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| **Lesson Title : Energy Storage Devices** | **Unit #:**  **1** | **Lesson #:**  **2** | **Activity #:**  **4** |
| **Activity Title: Batteries** |

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| **Estimated Lesson Duration:** | **5 Days** |
| **Estimated Activity Duration:** | **3 Days** |

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| **Setting:** | **Foundations of Engineering Class, 11-12 Grade** |

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| **Activity Objectives:**   1. Students will be able to explain how capacitors work 2. Students will be able to build capacitors out of household materials for under $5, and test them |

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| **Activity Guiding Questions:**   1. What makes a capacitor work? 2. What is the difference between a capacitor and a battery? 3. How can you make a capacitor charge faster and discharge slower? |

| **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):** NGSS: [HS-ETS1-1 Engineering Design](http://www.nextgenscience.org/pe/hs-ets1-1-engineering-design) Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. NGSS: [HS-ETS1-2 Engineering Design](http://www.nextgenscience.org/pe/hs-ets1-2-engineering-design) Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. NGSS: [HS-ETS1-3 Engineering Design](http://www.nextgenscience.org/pe/hs-ets1-3-engineering-design) Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. |

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| **Materials**: Video to watch about how a capacitor works:  <https://www.youtube.com/watch?annotation_id=annotation_1160083969&feature=iv&src_vid=u4FpbaMW5sk&v=f_MZNsEqyQw> |

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| **Teacher Advance Preparation:** For this activity, the teacher needs to understand how a capacitor generates electricity. |

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| **Activity Procedures:**   1. Watch the video on capacitors 2. Groups present their findings individually to the teacher 3. Revisit the challenge and its parameters 4. Build a capacitor that will charge 9 volts at the quickest rate, and discharges the 9 volts by running a fan at the slowest rate. 5. Test the design and then try to improve it using the engineering design process. |

**Formative Assessments:**

Student involvement in the discussion about capacitors

**Summative Assessments:**

Journal observations throughout this whole lesson

Engineering Design Process packet filled out

Final Rubric to score testing iterations and model design.

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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.  *Having them in groups helps with the different types of learning skills and abilities in the class. Since they got to go at their own pace and do different activities, they were allowed to create their own syllabuses.* |

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson.  *Having worked with micro-super capacitors in my RET research at UC over the summer I was extremely excited about this part of the lesson. I was hoping to have the students face the challenge of building their own capacitor and having it store enough energy to run a very small fan.*  *I was warned that it might not get to that point by my research partner John and he was correct. The students felt like failures because they were not generating voltage like they did with the batteries.*  *Next year I will be more aware that we will not be generating a large amount of voltage. We will be generating capacitance, which is the measure of how much energy a capacitor holds. It takes a lot of capacitors to make something run, and we did not get to that point.*  *I loved this entire experience and if I had the time, I would do this again.* |