batteries to Power Their Homes](https://www.youtube.com/watch?v=cNbsiZcwGSY&t=23s&list=PLwmxTr8NJ_llboxqx7Tgl-VjQYWWrhtUe&index=17)
* Disassembled laptop and/or power tool battery packs. See sample below.



* Student Handout: 1.1.1b Lithium Ion Batteries\_CBL Handout\_ADebbink

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| **Teacher Advance Preparation:** |

* You will need to obtain used laptop and / or power tool battery backs and safely disassemble them for students to observe. Watch the video below which shows how to disassemble a laptop battery to retrieve the individual lithium-ion cells.
  + Video: [18650 Cell Removal from Laptop Batteries (Fast and Safe)](https://youtu.be/B0-sEJB9Hyc)

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| **Activity Procedures:** |

**Day 1**

1. Have several disassembled used laptop batteries and power tool batteries out for students to observe. Have each lab group take 3-4 minutes to write down answers to the following questions to share out with the rest of the class.
   * What did you observe while looking at the disassembled battery?
   * What kind of questions do you have about these batteries?
2. Show the following video/videos which discuss how some people are using old batteries.
   * YouTube Video: [The Fixers Using Recycled Laptop Batteries to Power Their Homes](https://www.youtube.com/watch?v=cNbsiZcwGSY&t=23s&list=PLwmxTr8NJ_llboxqx7Tgl-VjQYWWrhtUe&index=17)
   * YouTube Video: [266 mile Trip on DIY EV TESLA BUS 18650 Batteries VW eSamba Ep 42 BBB](https://www.youtube.com/watch?v=DdnyycF5Gkg)
3. Handout the following sheet: 1.1.1b Lithium Ion Batteries\_CBL Handout\_ADebbink
4. Use the handout to introduce the Big Idea, generate a list of Essential Questions and a list of possible design Challenges.
   * (Big Idea) Energy Storage and Utilization
   * (Essential Questions) Tell students that these questions should be broad questions which have complex answers, may require research and testing, and cannot be simply answered with a YES or NO. Record the students’ Essential Questions on the board for the class to see. *Below is a list of possible essential questions*.
     1. How do we determine when the life a battery has come to an end?
     2. How can you extend the life of a battery back?
     3. What can be done with battery packs at the end of their life cycle?
     4. What can be done with all the rechargeable batteries which appear to have no usable life?
   * (Challenges) Tell students that they should generate a list of possible challenges where they could design a product or process related to one of the Essential Questions. *Below is a list of possible challenges*.
     1. Develop a set of guidelines to increase the life of a battery pack
     2. Design a battery pack for a specific application (bike generator, electric skateboard, power wall, solar storage, etc…)
     3. Design a process to test individual lithium-ion cells to determine which cells have more usable life and which cells will need to be recycled.
5. Tell the students that you will take the list of student Essential Questions and the design Challenge ideas and you will look them over and decide on an appropriate challenge for all classes to complete.

**Day 2**

1. Share the Essential Question and Challenge which you picked to complete. See below.
   * (Essential Question) What can be done with all the rechargeable batteries which appear to have no usable life?
   * (Design Challenge) Design a process to test individual lithium-ion cells to determine which cells have more usable life and which cells will need to be recycled.
2. Have the students generate a list of “Guiding Questions” to help them successfully complete the given design challenge. *Below is a list of possible Guiding Questions*.
   * Why do battery packs use many different individual battery cells?
   * What is inside of an individual cell in a laptop battery?
   * Why are there electric circuit boards connected to the cells inside a battery pack?
   * When is a battery considered to be “dead” or non-functional?
   * How can individual battery cells be tested in old battery packs?
   * How can we determine the amount of energy a battery can store?
   * How can we determine the amount of electric charge stored in a battery?
   * What are measureable characteristics which are indicators of how much life is left in a battery?
   * What are safety considerations when working with lithium-ion batteries?
   * Why do lithium-ion batteries have a limited life?
   * What can be done to increase the expected life of a lithium-ion battery?
3. Have students share out their Guiding Questions while the teacher records the questions on the board. Tell the students that we will work on answering the Guiding Questions over the next week so that they will be able to successfully complete the design Challenge.
4. If time remains in the period, begin Activity #2: “Battery University”.

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

This activity provides many opportunities for the teacher to formatively assess the students’ knowledge about batteries and energy storage. The teacher is able to walk around the classroom while students are generating Essential Questions, possible Challenges and Guiding Questions. The teacher can passively observe and actively ask questions to probe for understanding. The students will also be verbally sharing their ideas with the class. This will provide additional opportunities for the teacher to formatively assess the students’ knowledge about batteries and energy storage.

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

There will be no summative assessments for this activity.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  Refer to Activity Template for details. |

The nature of this introduction to challenge based learning gives different types of learners an opportunity to interact with the ideas in different ways. Hands-on learners will get to touch and hold a battery pack during the introductory discussion. Visual learners will be able to visually inspect the battery packs, watch the introductory video, and watch their peer’s ideas recorded on the board. Audible learners will benefit from the small and large group discussions throughout the entire activity. Regardless of learning style preference, all learners will benefit from having the information presented in various ways.

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

The amount of time it took for students to observe the battery packs, write down their observations and questions, and have a class discussion was much longer than originally anticipated. It was a challenge during the first day for students to have enough time to come up with some challenges based their chosen essential question. Because of the time crunch, several students ended up recording more questions they wanted to answer, related to their chosen essential question, rather than a specific challenge or project they wanted to do. In the future, I would make sure to save enough time during the first day of the activity for students to develop a challenge.

The second day of activity number one went quickly and we had more than half the class to start activity number two: Battery University. We were able to discuss the different types of batteries, specific power, specific energy, and safety considerations for lithium-ion batteries.