Resistance

Concept
The purpose of this lab is to introduce basic equipment and circuit-building techniques and to investigate ohmic and non-ohmic behavior, power dissipation, Kirchoff's Laws, and voltage dividers.

Helpful hints and warnings
Small resistors are guaranteed to dissipate at least 1/4 Watt without suffering damage from the heat. So, for use in a circuit, ensure that the power dissipated in each resistor in your circuit does not exceed this value unless instructed to do so. The fundamental definition of power dissipated within any object is $P = IV$, where $P$ is the power in Watts, $I$ is the current in Amperes and $V$ is the potential difference across the object in Volts. If the object is ohmic, then $V = IR$ can be used in the expression for power to yield $P = I^2R = V^2 / R$.

The input resistance of a DMM (digital multimeter) acting as a voltmeter, $R_{input}$, is not infinite. Thus, a DMM will act as another resistor in series with your circuit, thereby reducing the measured potential by virtue of an inadvertant voltage divider. Usually, $R_{input} \geq 10 M\Omega$. Likewise, a DMM acting as an ammeter does not have the ideal zero resistance and will introduce an additional potential drop to the circuit.

Be careful with diodes, as they can be damaged by excessive current. Using a resistor $R$ in series with a diode ensures that the maximum current $I = (V_{battery} - V_{diode}) / R$ is reasonable.

Experimental Instructions
1. $I(V)$ curves and Ohmic behavior
The goal of this first experiment is to measure the $I(V)$ curves of some simple components and distinguish between Ohmic and non-Ohmic behavior.

   a. For the first case, choose a resistor with $R = 100 \Omega$ and measure the resistance directly with the DMM. Does this measurement alone tell you that the resistor exhibits Ohmic behavior? To investigate the Ohmic behavior, use your voltage source and a potentiometer as shown below. If you have two DMMs, you can use one DMM to measure the potential $V$ across the resistor and another DMM to simultaneously measure the current $I$ through the resistor, as shown at right. If you have one DMM, you must alternate between the two diagrams on the left.
(i) Adjust the potentiometer through its full range of values and plot $I$ versus $V$. On the graph indicate your best estimate of the uncertainties in both potential and current. If the DMM reading is steady, then the uncertainty is $\pm 1/2$ the last digit. If the DMM reading fluctuates, then the uncertainty can be estimated to be $\pm 1/2$ the maximum range of fluctuation.

(ii) Is the behavior Ohmic to within the estimated error, that is, is $I$ linear with $V$ with a slope of $1/R$?

b. Measure the $I(V)$ curve of a simple diode (e.g. diode rectifier IN4007 in your kits). Modify your circuit to include the 100 Ω resistor as a current-limiting resistor and the diode as the test component, as shown at right. The limiting resistor is used because if too much current passes through the diode, the excessive power dissipated will lead to overheating and failure.

c. Measure the $I(V)$ curve of a light-emitting diode (LED). You will find that the forward bias voltage required to make the LED conductive and bright is greater than that observed for the simple diode. Is there a connection between the forward drop and the color of your diode?

REMOTE OPTION: If you do not have equipment, you can do this experimentally remotely. The remote experiment has the circuit shown at right and you can choose among 4 test components. The measured voltages $V_1$ and $V_2$ can be used to determine the current $I$ through and the voltage $V$ across the test component.

2. Potential or voltage divider

a. Build a potential divider using the approximate values $R_1 = 100\,\Omega$ and $R_2 = 100\,\Omega$. Measure the output potential of the divider (i.e. across the load resistor) as you vary the value of the load resistance over the full range of the potentiometer. Over what range of load resistance would you declare this divider to be a reasonable "constant potential source?"

b. Make the same measurements for a divider with the approximate values $R_1 = 1k\,\Omega$ and $R_2 = 1k\,\Omega$. Is this a better or worse "constant potential source?"

REMOTE OPTION: very similar.