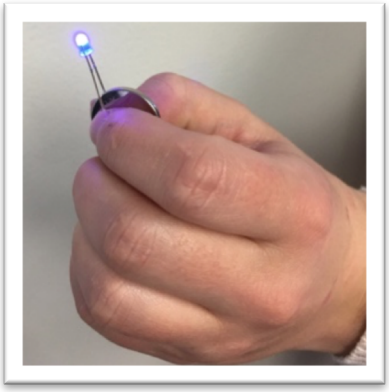
Paper Circuits

Gather the following materials:

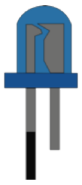
- Copper conductive tape cut into 18" pieces, 4 pieces per student*
- 3mm LEDs, 6 per student*
- 3-volt coin cell battery, one per student*
- Transparent tape, one per student or group of students
- Black permanent marker, one per student or group of students
- Binder clips, one per student (optional)
- *Paper Circuits* activity handout, 1 per student

*These items are included in the Paper Circuits kit, which is available from agclassroomstore.com.



Activity 1: Creating a Simple Circuit

1. Locate the positive side of the battery by locating the "+" marking. The unmarked side of the battery is the negative side.
2. Examine a LED, or ***Light-Emitting Diode***. A LED converts electrical energy into light. The *leads* of the LED are often referred to as legs. The longer leg of the LED is the positive side (+) or the *anode* and the shorter leg is the negative side (-) or *cathode*. Current always flows from the anode to the cathode.
3. Mark the anode or positive leg of each LED with a black marker.



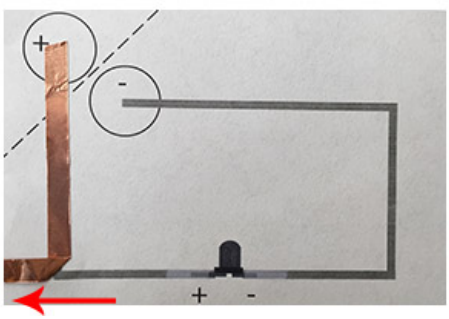
Positive + Negative –

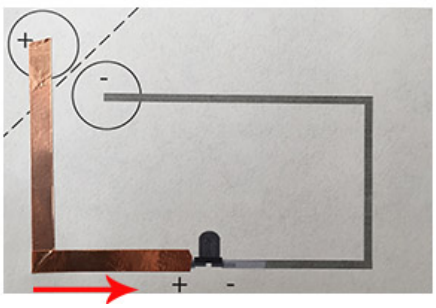
4. Using 1 LED, place the positive leg of the LED to the positive side of the battery and the negative leg of the LED to the negative side of the battery. Using your thumb and forefinger, apply a small amount of pressure to the LED legs to ensure a good connection. The LED should light up. Connecting the LED to the battery created a circuit. A **circuit** is a path through which electricity flows. If the LED is connected backwards it will not light up.
5. Test and mark the positive leg of all five LEDs before moving to the next activity.

Activity 2: Paper Circuits

Now that you know how to complete a circuit, you will create four basic circuits using paper, copper tape, LEDs, transparent tape and your 3V coin cell battery. Before you begin, here are a **few tips** for working with the copper tape:

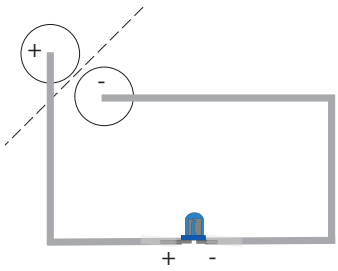
- Keep tape in one piece until you get to a gap or break in the line.
- To turn a corner, keep the tape in one piece. Fold and crease the copper tape in the opposite direction of the turn. The sticky side will be facing up. Then, fold tape back down in the direction of the turn.



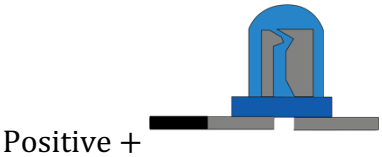


Circuit 1: Closed Circuit

A closed circuit is a complete circuit that allows current to flow.



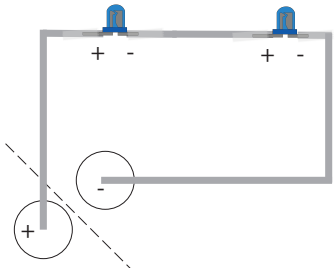
1- View the Closed Circuit video tutorial https://youtu.be/2Nzt9Pm9ATA.
2- Remove a small amount of paper backing from the copper tape. The top side of the copper tape is conductive; it allows electricity to flow through it. The sticky side of the tape is not conductive. Starting in the middle of the positive battery circle, place copper tape on the grey line following a path toward the negative battery circle. Remove the paper backing as you lay down the tape. Leave a gap in the copper tape for the LED.
3- Bend the legs of the LED out so the LED will lay flat on the conductive tape.



4- Tape the legs of the LED to the copper tape path using clear tape. Be sure the positive "+" leg of the LED is sitting on the copper tape coming from the positive "+" battery circle.
5- Place the battery in the battery circle marked with a negative "-". The positive side of the battery will be facing up.
6- Fold the corner of the circuit along the dotted fold line. The positive side of the circuit should touch the positive side of the battery and the LED should light up. Optional: Use a binder clip to hold the battery in place.
7- Label this diagram as a "closed circuit."

Circuit 2: Series Circuit

A series circuit is a complete circuit in which the same current flows through all components of the circuit.

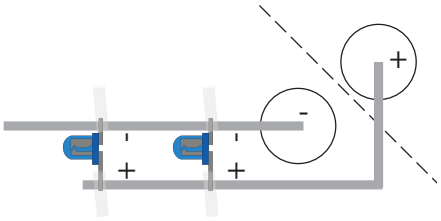


1- View the Series Circuit video tutorial https://youtu.be/CAhIGqRfZNI.
2- Place copper tape on the grey line following a path from the middle of the positive battery circle toward the negative battery circle. Leave a gap for the LEDs.
3- Bend the legs of the LEDs out and tape the legs of the LEDs to the copper tape path using clear tape.
4- Place the battery in the battery circle marked with a negative "-".
5- Fold the corner along the dotted fold line. The positive side of the circuit should touch the positive side of the battery and the LED should light up.
6- If the LEDs do not light up, the LEDs in this circuit are drawing more current than one 3V battery provides. What happens when two 3V batteries are stacked on top of each other? Pair up with a classmate and use 2 batteries. Did the LEDs light up? Did you know that different color LEDs draw different amounts of current?
7- Label this diagram as a "series circuit."

Circuit 3: Parallel Circuit

A parallel circuit is a complete circuit in which the current flows through multiple paths to the components of the circuit.

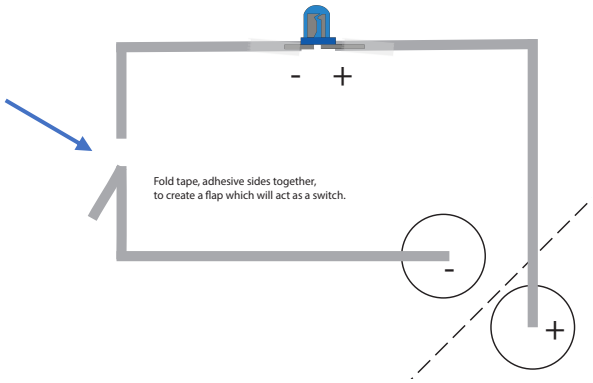
1- View the Parallel Circuit video tutorial https://youtu.be/izY5WaQzCZA.
2- Place the copper tape on the grey line starting in the middle of the battery circles. **Do not** leave a gap for the LEDs.
3- Bend the legs of the LEDs out and tape the legs of the LEDs to the copper tape path using clear tape.
4- Place the battery in the battery circle marked with a negative "-".
5- Fold the corner along the dotted fold line. The positive side of the circuit should touch the positive side of the battery and the LED should light up.
6- How many LEDs can you add to this circuit before the LEDs look dim? How many LEDs can you add to this circuit before they won't turn on at all?
7- Label this diagram as a "parallel circuit."



Circuit 4: Open Circuit

An open circuit is a broken circuit. Current cannot flow through the circuit until it is completed with a switch. You are going to create a switch that will close the open circuit.

1. View the Open Circuit video tutorial https://youtu.be/rO3voO-UUdk.
2. Starting at the gap in the circuit create a flap. With the paper backing on, fold 1" of tape adhesive sides together. Open the tape and remove the backing. Refold the tape on the same fold allowing the adhesive to adhere. **Do not** tear the tape. Leave the flap attached strip of tape and place the tape on the grey line following the path to the negative battery circle. The flap will become a **switch** in the completed circuit.
3. Place copper tape on the grey line following a path starting from the positive battery circle toward the negative battery circle. Leave a gap for the LED.
4. Bend the legs of the LED out and tape the legs of the LED to the copper tape path using clear tape.
5. Place the battery in the battery circle marked with a negative "-".
6. Fold the corner along the dotted fold line. The positive side of the circuit should touch the positive side of the battery and the LED should **not** light up. Optional: Use a binder clip to hold the battery in place.
7. When the flap is sticking up, the circuit is open or broken. The LED will not light up.
8. When the flap is folded down, closing the gap, the circuit becomes a closed circuit and the LED will light up. The flap is acting as a switch to open and close the circuit.
9. Label this diagram as an "open circuit." (Remember the open circuit closes with a switch.)



If the LED doesn't light up, try these troubleshooting tips:

- Smooth any wrinkles out of the copper tape
- Make sure the corners are as flat as possible
- Make sure the copper tape isn't crossing itself
- Make sure there are no breaks in the tape
- Make sure the legs of the LED are firmly taped to the copper tape
- Flip the battery over
- Try a new battery
- Try a new LED
- Use the same color LEDs when a circuit requires more than one
- Use a multimeter to check continuity and polarity
- Solder the LED leads to the copper tape