PHYS 2212L - Principles of Physics Laboratory II

Laboratory Advanced Sheet
Resistors

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1. Objectives. The objectives of this laboratory are

   a. to verify the linear dependence of resistance upon length of a conductor of uniform diameter, and

   b. to understand the use of a Wheatstone bridge to measure unknown resistances.

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2. Theory.

   a. The resistance of a conducting wire is given by

$$R = \rho L/A \qquad (1)$$

   where

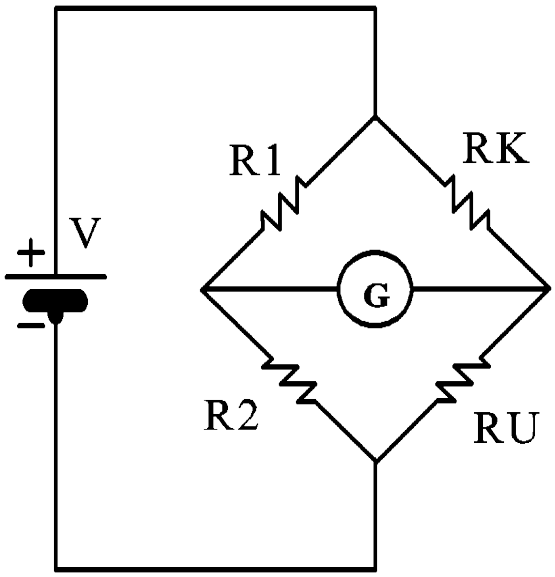
   R is the resistance of the conductor in units of ohms (Ω),

   ρ is the resistivity of the conducting material in units of (Ω m),

   L is the length of the conductor in units of m, and

   A is the cross-sectional area of the conductor in units of m^2.

   b. The Wheatstone bridge consists of three resistors of known resistance, one resistor of unknown resistance, a voltage source and a galvanometer connected in a circuit which allows the resistance of the unknown resistor to be determined. Figure 1 below shows the Wheatstone bridge circuit.



In this experiment (but not in all Wheatstone bridges), resistors, R_1 and R_2, are provided by a 1.00 m long conducting wire that may be tapped at any point along its length to divide its total resistance into two parts, R_1 and R_2. Resistor, R_K, is the resistor of known resistance; resistor, R_U, is the resistor of unknown resistance. The resistances of R_1 and R_2 are varied until the galvanometer indicates that no current flows across it. In this condition the potential difference across the galvanometer is zero. If current, I_1, flows through resistors R_1 and R_2, and current, I_2, flows through resistors R_K and R_U, then

$$I_1 R_1 = I_2 R_K$$

$$I_1 R_2 = I_2 R_U$$

Dividing the second of these equations by the first, and solving for R_U, yields

$$R_U = R_2 R_K / R_1$$

Since R_1 and R_2 are formed from the same wire conductor, when equation 1 substituted into the last equation, the result is

$$\mathbf{R_U = L_2 R_K / L_1} \qquad \mathbf{(2)}$$

where

L_1 and L_2 are the lengths of the conducting wires forming R_1 and R_2.

c. In this experiment the use of equation 2 above depends upon the linear relationship between resistance and length of a conducting wire described in equation 1. Therefore, verification of the linear relationship between resistance and length of a conducting wire of uniform cross-sectional area must precede measurements with the Wheatstone bridge.

1) The first objective of this experiment is to verify that linear relationship. This will be accomplished by placing a constant potential difference across the full length of the wire and measuring the voltage drop across a variety of partial lengths of the wire. Since the current in the wire is constant, the voltage drop across a given portion of the wire is proportional to the resistance of that portion of the wire. Thus, a graph of voltage drop versus wire length should be a straight line.

2) For the second objective, a single known resistance will be used in the Wheatstone bridge apparatus to determine the resistances of a variety of resistors. The actual values of the resistances will be determined using a multimeter and the percent discrepancy in the results will be calculated. A graph of the percent discrepancy versus actual resistance will be used to develop conclusions about the suitability of the Wheatstone bridge method for measuring resistance.

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3. Apparatus and experimental procedures.

a. Equipment.

1) Wheatstone bridge apparatus.

2) Variety of resistors.

3) Galvanometer

4) Multimeter.

5) Power supply

6) Connecting wires.

b. Experimental setup. A figure for the experimental setup will be provided by the student.

c. Capabilities. Capabilities of the equipment items listed in paragraph 3a will be provided by the student.

d. Procedures. Detailed instructions are provided in paragraph 4 below.

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4. Requirements.

a. In the laboratory.

1) Your instructor will introduce you to the equipment to be used in the experiment.

2) Measurements to verify the linear relationship between resistance and length of a wire conductor will be made.

3) Measurements of unknown resistances will made using the Wheatstone bridge apparatus and a multimeter.

4) Your instructor will discuss methods to be used to prepare your data for plotting using the Microsoft Excel™ spreadsheet program.

b. After the laboratory. The items listed below will be turned in at the beginning of the next laboratory period. A complete laboratory report is **not** required for this experiment.

Para 3. Apparatus and experimental procedures.

1) Provide a figure of the experimental apparatus (para 3b).

2) Provide descriptions of the capabilities of equipment used in the experiment (para 3c).

Para 4. Data. Data tables are included at Annex A for recording measurements taken in the laboratory. A copy of these tables must be included with the lab report. Provide the items listed below in your report in the form a Microsoft Excel™ spreadsheet showing data, calculations and graphs. The spreadsheet will include:

1) A table of data from the linearity measurements.

2) The value of the known resistance, R_K.

3) A table with data from the Wheatstone bridge measurements. The table should include columns for nominal resistance, resistance measured using the multimeter, lengths L_1 and L_2, the resistance calculated from the Wheatstone bridge measurements, and the percent discrepancy.

4) Graphs of

a) Voltage drop versus length of wire conductor that includes a regression line (trend line) and its equation.

b) Percent discrepancy versus actual resistance. Use a linear axis scale for the percent discrepancy and a logarithmic axis scale for the actual resistance.

5. Results and Conclusions.

a. Results.

1) A statement regarding the verification of the linear relationship between resistance and length of a wire conductor.

2) A statement regarding the capabilty of the Wheatstone bridge apparatus to measure resistance when used in the configuration of this experiment.

b. Conclusions.

1) Description of the sources of systematic error in the experiment.

2) Description of the sources of random error in the experiment.

Annex A
Data

1. Linearity measurements.

length (cm)	voltage drop (V)
10	
15	
20	
25	
30	
35	
40	
45	
50	
55	
60	
65	
70	
75	
80	
85	
90	

95	

2. Resistance measurements.

a. Known resistance, R_K. Use a nominal 3.3 kΩ resistor.

Known resistance R_K (kΩ)

b. Wheatstone bridge measurements.

Resistance nominal (kΩ)	Resistance multimeter (kΩ)	Length L_1 (cm)
0.47		
0.68		
1.0		
1.5		
2.2		
3.3		
4.7		
6.8		
10		

15		
22		
33		
47		

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