Name: ___________________________

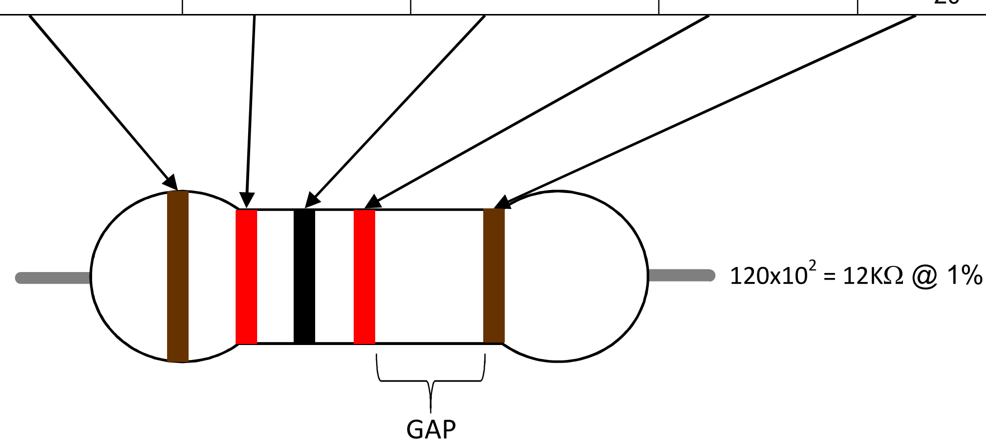
# Ohm’s Law and Resistor Lab

## Discussion Overview

Through-hole resistors use a color coded scheme to represent the value of the resistor. This scheme uses different colors, shown in Table 1 below, to designate a different digit.

Table 1 - Resistor Color Coding Scheme

| Color | Significant Digits | | | Multiplier | Tolerance (%) |
|---|---|---|---|---|---|
| Black | 0 | 0 | 0 | x $10^0$ = x 1 | |
| Brown | 1 | 1 | 1 | x $10^1$ = x 10 | 1 |
| Red | 2 | 2 | 2 | x $10^2$ = x 100 | 2 |
| Orange | 3 | 3 | 3 | x $10^3$ = x 1K | |
| Yellow | 4 | 4 | 4 | x $10^4$ = x 10K | |
| Green | 5 | 5 | 5 | x $10^5$ = x 100K | 0.5 |
| Blue | 6 | 6 | 6 | x $10^6$ = x 1M | 0.25 |
| Violet | 7 | 7 | 7 | x $10^7$ = x 10M | 0.1 |
| Grey | 8 | 8 | 8 | x $10^8$ = x 100M | 0.05 |
| White | 9 | 9 | 9 | x $10^9$ = x 1G | |
| Gold | | | 3rd digit significant only in a 5 band configuration | x $10^{-1}$ = x 0.1 | 5 |
| Silver | | | | x $10^{-2}$ = x 0.01 | 10 |
| None | | | | | 20 |




Depending on the tolerance value, a resistor might contain 4 or 5 bands. Resistors with tolerances larger than or equal to 5% contain only 4 color bands while resistors with tolerances smaller than 5% contain 5 color bands. Regardless of the number of bands, the last (right most) color band signifies the tolerance value; the color band second to last signifies the magnitude (exponent) or the multiplier; and the remaining bands signify the digits in the precision part of the value. Therefore, a 4 color band resistor has 2 significant digits in its precision part while a 5 color band resistor has 3 significant digits.

The color bands are read from left to right where the tolerance band is the right most band with a gap between the tolerance band and the rest of the bands as shown in the diagram above.

In the example above, there are 5 color bands; therefore, the first 3 bands are significant digits, the fourth band is the exponent, and the right most band is the tolerance. The first (left most) band is brown = 1, the second band is red = 2 and the third band is black = 0. Therefore, the significant digits are 120. The fourth band is red = 2, and therefore, the exponent is 2. Combining the precision part and the exponent part gives us the value $120 \times 10^2$ or 12KΩ for the value of the resistor. The left most band is brown = 1 which indicates that the tolerance of this resistor is 1%.

## Ohm's Law

Ohm's law is the most basic law of electricity. It was formulated in 1827 by the German physicist and mathematician Georg Simon Ohm. Through his experiments, Ohm discovered the relationship between voltage difference, current and resistance. He noticed that as he increased the voltage difference across a fixed resistance, the current increased proportionally. In language of math, we should this direct proportionality as follows.

$$I \propto V$$

On the other hand, he noticed that if he kept the voltage difference the same but increased the resistance, the current decreased. Therefore,

$$I \propto \frac{1}{R}$$

No other parameter in the circuit affected the amount of current. Therefore, voltage difference and resistance were the only factors affecting the current flowing in the circuit. Based on these observations, he derived the following equation known as Ohm's law.

$$I = \frac{V}{R}$$

The unit of potential (voltage) difference is Volts; that of resistance is Ohms (Ω); and the unit of current is Amperes. If V is given in mV and R in Ohms, current will be in mA.

Other useful forms of Ohm's law are

$$V = IR$$

$$R = \frac{V}{I}$$

## Voltmeters

Voltmeters (usually part of a multi-meter) are used for measuring the voltage difference between two points in a circuit. Since voltmeters measure voltage differences, the probes are placed across the circuit of interest (for example, a resistor).

The positive or red lead of the voltmeter is connected to the point where the current enters the circuit, and the negative or black lead is connected to the point where the current leaves the circuit. If you do not know the direction of the current, connect the probes in a configuration of your choosing. If the measured voltage is positive, it means that the current is entering the circuit where the positive or red lead is connected, and it's exiting the circuit where the negative or black lead is connected. If the measured voltage is negative, then the current is flowing in the opposite direction of what you thought.

To use a voltmeter, follow the steps below:

1. Set the multi-meter for measuring voltage. Make sure the setting reflects the range of voltages you are trying to measure.
2. Connect the positive and negative leads across the circuit or component that you are trying to measure the voltage difference for.
3. Read out the measured value on the multi-meters display. Pay close attention to the units displayed on top of the display.

# Procedure

## Resistance Color Coding Scheme

1. Given the nominal values and tolerances in the table below, determine and record the corresponding color code bands:

| Value | Band 1 | Band 2 | Band 3 | Band 4 | Band 5 |
|---|---|---|---|---|---|
| 27 @ 10% | | | | | |
| 125 @ 1% | | | | | |
| 2.7K @ 5% | | | | | |

2. Given the color codes in the table below, determine and record the nominal values and tolerances in each row:

| Colors | Nominal | Tolerance | Minimum | Maximum |
|---|---|---|---|---|
| Red-red-black-silver | | | | |
| Blue-gray-black-gold | | | | |
| Brown-green-gray-red-red | | | | |
| Gray-red-yellow-none | | | | |

Name: ______________________

## LED Circuit

In this part of the lab, you will be building the following simple circuit. As part of this experiment, you will be asked to determine the value of the current limiting resistor based on a desired current through the LED.

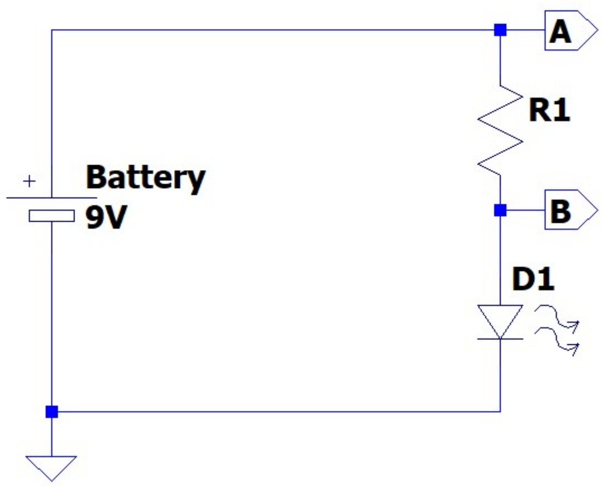



Figure 1 - Simple LED Circuit

A. Use a red LED for D1
    a. Assume the forward voltage $V_f = 2.2V$

B. Determine the value for resistor $R_1$
    a. We would like to limit the current flowing through the LED to $I_f = 10ma$.
    b. Given that the battery voltage is $V_{Bat} = 9V$ and the forward voltage of the LED is $V_f = 2.2V$, what is the voltage across the resistor $R_1$, $V_{AB}$?

    $V_{AB} = V_{Bat} - V_f =$ ____________________ $V$

    c. Therefore, applying Ohm's Law to R1:

    $R_1 = \frac{V_{AB}}{I_f} =$ _________________________ $\Omega$

    d. Use a voltmeter to measure the voltage across the LED (forward voltage $V_f$).

    $V_f =$ _______________________ $V$

    e. Use the voltmeter to measure the voltage across the resistor ($V_{AB}$).

    $V_{AB} =$ ______________________ $V$

f. How does this value compare to what you calculated in step b.

g. What value resistor would you have to use to get $I_f = 20ma$ through the LED?

h. Would this new value make the LED brighter or dimmer?

i. Replace $R_1$ with a photo-resistor. Use test clips to connect the photo-resistor to the circuit.

j. Take the photo-resistor under the desk to reduce the light shining on it. What happens with the LED? Why?

k. Use your phone's flash light to shine light on the photo-resistor. What happens with the LED? Why?