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| **Lesson Title : Battery Basics** | **Unit #: 1** | **Lesson #:**  **1** | **Activity #:**  **2** |
| **Activity Title: Battery University** |

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| **Estimated Lesson Duration:** | **3 days** |
| **Estimated Activity Duration:** | **1 day** |

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

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| **Activity Objectives:** |

* The students will be able to identify safety considerations when working with lithium-ion battery cells.
* The students will be able to investigate why individual battery cells are connected in series and/or parallel.
* The students will be able to calculate the amount of electric charge an individual battery cell can transfer from one terminal to another given the battery’s capacity in milliamp-hours.
* The students will be able to calculate the amount of energy stored in a battery based on its stated voltage and capacity.
* The students will be able to identify battery characteristics which can differentiate good cells from bad cells.

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| **Activity Guiding Questions:** |

* What are safety considerations when working with lithium-ion batteries?
* 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 we determine the amount of electric charge stored in a battery?
* How can we determine the amount of energy a battery can store?
* What are measureable characteristics which are indicators of how much life is left in a battery?
* Why do lithium-ion batteries have a limited life?
* Why do battery packs use many different individual battery cells?

| **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):** |

**5.C.3.4:** The student is able to predict or explain current values in series and parallel arrangements of resistors and other branching circuits using Kirchhoff’s junction rule and relate the rule to the law of charge conservation. **[SP** **6.4, 7.2]**

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

* 1.1.2c Lithium Ion Batteries\_Battery University Presentation
* D-Cell Batteries
* D-Cell Battery Holders
* Electric Multi-Meters

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| **Teacher Advance Preparation:** |

* There is NO advanced preparation for this activity.

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| **Activity Procedures:** |

**Day 1**

1. Review the relevant Guiding Questions which focus on the safety, capacity and testing of individual lithium-ion cells which were previously generated by the students. *See the list of Guiding Questions above*.
2. Discuss the information found in the presentation file “1.1.2c Lithium Ion Batteries\_Battery University Presentation”. *See the content topics listed below*.
   * Battery Chemistry and Voltages
   * Battery Safety and Internal Resistance
   * Battery Charging and Discharging Specifications
   * Battery Capacity and Charge
     1. Voltage vs. Discharge Capacity Curves
     2. Voltage vs. Energy Curves
   * Battery Self Discharge
   * Battery Energy Storage
   * Series and Parallel Configurations of Battery Cells
3. Give student lab groups 5 – 10 minutes to investigate the results when individual battery cells are connected in series and / or parallel. Have students use the D-Cell batteries, D-cell battery holders, and electric multi-meters for the investigation. Students should answer the following questions on a whiteboard to share with the class.
   * What happens when you connect individual battery cells in series?
   * What happens when you connect individual battery cells in parallel?
   * What is the advantage of connecting individual battery cells in series?
   * What is the advantage of connecting individual battery cells in parallel?

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

The teacher is able to walk around the classroom while students are investigating series and parallel configurations of battery cells to 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 series and parallel combinations of battery cells.

**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.

Content from this activity will be assessed on the post-test for the challenge based learning unit. *See the following document*.

* 1.0.0a Lithium Ion Batteries\_Pre and Post Test

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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. |

This activity gives different types of learners an opportunity to interact with the ideas in different ways. Hands-on learners will get to physically arrange different configurations of batteries and physically take measurements for each configuration. Visual learners will be able to identify with the pictures, numbers and graphs in the presentation. Audible learners will benefit from the teacher’s verbal presentation and the small and large group discussions with the different battery configurations. 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. |

It ended up taking an extra day to finish discussing the content related to lithium-ion batteries. The section which took more time than expected was having the students look at the specification sheets for different lithium-ion cells and answer specific questions about each cell. The ensuing discussion about the information they found was worthwhile, but lengthy. In the future activity number two should be completed over two and a half days rather than just one.