Ohm's Law – Matt Schuchhardt

Purpose
This lesson serves as a general introduction to electricity. In this lesson, I target students who have already learned about batteries in their electrochem unit, but don't actually have much of an understanding about how electricity works beyond that point.

Overview
We explain Ohm's law and relate it back to an analogy of water flow. The students will also build all of the circuits we discuss in the lab, and have them implement their own dimmer switch. We also have the students compare the various aspects of parallel and series circuits in lab.

Student Outcomes
Students will be able to build a series and parallel circuit consisting of a potentiometer, battery, motor, and LED
Students will be able to describe Ohm's law and relate it to the flow of electricity
Students will be able to describe how a dimmer in their house works

Time
1 70-minute class period

Level
Sophomore honors chemistry

Materials and Tools
Powerpoint presentation
Per group:
- One DC motor (9V, should be rated for a sufficiently low current)
- One LED
- One 1K (or so) resistor
- One 9V battery
- Multimeter
- Sufficient (~5) alligator clips.

Preparation
Preparing the lab kits – per group, you need one DC motor, one LED, 1K (or so) resistor, a 9V battery, a multimeter, and sufficient alligator clips.

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Prerequisites

Students should have some understanding of batteries in advance – the general knowledge of electricity conferred by an electrochem unit should be sufficient.

Background

(borrowed from Wikipedia)
A battery is a device that can store electricity. Some are rechargeable, and some are not. They store direct current (DC) electricity.

A battery really means two or more wet or dry cells connected in series for more voltage, or in parallel for more current, although people often call a cell a battery. AA, AAA, C, and D batteries all have 1.5 volts. The voltage of a cell depends on the chemicals used while the amount of power or current it can supply also depends on how large the cell is; a bigger cell of a given type can supply more amps, or for a longer time.

Teaching Notes

- Begin by asking students to sit down and "Describe what you think happens electrically when you dim a light" (slide 1)
- Describe precisely what an electrical circuit. Relate back to lightning – electricity has to travel through a complete path – if it's not moving, it's not doing anything! (slide 3)
- Describe how the electrons flow. The potential difference in the battery causes electrons to flow through the light. Another name for flowing electrons is electricity. (slide 4)
- Different loads that you can attach to a circuit – lights, motors, cell phones, laptops, smoke detectors. A load is simply something which uses electricity to perform some task. (slide 5)
- What happens if you remove a wire? It breaks the circuit. Electrons can no longer flow. This is what a switch does. Ask students if they describe this as a switch before you reveal this to them. (slide 6)
- Let the students create a series circuit (connected in a line). If they finish ahead of time, let them experiment and see if they can make a circuit with an LED and motor, where if you disconnect the motor, the LED stays lit. This is a parallel circuit (next slide). (slide 7)
- Discuss what happens to the circuit when you disconnect various wires. A series circuit will be broken if a wire is disconnected, but the other light in a parallel circuit will stay on if one wire is disconnected, since there are multiple connections to the battery. Be very specific about the path that electricity will be able to take. (slide 8)
- Relate this back to a pipe analogy – small pipe = high resistance, large pipe = low resistance; consider a straw vs a PVC pipe. If you attach a straw to your sink, a low amount of water (current) will flow, due to the high resistance. Vice-versa with a PVC pipe. This is similar to the V=IR formula (use some fake numbers to represent this). Given a constant pressure (voltage), the amount of water (current) that flows is dependent on the resistance. (slide 9)
- Low; high (slide 10)
- Potentiometer is simply a variable resistor. There are three terminals - students will have to figure out which two terminals causes the resistance to actually change using their multimeters. If they do this wrong, the resistance will not change when the dial is moved. (slide 11)
- This should be fairly simple – same as before, but with a potentiometer as well. If there's time, have them tack on the LED circuit in parallel, so that you can change the speed of the motor while keeping the LED on a (theoretically: the maximum battery may change this) constant brightness. (slide 12)

- If there's time, you can show them how the voltage difference across the motor changes due to the multimeter. This is a bit more complex, however, so you can skip this unless you are very comfortable with electrical circuits. (slide 13)
- Describe what is going on at the circuit level when we dim the lights (slide 15 exit ticket)

Assessment

Pre-class task – describe how you think a dimmer works
Exit ticket – describe again how a dimmer works at the circuit level
Hands-on group lab work with circuits
Class discussion and think-pair-share sessions

Additional Information

LEDs are directional - the shorter end should be attached to the more negative part of the circuit. Try flipping them around in the circuit if they don't work.
Always add a resistor in series with the LED – they will burn out if directly connected across a battery w/o resistance.