Ohm's Law

Objectives

- Become familiar with the use of a digital multi meter to measure DC voltage and current.
- Construct a circuit using resistors, wires and a breadboard from a circuit diagram.
- Construct series and parallel circuits.
- Test the validity of Ohm's law.
- Reduce a complicated resistance circuit to a simple one-resistor equivalent circuit.

Introduction

In this experiment, the 3 essential parts of a circuit – power supply (or battery), wires, and resistors will be used. The learning aim will be how resistors affect the current of electrons that flows through them, and how connecting resistors in different ways changes their behaviour.

Theory

One of the fundamental laws describing how electrical circuits behave is Ohm's law. According to Ohm's law, there is a linear relationship between the voltage drop across a circuit element and the current flowing through it. Therefore, the resistance R is viewed as a constant independent of the voltage and the current. In equation form, Ohm's law is:

$$V = I \cdot R \qquad (1)$$

Here, V is the voltage applied across the circuit in volts (V), I is the current flowing through the circuit in units of amperes (A), and R is the resistance of the circuit with units of ohms (Ω). Eq.1 implies that, for a resistor with constant resistance, the current flowing through it is proportional to the voltage across it. If the voltage is held constant, then the current is inversely proportional to the resistance. If the voltage polarity is reversed (that is, if the applied voltage is negative instead of positive), the same current flows but in the opposite direction. If Ohm's law is valid, it can be used to define resistance as:

$$R = {}^{V}\!/_{I} \qquad (2)$$

where R is a constant, independent of V and I.

Method

The Digital Multimeter

As its name suggests, a multimeter has multiple functions. It can be used for several different purposes, two of which are a voltage measuring device (a voltmeter) and a current measuring device (an ammeter). We will use these functions in this experiment.

To use the multimeter as a voltmeter, the dial selector is set to one of the positions labeled "V". The probing cables are then connected to the plugs labeled "VΩ" and "COM". There are two types of "V" settings. The setting with the tilde (~) over it is used for measuring AC voltage. The other type of "V" setting has two lines over the V, one line is solid and the second line is dashed, to indicate DC voltage. AC is an abbreviation for alternating current. An AC voltage is a voltage whose magnitude and polarity vary with time. DC is an abbreviation for direct current. A DC voltage is a constant voltage. During this experiment, only the DC setting is used. There are two DC voltage settings on the multimeter: "V" and "mV". When using the "mV" setting, the output of the multimeter will be in millivolts. Whether the multimeter is used to measure voltage (as a voltmeter) or current (as an ammeter), one cable is always connected to the COM plug. If the multimeter is used to measure current, the other lead is connected to either the 10A plug or the 400mA plug. A voltmeter must be connected in parallel (across) to the circuit element of interes. Since the voltmeter measures potential difference between two points, it is easy to connect. To measure the potential difference (voltage drop) across a resistor, use two cables to connect the plugs of the voltmeter to the circuit across the resistor (one cable before the resistor and a second cable after the resistor). A voltmeter typically has a very large internal resistance; therefore, very little current will flow through it. Consequently, the current in the circuit will be approximately the same before and after the voltmeter is connected. To use the multimeter as an ammeter, the dial selector is set to one of the positions labeled "A". Similar to the voltmeter settings there are AC and DC settings. Like the voltmeter, two cables must be connected to the ammeter. One of your cables MUST be connected to the plug labeled "COM". The second cable can be connected to one of two possible plugs —- either the "10A" plug or the "400mA" plug. If you have a large amount of current (anything above 400 mA), you must connect the cable to the terminal marked "10A". If you put it in the "400mA" terminal you could damage the multimeter. If you are unsure if you have too much current for the 400 mA plug, start with the 10A plug. If you do not get any reading at all (i.e. 0.00), you have a very small current and can then move the cable to the 400 mA plug. An ammeter must be connected in series with the circuit element of interest. This means that unlike measuring voltage, if you want to measure current you must break the circuit and wire the ammeter in. All of the current must flow through the ammeter in order for it to be measured. An ammeter typically has a very small internal resistance. Therefore, the current in the circuit is approximately the same before and after the ammeter is connected.

Resistor color codes

Most resistors are coded with color bands around one end of the resistor body. Using the resistor color code system is similar to using scientific notation. Scientific notation uses a number between 0 and 9.9 multiplied by some power of ten. The resistor color code system uses a number between 01 and 99 multiplied by some power of ten. These color bands tell the value of the resistance. Starting from the end, the first band represents the first digit of the resistance value and the second band the second digit. The third band represents the power of ten multiplying the first two digits. The fourth band represents the tolerance. If the fourth band is absent, it means the tolerance is 20%. Table 1 is a color code chart, from which one can tell the resistance of a resistor.

Table 1 - Resistor color codes

Colour	First digit	Second digit	Power of 10	Tolerance
black	0	0	0	-
brown	1	1	1	-
red	2	2	2	-
orange	3	3	3	-
yellow	4	4	4	-
green	5	5	5	-
blue	6	6	6	-
violet	7	7	7	-
gray	8	8	8	-
white	9	9	9	-
gold	-	-	-	5%
silver	-	-	-	10%
none	-	-	-	20%

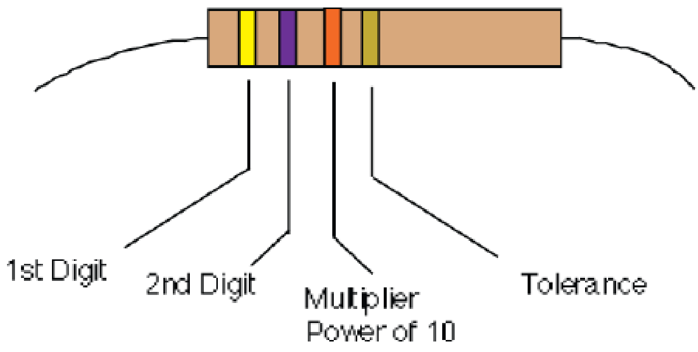

Figure 1 – Example of a resistor

Procedure

1. Construct the circuit shown in Figure 2.

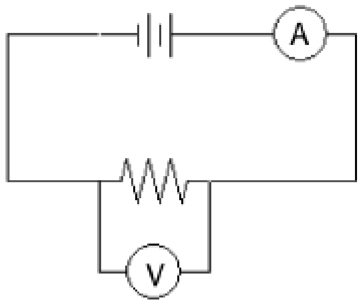

Figure 2

2. Set the voltage from 0-10 in steps of 1 Volt and fill Table 2.
3. Plot the graph of current versus voltage and from the graph calculate the resistance of resistor.
4. Read the resistance of the resistor from the colour codes and compare your results.

Table 2 – Experimental Results

Voltage (Set) – V	Voltage (measured) – V	Current (measured) – mA
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		