Series & Parallel

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When you have two or more components in a circuit, they can be connected in two primary ways.

When connected such that current flows from one component directly into another, the circuit is considered to be connected in **series**, as the current must flow serially through the components.

If the components are connected such that current can simultaneously flow through components, the circuit is said to be a **parallel** connection.

Different types of components exhibit different types of behavior depending on how they are connected. And, current generally follows the path of least resistance.

We'll look briefly at resistors. When connected in series the resulting resistance is simple to calculate, you just sum the values of the resistors and treat it like one big resistor of that value. This can be useful if you need to get a particular value, but don't have a component with that exact value. You can just find others that add up to what you need.

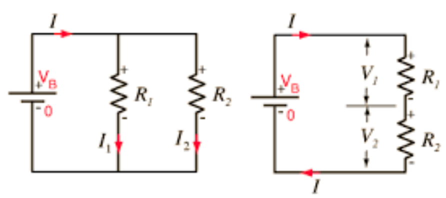
In parallel, the net resistance is always lower than the resistance of either individual resistors. This may seem counter intuitive at first, but consider the pipe and water flow analogy again. Using some small diameter restrictor pipes as resistor stand ins. Imagine tapping a larger pipe in two places and putting one restrictor pipe in each hole, then connect the output of those two restrictor pipes back into another large pipe. The total flow must be greater than the flow of a single restrictor pipe.

To calculate the actual electrical resistance value of multiple resistors connected in parallel, multiply the values then divide them by their sum to get the effective value. (see figure below)

Of course, Capacitors behave differently, essentially the opposite of Resistors; The capacitance of multiple Capacitors in parallel is the sum of all those in parallel, whereas the value of those in series is always less than any individual Capacitor

This course is mostly focused on programming, so there is no need to delve too deeply into analog circuitry. You will be connecting various devices to your micro-controller so a rough working knowledge of circuitry and the associated terms will be valuable.

Although this experiment is pretty trivial, it will let you get comfortable with how the breadboard is connected and inserting and moving various components around the board.



Parallel resistors

$$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2}$$

Series resistors

$$R_{equivalent} = R_1 + R_2$$

Resistors
Series Vs Parallel Law

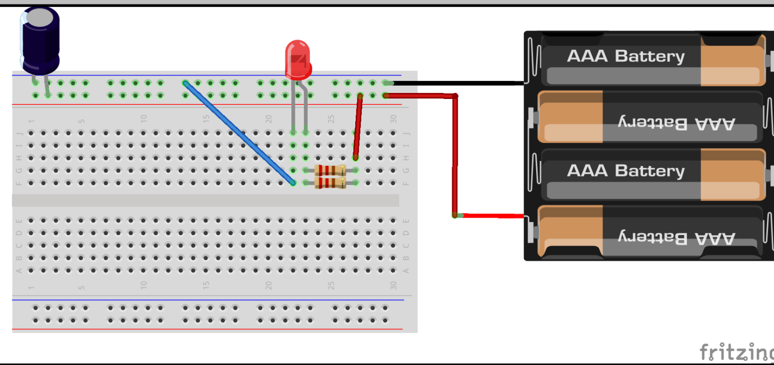
$$R_{Series} = R_a + R_b$$

$$R_{Parallel} = \frac{(R_a \cdot R_b)}{(R_a + R_b)}$$

Capacitors
Series Vs Parallel Law

$$C_{Series} = \frac{(Ca \bullet Cb)}{(Ca + Cb)}$$

$$C_{Parallel} = Ca + Cb$$

<table>
<tr><th>Components</th><th colspan="2">Wiring Diagram</th></tr>
<tr><td>✓Battery Pack
✓Breadboard
✓Any single-color LED
✓Resistor x2
✓Capacitor</td><td colspan="2">
</td></tr>
<tr><th colspan="3">Connection Instructions</th></tr>
<tr><td colspan="3">Building on our previous setup, simple add another resistor from G27 to G23. This connects them in parallel.

To connect them in series, connect one from G23 to B25 and one from D25 to G27. As always, before powering your circuit, trace the flow of electricity and be sure that it flows though first one resistor, then another then your led and then back to the power source.</td></tr>
<tr><th>Sketch(es)</th><td colspan="2">——</td></tr>
<tr><th colspan="3">Analysis Questions</th></tr>
<tr><td colspan="3">What happens to the brightness in each configuration?
How long does it stay illuminated when disconnected from power in each configuration?</td></tr>
<tr><th colspan="3">Programming Tasks</th></tr>
<tr><td colspan="3">——</td></tr>
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