Basic Circuits with Paper Circuits

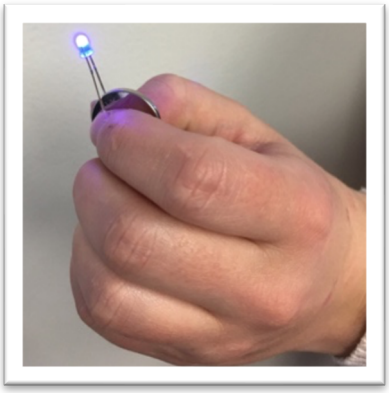
Materials Needed:

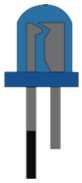
- Copper conductive tape (four 18” pieces per student)*
- 3mm LEDs (6 per student)*
- 3-volt coin cell battery (1 per student)*
- Transparent tape (1 per student or group)
- Black permanent marker (1 per student or group)
- Paper Circuits Activity Instructions (1 per student)*

*Items are included in the Paper Circuits kit, available from agclassroomstore.com.

Activity 1: Creating a Simple Circuit

1. Identify the positive side of the battery by locating the marked "+" sign. The side without a marking is the negative side.
2. Take a close look at a Light-Emitting Diode (LED). LEDs transform electrical energy into light. The longer leg of the LED is called the anode or positive (+) leg, while the shorter leg is the cathode or negative (-) leg. Remember, current always flows from the anode to the cathode.





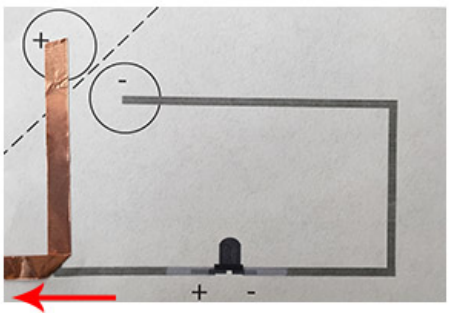
Anode, positive + Cathode, negative –

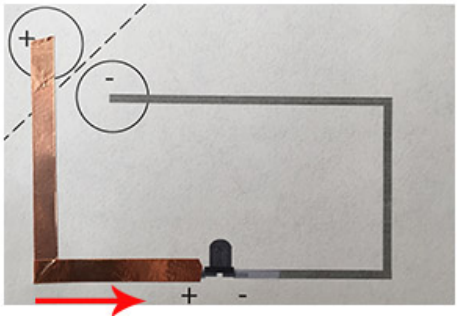
3. Position the LED legs around the battery, ensuring that the longer leg touches the positive side of the battery, and the shorter leg touches the negative side. Apply gentle pressure with your thumb and forefinger to secure a good connection. The LED should light up. If the LED is connected the wrong way, it won't light up. This connection of the LED to the battery forms a circuit, which is a pathway for electricity.
4. Use a black permanent marker to mark the positive leg of all six LEDs for clarity.

Activity 2: Creating Four Basic Circuits with Paper Circuits Template

Using the paper circuits template, copper tape, LEDs, transparent tape, and a 3-volt coin cell battery, create four basic circuits. Maintain the copper tape as a continuous line until you encounter a gap or need to make a turn When turning corners, fold and crease the tape in the opposite direction of the turn, ensuring the sticky side is facing up. After folding, bring the tape back down in the direction of the turn. For visual guidance on turning corners, refer to the video tutorial on How to Turn a Corner.

https://youtu.be/1Pz7MjGbP4U



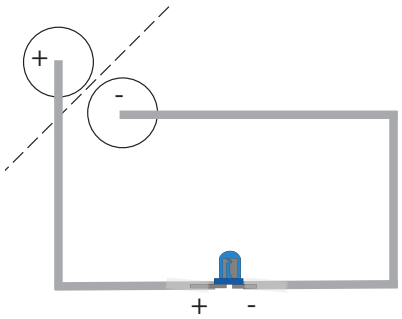


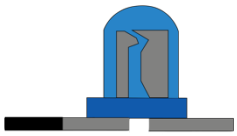
Circuit 1: Creating a Closed Circuit: Step-by-Step Guide

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

https://youtu.be/2Nzt9Pm9ATA

1- Watch the Closed Circuit video tutorial.
2- Peel off a small section of the paper backing from the copper tape. The top side of the copper tape is conductive allowing electricity to flow. The sticky side, however, is not conductive. Starting from the middle of the positive battery circle, place copper tape on the grey line of the template. Follow the path toward the negative battery circle, removing the paper backing as you lay down the tape. Leave a gap or break in the copper tape for the LED.
3- Bend the legs of the LED outward so the LED lies flat on the conductive tape.





Positive + Negative -

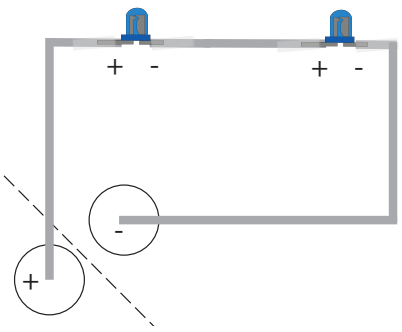
4- Use clear tape to secure the legs of the LED to the copper tape path. Ensure that the positive "+" leg of the LED aligns with the copper tape originating from the positive "+" battery circle.
5- Place the battery in the battery circle marked with a negative "- ." The positive side of the battery will be facing up.
6- Fold the corner of the paper along the dotted fold line. Ensure that the positive side of the circuit touches the positive side of the battery, causing the LED to light up.
7- Label the diagram as a "closed circuit."

Circuit 2: Creating a Series Circuit: Step-by-Step Guide

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

https://youtu.be/CAhIGqRfZNI

1- Begin by watching the Series Circuit video tutorial for visual guidance.
2- Place the copper tape on the grey line of the template, following a path from the middle of the positive battery circle toward the negative battery circle. Leave a gap in the copper tape for the LEDs.
3- Bend the legs of the LEDs outward. Tape the legs of the LEDs to the copper tape.
4- Place the battery in the battery circle marked with a negative "-."
5- Fold the corner along the dotted fold line. Ensure that the positive side of the circuit should touches the positive side of the battery.
6- Verify if the LEDs light up. If they don't, consider using two batteries stacked one on top of each other for more current.
Note: Different color LEDs draw different amounts of current.
7- Label the diagram as a "series circuit."

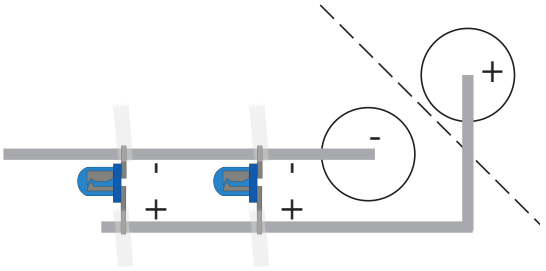


Circuit 3: Creating a Parallel Circuit: Step-by-Step Guide

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

https://youtu.be/CAhIGqRfZNI

1- For visual guidance, watch the Parallel Circuit video tutorial.
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 outward. Tape the legs of the LEDs to the copper tape.
4- Place the battery in the battery circle marked with a negative "-."
5- Fold the corner along the dotted fold line. Ensure that the positive side of the circuit touches the positive side of the battery, causing the LED to light up.
6- Experiment with adding multiple LEDs to the circuit and observe how many can be added before they start to look dim. Determine the maximum number of LEDs that can be added before they won't turn on al all.
7- Label the diagram as a "parallel circuit."

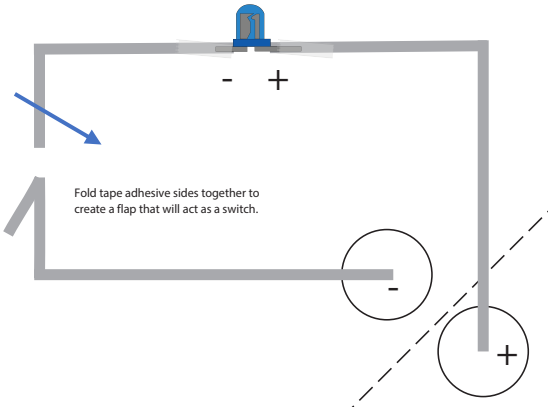


Circuit 4: Creating an Open Circuit with a Switch: Step-by-Step Guide

An open circuit is a broken circuit. Current cannot flow through the circuit until it's closed with a switch. Create a switch that will close the open circuit.

https://youtu.be/rO3voO-UUdk

1. Begin by watching the Open Circuit video tutorial for visual guidance.
2. Starting at the gap in the circuit, create a flap. Fold 1" of tape adhesive sides together with the paper backing attached. Open the fold 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 to the strip of tape. 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 the copper tape on the grey line following a path 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 will **not** light up.
7. When the flap is sticking up, the circuit is open or broken. The LED will not light up.
8. When the flap is down, the circuit becomes a closed circuit, and the LED will light up.
9. Label the diagram as an "open circuit. "



Troubleshooting Tips for Paper Circuits:

1. **Smooth Out Copper Tape:** Ensure the copper tape is free of wrinkles or folds to maintain a continuous conductive path.
2. **Flat Corners:** Keep corners as flat as possible to avoid interruptions in the circuit.
3. **Avoid Crossing Copper Tape:** Ensure that the copper tape does not overlap or cross itself, which can disrupt the flow of electricity.
4. **Check for Tape Breaks:** Inspect the tape to make sure there are no breaks or interruptions along the path.
5. **Secure LED Connections:** Confirm that the legs of the LED are securely connected to the copper tape for a reliable circuit.
6. **Battery Polarity:** Double-check that the battery is inserted with the positive side facing the positive markings and the negative side facing the negative markings.
7. **Try a New Battery:** If the circuit fails to work, try using a new battery to rule out potential battery issues.
8. **Try a New LED:** Test with a different LED to eliminate the possibility of a faulty LED.
9. **Consistent LED Colors:** When using multiple LEDs in a circuit, ensure they are of the same color to maintain consistent current requirements.
10. **Use a Multimeter**: Employ a multimeter to check for continuity (uninterrupted flow) and verify polarity in the circuit.
11. **Solder LED Leads:** For enhanced stability, consider soldering the LED leads to the copper tape, ensuring a secure connection.

By following these troubleshooting tips, you can identify and resolve potential issues in your paper circuits, ensuring a successful and functional project.