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| **Lesson Title :** Experimental Design | **Unit #:** | **Lesson #:** | **Activity #:**  1 |
| **Activity Title:** Electrical Conductivity in Materials |

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| **Estimated Lesson Duration:** |  |
| **Estimated Activity Duration:** | 2 class periods |

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| **Setting:** | Classroom |

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| **Activity Objectives:** |

1. Students will be able to measure electrical current in a wire.
2. Students will be able to identify properties affecting conductivity.
3. Students will understand and be able to apply the components of experimental design.
4. Students will be able to analyze experimental results statistically.

**Activity Guiding Questions:**

1. Why is energy storage important?
2. What properties are important to energy storage?
3. How can type of material affect conductivity?
4. What properties (thickness, length, temperature, type of material) affect conductivity?
5. Is cost an issue?

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| **NGSS Practices of Science and Engineering / Crosscutting Concepts** |

| **Practices of Science and Engineers (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
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| 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 |  |

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| **Unit Academic Standards (Ohio State Revised Science Education Standards and/or NGSS Content, Common Core etc.):** |

CCSS.MATH.CONTENT.HSS.ID.B.6.A - Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context.

[CCSS.MATH.CONTENT.HSS.ID.B.6.C](http://www.corestandards.org/Math/Content/HSS/ID/B/6/c/) - Fit a linear function for a scatter plot that suggests a linear association.

[CCSS.MATH.CONTENT.HSS.ID.C.7](http://www.corestandards.org/Math/Content/HSS/ID/C/7/) - Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.

[CCSS.MATH.CONTENT.HSS.ID.C.8](http://www.corestandards.org/Math/Content/HSS/ID/C/8/) - Compute (using technology) and interpret the correlation coefficient of a linear fit.

[CCSS.MATH.CONTENT.HSS.ID.C.9](http://www.corestandards.org/Math/Content/HSS/ID/C/9/) - Distinguish between correlation and causation.

**Cognitive Demands (Ohio State Revised Science Education Standards)**

| **Expectations for Learning Cognitive Demands (Check all that apply)** |
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| Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| Demonstrating Science Knowledge **(D)** |
| Interpreting and Communicating Science Concepts **(C)** |
| Recalling Accurate Science **(R)** |

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

1. Hook PowerPoint
2. Pre-assessment/post-assessment
3. Supplies**:**

* Nichrome wire of two different diameters
* Steel or aluminum wire, copper wire, and nichrome wire of same diameter
* Multimeter
* Wire cutters
* Meter stick
* Two D cell 1.5V batteries
* Electrical tape
* Lead wire

1. Worksheet

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| **Teacher Advance Preparation:** |

1. Know how to use a multimeter.
2. Know how to set up batteries and multimeter together.
3. Check if resistance wire gets hot at short lengths when connected to power source.

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| **Activity Procedures:** |

Activity 1: Measuring electrical conductivity in different materials

1. Show the hook presentation.
2. Discuss with the class electrical conductivity and where this is applied.
3. What types of technology use electrical energy storage?
4. What types of technology could electrical energy storage be used in that it is not currently?
5. What are some limitations regarding electrical energy storage?
6. Discuss what material properties affect conductivity such as thickness, length, temperature, and type of material.
7. Give instructions and demonstrate to students how to use a multimeter for measuring current.
8. Make sure each student knows the diameters of each wire type.
9. Have each group take a 100 cm long piece of one wire.
10. Have them tape the wire onto the meter stick by placing a piece of tape at 5 cm, 25 cm, 55 cm, and 95 cm. The ends of the wire should hang slightly off both ends of the meter stick.
11. Tape one end of the lead wire onto the positive terminal of the battery and attach the other end of the lead wire to the end of the wire on the meter stick by twisting the two ends together.
12. In each group, have one student hold the black lead from the multimeter to the negative terminal on the battery.
13. Have another student hold the red lead from the multimeter to the wire at the 100 cm mark.
14. Have another student record the current reading from the multimeter.
15. Repeat steps 8 and 9 measuring the current every 10 cm (90, 80, 70, etc.) and stopping once they reach 10 cm mark on the meter stick).
16. Repeat steps 8, 9, and 10 with each type of wire.
17. Complete the worksheet.

**Formative Assessments:**

As students are working, ask them the following questions as a formative assessment:

1. What type of data are you collecting for each experiment? Why? What other factors are you considering for this experiment? Why?
2. What results are you finding? Why do you think you are getting these results?

**Summative Assessments:**

At the conclusion of the activity, students will be asked to present their findings and statistical interpretations of their data (Slope and Intercept in context). This work is included in the activity worksheet.

The post-assessment is also a summative assessment.

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| **Differentiation:** |

For students that are not meeting the level set by the standard, I would differentiate by having an extra helper to guide them through the activity. This helper could be a support educator or an advanced student from NHS.

For students that have shown mastery of the standard and are ready to extend beyond this activity, I would have them modify the experiment to include a 3rd variable and analyze the data as a multi-variable regression.

This activity includes a pre-assessment to help get students thinking about the concepts involved before the activity is carried out. The activity includes group work so that students will not have to complete all the work by themselves and within each group each student will have a specific task to complete. After the group section of the activity, each student will complete a worksheet by themselves using the information gathered during the activity.

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| **Reflection:** |

The overall activity worked well and students were engaged. The part of the activity where the effect of temperature on conductivity was to be tested did not work but this led to the students learning more about experimental design as we discussed the reasons that this did not work. It incorporated critical thinking into the activity. Many concepts were covered such as the reasons for collecting data, how to collect data, how to set up an experiment, and how to analyze the data using statistical concepts. This activity demonstrated how statistics can be used in a real life situation to determine the effects of material properties.

The introduction of the activity took longer than expected but once the experiment started it progressed smoothly. As the engineering and science concepts were introduced in the form of verbal questions one student wanted to answer all of the questions. In the future, this could be handled by calling on students individually to answer so that more students have the opportunity to think about the answers. Although time was given for students to think about the answers to the questions individually, some time for peer discussion could have been introduced in order to elevate the critical thinking and learning experience.