

Squishy Circuits

Squishy Circuits are educational kits used to teach students about electricity and circuits using non-traditional manipulatives. The kits contain a switched battery holder and components (LEDs, motor, and speakers – not conductors). Instead of using hard wire conductors, soft dough provides electrical connectivity from the power source to the electrical components. Squishy Circuits were developed by the Playful Learning Lab at the University of St. Thomas. The kits are sold at the Squishy Circuit Store <http://squishycircuitsstore.com/kits.html> .

The advantages of using Squishy Circuits over more traditional methods is that it offers a more tactile experience for the child and illustrates that different materials offer different current-carrying capabilities. Every material falls somewhere on the spectrum between the perfect insulator to the perfect conductor. Electrician connections are easily made and unmade by just moving dough or inserting or removing the component into the dough.

Background Information on Dough

The Squishy Circuits Guide from St. Thomas University contains links for **conducting and insulating dough**. The salt content in conductive dough is responsible for making the dough conductive. Heating the dough ionizes the sodium and chloride and promotes conductivity.

The conductive dough recipe produced a dough that was pleasingly soft and easy to shape, and remain soft with time. Squishy Circuit Dough recipe for conductive dough makes about one pound of dough, enough for 4 groups. All-purpose flour worked better than bread flour. This recipe is less desirable if students are mixing up the dough since it requires cooking. The dough recipe from Lava Layering Lesson plan from NASA's "Exploring the Moon – A Teacher's Guide with Activities" has twice as much salt for the same amount of flour but does not require cooking.

The Squishy Circuit recipe for insulating dough calls for sugar instead of salt and oozes more. The insulating dough made from the recipe started out a shiny white. About a month later, the dough changed into a glob of black moldy slime. Modeling clay worked out to be a better choice for insulating materials. Although not as pliable, it comes in a variety of colors and works well as an insulation material. Since it doesn't mix well with play dough, it's easier to separate from the conductive dough during clean up.

Our staff still prefers to purchase dough rather than mix up batches of the conductive dough. If one regularly makes the dough, one will likely become adept, but you also might make a bad batch before you learn how long to cook the dough.

It is recommended to purchase dough or model clay instead of making dough according to the recipes. Purchasing the dough rather than purchasing the materials to make the dough yields a more consistent dough, and form more time efficient. The Sargent Art brand of dough is less expensive than Play-Doh yet still comes in a variety of colors. Other brands of dough will probably work, but Sargent Art is the brand of dough used by iSPACE.

Squishy Circuit Components

Battery Pack:

Four AA batteries in the battery pack are electrically connected to each other in **series**, NOT in parallel. Geometrically the batteries are placed in the **physically parallel** to each other, but the electrically they are in series. Therefore, the total voltage between the black and red leads of the power supply is the sum of the voltages of the individual batteries. With new batteries, the voltage across the terminals will be 6 volts (4 batteries x 1.5 volts each = 6 volts), which limits the currents to safe levels. When inserting the batteries, it's a great opportunity to remind the students to match the symbols on the batteries with those on the battery holder for correct polarity. The anode (+) and cathode (-) are marked on the batteries and need to correspond to the + and - on the battery pack.

When the battery pack is switched on, students **should not touch the leads to each other**, creating a short across the batteries. Many electrons will take this "short cut" to the + terminal, generating heat and draining the batteries.

LEDs:

LED is an acronym for **L**ight **E**mitting **D**iode. There are 25 LEDs in each kit, 5 of each color. Of the five various colors, the red LED has the lowest threshold (minimum voltage needed to light the diode) and therefore will light the easiest.

The electronic symbol for the diode is a reminder that current flowing in the direction of the arrow causes the diode to emit light. A diode will try to block current flowing in the opposite direction. If the voltage exceeds the diode's maximum, it will cause irreversible damage and burn out the diode.

For correct polarity, the LED should be inserted into a complete circuit so the slightly longer lead is closer (electrically) to the battery pack's red wire. Since the difference in the length of the leads is hard to discern when the leads are spread apart, it's easiest to check for correct polarity by just removing and re-inserting the LED in the opposite direction.

Safety

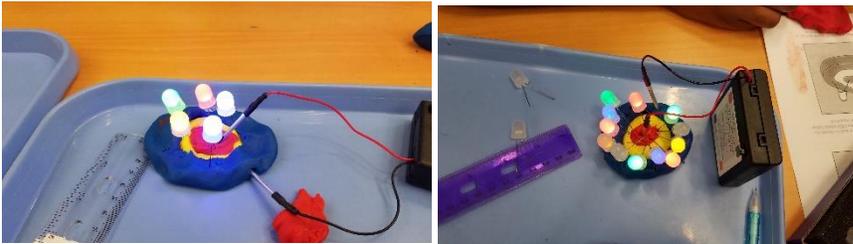
- ▶ Don't short the battery pack by touching the two metal leads together.
- ▶ Don't touch the battery pack's leads to the legs of a LED.
- ▶ Make sure there is at least 2 inches of dough in your complete loop before the battery is switched on.

Activities:

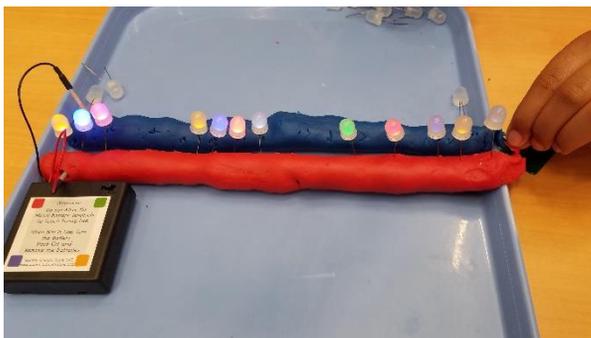
The following classroom guides are excellent resources for introductory activities:

- ❖ **Squishy Circuits Classroom Guide from St. Thomas University** - pdf file with links recipes for conducting and insulating dough and "Squishy Circuits Basics". The Squishy Circuits Basics would be appropriate for a student handout.
- ❖ **Classroom Activity Student Squishy Circuits from Science Buddies** – student guide with vocabulary and excellent photographs of the Squishy Circuit activities.

- ▶ Try shapes for the dough and different ways of connecting them.



- ▶ What did you discover?
- ▶ Come up with a question you can solve with the Squishy Circuits
- ▶ Which diode takes the least amount of voltage to turn on?
- ▶ Which Diode is the hardest to turn on?



This photo shows a student examining the difference between the colors with slightly different voltages. The further away from the power source (the lower the voltage) the less brightly the diodes will light, with the effect seen more prominently with the blue LED than the red.

For questions or more information, check out our website: iSPACEscience.org,
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