Exploring Electricity | Teacher Notes

Introduction

Electricity is important and all around us! From the early days of the electric telegraph and electric power, to modern computers, cell phones, and the internet, inventions based on electricity have created profound changes in society and impacted nearly every aspect of human life. Electricity is also fun and creative! We can use electrical circuits to make things light up, move, and sense the world around us. In this activity, students will explore controlling electrical devices with a microcontroller.

Goal

Students will create an electrical circuit and explore the power of electricity by testing out various conductors, insulators, and resistors.

Safety note: We will be working with 3 volts — the voltage from two AAA batteries. That voltage is safe. In contrast, the electrical current in household wiring is 120 to 220 volts, depending on where you live. That voltage is high enough to give a bad shock and cause serious harm. To be safe, stick to circuits powered by batteries or a USB cable.

Materials needed

- micro:bit
- LED with built-in resistor
- Piezo speaker or Electfreaks Basic:bit
- Alligator clips
- An assortment of materials to test: paper, coins, fruit, water, playdoh, aluminum foil, your body, etc.

Procedure

Background Knowledge & Introduction

- Ask students what they already know about **circuits** and the **flow of electricity.** Explain that a simple electrical circuit includes three things:
    - An electrical power source, such as a battery, an AC adaptor, or the USB cable from your computer
    - An electrical device, such as a light (LED), buzzer, or motor
    - Wires (or other conductors) that allow electricity to flow between the power source and the device

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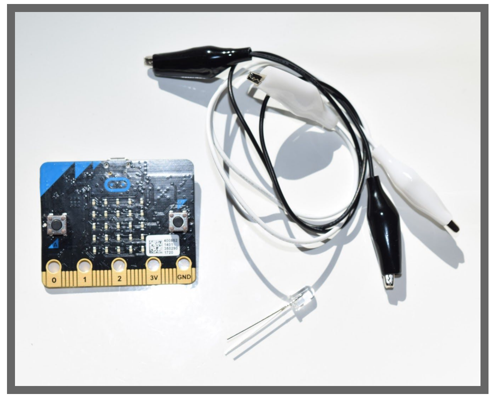
Activity 1 | Create a Simple Circuit



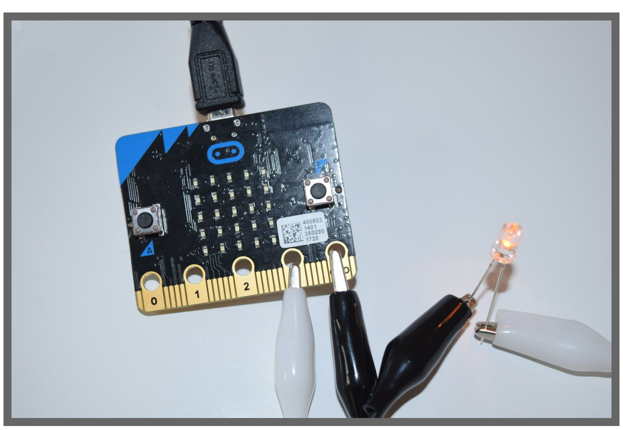
In this activity, students will make a simple circuit using the micro:bit as the power source, an LED as the output device, and alligator clips as the wires to connect them together into a circuit.

The key idea of circuits is that electricity flows from the positive terminal of the power source (often marked "+" or "3v" or "V") through the device then back to the negative or "ground" terminal of the power source. This path creates a loop or "complete circuit" through which electricity can flow. If there is a break anywhere in this path, the electricity cannot flow and the device does not turn on. That is called an *open circuit*.

A *short circuit* is a direct path from the positive to the negative terminal of the power source that does not go through any device. A short circuit allows too much electricity to flow at once, like releasing all the water behind a dam. In your home, a short circuit in an appliance will trip a circuit breaker or blow a fuse. With the micro:bit, a momentary short circuit will just cause it to reset but a short circuit that persists for many seconds will make the micro:bit get hot and could damage it. To avoid that, always be sure there is an LED or other device in your circuit.

Connect one alligator clip between the "3v" pad of the micro:bit and one leg of the LED. Connect the other alligator clip between the other leg of the LED and the "GND" pad. The LED should light up. If it does not, reverse the wires connected to the LED. An LED only conducts electricity in one direction, like a one-way street. Note a shortcut: the longer leg of the LED should be connected to the "3v" pad.

When there is a complete circuit, the LED lights up. The electricity starts at the "3v" pad. It flows through one alligator clip to the LED, then out the other leg of the LED and through the other alligator clip to the "GND" pad. Disconnecting an alligator clip will open the circuit, preventing the electricity from flowing and will make the LED turn off. That is exactly how a switch works.



Fun Fact!
The word *electricity* comes from *elektron*, the Greek word for amber. Amber is a kind of rock that is actually fossilized tree resin. Around 600 BC, the Greek philosopher Thales of Miletus noted that a piece of amber rubbed with cat's fur would attract light objects such as feathers. No one knows what the cat thought about his experiments.

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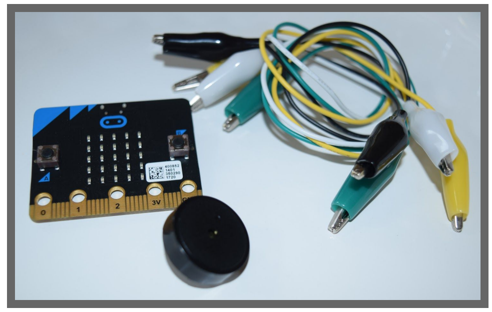
Activity 2 | Explore Conductors, Insulators, and Resistors

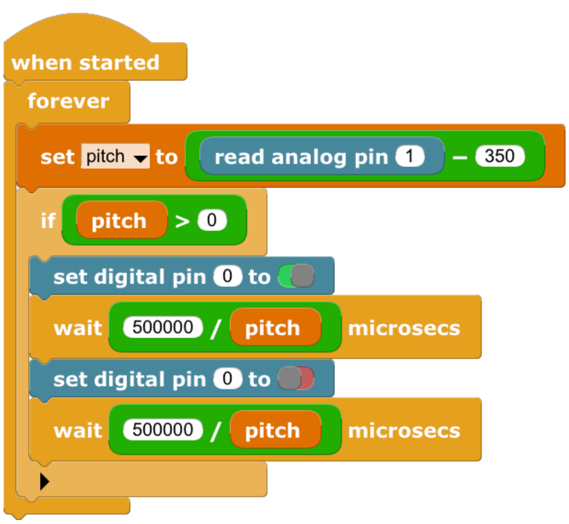
To begin the second part of this activity, introduce the vocabulary of **conductors, insulators,** and **resistors**.

- Conductors: materials that allow electricity to flow through them easily
- Insulators: materials that do not allow electricity to flow at all
- Resistors: materials that allow limited electricity to flow

First, we will write a script that will allow us to explore the difference between conductors, insulators, and resistors. The amount of electrical current will control the pitch of a tone played through an external sound device connected to the micro:bit - the higher the pitch, the better the conductor! If using a piezo speaker, use alligator clips to connect the speaker to the pads marked "0" and "GND" on the micro:bit. If using the basic:bit, make sure the speaker is turned on.



Have students create the following script (or provide it in a starter project):



Teaching Note: What does this script do? The magic here is the *read analog pin* block. This gives a number between 0 and 1023 based on the voltage that it senses. When you touch the two alligator clips to something that conducts electricity, at least a little, then a tiny bit of current flows from the 3v pin to pin 1, raising the voltage and causing the *read analog pin* to return a bigger number. If the alligator clips are connected to an insulator or not connected to anything at all, no current can flow, so the pin settles to a lower voltage. It doesn't go all the way down to 0 because the micro:bit circuit has a built-in resistor that lets a very tiny bit of current flow from 3v to pin 1. The pin's resting level is around 350. The script subtracts that number so the "pitch" variable will be about 0 when the alligator clips are not connected to anything. The rest of the script turns the "pitch" number into a sound you can hear through the speaker. The higher the pitch, the shorter the wait times, resulting in a higher frequency sound.

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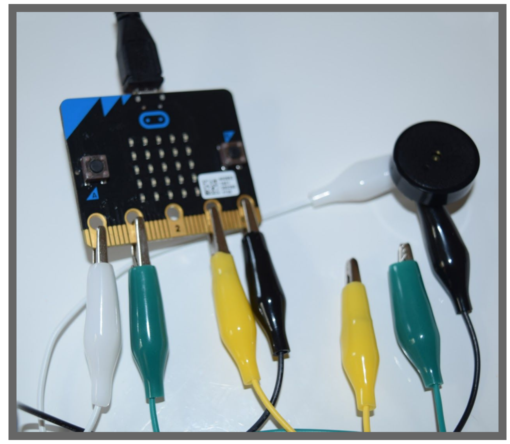
Connect two alligator clips to the pins marked "1" and "3v" on the micro:bit. Start your script and test it by touching the two alligator clips together. If everything is connected correctly, you should hear a high-pitched tone.



By touching the ends of the alligator clips to various materials, you'll be able to hear how well they conduct electricity. If you hear nothing, then the material does not conduct and it is an insulator. If you hear the same high-pitched sound you get when you touch the alligator clips to each other, then it conducts very well. If you get a low pitched sound, then it does conduct electricity, but it limits how quickly it flows, the way kinking a garden hose slows the flow of water.

Have students try lots of materials and note if they hear a high pitched sound, a low pitched sound or nothing. Discuss the results. Ask students to look for patterns. For example: metals are conductors, plastics and wood are insulators, and things with water in them (like humans!) are in between and are resistors.

Extended Activities

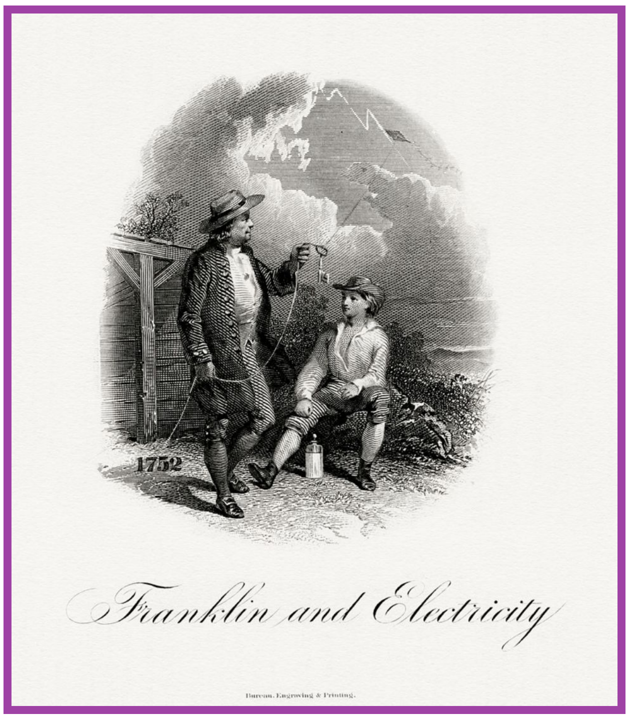
1. A switch or button allows us to deliberately make or break the path of the electricity to turn the device on and off. Have students create their own switches and buttons using cardboard and aluminum foil or copper tape, paper clips, and other materials. For an example of how to do this, check out this Paper Circuits activity from Lesley University (http://bit.ly/2Lh4t1k).

2. Use an analog input sensor (or "dial") with the script from activity two. Explore with students how the dial changes the pitch and what that means about the flow of electricity. The dial is a variable resistor. Inside is a strip of resistive material. The knob of the dial is attached to a wiper arm that slides along that strip, increasing or decreasing the amount of resistive material through which the electricity must flow.

3. Have students make their own variable resistor by drawing a thick, heavy line a quarter inch wide and a few inches long with a pencil. Go back and forth many times and bear down hard on the pencil — you want to get a lot of graphite onto the paper. A soft pencil works better than a hard one and a graphite pencil from an art store works really well. Touch one alligator clip to the end of the line and slide the other one back and forth. Compare this effect with the dial.

Benjamin Franklin and Electricity

Benjamin Franklin did many experiments with electricity, which people were just figuring out at the time. Some people thought there were two kinds of "imponderable electrical fluids", positive and negative. Franklin thought that there was actually only one kind of fluid. Too much of that fluid created a positive charge and too little created a negative charge. Franklin's theory was correct except for one small detail: an excess of his fluid (which we now call "electrons") creates what he called the negative charge. In short, with no way of knowing and 50/50 odds, he got "positive" and "negative" backwards. Although we talk about the electricity as traveling from positive to negative in an electric circuit, it is actually the negatively charged electrons that move and they flow from negative to positive.



Franklin knew the difference between conductors and insulators. Thus, when he did his famous kite experiment in 1752, he tied a silk ribbon (insulator) to the wet kite string (conductor) and stood under a roof to keep the ribbon dry. He succeeded in drawing enough electricity from the clouds to create sparks, demonstrating that lightning was electricity. Fortunately for him, the kite did not attract a direct lightning strike. In spite of using the silk ribbon to insulate himself from the kite string, Franklin could have been seriously hurt by a lightning strike. For more details, visit [Benjamin Franklin Kite Experiment](http://bit.ly/2XB7Bvw) (http://bit.ly/2XB7Bvw).