<u>Appendix A:</u> Information and Unit Outline

Integrated Math/Science Lesson - Resistors

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<u>Information</u>

Topic/Title Measurement and Statistics

Special Notes In the following lesson, students will predict and measure the resistance in ohms of resistors using the color–coding scheme designed to label actual resistors. Then they will present their data in a graph. The methods of instruction are expository/lecture and Laboratory/Investigation/Data Collection.

Objectives: Students will:

1. Estimate, in ohms, the resistance of resistors.
2. Measure, in ohms, the resistance of the resistors to 3 significant figures.
3. Present the ohm measurement data in an appropriate graph.

National Council on Teaching Mathematics (NCTM) Content and Process Standards:

1. <u>Algebra:</u> Understand patterns, relations, and functions. Represent and analyze mathematical situations and structures using algebraic symbols.
2. <u>Communication:</u> Communicate their mathematical thinking coherently and clearly to peers, teachers, and others. Use the language of mathematics to express mathematical ideas precisely.
3. Use both descriptive and inferential statistics to analyze data, make predictions, and make decisions – **WA-COMP.MA.S10**

Washington Essential Academic Learning Requirement (EALRs), Grade Level Expectations (GLEs) and National Science Education Standards (NSES)

1. Explain how to improve the validity of an investigation (e.g., control more variables, better measuring techniques, increased sample size, control for sample bias, include experimental control condition when appropriate, include a placebo group when appropriate). **WA-GLE.SC.2.4.9-10.5**
2. Probability and Statistics **– WA-COMP.BIO.K1.1.2, WA-COMP.CHEM.K1.1.3, WA-COMP.EAR.K1.1.2, and WA-COMP.PHY.K1.1.4**
3. Technological applications of electricity and electronics. **WA-COMP.PHY.K1.4.2**
4. Unifying Concepts and Processes -- As a result of activities in grades K-12, all students should develop understanding and abilities aligned with constancy, change, and measurement. **NSES-S.K-12.3**

5. Explain how science and technology could be used to solve all or part of a human problem and vice versa (e.g., understanding the composition of an Earth material can be useful to humans, such as copper ore being used to make copper wire). **WA-GLE.SC.3.1.1.9-10.1**

Materials: handouts titled *Table of Values for Color Coding Resistors*, *Colors of Resistance – A Study in Measurement and Statistics*, black tape, paper, markers, rulers, resistors, TI-Calculators, and Laptops with EXCEL spreadsheet from MicroSoft Office.

Activity Outline – 5 Lessons

I. Introduction

(Method: Expository with Student Discourse)

***Background:* What is the science inside of carbon composition resistors?**

For students to understand how carbon composition resistors function, they require knowledge from three different scales that starts at the nanoscopic (1×10^{-9} m), proceeds to the microscopic (1×10^{-6} m), and finishes at the macroscopic ($>1 \times 10^{-3}$ m). Students must start at the nanoscopic scale of graphite particles to understand that carbon-carbon double bonds facilitate the flow of electrons (electrical conduction). At the microscopic scale, students need to know that graphite and silica sand create a composite material that resists the flow of electricity (electrical resistance). Finally, it is imperative that students understand the macroscopic components of a resistor so that they can comprehend how the resistor functions as a part of an electrical circuit and how to identify color coding that represent units of electrical resistance. A PowerPoint that was used at NCTM Conference, 2008, is used in this portion of the unit.

***Part 1:* What does the color code on a resistor mean?**
(Pre-Test – Quantitative Assessment)

A. Define a resistor and ohms. Be sure students understand that the symbol omega (Ω) represents a unit, like meters, not a variable that has a value.

B. Pass around several resistors. Ask these questions

1. What do you notice about these resistors? (colored bands)
2. Why are resistors useful?
3. Who might use resistors?

C. Distribute the handout *Table of Values for Color Coding Resistors*

1. Show the students a particular resistor and tell them what the estimated resistance is in ohms. Have them brainstorm to determine how the color code is used to identify the resistance, in ohms, of the resistor. Have students share their conjectures.
2. Once conjectures have been made, identify the correct ones and go over an example of finding the resistance of the resistor using the color bands.

3. Ask these questions?

a. Will all resistors with identical color bands have the same resistance in ohms? Why or why not?

b. How can we determine how the resistances in ohms for a group of resistors vary?

c. What type(s) of graphs would be most appropriate for displaying the resistance data? Predict how the graph might look.

d. Will graphs of say 30 data points for the resistors resemble a graph of the data from the entire class?

II. Lesson Body

(Method: Laboratory/Investigation/Data Collection)

<u>Part #2:</u> What color bands are on our resistors?

A. Distribute the handout titled *Colors of Resistance – A Study in Measurement and Statistics*, packets of resistors (>30), materials for graphing. Set up measurement equipment for each group. Have groups complete Exercises #1 and #2.

B. Ask the following questions of groups or the class at appropriate times.

1. What does the gold or silver band on the resistor represent?

2. Is the formula for percent error similar to any other formulas you have seen? What formulas?

3. What type or types of graphs would be appropriate to display the data you collected in Exercise #2? Why did you choose this type of graph?

<u>Part #3:</u> What do statistics say about resistor color codes?

A. Have students prepare graphs of their group's data, including mean, one %RSD, and two %RSD.

B. Have students enter their data into a software spreadsheet set up for the entire set of data from the class. (Can use Excel, MicroLab, or other software systems that handle statistical data.) From these data, students predict the color bands on their resistors.

C. Have each group display and explain their graph for the class.

D. These questions will assess students' knowledge of the terms and concepts of the lesson.

1. Which graphs are similar?
2. Would a graph of the class data be similar to the graphs of groups? Why or why not?
3. Explain the science of creating and separating resistors in a manufacturing environment.

E. Students reveal the actual color code to reveal that their prediction was incorrect!

III. Closure

(Method: Student–Directed)

<u>Lesson #4:</u> Is this painted color code valid for our resistors

A. Get a graph and plot the painted-on color band to see if these color bands are legitimate.

B. Validate or invalidate, using %RSD and 2 standard deviations, if the painted-on color bands are a legitimate value for their batch of resistors.

<u>Lesson #5:</u> Why doesn't our prediction match the color code?

A. Make a graph with EXCEL displaying the class data and place the actual color band mean of the resistors along with the %RSD.

B. Make it explicit that the actual color code on the resistor with % error contains almost two standard deviations above and below the mean and is a plausible explanation for the colored bands, including the metallic band on the resistors.

C. Students will now work on their final projects, answering the project question.

<u>Project Question:</u> Why doesn't our prediction match the actual color code?

State your conjecture for why your prediction from the experimental data does not match the actual color bands found on your resistors. Support your conjecture using the following:

Item 1 - Science of carbon composition resistors
Item 2 - Experimental statistical data
Item 3 - Researched prices of carbon composite resistors
Item 4 - Two additional valid and reliable sources not provided in class

Include the four items above within your report. Cite these references in your paper and/or embed graphs or other information in your report. The paper must be typed, contain correct grammar, spelling, and punctuation. The paper must be logical and convincing when offering your argument for why the predicted color code does not match the actual color code found on the resistors.