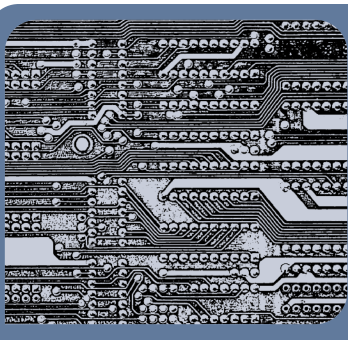


# Circuit Circus

Students construct and experiment with simple electrical circuits using batteries, wires, and bulbs.

**Grade Level:** 5–8

**Subject Areas:** English Language Arts, Mathematics, Science

**Setting:** Classroom

**Time:**
***Preparation:*** 50 minutes
***Activity:*** Two 50-minute periods

**Vocabulary:** Battery, Closed circuit, Conversion device, Electrical circuit, Electric current, Electricity, Electron, Open circuit, Parallel circuit (Parallel connection), Resistance, Series circuit (Series connection), Switch

## Major Concept Areas:

- Energy flow in systems
- Development of energy resources

## Objectives

Students will be able to:
- define an electrical circuit;
- construct an electrical circuit; and
- distinguish between parallel and series circuits.

## Rationale

Learning about electrical circuits helps students explain how humans have used technology to further their ability to use energy.

## Materials

- Copies of the following pages:
  - 12 ***Electron E Squares***
  - ***Diagram of a Series Circuit*** (optional)
  - ***Diagram of Parallel Circuits***
  - ***Which Ones Work?***
  - ***Which Are Parallel Circuits?***
  - ***A Working Electrical Circuit Crossword Puzzle***
- Three signs for students to wear labeled "I am a battery"
- One sign for a student to wear labeled "I am a light bulb"
- A 16-foot (4.85 m) piece of string
- Find additional resources related to this activity on keepprogram.org > Curriculum & Resources
- Each group will need the following:
  - One flashlight
  - At least 1 D battery (preferably rechargeable)
  - At least 2 #48 light bulbs or flashlight bulbs
  - Four pieces of #22 plastic-coated wire or #24 enamel-coated wire (see **Getting Ready**) NOTE: An alternative is to use segments of holiday tree lights
  - Two bulb holders or sockets (optional)
  - At least 1 battery holder (or thick rubber band and two attached Fahnestock clips; see ***Making Battery Holders*** (optional)

## Getting Ready:

Most of the materials for this activity are available from hardware or electronics stores and science supply companies. Have students bring in flashlights. Cut the wire into 8-inch (20 cm) lengths. If you are using plastic-coated or enamel-coated wire, remove about 1.6 inches (4 cm) of plastic or enamel from each end of the wire, so that 1.6 inches (4 cm) of bare wire shows at each end. Beware —there is a clear enamel-coated wire that is easily mistaken for bare copper wire. The enamel coating on this wire (like the plastic coating on other wires) is a nonconductor and must be scraped or sanded off the ends of the wire before the wire can be used as a conductor of electricity. Test the bulbs and batteries to make sure they work.

## Background

What would your life be like if every time one of the light bulbs in your house burned out, all the light bulbs turned off? Imagine running around trying to figure out which bulb was the culprit! Why doesn't this happen?

Your house is wired so that the electric current for each light bulb flows independently. A simplified definition of an electric current is moving electrons. Electrons move because of the energy provided by a battery, a generator, or a similar source of electricity (see ***Anatomy of a Battery***). They move only when a complete conducting path away from and back to the source exists. This complete path is called a closed circuit.

Electrons flow through materials, such as copper wire, that will conduct them. The amount of the flow (the size of the current) is determined by the strength of the source (its voltage) and the resistance to the electron's motion in the circuit. Resistance is anything that slows down or impedes the flow of electrons. Electrons move more easily through some materials than others. In an open circuit there is no current or flow of electrons. An open circuit occurs if a switch is opened, a wire is broken, or a nonconducting connection is made (with a piece of string instead of a wire, for example).

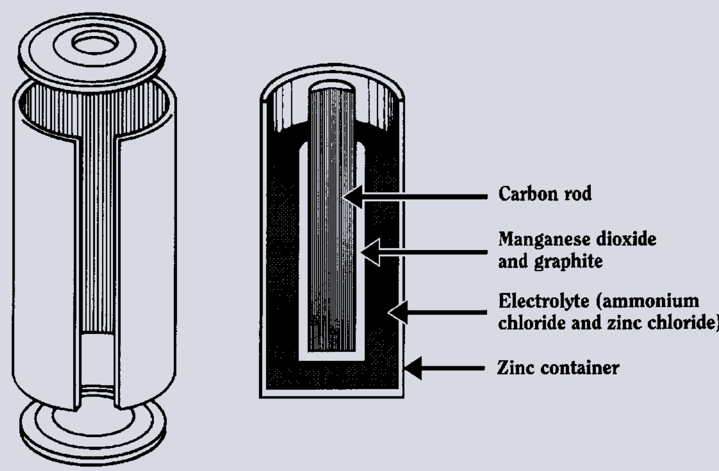
### Anatomy of a Battery

When you look at a common carbon flashlight battery, you don't see the working parts. What you see are coverings. The battery consists of a zinc container filled with a black, moist material in which there is a carbon rod. A battery is simply a bucket of gunk (manganese dioxide, graphite, ammonium chloride, and zinc chloride) with a stick in it. This common dry cell produces electricity from chemical reactions among three materials:

- The metal zinc (the outside container)
- An electrolyte—a wet paste of ammonium chloride and zinc chloride (between the container and the center of the battery)
- A paste of manganese dioxide and powdered graphite (in the center of the battery and surrounding the carbon rod)

The chemicals in the battery react with a metal (such as zinc), which causes extra electrons to be placed on the metal. The metal becomes the negative terminal of the battery, and holds the extra electrons in place (potential energy). When the battery is connected in a closed circuit, the electrons from the negative terminal are attracted to the positive terminal of the battery, which causes them to flow through the wire to get from one end of the battery to the other. When the electrons reach the positive terminal, the chemical reactions in the battery continue to take place, doing work by moving the electrons back to the negative terminal. The electrons travel through the carbon rod, which serves as a conductor and does not chemically interact with the chemicals.

It is possible to take apart a battery but it is a bit of a struggle. Dismantling a battery should only be demonstrated by an adult. Wear protective gloves because there is danger of being cut by sharp metal. Use pliers to peel away the cardboard and/or metal side covering of the battery. With the cylindrical side removed, the metal top and bottom caps easily come off. You will find a black rod sticking up a short distance on the top of the battery. The rod is made of carbon and care should be taken not to break it. The tar from around the carbon rod can be removed and discarded. What is left is the actual working battery.



The basic components in a closed circuit include a source, conducting connections (wires, for instance), and a converting device—something like a light, a heater, or a motor—that changes electrical energy to light, heat, or motion, respectively.

The source, such as a battery, provides the energy. The source is like a pump that lifts up water and lets it run through a network of pipes. The whole process of converting energy from one form to another is continuous as long as the source is connected and the circuit is complete. Electrons move through the circuit with as many leaving the source as returning to it. Some energy, however, is lost to resistance in the circuits or is converted to another form in the conversion device. The converted energy is dissipated from the circuit (usually escaping as heat). Two simple examples of a closed circuit are a series circuit (or series connection) and a parallel circuit (or parallel connection). In a series connection, all the components are in line (see ***Diagram of a Series Circuit***), and therefore, the current must flow through each component. The resistances are additive. A light bulb, specifically its filament, is the component that adds resistance to a circuit. The more light bulbs, the more resistance.

In a parallel connection, there are several paths available and the current divides according to the resistance in each path (see ***Diagram of Parallel Circuits***). The current "follows the path of least resistance." It is clear that the failure of one component (a blown bulb that results in an open circuit, for example) has more consequences in a series connection than in a parallel connection. Home lighting is wired with parallel connections rather than series. Otherwise, much of our time would be spent testing for burned-out light bulbs.

## Procedure

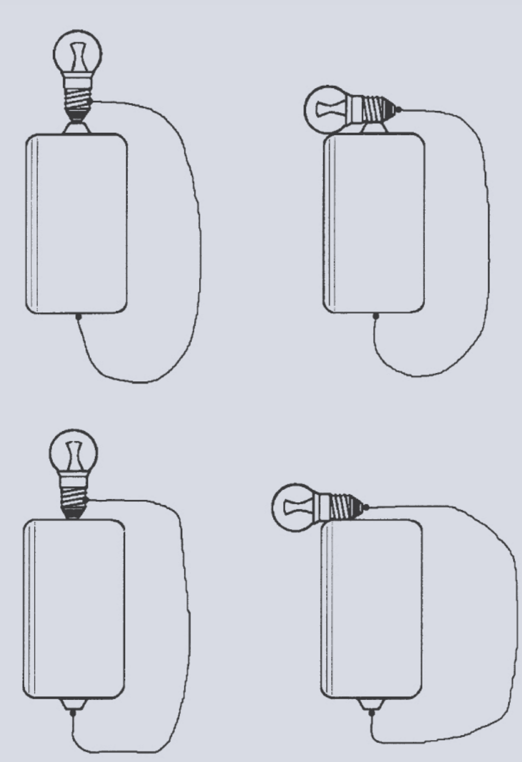
### Orientation

Have students work in groups of two or three. Give each group a flashlight. Instruct students to turn the flashlight on and off, to take out the batteries, and put them back in properly. Tell students to carefully observe the inside and outside of the flashlight and note what they see. If possible, have students remove the light bulb. If not, provide students with a flashlight bulb. **Caution: Some parts may be made of glass and should be handled carefully.** Provide groups with one piece of wire and challenge students to light the bulb without using the flashlight container. When someone has figured out how to make the light bulb shine, discuss the strategy used. It should be noted that there is a continuous metal pathway between the light bulb and the ends of the batteries. Point out that the bulb lights whether one or two batteries are used. Students can vary the position of the light bulb, wire, and battery to see if they can still get the bulb to light. **Caution: The batteries may get hot. Students should keep the bulb lit no more than 15 seconds.**

Have students draw at least one setup for how a battery, light bulb, and wire can be connected to make the bulb light (See **Lighting Possibilities**). Note which parts of the bulb are being touched by the wire and the battery (both the metal threaded area of the side and the bottom of the bulb must be in contact with metal).

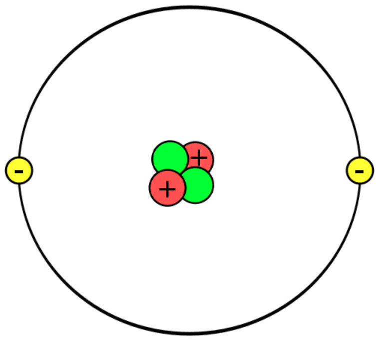
Ask students to identify the different forms of energy that are present in the lit bulb, the battery, and the wire. They should note that the battery contains stored chemical energy and the light bulb has light and heat energy. The may also know that electrical energy is present.

### Lighting Possibilities



## Steps

**1.** Tell students that electrical energy involves the movement of electrons. Draw a simple sketch of an atom, mentioning that atoms are the tiny particles that make up all materials. Explain that electrons are negatively charged components of the atom and that the nucleus has a positive charge. Electricity involves movement of electrons from one atom to another.




**2.** Show students the cutouts from the ***Electron E Squares*** page. Explain that each "e" represents one electron. Have 12 students come to the front of the class.

- Assign three of the students to be the battery, provide them with the "I am a battery" signs, and have them stand in a line. The battery has atoms that contain electrons, so give each "battery" student an electron.
- Another student is the light bulb. The light bulb also has atoms with electrons, so give the "light bulb" student the "I am a light bulb" sign and an electron.
- Ask the rest of the students to be the wire and stand in a line. The "wire" students receive electrons because wires have atoms. Have these students stand in a line, holding the piece of string.

**3.** Challenge the group of students to arrange themselves so that they illustrate how the light bulb, wire, and battery are arranged to make the bulb light.

**4.** Explain that when this connection is made, electrons can flow out of the battery. Beginning with the battery student on the end opposite the light bulb, have students pass their electrons around in a circle—battery ("negative" terminal) to the wire, to the light bulb, to the battery ("positive" terminal) (see ***A More Accurate Simulation*** for a better representation of energy flow in a battery.). Explain to students that this flow of electrons is called a closed circuit.

**5.** Have students return to their original working groups. Hand out additional pieces of wire (each group should have at least four) and one more light bulb to each group. NOTE: An alternative is to hand out segments of holiday tree lights. Challenge groups to use the wires and one battery to make two bulbs light (neither bulb should directly touch the battery). **Caution: The batteries may get hot. Light bulbs should be lit no more than 15 seconds.** An option is to provide students with battery holders (see ***Making Battery Holders***).

**6.** Encourage students to find two different ways to light the two bulbs.

- A series circuit or connection. See ***Diagram of a Series Circuit***. Have students draw a picture of this type of circuit and trace the flow of electrons. Ask students what happens if one bulb is removed. Students can also add more bulbs to the series and observe what happens to the brightness of the bulbs. The term resistance can be introduced here.
- A parallel circuit or connection is when each light

### A More Accurate Simulation

To better represent the electron flow through a battery, have three students represent the battery. Make one student the "negative" terminal and give this student three electrons. The second student will be the "positive" terminal and initially has no electrons. The third student represents the "chemicals" in the battery (where the reaction takes place; see ***Anatomy of a Battery***) and also begins with no electrons. The "negative" and "positive" students should be separated by about eight feet. Show students the "+" and "-" on a battery. When the circuit is completed and current flows, electrons are passed along the circuit and move to the positive terminal (the negative electrons are attracted to positive). When the "positive" student receives an electron, it is handed over to the "chemical" student who then runs over and hands the electron to the "negative" student. Having the "chemical" student run back and forth a short distance between the "positive" and the "negative" student represents the work done by the chemical reactions in the battery to keep the charge separated (it's analogous to a pump continually pumping water uphill). The "negative" student having more than one electron at a time represents the battery's ability to keep the charges separated.

## Making Battery Holders

Assemble the battery holders from one thick rubber band and two Fahnestock clips. The rubber band should be just big enough to fit around the D cell battery lengthwise. Stretch the rubber band and slide it between the spring tab and the loop on the Fahnestock clip. You might have to bend the spring tab up a little to get the rubber band through. Have students help you with this. The Fahnestock clip works by pressing down the spring tab, inserting the end of wire in the loop, and releasing the tab so it springs upward and holds the wire tightly in the loop. If the wire is not secure, remove the wire and bend the spring tab away from the loop and try again.

Warn students that the bulbs need not be tightly screwed into the sockets. All that is necessary is that the socket parts touch the thread and bump parts of the bulb. Excessive tightening will bend some sockets out of shape.

bulb has its own electrical circuit. See ***Diagram of Parallel Circuits***. Have students draw a picture of this type of circuit and trace the flow of electrons that travel to and from each light bulb. What happens this time if they remove one of the light bulbs? How does the brightness of the bulbs in a parallel circuit compare to the bulbs in a series circuit?

## Closure

Ask students whether they think their home lighting uses series or parallel circuits. What would be the problem with a series circuit for home lighting? Ask students how they open and close circuits almost every day. Discuss how flipping a light switch on allows the electrical current to flow (closes the circuit) and turning off the light opens the circuit.

Have students keep an inventory of how often they "complete electrical circuits" during their day and compare their tallies. Emphasize the importance of electricity in their lives.

Hand out copies of ***A Working Electrical Circuit Crossword Puzzle*** for students to complete.

## Assessment

### Formative

- Can students define what an electrical circuit is?
- Did students successfully light the bulb?
- Are they able to construct both a parallel and series circuit?
- Did they correctly complete ***A Working Electrical Circuit Crossword Puzzle***?

### Answers to Crossword Puzzle

| Across | Down |
|---|---|
| 3. Series | 1. Circuit |
| 5. Converted | 2. Switch |
| 6. Filament | 4. Resistance |
| 7. Electron | 8. Battery |
| 11. Atom | 9. Parallel |
| 12. Conductor | 10. Current |
| 13. Voltage | |

### Summative

- Hand out copies of ***Which Ones Work?*** and ***Which Are Parallel Circuits?*** and have students complete the work sheets. Answers: 1, 5, and 6 will light; all but circuit 2 are parallel.
- Challenge students to design a model home out of shoeboxes. Each room should have its own light that can be turned on and off without affecting the other rooms. Students can turn off the light by unscrewing the light bulb.

## Extension

Have students investigate which materials conduct electricity and which do not. Instruct them to make a simple circuit (one light bulb, one or two wires, and a battery). They should cut one of the wires in half. Test different materials by placing them between the cut ends of the wire. Which materials are conductors (close the circuit) and which are insulators (do not close the circuit)? Materials that students can test include plastic and metal spoons, jewelry, yarn, pencils, pens, a ruler, and paper.

## Credits

Simulation modified from Tennessee Valley Authority. "Electron Game" p. EL-27 in *Energy Sourcebook: Elementary Unit*. Knoxville: Tennessee Valley Authority, 1992. Used with permission, All rights reserved.

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## Related KEEP Activities

This activity works well in a unit on electricity (see K–5 Energy Sparks for Theme II: "Electricity in Our Lives"). Follow this activity by having students explore other sources of electricity, such as "Fueling Around," "Digging for Coal," and "Waterwheels, Windmills, and Turbines." Batteries as a potential source of electrical energy are introduced in "Potentially Kinetic." This is also a good place to stress electrical safety rules. See K-5 Energy Sparks for Theme II: "Electricity in Our Lives."
More advanced students may want to build a model electric motor; see "Electric Motors and Generators." A possible extension is found in 6-12 Energy Sparks for Theme II: "Make a Light Bulb."



The Wisconsin K-12 Energy Education Program is supported through funding from

Wisconsin K-12 Energy Education Program (KEEP)
College of Natural Resources
University of Wisconsin-Stevens Point

# Electron E Squares

## Instructions

Make two copies of this page and cut around the squares.

| | |
|---|---|
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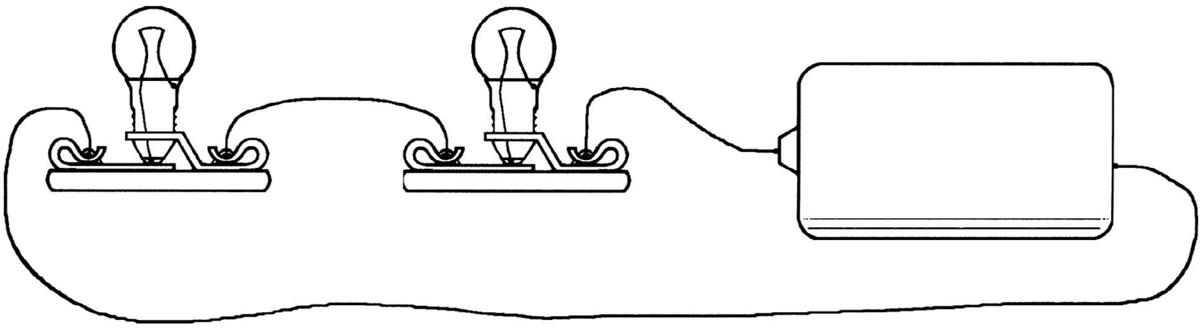
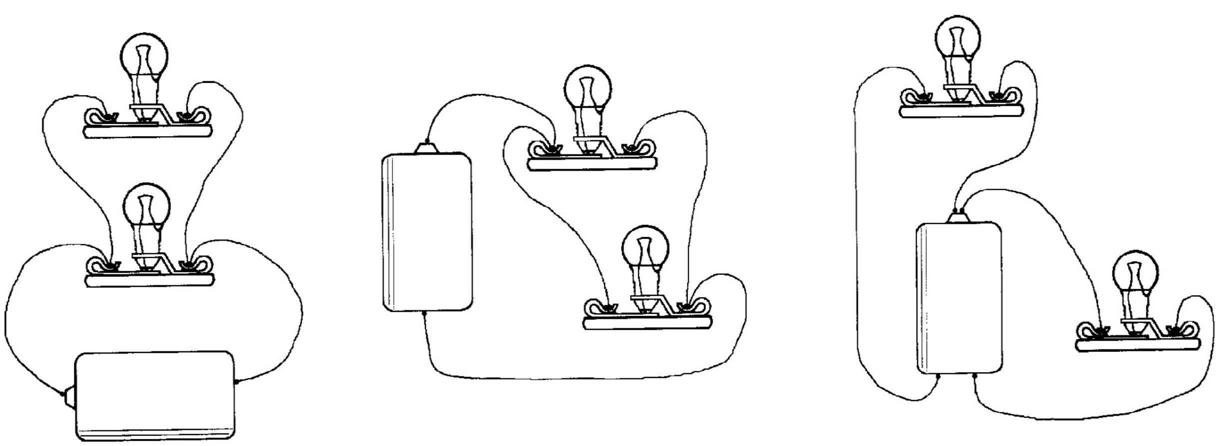
# Diagram of a Series Circuit



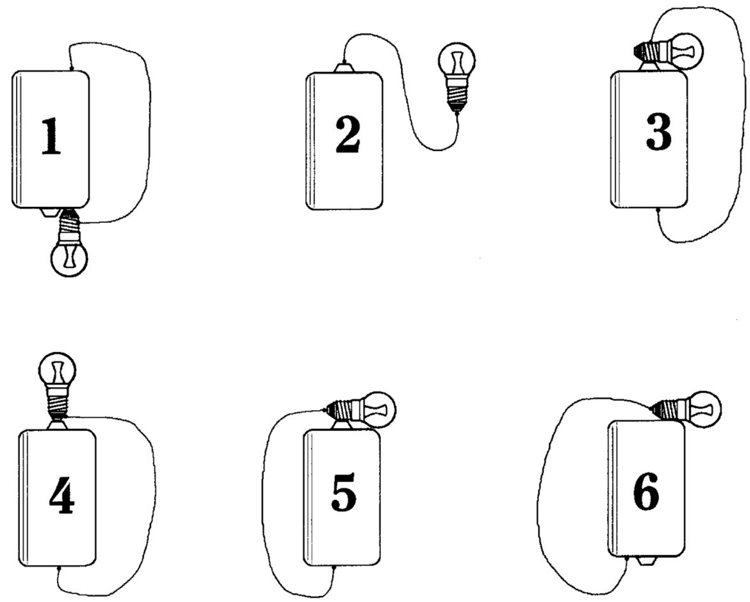
# Diagram of Parallel Circuits



# Which Ones Work?

**Instructions**

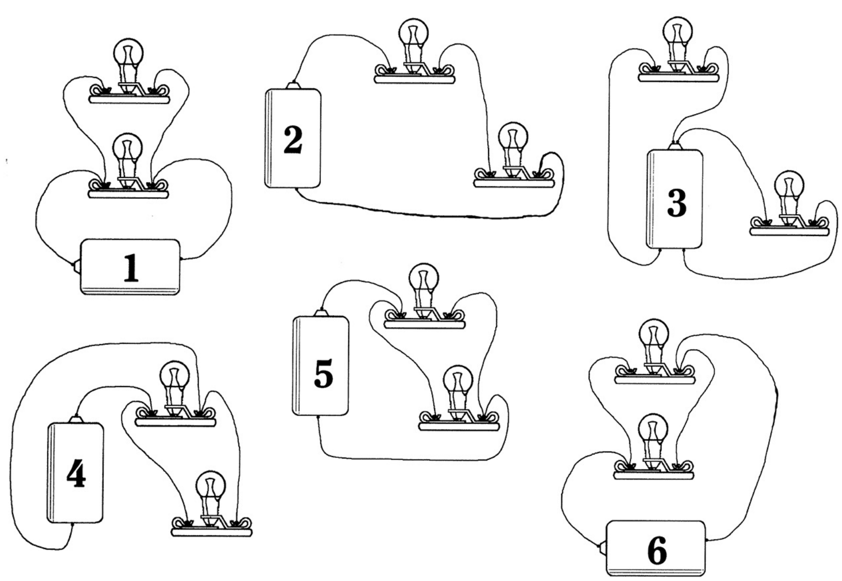
For each arrangement, if you think the bulb would light, write the word "light" next to the bulb.



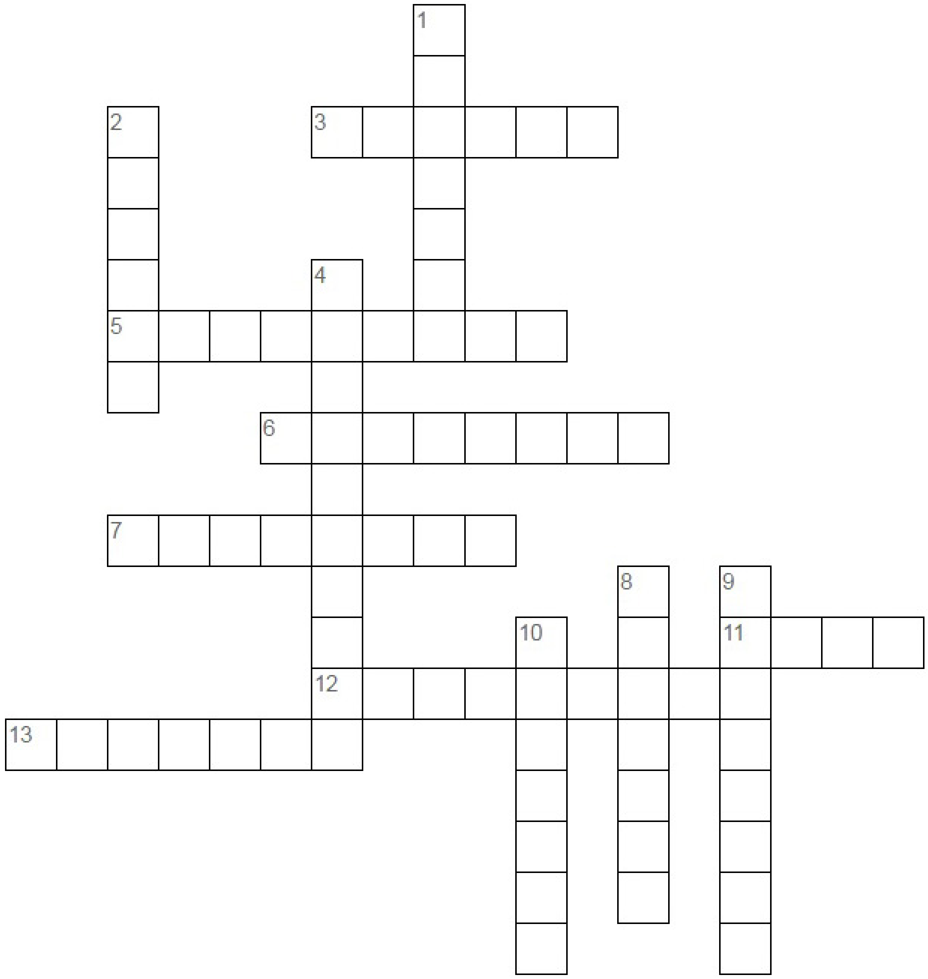

# Which Are Parallel Circuits?

**Instructions**

Write a "p" by each of the following circuits that you think is a parallel circuit.



# A Working Electrical Circuit Crossword Puzzle




## Across

3. A ________ circuit is an example of a closed circuit where all components are in line.

5. Energy can be ________ from one form to another.

6. The part of the bulb that adds resistance to a circuit.

7. Part of an atom that has a negative charge.

11. Electricity involves movement of electrons from one ________ to another.

12. Electrons flow through materials, such as a copper wire that will serve as a ________.

13. The rate at which energy, electricity, or electromagnetic forces are drawn from a source.

## Down

1. The past of electrons away from and back to the energy source is called a closed ________.

2. Used to open or close a circuit.

4. Anything that slows down or impedes the flow of electrons.

8. An energy source which has both electrical and chemical energy.

9. A ________ circuit is a closed circuit where there are several paths available and the current divides according to the resistance in each path.

10. Moving electrons.