

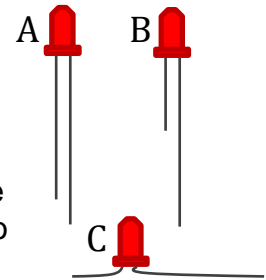
RGB Light Show Paper Circuit

Materials

RGB Paper Circuit Templates Printed on White Cardstock
Reflection Box Templates Printed on White Cardstock
3mm LEDs - Red, Green, and Blue
Copper Tape with Conductive Adhesive ¼" Wide
Button Batteries 2032
Medium Binder Clips 5/8" Capacity

Materials Prep

LEDs only work when electricity is flowing through them in the correct direction. LEDs (light emitting diodes) have a negative (shorter) lead and a positive (longer) lead. There is just a slight difference between the lengths of the two leads. (Figure A) It is best to snip about a quarter inch off the negative lead to make it even shorter. (Figure B) This can be done with wire cutters or scissors. It is also recommended that you split the two leads apart. (Figure C) Make sure the leads are not touching each other.



Students will need about 32" of copper tape to complete the circuit. This can be cut in advance of the lesson to expedite circuit construction. They do not need scissors to cut the copper tape. It can be torn easily with your hands.

Student Directions to Construct Paper Circuit

- Measure and cut a piece of copper tape to match the length of the darkest grey line on the template. Carefully adhere the copper tape to the circuit template.
 - **NOTE:** Do NOT pull the backing off the long length of copper tape. It will curl up and is hard to straighten out.
- Next, put a piece of scotch tape on top of the copper tape you just put down on the template. This will insulate the bottom copper tape from the copper tape you will place on top of it later.
- Now, let's make switches for the LEDs. To build the switches for the three locations in the circuit, you need to take 3.25" pieces of copper tape and fold them back at the 2" mark and then forward to line the end up with the first fold at the 2" mark. You are essentially making a tape tag, which will be used as the switch.
- Tape the switch in place starting at the end in the battery circle and then sticking the tape to itself to create the switch at the end. By using the tape tag to either open or close the circuit across the gap, it becomes a switch.
- Repeat the last two steps to make all three switches.
 - **NOTE:** These switches need to be one single piece of copper tape otherwise the difference in resistance impacts the performance of the circuit.



- Now you can measure and lay down copper tape along the rest of the circuit template. For the sections with 90° turns, it is easier to make the bend in the tape before you peel the backing off and then slowly adhere that leg to the template, keeping it all one piece.
- Use small 3/4" pieces of copper tape to affix the positive (long) and negative leads of the LEDs on right on top of the copper tape wires already place on the template.
 - **NOTE:** Be careful about where you put the negative (short) leg and the positive (long) leg of the LEDs – it matters.
- Fold the paper circuit template over on the solid line along each corner. It is easier to fold it backward and then fold it forward.
- This circuit uses one battery to power the red LED and another battery to power the green and blue LEDs. Place a 2032 button battery down on the negative battery circle for the red LED circuit with the negative side down and the positive side (with writing) up.
- Fold the paper circuit over to connect the circuit to the battery on the positive side and use a medium binder clip to hold it securely in place. Check to make sure the red LED will light up when the switch is closed.
- Repeat the last two steps to power the green and blue LEDs. Once the battery is in place, be sure the green and blue LEDs will both light up when their switches are closed.

Student Directions for Building the Reflection Box

- Cut out the reflection box template by cutting all of the dotted lines.
- Next, fold in along all of the solid lines.
- Finally, secure the reflection box using tape at each corner flap.

Student Directions for Experimenting with the REAL Primary Colors of Light

- Place the Reflection Box over the top of all the LEDs.
- Now, play to discover which colors you can create!
 - Try the LEDs in different combinations to see what color the Reflection Box becomes.
 - How many different colors can you create?
 - How might you be able to create even more colors?
 - What color do you get when you light all three up at the same time?
- Next, turn the box on its side and stand it up about three inches from the lights so it acts like a screen.
- Place a pen or pencil between the LEDs and the white screen created by your box.
 - What do you notice? What do you wonder? What colors do you see?

Teacher Facilitation

When the students have the Reflection Box on top of the LEDs, they should notice they can create red, green, and blue light, of course, by simply turning the LEDs on one at a time. They should also notice they can create cyan, yellow, and magenta (USE THESE WORDS TO DESCRIBE THE COLORS THEY SEE) when they light up the LEDs in combinations of two at a time. Red + Blue = Magenta; Red + Green = Yellow; Green + Blue = Cyan; They should also notice they can create white when they have all three LEDs on at the same time. Red + Green + Blue = White;

When using the Reflection Box as a screen, students should notice the colored shadows. Can they figure out where they are coming from? They should also notice the colors red and blue when the colored shadows overlap.

What the Heck?

The primary colors have been taught incorrectly for DECADES. The primary colors are NOT blue, yellow, and red. In fact, if you ask a physicist what the primary colors are, they will respond with a question back: Do you want to know the primary colors of light or of paint/pigments? The primary colors of paint/pigments are not blue, yellow, and red but rather cyan, yellow, and magenta – the same colors of ink we load into color printers and copiers. The primary colors of light are red, green, and blue – the colors of the LEDs we use in this experiment and also the colors used in tiny pixels on our televisions, computer screens, and smartphone screens to create the colorful images our eyes see.

There is a beautiful connection between the two sets of primary colors. The secondary colors of light are the primary colors of paint! (The opposite is also true, the secondary colors of paint are the primary colors of light.) Secondary colors are created when you mix two primary colors together. So, when students were turning on the LEDs in combinations of two, they were discovering the secondary colors of light – cyan, yellow, and magenta. When all three LEDs are on, we see white.

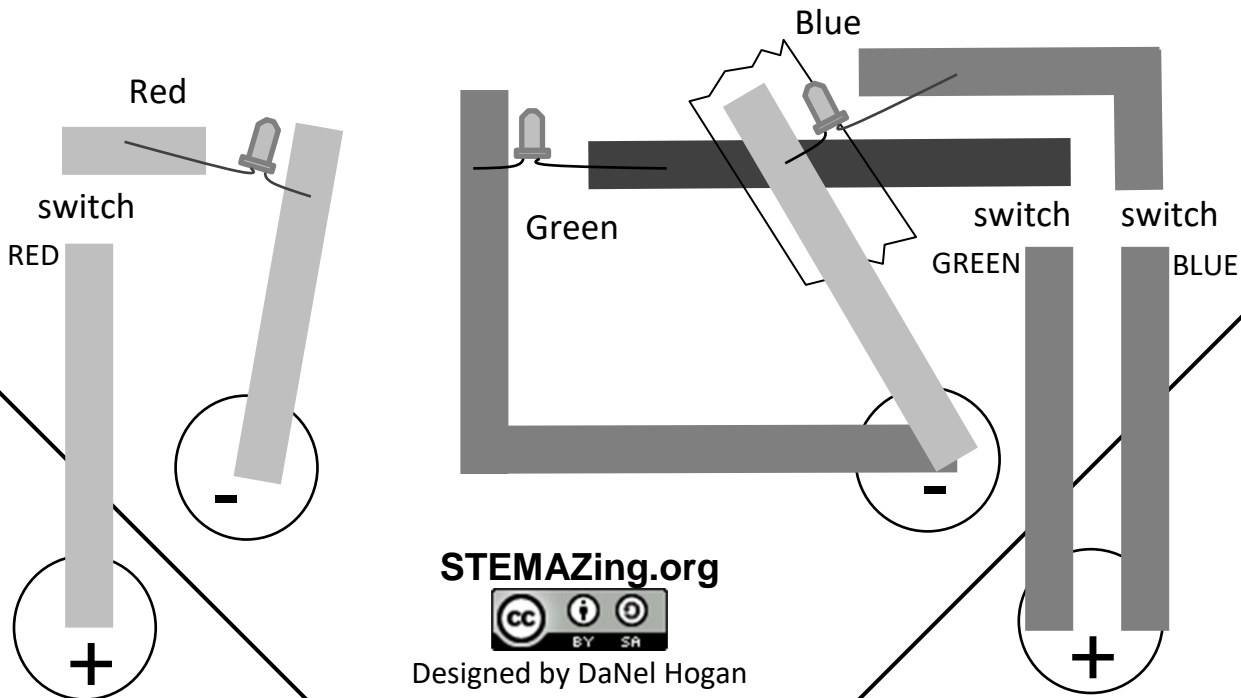
Students can confirm their findings and check out all the colors you can create by changing the intensities of the colored lights using this PhET Color Vision simulation: <http://bit.ly/PhETColorVision>

Have students explore the primary colors more using the afterimage optical illusions found here: <http://bit.ly/PrimaryColorAfterimage>

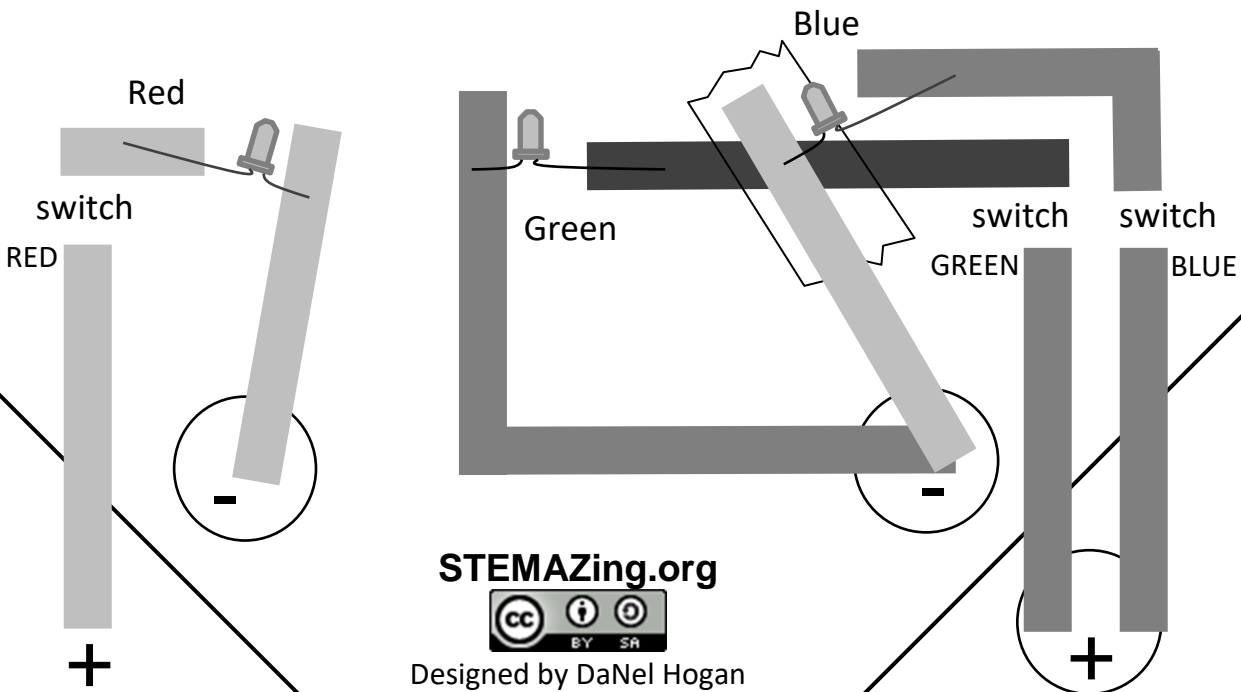
And, if you have far too much time on your hands, learn a lot more about how we see by exploring vision through optical illusions in this TED Talk by Beau Lotto: <http://bit.ly/TEDtalkVision>

Cut out templates along the dotted lines.

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	STEMAZing.org Reflection Box	
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