

# SERIES AND PARALLEL CIRCUITS

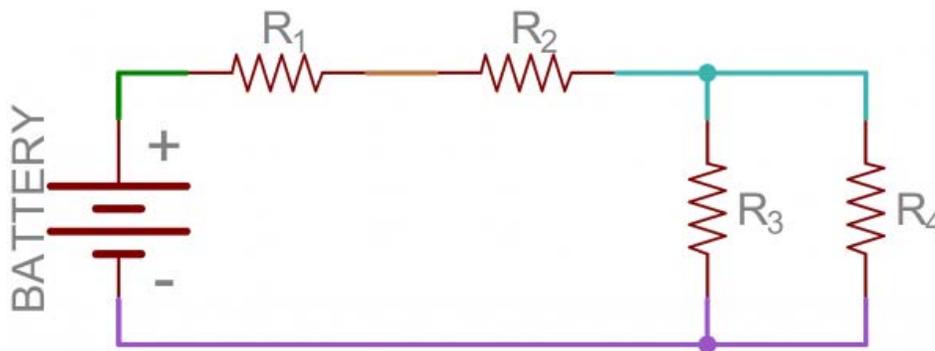
Simple circuits (ones with only a few components) are usually fairly straightforward for beginners to understand. But, things can get sticky when other components come to the party. Where's the current going? What's the voltage doing? Can this be simplified for easier understanding? Fear not, intrepid reader. Valuable information follows.

In this tutorial, we'll first discuss the difference between series circuits and parallel circuits, using circuits containing the most basic of components – resistors and batteries – to show the difference between the two configurations. We'll then explore what happens in series and parallel circuits when you combine different types of components, such as capacitors and inductors.

## Series Circuits

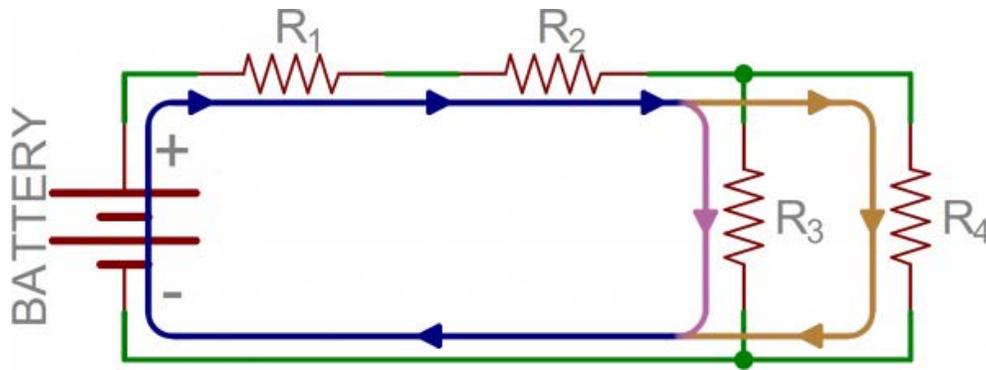
### Nodes and Current Flow

Before we get too deep into this, we need to mention what a **node** is. It's nothing fancy, just the electrical junction between two or more components. When a circuit is modeled on a schematic, the nodes are the wires between components.



*Example schematic with four uniquely colored nodes.*

That's half the battle towards understanding the difference between series and parallel. We also need to understand **how current flows** through a circuit. **Current** flows from a high **voltage** to a lower voltage in a circuit. Some amount of current will flow through every path it can take to get to the point of lowest voltage (usually called ground). Using the above circuit as an example, here's how current would flow as it runs from the battery's positive terminal to the negative:

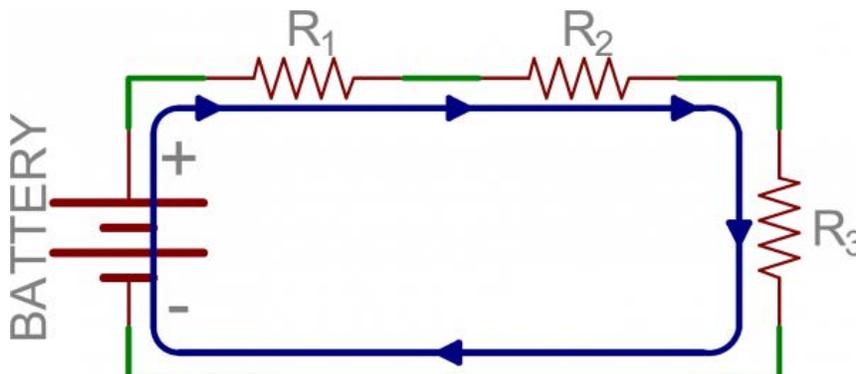


Current (indicated by the blue, orange, and pink lines) flowing through the same example circuit as above. Different currents are indicated by different colors.

Notice that in some nodes (like between  $R_1$  and  $R_2$ ) the current is the same going in as at is coming out. At other nodes (specifically the three-way junction between  $R_2$ ,  $R_3$ , and  $R_4$ ) the main (blue) current splits into two different ones. *That's* the key difference between series and parallel!

## Series Circuits Defined

Two components are in series if they share a common node and if the **same current** flows through them. Here's an example circuit with three series resistors:

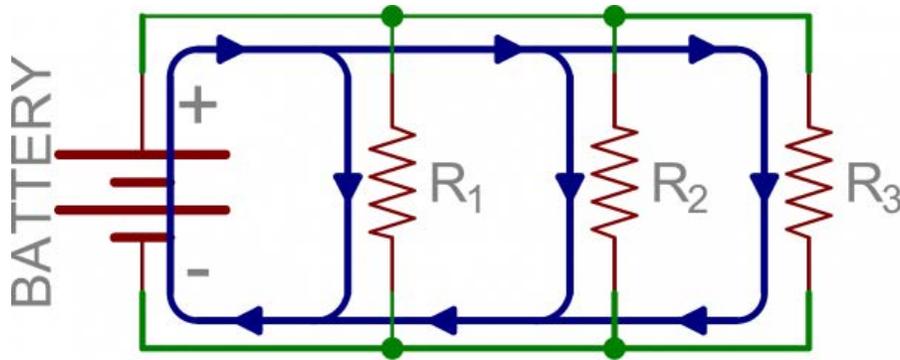


There's only one way for the current to flow in the above circuit. Starting from the positive terminal of the battery, current flow will first encounter  $R_1$ . From there the current will flow straight to  $R_2$ , then to  $R_3$ , and finally back to the negative terminal of the battery. Note that there is only one path for current to follow. These components are in series.

## Parallel Circuits

### Parallel Circuits Defined

If components share *two* common nodes, they are in parallel. Here's an example schematic of three resistors in parallel with a battery:

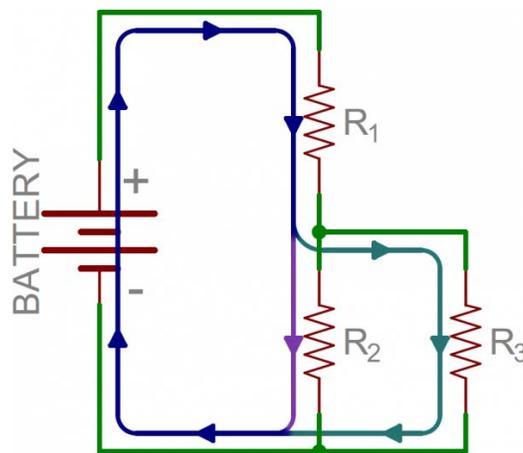


From the positive battery terminal, current flows to  $R_1$ ,  $R_2$ , and  $R_3$ . The node that connects the battery to  $R_1$  is also connected to the other resistors. The other ends of these resistors are similarly tied together, and then tied back to the negative terminal of the battery. There are three distinct paths that current can take before returning to the battery, and the associated resistors are said to be in parallel.

Where series components all have equal currents running through them, parallel components all have the same voltage drop across them – series:current::parallel:voltage.

## Series and Parallel Circuits Working Together

From there we can mix and match. In the next picture, we again see three resistors and a battery. From the positive battery terminal, current first encounters  $R_1$ . But, at the other side of  $R_1$  the node splits, and current can go to both  $R_2$  and  $R_3$ . The current paths through  $R_2$  and  $R_3$  are then tied together again, and current goes back to the negative terminal of the battery.



In this example,  $R_2$  and  $R_3$  are in parallel with each other, and  $R_1$  is in series with the parallel combination of  $R_2$  and  $R_3$ .