DC Circuits (Combination of resistances)

EQUIPMENT NEEDED:
- Circuits Experiment Board
- One D-cell Battery
- Wire leads
- Multimeter
- 100, 330, 1k Ω resistors

Purpose
The purpose of this section is to begin experimenting with the variables that contribute to the operation of an electrical circuit.

Procedure
1. Find the three resistors that have values as indicated by their color code; R₁ = 100 Ω, R₂ = 330 Ω, and R₃ = 1000 Ω. Enter their color codes in Table 4.1 below. You will refer to these resistors as #1, #2, and #3, respectively.

2. From the color code, determine the manufacturer's stated resistance of each and enter the value in the column labeled "Coded Resistance" in Table 4.1. Enter the Tolerance value as indicated by the color of the fourth band under "Tolerance".

3. Use your Multimeter to measure the resistance of each resistor and enter these values in Table 4.1.

4. Since we do not know the real or true value of the resistance, you cannot calculate a percentage error. To compare your measured value with the manufacture's coded value, you should calculate the percentage difference.
   \[ \text{Percentage Difference} = \left( \frac{|\text{measured} - \text{coded}|}{\frac{1}{2} (\text{measured} + \text{coded})} \right) \times 100\% \]

Reference for Resistors

<table>
<thead>
<tr>
<th>Color</th>
<th>1st Digit</th>
<th>2nd Digit</th>
<th>No. of Zeros</th>
<th>Fourth Band</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>0</td>
<td></td>
<td></td>
<td>None</td>
<td>±20%</td>
</tr>
<tr>
<td>Brown</td>
<td>1</td>
<td></td>
<td></td>
<td>Silver</td>
<td>±10%</td>
</tr>
<tr>
<td>Red</td>
<td>2</td>
<td></td>
<td></td>
<td>Gold</td>
<td>±5%</td>
</tr>
<tr>
<td>Orange</td>
<td>3</td>
<td></td>
<td></td>
<td>Red</td>
<td>±2%</td>
</tr>
<tr>
<td>Yellow</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Violet</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gray</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Example: Suppose the colors are (in order from the end closest to the color bands) are red red orange red. This means the resistance is 22000 ohms plus or minus 2% of 22000 or 22 ± 0.44 kΩ.
<table>
<thead>
<tr>
<th>Colors 1st</th>
<th>Colors 2nd</th>
<th>Colors 3rd</th>
<th>Colors 4th</th>
<th>Coded Resistance</th>
<th>Measured Resistance</th>
<th>% Difference</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td></td>
<td></td>
<td></td>
<td>100 Ω</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#2</td>
<td></td>
<td></td>
<td></td>
<td>330 Ω</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#3</td>
<td></td>
<td></td>
<td></td>
<td>1000 Ω</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.1

Q. How do the % differences you calculated for your resistors compare with the manufacturer’s tolerances?

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**Project 1: Resistors in Series**

**Activity 1: Equivalent resistance**

1. Connect the three resistors in SERIES, figure 4.1, using the spring clips on the Circuits Experiment Board to connect the leads of the resistors together without bending them. Measure the resistances of the combinations as indicated on the diagram by connecting the leads of the Multimeter to the points at the ends of the arrows.

![Figure 4.1 Series](image)

Q. What is the apparent rule for combining resistances in series? Cite evidence from your data to support your conclusions.
Activity 2: Measuring Voltages and Currents within Series Circuits

1. Connect the series combination of the three to the D-cell battery. Note which end is connected to the negative and which is connected to the positive terminals.

2. Set the Multimeter to measure dc voltage on an appropriate range of sensitivity. Measure the voltages across the individual resistors and then across the combinations of resistors. Be careful to observe the polarity of the leads (red is +, black is -). Record your readings below. (The values of the can be used from the measurements you made in Activity 1.)

![Figure 4.2 Series](Image)

Project 2: Resistors in Parallel

Activity 1: Equivalent resistance

1. Construct PARALLEL combinations of resistors, first using two resistors at a time to make \( R_{12}, \ R_{23}, \) and \( R_{13}, \) and then using all three for \( R_{123}. \) Measure and record the resistances.

![Parallel](Image)
Q. What is the apparent rule for combining resistances in parallel? Cite evidence from your data to support your conclusions.

Activity 2: Measuring Voltages and Currents within Parallel Circuits

1. Now connect the parallel combination of resistance to a battery like in the circuit of figure 4.4.

2. Set the multimeter to measure current. Measure the total current provided from the battery, and the current through each resistor by breaking the circuit and inserting the multimeter into each position indicated in Figure 4.5. Recall that in order to measure current, the multimeter must be in series so that current flows through the meter.

3. Also measure and record the indicated voltages.

Parallel

![Figure 4.4](image1)

![Figure 4.5](image2)
\[ \begin{align*}
I_0 &= \underline{\quad} \\
R_1 &= \underline{\quad} \quad I_1 &= \underline{\quad} \quad V_1 &= \underline{\quad} \\
R_2 &= \underline{\quad} \quad I_2 &= \underline{\quad} \quad V_2 &= \underline{\quad} \\
R_3 &= \underline{\quad} \quad I_3 &= \underline{\quad} \quad V_3 &= \underline{\quad} \\
R_{123} &= \underline{\quad} \quad I_4 &= \underline{\quad} \quad V_{123} &= \underline{\quad}
\end{align*} \]

**Discussion**

1. According to the data you recorded in the Table with Figure 4.2, what is the pattern for how voltage gets distributed in a series circuit of resistors?

Do your results confirm Kirchhoff’s Loop rule? (Is the voltage rise due to the battery equal to the sum of the voltage drops across the resistors?) Show your work.

2. Is there any relationship between the size of the resistance and the size of the voltage across it for resistors in a series circuit?

3. Utilizing the data you recorded for Figure 4.5, what is the pattern for how current gets distributed in a parallel circuit of resistors?
Do your results confirm Kirchhoff’s Junction (or Node) rule? (Is the current from the battery equal to the sum of the currents through the resistors?) Show your work.

4. Is there any relationship between the size of the resistance and the size of the current through it for resistors in a parallel circuit?

5. For each resistor in Figure 4.5, compare the product of current times resistance to the measured value of the voltage across the resistor. How should these compare?
HOMEWORK

1. Calculate the equivalent (total) resistance of this combination of resistances.

\[ R_1 = 100 \text{ k}\Omega \]
\[ R_2 = 200 \text{ k}\Omega \]
\[ R_3 = 300 \text{ k}\Omega \]

2. In the circuit shown, calculate the voltage difference between points A and B.

Where \[ V = 30 \text{ volts} \]
\[ R_1 = 250 \text{ }\Omega \]
\[ R_2 = 300 \text{ }\Omega \]
\[ R_3 = 350 \text{ }\Omega \]

4. Find the total current supplied by the battery.

Where \[ V = 30 \text{ volts} \]
\[ R_1 = 250 \text{ }\Omega \]
\[ R_2 = 300 \text{ }\Omega \]
\[ R_3 = 350 \text{ }\Omega \]