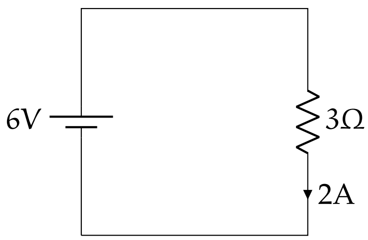
Chapter 1

DC Circuit Analysis

In the most basic circuit, you have only a battery and a resistor:

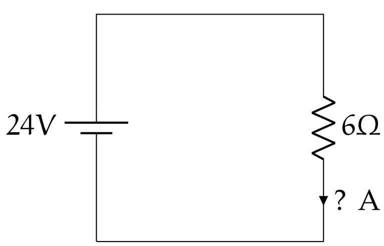


For this situation, you only need Ohm's Law: $V = IR$. In this case, $6V = 3\Omega \times 2A$.

Exercise 1 Ohm's Law

Working Space

How many amps are going around the circuit?

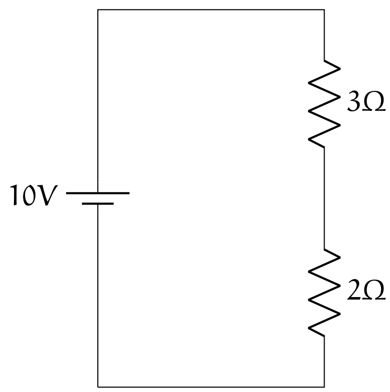


Answer on Page 7

1.1 Resistors in Series

When you have two resistors wired together in a long line, we say they are "in series." If you have two resistors R_1 and R_2 wired in series, the total resistance is $R_1 + R_2$.

In this diagram, for example, the total resistance is 5Ω.



The current flowing through the circuit, then, is $10/5 = 2A$.

By Ohm's law, the voltage drop across the upper resistor is $IR = 2A \times 3\Omega = 6V$.

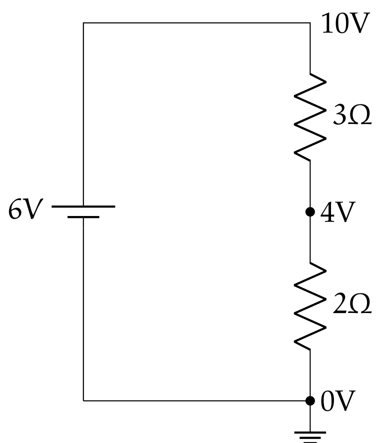
The voltage drop across the lower resistor is $IR = 2A \times 2\Omega = 4V$.

Notice that the battery pumps the voltage up to 10V, then the two resistors drop it by exactly 10V. This is known as "Kirchhoff's Voltage Law":

Kirchhoff's Voltage Law

As you make a loop around a circuit, the sum of the voltage increase must equal the sum of the voltage decrease.

The negative end of the battery is connected to "ground" (it has zero voltage). We can then draw a diagram with the voltages (That symbol in the lower right represents a connection to ground).

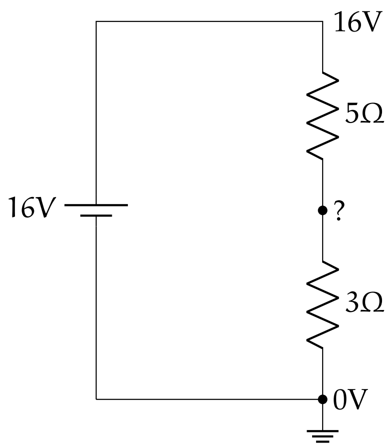


Exercise 2 Resistors In Series

Working Space

What is the current going around the circuit?

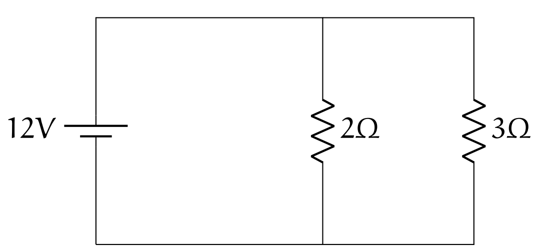
What is the voltage drop across each resistor?



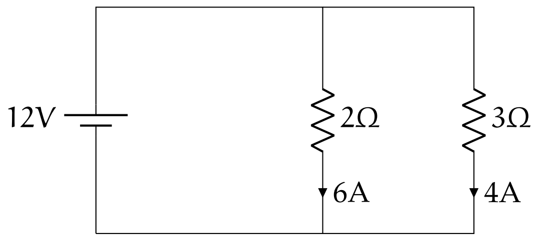
Answer on Page 7

1.2 Resistors in Parallel

Observe the following circuit. Note that the current can go two different paths.



There is 12 volts pushing current through both resistors. So 6A will go through the 2Ω resistor and 4A will go through the 3Ω resistor. Note that even though there is a path of least resistance (2Ω), the current is still devided evenly among both branches.



Thus, a total of 10 A will be going through the battery.

Imagine you are a battery. You can't see that you have two resistors. What does it feel like to you? $\frac{V}{I} = R$, and $V = 12$ and $I = 10$. This means the effective resistance of the two resistors in parallel is $\frac{12}{10}$ or $\frac{6}{5}\Omega$.

Resistance in Parallel

If you have several resistances $R_1, R_2, \ldots, R_n$ wired in parallel, their effective resistance R_t is given by

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}$$

In our example:

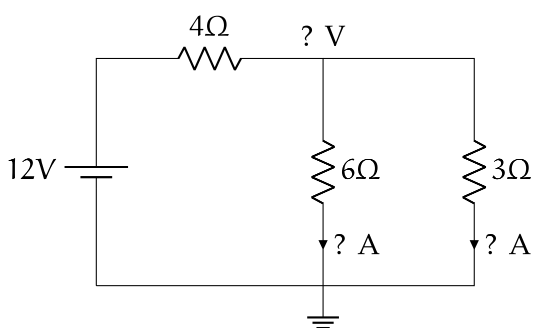
$$\frac{1}{R_t} = \frac{1}{2} + \frac{1}{3} = \frac{5}{6}$$

Thus, $R_t = \frac{6}{5}\Omega$.

Exercise 3 Resistors In Parallel

Working Space

What is the current going through the battery? What is the drop over the 4Ω resistor? What is the current in each branch?



Answer on Page 7

1.3 Kirchhoff's Current Law

States that all currents coming into a junction (or node) must equal the currents leaving that junction. Why? Because first of all, energy is always conserved, meaning it cannot be lost or destroyed within the equations in the first place. Secondly, each circuit is conservative, meaning it cannot lose voltage, and thus, cannot lose current. As you go around a loop, the starting point must have the same chargable amount as it did when you began, so any increases and decreases along the loop have to cancel out for a total change of zero.

Kirchhoff's Current Law

The sum of current into a junction equals the sum of current out of the junction.

Appendix A

Answers to Exercises

Answer to Exercise 1 (on page 1)

$V = IR$ so $I = \frac{V}{R} = \frac{24V}{6\Omega} = 4A$.

Answer to Exercise ?? (on page 3)

There is a total resistance of 8Ω, so your 16V will push 2A of current around the circuit.

2A going through a 5Ω resistor represents a 10V drop.

2A going through a 3Ω resitor represents a 6V drop.

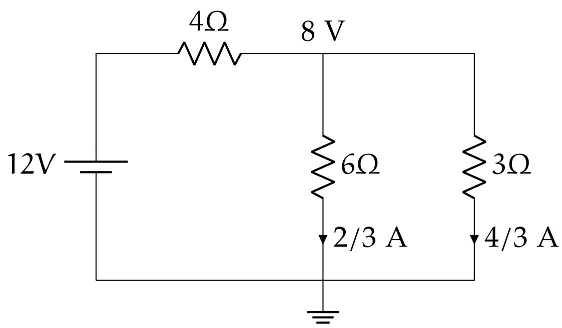
Answer to Exercise 3 (on page 5)

The effective resistance of the 6Ω and the 3Ω is 2Ω because

$$\frac{1}{R_T} = \frac{1}{6} + \frac{1}{3} == \frac{1}{2}$$

This means the battery experiences a resistance of $4\Omega + 2\Omega = 6\Omega$. A 12V will push 2A through a resistance of 6Ω.

The voltage drop across the 4Ω resistor is $2A \times 4\Omega = 8V$. Thus there will be a 4V drop across the two resistors in parallel. So 2/3 A will flow through the 6Ω resistor. 4/3 A will flow through the 3Ω resistor.


4Ω
8 V
12V
6Ω
3Ω
2/3 A
4/3 A

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