General Physics Lab 3

Ohm's Law

Objectives:

- To study the relation between current and voltage in direct current circuits

Equipment:

- Multimeter with Probes
- Breadboard
- Jumper Wire Kit (optional)
- 9V Battery
- 9V Battery Connector
- 1 kΩ Resistor (brown, black, red, gold)
- 2 kΩ Resistor (red, black, red, gold)
- 3 kΩ Resistor (orange, black, red, gold)
- 4.3 kΩ Resistor (yellow, orange, red, gold)
- 5.1 kΩ Resistor (green, brown, red, gold)

Physical Principles:

Ohm's Law

The electric potential at a point, measured in volts, is the work per unit charge required to move a charge from some arbitrary reference point to that point. Voltage is sometimes called the electromotive force, as it "pushes" the current through circuits. When a voltage, V, is applied across a conductor the resulting current, I, is directly proportional to the applied voltage. Ohm's Law appears as

$$V = IR \ , \qquad (1)$$

where R is called the resistance and is measured in ohms (Ω).

Rearranging Eq. (1), we find,

$$I = V/R \ . \qquad (2)$$

If the voltage is held constant while the resistance is varied, we can expect a plot of I vs. 1/R to be a straight line with slope = V.

Procedure:

Measure Resistance

1. Locate the 1 kΩ, 2 kΩ, 3 kΩ, 4.3 kΩ, and 5.1 kΩ resistors from your lab kit.

   You can tell the resistor's nominal value from the 4 or 5-band color code printed on the resistor. To interpret this code, look up a resistor color code table or use an online calculator such as this one: https://resistorcolorcodecalc.com/.

2. Turn the multimeter dial to measure ohms (Ω) and set it to the lowest range that will give a value. This will most likely be the 2000 Ω range or the 20k range.
3. Insert the black probe into the common (COM) port and the red probe into the port for resistance (Ω).
4. One at a time, carefully (it is easy to bend the resistor leads and hard to re-straighten them) place the resistors in the breadboard and measure the individual resistances in ohms (see Fig. 1).

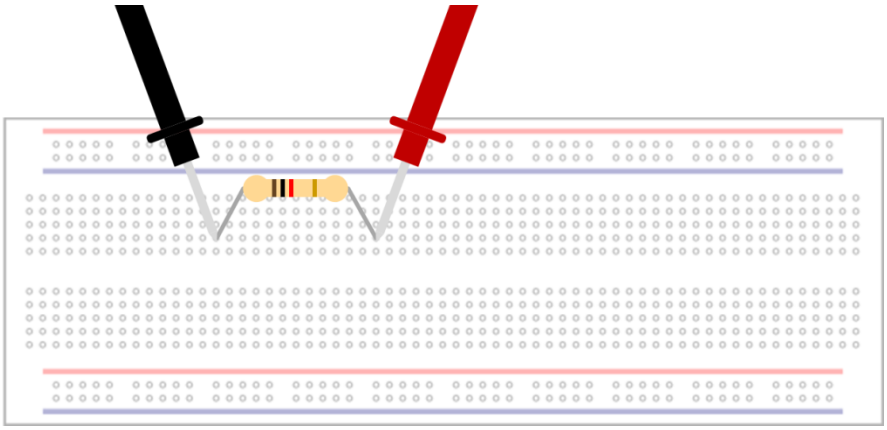

Fig. 1: Carefully place each resistor in the breadboard as shown and measure the individual resistance of each.

Measure Voltage

1. Turn the multimeter dial to measure DC voltage (V ⎓) and set it to the 20V range.
2. Insert the black probe into the common (COM) port and the red probe into the port for Voltage (V).
3. Touch one probe to each pole of the 9V battery to measure its voltage (see Fig. 2). Record the value.

   Nominally the battery is 9V, but when new it is often a little higher than this. If the voltage has dropped below 8.5V, replace it with a different battery.

WARNING: Never attempt to measure across the poles of a battery or other power source while the multimeter is in current mode (A). Doing so will blow the internal fuse or even destroy the multimeter.

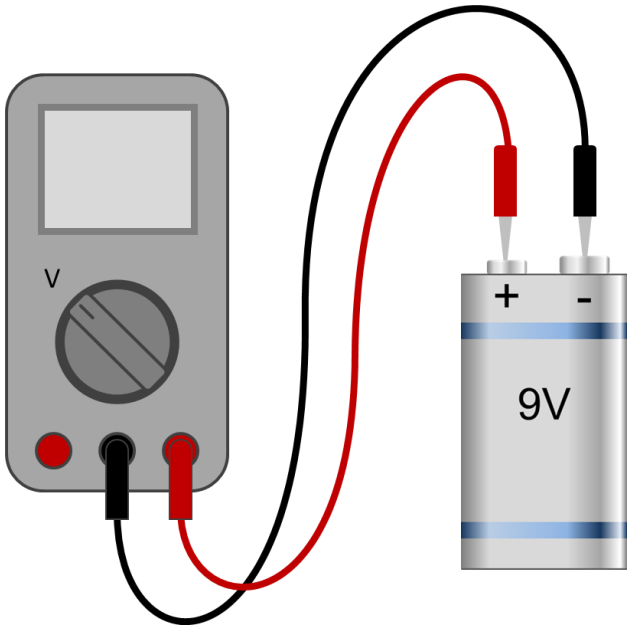

Fig. 2: Set multimeter dial to measure voltage (20V range), black probe in COM port, red probe in V port. Touch red probe to positive battery pole and black probe to negative battery pole.

Measure Current

1. Remove the multimeter from the battery and turn the dial to measure DC current (amps). Start on the 200 mA range and if the value is less than 20 mA, switch to the 20 mA range.
2. If the red probe is not already in the mA port, move it to that port.
3. Build the following circuit on your breadboard using the 1 kΩ resistor (see Fig. 3).

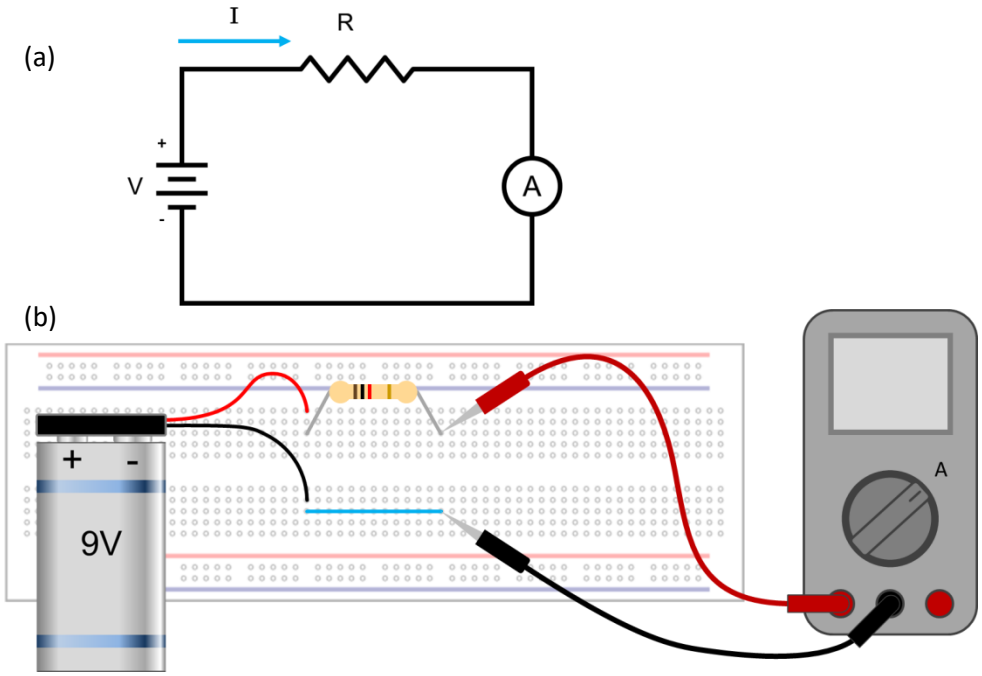

Fig. 3: (a) Circuit diagram with battery, resistor, and ammeter attached in series.
(b) Suggested breadboard wiring diagram. Make sure the wires and leads that are supposed to be connected are inserted in the same row of 5 holes.

4. Measure the current in amps (likely displayed in mA so you may need to convert). Record the current in your eJournal next to the corresponding resistance (previously measured).
5. Replace the 1 kΩ resistor with the 2 kΩ resistor and repeat the current measurement.
6. Continue swapping out the resistors for the 3 kΩ, 4.3 kΩ, and 5.1 kΩ and record the current and resistance for each new resistor.

IMPORTANT: When you finish the experiment, turn off the multimeter to save the battery. The simpler inexpensive multimeters often do not shut off automatically.

Analysis:

Eq. (2) suggests that a plot of I (y-axis) vs. 1/R (x-axis) should result in a straight line with a slope equal to V.

1. Construct a plot of I vs. 1/R (using your measured resistances, not the nominal color band values) and perform a linear fit. Record the slope.
2. Use a percent difference to compare the slope of the straight line to the previously measured battery voltage.

$$\%Diff = \frac{|measured\ voltage - slope|}{measured\ voltage} \times 100\%$$