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| **Lesson Title : Modeling Non-Ideal Batteries, Testing and Construction** | **Unit #: 1** | **Lesson #:**  **2** | **Activity #:**  **5** |
| **Activity Title: Battery Pack Construction** |

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| **Estimated Lesson Duration:** | **10 days** |
| **Estimated Activity Duration:** | **2 day** |

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

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| **Activity Objectives:** |

* The students will be able to construct a battery pack with used lithium-ion cells.

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| **Activity Guiding Questions:** |

* How can we use the used cells in a dead battery back?

| **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) |

* 18650 Battery Cell Connectors (from Activity #4)
* Black Wire
* Red Wire
* Wire Cutters
* Wire Strippers
* [Electrical Tape](https://www.amazon.com/Polyimide-High-Temperature-Resistant-Multi-Sized-Soldering/dp/B077GLM37D/ref=sr_1_cc_4?s=aps&ie=UTF8&qid=1530653674&sr=1-4-catcorr&keywords=battery+electrical+tape+high+temp)
* [Soldering Iron](https://www.amazon.com/SunFounder-Station-SF-888D-Soldering-Temperature/dp/B079NGQ3MX/ref=sr_1_4?s=electronics&ie=UTF8&qid=1530652554&sr=1-4&keywords=heat%2Bgun&th=1)
* [Solder with Flux](https://www.amazon.com/Alpha-AT-31604-60-40-Solder-Ounces/dp/B00030AP48/ref=pd_bxgy_147_img_2?_encoding=UTF8&pd_rd_i=B00030AP48&pd_rd_r=99441ff3-7f06-11e8-9061-3d1068c3cd02&pd_rd_w=3ZEF9&pd_rd_wg=dYkSx&pf_rd_i=desktop-dp-sims&pf_rd_m=ATVPDKIKX0DER&pf_rd_p=3914568618330124508&pf_rd_r=G441SYD6MTRAB6KN39DJ&pf_rd_s=desktop-dp-sims&pf_rd_t=40701&refRID=G441SYD6MTRAB6KN39DJ&th=1)
* [Heat Shrink Wrap](https://www.amazon.com/uxcell-100mm-Length-Shrink-Batteries/dp/B06X3XVBV2/ref=sr_1_3?s=electronics&ie=UTF8&qid=1530652373&sr=1-3&keywords=battery+pack+heat+shrink)
* [Heat Gun for Shrink Wrap](https://www.amazon.com/PORTER-CABLE-PC1500HG-1500-Watt-Heat-Gun/dp/B004Q04X44/ref=sr_1_6?s=hi&ie=UTF8&qid=1530652913&sr=1-6&keywords=heat+gun)
* [Micro USB Charging Protection Circuit](https://www.amazon.com/Micro-USB-5V-Battery-Charger/dp/B01LHD9D7E/ref=pd_bxgy_23_img_2?_encoding=UTF8&pd_rd_i=B01LHD9D7E&pd_rd_r=fe26f02e-7888-11e8-9336-4502b179e98a&pd_rd_w=SMHaw&pd_rd_wg=rvs2n&pf_rd_i=desktop-dp-sims&pf_rd_m=ATVPDKIKX0DER&pf_rd_p=3914568618330124508&pf_rd_r=DGJ9JPRGBNSRGHNAMBR2&pf_rd_s=desktop-dp-sims&pf_rd_t=40701&psc=1&refRID=DGJ9JPRGBNSRGHNAMBR2) – This allows the constructed lithium-ion battery pack to be charged with a micro USB charging cable. This provides charging protection, so the battery pack is not over charged.
* [DC to DC Boost Converter with USB Output](https://www.amazon.com/Micro-USB-5V-Battery-Charger/dp/B01LHD9D7E/ref=pd_bxgy_23_img_2?_encoding=UTF8&pd_rd_i=B01LHD9D7E&pd_rd_r=fe26f02e-7888-11e8-9336-4502b179e98a&pd_rd_w=SMHaw&pd_rd_wg=rvs2n&pf_rd_i=desktop-dp-sims&pf_rd_m=ATVPDKIKX0DER&pf_rd_p=3914568618330124508&pf_rd_r=DGJ9JPRGBNSRGHNAMBR2&pf_rd_s=desktop-dp-sims&pf_rd_t=40701&psc=1&refRID=DGJ9JPRGBNSRGHNAMBR2) – This allows the battery pack to provide a constant 5V output so that it can charge anything that plugs into a standard USB port. This also provides discharge protection for the battery pack using a low voltage cutoff.
* [USB to Micro USB Charging Cables](https://www.amazon.com/dp/B011KLFERG/?coliid=IS77KR2CO741M&colid=1AWTMN9VZWM4B&psc=0&ref_=lv_ov_lig_dp_it) – this is needed to charge the battery pack from a standard USB port.
* [10 Port USB Charging Hub](https://www.amazon.com/dp/B00OJ79UK6/?coliid=I339P299APB4MV&colid=1AWTMN9VZWM4B&psc=0&ref_=lv_ov_lig_dp_it) – this will be used to charge all of the constructed battery packs.
* Lithium Solar Charger – this is used to charge a larger battery pack with a variable voltage source such as solar panels or a bicycle generator.

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| **Teacher Advance Preparation:** |

The teacher should use assemble an example battery pack using a 1 or multiple lithium-ion cells in parallel which can be charged using a standard USB port and can then be used to charge another device with its own USB charging port. (FUTURE: An example image will be included below)

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| **Activity Procedures:** |

**Day 1**

1. Discuss how the students will use their tested cells which have usable life to make a battery pack which can charge any device using a USB plug (cell phone, tablet, small drone, etc…)
2. Discuss the construction basics listed below.
   * The Micro USB Charging Protection Circuit is used to protect the battery from overcharge, more than 4.2V. It also allows the battery to be charged using a micro USB cable.
   * The DC to DC Boost Converter with USB Output allows the 4.2 – 2.5V battery pack to provide a constant 5V output so that it can charge anything that plugs into a standard USB port. This also provides discharge protection for the battery pack using a low voltage cutoff so the battery will stop discharging when the voltage reaches 2.5V.
   * Demonstrate how to use a soldering iron to make the electrical connection between the lithium-ion battery holder and the charging and discharge circuits.
   * Use red wire for the positive battery terminals and black wire for the negative battery terminals.
   * Cover the exposed soldered connections with electrical tape to prevent shorts.
3. Have the lab groups use the micro USB charging cables and the 12 Port USB Charging Hub to charge fully charge their battery pack.

**Day 2**

1. Have the students disconnect their fully charged battery pack and test it by charging their cell phone.

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

This activity provides several opportunities for the teacher to formatively assess the students as they construct their battery pack. The teacher is able to walk around the classroom while students are constructing the battery pack to assess their understanding of the battery pack design and their ability to use solder to make electrical connections.

**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. |

This activity gives different types of learners an opportunity to interact with the ideas in different ways. Hands-on learners will get to physically construct the battery pack using their tested lithium-ion cells. Visual learners will be able to identify with the sample battery pack. Audible learners will benefit from the verbal presentation of construction steps given by the teacher. Regardless of learning style preference, all learners will benefit from having the information presented in various ways.

The nature of small group, collaborate work allows students who need more guidance to receive it. In small collaborate groups, the first place that students often receive help is from their peers. The teacher can also walk around listening to the student discussions and ask probing questions to help guide students toward a correct understanding. This allows the teacher to see where students are struggling and need extra guidance or help.

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

This entire challenge-based learning unit was completed close to the end of the first semester. Since early activities in the unit took longer than expected, I decided to save this last activity when we have more time at the end of the year, after the AP Physics 2 exam by the College Board. I will add reflections about the successes and shortcomings after the activities completion.