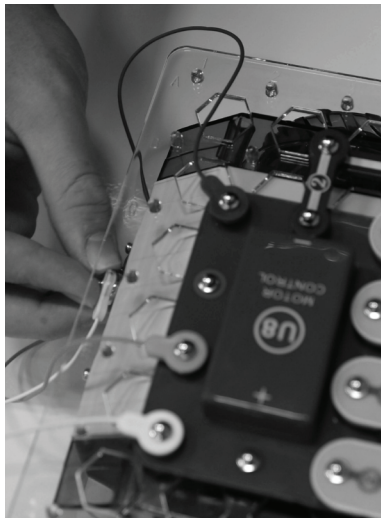
Introduction to Electricity

Electricity is the movement of subatomic charged particles (called **electrons**) through a material due to electrical pressure across the material, such as from a battery. We can think of electricity similarly to how we think of the flow of water, and we can think of circuits like a plumbing system of pipes, valves, and faucets controlling the flow.



Power sources, such as batteries, push electricity through a circuit, like a pump pushes water through pipes. Wires carry electricity, like pipes carry water. Switches and transistors control the flow of electricity like valves and faucets control water. Resistors limit the flow of electricity, similar to how blockages can slow down the flow of water.

The electrical pressure exerted by a battery or other power source is called **voltage** and is measured in volts (V). Notice the "+" and "–" signs on a battery; these indicate which direction the battery will "pump" the electricity. This is similar to the pressure that pushes water through a pipe or hose.

The **electric current** is a measure of how fast electricity is flowing in a wire, just as the water current describes how fast water is flowing in a pipe. It is expressed in amperes.

The **power** of electricity is a measure of how fast energy is moving through a wire. Power is voltage multiplied by current and is expressed in watts.

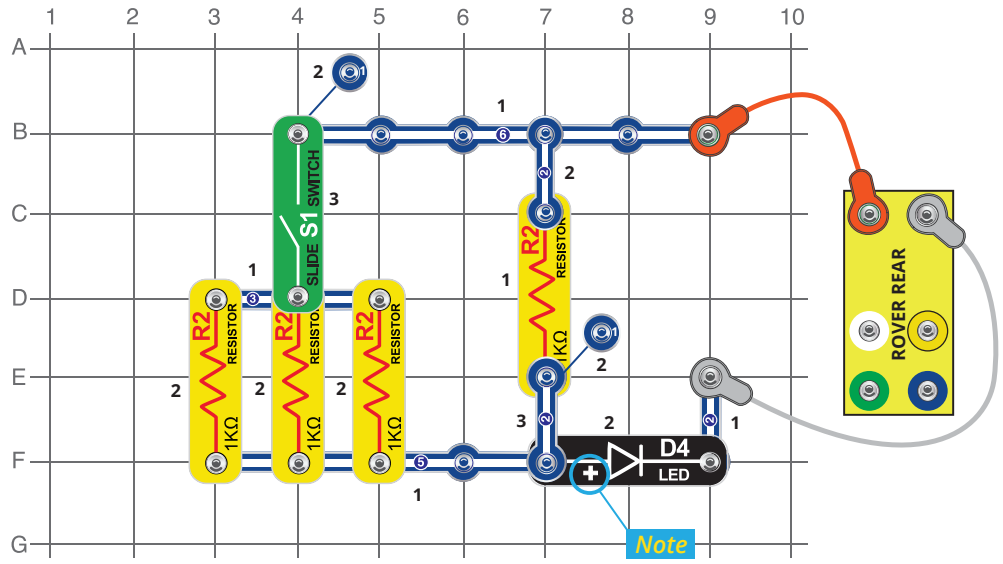
The **resistance** of a component or circuit represents how much it resists the electrical pressure (voltage) and limits the flow of electric current. Voltage is current multiplied by resistance. When the resistance increases, less current flows, and vice versa. Resistance is measured in ohms.

Nearly all of the electricity used in our world is produced by enormous generators driven by steam or water pressure. Wires are used to efficiently transport this energy to homes and businesses where it is used. Motors can then convert the electricity into mechanical form to drive machinery and appliances. The most important aspect of electricity in our society is that it allows energy to be easily transported over distances, large and small. Power lines transport energy across miles, while tiny circuit boards transport energy to power our phones and computers.

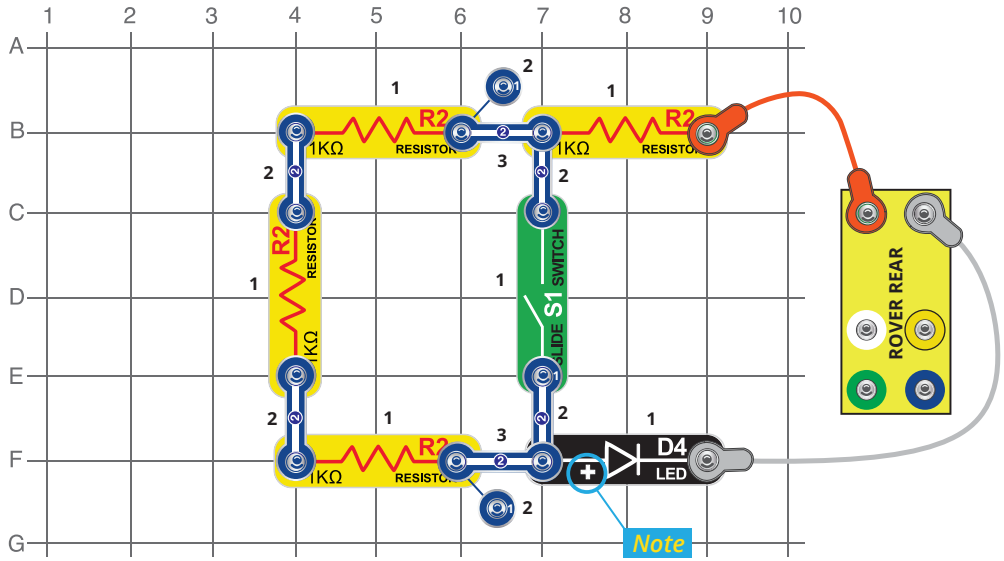
Circuits are the basis of all electronics. There are two ways of arranging parts in a circuit: in series or in parallel. Placing components in series increases the resistance; highest value dominates. Placing components in parallel decreases the resistance; lowest value dominates. The parts within these series and parallel sub-circuits may be arranged in different ways without changing what the circuit does. Large circuits are made of combinations of smaller series and parallel circuits.

First, we will introduce the circuit components included in this kit and how to build circuits, then we will introduce the basics of programming, and finally, we will combine programming and circuitry together.

Introduction to Circuits



Numbers next to components indicate the order and level of placement.



Numbers next to components indicate the order and level of placement.

Resistors

OBJECTIVE: TO LEARN THE BASICS OF RESISTANCE AND BUILDING CIRCUITS

RESISTORS IN PARALLEL

Build the circuit and connect the jumper wires as shown. The LED will be on, but the resistor is limiting the electricity through it.

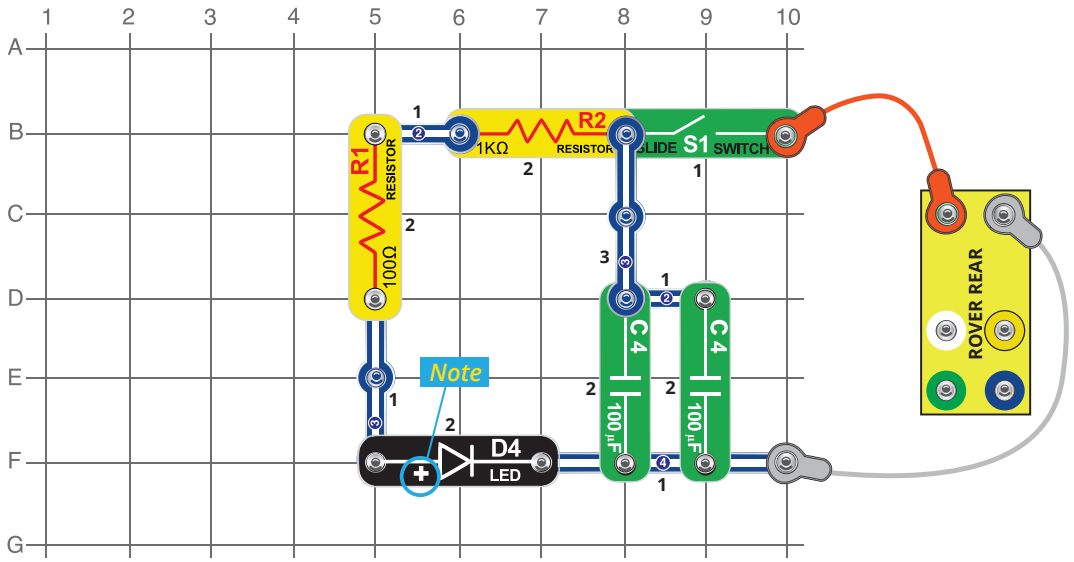
Turn on the switch to place three other resistors in parallel (notice how they make parallel lines) with the first one. This increases the flow of electricity to the LED and makes it brighter. Placing other resistors in parallel reduces the total resistance.

RESISTORS IN SERIES

Build the circuit and connect the jumper wires as shown. The LED will be on, but the four resistors are limiting the electricity through it.

Turn on the switch to bypass three resistors that are in series with the first one (notice how they are lined up, one after the other). This increases the flow of electricity to the LED and makes it brighter. Placing other resistors in series increases the total resistance.

Introduction to Circuits



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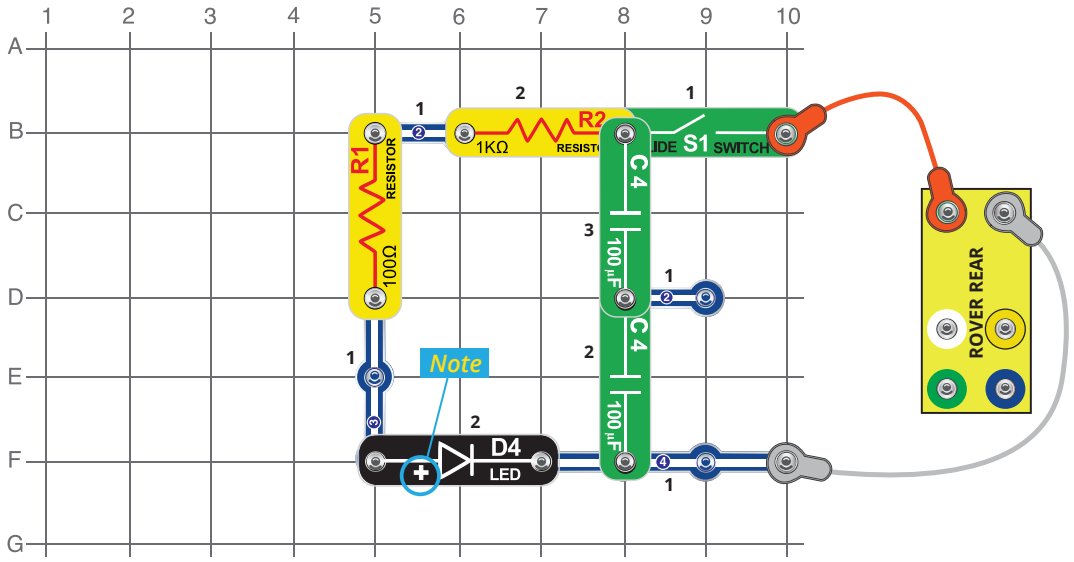


Numbers next to components indicate the order and level of placement.

Capacitors

OBJECTIVE: TO LEARN THE BASICS OF CAPACITANCE AND BUILDING CIRCUITS

CAPACITORS IN PARALLEL

Build the circuit and connect the jumper wires as shown. Turn the switch on and the LED will turn on. Turn the switch off and the LED will go off slowly.

Electricity stored in the capacitors keeps the LED on after the batteries have been disconnected. If you remove one capacitor, then the LED will turn off faster since less electricity will be stored. If you remove both capacitors, the LED will turn off immediately.

CAPACITORS IN SERIES

Build the circuit and connect the jumper wires as shown. This is the same circuit as above, but with the capacitors connected differently. Turn the switch on and off, and watch how quickly the LED turns off.

The LED doesn't stay on as long with this circuit because capacitors connected in series store less electricity than when in parallel. This is the opposite of how we combined resistors. Capacitors connected in series cannot store as much electricty, but can be used with higher voltages.

Avoiding Short Circuits

After building the circuits in this manual, you may wish to build your own. Use the projects in this manual as a guide, as many important design concepts are taught throughout. Every circuit will include a power source, a resistance (which may be a resistor or another integrated part), and wiring paths between them and back.

Electricity flowing in a path in a circuit will always take the path of least resistance, and a circuit with no or low resistance is known as a short circuit. You must be careful not to create these short circuits, as this will damage your components and quickly drain your batteries.

BUILDING CIRCUITS

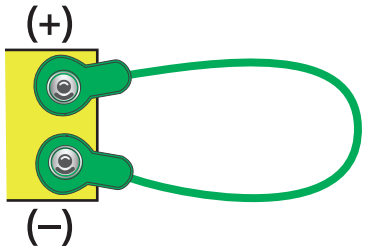
Remember to always...

- Use eye protection when experimenting on your own
- Include at least one component that will limit the current in the circuit, such as a resistor or a component with internal resistance, such as an LED
- Use switches and capacitors in conjunction with other components that will limit the current through them; failure to do this will create a short circuit
- Disconnect your power source immediately if something appears to get hot
- Check your wiring before turning on a circuit, and check the path the electricity will flow through

Never do the following...

- Connect the rover to an outlet in your home
- Leave a circuit unattended when turned on
- Connect other power sources to your rover or Smart Module

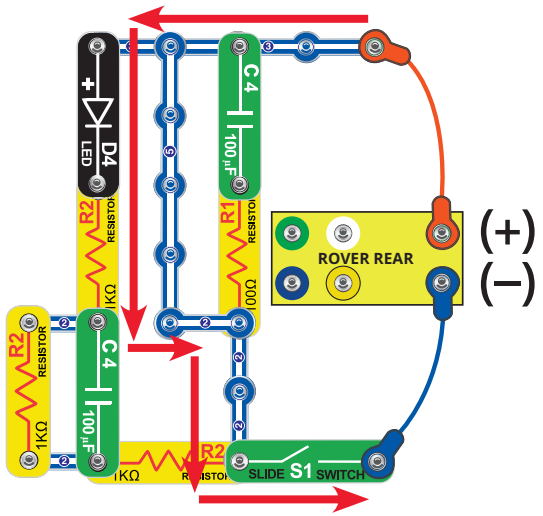
DO NOT BUILD: SHORT CIRCUITS



NEVER BUILD

Placing a jumper wire directly across the battery snaps is a short circuit.

When the switch is turned on, this large circuit has a short circuit path (as shown by the arrows). The short circuit prevents any other portions of the circuit from ever working.



NEVER BUILD

Circuit Troubleshooting

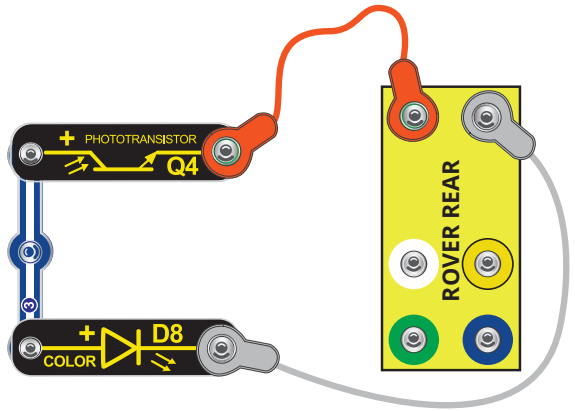
For the Rover Body, Jumper Wires, Slide Switch (S1), Snap Wires, Horn (W1), White LED (D4), Resistors (R1 and R2), Motor Control (U8) module, and Capacitors (C1 and C4): Please see "Advanced Troubleshooting" in the R/C Snap Rover® (Model 753131) manual, available online at **elenco.com/manuals**. All the necessary Snap Circuits® components to conduct troubleshooting via this manual are included in your Smart Rover kit.

For the Press Switch (S2): Please use the troubleshooting instructions for the Slide Switch (S1) above.

For the Color Changing LED (D8) and Slow Changing LED (D12): Please use the troubleshooting instructions for the White LED (D4) above.

For the Programmable Fan (M8), NPN Transistor (Q2), and Selector (S8): Please see "Advanced Troubleshooting" in the Snap Circuits® Arcade (Model SCA200) manual, available online at **elenco.com/manuals**. All the necessary Snap Circuits® components to conduct troubleshooting via this manual are included in your Smart Rover kit. Instead of connecting the circuit to the Battery Holder (B3), you will connect it to the rover rear battery snaps, as indicated on page 11 of this Smart Rover manual. For the Q2 and S8 tests, use any of your D4, D8, or D12 LEDs in place of the LEDs shown in the SCA200 tests.

For the Phototransistor (Q4) and Speaker (S2): For the Phototransistor (Q4), use the mini circuit shown here, varying the amount of light shining on Q4 should change the brightness of D8. For the Speaker (SP), use the same mini circuit but replace Q4 with SP. You should hear sound from the speaker as D8 color changes, though the sound will not be very loud. If there is no sound, then the speaker is broken.



Smart Module: If you believe you have issues with your Smart Module, including the Raspberry Pi or the camera within the component, please visit The Smart Factory @ Wichita website at **thesmartfactory.io**.

For all other Snap Circuits® components, please contact Elenco® Electronics Customer Support via **elenco.com** or by emailing **support@elenco.com**.

CONFORMS TO ALL APPLICABLE U.S. GOVERNMENT REQUIREMENTS

WARNING: Always check your wiring before turning on a circuit. Never leave a circuit unattended while the batteries are installed. Never connect additional batteries or any other power sources to your circuits. Discard any cracked or broken parts.

ADULT SUPERVISION: Because children's abilities vary so much, even with age groups, adults should exercise discretion as to which experiments are suitable and safe (the instructions should enable supervising adults to establish the experiment's suitability for the child). Make sure your child reads and follows all of the relevant instructions and safety procedures and keeps them on hand for reference.

This product is intended for use by adults and children who have attained sufficient maturity to read and follow directions and warnings.

Never modify your parts, as doing so may disable important safety features in them and could put your child at risk of injury. The packaging has to be kept since it contains important information.

BATTERIES:

- Use only 1.5V AA type in the rover body.
- Insert batteries with correct polarity.
- Non-rechargeable batteries should not be recharged. Rechargable batteries should only be charged under adult supervision and should not be recharged while in the product.
- Remove batteries when they are used up.
- Do not mix alkaline, standard (carbon-zinc), or rechargeable (nickel–cadmium) batteries.
- Do not mix old and new batteries.
- Do not connect batteries in parallel.
- Do not short circuit the battery terminals.
- Never throw batteries in a fire or attempt to open their outer casing.
- Batteries are harmful if swallowed, so keep away from small children.

WARNING: the Smart Rover should ONLY be powered using AA batteries. The Smart Module should ONLY be powered using the power cord provided. Neither should ever be used with Snap Circuits® battery holders or other power sources!

WARNING: ELECTRIC TOY
The Smart Rover is rated for ages 10 and older, and is not recommended for children under 10 years of age.

WARNING: SHOCK HAZARD
The Smart Module should ONLY be powered using the power cord provided.

Warning to Snap Circuits® Owners
Do not use parts from other Snap Circuits® sets with this kit. The Smart Rover uses higher voltage, which could damage those parts.