NAME PERIOD DATE

# LOAD AND SOLAR PANELS

## Driving Question | Objective

How do voltage, current, resistance, and power change as load increases in a series circuit?

Power is the rate at which electrical energy is either being produced or used up. A device in a circuit that uses power is called a load. Some devices add a higher load to a circuit than others. For example, lights may dim when a high load device like an air conditioner turns on. It uses a lot of current when it runs, reducing the power available to lights and everything else on the same circuit. In addition, some devices may release heat when they run. Heat is a sign that a device has a high load and is using a lot of power.

Plugging too many devices into an electrical outlet is unsafe. When too much power moves through wires, a circuit overload may occur. When designing a solar panel system for a home, consider the total power needs of all loads that will be connected to the system.

## Materials

- Voltage sensor with red and black banana plug leads
- Current sensor with red and black banana plug leads
- Alligator clip adapters (2), red and black
- Alligator clip leads (2), black and green
- Solar panel with toothpicks taped behind center line
- LED
- Buzzer
- 33-Ω Resistor
- Ruler or meter stick
- Adjustable lamp with a minimum 60-W (incandescent) or 23-W (CFL) bulb
- Solar panel from a previous activity

## Safety

Follow these important safety precautions in addition to your regular classroom procedures:

- Caution: Lamp may become very hot.

## Consider

1. Which device most likely has the highest load when it is running?

   a) Cell phone charger

   b) PASCO sensor

   c) Electric mixer or blender

   d) Toaster

2. Predict what will happen to the amount of voltage used as more loads are added to a circuit.

_____

_____

_____

3. Predict what will happen to the total amount of resistance in a circuit as more loads are added.

_____

_____

_____

4. Predict what will happen to the amount of solar power used as more loads are added to a circuit.

_____

_____

_____

## Investigate

1. Connect voltage and current sensors. Use **Help (?)** if necessary.

2. Insert banana plug leads into sensors if necessary. Use red for (+) and black for (-).

3. Build a page with 2 digits displays. Choose Voltage for the first digits display and Current for the second digits display. Change the units for Current from amps (A) to milliamps (mA). Use **Help (?)** if necessary.

4. In the Sampling Options menu, change Sampling Mode to Manual, change Sampling Rate to 2, and change Sampling Rate Units to seconds. Use **Help (?)** if necessary.

5. Set the lamp on its side 30 cm from the panel. Use the panel holder from a previous activity to position the panel at $90^0$. Turn on the lamp.

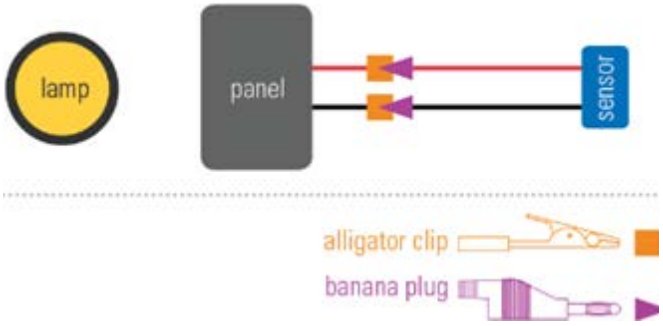


Figure 1: Zero load circuit for voltage or current sensor

6. Start collecting data.

7. Build the zero load circuit with the voltage sensor as shown in Figure 1.

8. Find the highest reading over 30 seconds. Use this method to collect data throughout this activity.

9. Record voltage in Table 1 on Page 5 for 0 loads.

10. Repeat Steps 7-9 replacing the voltage sensor with the current sensor. Record current for 0 loads in Table 1.

11. Add alligator clip adapters to the voltage sensor leads. Build the 1-load resistor circuit as shown in Figure 2.

12. Find and record the highest 1-load voltage in Table 1.

13. Re-arrange the circuit as shown in Figure 3 to measure and record the highest 1-load current in Table 1.

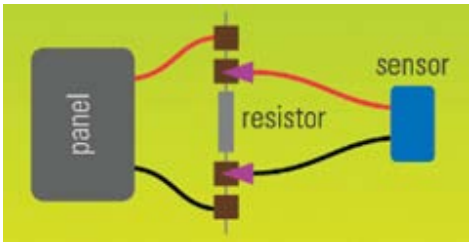


Figure 2: 1-load resistor circuit, voltage

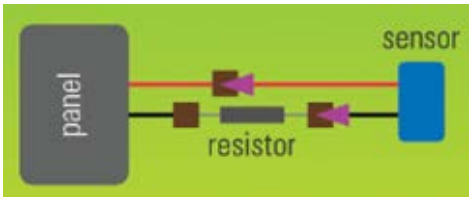


Figure 3: 1-load resistor circuit, current

14. Inspect the LED. The long end that extends from the larger piece of metal inside the dome is the (+) side.

15. Replace the resistor with the LED. Set up the circuit to record voltage as shown in Figure 4. Enter voltage in Table 1.

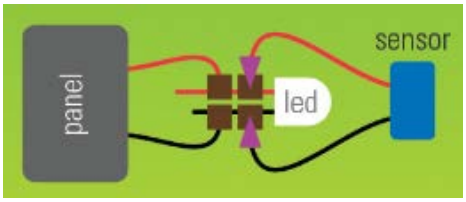


Figure 4: 1-load circuit with LED for voltage sensor


Figure 5: Connection Key

16. Set up the circuit to record current as shown in Figure 6. Enter current in Table 1.

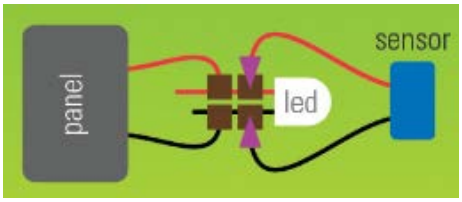


Figure 6: 1-load circuit with LED for current sensor

17. Replace the LED with the buzzer. Set up the circuits to record voltage and current as shown in figures 7 and 8. Enter voltage and current for the 1-load buzzer circuit in Table 1.

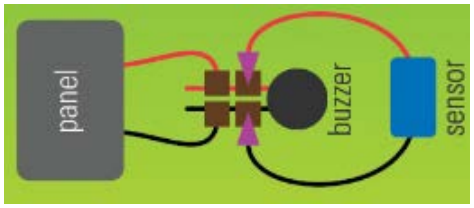


Figure 7: 1-load circuit with buzzer for voltage sensor

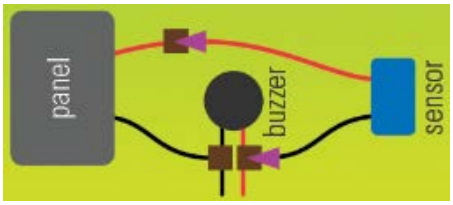


Figure 8: 1-load circuit with buzzer for current sensor

18. Build a 2-load circuit as shown in Figure 9. Attach the voltage sensor at each of the 3 locations shown. Record voltages for 2 loads at each location in Table 1.

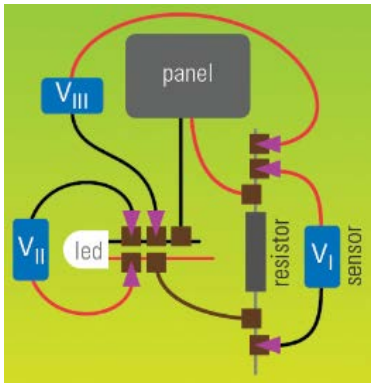


Figure 9: 2-load circuit for 3 voltages

19. Set up the circuit to measure current in 3 locations as shown in Figure 10. Enter currents for each location in Table 1.

20. Build a 3-load circuit as shown in Figure 11. Attach the voltage sensor at each of the 4 locations shown. Record voltages for 3 loads at each location in Table 1.

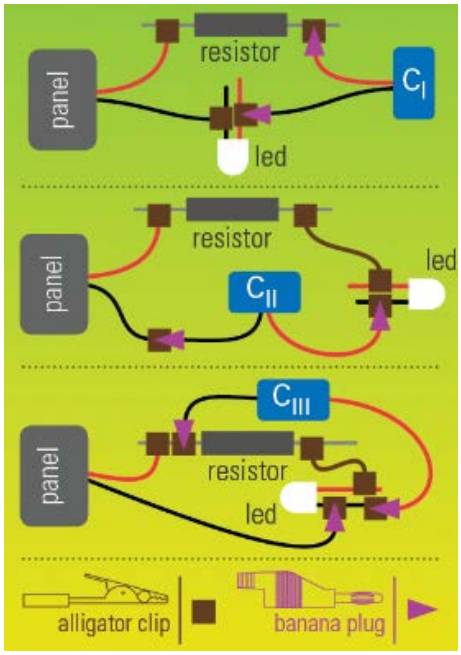


Figure 10: 2-load circuit for 3 currents

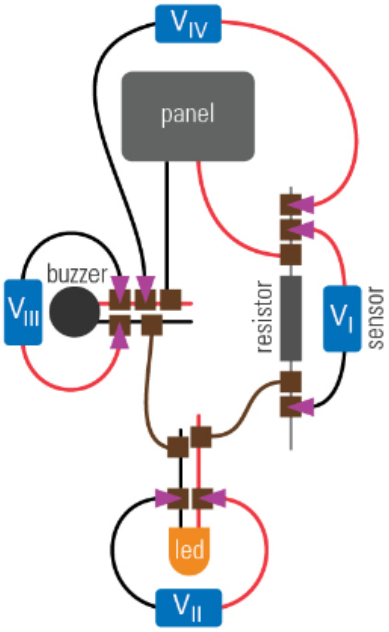


Figure 11: 3-load circuit for 4 voltages

21. Set up the circuit to measure current in 4 locations as shown in Figure 12. Enter currents for each location in Table 1.

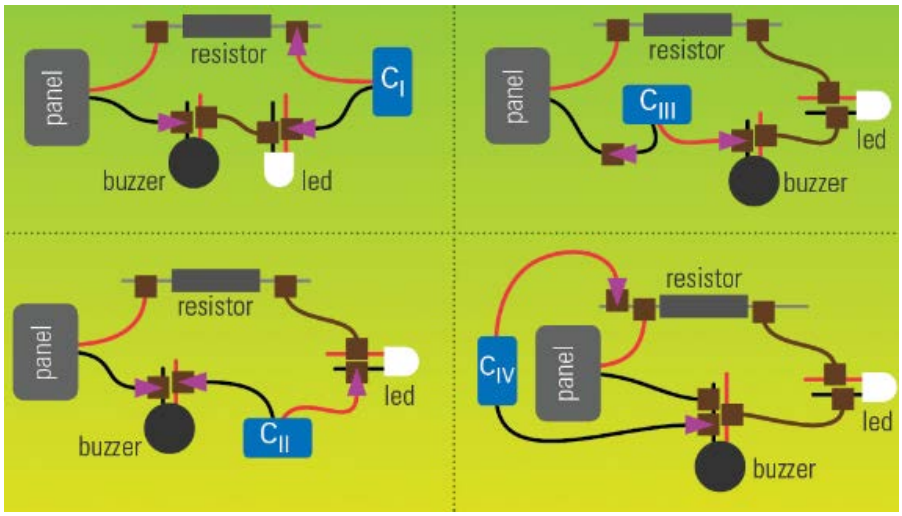


Figure 12: 3-load circuit for 4 currents

22. Turn the lamp off.

Table 1: Load Data

| Number of Loads | Voltage (V) | Current (mA) | **Resistance (Ω)** | Power (mW) |
|---|---|---|---|---|
| 0 | | | | |
| 1, Resistor | | | | |
| 1, LED | | | | |
| 1, Buzzer | | | | |
| 2, Location I | | | | |
| 2, Location II | | | | |
| 2, Location III (circuit total) | | | | |
| 3, Location I | | | | |
| 3, Location II | | | | |
| 3, Location III | | | | |
| 3, Location IV (circuit total) | | | | |

## Analyze

1. Use the following formula to calculate resistance for each number of loads. Enter your answers in Table 1 under Resistance.

   Resistance (Ω) = [Voltage (V) / Current (mA)] x 1000

2. Use the following formula to calculate power for each number of loads. Enter your answers in Table 1 under Power.

   Power (mW) = Voltage (V) x Current (mA)

3. According to your 2- and 3-load circuit data, the total ____ equals the sum of all loads.

   a) Current

   b) Voltage

4. According to your 2- and 3-load circuit data, total ____ is equal to each load's individual value.

   a) Current

   b) Voltage

5. According to your data, what happens to voltage when a circuit changes from no load to one or more loads such as a resistor, LED, or buzzer?

   a) Increases

   b) Decreases

   c) Stays the same as no load

6. According to your data, what happens to current when a circuit changes from no load to one or more loads such as a resistor, LED, or buzzer?

   a) Increases

   b) Decreases

   c) Stays the same as no load

7. Were your predictions for voltage, resistance, and power used correct? Support your answer with data.

_____

_____

_____

8. Why would a solar panel customer need to know power usage patterns in their household before purchasing a solar panel system?

_____

_____

_____

## Extend

In this activity, you set up a series circuit. Another way to set up a circuit is called parallel. Research how parallel circuits are built then redesign this experiment to discover how voltage, current, and resistance behave with loads in a parallel circuit. Get your instructor's approval before performing your experiment.