Maker Programs in Vermont Libraries: Spark a Culture of Innovation presents:

Build playful and colorful sculptures using conductive play dough. Using jumbo LEDs and batteries you'll learn to build parallel and series circuits and then use these patterns to build unique sculptures that light up!

Workshop Objectives

During the course of this workshop, participants will:

- Learn about circuits made of conductive and insulating materials.
- Build and compare parallel and series circuits.
- Add components to circuits and explore resistance and short circuits.
- Create an inventive sculpture using dough and components.

Suggested Ages

6-12 is optimal, older participants often get bored quickly with this activity.

Next Generation Science Standards Addressed

- K-PS2- 1,K-PS2-2. Simple tests can be designed to gather evidence to support or refute participant ideas about causes.
- 1-PS4-4.Use tools and materials provided to design a device that solves a specific problem.
- 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.
- 4-PS3-2,4-PS3-3.Energy can be moved from place to place by moving objects or through sound, light, or electric currents.

For more information on NGSS, please visit http://www.nextgenscience.org

Materials

For each participant:
- 4-8 10mm LEDS
- Battery Pack
- Batteries
- Safety Glasses
- Mini screwdriver for battery packs

For each group:
- Conductive dough in various colors (each recipe makes enough for 4 participants, for a group of 20, make 5 colors and separate)
- Insulating dough (participants need less of this, one recipe per 6-7 participants is enough)
- Plastic sculpting tools (for PlayDoh)
- Conductive materials (wires, mesh, etc.)
- Motors (~30mA)
- Buzzers (mechanical or piezoelectric, less than 30mA)
- Googly eyes and toy parts
- Disposable table cloth

Tools to make dough:
- Mixing bowl
- Wooden mixing spoon
- Saucepan (can be cleaned after making dough, but you may want to use an older pan)
- Hot plate or stove
- Airtight containers (plastic bags, plastic containers)
- Measuring cups/spoons

Preparation: Making the Dough

Conductive Dough

Ingredients:
1 cup Water
1 1/2 cups Flour
1/4 cup Salt
3 Tbsp. Cream of Tartar*
1 Tbsp. Vegetable Oil
Food Coloring (optional)
*9Tbsp. of Lemon Juice may be substituted

Procedure:
1. Mix water, 1 cup 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. Flatten it out and let 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.
8. Keep refrigerated. If stored properly, the dough should keep for several weeks.

Insulating Dough

Materials:
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.)

Procedure:
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.
8. Keep refrigerated. If stored properly, the dough should keep for several weeks.

These recipes were copied from the Squishy Circuits website. For images and metric measurements, please visit the website at http://courseweb.stthomas.edu/apthomas/SquishyCircuits/index.htm

Safety Considerations

LEDs can explode. This happens rarely, but have participants wear goggles!
The dough is edible. Disgusting tasting, but edible. If a child eats some, no action needs to be taken.
The dough can make a big mess. Make sure that tables, carpets and good clothes are safe guarded—the food coloring can dye many materials.

Running a Squishy Circuit Session

Warm up (optional)

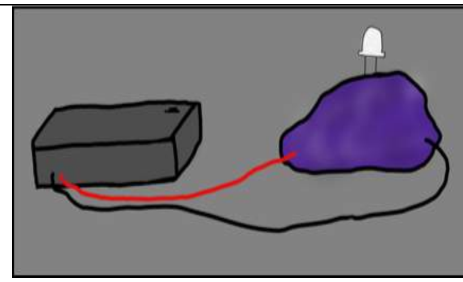
1. Explain that we will be using dough to make circuits. Discuss the definition of **circuit**: a closed path or loop around which an electric current flows.
2. Explain that there are different types of circuits. Today we will be exploring **parallel** circuits and **series** circuits.
3. Play the **circuit game**. I find that it helps to have this game as a reference when you are talking about the dough circuits.
    a. Divide the group into two equal groups.
    b. Have one group create a **series circuit** by standing side by side in a line. In a series circuit, the electricity travels from the positive to the negative pole of each component as it completes the circuit. Tell the first person in the line that he/she is the battery. Give that person an object (I generally use a play dough tool as they are handy.) Tell the last person in the line that he/she is the light. The circuit needs to move the object from the first person in line to the last as quickly as possible, BUT each individual must take the object in one hand, touch their head with it, then touch their feet with it (to signify the electricity moving through the component), then transfer it to the other hand before handing the object to the next person. See how fast the energy can get from the battery to the light.
    c. Have the other group create a **parallel circuit** by lining up, one behind the other. Explain that in a parallel circuit, all the components are parallel, so the electricity moves in a line. Have all the members of the group hold up their right hands near the shoulder of the person in front of them. Tell the first person in the line that he/she is the battery. Give that person an object. Tell the last person in the line that he/she is the light. The circuit needs to move the object from the first person in line to the last as quickly as possible. Each person takes the object as it is passed over the shoulder of the person in front of them then passes it over their own shoulder. See how fast the energy can get from the battery to the light.
    d. As each group practices, look for anyone that makes an error or drops the object. Explain that the electricity stopped where the mistake happened and that this can happen in an electric circuit, either by breaking the circuit or crossing it incorrectly in a short circuit.
    e. When both groups are clear on the task, have them race to see which group can move the electricity from the battery to the light first. The series circuit group will soon complain that it cannot beat the parallel group. Move members of the series group to the parallel group until the times are roughly tied. Count the members of each final group.
    f. Explain that the series circuit group was encountering more **resistance**. Ask if anyone can define resistance. Explain that in circuits, resistance is a measure of how hard it is for the electricity to move through a circuit and that both materials and types of circuits affect resistance. The parallel circuit group had much lower resistance than the series circuit group and that is true in electric circuits too.

Exploring circuits with dough

Distribute dough, battery packs, safety glasses and LEDs to participants. I tend to hold back on the other materials until the guided exploration is done. Have the group put on their glasses and walk through and discuss the following steps:

Begin with one lump of the conductive dough. Insert the battery pack's wires into the dough on opposite sides. Next, insert a LED into the dough.

Does the LED light up?



Separate the conductive dough into two pieces. Plug one wire from the battery pack into each piece and bridge the gap with a LED.

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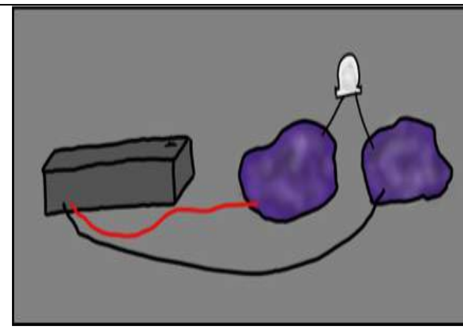

The LED only works in one direction. This is called **polarity**. Take the LED out. Notice how one "leg" is slightly longer than the other one. The longer terminal should be attached to the positive or red wire from the battery pack.

Experiment with this until the LED lights up

Next, with your LED on, take the two pieces of conductive dough and push them together or add some dough to connect them.

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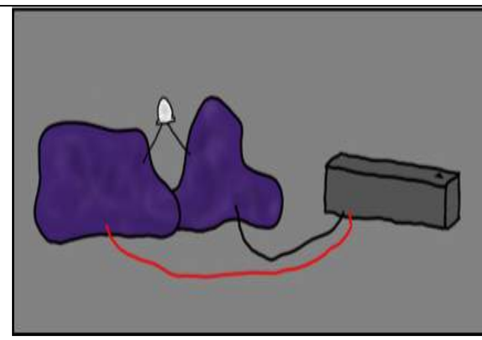
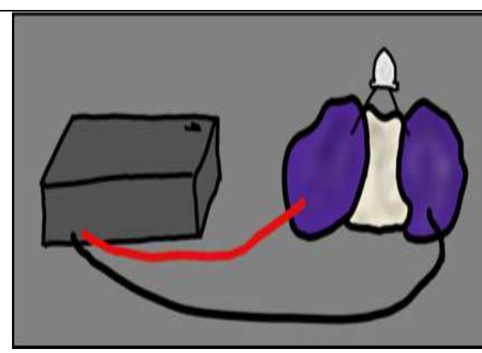


Notice that the LED went out. This is because a short circuit was created. Electricity flows in a loop called a circuit, which begins and ends at the battery pack. Electricity takes the path of least resistance, meaning it goes through whatever loop is easiest to flow through. In this case, the conductive dough is less resistive than than the LED, so the electricity chooses to go around the LED and through the dough

Separate the two pieces, the LED should once again light up because the electricity must go through the LED to complete the circuit.

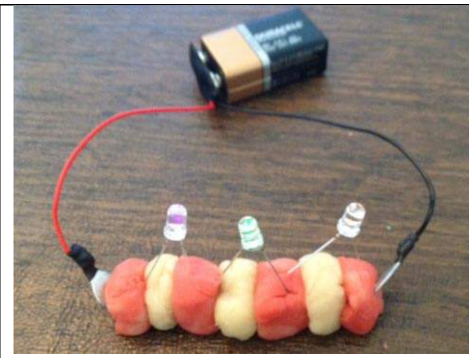
Create a "sandwich" with the insulating dough between two pieces of conducting dough.

The insulating dough does not let electricity flow through it easily. It acts like a wall to electricity. Therefore, the electricity has to go around the insulating dough and through the LED, which lights the LED.



Challenge: How many LEDs can you get to light up in this "sandwich" form? Add layers of insulating and conductive dough and make sure you keep your polarity straight.

Have individuals/groups try this and see how many LEDs can be added before they no longer glow.

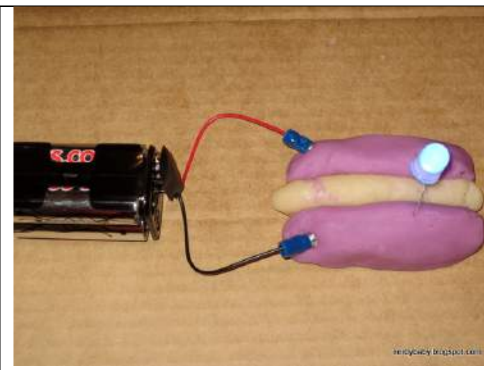


Stop and check: Is this a series circuit or a parallel circuit? Notice that the LEDs are side by side. It is a **series circuit**.

Remove an LED from the middle of the sandwich. Do the other lights go out?

In a series circuit, as LEDs are added they will get more dim because there is less electricity available to power them. If one of the LEDs is taken out, the entire circuit is broken and all of the lights will go out.

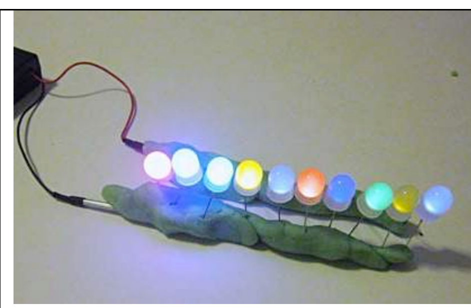
Take the battery leads out of the circuit. Make two long "snakes" with conductive dough. Make one long snake with insulating dough. Put the insulating snake between the conductive snakes. Insert one of the battery packs leads into each of the snakes. Add an LED. Does it light up? If not, check the polarity.



What happens if you pinch the snakes together at the end so the conducting dough touches? Again, this is a short circuit.

Challenge: How many LEDs can you get to light up in this "snake" form? Add LEDs and make sure you keep your polarity straight.

Have individuals/groups try this and see how many LEDs can be added before they no longer glow.



Stop and check: Is this a series circuit or a parallel circuit? Notice that the LEDs are parallel, standing behind one another. It is a **parallel circuit**.

Does the parallel circuit support more lights than the series circuit did? How does this relate to resistance in the opening game?

Remove an LED from the middle of the snake. Do the other lights go out?

In a parallel circuit, LEDs or other electrical items are connected to the dough each in their own loop or circuit. Since electricity flows through each LED independently, if one is removed or burns out, the others will continue to shine brightly.

Free building time

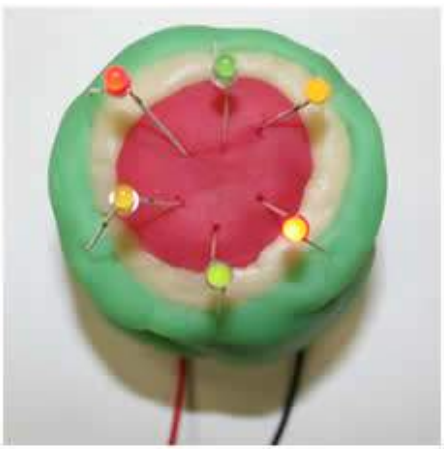
Now the real fun begins!

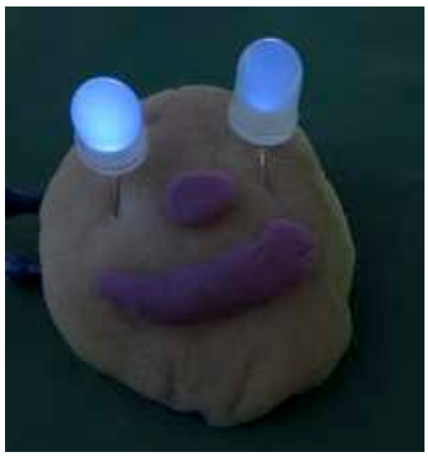
Introduce the other materials, explaining that the motors and buzzers work just like the LEDs—they have positive and negative terminals and must be incorporated into the circuit.

Introduce any metallic components. Explain that metal is an even better conductor than dough and that it too can be used in circuits.

Encourage participants to use all the materials to build sculptures that use series or parallel circuits. They may make animals or characters or flowers or hearts or whatever they wish.

For participants who are hesitant, encourage them to try any of the following:





Some participants may want to team up and make creations with multiple battery packs. Allow free building to go on as long as participants are engaged.

Closing Activity

Have participants admire each other's creations. Ask the group to identify if circuits are parallel or series. Celebrate all the creativity!

Vocabulary

Circuit: a closed path or loop around which an electric current flows
Series circuit: a circuit constructed with components in a single loop
Parallel circuit: a circuit constructed with each component having its own loop back to the energy source
Resistance: how well a material or object conducts electricity
Conductive dough: A conductor allows electricity to easily flow through it. In this recipe, the salt helps the electricity flow because it dissociates into positive sodium and negative chlorine ions
Insulating dough: An insulator does not let electricity flow through it easily. Because of this, they act as a wall to electricity and the electricity has to go around them. If a path around an insulator is not available, the circuit cannot be completed.

For More Information:

This activity was taken (in places verbatim) from the Squishy Circuits work done at the University of St. Thomas by AnnMarie Thomas and her grad students. There are other project examples and tutorials on the site. All of the material is free and open-source courtesy of the University of St. Thomas and can be found at: http://courseweb.stthomas.edu/apthomas/SquishyCircuits/index.htm

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