

Graphene Circuits

Estimated Time: 30-40 minutes

SUMMARY

Electricity is something that most of us use and see daily, but it might seem like a mystery. Even more mysterious is how another everyday object, the graphite in pencils, can be used to create a circuit seemingly out of nothing! In this activity, students will draw circuits on a piece of paper.

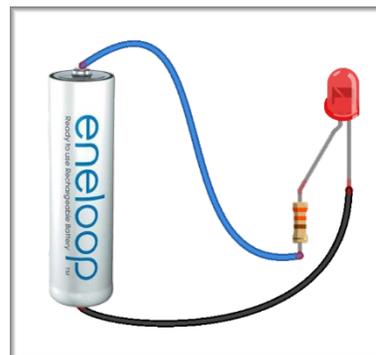
WHAT YOU'LL LEARN

- What graphene is and how it's different from graphite.

Materials Used (per student)	Resources Used
<ul style="list-style-type: none"> • Piece of paper (plus some extras) • Two short pieces of wire (~4cm each) • Sharpened pencil (not mechanical) • LED bulb (plus some extras), 1.5 V 	<ul style="list-style-type: none"> • Graphene: The Next Big (But Thin) Thing https://www.youtube.com/watch?v=Mcg9_ML2mXY

WHAT TO DO

1. Start the activity by discussing what a circuit is. What shape is a circuit? What is necessary for a circuit to function? Answers and guidance for instructors can be found in the Tips section on the next page.
2. To understand a graphene circuit, it helps to first understand and build a more traditional circuit from wires, the LED bulb, and a AA battery. An example circuit can be found in the image to the right. The critical features of a circuit are:
 - a. A full loop to carry from the electricity from the battery, to the LED, and back.
 - b. LEDs only work in one direction so if you don't have success one way, try another.
3. Once you have the circuit constructed, remove one of the wires. The LED should turn off because the circuit is now broken. Now we're going to try and replace that missing wire with graphene! Use your pencil to draw a patch of graphite onto the paper, the thicker the better but don't make it really long or wide since that can diffuse the electrical current.
4. Arrange the LED, battery, and remaining wire with the graphite patch to create a new circuit. With some experimentation you should see that electricity can flow through the patch of graphite as if it were a wire. It helps if there is a narrow band of graphite and if the distance isn't too far, but keep trying shapes and patterns to see what works and what doesn't.



Example LED Diagram ©
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5. Come up with a list of suggestions for the next person making graphite circuits. What sort of shapes and distances worked for your graphite circuits? What sort of shapes didn't work well? What's the most creative circuit you came up with?

TIPS

- AA batteries produce 1.5 V of electricity so make sure that the LEDs you get can run with that low a voltage. If you can only find 3 V ones (a more common variety) simply use two AA batteries and hold the positive end of one to the negative end of the other. This will act as a double-length battery that has the combined voltage of each of the batteries separately: $1.5V + 1.5V = 3V$.
- **Graphene** is a sheet of carbon one atom thick. As the video in the Resources section explains, graphene is a pretty incredible substance with some amazing properties including its strong ability to conduct electricity. **Graphite**, the mineral used as the "lead" in pencils these days, is made of tiny graphene particles stacked up in a column. When you write with a pencil by sliding the tip over paper, the graphene sheets slide off one by one like the bottom card from a deck of playing cards. In this experiment, you take advantage of that patch of graphene particles to conduct electricity, although it's very imprecisely created so it's not quite the amazing conductor that graphene in a lab would be.