# EE101: Multimeter Notes

In the lab we will use a digital multimeter (DMM) to measure resistance, voltage, and current in our circuits. There are pushbuttons on the meter to indicate which type of measurement is being made, and other pushbuttons to select the range (scale) for the measured values.

Be sure to note that the input connections on the meter are different for measuring current than for measuring voltage or resistance. Always make sure you have the proper input connections and pushbutton settings BEFORE attaching the meter to the circuit!

If you do not know the expected value of the measurement, first be sure that it does not exceed the maximum rating of the DMM. If it is within the limits, start with the range pushbutton set for a large number. If the value displayed by the meter is small compared to the range setting, push the appropriate smaller range setting to optimize the display. In other words, choose the smallest range setting that will accommodate the meter reading. This gives the most precision (number of digits) in the meter reading.
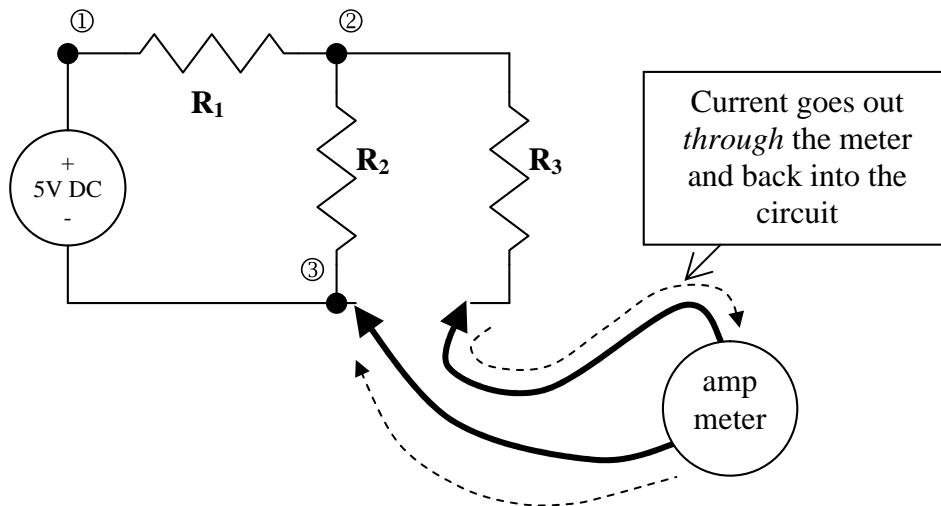
Voltage Measurement

(1) Voltage is the *potential difference* between two *nodes* in a circuit.

(2) Voltage is measured in the unit "volts" (V), which is "joules per coloumb": how much energy (joules) is required to move some charge (coloumb) between the two nodes.

(3) A *voltmeter* indicates the voltage between the two nodes. The meter has a very high *input resistance* so that essentially no current flows through the meter itself. The voltmeter is connected by touching the meter probes to the two nodes of interest. See the figure below: measuring voltage between node 2 and node 3.

(4) Voltage has a *polarity* (positive or negative). We will connect a red probe wire to the positive terminal on the voltmeter and a black probe wire to the negative terminal on the voltmeter. When the probes are connected to the circuit, the meter will indicate a positive value if the red probe is at a higher voltage (potential) than the black probe, and a negative value if the red probe is at a lower voltage than the black probe.
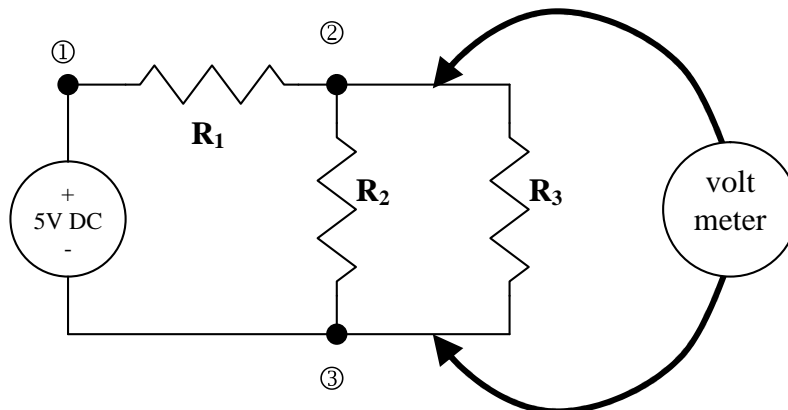
Current Measurement

(1) Current is the *rate of movement of electrical charge* through a *branch* in a circuit.

(2) Current is measured in the unit of "amperes" or just "amps" (A), which is "coulombs per second": how many coloumbs of charge move through the circuit branch in one second.

(3) An *ammeter* indicates the current in the circuit branch. The same current that flows in the circuit branch must be made to flow through the meter, so the meter must actually be placed in series with the branch. NOTE that unlike the voltage measurement, for current you must actually break the circuit and insert the meter into the branch where the current is to be measured. The ammeter has a very low *input resistance* so that it does not affect the current in the circuit. See the figure below: measuring current in branch containing R_3.

(4) Current has a *polarity* (positive or negative). We will connect the red probe wire to the positive current input on the ammeter and a black probe wire to the negative terminal on the ammeter. The meter will indicate a positive value if current flows *into* the red wire, through the meter, and *out* of the black wire back into the circuit. On the other hand, the meter will indicate a negative value if the circuit causes current to flow *into* the black wire, through the meter, and *out* of the red wire and back into the circuit.

Resistance Measurement

(1) Resistance is the ratio of voltage to current for a circuit element (typically a resistor).

(2) Resistance is measured in the unit "ohms" (Ω), which is "volts per amp": how much voltage across the element is required to pass some current (amps) through the element ($V = I\,R$).

(3) An *ohmmeter* indicates the resistance of an element. The element to be measured must be taken out of the circuit and connected in series with the meter. See the figure below: measuring the value of resistor R_3.

(4) Resistance is indicated as a magnitude (positive) number.