

Lesson #2: Build Your Own Graphite Potentiometer (Sensor)

A Teachers Guide

Outlook: Not many middle-school students know what a potentiometer is. A potentiometer is a basic electrical component widely used in circuits to vary sound, light or voltage. Usually they are “knobs”, “dimmer switches” or come in other forms. We can represent a potentiometer with graphite in this exercise. This is also an opportunity for them to do some research and discover what exactly a potentiometer is (see resource websites below) and experiment with a graphite potentiometer that they draw on paper.

Purpose: *To understand what a potentiometer is, what it does and how it acts as a sensor.* [Or leave it blank and have students fill this in]

This also assumes discussion of what a circuit is and a very basic introduction to electricity, in the context of either conductivity (middle school) or electricity (high school).

Student Learning Objectives: At the end of this lesson, students will:

1. Be able to construct a simple potentiometer with graphite and very basic electrical parts
2. Be able to operate a potentiometer and understand what it is measuring
3. Know how to apply potentiometers to a complex system for controlling variables

Topics Covered: voltage, potentiometers, variable resistance

CST:

Grade 7 7c-e

Grade 8 9a-c

Grade 9-12 Physics 5a-c

Materials: pieces of paper, assorted sticks of soft graphite (min of 2B), alligator clips, 9V battery source, voltmeter, LED

Procedures: Modified from <http://www.instructables.com/id/Make-a-Pencils-Lead-Potentiometer-Experimentatio/>

1. Gather all materials.
2. Draw on your piece of paper a 7" long by 2" wide rectangle with your graphite stick and fill it in completely (dark as possible) with the graphite. Record pencil lead type you used on sheet. Alternatively, use a 3"x5" card and have them draw a 2" wide pathway with the graphite stick. Label the same way.
3. Set multi-meter to 20K Ω and check resistance. Record value in table below.
4. Use the multi-meter to check battery by first setting it to 20V on the dial. Touch red lead to positive (+) node of battery, and black lead to negative (-) node. It should read around 9V. Replace battery if lower than 8.5V or if battery gets hot.
5. Once battery checks out, attach red alligator clip to one end of the graphite rectangle, and black alligator clip to opposite end of step and test voltage reading with multi-meter. Record value in table below.
6. Test with an LED by 1st attaching one end of each alligator clip to the 9V battery, and the alligator attached to the negative (-) (shorter) side directly to the short end of the LED. Gently bend the longer end (+) of the LED so that it will make contact with your graphite rectangle. Leave the alligator attached to the positive (+) side detached as you will use it in the following steps.
NOTE: DO NOT attach LED directly to 9V battery!!! You will burn out the LED instantly.
7. Gently set the LED's + lead to one end of the graphite rectangle and bring the unattached (+) alligator to the opposite end of the graphite rectangle. Record "dim" or "bright", or what you see in table below.
8. Keep LED stationary, and move the unattached alligator closer to the LED. Record "dim" or "bright", or what you see in table below.

Results:

Position of Leads	Resistance (Ω)	Voltage (V)	LED (Intensity)
Closest Together			
Farthest Apart			

Conclusion:

1. What happens when you move the two leads closer together in the 1st test?

The reading on the 20k setting is lowest when the leads are closest together. This means resistance is minimal at this point. (5 points)

2. What happens when you move them farther apart?

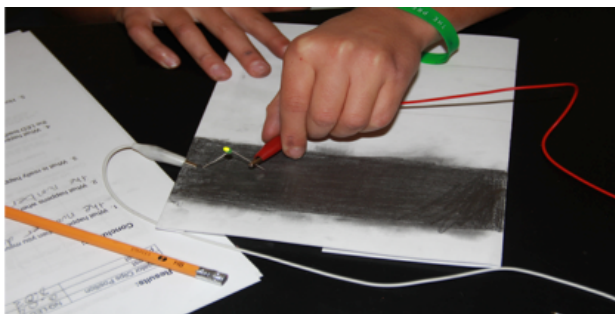
As the leads move farther apart, the reading gets higher, which means resistance is at its highest at this point. (5 points)

3. What is really happening as the leads are moved farther apart?

When the leads are moving, you are demonstrating variable resistance across a distance; a wiper in potentiometer terms. Electricity has farther to move across the graphite rectangle. This correlates to resistance.(5 points)

4. What happens to the LED as you bring the unattached alligator clip towards the LED lead?

The LED got brighter, because as the resistance decreased between the leads, the electrical current rose. (5 points)



5. How does the graphite rectangle represent a potentiometer? Explain.

This, or any, graphite rectangle has multiple layers of graphene which is highly conductive in its hexagonal carbon-atom configuration. With distance, the amount of resistance increases and you can detect this variation in resistance by running a “wiper” or multi-meter leads across the rectangle. (10 points)

Challenge:

Given a smaller (3x3”) piece of paper, create a potentiometer circuit that will give you the same readings as the farthest setting of the 7”x2” rectangle you did earlier. Draw the design (but you can draw lighter or darker than before) you came up with below, write down which different pencil lead type you used, record Ω for multi-meter reads closest and farthest, and results for LED display.

Extensions: If you have time, you can do any of the following:

1. Try different soft graphite pencils to see which one has the least resistance (i.e., 2B, 4B, 6B, etc) and tabulate data to come up with a correlation between softness and conductivity.
2. Try different brands of pencils to see which one has the least resistance (because of varied composition of graphite, clay and charcoal)
3. Make different shades (thicknesses) of graphite with the same #B to determine minimum thickness (shade) that conducts with minimal fluctuation in resistance.
4. Incorporate $I=V/R$ (commonly known as Ohm’s Law?) to calculate the amount of resistance in a given circuit (HIGH SCHOOL Standards of electricity)
5. Introduce parallel and series circuits.
6. Explore graphene, which in multiple layers makes up graphite.

Resources:

<http://en.wikipedia.org/wiki/Potentiometer>

<http://www.wisegeek.com/what-is-a-potentiometer.htm#>

<http://sound.westhost.com/pots.htm>

<http://www.brighthubengineering.com/commercial-electrical-applications/47625-potentiometers-explored-construction-and-working-principles/>

<http://en.wikipedia.org/wiki/Graphene>

<http://www.extremetech.com/tag/graphene>

