Next Generation Science Standards

Students who demonstrate understanding can:

3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.

4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

Standards Key

K = Kindergarten
3 = 3rd Grade
(numbered by grade)
MS = Middle School
HS = High School
PS = Physical Science
LS = Life Science
ES = Earth Science

TEACHERS GUIDE

ELECTRIC PAINT PEN
ITEM # 9200-10

ENERGY - ELECTRICAL CIRCUITS

A group of students at the Royal College of Art in London invented new ways to use electric paint – a paint that acts as a wire or conductive adhesive. It can be used to create circuits with small components, or repair electronics, including arduinos, remotes, PCBs, etc. Other conductive inks have been known for decades, including silver containing inks and conductive coatings used in manufacturing.

How does it work? The black paint has graphite (carbon) in it which conducts electricity once dried. It can be applied to a variety of materials including paper, cardboard, wood, plastic, glass, plaster, some rubbers, textiles, etc.

Materials

- electric paint pens
- printed paper circuit designs
- a variety of light emitting diodes
- copper wires
- alligator clips
- galvanometers
- voltmeters, and/or resistance probes (Vernier or Pasco work well – your high school will have these available)
- *Optional: flashing card activity packs – also available from bare conductive.*

Goals & Objectives

See page 4 for Next Generation Science Standards

DISCUSSION

1. Before you begin, brainstorm with your students what factors they think will affect the ability of a circuit to conduct well. Ask them how they know or why they believe the variable they identify will affect the voltage. Encourage them to develop hypotheses, with scientific reasons to support their hypotheses, and predictions to design an experiment. After experimentation, ask students to describe applications for which the conductive paint would be easier to use.

2. Research how silver is used in some conductive ink applications. Is it a superior conductive ink? Be specific using examples of applications and properties.

3. In what ways might conductive paints advance technological change? Brainstorm specific lines of inquiry, products, and/or applications.

4. What are the limitations of the paint? How might these limitations be improved?

VOCABULARY

- conductors
- current
- insulators
- light emitting diodes
- resistance
- series and parallel circuits
- voltage

ACTIVITIES

1. Paint a circuit with long lines and short lines with identical thickness and attach to an LED and power source. Use the included circuit template to guide your class. Does the LED light? Students can use the galvanometer or voltage probe to determine the voltage output of their battery before it is attached to the circuit and after it has passed through the circuit they draw by replacing the LED with the sensor. How has the voltage changed?

2. Repeat with a circuit that has thick short lines, and thick long lines and attach to an LED. Check the resistance of the painted “wires” again. How has it changed?

3. Compare these experiments with copper wires that are also long/short and thin with copper wires that are thicker. Do the copper wires or conductive paint work better? Can they make a painted wire that has an equivalent voltage output in the circuit?

4. Connect several LED in series and parallel circuits with copper wire and painted wires? How do they compare?

5. How will other variables (for example, temperature) affect the ability of the painted wires to conduct well? Challenge your students to design an experiment to test their variables. Be sure to approve their design before they test it.

6. The paint has powdered graphite (pure carbon) in it. Their pencils are also made of graphite. Does the graphite in their pencil complete a circuit? Why is graphite on its own not a good wire? (brittle). More advanced classes might explore the properties of graphite structure that allows it to conduct electricity although it is not a metal.

7. Physics students should compare the published resistance of the paint pen, Surface resistivity approx 55 ohms/square at 50 microns layer thickness, to their own results. What might cause any discrepancies? Can they improve their circuit?

8. The flashing card activity pack (http://www.bareconductive.com/make/how-to-run-a-workshop-with-the-flashing-card-activity-pack/) provides instructions for your students to create circuit art that lights up! They can take their card home to share.

9. Extensions and more ideas: Bare Conductive provides many other ideas and uses for conductive paint on their website, including tutorials, technical information, and accessories.