ADVANCED

SpaceDough

Leader Guide

Style Engineers

Fashion through science

WITH THIS ACTIVITY

- Advanced SpaceDough At a Glance
- Challenge Questions
- Making SpaceDough Handout
- Protecting Power Sources Handout

MODULE


We are Engineers!


Movement Improvement


Marvelous Materials


Smart Clothing


Patternmaking Tools n' Tech

Big Picture

This activity continues the exploration of electrical concepts introduced in Introductory SpaceDough. We suggest completing both of SpaceDough activities before exploring electronics in clothing with the Illuminating Fashion Activity.

What's the goal?

Young designers will explore series and parallel circuits. If desired, you may continue to explore other types of LEDs.

Grouping

Young designers are in teams of 4-6, with one leader per group.

Materials

What they need: (each)

ACTIVITY KIT:

- Large handful of SpaceDough (commercial Play Dough is less conductive, but it can be used.)
- 6V Battery pack (1)
- 4 AA batteries
- 5mm LEDs (3-6)
- 5mm RGB LED (1) (optional)

What you need: (per leader)

- A set of the materials listed above
- Extra battery packs
- Extra AA batteries
- Extra LEDs

Preparation Time: 45 Minutes

Activity Time: 45 Minutes

Difficulty: Level 3

SAFETY NOTE

The battery packs used in this exercise can pose a burn hazard if not properly used. Leaders are strongly recommended to explore the "protecting power sources" guide to making safer battery packs. If protected battery packs are not an option, battery packs must be handled carefully: leaders must make sure students NEVER allow bare positive and negative wires to touch and batteries MUST BE REMOVED from packs before storing.

Preparation

- Make enough SpaceDough for your young designers following the Make SpaceDough Handout.
- Prepare an Activity Kit for each designer

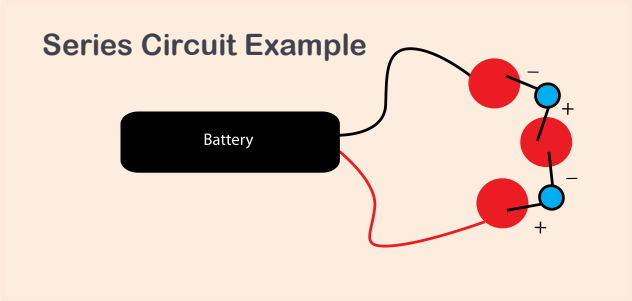
Let's Get Started!

1. Ask designers if they recall the concepts of conductors, insulators, polarity, open and short circuits from the Introductory SpaceDough activity. If they do not recall these concepts, or you have not done the Introductory SpaceDough activity, review.
2. Explain the activity and hand out a kit for each designer. Have the young designers put the AA batteries into the battery pack.
3. Reiterate the safety message: DO NOT TO TOUCH THE ENDS OF THE TWO WIRES COMING OFF THE BATTERY PACK TO EACH OTHER!

Series Circuits

1. Ask young designers to connect two LEDs in a line, one after the other using a ball of SpaceDough between each LED (see picture).

- They should have a circuit that is working.



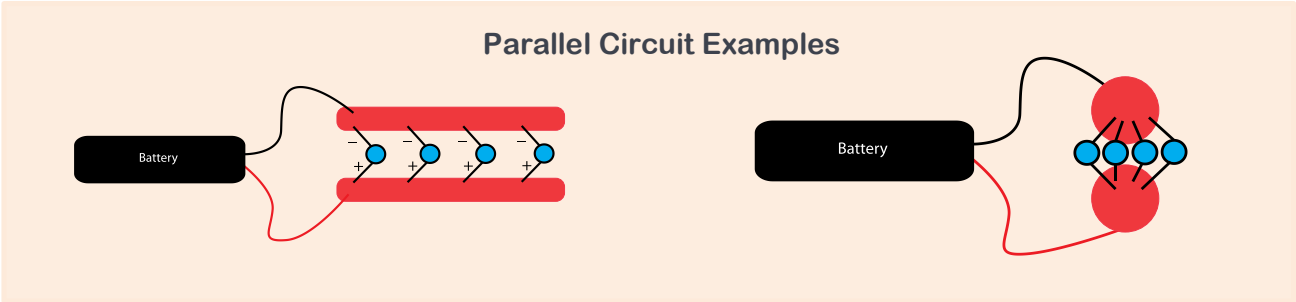
2. Now have them add more LEDs to the circuit in this manner.
    - **Ask:** How many LEDs were they able to light up this way?
    - **Answer**: This is a **series circuit** in which the LED closest to the power source has best access to the power source. The more LEDs there are, the less “push” each one gets. When there are too many, they no longer turn on. Usually more than 2 or 3 will not light up in a series.

VOCABULARY

Series Circuit: a circuit in which electricity passes from one component to the next component in a line -- it must pass through the first one before it reaches the second one. Voltage is consumed by each component, ultimately reducing the remaining current so that the components farthest away get none. Therefore, a relatively small number of LEDs can be powered in series circuits.

Parallel Circuits

1. Now have the young designers try to create a circuit with two LEDs in a configuration that they think will allow each LED equal access to electricity. Let them experiment to see if someone manages to make a parallel circuit. It should look something like these.



2. If their circuit does not already look like this, tell them to think of train tracks with SpaceDough as the parallel rails and LEDs as the ties crossing between (like the image on the left above).

    - **Ask**: For circuits that look like the picture on the left, are all of the negative legs connected to the negative battery lead?
    - **Answer**: Yes, even though the SpaceDough is stretched out, the LEDs are still connected directly to the battery.

3. Have them add more LEDs to this configuration.

    - **Ask**: How many LEDs can you light?
    - **Answer**: They should all light because this circuit, called a **parallel circuit**, allows all the LEDs access to equal amounts of voltage in the circuit.

VOCABULARY

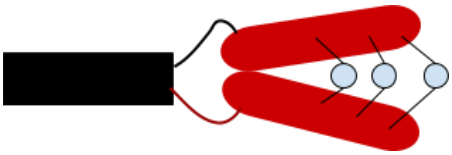
Parallel Circuit: a circuit in which all components are connected directly to both positive and negative battery leads. The same amount of voltage reaches all of the components in parallel without being reduced as it is in series circuits. Because of this, more LEDs can be powered at once.

4. Let them experiment with parallel circuit shapes.

    - **Ask**: What things can you change about the circuit and still make all the LEDs light up? What things can you not change?
    - **Answer**: You can change the shape and length of the SpaceDough, and the placement of the LEDs on the SpaceDough, but you cannot change the connections between positive and negative, and the fact that it must be a closed (but not short) circuit.

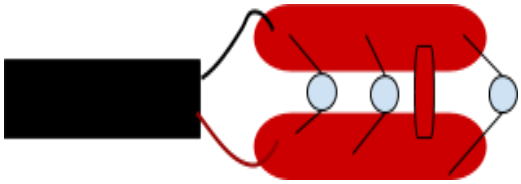
Short Circuits in Parallel Circuits

1. Remind the designers of short circuits. As them to create a short using the parallel circuit.



- **Ask**: What happened?
- **Answer**: Positive and negative paths touched, giving the current an easier route than going through LEDs.

2. Now have them take a piece of SpaceDough and make a bridge across the parallel between the LEDs.



- **Ask**: What happens?
- **Answer**: This also creates a short circuit. Designers may think that the LEDs close to the battery will still work, because the electricity has not yet reached the short. But the current will still find the path of least resistance and will not go through **any** LEDs.

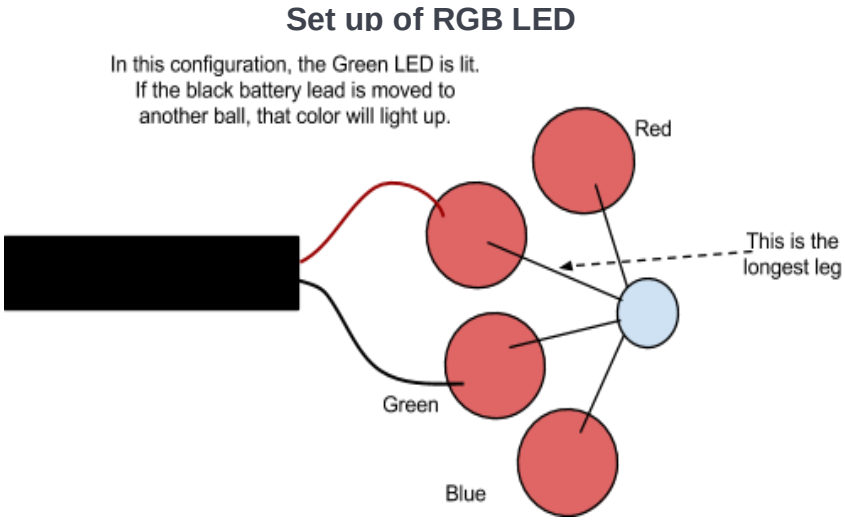
Optional Experimentation

1. **Resistance and Length/Diameter**: Have the young designers roll their Space Dough out into the longest, thinnest ropes they can, and then build a parallel circuit again using all LEDs. Place at least one LED as far as possible from the battery.

- **Ask**: What happened to the LEDs farthest away from the battery?
- **Answer**: If the SpaceDough gets long and thin enough, the resistance at the far end (away from the battery) will be much higher than the resistance close to the battery. This may make LEDs dimmer at the far end. The

SpaceDough acts like a pipe, and the electricity acts like water running through the pipe. If the pipe is too narrow, less water gets through.

2. **RGB LEDs:** Give each young designer an RGB LED. Encourage them to try to figure out how to set it up, prompting them by telling them the longest leg is the positive (see below).



RGB Discussion:

- If you look very closely at the LED, you can see the three different LEDs inside.
- The longest leg of the LED is a common positive leg. Each of the other leads is the negative leg of a different LED, one Red, one Green, and one Blue. Connecting a negative leg to ground completes a circuit for that LED and turns it on. If more than one of these leads is connected to ground, more than one color will light at the same time. They must be set up as a type of parallel circuit using just the one bulb.
- By turning on combinations of LEDs, you can get different colors out of the LED. This is how your television and computer screens work. Each tiny pixel has 3 colors available, just like the LED. By turning on different amounts of each color, the screen can produce any color at each pixel. Together, the pixels form a picture.

Wrap it Up

1. Discuss where and how young designers have seen LEDs used in clothing and accessories. Ask what they would design incorporating LEDs. Move on to the Illuminating Fashion Activity so they can light up some clothing!
2. To gain an understanding of how much of this material the young designers have learned use the Advanced Challenge Questions to test them on their knowledge.

Any areas of confusion should be cleared up before moving on to the *Illuminating Fashion* activities.

SAFETY NOTE: If you have not added resistors to your battery packs to protect them (see "Protecting Power Sources"), be sure to have the young designers REMOVE all batteries from battery packs before returning kits to you. Never store battery packs with batteries in them.

For More Information

- Circuit Basics using conductive dough: https://youtu.be/_8WEnfrZ5os
- LED tutorial: https://learn.sparkfun.com/tutorials/light-emitting-diodes-leds?_ga=1.248194368.658330718.1433775501
- Special thanks to the Squishy Circuits Project at the University of St.Thomas in Minnesota. http://courseweb.stthomas.edu/apthomas/SquishyCircuits/

Supply Specifics

Component	Specifications	Picture	Suggested Sources
Battery Pack	• 4 X AA battery pack, with wire leads (6 volt) • Multiple configurations are available, e.g. covered or with switches	 	www.amazon.com www.adafruit.com www.sparkfun.com www.digikey.com http://www.parts-express.com
LEDs	• 5 mm, 3.0-3.2 volts, 2 leads, clear white or another color (note that different colors may have different voltages)		www.amazon.com www.adafruit.com www.sparkfun.com www.digikey.com
RGB LED	• 5mm Diffused RGB Controllable LED		www.amazon.com www.adafruit.com www.sparkfun.com www.digikey.com

Challenge Question Answer Key

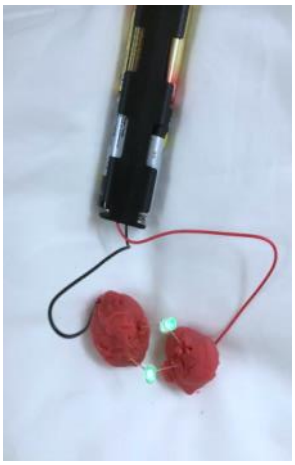
Which of these is a series circuit?

Circle your answer below.

A

B

C



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