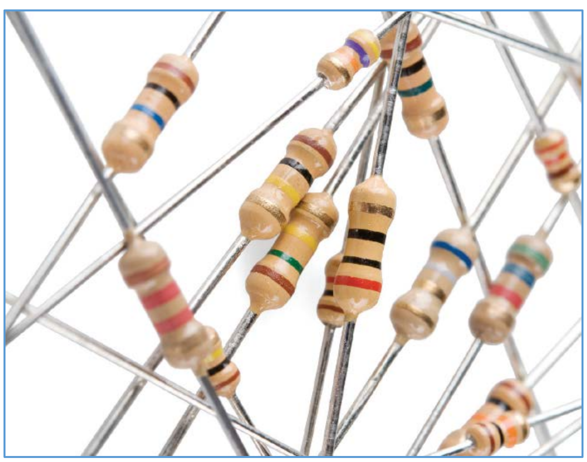
Ohm's Law & Resistivity

Equipment	Quan
resistors	3
low voltage power supply	1
multi-meters	2
resistance experiment board	1
light bulb, holder	1

Electrical resistors like the ones shown below are ubiquitous in modern electronics. Their ability to resist electric current is used for multiple purposes. Two common uses are to limit current in a part of a circuit to a desired level, or to set the potential difference between two points in a circuit to a desired level.



In the first lab, you learned about the color code system used to label a resistor with its resistance value. You were also introduced to Ohm's Law:

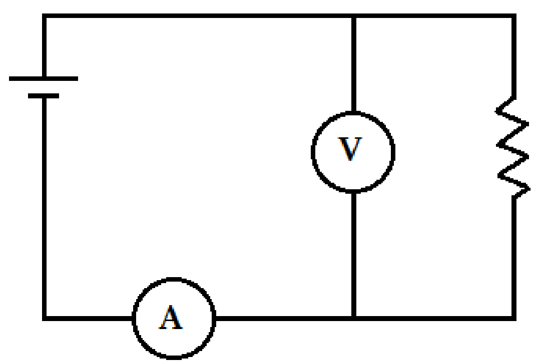
$$V = IR$$

Put into words this states: the current through a resistor is proportional to the potential difference between its electrodes, and it's inversely proportional to the resistance of the resistor. This gives us a good definition of resistance: the ohm value of a resistor is the number of volts per amp required to push current through it. Thus $1\ Ohm$ is equal to $1\ Volt$ per Amp, which can be written like this:

$$1\,\Omega = 1\,V/A$$

Plotting Ohm's Law

1. Assemble the circuit below, where the voltage source is the Low Voltage Power Supply, two multi-meters serve as the voltmeter and ammeter, and one of the test resistors serves as the resistor. This circuit will allow you to simultaneously measure voltage across and current through a resistor that is exposed to a potential difference across its electrodes.
2. Before the power supply is turned on, turn the voltage knob to zero and the current knob to the halfway setting.



3. For four voltage values, record in the table both voltage and current.
4. Make a graph plotting voltage as a function of current.
5. Find the slope of the best fit straight line that goes through the origin. This

should equal the resistance of the resistor.

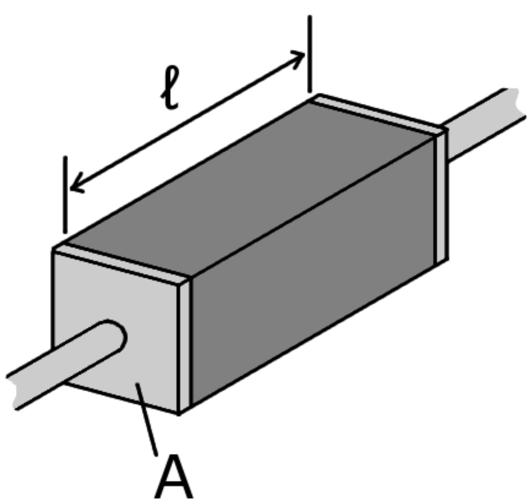
6. Calculate the percent error of the resistor's resistance, where your value is the measured value and the resistor's advertised value is the known value.
7. Repeat this procedure for two other resistors.

Resistor 1		Resistor 2		Resistor 3	
V	I	V	I	V	I

	R	slope	% error
Resistor 1			
Resistor 2			
Resistor 3			

Resistivity of a Material

Several properties of a resistor affect its level of resistance. The figure below illustrates this.



The dark colored part is the resisting material, and the light colored part is considered to have very little resistance (it's a good conductor). The resistance of the dark part is given by:

$$R = \frac{\ell}{A}\rho$$

ℓ is the length of material through which the current must travel, so not surprisingly, R is proportional to ℓ. But the greater the conducting cross section (A), the more paths are available to each electron, and the fewer the collisions with electrons in the material, so R is reduced. The quantity ρ is an intrinsic property of the material called the resistivity. Materials like copper have very low resistivities (making them good conductors), while materials like Teflon have very high resistivities (making them good insulators).

8. Measure the resistance between the connectors on the resistance wire board.

   $R =$ ___________Ω

9. Use a Vernier caliper or micrometer to measure the diameter of the wire in at least four places and find the average. Also measure the total length of the 2 wire assembly.

   $diam =$ ____________m

   $\ell =$ ____________m

10. From the wire diameter, find its cross section area.

    $A =$ ____________m^2

11. With this information and the above relationship between R, ℓ, A & ρ, find the resistivity of the wire material.

    $\rho =$ ____________$\Omega \cdot m$

12. Refer to a table of resistivities to see if you can identify the metal.

Temperature Dependence of Resistance

Most resistors are intended to maintain a preset level of resistance regardless of the current through them. But the resistivity of most materials is temperature dependent, and a high current can raise the temperature enough to alter the resistance value (upward for most materials).

13. In place of the resistor in the circuit that you used for the first part, connect the light bulb holder.
14. IMPORTANT FOR PROTECTION OF THE AMMETER: Since the currents that we'll be measuring are on the order of amps instead of milliamps, switch the wire on the ammeter from the mA socket to the A socket.
15. Measure current values for all the voltages in the table below. Instead of trying to set the voltages to exactly the prescribed value, set it close to this and record the actual value.
16. Use Ohm's Law to calculate the resistance of the filament at each of the voltage settings. You'll see that it changes a lot.
17. Disconnect the light bulb holder, and measure its resistance using an ohmmeter. Write this value into the R column in the zero volts row.
18. Make a graph of R as a function of I.

V (V)	Actual V (V)	I (A)	$R(\Omega)$
0	0	0	
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			