Lesson Six: Circuits
Center for Sensorimotor Neural Engineering
Lesson Plan Author: Phelana Pang

LESSON OVERVIEW

Activity Time: Four+ 50 minute periods.

Lesson Plan Summary:
In this lesson, students will learn about the basic components of a circuit. Students will design circuits using Snap Circuits kits, online animations, and classroom materials and draw corresponding circuit diagrams. Students will begin exploring control of output using various inputs (photoresistors, whistle chip, motor) in a circuit. This lesson will provide the circuitry fundamentals needed for students to design their sensory substitution device.

STUDENT UNDERSTANDINGS

Big Idea & Enduring Understanding:

- Circuits must be carefully designed and components properly arranged in order for it to function properly.
- A variety of inputs can go into a circuit. Depending on the resistance that results from the various inputs, outputs can be controlled.

Essential Question:

- What factors need to be considered when designing a functional circuit?

Learning Objectives:
Students will know…

- **The parts of a circuit:** circuits have a power source, current runs through wires and components, currents can cause output (motors, lights, etc).
- Circuits have various components that must be arranged in certain orientations to work.
- Parallel circuits involve components placed in separate loops of the same circuit; components placed in parallel will have the same voltage going across.
- Series circuits involve components placed in line. The same current flows through all components.
- Sensors vary the amount of resistance and therefore current/voltage in a circuit. This differing level of current/voltage can result in different outputs such as whether motors or lights are on or off.

Students will be able to…

- Follow a circuit diagram to build a functioning circuit.
- Differentiate between a circuit in parallel and a circuit in series.
- Create circuit diagrams for circuits in series and in parallel.
- Explain how a circuit works based on the components present.

Vocabulary:

- **Parts of a circuit**: circuit, electricity, battery/power, electrons, current, switch, open/closed, conductor, insulator, load, positive/negative terminals
- **Circuits**: circuit, battery/power, current, switch, open/closed, positive/negative terminals, resistor, LED, motor, diode
- **Parallel, series**

Standards Alignment: This lesson addresses the following Next Generation Science Standards

NGSS Cross-Cutting Concepts

- Systems and System Models
- Structure and Function
- Cause and Effect

NGSS Science & Engineering Practices

- Developing and Using Models

MATERIALS

Material	Description	Quantity
Student Handout 6.1: Exploring Circuits	Animations 1 to 6	1 copy per student
Student Handout 6.2: Snap Circuit Components	Students write down what the simplest components do	1 copy per student
Computers/laptops	For circuits animations	1 per student/pair
Elenco Electronics Snap Circuit 300 Kits	$45.99 from https://www.amazon.com/Snap-Circuits-SC-300-Electronics-Discovery/dp/B0000683A4	1 per group/pair
Document camera	For projecting Snap Circuit projects as students explain them to the class	1 for the class

TEACHER PREPARATION

1. Copy handouts as listed in the materials section above.

2. Find an appropriate article or video to teach about the basics of circuits. See Resources section.

3. Preview and go through the online interactive circuit activity.

4. Look over the Snap Circuit kits. You can pick out some projects in the project guide that comes with the kits that are appropriate to your students' level of understanding and engagement, or allow them to pick the ones that are interesting to them.

PROCEDURE

Engage: Robot Gripper Hand Circuitry (10 minutes)

1. Through discussion or journaling, review students' understanding of the circuit involved in the Robot Gripper Hand from Lesson 2. What were some requirements for the gripper hand to function? Tell students we will be learning more about circuits to gain a clearer understanding.

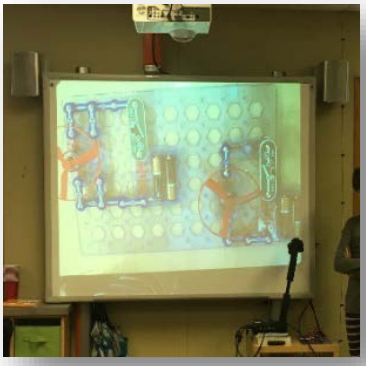
Explore and Explain: Introduction to Circuits (~90 minutes)

2. Introduction to circuits and terms.
    a. Find a video or reading which introduces circuits (see Resources section). Define terms, discuss definitions with small group, watch video again, and discuss drawings/examples with small group. Then draw simple circuit diagram with small group. (20+ min)

    b. Students can explore the online animations of circuits on the website from PCCL (Physics and Chemistry by Clear Learning). They can complete activities 1 through 6. Record observations and draw circuit diagrams on *Student Handout 6.1: Exploring Circuits.* (20+ min)
        i. http://www.physics-chemistry-interactive-flash-animation.com/electricity_interactive.htm

3. Snap Circuits Part 1 (50 min)
    a. Assess and group students based on experience with circuits (students with similar experience can work together, or you can pair a more experienced student with a novice).
    b. Choose a starting project from the Snap Circuit manual based on experience and interest
    c. Teacher circulates and asks students to explain circuits and components.
    d. Students use project instructions and background information on components in front of each manual.
    e. Students identify and describe function of different components on *Student Handout 6.2: Snap Circuit Components.*

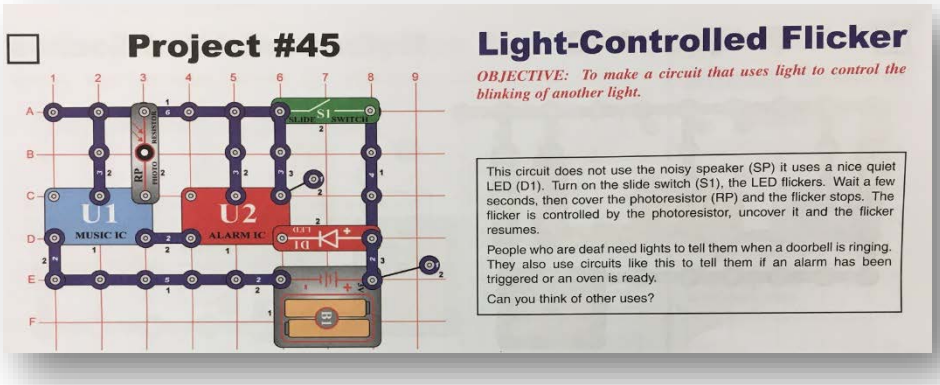
Evaluate:

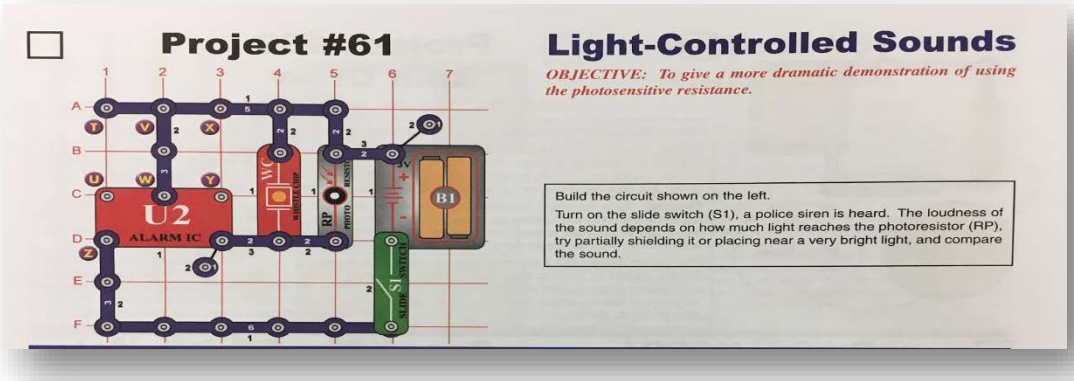


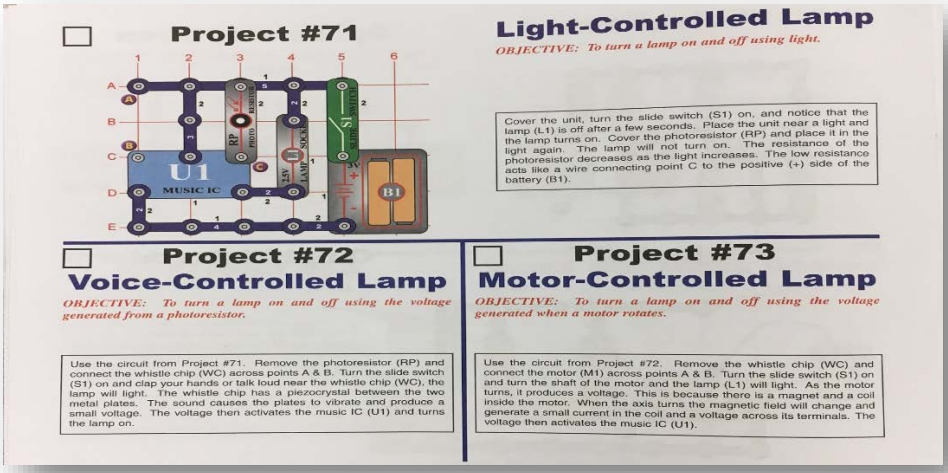
4. Snap Circuit, Part 2 (50+ minutes)
    a. Each pair picks a project number from the manual to set up and draw a corresponding circuit diagram.
    b. Students prepare a presentation for their circuit to be projected on the document camera. Suggested information to present include:
        i. Explain what the circuit does
        ii. What are important components and what do they do?
        iii. How are components connected? Are they in series? In parallel?
        iv. Circuit Diagram
        v. Possible Questions
        vi. Possible Modifications

Explore, Explain and Evaluate:

5. Snap Circuits Part 3 (50 min)
    a. Have groups go through projects # 45 Light-Controlled Flicker, #61 Light-Controlled Sounds, #71 Light-Controlled Lamp, and #72 Voice-Controlled Lamp in the project manual that comes with the Snap Circuit kits.
    b. Check in with each group before allowing them to move on to the next project.







Credit: Images are photographs of Elenco Electronics Snap Circuit project guide.

6. As a class, discuss:
    a. Inputs and outputs: Does it make sense to use a photoresistor as an input control if output is LED for a sensory substitution device? Why or why not?
        i. It doesn't make sense for the input and output to be the same if the purpose is to replace a sense. For example, the purpose of using a photoresistor, which senses light, is to help a person who is visually impaired. This person would not be able to detect the LED output.

    b. The importance of a resistor when using an LED.
        i. LEDs by themselves do not have enough resistance compared to motors and lamps. Too much current would result in damage to the LED. For a more detailed explanation: http://led.linear1.org/why-do-i-need-a-resistor-with-an-led/).

    c. The importance of the difference in voltage needed to power different outputs.
        i. A light bulb requires more power than an LED, and a motor requires even more power.

STUDENT ASSESSMENT

Assessment Opportunities: Student knowledge, skills, and concepts for this lesson will be assessed in a number of ways.

- The online animations are self-guided, and students cannot move forward until they set up circuits correctly. Teachers can collect the notes and diagrams recorded onto the handout for formal assessment.
- Teacher should circulate while students are building circuits to ask questions, give feedback, and answer questions.
- Presentation of Snap Circuit project: Students explain their understanding of the role of each component, how their circuit is put together, any trouble shooting, etc.

Student Metacognition:

- Provide students opportunities to come up with questions, reflect on their initial ideas about what they know and understand, and write them down in their lab notebook. They can add new/changing ideas to their lab notebook.

Scoring Guide:

Teacher Resource 6.1 and *6.2* provided scoring guides for the *Student Handouts*.

EXTENSION ACTIVITIES

Extension Activities:

- Students can do other animations on the online activity and present their findings to the class.
- Students can go further in the Snap Circuits projects depending on their level of understanding. The project manual offers many possibilities.

Adaptations:

- Kinesthetic adaptation: Act out a circuit, assigning different roles (battery, switch, output, wires) to different students. Tennis or ping pong balls can be used to simulate electrons.
- It is important to know the level of complexity of the Snap Circuit projects. Go through several of them with your students in mind to know what might be good starting points.
- For classes that already have experience with circuits, less time can be spent on the Snap Circuits.

TEACHER BACKGROUND & RESOURCES

Resources:

For introductory lessons and activities on electric circuits, see the resources below.

- PBS lessons on Electric Circuits
  - https://kcts9.pbslearningmedia.org/resource/phy03.sci.phys.mfe.lp_electric/electric-circuits/
- Bill Nye Video on Electricity
  - https://www.youtube.com/watch?v=ywHcssUjXD0
- Put a Spark in It! - Electricity unit from TeachEngineering
  - https://www.teachengineering.org/curricularunits/view/cub_electricity_curricularunit
- Sparkfun information and videos
  - https://learn.sparkfun.com/tutorials/series-and-parallel-circuits

Citations:

Snap Circuit kits are an educational product of Elenco Electronics.

Photograph by Phelana Pang.

Student Handout 6.1: Exploring Circuits

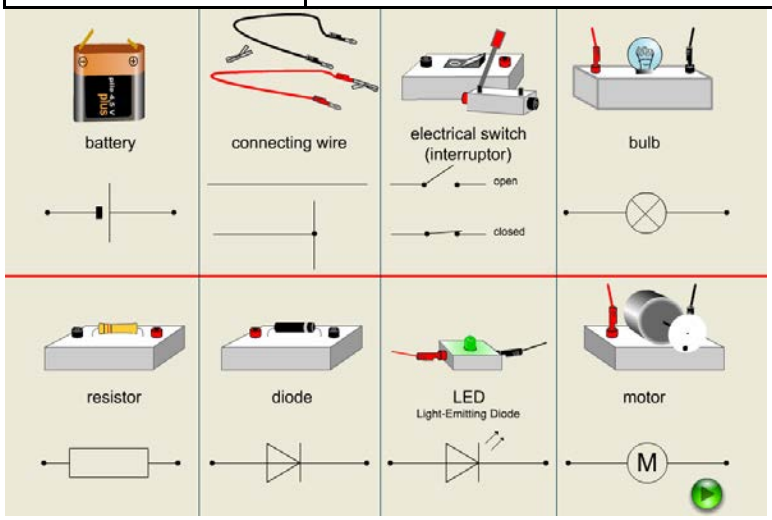
Name:_____ Date:_____ Period:_____

Go to the website: http://www.physics-chemistry-interactive-flash-animation.com/electricity_interactive.htm

Go through the Basic Circuits animations (1-6) and write/draw your observations.

Animation	**Observation/Notes/Diagrams**
1 - Simple Circuit	
2 - Parallel or Series Circuit	Series Parallel
3 - Short Circuit Activity	

4 - Short Circuit - Why it's dangerous	
5 - Circuit Diagram (see below for symbols)	
6 - Conductors v.Insulators	<u>Conductors</u> <u>Insulators</u>



Student Handout 6.2: Snap Circuit Components

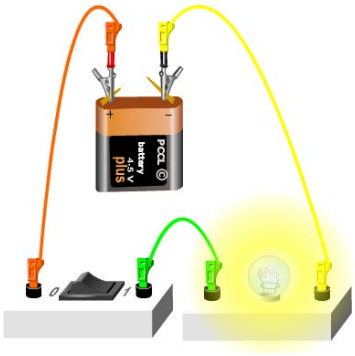
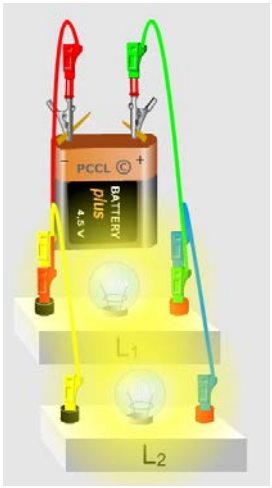
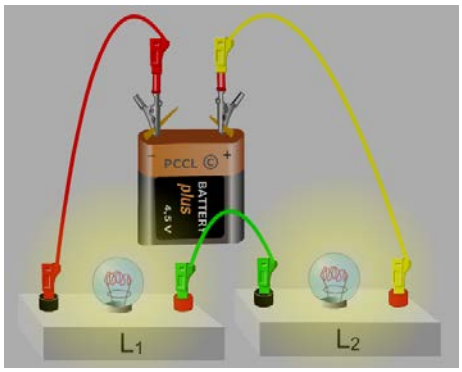
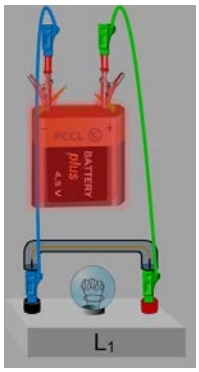
Name:_____ Date:_____ Period:_____

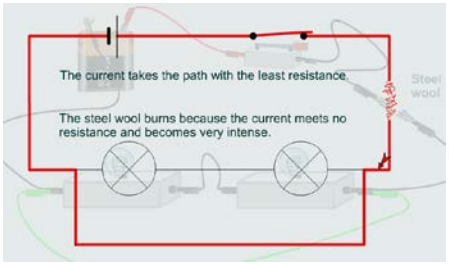
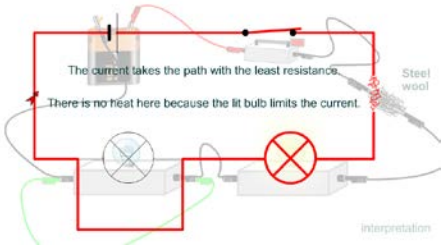
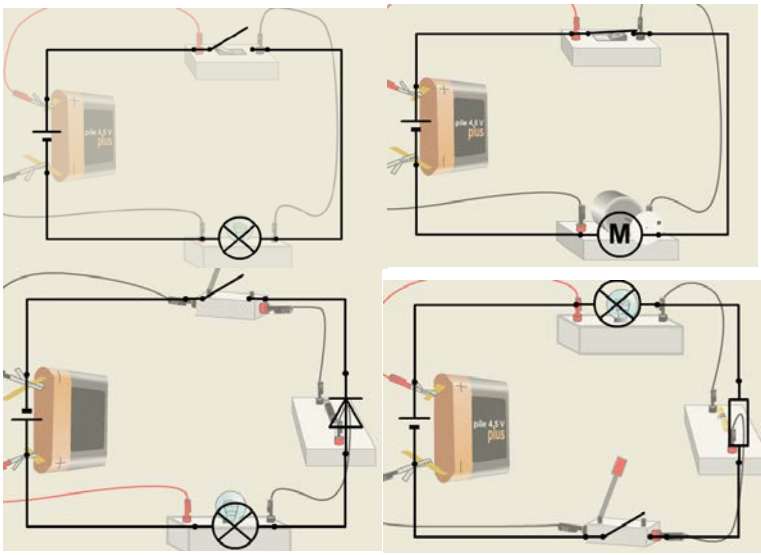
What does each do?

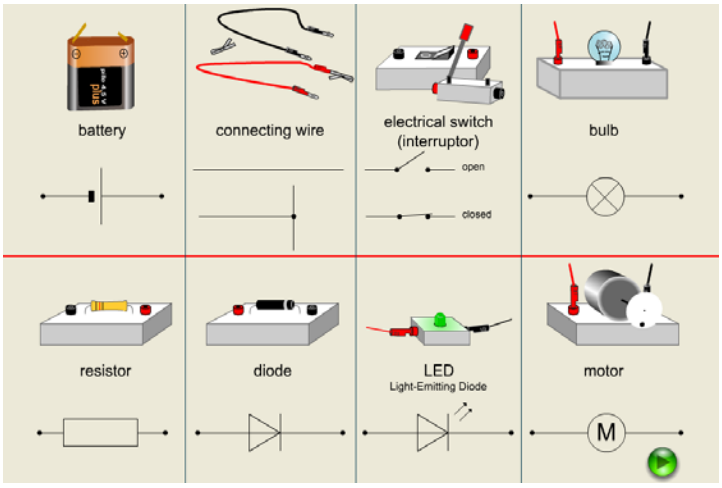
Component	Notes
(B1) Battery Holder - uses 2 1.5V type AA (not included) 	
(S1) Slide Switch 	
(S2) Press Switch 	
(RP) Photoresistor 	
(R1) 100Ω Resistor 	
(RV) Adjustable Resistor 	
(L1) 2.5V Lamp Socket 3.2V Bulb (3.2V, 0.2A) Type 14 or similar 	
(D1) Red Light Emitting Diode (LED) 	
(M1) Motor Fan 	

Teacher Resource 6.1: Exploring Circuits Answer Key

Go to the website: http://www.physics-chemistry-interactive-flash-animation.com/electricity_interactive.htm
Go through the Basic Circuits animations (1-6) and write/draw your observations.

Animation	Observation/Notes/Diagrams
1 - Simple Circuit	
2 - Parallel or Series Circuit	  Lamps are brighter in a parallel circuit. Lamps are dimmer in series.
3 - Short Circuit Activity	 When the shunt is added to bypass the lamp, the lamp does not light up and the battery flashes red.

4 - Short Circuit - Why it's dangerous	When a wire is used to bypass the two lamps, the steel wool burns up because the current is too intense. When only bypassing one lamp, the current encounters some resistance and does not burn up the steel wool. Short circuits can cause fire!  
5 - Circuit Diagram (see below for symbols)	
6 - Conductors v. Insulators	Conductors: alloy, copper, salt water, graphite, aluminum Insulators: water, glass, wood, plastic



Teacher Resource 6.2: Snap Circuit Components Answer Key

What does each do?

Component	Notes
(B1) Battery Holder - uses 2 1.5V type AA (not included) 	Provides power to circuit; total of 3V with 2 batteries
(S1) Slide Switch 	Control whether circuit is open or closed. Slide switch allows continuous on/off. Press switch results in open circuit unless held down continuously.
(S2) Press Switch 	
(RP) Photoresistor 	Resistance varies with amount of light. If light level is high, then resistance is low, increasing current flow. If light is low, then resistance is high.
(R1) 100Ω Resistor 	Resistors reduce current flow.
(RV) Adjustable Resistor 	The slider allows for variable resistance, working as a potentiometer.
(L1) 2.5V Lamp Socket 3.2V Bulb (3.2V, 0.2A) Type 14 or similar 	Possible load to put into circuit - lights up when circuit is closed.
(D1) Red Light Emitting Diode (LED) 	Possible load to put into circuit. As a diode, direction is important. Requires resistor.
(M1) Motor Fan 	Possible load to put into circuit. Often requires more power than a lamp.