Measuring Voltage, Current & Resistance

Unit: Electricity & Magnetism
NGSS Standards: N/A
MA Curriculum Frameworks (2006): 5.3
AP Physics 1 Learning Objectives: N/A

Knowledge & Understanding:
- how voltage, current and resistance are measured.
- how positive and negative numbers for voltage and current correspond with the direction of current flow.

Skills:
- measure voltage, current and resistance.

Language Objectives:
- Accurately describe how to measure voltage, current and resistance in an electric circuit, using appropriate academic language.

Labs, Activities & Demonstrations:
- Show & tell with digital multi-meter.

Notes:
Analyzing an electrical circuit means figuring out the potential difference (voltage), current, and/or resistance in each component of a circuit. In order to analyze actual circuits, it is necessary to be able to measure these quantities.

Measuring Voltage
Suppose we want to measure the electric potential (voltage) across the terminals of a 6 V battery. The diagram would look like this:

The voltage between points A and B is either +6 V or −6 V, depending on the direction. The voltage from A to B (positive to negative) is +6 V, and the voltage from B to A (negative to positive) is −6 V.

Use this space for summary and/or additional notes:
When measuring voltage, the circuit needs to be powered up with current flowing through it. Make sure that the voltmeter is set for volts (DC or AC, as appropriate) and that the red lead is plugged into the V Ω socket (for measuring volts or ohms). Then touch the two leads in parallel with the two points you want to measure the voltage across. (Remember that voltage is the same across all branches of a parallel circuit. You want the voltmeter in parallel so the voltmeter reads the same voltage as the voltage across the component that you are measuring.)

On a voltmeter (a meter that measures volts or voltage), the voltage is measured assuming the current is going from the red (+) lead to the black (−) lead. In the following circuit, if you put the red (+) lead on the more positive end of a resistor and the black (−) lead on the more negative end, the voltage reading would be positive. In this circuit, the voltmeter reads a potential difference of +6 V:

![Diagram of a voltmeter measuring +6 V](image)

If you switch the leads, so the black (−) lead is on the more positive end and the red (+) lead is on the more positive end, the voltage reading would be negative. In this circuit, the voltmeter reads −6 V:

![Diagram of a voltmeter measuring −6 V](image)

The reading of −6 V indicates that the potential difference is 6 V, but the current is actually flowing in the opposite direction from the way the voltmeter is measuring—from the black (−) lead to the red (+) lead.
**Measuring Current**

When measuring current, the circuit needs to be open between two points. Make sure the ammeter is set for amperes (A), milliamperes (mA) or microamperes (μA) AC or DC, depending on what you expect the current in the circuit to be. Make sure the red lead is plugged into appropriate socket (A if the current is expected to be 0.5 A or greater, or mA/μA if the current is expected to be less than 0.5 A). Then touch one lead to each of the two contact points, so that the ammeter is in series with the rest of the circuit. *(Remember that current is the same through all components in a series circuit. You want the ammeter in series so that all of the current flows through it.)*

On an ammeter (a meter that measures current), the current is measured assuming that it is flowing from the red (+) lead to the black (−) lead. In the following circuit, if you put the red (+) lead on the side that is connected to the positive terminal and the black (−) lead on the end that is connected to the negative terminal, the current reading would be positive. In this circuit, the current is +3 A:

![Diagram of a circuit with an ammeter showing current flow from red (+) lead to black (−) lead.]

As with the voltage example above, if you switched the leads, the reading would be −3 A instead of +3 A.
Measuring Resistance

Resistance does not have a direction. If you placed an ohmmeter (a meter that measures resistance) across points A and B, it would read 10 Ω regardless of which lead is on which point.

However, because an ohmmeter needs to supply a small amount of current across the component and measure the resistance, the reading is more susceptible to measurement problems, such as the resistance of the wire itself, how well the probes are making contact with the circuit, etc. It is often more reliable to measure the voltage and current and calculate resistance using Ohm’s Law (V = IR).