VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
http://studentorgs.vanderbilt.edu/vsvs/

Electrical Circuits

2018-2019 VINSE/VSVS Rural

Series and Parallel Circuits

(Adapted from Student Guide for Electric Snap Circuits by Elenco Electronic Inc.)

Acknowledgement: We want to thank NASA and the Tennessee Space Consortium for funds to purchase the electric circuit kits.

Goal: To learn about series and parallel circuits and their properties through the use of Elenco Snap Circuit™ kits.
Fits Tennessee standards

VSVSer **Lesson Outline**

________ **I. Introduction**
Discuss electric circuits (series and parallel circuits) and write the vocabulary on the board. Discuss electrical energy conversions illustrated by a hand generator.
Show students the Energy stick and how to complete a "human circuit".

________ **II. Activity – Making a Simple Circuit**
Students work in pairs and build a simple circuit.

________ **III. Activity– Using a Switch**
Students place a switch in the circuit in part II.

________ **IV. Activity – Measuring Current**
Students test the simple circuit with a meter. Students replace the bulb with an LED and observe that it uses less current.

________ **V. Activity – Building Series and Parallel Circuits**
One pair of students in the group builds a series circuit while the other pair builds a parallel circuit. Then they compare brightness of bulbs and current measurements to see what happens when one light is unscrewed in each circuit. After they have finished, students review series and parallel circuits.

________ **VI. Optional** - 2 pairs of students make parallel circuits using more than 2 light bulbs, with the meter in the circuit. Students unscrew a bulb, one at a time and record current measurements. Students understand the need to conserve electrical energy.

_________**VII Discussion**
Review the results of the lesson and the vocabulary words.

LOOK AT THE VIDEO BEFORE YOU GO OUT TO YOUR CLASSROOM
https://studentorg.vanderbilt.edu/vsvs/lessons/
USE THE PPT AND VIDEO TO VISUALIZE THE MATERIALS USED IN EACH SECTION.

Materials
16 ziploc bags containing materials for assembling series and parallel circuits
(1 board, 2 #1 snaps, 2 #3 snaps, 2 bulb holders, 1 LED bulb in holder,1 switch, 1 battery holder, 1 M5 meter)
1 binder containing:
1 training presentation
16 sets of Instruction Sheets

1 observation sheet
1 answer sheet (yellow)
1 Extra bag of 5 light bulbs
1 Extra bag of 5 batteries
5 hand held generators
4 energy sticks

Unpacking the Kit – What you will need for each section::

VSVSers do this while 1 person is giving the Introduction.

Important Note: Divide students into groups of four so that there are **7 groups**. There are fourteen sets of materials for pairs of students within groups to do the activities. Students will be working in pairs, so that one pair of the group will build the series circuit while the other pair of the group builds the parallel circuit. This will allow them to look at both circuits to see the difference in brightness of bulbs and meter measurements.

For Part I. Introduction

4 "Energy Sticks" in SEPARATE plastic bags, 5 hand generators, 1 bulb

For Parts II, III and IV Activities

14 ziploc bags containing circuit boards and materials,
14 sets of instruction sheets for building simple, series, and parallel circuits
30 observation sheets. Students have their own pencils.

For Parts V. Activity: Building Series and Parallel Circuits

Same as above, with Extra circuit for Demonstration

For Parts VI.

I. Introduction

Learning Goals:
Students differentiate between static and current electricity.
Students understand that electrons can flow only if the circuit is complete.

Why is the science in this lesson important?
Computer engineers are largely responsible for developing computer chips and circuit boards that are found in all of our technology. These chips and boards are made of complex electrical circuits just like the ones the students learn about in this lesson.
Scientist are developing robotic exoskeletons – the circuits in the machinery are responsible for the sensors and motors that strengthen the wearer.
Do not hand out materials until you have discussed the following background information.
Write the following vocabulary words on the board: **electricity, current, simple circuit, series circuit, parallel circuit, LED**

What is Electrical Energy?
Electrical energy is the energy of electric charges.

Ask students to tell you what they know about static electricity and current electricity:

Your Notes:

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Make sure the following is included in the responses:
There are 2 types of electricity, **static** and **current.**

Static electricity is the build-up of electrical charge. It does not flow. It can make your hair stand on end, or "zap" you when it is discharged. Lightning is an excellent example of static electricity being discharged.

Current electricity is moving electrical charge, (electrons). It moves as a result of electric charge build-up.

Current electricity flows through a **circuit**.

Ask students: Where does Electrical Energy come from?
Examples should include power plants, batteries, photocells, thermocouples, generators,
Show students the hand generator and tell them to look at the diagram on their observation sheet. Rotate the handle to activate it. Emphasize that there are NO batteries in the generator.

Ask students what energy conversions are taking place in this device. Have them circle all the conversions on their observation sheet.

How can electrical energy be stored?
Show students a battery. A battery supplies energy to an electric circuit by converting chemical energy to electric potential energy. Chemical reactions provide the energy that causes the electrons to flow in a circuit.

The electrons can flow only if the circuit is complete.

1. Show students one of the Energy sticks. Put a hand on each of the foil ends of the Energy Stick. The stick will flash lights and buzz.
2. Tell students that the stick is activated only when an electrical circuit has been completed.
3. Remove one hand to show the students that the stick no longer flashes or buzzes. The Energy Stick contains a small battery, and has a circuit that is highly sensitive. It can detect very small amounts of electricity that travel through the moisture on your skin.
4. Now have 2 or more VSVS members form a connected circle (by holding hands). Have 2 VSVSers each hold the foil at the opposite ends of the stick to complete a human chain of electricity. Show them a "human switch" by having one member drop a hand and break the circle, and then rejoin.
5. Tell students to look at their Observation sheet and ask them if they can name some energy conversions when the stick is activated. Tell them to circle the correct answers – chemical to electrical (battery to electrical) and the electrical to sound and light.
6. If time permits at the end of the lesson, see how many students can form a circle and activate the Energy stick. Or do this with smaller groups and a VSVS member.

Tell students they will be following diagrams on their instruction sheets to build a simple circuit.

IIA. Activity: Making a Simple Circuit

Learning Goals: Students understand how electrons flow through a circuit.

Materials
14 ziploc bags containing materials for series or parallel circuits

Your Notes:

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14 sets of instruction sheets for building simple, series, and parallel circuits
30 observation sheets

1) Hand out one bag containing circuit materials to each pair.
2) Tell the students to look at the grid and its components, and compare it with **Diagram #1** on their Instruction sheets. Tell them they will need to replace the components in the same way when they are finished with the activities.

   <u>Diagram #1</u>

3) Tell the students that the **snap circuits** we will use today contain flattened wires. Tell them to remove one of the **#3 connectors** and look at its underside. Point out the flattened wire connecting the two snaps. This wire carries the electrical current.
4) **Review the correct way to unscrew a light bulb – demonstrate the "righty tighty, lefty loosey" concept.**
5) Have **all pairs** of students follow Diagram #2 to build the simple circuit on their board.
6) Tell them **not** to connect one of the **#3 snaps** until they are **told to do so**.
7) Ask the students if the circuit is complete. *No*.
8) How can they tell? *The light bulb does not come on*. *No electrical flow*

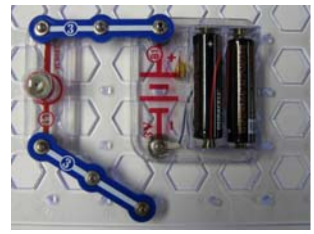


Diagram 2

9) What does it take to complete the circuit? *Connect the last snap, as seen in Diagram #2*
10) Tell the students to do this, and to note that the bulb now glows.
11) **11)** This is called **<u>a closed circuit.</u>** <u>Once the circuit is closed, electrons can flow through the circuit.</u>
12) Ask the students which way the electricity is flowing. *Electrons flow from the negative end (the "flat" end of a battery) to the positive end (the end with the "knob").*
13) Ask the students: What happens if you unscrew the light bulb? *The light goes out because the circuit has been broken.*

III. Activity: Using a Switch

Learning Goals: Students understand how electrons flow through a circuit.

1. Tell the students to replace one of the #3 snaps with the switch **(Diagram #3)**.
2. Sliding the switch to the "on" position is the same as completing the circuit – the light bulb then glows. Sliding the switch to the "off" position is the same as breaking the circuit—the light bulb no longer glows. Tell the students this is a simple way to control flow through the circuit.

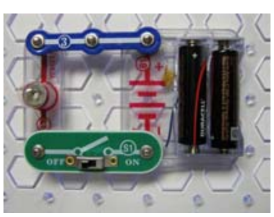
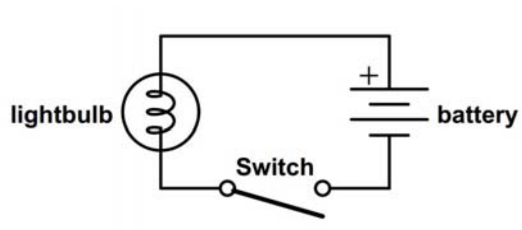


Diagram 3.



Simple Circuit

3. Tell students to look at the diagram of the simple circuit on their observation sheet and point out the relationship between the symbols and the electrical parts.

Your Notes:

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IV. Activity: Measuring Current

Learning Goals: Students understand how electrons flow through a circuit.

1. Show the students the meter and tell them it can measure both current and voltage. Briefly explain that voltage is a measure of electrical potential energy between two points. Explain that voltage is measured in volts and current is measured in amperes.
2. Show the students that the meter has 3 positions.

Move switch to:	You are measuring:	You read the scale located at:
All the way to the left (the 5V setting)	Voltage (V)	Upper scale reads between 0-5 volts
All the way to the right (the 1A setting)	Current (A)	Upper scale reads between 0-5 amps)
In the middle (1mA setting)	Very small current	Lower. Reads in milliamps

3. Measuring Current:

Tell the students:

1. That the meter must be in the circuit for it to be able to measure current.
2. Move the switch to the 1A setting.
3. Look at **Diagram #4** on the Instruction sheet. Remove the remaining #3 snap and replace it with the meter, as shown.

Diagram # 4

4. Turn the switch on and measure the current in amps (A).
5. Touch the light bulb and determine if the bulb feels warmer than its surroundings.
6. Record your observations and measurements in Part A on the Observation sheet.
7. Remove the snap containing the light bulb and replace it with the snap containing the LED.
8. Repeat steps 4-6.

Ask students:

Which light bulb saves electrical energy? How do you know?
Which light bulb would be more useful for keeping cooler temperatures in the house?
What energy conversions are taking place? Answers should include:

1. Electrical to Light.
2. Electrical to thermal (feel the light bulb while the circuit is closed).

V. Activity: Building Series and Parallel Circuits

Learning Goals: Students model energy flow and energy conversions in series and parallel circuits.

<u>Series and Parallel Circuits</u>

Tell students that there are two ways that a circuit can be connected: **series** and **parallel**.

Your Notes:

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- The difference between the two is how their parts are connected
- Each has properties that are unique to it.
- A normal circuit may have both series and parallel elements..
- The behavior of light bulbs in a circuit can be used to observe the differences between the types of circuits.

Diagram 5

Diagram 6

The instruction sheet also includes some questions under the diagrams for the series and parallel circuits to guide their observations of the difference between the two circuits.

1. Tell **one** pair in the group to build the **series circuit (Diagram #5)** while the **other pair** of the group builds the **parallel circuit (Diagram #6) -** point out that a #1 connector is placed on top of lamp holder on the left before a #3 is used to connect to the switch).
2. Tell the pairs within the group to compare the brightness of the bulbs in the two different circuits.
3. Measure the current flowing and record the data in Part B on the observation sheet.

Note: Students will observe the lights are dimmer in the series circuit but not in the parallel circuit. They will observe that the current in the series circuit is less that that in the parallel circuit. See Answer Sheet.

4. Tell the pairs within the group to show each other what happens when the one bulb is unscrewed.
5. Point out the relationship between the symbols and the electrical parts.

Note: Students will observe the other bulb goes out in the series circuit but not in the parallel circuit. (See Answer Sheet.)

Tell students to respond to the questions in Section B on the observation sheet for the circuits they have just tested.

Demonstration: One VSVS team member should take the demonstration simple circuit bag out, screw in the light bulb, and connect #3 snap to complete the simple circuit (from IIA). Go around the room and show them the bulb brightness in the simple circuit so they can compare brightness to that as well. (It's the same as the parallel circuit.)

If students are curious, help them to set up the parallel circuit as in **Diagram #7** and measure the current going through only 1 bulb in the parallel circuit. *It is about the same current as in the simple circuit.*

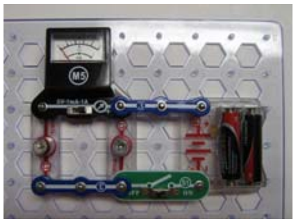

Diagram #7

VI. Optional: Saving Electricity

Allow the 2 pairs of students make **parallel circuits** using more than 2 light bulbs, with the meter in the circuit.

Your Notes:

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Unscrew a bulb, one at a time and record current measurements. Explain to students that this is the equivalent to turning off a light.
Electrical power is directly related to current used. The lower the current used, the less electrical power used.
While new technologies (such as solar power, wind power, LED lights…) can help reduce dependence on fossil fuels to generate electrical power, it is also important to conserve electrical energy by turning off appliances such as lights, heaters etc that are not being used.

VII. Discussion of Series and Parallel Circuits

Learning Goals: Students model energy flow and energy conversions in series and parallel circuits.

After students have finished responding to the questions about the series and parallel circuits they built, take a few minutes to review the differences that they observed. Make sure to include the following in your discussion:

- A series circuit only has one pathway for the electric current – a break in the circuit stops all flow of electric current.
- A parallel circuit has multiple pathways for the electric current to travel
  - a break in one pathway will still allow the current to go through the other pathways.

Review the responses for what happened with the light bulbs in their series and parallel circuits in terms of these concepts.

Lesson modifications by:
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By Matt Jackson, NSF Undergraduate Teaching Fellow, Vanderbilt University and
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Your Notes:

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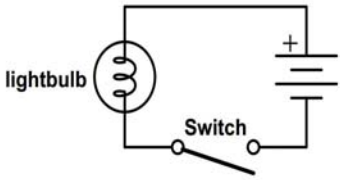
Electric Circuits Observation Sheet

Name ____



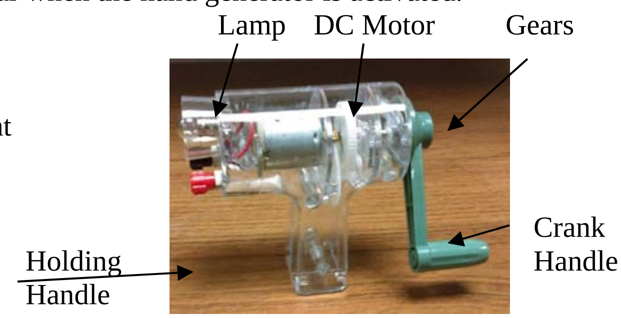
2 1.5V batteries

Wire --------

Introduction – Hand Generator

Circle the energy conversions that occur when the hand generator is activated.

chemical to electrical
mechanical to nuclear
mechanical to sound
mechanical to electrical to light
mechanical to electrical



Energy Stick

Circle the energy conversions when the stick is activated.

chemical to electrical
chemical to nuclear
electrical to sound
electrical to light
electrical to mechanical

A. Current Measurements

Current in the Simple Circuit with regular light bulb ____________

Current in the Simple Circuit with LED ____________

Which light bulb is warmer – regular or LED? ____________

Which light bulb saves electrical energy? How do you know? _________________________

Which light bulb would be more useful for keeping cooler temperatures in the house? _________

Current in the Series Circuit with regular light bulbs ____________

Current in the Parallel Circuit with regular light bulbs ____________

B Series and Parallel Circuits – Circle your answer.

1. The light bulbs in the series circuit were (brighter, dimmer, the same brightness) as those in the parallel circuit.

2. When one light bulb was unscrewed, the other light went out in the (series, parallel) circuit.

3. When one light bulb was unscrewed, the other light remained on in the (series, parallel) circuit.

4. The light bulb in the simple circuit was (brighter, dimmer, the same brightness) as the light bulb in the parallel circuit.

Observation Sheet – Answers
Electric Circuits

Introduction – Hand Generator

Circle the energy conversions that occur when the hand generator is activated.

~~chemical to electrical~~
~~mechanical to nuclear~~
mechanical to sound
mechanical to electrical to light
mechanical to electrical

Energy Stick

Circle the energy conversions when the stick is activated.

chemical to electrical
~~chemical to nuclear~~
electrical to sound
electrical to light
~~electrical to mechanical~~

B. Current Measurements

Current in the Simple Circuit with regular light bulb	**~1.2 A**
Current in the Simple Circuit with LED	**~.5 A**
Which light bulb is warmer – regular or LED?	Regular
Which light bulb saves electrical energy? How do you know?	LED

Which light bulb would be more useful for keeping cooler temperatures in the house? LED

Current in the Series Circuit with 2 regular light bulbs	**~1 A**
Current in the Parallel Circuit with 2 regular light bulbs	**~2.5 A**

A. Series and Parallel Circuits – Circle your answer.

1. The light bulbs in the series circuit were (brighter, **dimmer**, the same brightness) as those in the parallel circuit.
2. When one light bulb was unscrewed, the other light went out in the (**series**, parallel) circuit.
3. When one light bulb was unscrewed, the other light remained on in the (series, **parallel**) circuit.
4. The light bulb in the simple circuit was (brighter, dimmer, **the same brightness**) as the light in the parallel circuit.