

# Circuits

## *A Follow Up Lesson to the UC Irvine (UCI) Electricity Assembly*

### Next Generation Science Standards:

- 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.\* Examples electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound;

### **PS3.B: Conservation of Energy and Energy Transfer**

Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.

(4-PS3-2),(4-PS3-3) Light also transfers energy from place to place.

(4-PS3-2) Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced by transforming the energy of motion into electrical energy.

### ELA/Literacy:

- RI.4.1** Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. (4-PS3-1)*Extended Activity*
- RI.4.3** Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text. (4-PS3-1) *Extended Activity*
- W.4.2** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (4-PS3-1)*Extended Activity*
- W.4.7** Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2),(4-PS3-3),(4-PS3-4),(4-ESS3-1)*Extended Activity*
- W.4.8** Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4),(4-ESS3-1)

### Mathematics:

- MP.4** Model with mathematics. (4-PS4-2)
- 4.G.A.1** Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. (4-PS4-2)

## Overview:

This is a follow up lesson to be completed after the Electricity Assembly presented by the UCI Physics Department. Students will complete a hands-on activity using a circuit board provided by Terry Shanahan of UCI, [tshanaha@uci.edu](mailto:tshanaha@uci.edu). They will answer questions pertaining to the circuit board and provide an explanation and illustration to demonstrate their understanding of what a circuit is and how electrons move through a conductor. In addition, three extension lessons are provided.

**Lesson Objective:** Students will understand what makes a series and parallel circuit using the circuit board and will be able to illustrate each circuit.

**Language Objective:** Students will work with a partner to explain series and parallel circuits in their illustrations and write about a real life example for each. Students will explain their illustrations in detail.

**Classroom Management:** Students will work with a partner to answer the circuit questions. Students will use their inside voices to complete the activity.

## Engage (15-20 min)

This task should be completed following the Electricity Assembly. To begin, the teacher will have students review the vocabulary

“e” – electron

“R” – resistor

“C” - current

“V” – voltage

1. In a small group of 4, share one observation you made during the assembly that interested you and explain why it happened. Try to vary your observations by sharing different activities. Use *numbered heads* to share out. Use the sentence frame: “I liked the \_\_\_\_\_ best, because \_\_\_\_\_.”

2. Teacher will call on a few random students to share their examples after students have had time to share in their small groups.

3. All the students will be given an “e” (electron) card; a few will have an “R” card for resistor. Students will take their card and stand around the room. Teacher will instruct students to walk in a straight line as if they were traveling through a wire (conductor). They will take 2 steps forward and 1 step back to show the repulsion that happens when they approach another electron. As they move ahead, the electron in front repels them so they move backward but the electron behind also repels them so they move forward so they execute a little dance, moving back and forth while advancing slowly forward. Students will slow down when they hit a resistor. Teacher should explain that electrons don't always move in the same direction or at the same speed. To demonstrate this teacher should direct the students to turn around and move in the opposite direction.

Then the teacher can select a student to move quickly through the other students to demonstrate that electrons don't always move at the same speed. Be sure to explain that this is a simulation. Electrons behave a little differently in a real wire.

## Explore (15 min)

1. Teacher will pass out circuit boards to students. Students will be instructed to follow the directions on the Circuit Demonstration paper (page 6) and answer the questions. Students will work with a partner or in a small group.
2. After students have answered the questions, they will be asked to stand and share their results with another group. After 2-3 minutes, students will switch to share their results with a different pair of students.
3. Teacher will allow a few minutes for students to make any adjustments to their diagram or answers.
4. When they are finished, Teacher explains that they will illustrate each circuit. Illustration will be of one of the examples from the demonstration or of a real world application of each circuit, such as room lights or Christmas lights. Use worksheet or a blank piece of paper.

## Explain (15 min)

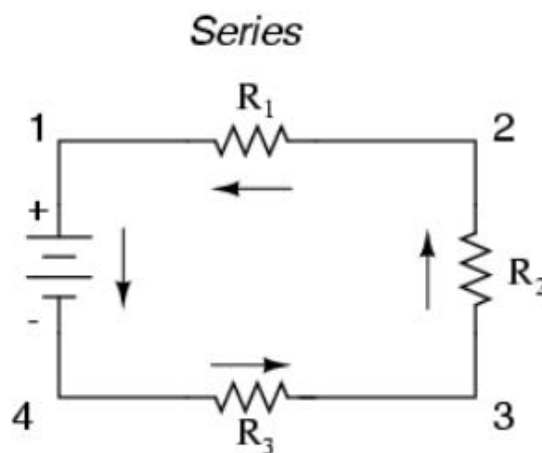
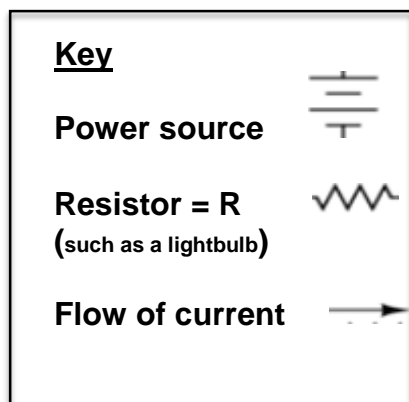
1. Working with their partner, students will write their own definition for both series and parallel circuits.
2. Each group will share their illustration and definition. Classmates will have time to ask questions.
3. After the groups have shared, teacher will share the circuit model below.

## Teacher Information

### Series Circuits

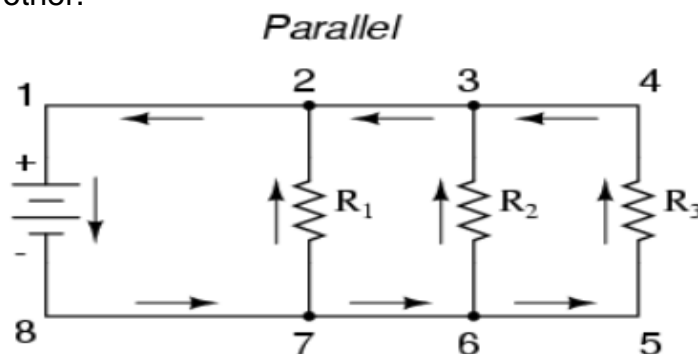
With simple series circuits, all components are connected end to end to form only one path for electrons to flow through the circuit.

R= resistor



## Parallel Circuits

With simple parallel circuits, all components are connected between the same two sets of electrically common points, creating multiple paths for electrons to flow from one end of the battery to the other.



## Evaluate

Teacher tells students to list things from the demonstration or other real world places where each of these circuits are used. Students will draw a simple parallel and series circuit independently in their science notebooks, labeling all parts. For accelerated learners, have them draw more complex circuits.

## Extend

1. Building a circuit: provide students with a D battery, wire or aluminum foil, and a small light bulb (flashlight replacement bulb). Instruct students to build a simple circuit. Once students have all been successful, allow students to build a more complex circuit by joining with another student. Allow students time to build with more than one student. Allow the engineers to surface.

2. Bill Nye: Electric Circuits video

(<http://www.youtube.com/watch?v=jWuExD7zCD4>)

Questions to ask following viewing the video:

1. What is electricity and where does it come from? Draw a picture of a simple circuit.
2. Compare water going through a hose to turning on a light.

3. The Fuse Box: <http://thefusebox.northernpowergrid.com>

Students may work independently or with a partner. This activity may be completed at home or in school.

Activity 1: How do electrical objects work? On this site, they refer to flashlights as torches.

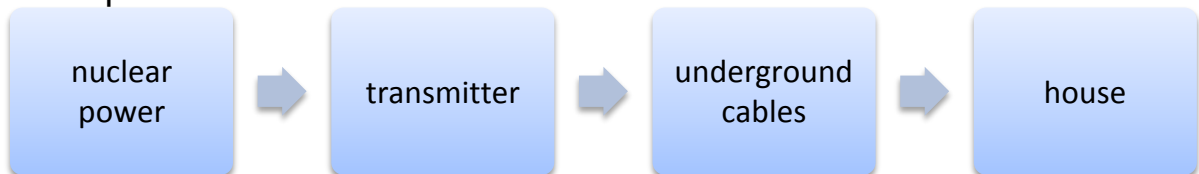
Practice turning on all 3 items. Pay careful attention to the circuit diagrams. Select 1 to illustrate. Write a brief description of what happens when the circuit is open and closed.

Activity 2: How does electricity get to your home?

Write how electricity gets to your home. Be sure to explain the function of the icons and draw an example of a pathway using a flow chart.

Technology: <http://thefusebox.northernpowergrid.com>

Example of flow chart:

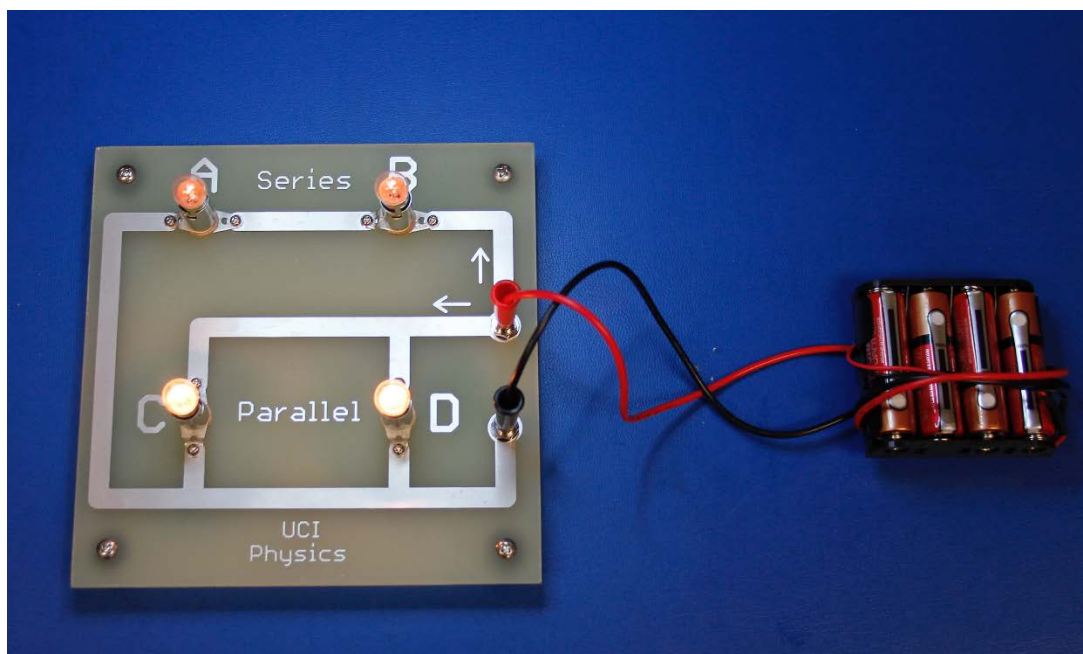


Activity 3: Ask your parents to show you the fuse box (circuit breaker) for your apartment or house. Ask what happens when too many electrical appliances are used on one circuit.

## Circuits Demonstration<sup>1</sup>

*Note: Connect a bulb to the circuit by pushing down and twisting to the right.  
Disconnect a bulb by pushing down and twisting to the left.*

1. Connect the bulb at C. Is the circuit complete?
2. Connect the bulbs at C and D. The circuit with the bulbs at C and at D is a Parallel Circuit.
3. Disconnect the bulbs at C and D.
4. Connect the bulb at A. Is the circuit complete?
5. Connect the bulbs at A and B. The circuit with bulbs at A and B is called a Series Circuit. Is the circuit complete?
6. Do you think the headlights of a car are wired in Parallel or in Series? Explain your answer. *[Hint: Would it be safe if both lights went out when one bulb failed?]*
7. Connect all four bulbs (A, B, C, and D). Which bulbs are brightest? Why are they brighter than the others?



<sup>1</sup> Circuit boards available from Terry Shanahan, tshanaha@uci.edu

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# VOCABULARY GUIDE

## **CONDUCTOR**

A type of material in which electric charges move around easily. Wires, for example, are made of conducting material.

## **CONSERVATION OF ENERGY**

Explains that energy can change from one form to another, but the total amount of energy always stays the same.

## **ELECTRIC CHARGE**

A property of an object that determines the strength of the electrical interaction with other charged objects. There are two kinds of charges: POSITIVE and NEGATIVE.

## **ELECTRIC CURRENT**

A flow of electric charges. More specifically, the amount of charges passing through a point every second. The direction of the flow in a typical electric circuit is DEFINED to be from the HIGHER VOLTAGE end of the battery to the LOWER VOLTAGE end, but the charge carriers are actually electrons, so the charges actually flow from the lower voltage to the higher voltage.

## **FORCE - ELECTRICAL**

The force that occurs due to the interaction between charges. This force can be either attractive or repulsive, depending on the sign of the charges; like charges repel each other, while opposite charges attract.

## **FORCE - GRAVITATIONAL**

The force that pulls any object on earth towards the center of the earth. Generally speaking, gravitational force is the force that occurs due to the interaction between two masses. In the case of an object falling to the ground, the object itself is considered to be one mass, and the earth the other mass. Gravitational force on earth is also often referred to as "weight."

## **FRICTION**

A force that resists the motion between two touching bodies

## **HEAT**

The transfer of Kinetic Energy from one body to another because of a difference in temperature.

## **HEIGHT**

Difference in elevation, measured relative to some pre-determined zero point. This zero point is typically the ground, but can be arbitrarily set anywhere to simplify calculation.

## **KINETIC ENERGY**

The energy that an object has due to its speed. The kinetic energy of an object is proportional to the square of its speed, so doubling the speed will increase the kinetic energy by four times as much (fact stated in typical DMV books)

**POTENTIAL ENERGY - ELECTRICAL**

The energy that a charged object has when placed inside an electric field, either an external field or one created by another charged object.

**POTENTIAL ENERGY - GRAVITATIONAL**

The energy that an object with a mass has when placed at a certain height from some zero reference point

**RESISTANCE**

Things that get in the way of the flow of charges in a conductor. In other words, resistance impedes current.

**VOLTAGE / POTENTIAL DIFFERENCE**

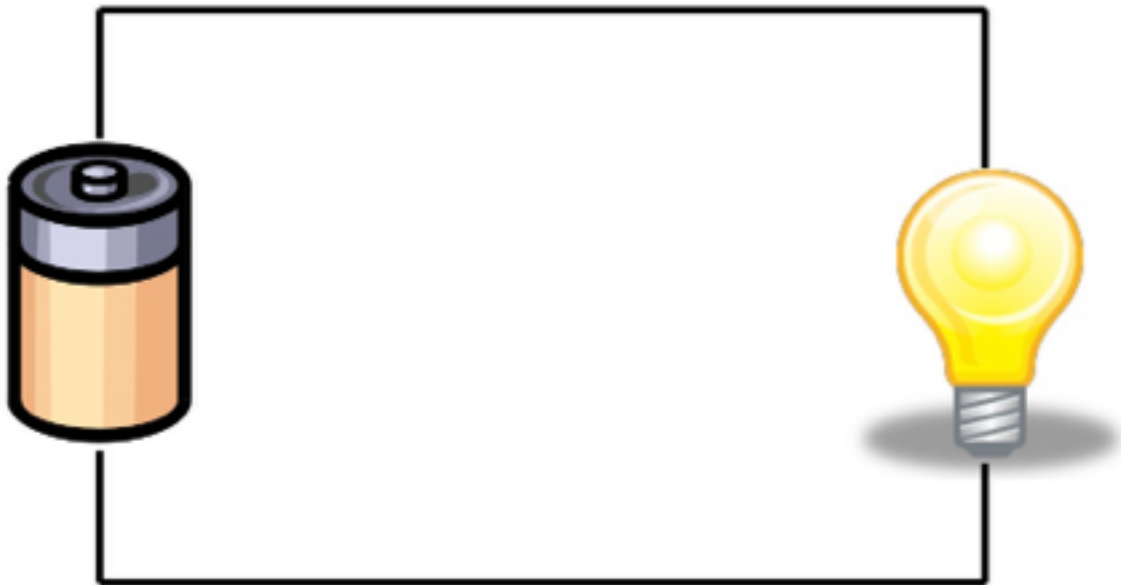
The quantity that measures the difference in electric potential; it is essentially just another way of saying "Potential Difference" (NOT potential energy difference). Voltage is created when there is a separation of charges. Because it takes **Work** to separate charges, we can say that there is some energy "stored" inside this separation of charges. In fact, when a charged particle goes through a potential difference, the charged particle gains potential energy.

**WORK**

Unlike the term "work" used on a daily basis, in Physics, Work is a form of energy (measured in Joules). Work is usually associated with the change in energy of an object, be it Potential or Kinetic. For example: Work is done when lifting a chunk of rock off the ground to a certain height, because the rock's Potential Energy changes. Work is also done with a car slows down or accelerates, because the car's Kinetic Energy changes.

## Draw a Circuit

Using the symbols that you have learned, turn the picture below into a circuit.



Circuit Diagram



## Draw a Circuit

Using the symbols that you have learned, create 2 different examples of circuits with 2-4 resistors.

**Circuit Diagram #1**



**Circuit Diagram #2**

