Electric Circuits

1. Simple Circuits Exploration

Subject Area:
Physics: Electricity

Time:
45-90 minutes

Standards: NGSS: HS-PS3.A

Code	Standards
PS3.A (HS-PS3-1) (HS-PS3-2)	Definitions of Energy: Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
(HS-PS3-2) (HS-PS3-3)	At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
(HS-PS3-2)	These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

Learning Objectives:
The student will be able to successfully
- set up a circuit→ including a simple circuit, series circuits, and parallel circuits
- understand the necessary components of a successful circuit: e.g., a complete loop, a power source, a device, a switch

Computational Thinking Objectives:
see end of lesson plan
Introduction:
In this lesson, students will learn what circuits are and how they work.

Introduction for the students:
An engineer working on an electrical device must know the basics of circuitry. In this activity,

you'll have an opportunity to mess around with a small assortment of materials.

Materials:

- Alligator leads
- ~3v flashlight bulbs w/sockets
- switches (ex: push button, toggle, knife)
- AA batteries
- Battery holder
- Various types of batteries
- 3v Piezo Buzzers

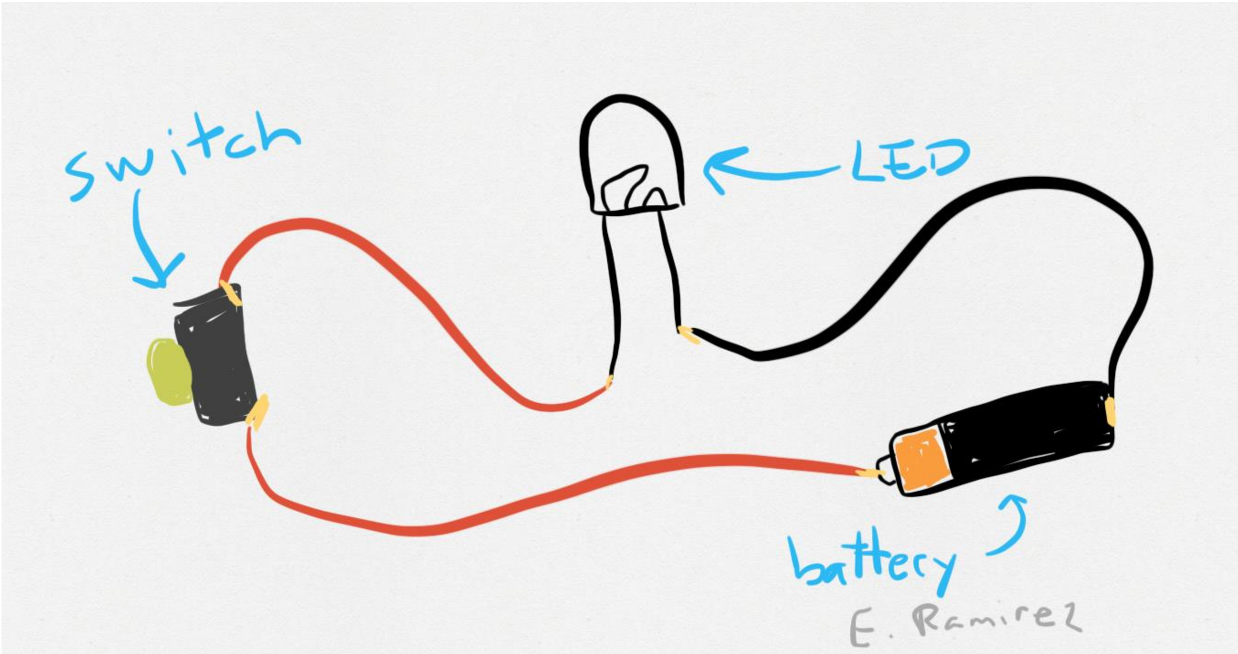
Most of these materials can be found online at American Science and Surplus (sciplus.com) or All Electronics (allelectronics.com).

Outline of Lesson:

> Notebooks (1 min): Draw a sketch of how you think you can use the available materials to get the lightbulb to light up.
>
> NOTE: Students can get intimidated by being asked to draw. Give an example of what you mean by a sketch, and reinforce it by only giving them a minute. This is a good time to develop expectations as a class for what the notebooks are used for. Build in table talk and think, pair, shares.

- Place students in groups of no more than 3 students.
- Each table should be equipped with light bulbs, buzzers, switches, and alligator leads.
- Have students play around with the equipment to get the lightbulb to light.
- Have them keep track in their notebooks (and on a class whiteboard, if possible) the variations they have attempted.

Figure 1:



Notebooks (3 min): How can you complicate the circuit? How would you add a switch? What purpose does it serve? Can you add another bulb and have both light up? What about the buzzer? What could these more complicated circuits be used for?- Draw first, then share out

Notebooks: (Pick 1)

- Algorithm design
  - Can you write down the steps you took to build your circuit, so that others can follow your instructions and make something similar?
- Decomposition
  - What are the difficulties you encountered during the process? How did you solve the problem?

CT in action!

- In computing, loops are a mechanism for running the same sequence multiple times (Brennan & Resnick, 2012). In circuits, loops allow for the circuit to keep running. Make sure students notice the importance of the circuit's "loops".

Possible Questions/Potential Responses:

Q. Why isn't my bulb lighting up?

- You may inspire students to discuss about the possible reasons. e.g., (a) You may have a short circuit. Encourage the development of metaphor (an abstraction, a CT concept). e.g, Electrons are cars going from point A in the battery to point B in the battery. The wires are roads. Light bulbs and buzzers are tollbooths. Switches are drawbridges. If a shortcut is presented, cars will take it, bypassing any toll booths. This is a “short circuit”. The cars will want to take the shortest route possible. If you have a connection that makes the path shorter than where the bulb is, those “cars” are not going to travel that far. They will take the shortcut. (b) Part of the circuit may not be complete. (c) The batteries may need to be replaced. (d) The bulb might be burnt out. What other metaphors might work?

- Once the student has proposed solutions and resolved the problem, this is a good opportunity to introduce the concept of decomposition. Ask them how they broke the problem down into its parts and, from there, identified the solution. It’s a kind of “debugging”. (e.g. Does the whole circuit not work? Do you know that each branch of the circuit works before you put them together?)

This is an exploratory activity, so many questions can be answered with “Let’s find out!” or “What do you think?” or “Let's ask this group if they can see what's happening here,” kind of response.

Creating an environment that:

- **Builds confidence in dealing with complexity**
- **Encourages persistence in working with difficult problems -** Let students know that this isn’t easy, and they are new at this, so it’s okay if they don’t get it right away, but that they should keep at it. There are many things that can go wrong, but it could be the materials and doesn’t reflect the skill of the student.
- **Allows for tolerance for ambiguity**
- **Works with open-ended problems with multiple solutions**
- **The ability to communicate and work with others to achieve a common goal or solution**
- **Encourages the questioning of given assumptions**

Formative assessment question suggestions (Feel free to design your own questions)

Component	Definition	Application	Sample Questions	My own questions
Abstraction	Making meaning of the patterns and removing unnecessary info (knowing what's important/ what's not)	Get rid of the extra info	Can you draw a diagram for your design (the circuits you built)?	
Decomposition	Breaking down a problem into component parts	Figure out the necessary components needed for a successful circuit	Can you break down the task to smaller pieces? e.g., how does part of the circuit work?	
Algorithm	Step-by-step procedures for inputs to produce outputs	Take the appropriate steps to set up a circuit	Can you write down the steps you took to build your circuit, so that others can follow your instruction and make something similar?	

Debugging	Systematically resolving defects	Fix any problems that arise	What are the difficulties you encountered during the process? How did you solve the problem? (e.g., if the LED is connected in the wrong way, switch it; if the LED is connected on holes that have a shortcut underneath, change the circuit; if the voltage is too high for a LED, connect a resistor with it)	
Pattern Recognition	Seeking commonalities	Draw diagram for different circuits Differentiate different types of circuits: simple, series, parallel, or mixed	What is needed for a successful circuit? What is needed for a series circuit?	
Evaluation	Assessing the effectiveness of a solution within the context of the problem	Design or choose an appropriate circuit for a given function	Does the circuit work for its function? e.g., does the switch control the loop that it is designed to control? Does the light bulb in the loop bright enough? Are the light bulbs in the circuits independent from each other? -- in other words, if one light bulb is broken, does it influence other light bulbs?	

2. Series and Parallel Circuits

Subject Area:
Physics: Electricity

Time:
45-90 minutes

Standards: NGSS: HS-PS3.A

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PS3.A (HS-PS3-1) (HS-PS3-2)	Definitions of Energy: Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
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(HS-PS3-2)	These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

Learning Objectives:
The student will be able to successfully
- differentiate between series and parallel circuits
- understand different characteristics of the two types of circuits and their unique strengths
- make real-world connections to their work and apply circuit knowledge to their lives

Computational Thinking Objectives:
see end of lesson plan.

Introduction:
In this lesson, students will create series and parallel circuits. Afterwards, they will be given some time to create their own circuits and scenarios for which their circuits may serve a purpose.

Introduction for the students:

An engineer working on an electrical machine must know the basics of circuitry. In this activity, you will create series and parallel circuits then have freedom to create something more complicated. Start thinking about how these circuits can be used in whatever device you might want to make. Remember what came out of your show and tell, asset mapping, data on your day, or about me tools. How might this apply to something you could create?

Materials:

- Alligator leads
- ~3v flashlight bulbs w/sockets
- switches (ex: push button, toggle, knife)
- Battery pack
- Various types of batteries
- 3v Piezo Buzzers

Most of these materials can be found online at American Science and Surplus (sciplus.com) or All Electronics (allelectronics.com).

Outline of Lesson:

- Ask students to build two different types of circuits: one in which turning off one light bulb causes a second light bulb to turn off; and one in which turning off one light bulb doesn't affect the other.
- Give students 5-10 minutes to explore on their own with the materials provided.
- In their notebooks, ask students to draw sketches of the two circuits they made, making note of any key similarities or differences.
- Ask students to explain what they discovered and give examples of where each type of circuit might be useful.
- Inform students that circuits that follow a single path for electrons to flow are called ***series*** circuits, while those that allow for multiple paths are called ***parallel*** circuits. Refer to Figures 2 and 3, respectively.

Figure 2:

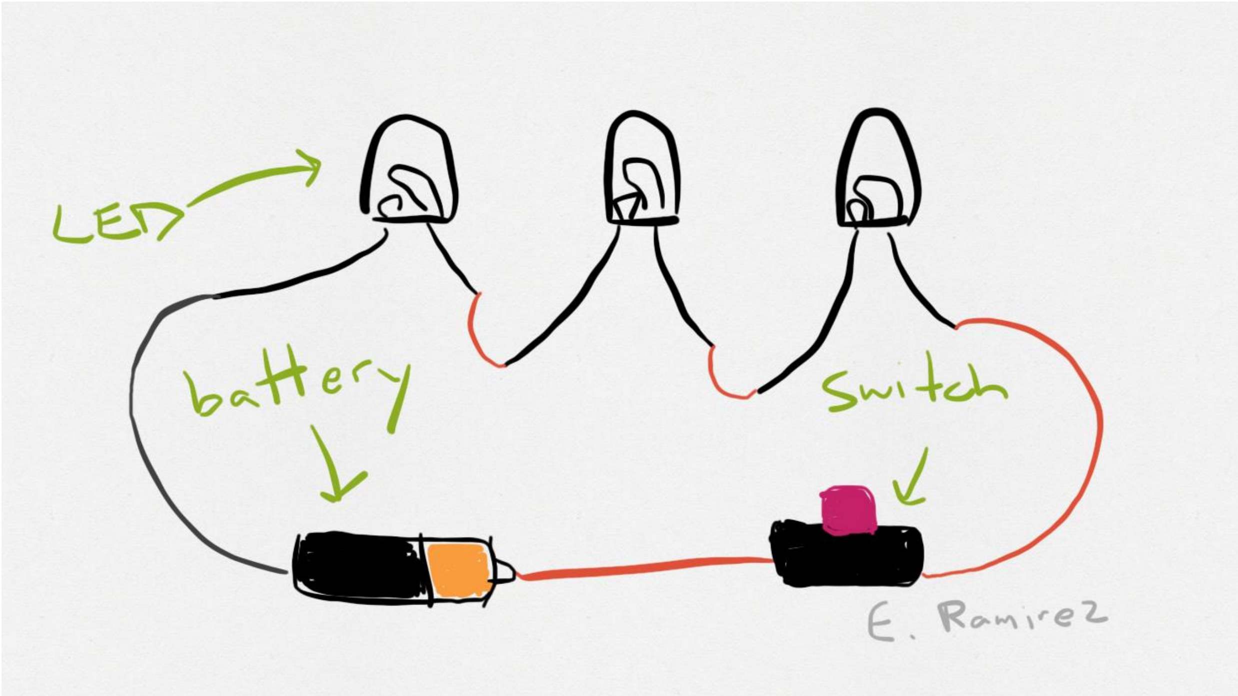


Figure 3:

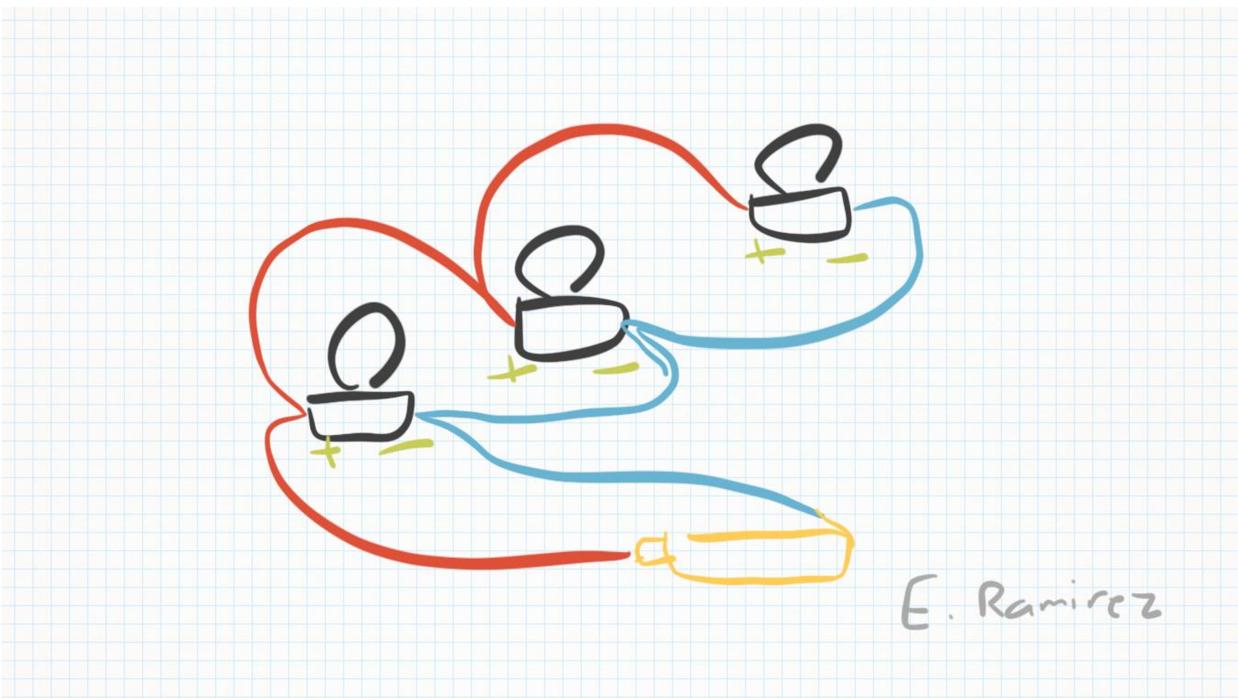
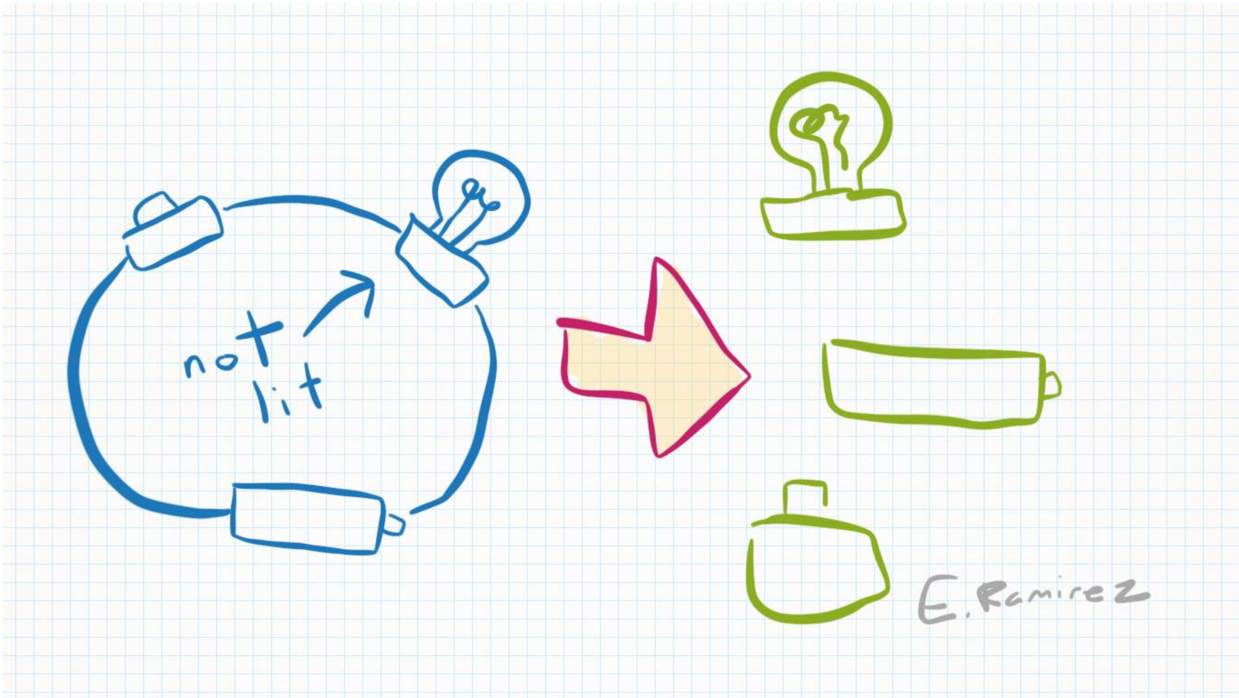


Figure 4:



Notebooks:

- Pattern recognition
    - What is needed for a successful circuit? Why?
    - What is needed for a series circuit?
    - What are characteristics of a series circuit? -- What would happen if a light bulb on the circuit is disconnected?
    - What is needed for a parallel circuit?
    - What are the characteristics of a parallel circuit? -- What would happen if a light bulb on the circuit is disconnected?

Challenge

- Explore how different circuit designs influence how light bulbs work. For example, when you adjust the following variables:
    - Number of batteries used,
    - Number of light bulbs used, and
    - How the light bulbs are connected--series and parallel.

Notebooks (10-15 min):

- Draw sketches for your initial design that you used to figure out the relationships between the batteries, light bulbs, and how they are connected.
- Pattern Recognition
    - Create a table and record the data you collected.
    - Find a pattern in the data and draw a conclusion.
    - Share out

CT in action!

- Most modern computer languages support parallelism – sequences of instructions happening at the same time (Brennan & Resnick, 2012). What is happening at the same time with parallel circuits?

Possible Questions/Potential Responses:

Q. Why if only one of my bulbs lighting up in the parallel circuit?

- Some bulbs may be out. The branch may not be well connected.
- This is another opportunity for introducing the concept of decomposition. It's best to introduce it after the student has resolved the problem in order to congratulate them on their ability to decompose problems.

This is an exploratory activity, so many questions may be answered by a "Let's find out!" kind of response. Additionally, these activities allow for students to go back and figure out why there is a problem. Maybe they should grab a new bulb or a new wire, who knows! Push them to make these discoveries on their own while they debug their circuits.

Creating an environment that:

- **Builds confidence in dealing with complexity -** Understanding series and parallel circuits can be complicated, but playing with the different types of circuits can build understanding.
- **Encourages persistence in working with difficult problems**
- **Allows for tolerance for ambiguity**
- **Works with open-ended problems with multiple solutions**
- **Ability to communicate and work with others to achieve a common goal or solution -**
- **The ability to communicate and work with others to achieve a common goal or solution**
- **Encourages the questioning of given assumptions**

Formative assessment question suggestions (Feel free to design your own questions)

Component	Definition	Application	Sample Questions	My own questions
Abstraction	Making meaning of the patterns and removing unnecessary	Take out extra info	Can you draw a diagram for your design (the circuits you built)? Is your design a series or parallel circuit? Why?	

	info (knowing what's important/ what's not)			
Decomposition	Breaking down a problem into component parts	Figure out the necessary compartments needed for a successful circuit	Can you break down the task to smaller pieces? e.g., how does branch of the circuit work? Does the whole circuit not work? Do you know that each branch of the circuit works before you put them together?	
Algorithm	Step-by-step procedures for inputs to produce outputs	Take the appropriate steps to set up a circuit	Can you write down the steps you took to build your circuit, so that others can follow your instruction and make something similar?	
Debugging	Systematically resolving defects	Fix any problems that arise	What are the difficulties you encountered during the process? How did you solve the problem? (e.g., if the LED is connected in the wrong way, switch it; if the LED is connected on holes that have a shortcut underneath, change the circuit; if the voltage is too high for a LED, connect a resistor with it)	
Pattern Recognition	Seeking commonalities	Draw diagram for different circuits Differentiate different types of circuits:	What is needed for a successful circuit? What is needed for a series circuit? What are characteristics of a series circuit? -- What would happen if a	

		simple, series, parallel, or mixed	light bulb on the circuit is disconnected? What is needed for a parallel circuit? What are the characteristics of a parallel circuit? -- What would happen if a light bulb on the circuit is disconnected? How is the brightness of the light bulbs related to the type of circuits the light bulbs are in? How is the brightness of the light bulb related to the number of batteries used and how the batteries are connected?	
Evaluation	Assessing the effectivenes s of a solution within the context of the problem	Design or choose an appropriate circuit for a given function	Does the circuit work for its function? e.g., does the switch control the loop that it is designed to control? Does the light bulb in the loop bright enough? Are the light bulbs in the circuits independent from each other? -- in other words, if one light bulb is broken, does it influence other light bulbs?	