South Florida Science Museum
Circuits Lab Program Curriculum
Designed for Grades 4-8

PROGRAM DESCRIPTION

Take an electrifying look at how electricity gets around. This hands-on lab allows students to create their very own functioning electrical circuits and introduces some fundamental concepts like open vs. closed circuits, the difference between conductors and insulators, and much more. Students will use their new-found knowledge to construct a simple motorized robot of their very own!

SUNSHINE STATE STANDARDS

- SC.4.P.10.1: Observe and describe some basic forms of energy, including light, heat, sound, electrical, and the energy of motion.
- SC.4.P.10.2: Investigate and describe that energy has the ability to cause motion or create change.
- SC.5.P.8.4: Explore the scientific theory of atoms (also called atomic theory) by recognizing that all matter is composed of parts that are too small to be seen without magnification.
- SC.5.P.10.1: Investigate and describe some basic forms of energy, including light, heat, sound, electrical, chemical, and mechanical.
- SC.5.P.10.2: Investigate and explain that energy has the ability to cause motion or create change.
- SC.5.P.10.4: Investigate and explain that electrical energy can be transformed into heat, light, and sound energy, as well as the energy of motion.
- SC.5.P.11.1: Investigate and illustrate the fact that the flow of electricity requires a closed circuit (a complete loop).
- SC.5.P.11.2: Identify and classify materials that conduct electricity and materials that do not.
- SC.7.P.11.2: Investigate and describe the transformation of energy from one form to another.
- SC.7.P.11.3: Cite evidence to explain that energy cannot be created nor destroyed, only changed from one form to another.

MATERIALS

**During the circuit building activities, the students will be working in groups of 4.*

UFO/Energy ball

Tesla coil

Spectrum tubes

Electrical wire (should be pre-cut into 4”-6” pieces with the ends stripped of insulating sheath)

Wire cutters/strippers

Conductive/insulating dough

C or D batteries for dough experiments

LED’s

Snap Circuit kits w/ AA batteries

Circuit diagrams

AA batteries for robots
Electrical or duct tape
Scissors
Craft sticks
Plastic cups
Electric 1.5V DC motors
Glue sticks

VOCABULARY

Circuit - an interconnection of electrical elements forming a complete path for the flow of current.
Conductor - a material or an object that conducts, heat, electricity, light, or sound.
Current - the amount of electric charge flowing past a specified circuit point per unit time.
Electricity - the physical phenomena arising from the behavior of electrons and protons that is caused by the attraction of particles with opposite charges and the repulsion of particles with the same charge.
Insulator - a material or an object that does not easily allow heat, electricity, light, or sound to pass through it. Air, cloth and rubber are good electrical insulators; feathers and wool make good thermal insulators.
Power - the rate at which work is done, expressed as the amount of work per unit time and commonly measured in units such as the watt and horsepower.
Resistance - the opposition of a body or substance to current passing through it, resulting in a change of electrical energy into heat or another form of energy.
Semiconductor - Any of various solid crystalline substances, such as germanium or silicon, having electrical conductivity greater than insulators but less than good conductors, and used especially as a base material for computer chips and other electronic devices.
Voltage - A measure of the difference in electric potential between two points in space, a material, or an electric circuit, expressed in volts.

SCRIPT FOR CLASS

Good morning/afternoon everyone! My name is _______________ and I'm going to show you some cool stuff about electricity. You guys are going to assemble your own electrical circuits to light up light bulbs, spin motors, and lots of other fun stuff. You'll even get to make your own wobbly, battery-powered microbot.

What is electricity?

First, we need to figure out exactly what electricity is. Electricity is "the physical phenomena arising from the behavior of electrons and protons that is caused by the attraction of particles with opposite charges and the repulsion of particles with the same charge." Does that sound confusing to anybody? Me, too. So, let's see if we can make that a little easier to think about.

Who can tell me what matter is? Exactly! Matter is anything that takes up space. The shoes on your feet, the chair you're sitting on, the air you're breathing - everybody take a big, deep breath…hold it!...okay let it out - all of that stuff is matter. What is that matter made of? Right, atoms and molecules! Atoms are the smallest particles, or pieces, that are considered matter. But to understand electricity, we need to think even smaller and look *inside* the atom. Inside each atom are even smaller particles called protons, neutrons, and electrons. Each of these particles has something called an electric charge. Protons have a positive charge, electrons have a negative charge, and neutrons have a neutral charge - that means it's neither positive nor negative. Things with the same electric charge will try to push each other away, or repel, while things with opposite charges will try to get closer together, or attract. The pushes and pulls generate a kind of energy that is the driving force behind electricity. For this class, we're going to focus on just one of these particles - the electron. The electron is what gives us the kind of electricity that we can use. Sometimes, these electrons will jump from one atom to another. Any time that happens, electricity is produced. So basically, the electricity that we use is just a bunch of electrons moving from one place to another. We can use the energy from these moving electrons to power machines or computers or lots of other things. What are some other things we use these moving electrons, or electricity, for every day?

Activity: Tesla coil and spectrum tubes
Use the Tesla coil to light up a few spectrum tubes. If possible, turn off some of the lights so the students can see the spark and the plasma inside the tube more easily. You may want to explain that this is not a very efficient way to transfer electricity because air is not a good conductor of electricity. That's why you have to hold the spectrum so close to the coil - the electricity can't travel very far through the air.

What is a circuit?
To get electricity to make our stuff work, we have to make it go where we need it by making a pathway for it to travel through. This pathway is called a circuit and it lets electricity flow to where we want it to go. Circuits can be made of different materials as long as they are conductors. A conductor is something that allows electricity to flow through it. Something that doesn't let electricity flow through it is called an insulator. These are good for keeping electricity away from certain places or protecting things or even people from electricity.

A circuit also has to make a big loop - that means the electricity always has to have a way to get back to where it started. If not, the circuit won't work and electricity won't be able to flow through it properly. Circuits that make complete loops and allow electricity to flow are called closed circuits. Circuits that don't make a complete loop are called open circuits. Sometimes we add things to a circuit that allow us to open or close the circuit - turn it off and on - whenever we want. These devices are called switches. Can you think of anything at home or at school that turns on and off with a switch?

Activity: Human Circuits

Explain to the students that you're going to make a model of a circuit where the students are playing the part of the conductor or insulator. Ask them if they think humans are conductors or insulators. Ask them if they can think of a way to find out for sure. After taking a few suggestions, show them the UFO ball and explain that it has a light and a noisemaker inside, as well as a battery to supply electricity. The only problem is the circuit between the battery and the rest of the ball is not complete. In order to light up the ball and have it make noise you have to complete the circuit. Ask what would happen if you closed the circuit with an insulator? (Nothing) Ask what would happen if you closed the circuit with a conductor? (The light would come on and the noisemaker would make a sound) Have the students hold hands and spread out to make a big circle. Make sure they're all holding hands with skin-to-skin contact. Stand between two of the students and have those two let go of each other's hand while still holding on to the hands of the students on the other side. Have the two students place a finger from their free hands on the UFO ball's metal leads to close the circuit. The ball should light up and the noisemaker should activate. If not, make sure everyone is still holding hands. As the students return to their seats, ask again if they think people are conductors or insulators based on their observations from the experiment.

Amps, Volts, Watts, and Ohms (middle school grades)

When people talk about electricity, they sometimes use words like amps or volts that can be kind of confusing. Imagine an electric circuit as a river. We call the flow of the water/electricity the current. There are some currents that move a lot of water and some that don't carry much at all. The amount of electricity flowing through a circuit is measured in units called amperes or amps for short. This would be the same as measuring how many liters or gallons of water are in the river. The strength of the current is measured in units called volts. These units are not directly related. It seems to make sense that more water in the river – or electricity in the circuit – would mean more power, but think of a river a mile wide that is only flowing at 0.1mph (about 9 ft/min or 2 in/sec). You would have little risk wading or even swimming in this river and being swept away by the current. On the other hand, think of a small stream only a few yards across where the water is flowing at 60mph. Trying to go into that river could be dangerous or even deadly. So, the combination of these two measurements is more important in telling how useful the current can be to do work. The amount of work the current does when used in electrical devices is measured in units called watts. Finally, ohms are a measure of something called resistance. Some conductors are better than others but none of them are perfect. This means that not all of the electricity available actually makes it through the circuit. Some of it is lost along the way either because it's been used to do work like light a light bulb or it's lost as heat because the conductor isn't very good. It's like trying to slide a heavy box across the ground – the smoother the surface the more energy actually goes towards moving the box and the easier it is to slide it. On a really rough surface, more energy is lost because goes to overcoming the greater amount of friction instead of moving the box. The smooth surface represents good conductors and the rough surface represents poor conductors.

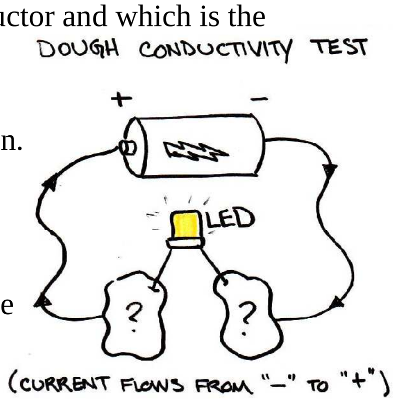
Squishy Circuits - conductive/insulating dough experiments (middle school grades)

Let's make some circuits. Every circuit needs a power source. Look at the materials and tell me what you think we're going to use as a power source. Right! We're going to use the battery. Now, what are we going to use as the conductor? Wires! You also have a few pieces of two special types of dough - one is an insulator and the other is a conductor. The last thing you should have some little lights called LED's. The LED's are what we are trying to power with our electrical circuits.

We're going to look at two kinds of circuits - series and parallel. A series circuit has all its components or parts lined up one after another around the circuit. As electricity is flowing through the circuit, it has to pass through one part before it can get to the next; there is only one path for the electricity to take. Parallel circuits have two or more different paths linked together.

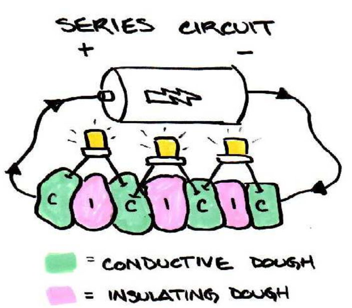
Activity: Squishy Circuits
Each group of 4 students will get a C or D battery, 2 pieces of wire, a small (golf ball sized) piece of each type of dough, and 3 LED's. Explain to the students that the LED's will only let the current flow in one direction so if it doesn't light up they might need to flip it around.

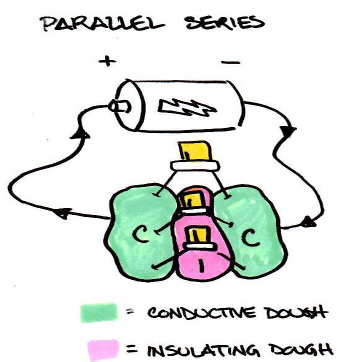
First, have the students figure out which type of dough is the conductor and which is the insulator. Set up a circuit that looks like the one here:



Remember, the LED's will only let the current flow in one direction. If it doesn't light up at first, make sure the students try flipping it around before they change to the other dough.

Once they have figured out which dough is which, they can practice building series and parallel circuits. Tell them to remove one LED from the circuit once they have it set up and working. The other LED's in the series circuit will go out because the circuit is no longer complete. The other LED's in the parallel circuit will remain lit because the electricity has alternative routes to complete the circuit.





*Sandwiching the dough like this insures that the circuit is only completed by a correctly oriented LED and not two pieces of conductive dough that are accidentally touching.

Snap Circuits Kits

Now, let's make some more complex circuits using the Snap Circuits kits. We'll make examples of series and parallel circuits and show you a few different ways we can convert electrical energy into other forms of energy like light, heat, or mechanical energy (energy that makes things move).

Activity: Snap Circuits
Each group of 4 students will receive 1 Snap Circuits kit. Pass out the circuit diagrams and give the students a moment to become familiar with the different pieces. No circuits should be built at this time. You may decide to let the students work freely by following the diagrams or you may wish to have a more structured activity where everyone builds the same circuits at the same time. If you choose the latter, pick 3-5 circuits and only pass out the diagrams for those circuits. Then, have the students build them together in order of increasing difficulty.

Microbots (*this activity will take at least 15-20 min*)

Each student needs a cup, 4 craft sticks, 1 piece of wire, a 1.5v DC motor, a glue stick, and 1 AA battery. You should also distribute the scissors and electrical/duct tape evenly amongst the students.

Tape 3 craft sticks to the inside of the cup. They should be spaced evenly around the cup's circumference and should all stick out the same length from the opening of the cup. These are the legs of the microbot so make sure they are taped tightly and won't wobble loose or fall off.

Use scissors to carefully make a slit across the bottom of the cup. The cut should be right across the middle of the cup bottom and be just wide enough to slide the 4th craft stick into. Slide the craft stick in about half way and tape it in place. This will be the neck.

Take the AA battery and tape it to the cup bottom just behind the neck.

Tape the DC motor to the free end of the neck to make the head. Make sure the tape does not interfere with the moving parts of the motor.

Carefully attach the glue stick to the top of the motor by inserting the spinning piece on top of the motor into the side of the glue stick. Make sure the glue stick is slightly off center so the microbot will wobble and walk.

Use electrical tape to secure the extra wire to one side of the battery - it doesn't matter which. Be sure the metal strands of the wire are making good contact with the battery. Tape one wire from the motor to the other end of the battery making sure there is good contact between the metal of the battery and the metal part of the wire. There should now be a motor wire connected to the battery, a motor wire with a free end, and a piece of wire with one end attached to the other side of the battery. To close the circuit and turn the robot on just connect the two free wire ends.