Lab 2
Resistive Circuits

All prelabs are to be completed on separate paper and turned in at the beginning of the lab period (make a copy to use during the lab). All lab exercises must be completed in the comp book, using blue or black ink. No answers are complete without units!!

Deciphering the Resistor Color

Note: carbon composition resistors will be used.

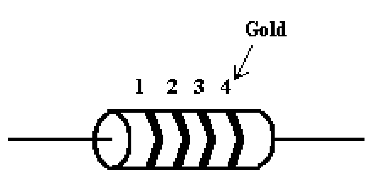
Resistors are labeled with colored stripes. Each color corresponds to a digit between 0 and 9 as listed in the table below. The resistor value is made up of two significant digits (the first two stripes) times ten to the power of the third stripe. The fourth stripe designates the tolerance as a percentage (the actual value could vary from the labeled value by up to that amount). The decimal point comes after the second digit. The first digit will never be a zero unless the resistor value is a single digit number (1Ω thru 9Ω). Be careful distinguishing colors, different manufacturers use slightly different colors so the difference between certain colors (especially red and orange) can be difficlut to tell apart. When in doubt, use a meter and measure it.

You can use the following standard form:

$$(first\ stripe)(second\ stripe) \times 10^{third\ stripe} \pm (fourth\ stripe)\% \tag{1}$$

For example, a 1kΩ resistor should look like this: 10×10^2, i.e., (brown black) times ten to the 2 (red) or "brown-black-red."

If the last stripe is gold, then the tolerance is 5% which means that the actual value will be within 5% of 1kΩ. Therefore the actual value should be between 950Ω and 1050Ω.



Color	**Value**	**Multiplier**	**Tolerance**
Black	0	1	
Brown	1	10	
Red	2	100	2%
Orange	3	1,000	
Yellow	4	10,000	
Green	5	100,000	
Blue	6	1,000,000	
Violet	7	10,000,000	
Gray	8	100,000,000	
White	9	1,000,000,000	
Gold			5%
Silver			10%

Prelab Exercises

1. Using the resistor color code chart above, list the three colors (in proper order) that would be found on the following resistors:
   (a) 23,000Ω
   (b) 670Ω
   (c) 1,000Ω
2. The resistors in Figure 1 are said to be in **series**. That is, they are connected one after another to each other, with no other circuit elements connected where each is joined. For series resistors, the equivalent resistance, R_{eq}, is obtained by simply adding the resistance values ($R_1 + R_2 + \cdots$). An equivalent circuit for the one in the figure would simply be one resistor with the value that you calculated for it. Determine the equivalent resistance, R_{eq}, for this network and draw an equivalent circuit.

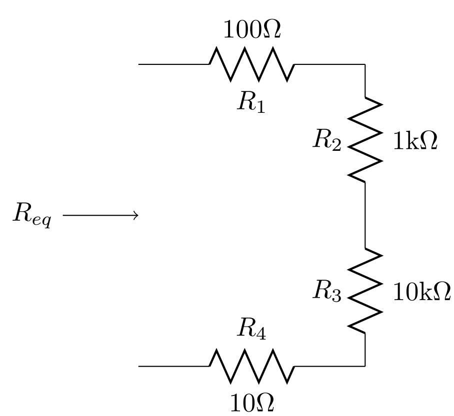


Figure 1:

3. The resistors in Figure 2 are said to be connected in **parallel** with each other. Parallel circuit elements are elements which are joined to each other at both terminals. The equivalent resistance for parallel resistors is calculated by adding the reciprocals of each resistor, and then taking the reciprocal of that sum. Determine the equivalent resistance, R_{eq}, for this network.

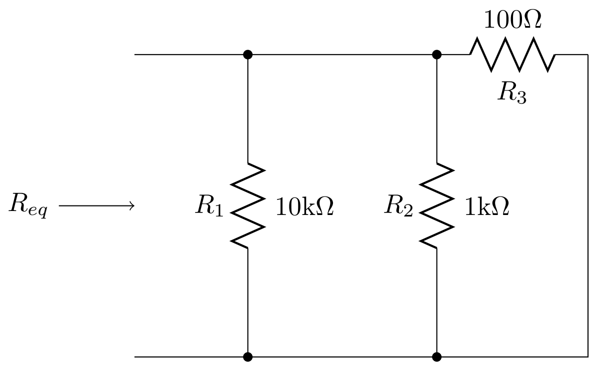


Figure 2:

4. For Figure 3, using your knowledge of Kirchoff's Voltage Law and Ohm's Law, calculate the values for I_a and I_b. With this information and Kirchoff's Current Law, determine the value for I_s

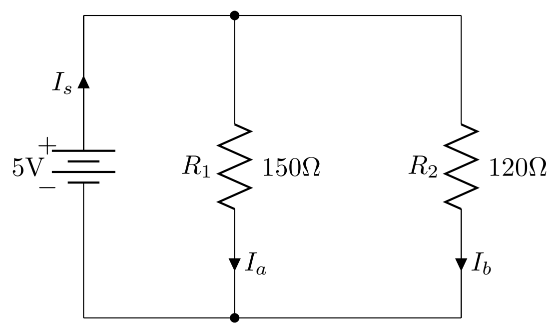


Figure 3:

5. Draw an equivalent circuit for the network shown in Figure 4 by calculating an equivalent resistance for the two resistors. Then, determine the value of I_s by using what you know about KVL, KCL, and Ohm's Law. Once you have determined the value for I_s, refer to the original schematic and calculate the values for V_1 and V_2

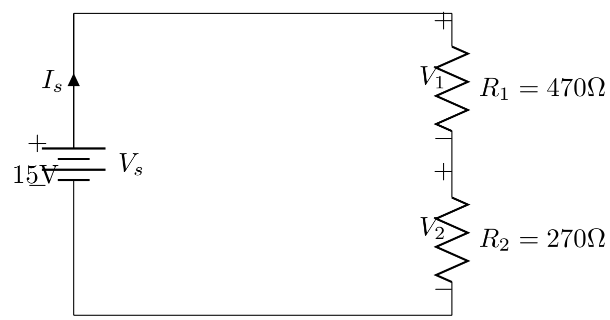


Figure 4:

Lab Exercises

1. Take the resistors out of their bag. Make sure there are 8 of them. Make a chart with headings like the one below. List each resistor by its color bands (see column "Resistor Color Bands" below). Using the color code scheme given on the chart, determine the values for each resistor and write these in the column under "Value". **If you are color-blind, now is a good time to mention this!** When you have done this for each resistor, measure the resistor values with a multimeter (set to ohms). Write this value in the "Measured Value" column. When you are measuring resistances, be sure not to grab the leads with your hands, because you will, in effect, be including your own resistance (in parallel) to that resistor (and this may affect the answer you get). All the resistors in this lab have a tolerance of 5% (as indicated by the gold band on the end). Indicate whether or not the resistors are within tolerance in the last column. You will be using these again later in this lab, so be sure to keep them organized. When you are finished with the lab, put the resistors back in their bag.

Color Bands	**Labeled Value**	**Measured Value**	**% Difference**	**Within Tolerance**
br-blk-r-(gold)	1 kΩ	1.04kΩ	4.0%	yes

Exercises 2 - 5 require you to build circuits on a protoboard. For all of these circuits, proper breadboarding technique will be expected. This includes using the built-in runners on the breadboards when applicable, using wire cut to proper lengths, and using a proper amount of breadboard space. In short, the circuits you build should be "readable." Any circuit that does not demonstrate proper breadboarding technique will have to be rewired.

2. Using resistors and wire, build the circuit from Prelab Part 2. **Power does not need to be applied to this circuit**. Use the multimeter to measure the equivalent resistance (R_{eq}) of the circuit. What value do you measure, and how does this compare to the value you calculated in the prelab? (Perform a percent difference between the measured value and the expected value of the equivalent resistance.) The equivalent resistance value you measured here was probably not exactly what you had calculated in the prelab. What reasons can you think of to account for this difference?

$$\%error = \frac{Experimental - Theoretical}{Theoretical} \times 100\% \qquad (2)$$

3. Follow all the instructions from number 2 above for Prelab Part 3.

4. Build the circuit from Prelab Part 4. **Ask one of the lab assistants to check your circuit before applying power to it.**

   (a) **Measuring current using Ohm's Law:** Using a volt meter, determine the value for I_a by first measuring the voltage drop across the resistor, and then, solve for the current using Ohm's Law. Measure the voltage drop first with the meter probes one way (red/black), then the other (black/red). What affect, if any, does switching the probes have on your measured voltage value? Write down your answer for I_a (positive answer). In the same way, measure and record the value of I_b. Perform a percent difference between these current values and the ones you calculated in the prelab exercise for this circuit.

   (b) Now, measure I_a and I_b directly by using the multimeter set to measure current by "breaking" each branch of the circuit - remember, do not attach the leads in parallel with the resistor! Be sure you understand how to do this, if you are not sure, ask before trying something because you can damage the meter by measuring current incorrectly. Record the values. Perform a percent difference between these current values and the ones you calculated in the prelab exercise for this circuit.

   (c) Determine the source current (I_s) by "breaking" the circuit and using a current meter. I_s this value for I_s equal to the sum of what you measured for I_a and I_b?

5. With the help of a multimeter, set the protoboard's adjustable source voltage to as close to 15Vas you can make it. This will be Vs for the circuit in Prelab Part 5. Record the actual value you set for V_s. Build the circuit from Prelab Part 5, and as always, ask one of the lab assistants to look over your circuit before applying power to it. With the multimeter, measure V_1 and V_2. Perform a percent difference between your measured voltages for V_1 and V_2 and those values that you calculated in the prelab. Do these two (measured) values add up to equal the value that you set for your source voltage?