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Experiment 2.05: Wheatstone Bridge

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I. EXPERIMENT 2.05: WHEATSTONE BRIDGE

A. Abstract

The Wheatstone bridge circuit is used to determine the resistances of several resistors.

B. Formulas

$$R = \left(\frac{L_L}{L_R}\right) R_0 \tag{1}$$

This equation is specific to the Wheatstone bridge circuit in the balanced condition described below.

Resistor color codes:

color	no.
black	0
brown	1
red	2
orange	3
yellow	4
green	5
blue	6
violet	7
gray	8
white	9

$$R = (10c_1 + c_2) \times 10^{c_3}$$

where $(c_1\ c_2\ c_3)$ represents the resistor's 3-color bands and R is the value of the resistance in Ohms.

C. Description and Background

The Wheatstone bridge circuit is used as one of two methods to determine the resistances of five carbon composition resistors. The second method uses an Ohmmeter. The rated re-

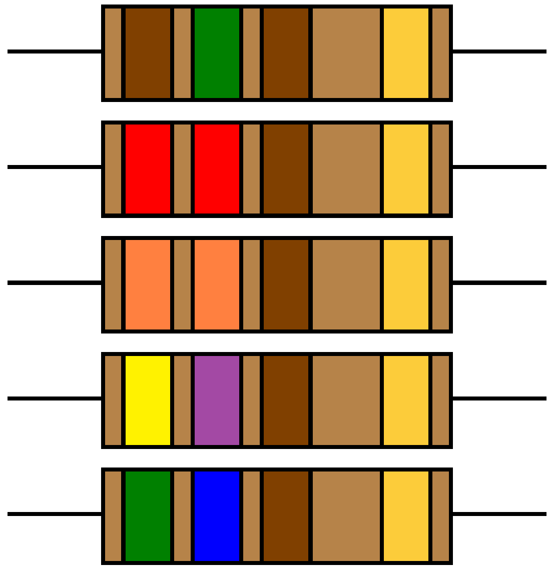

FIG. 1. The resistors used in the experiment.

sistances of the resistors are color encoded as follows $R = (10c_1 + c_2) \times 10^{c_3}$, where (c_1, c_2, c_3) are the three colors from left to right in Fig. 1.

In Figure 2 below, the slider, S, is moved along the length of a meter long wire, and a contact button is pressed resulting in the circuit depicted in the schematic of Fig. 3.The contact button splits the wire into to lengths, L_L and L_R with resistances $R_L = \rho L_L/A$ and $R_R = \rho L_R/A$, repectively. In the balanced condition, the galvanometer registers no current flow.so that $\Delta V_{ab} = \Delta V_{ad}$ and $\Delta V_{cb} = \Delta V_{cd}$. Equation (1) then follows from Ohm's law. The resistance, R, is the test resistor (or unknown); the resistance, R_0, is a dialable resistance box. By setting a value for R_0, and finding the location of the slider in the balanced condition, *i.e.*, the values of L_L and L_R, the value of R can be determined.

D. Procedure

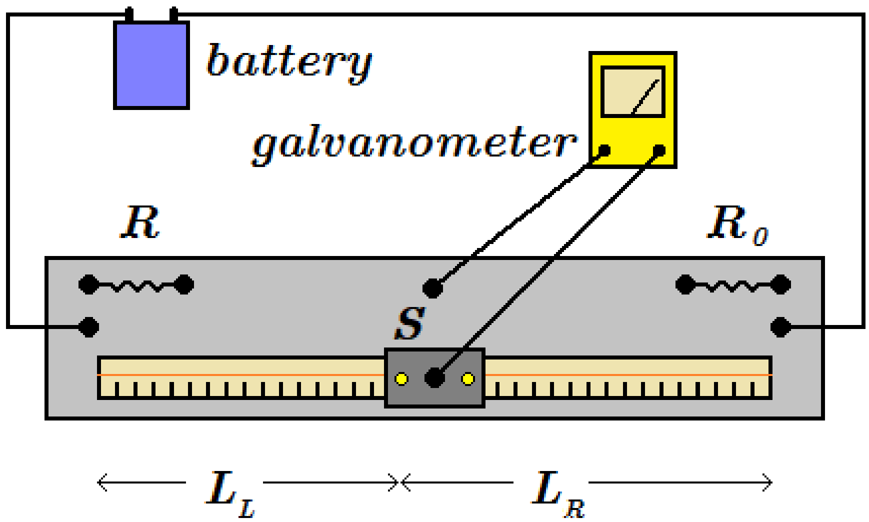

FIG. 2. Wheatstone bridge set-up for the experiment.

1. Set up the Wheatstone circuit in the figure. Note that the portion of the slider wire labelled L_L is on the side of the set-up with the unknown resistance R.
2. Select a resistor (R in the figure) to analyze; color decode its resistance and record this value.
3. Set the R_0 resistance (a resistance box) to be about 10% greater than the color value.
4. Move the slider so that the needle on the galvanometer is not deflected.This is referred to as the balanced condition, and Eq. (1) holds.
5. Record the length of the resistive wire to the left and to the right of the slider.
6. Set the R_0 resistance to be about 10% less than the color value.
7. Move the slider so that the needle on the galvanometer is not deflected.
8. Record the length of the resistive wire to the left and to the right of the slider.
9. Measure the resistance using the ohmmeter. See Appendix I at the end of this document for important instructions on the use of multimeters.

10. Repeat this procedure for other resistors.

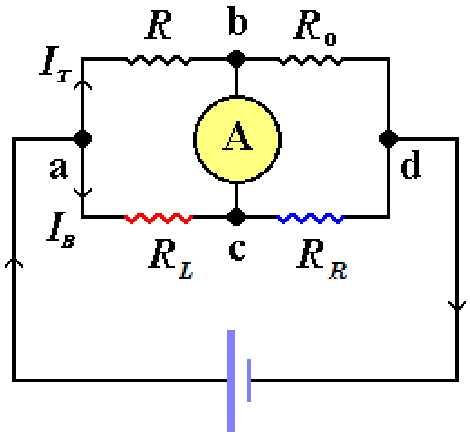

FIG. 3. Wheatstone bridge schematic.

E. Measurements

<table>
<tr><td rowspan="2">resistor</td><td rowspan="2">$R_{\text{by color}}$ [Ω]</td><td>$R_0^{(+)} \approx 1.1\ R_{\text{by color}}$ [Ω]</td><td>$L_L^{(+)}$ [cm]</td><td>$L_R^{(+)}$ [cm]</td><td rowspan="2">R_{Ohmmeter} [Ω]</td></tr>
<tr><td>$R_0^{(-)} \approx 0.9\ R_{\text{by color}}$ [Ω]</td><td>$L_L^{(-)}$ [cm]</td><td>$L_R^{(-)}$ [cm]</td></tr>
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F. Instructions

1. Use Eq. (1) to calculate the resistance of each resistor analyzed twice, once with the (+) data and once with the (-) data.

2. Use the calculated values, R_{WB}, for resistors 1-5 to determine the percent errors taking R_{Ohmmeter} as the accepted value.

G. Calculations

resistor	$R^{(+)}$ [Ω] / $R^{(-)}$ [Ω]	$R_{\mathrm{WB}} = \left(R^{(+)} + R^{(-)}\right)/2$ [Ω]	%-Err (R_{WB})
1			
2			
3			
4			
5			