BLACK HOLES EDITION
(PAPER CIRCUITS #3)

NASA'S UNIVERSE OF LEARNING

A hands-on activity using printable templates and creating simple paper circuits. Good for MakerFaires, libraries, classrooms and other STEM related events where participants can create their own take-away.

What is a Paper Circuit?
Paper circuits help learners of all ages explore the basics of electricity (energy that results from the existence of charged particles like electrons or protons) and conductivity (the degree to which a material can conduct electricity). Paper circuits function as simple low-voltage electronic circuits (a path through which electrons from a voltage or current source flow) made using paper, LED lights, a type of conductive tape such as copper, as well as a small battery for the power source.

Directions: Download the attached .pdf and print double-sided (so the shapes are lined up) and cut in half (you will get two handouts per page)

1. Have participants cut out the rectangle - see handout for instructions
2. Ask participants to fold paper in half on the dashed line so that the directions are on the INSIDE/images are on the OUTSIDE.
3. Punch a hole for the LED light - see template
4. Following the remaining steps outlined on the handout - placing copper tape, finding the positive lead on the LED and affixing the leads to the circuit, and folding over with the coin battery.
5. Use a binder clip to hold battery in place on the circuit (so the light stays on)

Troubleshooting

- Flip the battery over. If the LED was put in backwards, it just means the positive and negative parts of the circuit are reversed
- Check all connections - around the LED leads, alignment with the battery, any broken places in the copper tape. Use more tape to reinforce connection.

Cost: About $0.50 (50 cents) per item, estimates are provided in the materials list

Time: about 5 minutes to make a single item

Materials:

- Coin Batteries ($0.30 each)
- Copper tape with conductive adhesive ($0.10) - Less than 12 inches per badge
- LED's ($0.05)
- Small binder clips ($0.05)
- NASA Images of exploding stars/ pulsars/neutron stars (download template here: chandra.si.edu/make/ template.pdf)
- Hand held hole punchers
- Small trash can – little bits of trash are produced during the activity

The Science: Black Holes

A black hole is a dense, compact object whose gravitational pull is so strong that - within a certain distance of it - nothing can escape, not even light. These bizarre objects are found across the Universe -- within double star systems and at the centers of galaxies where giant black holes grow. X-ray telescopes like NASA's Chandra X-ray Observatory can see superheated matter that is swirling toward the event horizon of a black hole, and help reveal how black holes impact their environments, how they behave, and their role in helping shape the evolution of the cosmos.

In 2019, the Event Horizon Telescope (EHT), a network of radio antennae around the globe, captured the first image of a black hole's shadow. The black hole is located in the galaxy Messier 87, or M87, which is about 60 million light years from Earth. Many other telescopes have studied the M87 system and will continue to investigate the intriguing mysteries of black holes.

Glossary

star: a luminous ball of gas, mostly hydrogen and helium, held together by its own gravity.

pulsar: a rapidly rotating neutron star, that emits regular pulses of radio waves and other electromagnetic radiation at rates of up to one thousand pulses per second.

black hole: a place in space where gravity pulls so much that even light can not get out. The gravity is so strong because matter has been squeezed into a tiny space. This can happen when a star is dying.

neutron star: an extremely compact star produced by the collapose of the core of a massive star in the supernova process.

white dwarf: the end phase of a Sun-like star in which all the material contained in the star, minus the amount blown off in the red giant phase, is packed into a volume one millionth the size of the original star.

supernova: an explosion produced when a white dwarf becomes unstable due to the accretion of too much material or merger with another white dwarf.

supernova remnant: the structure resulting from the explosion of a star in a supernova. The supernova remnant is bounded by an expanding shock wave, and consists of ejected material expanding from the explosion, and the interstellar material it sweeps up and shocks along the way.

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(PAPER CIRCUITS TEMPLATE)

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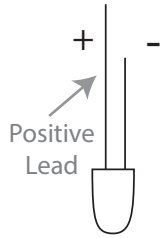
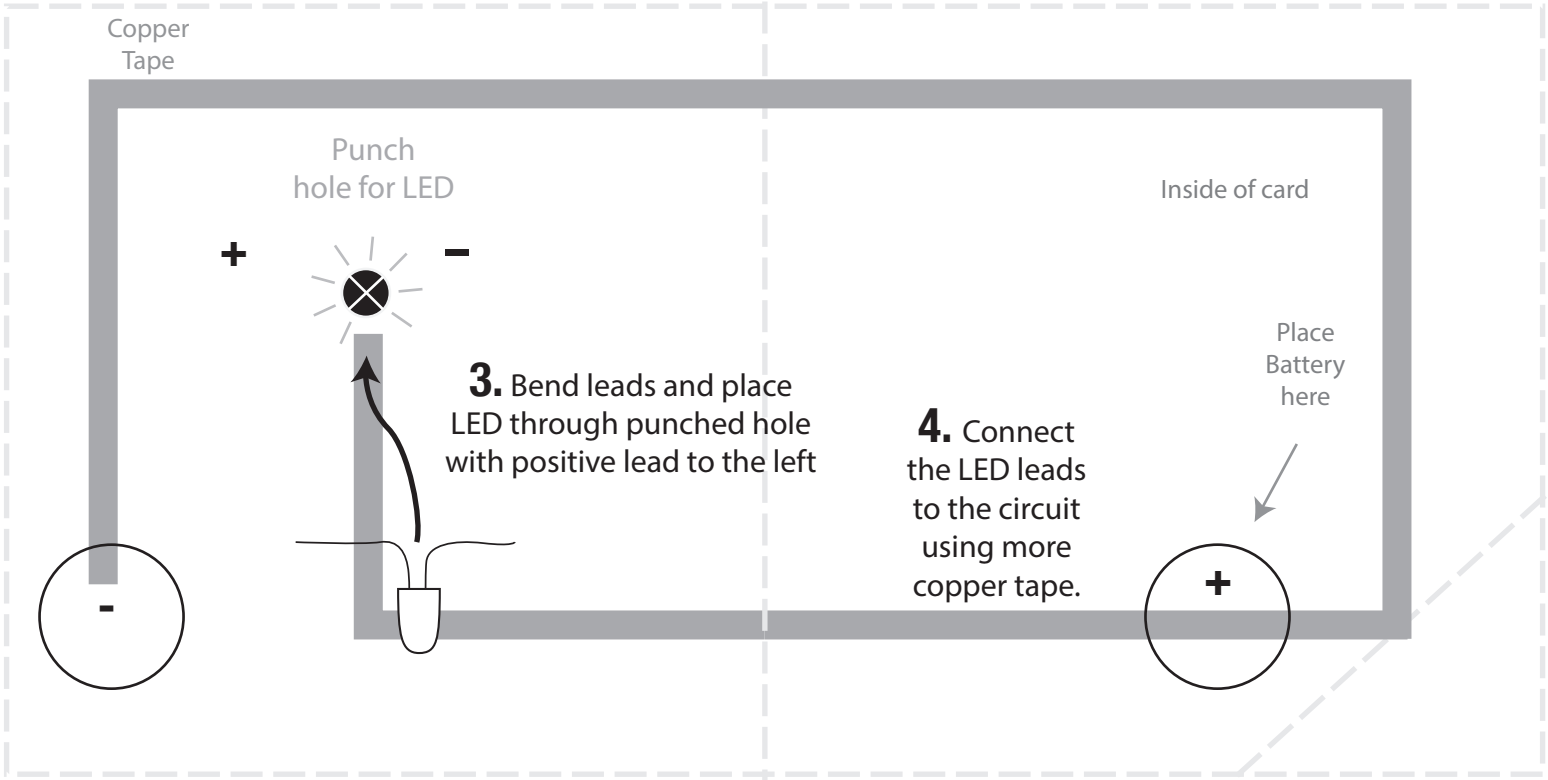
1. Place copper tape along the gray lines

2. Find positive lead on LED. (it's longer)





3. Bend leads and place LED through punched hole with positive lead to the left

4. Connect the LED leads to the circuit using more copper tape.

Image on opposite side here

5. Place battery and fold. Use binder clip to make connection.