Appendix B: Student Activity Sheets

***Exercise #1:* What does the color code of a resistor mean?**

Name(s):_______________ _______________ Date:__________

Materials: baggies of 5 different resistors

baggie of x>30 - 56ohm+/-10% error resistors

Digital multimeters –DMM or ohm meters

Prior Knowledge/Skills:

Prior Knowledge:

- Resistance, measured in ohms, is a measure of resistance to electrical current.
- Basic electronic symbol for resistance in ohms is the Greek sign omega, Ω.
- How to create a two-axis scatter plot.

Skills:

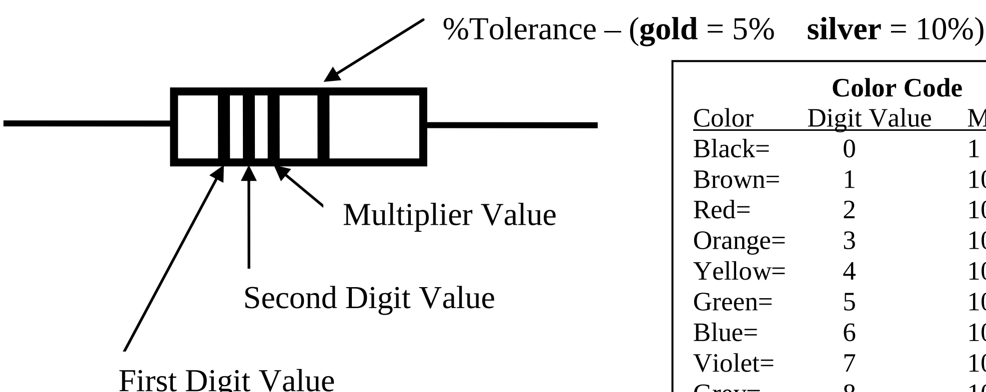
- Using a Digital Multimeter
    - Configuring the DMM’s test leads to read resistance in ohms
    - Changing the DMM’s adjustable dial to measure various magnitude resistors to no less than three significant figures

Safety Note: When properly configured with alligator clip leads, a DMM can reliably reproduce measured values from each of the resistors. Alligator clips are meant to pinch onto conductive wires and test leads from DMMs. DMM leads are sharp enough to penetrate plastic insulators on electrical wires. If students don’t pay attention both pinching and poking of fingers can take place during this hands-on experiment.

<u>A short explanation</u>: The Colors of Resistance

A resistor is an electronic component that reduces the flow of electrons in a circuit, causing electrical “resistance”. Resistance is measured in units of ohms and is represented by the capital Greek symbol omega (**Ω**).

Resistors can be created in many ways. The ones provided in class come in cylindrical plastic packages with metal leads out either end. Within the plastic cylinders are small granules of carbon that complete an electronic circuit that resists the flow of electrons. Resistors are mass manufactured with different values and degrees of accuracy. The color code below offers a way of predicting the value of a resistor, Figure 1.



Color Code

Color	Digit Value	Multiplier
Black=	0	1
Brown=	1	10^1
Red=	2	10^2
Orange=	3	10^3
Yellow=	4	10^4
Green=	5	10^5
Blue=	6	10^6
Violet=	7	10^7
Grey=	8	10^8
White=	9	10^9

<u>Figure 1:</u> The farthest left non-metallic band is the first digit value, the second band is the second digit value, and the third band is the multiplier value. The fourth band indicates the accuracy of the resistor – which will be discussed later in the lesson.

If a resistor has a color coding of green, black, and red, this translates as:

$$\text{Green Digit Value, Black Digit Value, X } 10^{\text{Red Digit Value}}\,\mathbf{\Omega}$$

or

$$50 \times 10^2\mathbf{\Omega} = \mathbf{5000\Omega}$$

<u>Q:</u> What would be the resistor's value that has a <u>red</u>, <u>violet</u>, and <u>yellow</u>?

Red	Violet	Yellow
______	______	10____

<u>Exercise 1</u>: Validating Individual Resistors Values

a) In small plastic bag #1, your group will find 3 loose resistors. It is your job to work together in deciphering the color code on the resistor and translating this into a value that predicts each resistor's value. In the first two columns below, write the color code of the first three colored bands and the predicted numeric value. Once you have done this, go onto part b of this exercise.

Resistor	Three Band Color Code	Predicted Resistance (Ω)	Measured Resistance (Ω)
1			
2			
3			

Data Table #1: Resistors and their values.

b) After predicting each of your resistor's values, your instructor will help your group to use the Digital Multi-Meter (DMM) in measuring the actual resistance of the five resistors, seen in Figure 2 below. Be sure to adjust your DMM dial that offers the most significant figures AND pay attention to the units that the DMM displays. As you measure each of the five resistors, write and the measured value in Data Table #1 for each of your resistors.

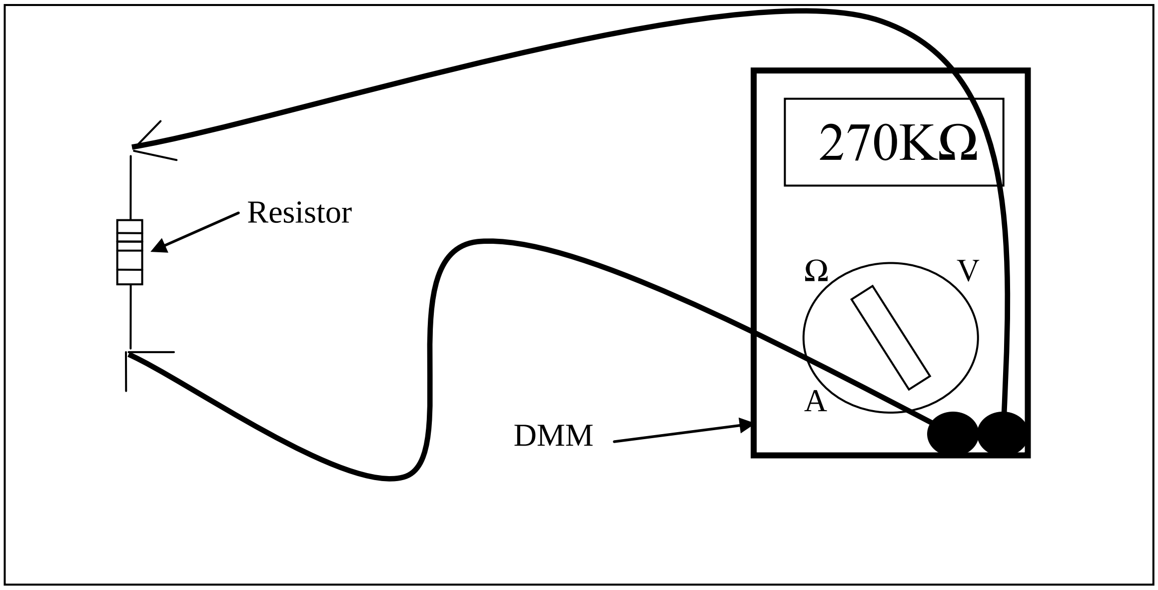


Figure 2: Connect your black test lead into the "COM" or common terminal and your red test lead into the "V, Ω" terminal. Set the circular dial selector to the resistance or **Ω** setting on your DMM. Lay the resistor flat on the desktop and make good contact with the resistor. Do not poke yourself or your partner in this process.

c) Now calculate the %Error from the data in Table #1. After calculating error, write the observed fourth metallic band colored band and the associated % Tolerance.

Resistor	% Error	Fourth Metallic Colored band on Resistor (Gold or Silver?)	% Tolerance
1			
2			
3			

Data Table #2: % Error , fourth metallic colored band, and %Tolerance. **(% Error = [(Predicted – Measured)/Measured] * 100%)**

Q: **How does the calculated %Error compare with the predicted % Tolerance?** ***(In essence, do all of your resistor %Tolerance color code values match your calculated % Error values?)*** **Why do you think this is (or is not) the case?**

A Small Recap: (Check on your previous work…and % Tolerance!)

If a resistor has blue, brown, orange, and **silver** colored bands:

$$\text{Blue Digit Value, Brown Digit Value, } \times 10^{\text{Orange Digit Value}}\,\boldsymbol{\Omega} \pm \textbf{Silver \%}$$

or

$$61 \times 10^{3}\boldsymbol{\Omega} \pm 10\% = \mathbf{61{,}000\Omega \pm 10\%}$$

Q1: What is the predicted value of resistor with a **brown, blue, green** and **gold**?

______ ______ $10^{\_\_\_}$ ± _____

Q2: What is the predicted value of resistor with a **blue, blue, blue** and **silver?**

______ ______ $10^{\_\_\_}$ ± _____

Q3: What is the predicted value of resistor with a **brown, black, white** and **gold?**

______ ______ $10^{\_\_\_}$ ± _____

<u>Exercise 2</u>: What are the color codes of the unknown individual resistors?

a) On a purple paper, your group will find 3 resistors whose color codes are not revealed to you. It is your job to work together in deciphering the color code on the resistor by measuring, predicting, and then validating each resistor's value!

<u>DO NOT REMOVE THE BLACK TAPE UNTIL INSTRUCTED TO DO SO!</u>

b) In the first column below, write the MEASURED resistance for each of the resistors, rounding to two significant figures and including the multiplier. In the second column, use the measured value to PREDICT the three colored bands that you would expect to be painted on the resistor. the predicted numeric value, and the expected tolerance from the fourth colored band for each of the five resistors.

Resistor	**MEASURED Resistance (Ω)**	**PREDICTED Color Code for Resistor (Three bands of color)**
1	__ __10___	_______ _______ _______
2	__ __10___	_______ _______ _______
3	__ __10___	_______ _______ _______

Data Table #3: Use the measured resistor value to predict the color code.

<u>Once you have measured and predicted a color code, you may remove the black tape to reveal the actual color code.</u>

c) Reveal the actual color code, write the expected resistance, and calculate % Error using measured values from Table #3.

Resistor	ACTUAL Color Code on Resistor (Three bands of color)	EXPECTED Resistance (Ω)	% Error
1	_____ _____ _____	__ __$10^{___}$	
2	_____ _____ _____	__ __$10^{___}$	
3	_____ _____ _____	__ __$10^{___}$	

Data Table #4: Reveal the actual color code, write the expected resistance, and calculate % Error.

d) Now compare your %Error with the actual % Tolerance. Do they match up or not?

Resistor	% Error	Fourth Band of Color on Resistor	% Tolerance	% Error matches % Tolerance?
1				YES / NO
2				YES / NO
3				YES / NO

Data Table #4: Do calculated % Error and %Tolerance match.

How does the calculated %Error compare with the predicted % Tolerance? *(In essence, do all of your resistor %Tolerance color code values match your calculated % Error values?)* Why do you think this is (or is not) the case?

Exercise #3: A batch of Resistors (In the dark!)

You will be provided with 30-40 resistors that have been fastened to a piece of pink paper. The black tape is so that you cannot know what the color code is on the resistors. It is your task to measure each of these resistors and record the data in the table provided. **(Data Table #5) Please record your data to at least three significant figures and don't remove the black tape!**

Resistor Value (Ω)

Data Table #5: Record your Resistor Resistances in this table.

<u>Lesson #4:</u> What do statistics and graphs tell us about our resistors?

Some Calculations:

Once you have recorded the data, use Microsoft Excel to calculate the following information:

Range (max and min **Ω**)	Mean (**Ω**)	Standard Deviation (Ω)	Relative Standard Deviation (RSD%)
Max: __________Ω Min: __________Ω			

<u>Data Table #3:</u> Statistical Values for your resistor population.

<u>Some HELP with TI Graphing Calculators (TI83 or TI84)?</u>

1. Clear out any old stats by doing the following. You only really need to clear out L1, or Column 1.
   a. [STAT] → [4] → [2nd][1] → [ENTER]
   b. [STAT] → [4] → [2nd][2] → [ENTER]
   c. [STAT] → [4] → [2nd][3] → [ENTER]
2. Enter the data for which you want to find the mean and standard deviation into L1.
3. Now find the statistics needed.
   a. [STAT]
   b. Arrow to CALC.
   c. Pick 1. Hit [ENTER] and you will see 1-VAR Stats.
   d. Hit [ENTER] once more.
4. Read $\bar{x}$, mean, and σx, standard deviation. Notice you can get other statistics, as well.
5. If you want to calculate some statistics on values in L2, follow this process.
   a. [STAT]
   b. Arrow to CALC.
   c. Pick 1. Hit [ENTER] and you will see 1-VAR Stats. Type [2nd][2] for L2.
   d. Hit [ENTER] once more.

Can't Resist Those Resistors!

Materials: ruler, markers, sheet of freezer paper, sheet of standard white paper, calculator, your resistor data

Definition: Statistics – 1. quantitative data on any subject 2. the classification and interpretation of these data (adapted from The Harper Collins Dictionary of Mathematics)

In your group, complete the following tasks. Use the space provided to write notes. For the next class meeting, be prepared to turn in this note sheet, your results on the standard paper, and your results on the freezer paper "poster." You will be sharing your posters with the class.

Task 1: Brainstorm: Make a list of the various types of statistics that can be used to describe a data set. Then choose the types of statistics you will use to describe your resistor data set.

Task 2: Calculate and Write: Calculate the statistics that your group chose in Task 1. Draft a short summary of your data using your statistics.

Task 3: Brainstorm: Make a list of the various types of graphs that can be used to describe a data set. Be open–minded to all possibilities. Then choose one type of graph you will use to describe your resistor data set.

Task 4: Graph and Write: Make a "draft graph." If you decide the graph does not present the data in an appropriate way, go back to Task 3. Then draft a short description of what your graph tells the reader about the data set.

Task 5: Refine and Present: Refine your statistics, graph, and paragraphs. Present them on both the standard paper and the freezer paper. Use technology for graphs, if you prefer, as long as you can size items appropriately for the freezer paper display.

Lesson #5: ***Why doesn't our prediction match the actual color code?***

Student Guidelines for the Project Report:

Project Question: 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 4 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.