

DC Circuits

Objectives

The objectives of this lab are:

- 1) to construct an Ohmmeter (a device that measures resistance) using our knowledge of Ohm's Law.
 - 2) to determine an unknown resistance using our Ohmmeter.
 - 3) to verify Ohm's law.
 - 4) to verify Kirchhoff's Rules by adding the voltage differences around a loop and by adding currents going into and out of a junction.
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Review of Ohm's Law:

The potential drop across a resistor is given by Ohm's Law:

$$V = IR$$

where I is the current and R is the resistance.

Kirchhoff's Rules:

Kirchhoff's Rules are a set of two rules which, along with Ohm's Law, allow you to solve for the current, voltage, or resistance of a circuit.

Kirchhoff's Rule #1--The Junction Rule: When wires meet at an intersection, the **algebraic** sum of all the currents going through the intersection must equal zero. Put another way:

the current going in = the current going out

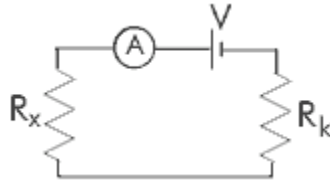
This is just another way of saying that charge is conserved.

Kirchhoff's Rule #2--The Voltage Rule: The sum of the voltages gained or lost in a circuit loop must equal zero. Put another way:

the energy gained = the energy lost when going around a loop.

As electrons go across a battery they gain electrical potential energy. As they go across a resistor, they lose that energy. The energy lost should equal the energy gained, so that when they come back to the same point (i.e. they go in a loop) they should have the same energy as before.

Constructing an Ohmmeter:



Using the circuit shown, the result of Kirchhoff's Laws are:

$$V = IR_x + IR_k$$

Rearranging this formula for R_x , an unknown resistor, in terms of R_k , a known resistor, and V , a known voltage source (a battery), we easily obtain:

$$R_x = V/I - R_k$$

We know R_k (it is given). We can measure the voltage, V , with a voltmeter and we can measure the current, I , using a galvanometer. The current is proportional to the deflection of the needle in the galvanometer:

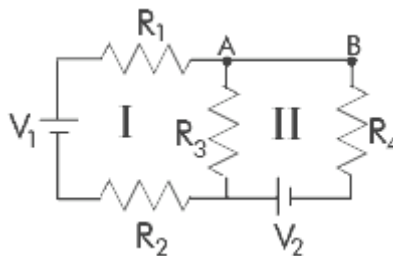
$$G = kI$$

where k is just some constant of proportionality. Plugging this in, we have the equation:

$$R_x = (kV)/G - R_k$$

which is a linear equation (of the form $y = mx + b$). Unfortunately you don't know the constant of proportionality (and I'm not telling!). Since you don't know k , you have to first figure it out by trying some known R_x . Once you have k , then you can use your ohmmeter with an unknown R_x .

Verifying Kirchhoff's Rules:



We want to verify Kirchhoff's two rules. First we will verify the voltage rule by measuring the voltages around the loops. (Remember that you don't know theoretically which way the current will flow at this point). Second we will verify that the current coming into node A equals the current going out of node A.

Procedure:

Part I: Constructing an Ohmmeter:

Obtain: 1 tester board, 1 galvanometer, 5 different resistors (R_x), and a R_k resistor of 1.8 k (Brown-Grey-Red-Gold resistor code)

1) Create the ohmmeter circuit on the tester board. Make sure everything is connected in series in the board.

2) Choose $R_k = 1.8 \text{ k}$ (or Brown-Grey-Red)

3) Calibrate your ohmmeter by using 5 known values of R_x and creating a plot of R_x versus $1/G$. Use resistor (R_x) values 1.5k, 1.8k, 2.7k, 3.9 k, and 6.8 k. (Other values of R_x may be substituted in the event that we run short of resistors, as long as you get five distinct points of the range 10 k.)

4) Obtain a regression line slope and y-intercept, using the Graph program on the computer. From this plot you can obtain the value of k and the measured value of R_k .

5) Obtain an unknown resistor and use your graph to determine the resistance. Use your slope and intercept from step 4 to do this.

Part II: Verifying Kirchhoff's Rules:

1) Create the circuit shown in class on the tester board. All the resistors should have a resistance of 2.2 k (Red-Red-Red-Gold).

2) Check your circuit. An improper connection here is easy to make and will throw off all your results.

3) Find the voltage across all the batteries and the resistors. Remember, the orientation of the probes of your multimeter is important: if you reverse the leads across one of the resistors the loop will not sum to zero.

4) Find the direction and magnitude of the currents going into and out of the node marked A. Again, be careful with the orientation of the leads.

5) Before you leave, please make sure you turn off the multimeter.

Data:

Part I: Constructing an Ohmmeter

R_k : _____ +/- _____ (given value)

color code of the unknown resistor: _____

Voltage of the battery: : _____ +/- _____ (measured, not assumed)

R_x ()	Meter Deflection, G	1/G

G for unknown resistor: _____

1/G for unknown resistor: _____

k : _____ +/- _____ (from graph)

R_{unknown} : _____ +/- _____ (from graph)

R_k : _____ +/- _____ (from graph)

Part II: Verifying Kirchhoff's Rules:

Voltage Rule

Loop I:

V_1 : _____ +/- _____

V_{R1} : _____ +/- _____

V_{R2} : _____ +/- _____

V_{R3} : _____ +/- _____

sum: _____ +/- _____

Loop II:

V_2 : _____ +/- _____

V_{R3} : _____ +/- _____

V_{R4} : _____ +/- _____

sum: _____ +/- _____

Current Rule:

Junction A:

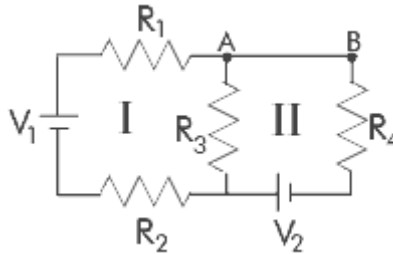
I_1 : _____ +/- _____

I_2 : _____ +/- _____

I_3 : _____ +/- _____

sum: _____ +/- _____

Draw the directions of the current on the circuit below:



Assignment:

1. In part II of the experiment, you should have noticed that one of the resistor voltages you measured was positive instead of negative. Does this mean that an electron is gaining energy when it goes through this resistor? Explain
2. Why should a voltmeter have a high resistance? Why should an ammeter have a low resistance? (Hint: A meter should be "invisible" to the circuit. It should not change the voltage or current of the element it is reading.) You may want to draw some simple circuits.