I Introduction

A circuit consists of electrical elements connected together. Engineers use electric circuits to solve problems that are important to modern society. In particular:

1. Electric circuits are used in the generation, transmission, and consumption of electric power and energy.

2. Electric circuits are used in the encoding, decoding, storage, retrieval, transmission, and processing of information.

In this chapter, we will do the following: Represent the current and voltage of an electric circuit element, paying particular attention to the reference direction of the current and to the reference direction or polarity of the voltage. Calculate the power and energy supplied or received by a circuit element. Use the passive convention to determine whether the product of the current and voltage of a circuit element is the power supplied by that element or the power received by the element.

II Electric Circuits and Current: The outstanding characteristics of electricity when compared with other power sources are its mobility and flexibility. Electrical energy can be moved to any point along a couple of wires and, depending on the user's requirements, converted to light, heat, or motion. An electric circuit or electric network is an interconnection of electrical elements linked together in a closed path so that an electric current may flow continuously.

Consider a simple circuit consisting of two well-known electrical elements, a battery and a resistor, as shown in Figure 1.2-1. Each element is represented by the two-terminal element shown in Figure 1.2-2. Elements are sometimes called devices, and terminals are sometimes called nodes.

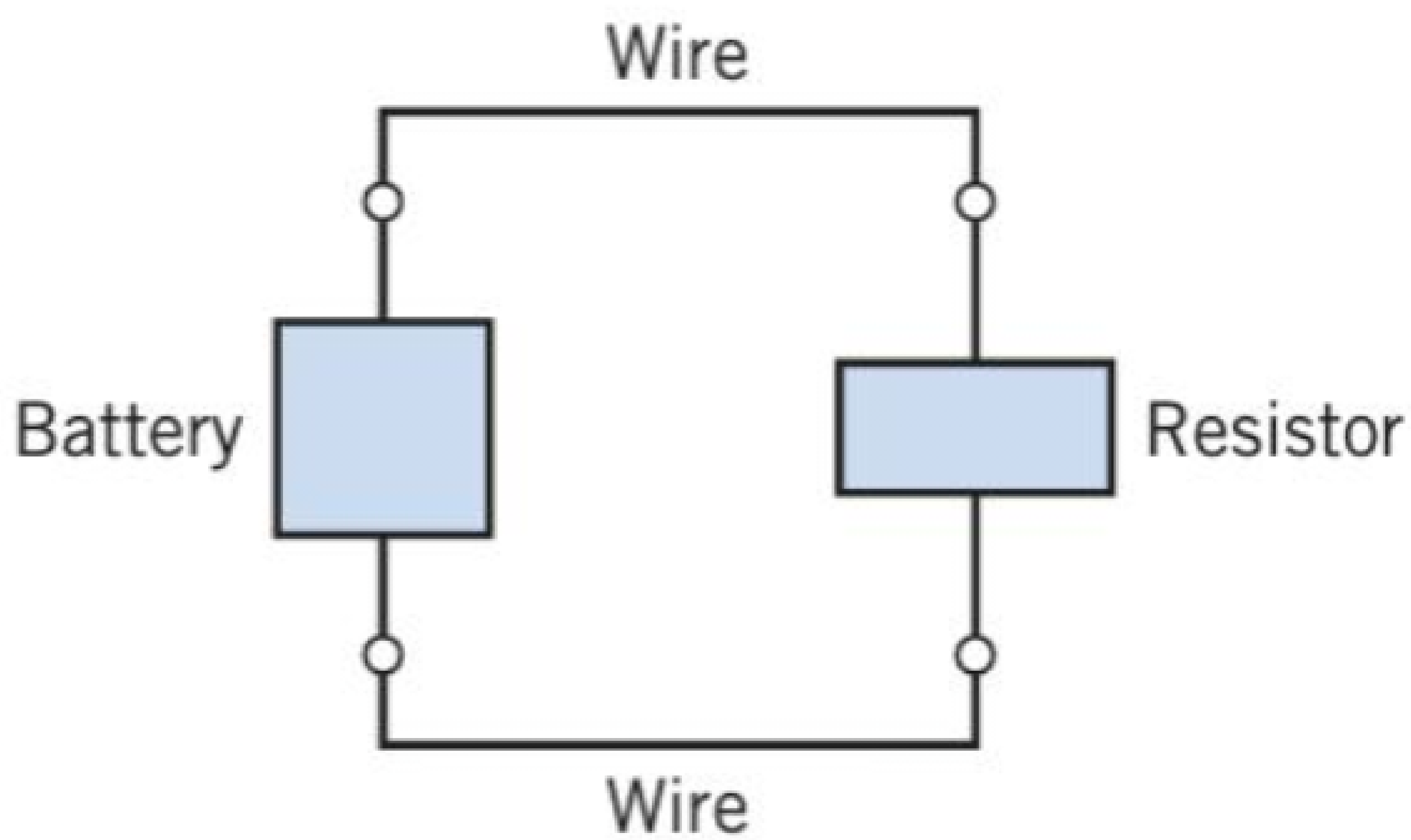


FIGURE 1.2-1 A simple circuit.

FIGURE 1.2-2 A general two-terminal electrical element with terminals a and b.

Charge may flow in an electric circuit. Current is the time rate of change of charge past a given point. Charge is the intrinsic property of matter responsible for electric phenomena. The quantity of charge q can be expressed in terms of the charge on one electron, which i s 1.602 10^{-19} coulombs. Thus, 1 coulomb is the charge on 6.24 10^{18} electrons. The curre nt through a specified area is defined by the electric charge passing through the area per unit of time.

Thus, q is defined as the charge expressed in coulombs (C). Charge is the quantity of ele ctricity responsible for electric phenomena. Then we can express current as $i = dq/dt$, The unit of current is the ampere (A); an ampere is 1 coulomb per second.

FIGURE 1.2-4 A direct current of magnitude I.

similar but different. They are the same size but have different directions. Therefore, i_2 is the negative of i_1 and

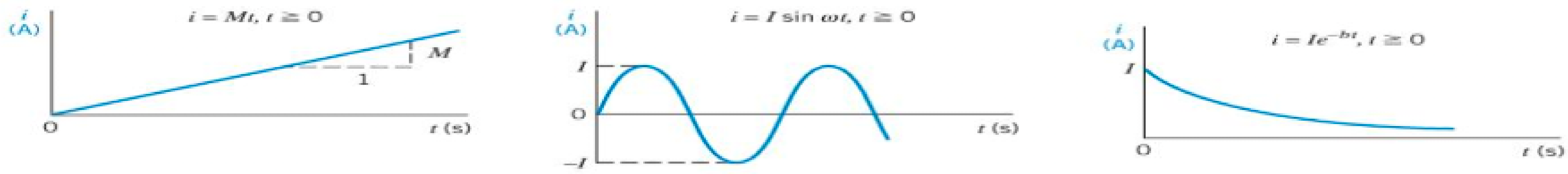
$$i_1 = -i_2$$

We always associate an arrow with a current to denote its direction. A complete description of current requires both a value (which can be positive or negative) and a direction (indicated by an arrow).

If the current flowing through an element is constant, we represent it by the constant I, as shown in Figure 1.2-4. A constant current is called a *direct current* (dc).

> A **direct current** (dc) is a current of constant magnitude.

A time-varying current $i(t)$ can take many forms, such as a ramp, a sinusoid, or an exponential, as shown in Figure 1.2-5. The sinusoidal current is called an *alternating current* (ac).



(*a*) (*b*) (*c*)

FIGURE 1.2-5 (*a*) A ramp with a slope M. (*b*) A sinusoid. (*c*) An exponential. I is a constant. The current i is zero for $t < 0$.

If the charge q is known, the current i is readily found using Eq. 1.2-1. Alternatively, if the current i is known, the charge q is readily calculated. Note that from Eq. 1.2-1, we obtain

$$q = \int_{-\infty}^{t} i\, d\tau = \int_{0}^{t} i\, d\tau + q(0) \tag{1.2-2}$$

where $q(0)$ is the charge at $t = 0$.

Example 1.2-1 Current from Charge

Find the current in an element when the charge entering the element is

$$q = 12t \text{ C}$$

where t is the time in seconds.

Solution

Recall that the unit of charge is coulombs, C. Then the current, from Eq. 1.2-1, is

$$i = \frac{dq}{dt} = 12 \text{ A}$$

where the unit of current is amperes, A.

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Example 1.2-2 Charge from Current

Find the charge that has entered the terminal of an element from $t = 0$ s to $t = 3$ s when the current entering the element is as shown in Figure 1.2-6.

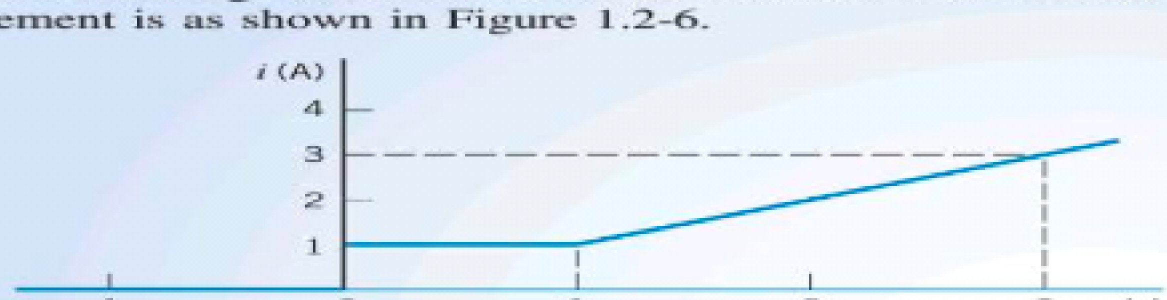


FIGURE 1.2-6 Current waveform for Example 1.2-2.

Solution

From Figure 1.2-6, we can describe $i(t)$ as

$$i(t) = \begin{cases} 0 & t < 0 \\ 1 & 0 < t \le 1 \\ t & t > 1 \end{cases}$$

Using Eq. 1.2-2, we have

$$\begin{aligned} q(3) - q(0) &= \int_0^3 i(t)dt = \int_0^1 1\, dt + \int_1^3 t\, dt \\ &= t\Big|_0^1 + \frac{t^2}{2}\Big|_1^3 = 1 + \frac{1}{2}(9-1) = 5 \text{ C} \end{aligned}$$

Alternatively, we note that integration of $i(t)$ from $t = 0$ to $t = 3$ s simply requires the calculation of the area under the curve shown in Figure 1.2-6. Then, we have

$$q = 1 + 2 \times 2 = 5 \text{ C}$$

III System of units

In representing a circuit and its elements, we must define a consistent system of units for the qu occurring in the circuit. At the 1960 meeting of the General Conference of Weights and Measures, the representatives modernized the metric system and created the Système International d'Unites, commonly called SI units.

> **SI** is *Système International d'Unités* or the International System of Units.

The fundamental, or base, units of SI are shown in Table 1.3-1. Symbols for units that represent proper (persons') names are capitalized; the others are not. Periods are not used after the symbols, and the symbols do not take on plural forms. The derived units for other physical quantities are obtained by combining the fundamental units. Table 1.3-2 shows the more common derived units along with their formulas in terms of the fundamental units or preceding derived units. Symbols are shown for the units that have them.

Table 1.3-1 SI Base Units

	SI UNIT	
QUANTITY	NAME	SYMBOL
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Table 1.3-2 Derived Units in SI

QUANTITY	UNIT NAME	FORMULA	SYMBOL
Acceleration — linear	meter per second per second	m/s^2	
Velocity — linear	meter per second	m/s	
Frequency	hertz	s^{-1}	Hz
Force	newton	$kg \cdot m/s^2$	N
Pressure or stress	pascal	N/m^2	Pa
Density	kilogram per cubic meter	kg/m^3	
Energy or work	joule	$N \cdot m$	J
Power	watt	J/s	W
Electric charge	coulomb	$A \cdot s$	C
Electric potential	volt	W/A	V
Electric resistance	ohm	V/A	Ω
Electric conductance	siemens	A/V	S
Electric capacitance	farad	C/V	F
Magnetic flux	weber	$V \cdot s$	Wb
Inductance	henry	Wb/A	H

Table 1.3-3 SI Prefixes		
MULTIPLE	PREFIX	SYMBOL
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

The basic units such as length in meters (m), time in seconds (s), and current in amperes (A) can be used to obtain the derived units. Then, for example, we have the unit for charge (C) derived from the product of current and time (A · s). The fundamental unit for energy is the joule (J), which is force times distance or N · m.

The great advantage of the SI system is that it incorporates a decimal system for relating larger or smaller quantities to the basic unit. The powers of 10 are represented by standard prefixes given in Table 1.3-3. An example of the common use of a prefix is the centimeter (cm), which is 0.01 meter.

The decimal multiplier must always accompany the appropriate units and is never written by itself. Thus, we may write 2500 W as 2.5 kW. Similarly, we write 0.012 A as 12 mA.

EXAMPLE 1.3-1 SI Units

A mass of 150 grams experiences a force of 100 newtons. Find the energy or work expended if the mass moves 10 centimeters. Also, find the power if the mass completes its move in 1 millisecond.

Solution

The energy is found as

$$\text{energy} = \text{force} \times \text{distance} = 100 \times 0.1 = 10\ \text{J}$$

Note that we used the distance in units of meters. The power is found from

$$\text{power} = \frac{\text{energy}}{\text{time period}}$$

where the time period is 10^{-3} s. Thus,

$$\text{power} = \frac{10}{10^{-3}} = 10^4\ \text{W} = 10\ \text{kW}$$

EXERCISE 1.3-1 Which of the three currents, $i_1 = 45\ \mu\text{A}$, $i_2 = 0.03\ \text{mA}$, and $i_3 = 25 \times 10^{-4}\ \text{A}$, is largest?

Answer: i_3 is largest.

IV Power and energy

The power and energy delivered to an element are of great importance. For example, the useful output of an electric lightbulb can be expressed in terms of power. We know that a 300-watt bulb delivers more light than a 100-watt bulb.

Power is the time rate of supplying or receiving power.

Thus, we have the equation

$$p = \frac{dw}{dt} \tag{1.5-1}$$

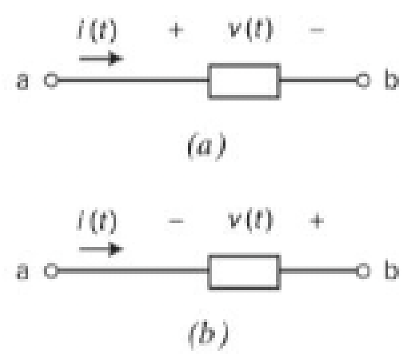


FIGURE 1.5-1 (*a*) The element voltage and current **adhere** to the passive convention. (*b*) The element voltage and current **do not adhere** to the passive convention.

where p is power in watts, w is energy in joules, and t is time in seconds. The power associated with the current through an element is

$$p = \frac{dw}{dt} = \frac{dw}{dq} \cdot \frac{dq}{dt} = v \cdot i \tag{1.5-2}$$

From Eq. 1.5-2, we see that the power is simply the product of the voltage across an element times the current through the element. The power has units of watts.

Two circuit variables are assigned to each element of a circuit: a voltage and a current. Figure 1.5-1 shows that there are two different ways to arrange the direction of the current and the polarity of the voltage. In Figure 1.5-1*a*, the current is directed from the + toward the – of the voltage polarity. In contrast, in Figure 1.5-1*b*, the current is directed from the – toward the + of the voltage polarity.

First, consider Figure 1.5-1*a*. When the current enters the circuit element at the + terminal of the voltage and exits at the – terminal, the voltage and current are said to "adhere to the passive convention." In the passive convention, the voltage pushes a positive charge in the direction indicated by the current. Accordingly, the power calculated by multiplying the element voltage by the element current

$$p = vi$$

is the power **received** by the element. (This power is sometimes called "the power absorbed by the element" or "the power dissipated by the element.") The power received by an element can be either positive or negative. This will depend on the values of the element voltage and current.

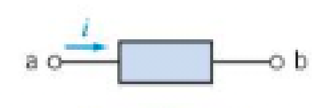
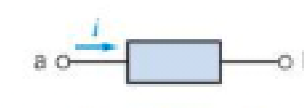
Next, consider Figure 1.5-1*b*. Here the passive convention has not been used. Instead, the current enters the circuit element at the – terminal of the voltage and exits at the + terminal. In this case, the voltage pushes a positive charge in the direction opposite to the direction indicated by the current. Accordingly, when the element voltage and current do not adhere to the passive convention, the power calculated by multiplying the element voltage by the element current is the power **supplied** by the element. The power supplied by an element can be either positive or negative, depending on the values of the element voltage and current.

The power received by an element and the power supplied by that same element are related by

$$\text{power received} = -\text{power supplied}$$

The rules for the passive convention are summarized in Table 1.5-1. When the element voltage and current adhere to the passive convention, the energy received by an element can be determined

Table 1.5-1 Power Received or Supplied by an Element

POWER RECEIVED BY AN ELEMENT	POWER SUPPLIED BY AN ELEMENT
	
Because the reference directions of v and i adhere to the passive convention, the power $p = vi$ is the power received by the element.	Because the reference directions of v and i do not adhere to the passive convention, the power $p = vi$ is the power supplied by the element.

from Eq. 1.5-1 by rewriting it as

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EXAMPLE 1.5-3 Power, Energy, and the Passive Convention

Consider the circuit shown in Figure 1.5-4 with $v(t) = 12e^{-8t}$ V and $i(t) = 5e^{-8t}$ A for $t \geq 0$. Both $v(t)$ and $i(t)$ are zero for $t < 0$. Find the power supplied by this element and the energy supplied by the element over the first 100 ms of operation.

FIGURE 1.5-4 The element considered in Example 1.5-3.

Solution

The power

$$p(t) = v(i)\, i(t) = \left(12e^{-8t}\right)\left(5e^{-8t}\right) = 60e^{-16t} \text{ W}$$

is the power *supplied* by the element because $v(t)$ and $i(t)$ do not adhere to the passive convention. This element is supplying power to the charge flowing through it.

The energy supplied during the first 100 ms = 0.1 seconds is

$$\begin{aligned} w(0.1) &= \int_0^{0.1} p\, dt = \int_0^{0.1} \left(60e^{-16t}\right) dt \\ &= 60 \frac{e^{-16t}}{-16}\bigg|_0^{0.1} = -\frac{60}{16}\left(e^{-1.6} - 1\right) = 3.75\left(1 - e^{-1.6}\right) = 2.99 \text{ J} \end{aligned}$$

EXAMPLE 1.5-4 Energy in a Thunderbolt

The average current in a typical lightning thunderbolt is 2×10^4 A, and its typical duration is 0.1 s (Williams, 1988). The voltage between the clouds and the ground is 5×10^8 V. Determine the total charge transmitted to the earth and the energy released.

Solution

The total charge is

$$Q = \int_0^{0.1} i(t)\, dt = \int_0^{0.1} 2 \times 10^4\, dt = 2 \times 10^3 \text{ C}$$

The total energy released is

$$w = \int_0^{0.1} i(t) \times v(t)\, dt = \int_0^{0.1} \left(2 \times 10^4\right)\left(5 \times 10^8\right) dt = 10^{12} \text{ J} = 1 \text{ TJ}$$

EXERCISE 1.5-1 Figure E 1.5-1 shows four circuit elements identified by the letters *A*, *B*, *C*, and *D*.

(a) Which of the devices supply 12 W?

(b) Which of the devices absorb 12 W?

V Elements of circuits

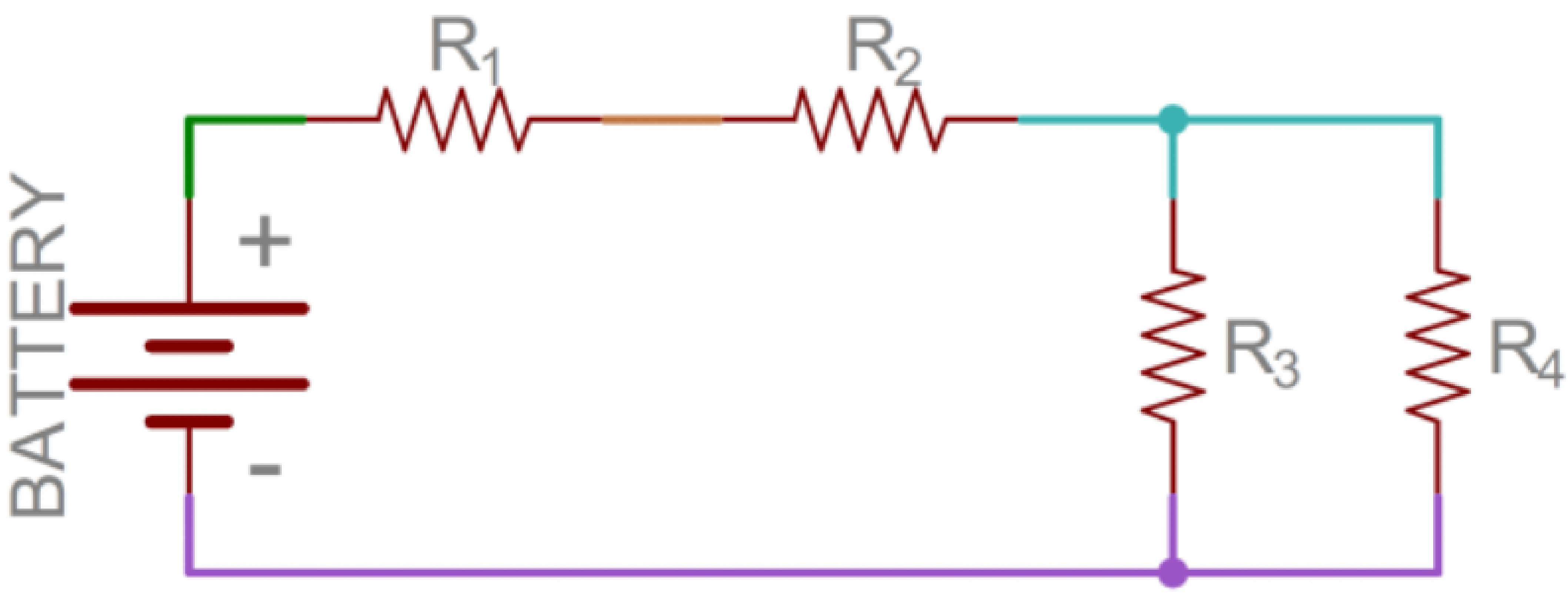
V-a) Resistors

Introduction

Series Circuits

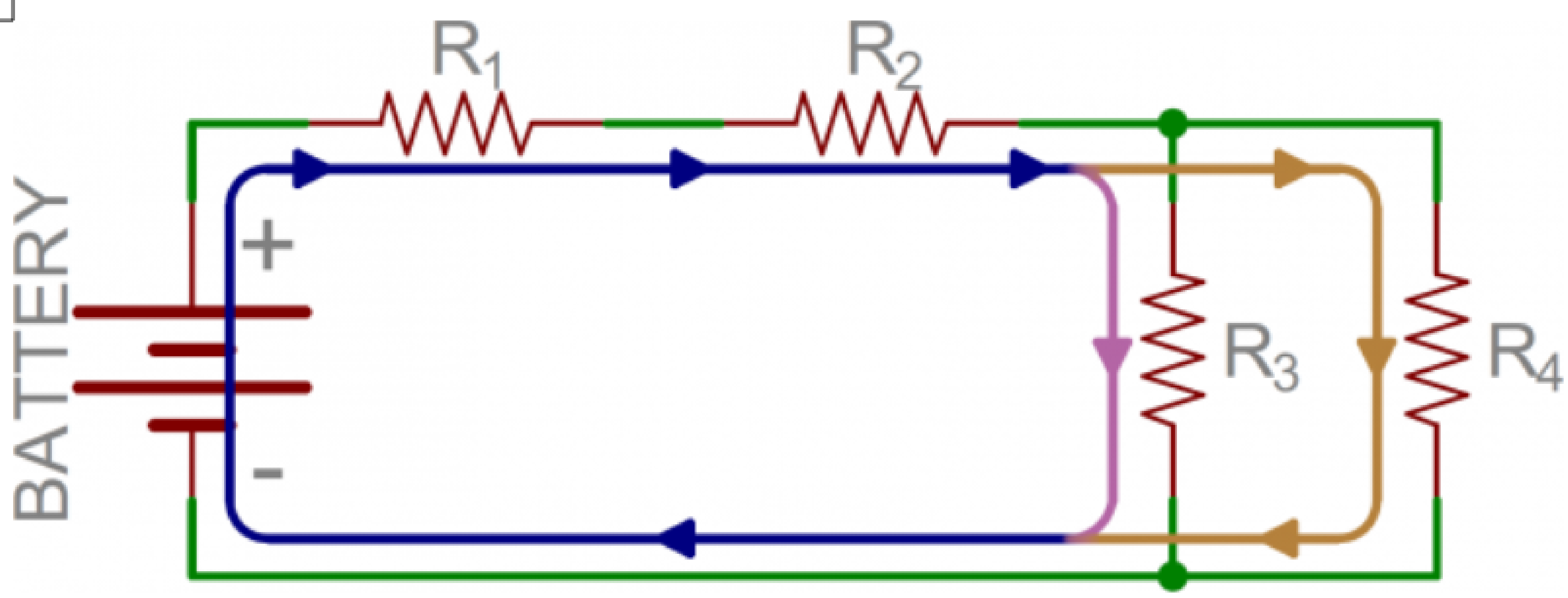
Nodes and Current Flow

Before we get too deep into this, we need to mention what a node is. It's nothing fancy, ju st representation of an electrical junction between two or more components. When a circ uit is modeled on a schematic, these *nodes represent 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 hig h *voltage* to a lower voltage in a circuit. Some amount of current will flow through every p ath it can take to get to the point of lowest voltage (usually called ground). Using the abo ve circuit as an example, here's how current would flow as it runs from the battery's positi ve terminal to the negative:

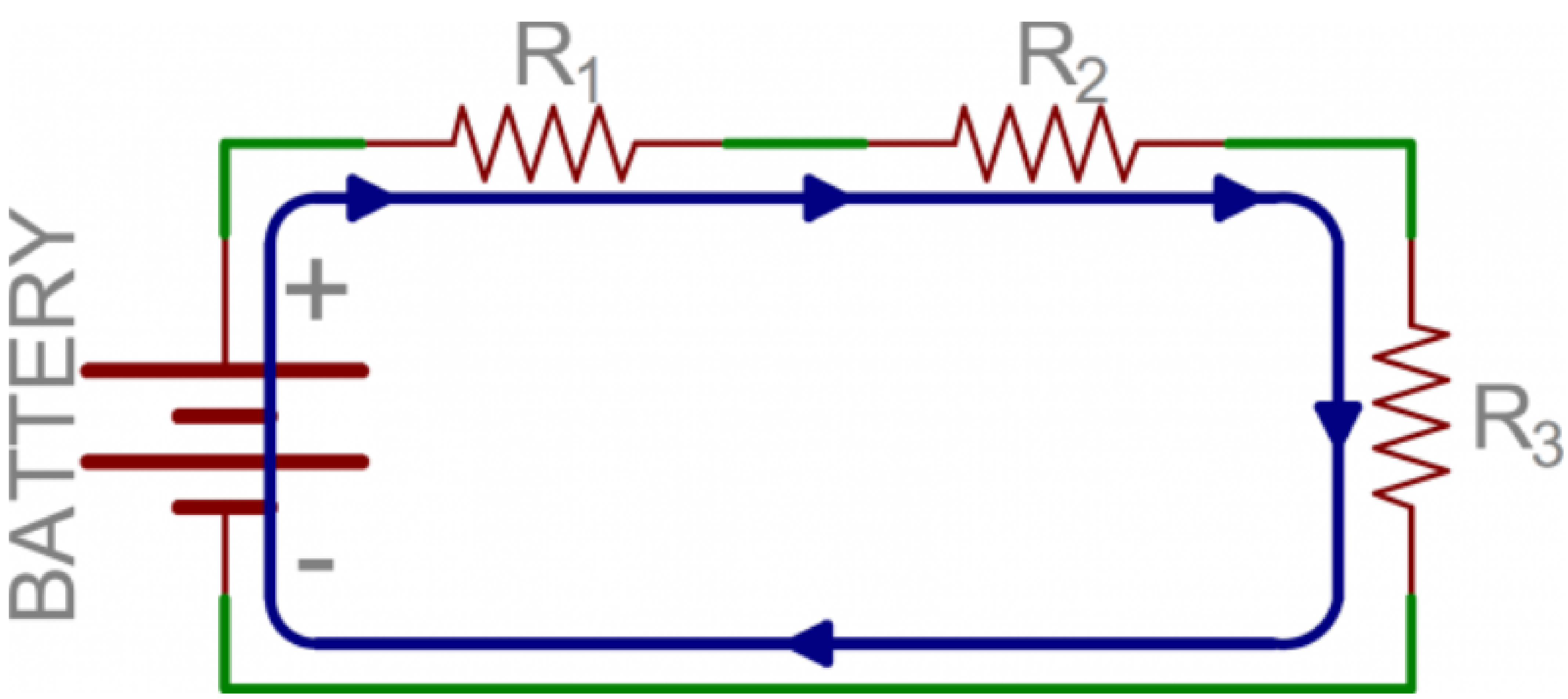


Current (indicated by the blue, orange, and pink lines) flowing through the same example circuit as above. Different currents are indicated by different colors.

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 se ries and parallel!

Series Circuits Defined

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

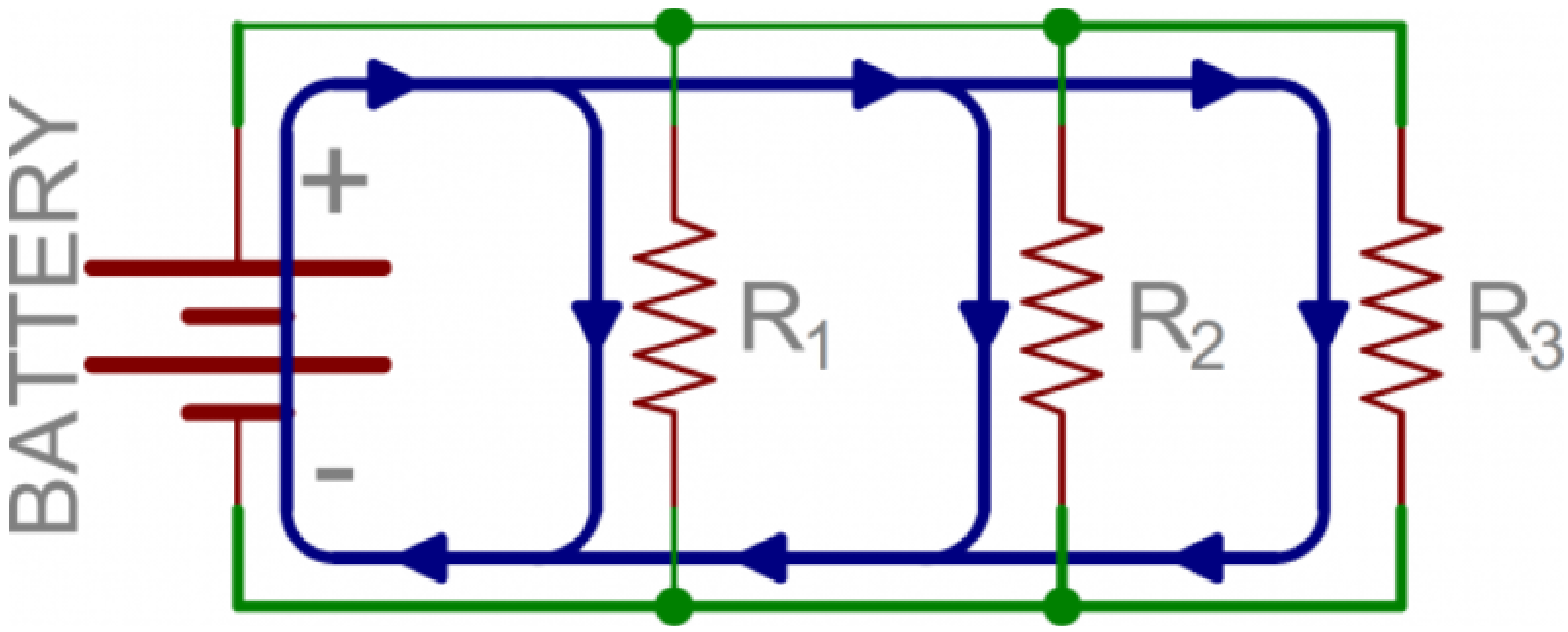


There's only one way for the current to flow in the above circuit. Starting from the positive terminal of the battery, current flow will first encounter R_1. From there the current will flow straight to R_2, then to R_3, and finally back to the negative terminal of the battery. Note tha t there is only 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 schemat ic of three resistors in parallel with a battery:

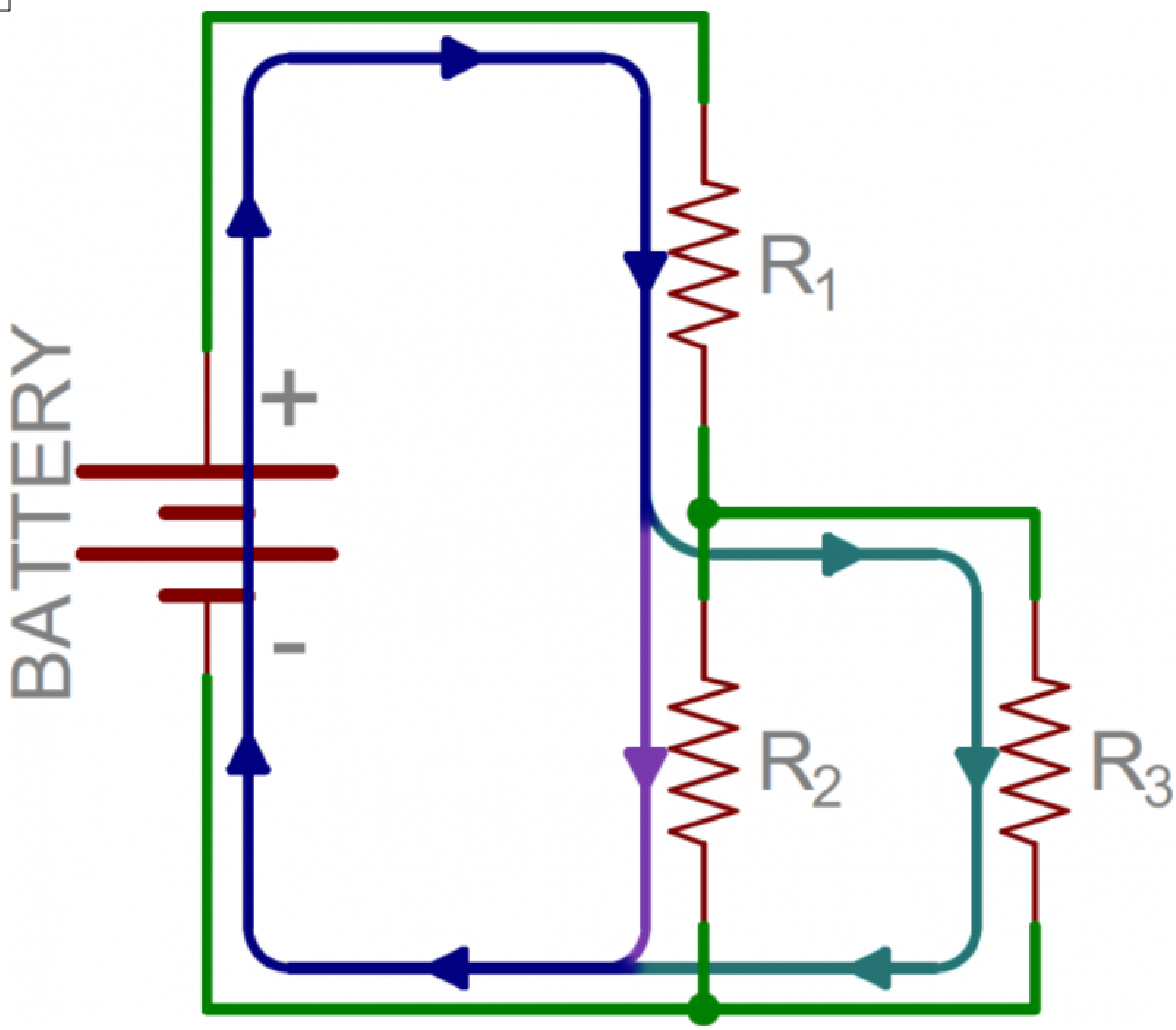


From the positive battery terminal, current flows to R_1... and R_2, and R_3. The node that con nects the battery to R_1 is also connected to the other resistors. The other ends of these re sistors are similarly tied together, and then tied back to the negative terminal of the batter y. There are three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

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

Series and Parallel Circuits Working Together

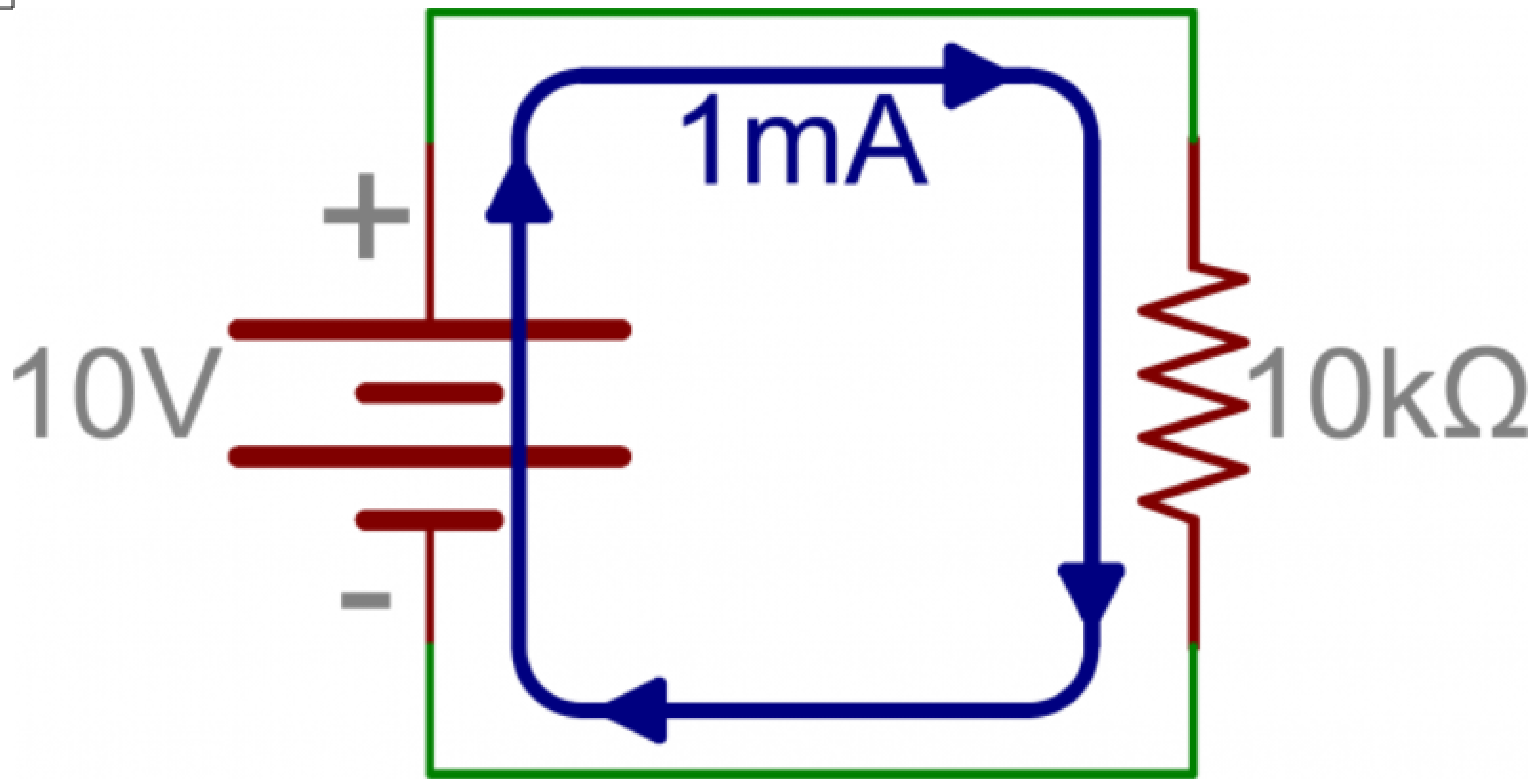
From there we can mix and match. In the next picture, we again see three resistors and a battery. From the positive battery terminal, current first encounters R_1. But, at the other si de of R_1 the node splits, and current can go to both R_2 and R_3. The current paths through R_2 and R_3 are then tied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



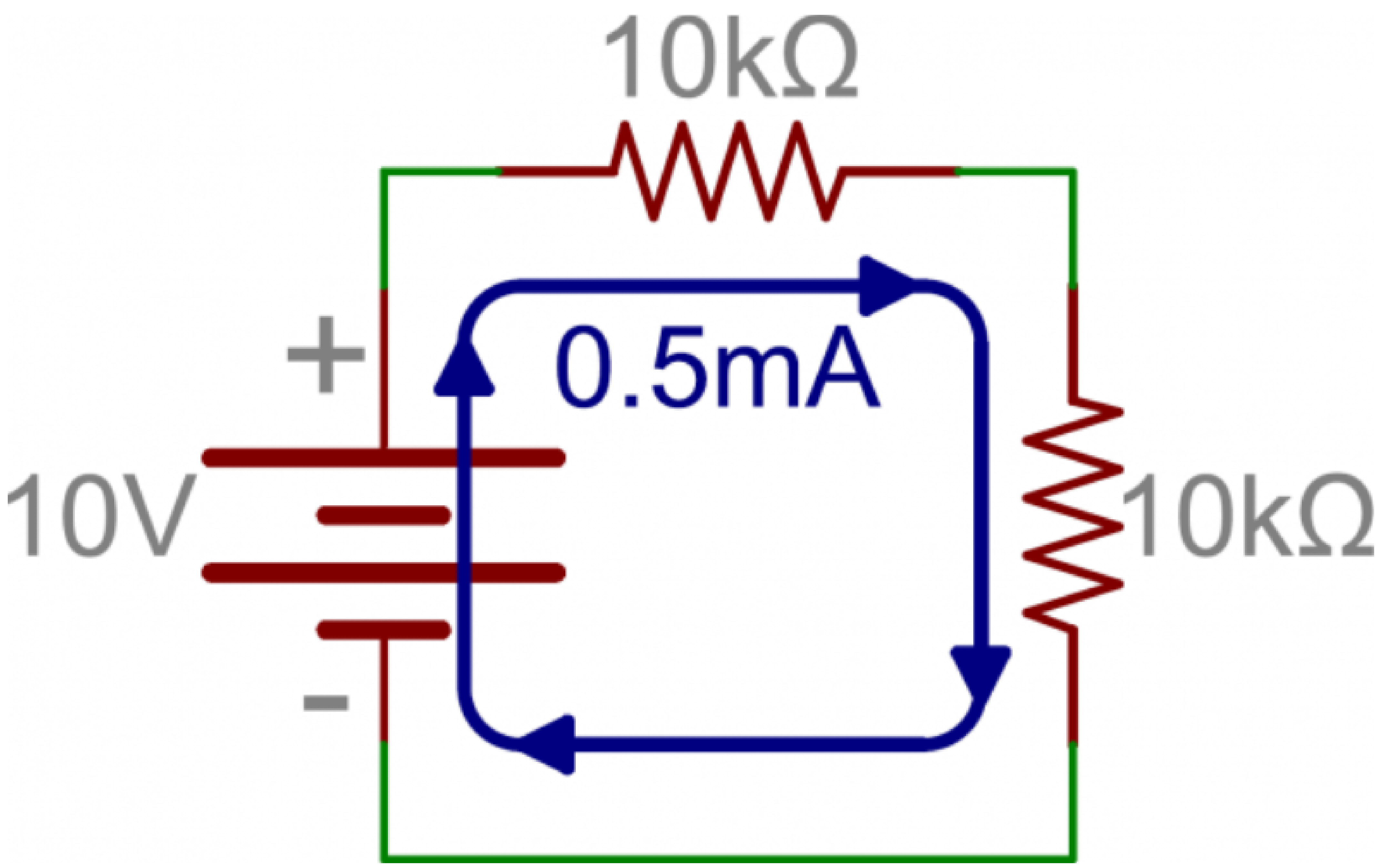
In this example, R_2 and R_3 are in parallel with each other, and R_1 is in series with the paral lel combination of R_2 and R_3.

Calculating Equivalent Resistances in Series Circuits

Here's some information that may be of some more practical use to you. When we put res istors together like this, in series and parallel, we change the way current flows through th em. For example, if we have a 10V supply across a 10kΩ resistor, *Ohm's law* says we've g ot 1mA of current flowing.



If we then put another 10kΩ resistor in series with the first and leave the supply unchang ed, we've cut the current in half because the resistance is doubled.



In other words, there's still only one path for current to take and we just made it even hard er for current to flow. How much harder? 10kΩ + 10kΩ = 20kΩ. And, that's how we calcula te resistors in series -- just add their values.

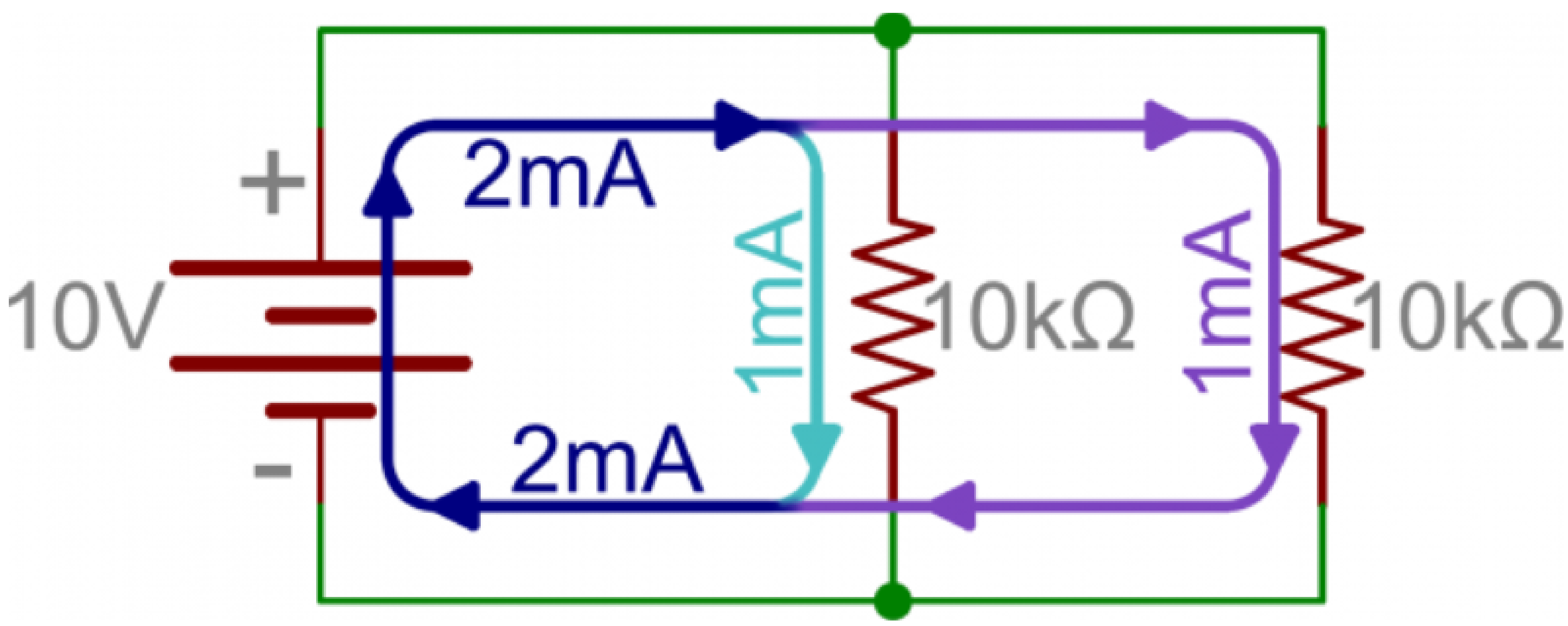
To put this equation more generally: the total resistance of *N* -- some arbitrary number of

– resistors is their total sum.

$$R_{tot} = R_1 + R_2 + ... + R_{N-1} + R_N$$

Calculating Equivalent Resistances in Parallel Circuits

What about parallel resistors? That's a bit more complicated, but not by much. Consider the last example where we started with a 10V supply and a 10kΩ resistor, but this time we add another 10kΩ in parallel instead of series. Now there are two paths for current to take. Since the supply voltage didn't change, Ohm's Law says the first resistor is still going to draw 1mA. But, so is the second resistor, and we now have a total of 2mA coming from the supply, doubling the original 1mA. This implies that we've cut the total resistance in half.



While we can say that 10kΩ || 10kΩ = 5kΩ ("||" roughly translates to "in parallel with"), we're not always going to have 2 identical resistors. What then?

The equation for adding an arbitrary number of resistors in parallel is:

$$\frac{1}{R_{tot}} = \frac{1}{R_1} + \frac{1}{R_2} + ... + \frac{1}{R_{N-1}} + \frac{1}{R_N}$$

If reciprocals aren't your thing, we can also use a method called "product over sum" when we have two resistors in parallel:

$$R_{tot} = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

However, this method is only good for two resistors in one calculation. We can combine more than 2 resistors with this method by taking the result of R1 || R2 and calculating that value in parallel with a third resistor (again as product over sum), but the reciprocal method may be less work.

Series Circuits

Nodes and Current Flow

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Node example schematic

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 :

Example of current flow through circuit

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

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Schematic : Three resistors in series

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Schematic : Series and Parallel Resistors

In this example, R2 and R3 are in parallel with each other, and R1 is in series with the par allel combination of R2 and R3.

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Schematic : Single Resistor in series with battery

If we then put another 10kΩ resistor in series with the first and leave the supply unchang ed, we've cut the current in half because the resistance is doubled.

Schematic : Two series resistors in series with a battery

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To put this equation more generally : the total resistance of N – some arbitrary number of – resistors is their total sum.

Schematic snippet : N resistors in series

Equation : Rtot = R1+R2+…+R(N-1)+RN

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The equation for adding an arbitrary number of resistors in parallel is :

1/Rtot = 1/R1 + 1/R2 + … + 1/R(N-1) + 1/RN

If reciprocals aren't your thing, we can also use a method called "product over sum" when we have two resistors in parallel :

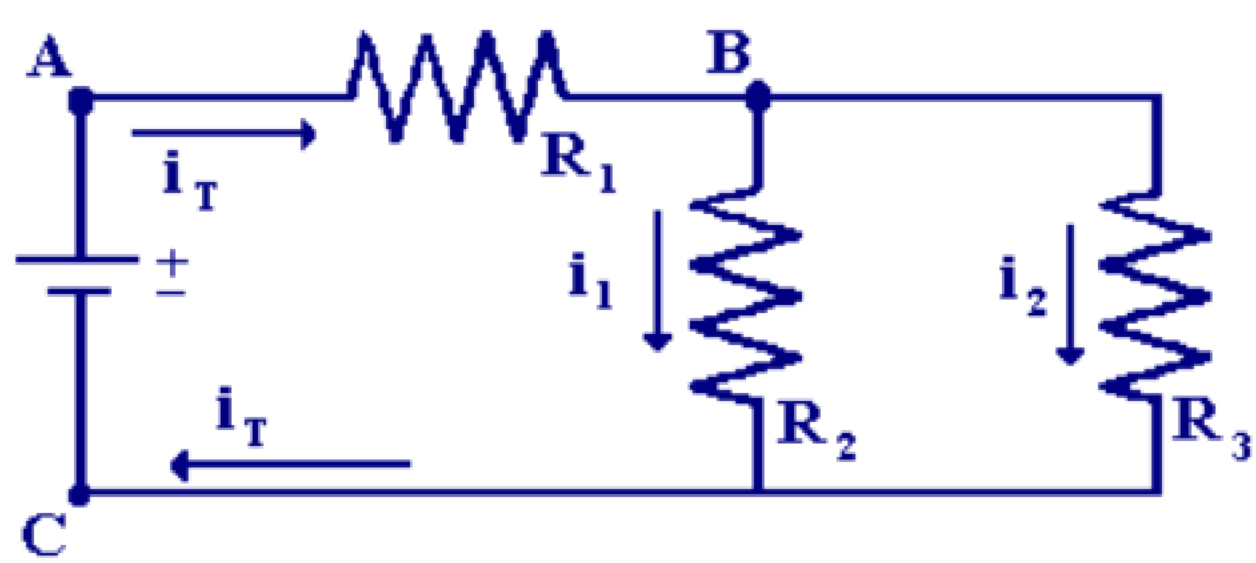
R1||R2 = R1*R2/(R1+R2)

However, this method is only good for two resistors in one calculation. We can combine more than 2 resistors with this method by taking the result of R1 || R2 and calculating that value in parallel with a third resistor (again as product over sum), but the reciprocal method may be less work.

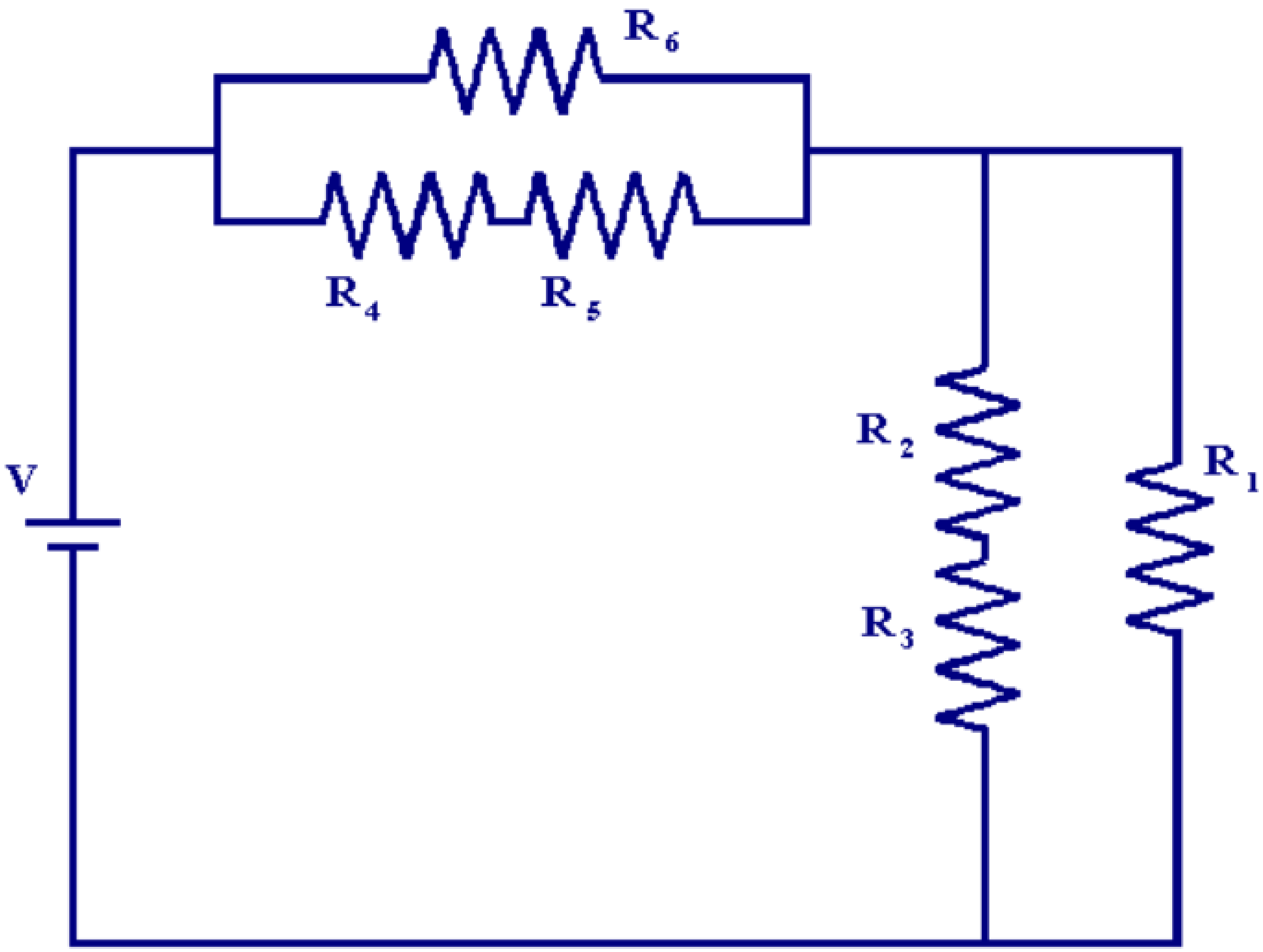
In this section we look at how to analyse circuits which contain resistors in series and parallel combinations.

Identifying and Analysing Parallel Circuits

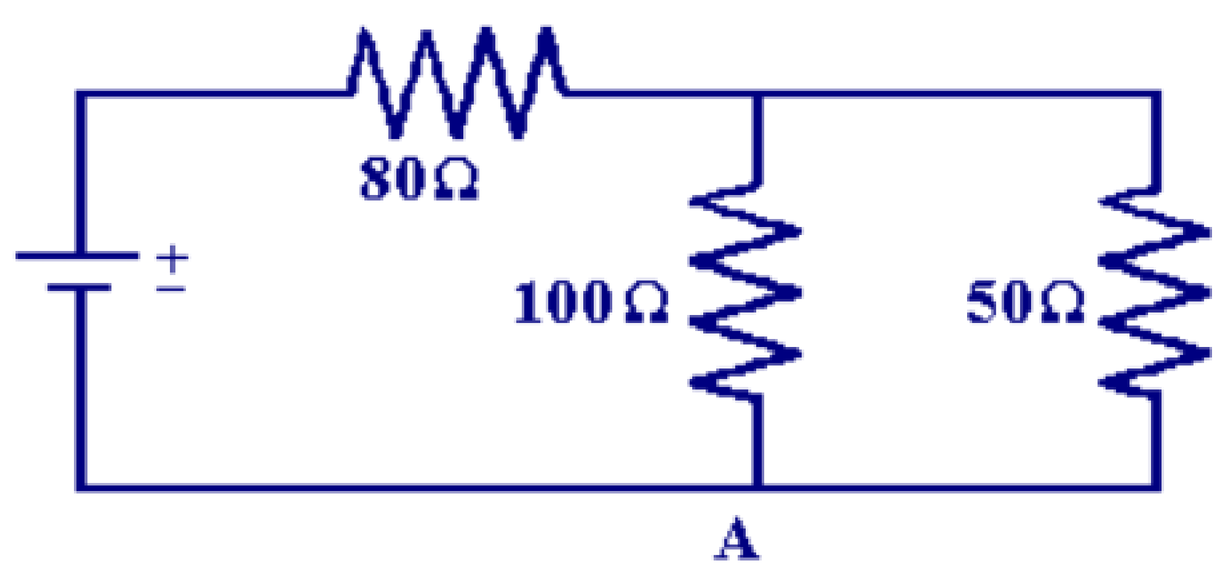
The figure below shows a basic circuit which contains a series-parallel combination of resistors. The resistance from point *A* to point *B* is **R1**, the resistance from *B* to *C* is the combination of **R2** and **R3** in parallel. The total circuit resistance (from point *A* to *C*) is the series resistor **R1** in combination with the parallel components.



A more complex example of a series-parallel resistor circuit is shown below



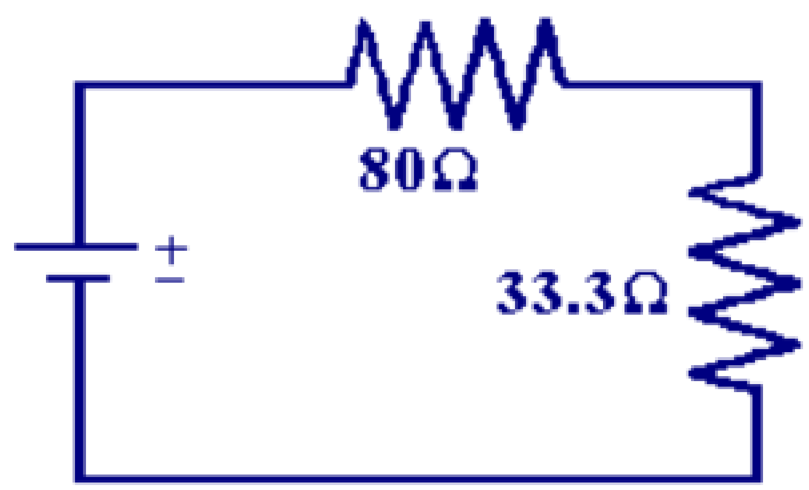
here the resistor R6 is in parallel with the resistors **R4** and R5. Also the resistors **R3**, **R2** an d **R1** form a parallel combination. It is also clear that the two parallel combinations are in series with one another. To calculate the total resistance of a series-parallel circuit we us e the techniques we have developed in the two previous sections. To illustrate the basic a nalysis procedures we will use a couple of examples. First we consider the circuit below



and wish to calculate the total circuit resistance. The current will clearly pass through the 80 Ω resistor before splitting into two components in the parallel combination, at point *A* the parallel branch currents will recombine and flow to the positive terminal. To calculate the total circuit resistance first we work out the effective resistance of the parallel combin ation, using the method from the previous section.

Rparallel *= 1/(1/100 + 1/50) = 33.3 Ω*

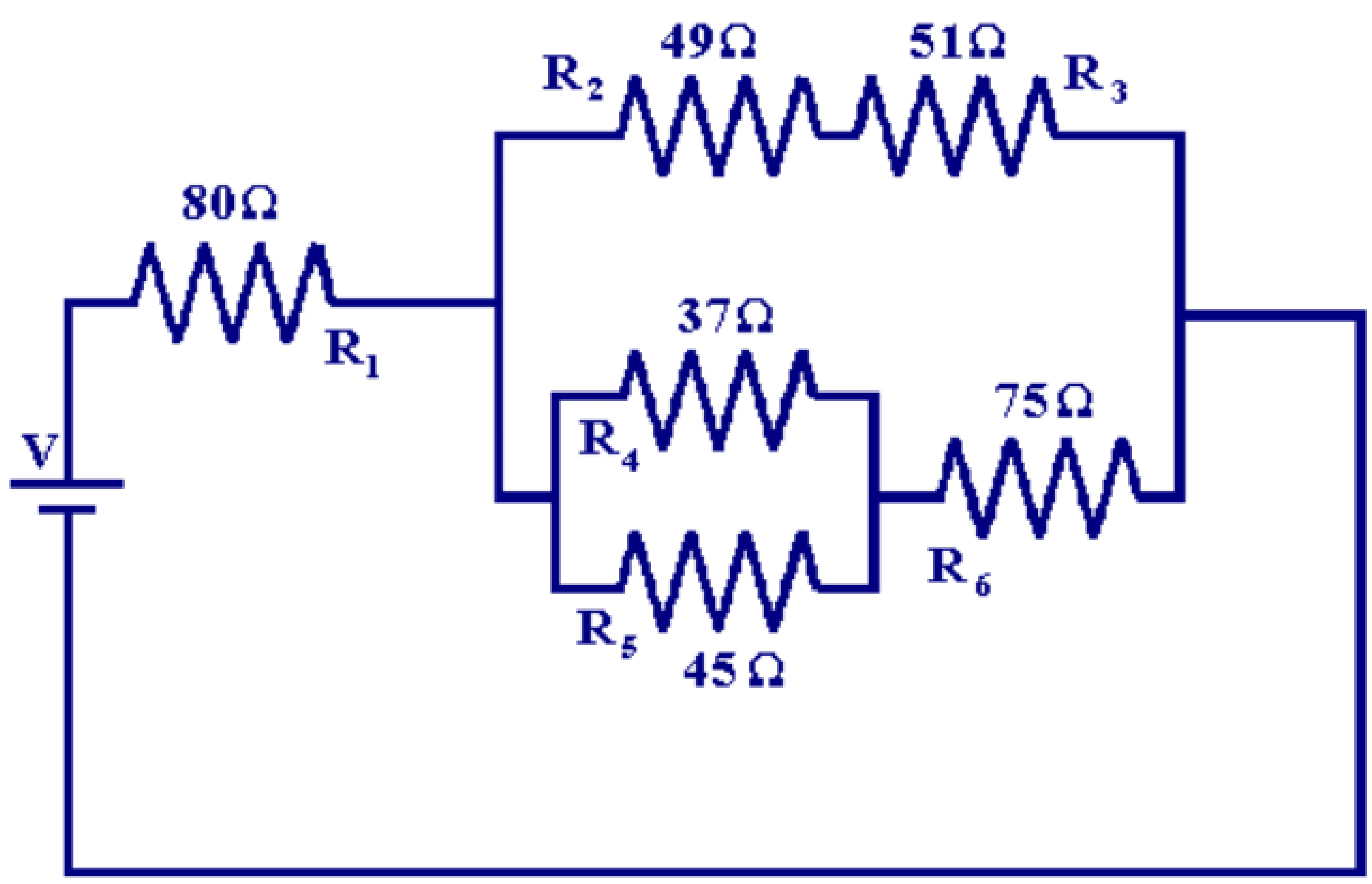
Using this result we can redraw the circuit above as follows



The total circuit resistance can now be calculated by summing the two series resistances.

RT *= 80 + 33.3 = 113.3 Ω*

Next we will examine the slightly more complex circuit below.



Using the same procedure as above we first work out the equivalent resistance of each of the parallel combinations to get the effective resistance in series with **R1**. We begin with t he resistors **R4** and **R5**

R_{5-4} = 1/(1/37 + 1/45) = 20.3 Ω

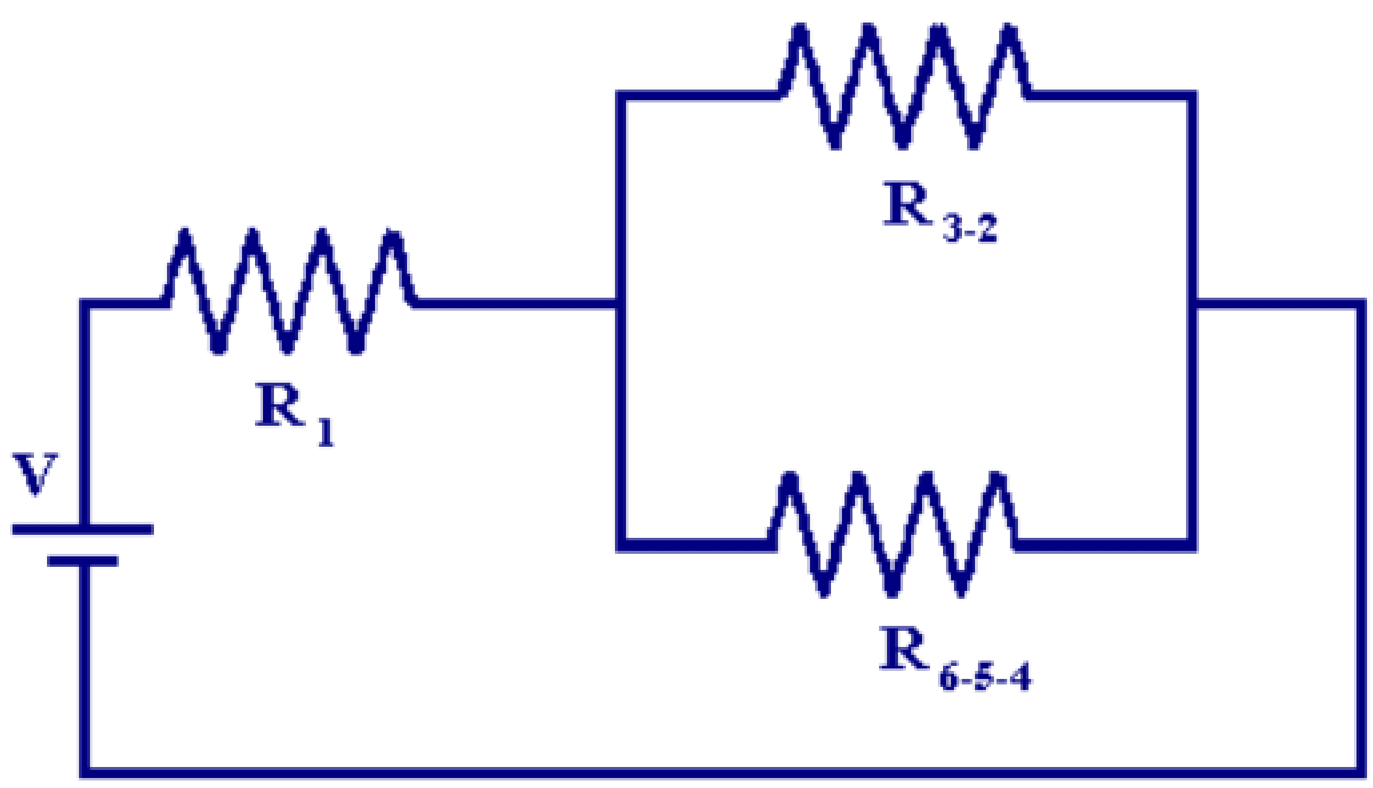
Now we work out the resistance in each of the parallel branches. For the top branch the resistance is equal to the sum of the resistors **R2** and **R3**

R_{3-2} = 49 + 51 = 100 Ω

for the bottom branch it is equal to the sum of the resistors **R6** and **R5-4**

R_{6-5-4} = 75 + 20.3 = 95.3 Ω

Now we are left with a circuit equivalent to the figure below



So all that is left is to work out the effective resistance of the parallel combination **R6-5-4** and **R3-2**

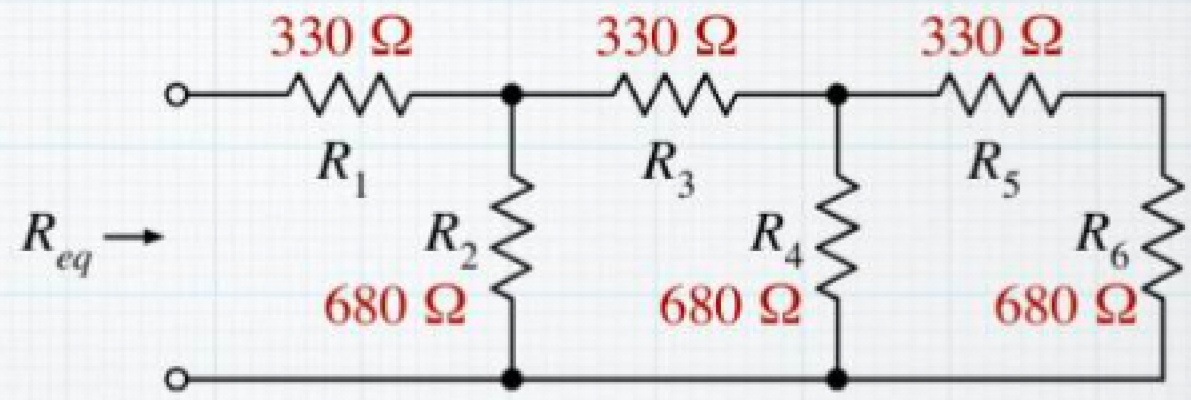
$R_{6-5-4-3-2}$ = 1/(1/100 + 1/95.3) = 48.8 Ω

So the total circuit resistance is

R_T = 80 + 48.8 = 128.8 Ω

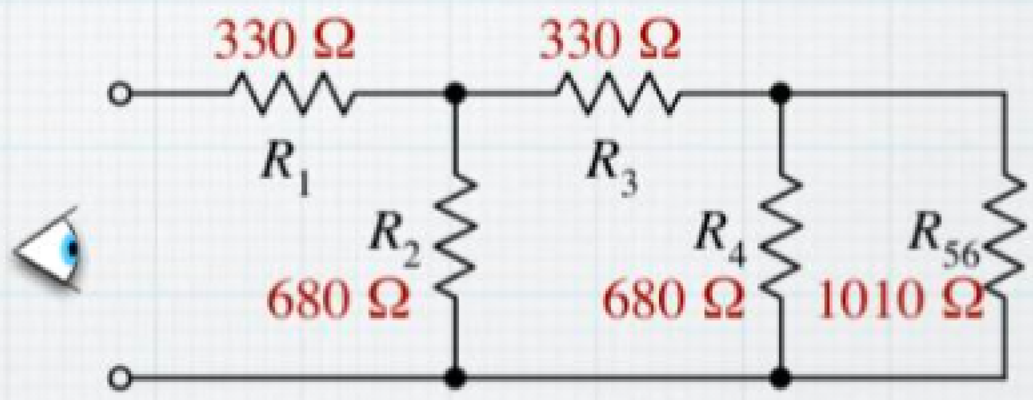
Example 1

Find the equivalent resistance looking into the indicated port of the "ladder network" shown.

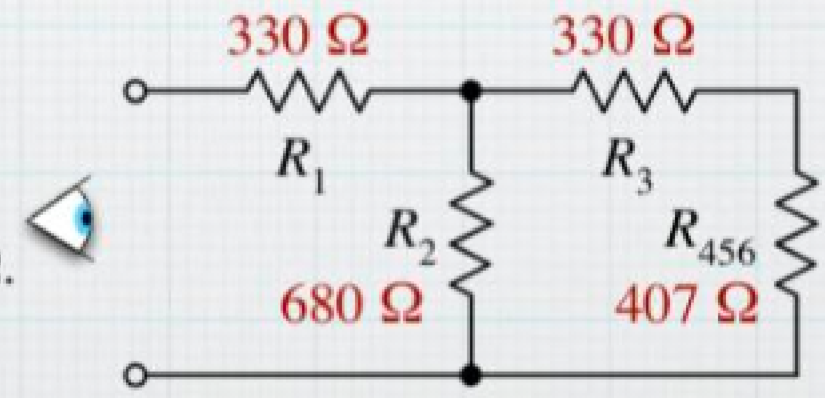


1. Starting at the "far end", we see that R_5 and R_6 are in series.

$R_{56} = R_5 + R_6 = 1010\ \Omega$.

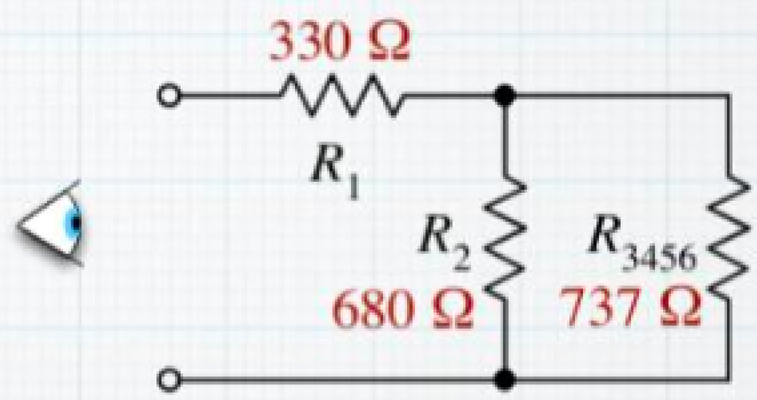


2. R_4 is in parallel with R_{56}.
$R_{456} = (1/R_4 + 1/R_{56})^{-1} = 407\ \Omega$.



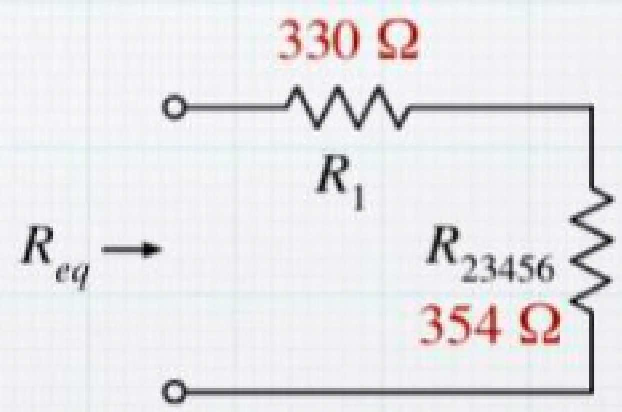
Example 1 (cont.)

3. R_3 and R_{456} are in series.
$R_{3456} = R_3 + R_{456} = 1010\ \Omega$.



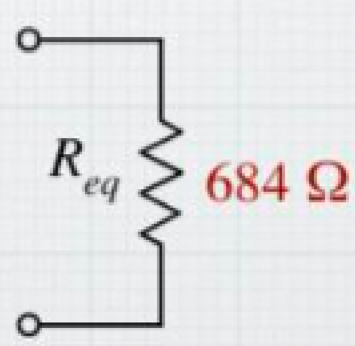
4. R_2 is in parallel with R_{3456}.

$$R_{23456} = \frac{1}{\frac{1}{R_2} + \frac{1}{R_{3456}}} = 354\,\Omega$$



(OK — the subscripting thing is getting a bit ridiculous.)

5. Finally, R_{eq} is the series combination of R_1 and R_{23456}.
$R_{eq} = 330\ \Omega + 354\ \Omega = 684\ \Omega$.



la puissance et l'énergie électrique

La relation entre la puissance et l'énergie électrique

La puissance électrique

La **puissance électrique** correspond au travail que peut fournir un appareil électrique à chaque seconde. Plus précisément, la puissance électrique indique la quantité d'énergie qu'un appareil peut transformer durant une période de temps.

L'unité de la puissance est le watt (W)

. Elle est mesurée en calculant le produit de la différence de potentiel et de l'intensité du courant dans un circuit.

$P=U\times I$

où
P représente la puissance (W)

U représente la différence de potentiel (V)
I représente l'intensité du courant (A)

Un chauffe-eau fonctionne sous une tension de 240 V

et l'intensité du courant qui y circule est de 18,75 A. Quelle est la puissance du chauffe-eau?
$U=240$ V, $I=18{,}75$ A, $P=$?$P=U\times I \Rightarrow P=240\ V\times 18{,}75\ A=4\ 500\ W$ La puissance du chauffe-eau est 4 500 W

.

Un fer à repasser consomme une puissance de 1 200 W

. Sachant que l'intensité du courant dans le circuit électrique est 10 A, quelle est la résistance de cet élément?
Pour trouver la résistance à partir de la loi d'Ohm, il faut tout d'abord déterminer la tension.
$P=1\ 200$ W. $I=10$ A. $U=$?$P=U\times I \Rightarrow U=P/I=1\ 200\ W/10\ A=120\ V$, La loi d'Ohm permet ensuite de déterminer la résistance de l'élément.
$U=R\times I \Rightarrow R=U/I=120\ V/10\ A=12\ \Omega$ La résistance de l'élément dans le fer à repasser est 12 Ω

.

L'énergie électrique

L'**énergie électrique** représente l'énergie fournie sous forme de courant électrique.

L'unité reconnue par le système international des unités (SI) est le Joule (J). L'énergie électrique est calculée en déterminant le produi t de la puissance électrique et du temps d'utilisation.

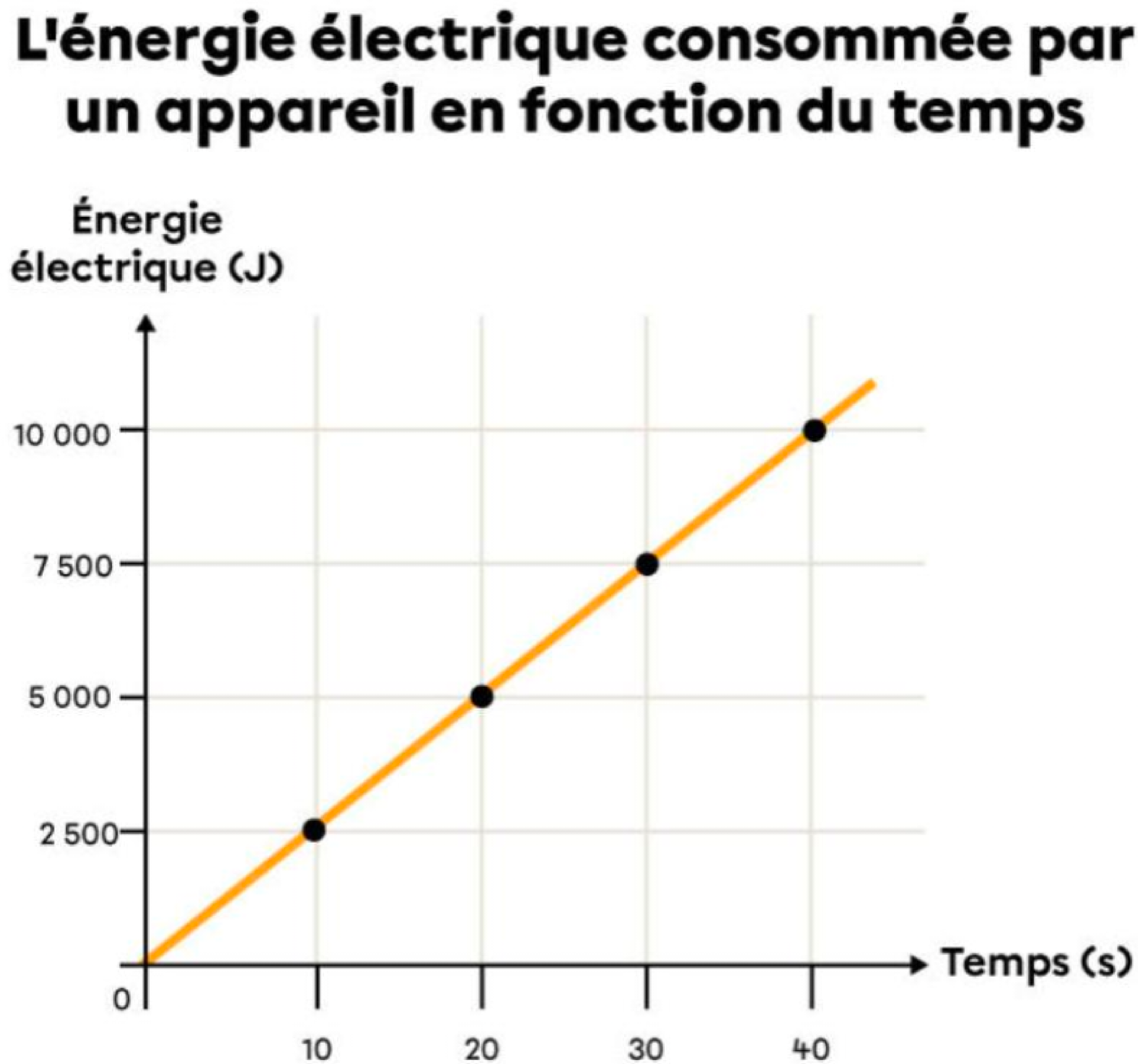
$E=P\times \triangle t$

où
E représente l'énergie électrique (J)
P représente la puissance (W)
$\triangle$t représente le temps (s)

De cette relation, il est possible de déterminer qu'un appareil puiss ant utilisé durant une certaine période de temps consommera plus d'énergie qu'un appareil ayant une plus petite puissance utilisé dur ant la même période de temps.

De plus, pour deux appareils de même puissance, l'appareil qui con sommera le plus d'énergie sera celui dont le temps d'utilisation est le plus élevé.

La relation entre la puissance, le temps et l'énergie électrique peut être représentée dans un graphique.



La pente de ce graphique permet de déterminer la puissance de l'a ppareil.

En utilisant les points (0,0)

et (40,10 000), la pente peut être calculée de la façon suivante.
$E=P\times \triangle t \Rightarrow P=E \triangle t P=10\ 000\ J - 0\ J 40\ s - 0\ s P=250\ W$
L'appareil utilisé a une puissance de 250 W

.

Important!

Il est également possible de calculer l'énergie électrique consomm ée par un appareil en kilowattheures (kWh)

. Pour ce faire, il faut que la puissance soit transformée en kilowatt s et le temps, en heures.

Si la quantité d'énergie en joules a déjà été déterminée, l'équivalenc e suivante peut être utilisée pour convertir une quantité d'énergie e n joules vers les kilowattheures et vice versa.
1 kWh = 3 600 000 J

Vous faites fonctionner un four de 2 500 W

pendant 36 minutes. Quelle quantité d'énergie électrique, en Joule s, sera consommée?
$P=2\ 500\ W$, $\triangle t=36\ min = 2\ 160\ s$, $E= ?$ $E=P\times\triangle t \Rightarrow E=2\ 500\ W\times 2\ 160\ s=5\ 400\ 000\ J$ Le four consommera 5 400 000 J

d'énergie électrique.

Un micro-ondes de 1 100 W

est utilisé durant trois minutes. Quelle quantité d'énergie électrique, en kilowattheures, sera consommée?
$P=1\ 100\ W = 1,1\ kW$ $\triangle t=3\ min = 0,05\ h$ $E= ?$ $E=P\times\triangle t \Rightarrow E=1,1\ kW\times 0,05\ h=0,055\ kWh$ Le micro-ondes consommera 0,055 kWh

d'énergie électrique.