Squishy Circuits

The Big Ideas

- Science is a process of gaining knowledge through observation and experimentation.
- An electrical circuit is a pathway for a current of electricity. This electrical current is used to do work such as light an LED.
- Some materials, known as conductors, allow electricity to flow through, while others, known as insulators, do not.
- Some basic circuits are open vs. closed circuits, a short circuit, and parallel vs. series circuits.

Background

This activity is an exploration of electrical circuits through play dough. In this instance, current electricity is created by the flow of electrons, carrying an electric charge, through a conductive material. (It can also be carried by ions.) A conductive material, such as metal, typically has many free electrons that are easily dislodged from their orbits. Materials that do not allow the flow of electricity are known as insulators.

An electrical circuit is a closed looped pathway for the flow of electricity. Typically, it contains an energy source and a load, a component or set of components that uses electricity energy for work. Finally, wires are typically used to move the electricity from the battery through the load. Modern electrical circuits range in complexity from simple lamps, to complex computers. This activity explores various circuit arrangements to power one or more LEDs. In particular, it explores open vs. closed circuits, short circuits, and parallel vs. series circuits.

For our circuits, a battery will be the energy source and LEDs will be used for the load. The part of the wires will be played by play dough, which due to its high salt content and some acidity is conductive. Insulating dough is also available to buffer the conductive dough and allow for the creation of larger structures.

Materials – for 16 people

<u>Conductive Dough</u>

1 cup Water
1 1/2 cups Flour (A gluten free version of this dough can be made by replacing the flour with gluten-free flour.)
1/4 cup Salt
3 Tbsp. Potassium bitartrate (aka Cream of Tartar) or 9 Tbsp. of Lemon Juice may be substituted
1 Tbsp. Vegetable Oil
Food Coloring (optional)

Insulating Dough

1 1/2 cup Flour
1/2 cup Sugar
3 Tbsp. Vegetable Oil
1/2 cup Deionized (or Distilled) Water (Regular tap water can be used, but the resistance of the dough will be lower.)

Demonstration

24 LEDs
8 6V batteries
Wires or alligator clips, if necessary, to connect battery to dough or other loads

Preparations

Conducting dough

http://courseweb.stthomas.edu/apthomas/SquishyCircuits/conductiveDough.htm

1. Mix water, 1cup of flour, salt, cream of tartar, vegetable oil, and food coloring in a medium sized pot.
2. Cook over medium heat and stir continuously.
3. The mixture will begin to boil and start to get chunky.
4. Keep stirring the mixture until it forms a ball in the center of the pot.
5. Once a ball forms, place the ball on a lightly floured surface.
   WARNING: The ball will be very hot. We suggest flattening it out and letting it cool for a couple minutes before handling.
6. Slowly knead the remaining flour into the ball until you've reached a desired consistency.
7. Store in an airtight container or plastic bag. While in the bag, water from the dough will create condensation. This is normal. Just knead the dough after removing it from the bag, and it will be as good as new. If stored properly, the dough should keep for several weeks.

Insulating dough

http://courseweb.stthomas.edu/apthomas/SquishyCircuits/insulatingDough.htm

1. Mix solid ingredients and oil in a pot or large bowl, setting aside ½ cup flour to be used later.
2. Mix with this mixture a small amount of deionized water (about 1 Tbsp.) and stir.
3. Repeat this step until the mixture absorbs a majority of the water.
4. Once your mixture is at this consistency, knead the mixture into one "lump".
5. Knead more water into the dough until it has a sticky, dough-like texture.
6. Now, knead in flour to the dough, until a desired texture is reached.
7. Store in an airtight container or plastic bag. While in the bag, water from the dough will create condensation. This is normal. Just knead the dough after removing it from the bag, and it will be as good as new. If stored properly, the dough should keep for several weeks.

Table Setup Recommendations

About ¼ of the each dough is sufficient for a table of 4 people.
If possible, pass out materials after step 1.

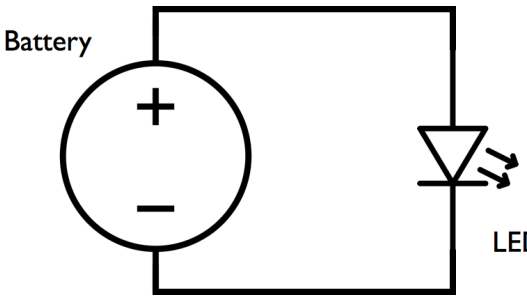
Presentation

1. Introduce that they are going to be scientists for the next few minutes, and they will be observing and experimenting with electrical circuits. Ask where they find electrical circuits in their everyday lives. Accept all reasonable answers, and summarize that electrical circuits are all electrical devices from computers (complex circuits) to lamps (simple circuits).
2. **Identifying Components**: The materials in front of them will be used to make some simple circuits. Ask them to identify the following components:
    a. *Battery*: The source of electrical energy. Connecting the positive and negative leads generates an electric current.
    b. *Light-Emitting Diode (LED):* Emits light when an electric current run through the wires.
    c. *Play dough*: Connections between the battery and LED.
3. **Building the first circuit:** Ask them to make/demonstrate two balls (about ¾ in. diameter) of the colored dough. [Choose Path (a) or (b): Path (a) asks them to experiment with the design on their own. Path (b) leads them step-by-step through the process.] If possible during the explanation, draw the LED circuit diagram shown below. WARNING: Do not connect the battery to the LEDs directly, as they are not designed to withstand 6V for an extended period.
    a. Each group should also get a battery and one LED. Ask them to make the LED light up using all 4 components, but that they should not directly connect the battery to the LED, since this might damage the LED. When they have been succeeded inquire as to what they've learned about when the LED turns on and when it doesn't. In particular, that (1) the LED only lights up when it's in a certain direction and (2) the two balls can't touch.
    b. Plug one end of the battery into one ball and the other end of the battery the other. Then, plug the ends of the LED into separate balls, like a bridge. Ask how many of them worked (about half of them should work). Then ask everyone to pull out his or her LED, flip it around, and reinsert into the dough. It should have flipped on or off. Explain that an LED only works if the electricity is flowing in the correct direction.
4. **Electric Current**: Reset their circuits to the 1 LED circuit. Explain that they've created a **loop** from the positive end of the battery through one dough ball, the LED, the other dough ball, and into the negative end. This allows an electrical current to flow.

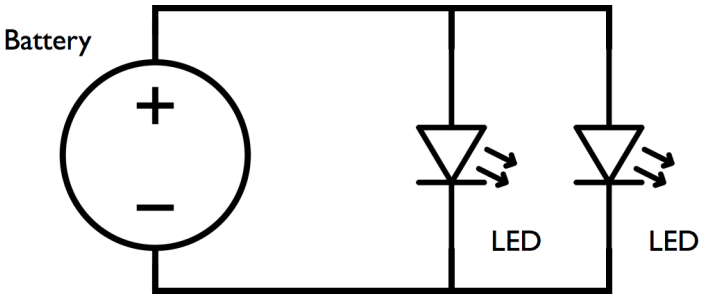
5. **Open vs. Closed Circuit**. Reset their circuits. Ask them to pull off one of the leads. This breaks the pathway, preventing electricity from flowing. This is an open circuit. When the loop is complete, it's a closed circuit.
6. **Short circuit**: Reset their circuits. Ask them to make another dough ball and connect the two balls. This will turn off the light, because it creates shortcut for the electricity. This is a short circuit. The same thing happens when the two balls touch. This dough is *conductive* and allows electricity to flow through it.
7. **Sandwich**: Reset their circuits. Then what happens if you connect the two balls with a ball of the white (insulating) dough? It will not turn off because electricity cannot flow through this dough. This dough is *insulating*. Ask them to create/demonstrate a sandwich of two conducting balls with insulating dough in between and to create a circuit with an active light.
8. **Parallel Circuit**: Ask them to get another LED, and see if they can get two lights to turn on. This is a parallel circuit, because there are parallel paths for the electricity. If possible, draw the parallel circuit shown below.
9. **Series Circuit**: Ask them to create a larger sandwich by adding an insulator ball and a conductive ball. Can they turn on two LEDs using all three conducting balls? This is a series circuit, because there is one path going through both. What happens when they remove one of the LEDs? This breaks the path creating an open circuit. If possible, draw the series circuit shown below.
10. **3 LED Sculpture**: Challenge them to come up now to create a CREATURE that uses three or more LEDs. Be creative.

Diagrams

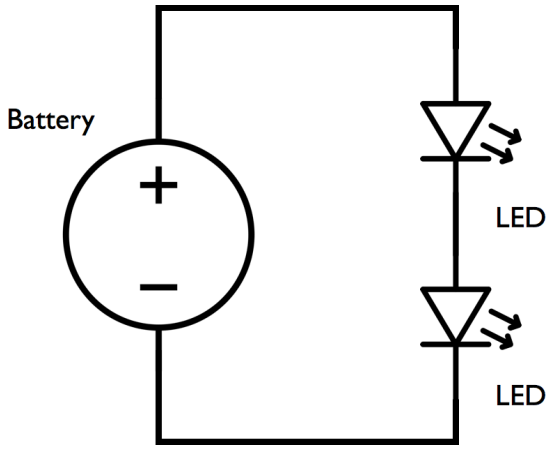
a. LED Circuit
(This circuit should be made with a resistor on the positive connection between the battery and LED. It is not shown as the dough is resistive).



b. Parallel Circuit



c. Series Circuit



Resources

Squishy Circuits by the Thomas Lab at Univ. of St. Thomas
http://courseweb.stthomas.edu/apthomas/SquishyCircuits/
The Tinkering Studio Blog
http://blogs.exploratorium.edu/tinkering?s=squishy+circuit&x=0&y=0
Squishy Circuits Blog
http://squishycircuit.blogspot.com/
All About Circuits
http://www.allaboutcircuits.com/