Circuit Basics

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Physics 210L
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Abstract—Placeholder

CONTENTS

I. INTRODUCTION

THIS experiment will investigate an important property common to all electrical circuits known as resistance. The relationship between resistance, current, and potential difference (Ohm's Law) will be examined and utilized.

Objectives The experimental objectives of this three part activity are:

1) Part 1: To measure the resistance of test leads.
2) Part 2: To learn how to wire a circuit on a Proto-board and to study the effects of ammeters and voltmeters in a circuit.
3) Part 3: To learn how to wire series and parallel circuits.

II. THEORY

III. METHODOLOGY

Part 1

1) X leads were wired together in series.
2) The resistance of the entire series of leads ($R_e q$) was measured with a multimeter and recorded.
3) The number of leads used (n_L) was recorded.
4) The length of series of leads was measured with a meter stick and recorded.

Part 2

1) A digital multimeter was used to measure the resistance between points in the protoboard in order to determine its internal wiring.
2) The circuit shown in Figure **??** was constructed with $R_1 = n$ and $\varepsilon = e$, both in series with the DMM in ammeter mode.
3) The current I_1 through resistor R_1 was measured and recorded.

4) A DMM in voltmeter mode was wired across R_1 and the change in ammeter's reading was recorded as I_2.
5) The voltmeter was replaced with an analog voltmeter on the 1.5 V scale, and the change in the ammeter's reading was recorded as I_3.
6) The analog voltmeter was disconnected, and its resistance was measured while on the 1.5 V scale with a DMM and recorded as V_{analog}.
7) The measurement of resistance was repeated for the digital voltmeter and recorded as V_{digital}.
8) The circuit was reset to the state shown in **??**.
9) A DMM in voltmeter mode was wired across the resistor R_1 and the battery.
10) The voltage across R_1 was recorded as V_1, and the voltage across the battery was recorded as ϵ_1.
11) The multimeter was left on the scale used for the previous measurement, and its resistance was measured. The scale setting and resistance were recorded.
12) The previous measurements were repeated using a different ammeter scale. The voltage was recorded as V_2 and ϵ_2. The scale and resistance of the ammeter were also measured and recorded.

Part 3

1) **Series Resistor Combinations**

   a) Measured the resistance of the three resistors provided.
   b) A series circuit was built with these resistors on a protoboard, and the equivalent resistance was measured with an ohmmeter.
   c) A power supply was chosen to connect to the series circuit. The maximum current the circuit could carry was calculated, given that the resistors had a power limitation of 1/4 W. The maximum current and voltage were recorded.
   d) The power supply was wired to the circuit, and the voltages across the power supply and across each resistor were measured.

2) **Parallel Resistor Combinations**

   a) Two of the resistors were chosen, and a parallel combination was constructed on the protoboard. The equivalent resistance of the circuit was measured and recorded.
   b) A power supply was selected, and the maximum theoretical voltage and current were calculated and recorded.
   c) The circuit was powered by the supply, and the currents through the power supply and through each of the resistors were measured.

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IV. DATA

Part 1

Number of Test Leads Used:	<u>Stuff</u>
Total Resistance of Test Leads:	<u>Stuff</u>

Part 2

Current through R_1:

$$I_1 = nA$$

Current through R_1 (with digital voltmeter in circuit):

I_2	nA
Deviation from I_1:	nA

Current through R_1 (with analog voltmeter in circuit):

I_3 :	nA
Deviation from I_1:	nA

Meter Resistance Measurements:

$$R_{\text{analog-voltmeter}} = n$$
$$R_{\text{digital-voltmeter}} = n$$

Voltage Measurements with DMM:

Resistor Voltage:	$n\Omega$
Battery Voltage:	$n\Omega$

Ammeter Resistance for above measurement:

Scale Used: n $\qquad R_{\text{digital-ammeter}} = nA$

Voltage Measurements with DMM (with ammeter at different scale):

Resistor Voltage:	$n\Omega$
Battery Voltage:	$n\Omega$

Ammeter Resistance for previous measurement:

Scale Used: n $\qquad R_{\text{digital-ammeter}} = nA$

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V. ANALYSIS AND RESULTS

Part 1
Calculate the average resistance of a test lead and describe the method used.
Part 2
Explain the observations made in items 3 and 4. What is the most important characteristic of a voltmeter, and why?

Explain any discrepancies in item 6 with voltage measured across the resistor using the multimeter. Does the ammeter affect the circuit? If so, how?
Part 3
1) Series:
   a) Calculate the series equivalent resistance and compare it (with percent difference) to the measured value.
   b) Verify Kirchoff's Voltage Rule by comparing the sum of the voltage drops across each of the resistors with the measured terminal voltage V_T.
   c) Verify the voltage divider expression for one of the resistors, $V_{Ri} = \Delta V_S R_i / \sum R_i$
2) Parallel:
   a) Calculate the parallel equivalent resistance and compare it (with percent difference) to the measured value.
   b) Verify Kirchoff's Current Rule by comparing the sum of the currents through the resistors with the measured current I_s.
   c) Verify the current divider expression by calculating the current through one resistor and comparing it with the measured value, $I_{Ri} = I_S R_{eq} / R_i$

APPENDIX A
DERIVATION

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Part 2

Series

Maximum Current = n $\qquad\qquad$ Maximum Voltage = nV

Measured Resistance Values: $R_1 = n$ $\qquad\qquad R_2 = n R_3 = n$

Series Equivalent Resistance: $R = n$

$V_{\text{Supply}} = n V_1 = n$ $\qquad\qquad V_2 = nV V_3 = nV$

Parallel

Maximum Voltage = nV

Measured Resistance: $\qquad\qquad R_1 = R_2 =$

Parallel Equivalent Resistance: $R =$

$V_{\text{Supply}} = nV$

$I_S = nV$ $\qquad\qquad I_1 = nV I_2 = nV$