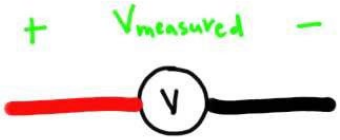
Measuring Voltage, Current, and Resistance: More often than not, parameters of electrical interest, such as voltage, current, and resistance, are measured with a device called a multimeter. As a matter of nomenclature, when a multimeter is configured to measure voltage, it's called a voltmeter; when it's configured to measure current, it's called an ammeter; when it's configured to measure resistance, it's called an ohmmeter.

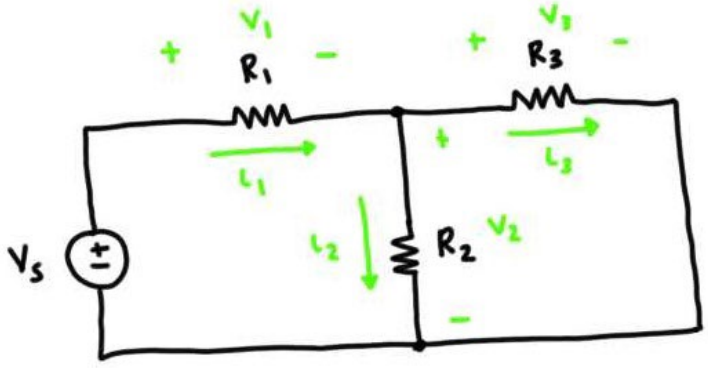
Voltmeter: The voltmeter is a two terminal device that is represented schematically in the figure below. Note that one probe is colored red, while the other is colored black. To measure a desired voltage, the red probe is placed at the higher (or plus) voltage, while the black probe is placed at the lower (or negative) voltage.



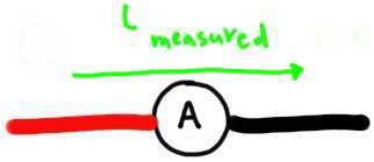
1) An ideal voltmeter must be placed in _____ with the element whose voltage you wish to measure.

2) The internal resistance of an ideal voltmeter is _____.

3) For the circuit below, draw in where the voltmeter must be placed in order to measure the voltages v_1, v_2, and v_3.



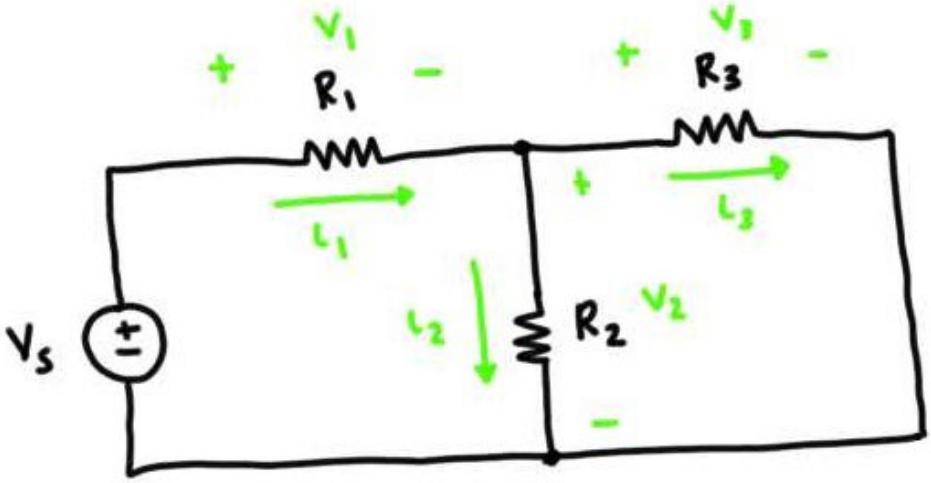
Ammeter: The ammeter is a two terminal device that is represented schematically in the figure below. Just like the voltmeter, one probe is colored red, while the other is colored black. To measure a desired current, the red probe is placed at the node at which the current is entering, while the black probe is placed at the node at which the current is exiting.



1) An ideal ammeter must be placed in _____ with the element whose current you wish to measure.

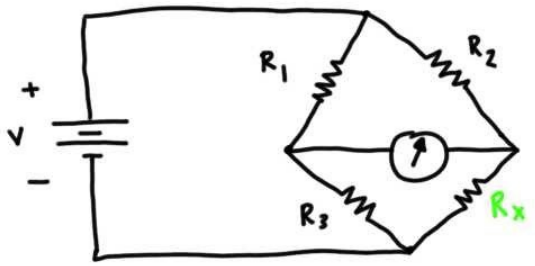
2) The internal resistance of an ideal ammeter is _____.

3) For the circuit below, draw in where the voltmeter must be placed in order to measure the currents i_1, i_2, and i_3.



Measuring Resistance: The Wheatstone Bridge

1) The circuit shown is balance when $R_1 = 100\ k\Omega$, $R_2 = 1\ M\Omega$, and $R_3 = 150\ k\Omega$. The bridge is energized from a 20 V dc source. What is the value of R_x?



2) For another unknown resistor, the Wheatstone bridge circuit shown above is balanced when $R_1 = 30\Omega$, $R_2 = 20\Omega$, and $R_3 = 15\Omega$. The bridge is energized from a 5 V dc source. What is the value of R_x?

Wye-to-Delta and Delta-to-Wye transformations:

1) Question: Can all resistive networks be reduced to a single equivalent resistor by using the rules for the addition of resistors in series and parallel only? *Hint:* Suppose the galvanometer shown in the Wheatstone bridge circuit above were replaced by a resistor.
2) Find the current and power supplied by the 40V source shown in the circuit below.