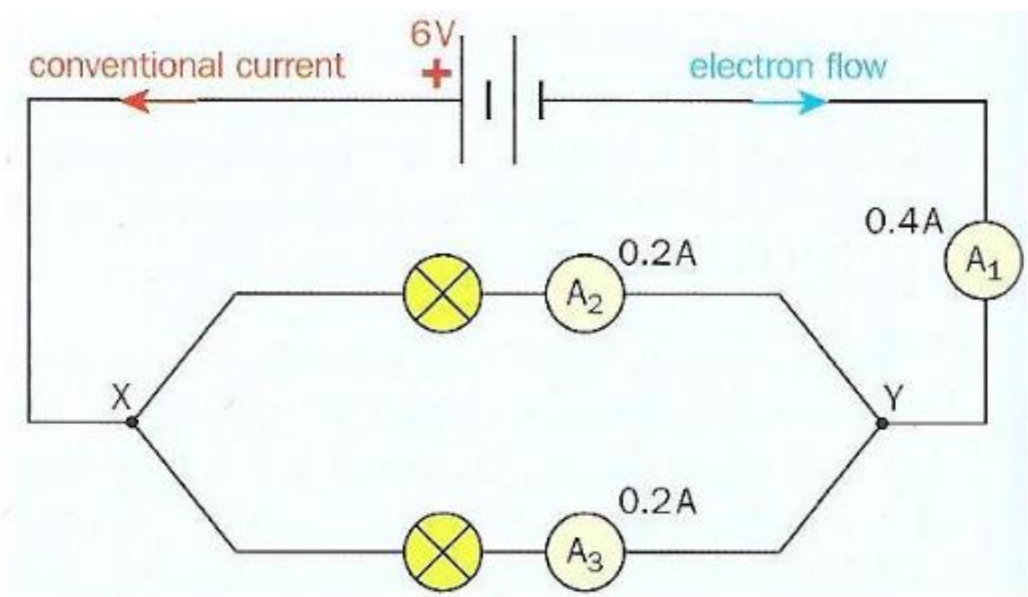
Circuits

Recall That

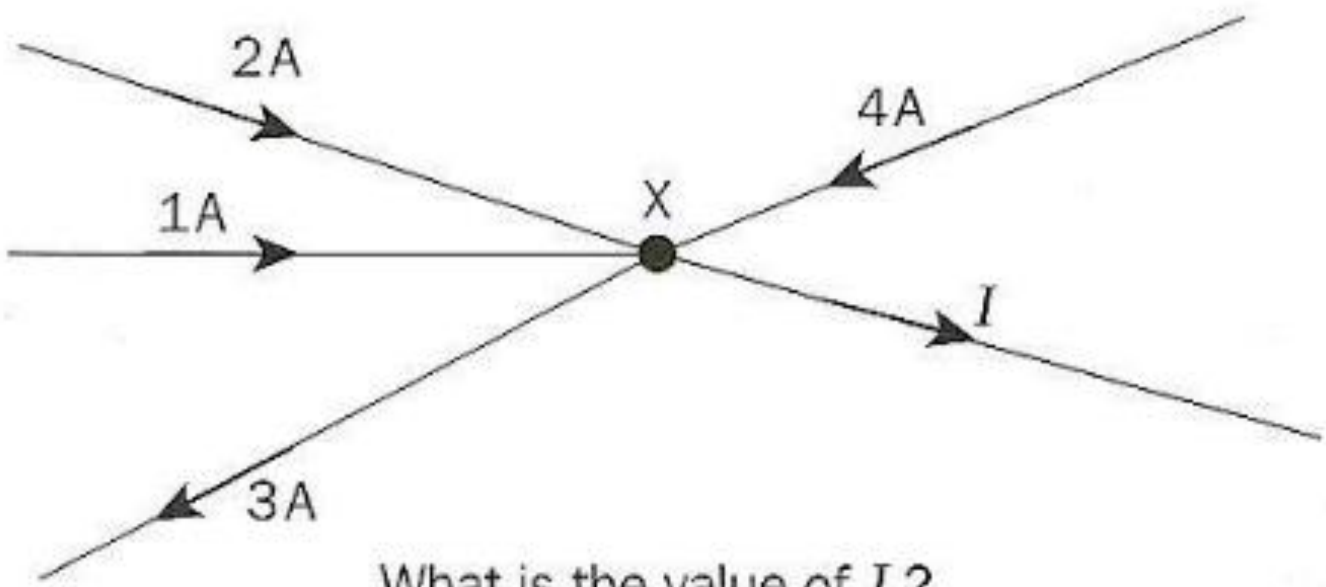
In a series circuit, the current is the same at all points.

In a parallel circuit, the current leaving and returning to the supply is the sum of the currents in the separate branches.



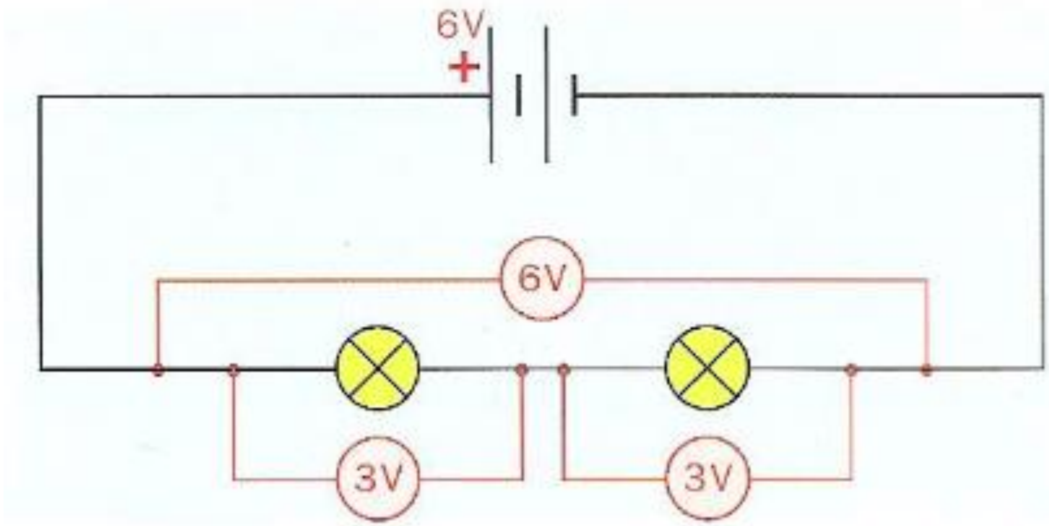
Kirchhoff's first law:

The sum of the currents flowing into a point equals the sum of the currents flowing out of that point.



What is the value of I?

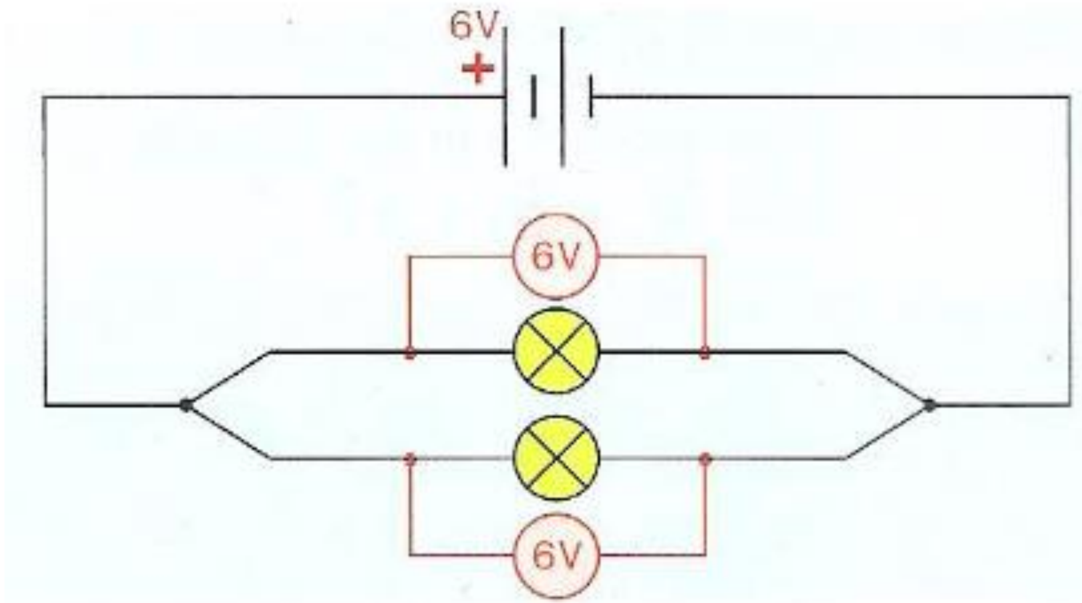
Energy transfer in a series circuit.



The two lamps in **series** have equal brightness, but each lamp is less bright than if it is connected to the battery on its own.

In a series circuit, the total p.d. across all the lamps is the sum of the p.d.s across the separate lamps.

Energy transfer in a parallel circuit



In our **parallel** circuit each lamp is just as bright as if it were connected to the battery on its own.

In a parallel circuit, the p.d. across each branch is the same.

Resistors in Series

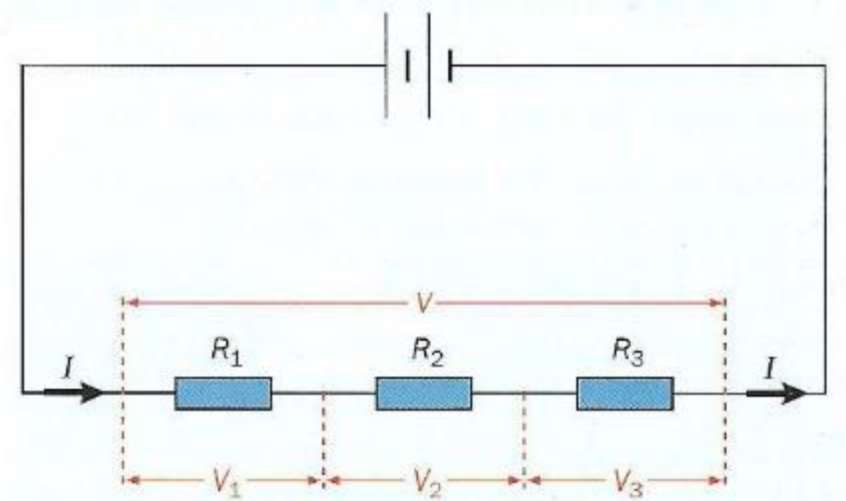
the current through each resistor in series is the same

the total p.d. V across the resistors is the sum of the p.d.s across the separate resistors, so: $V = V_1 + V_2 + V_3$

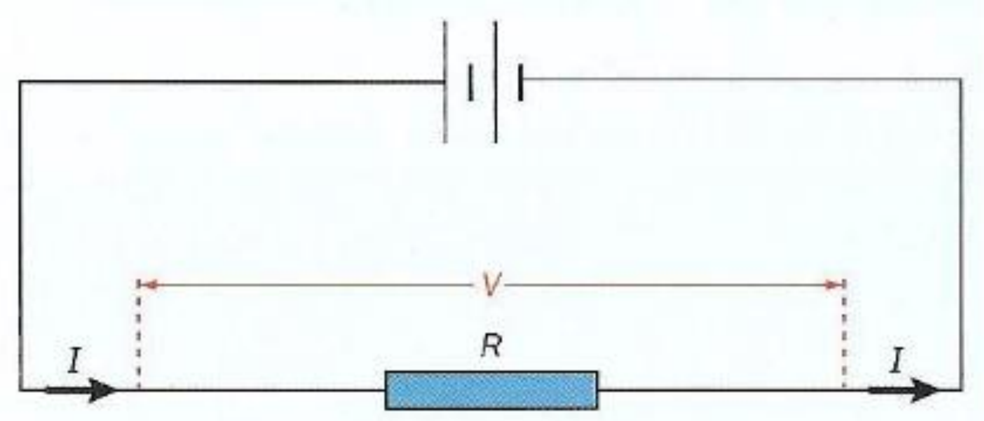
the combined resistance R in the circuit is the sum of the separate resistors:

$$R = R_1 + R_2 + R_3$$

Equivalent

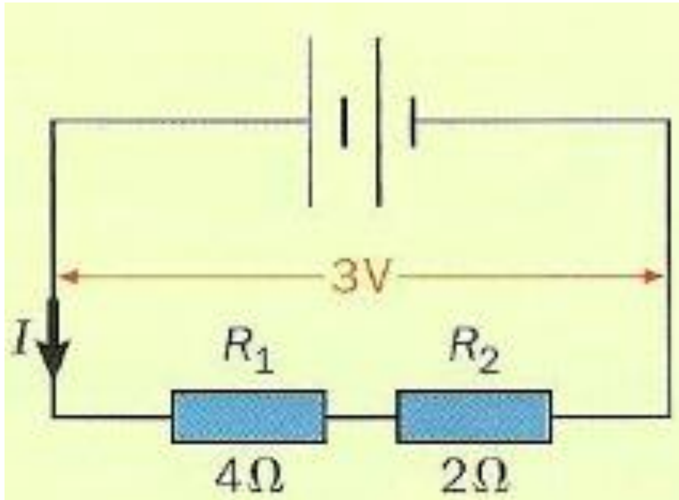


Original circuit



Equivalent circuit

Example 1



A p.d. of 3 V is applied across two resistors (4 Ω and 2 Ω) connected in series, as shown:

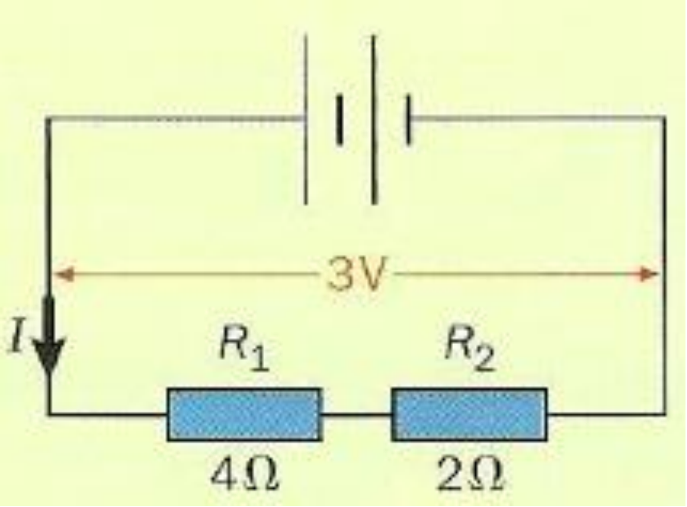
Calculate a) the combined resistance,

b) the current in the circuit,

c) the p.d. V_1 across the 4 Ω resistor,

d) the p.d. V_2 across the 2 Ω resistor.

Example 1 continued



a) The combined resistance $\boldsymbol{R} = \boldsymbol{R_1} + \boldsymbol{R_2}$

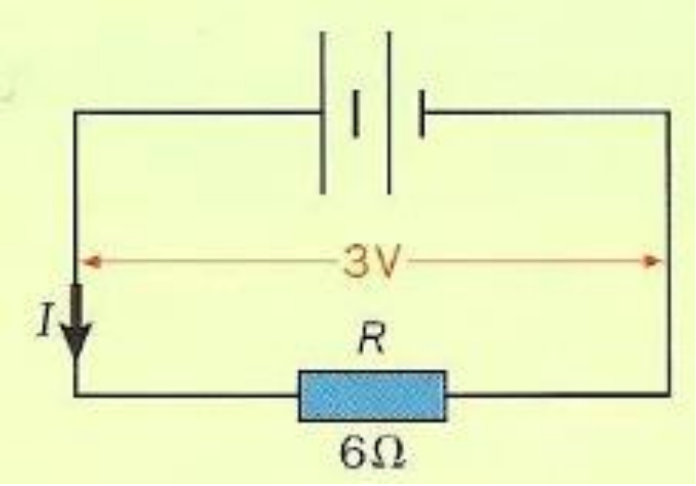
$$\therefore \quad R = 4\,\Omega + 2\,\Omega \quad = \underline{6\,\Omega}$$

Example 1 continued

b) the current in the circuit,

Now redraw the circuit as an equivalent circuit:

$\boldsymbol{V = I R}$ for the combined resistance

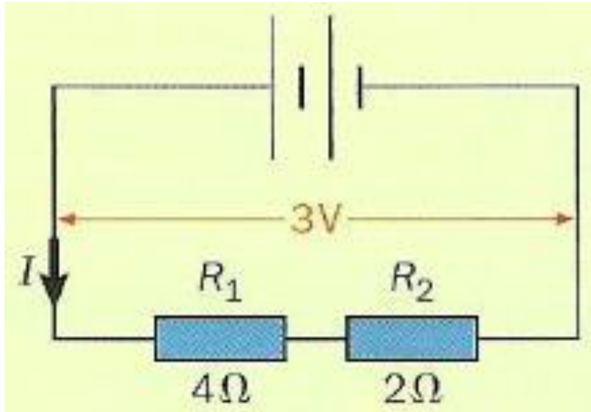


$$3\ \text{V} = I \times 6\ \Omega$$

$$\therefore\ I = 0.5\ \text{A}$$

Example 1 continued

c) the p.d. V_1 across the 4 Ω resistor,



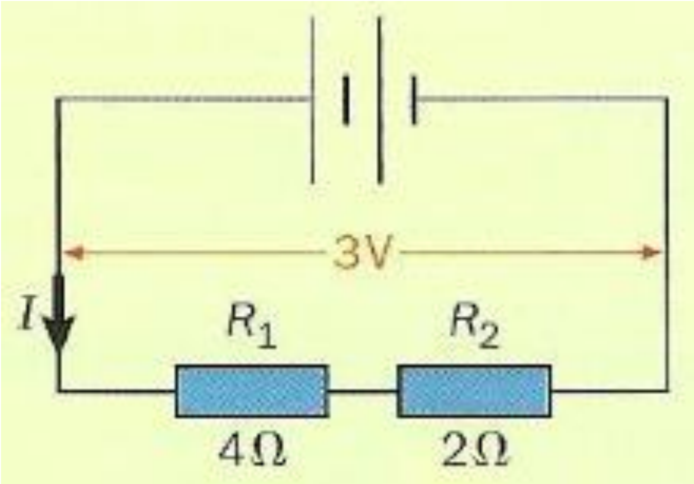
In the original circuit:

$\boldsymbol{V_1 = I R_1}$ for the 4 Ω resistor only

$$V_1 = 0.5\,\text{A} \times 4\,\Omega$$

$\therefore V_1 = 2\,\text{V}$ across the 4 Ω resistor

Example 1 continued



$$V_2 = I R_2$$ for the 2 Ω resistor only

$$V_2 = 0.5\ \text{A} \times 2\ \Omega$$

$$\therefore\ V_2 = 1\ \text{V}$$ across the 2 Ω resistor

Resistors in parallel

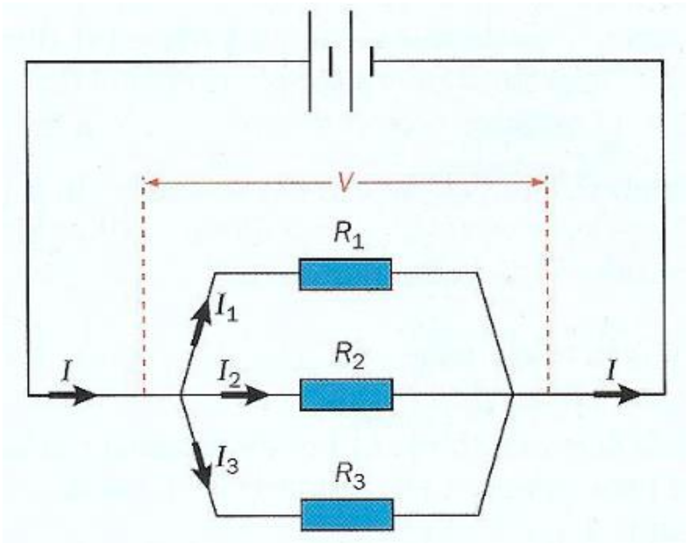
the p.d. across each resistor in parallel is the same

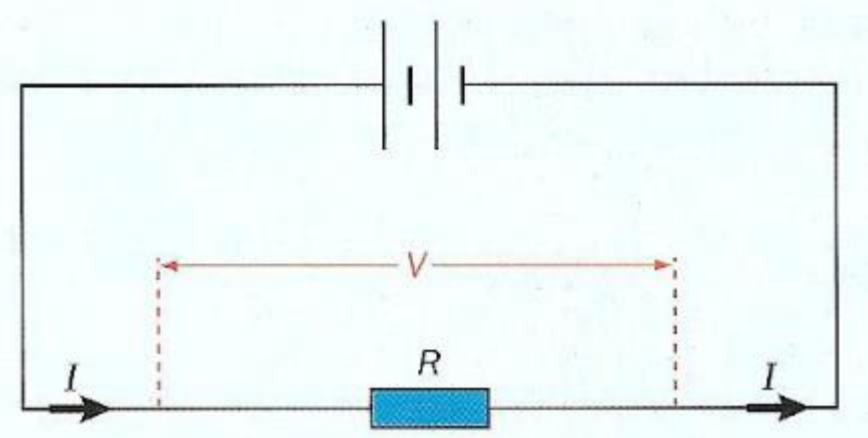
the current in the main circuit is the sum of the currents in each of the parallel branches, so: $I = I_1 + I_2 + I_3$

the combined resistance R is calculated from the equation:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

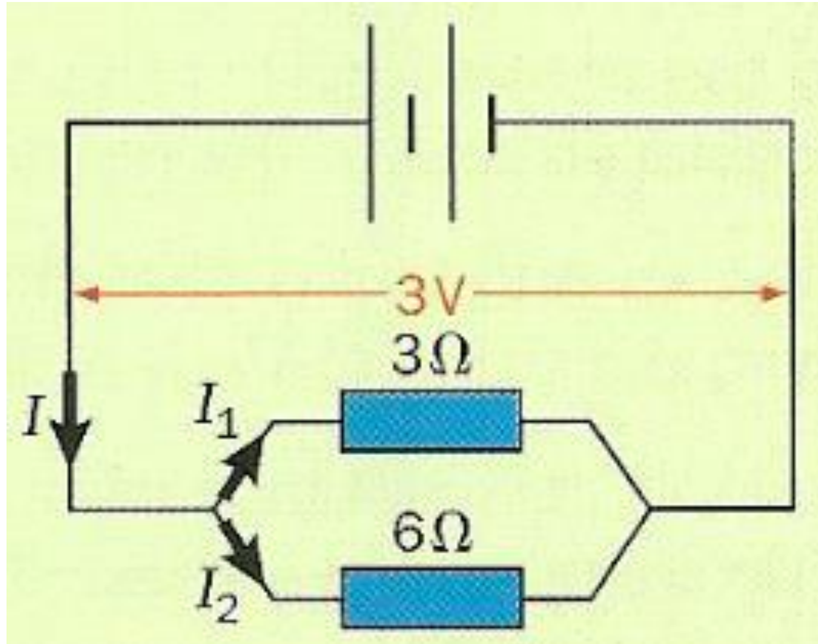
Equivalent





Equivalent circuit

Example 2



A p.d. of 6 V is applied across two resistors (3 Ω and 6 Ω) in parallel. Calculate:

a) the combined resistance,
b) current I in the main circuit,
c) current I_1 in the 3 Ω resistor,
d) current I_2 in the 6 Ω resistor.

Example 2 continued

a) the combined resistance,

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

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

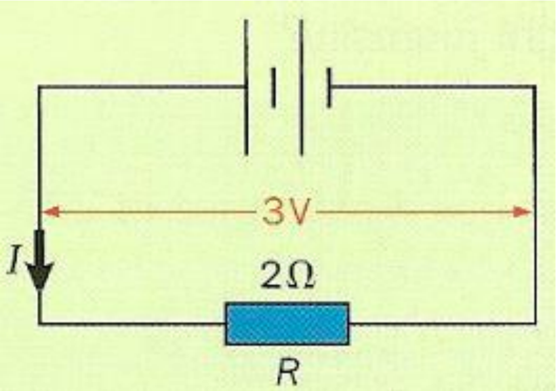
Since $\frac{1}{R} = \frac{1}{2}$ then $\frac{R}{1} = \frac{2}{1}$

so: $\underline{R = 2\,\Omega}$

Example 2 continued

b) current I in the main circuit,

redraw the circuit as an equivalent circuit:



$V = IR$ for the combined resistance

$6\,V = I \times 2\,\Omega$

$\underline{I = 3\,A}$ in the main circuit.

Example 2 continued

c) current I_1 in the 3 Ω resistor,

$\boldsymbol{V = I_1 R_1}$ for the 3 Ω resistor only

$6\text{ V} = I_1 \times 3\ \Omega$

$I_1 = 2\text{ A}$ in the 3 Ω resistor.

Example 2 continued

d) current I_2 in the 6 Ω resistor.

$\boldsymbol{V} = \boldsymbol{I_2} \ \boldsymbol{R_2}$ for the 6 Ω resistor only

$6\,\text{V} = I_1 \times 6\,\Omega$

$I_1 = 1\,\text{A}$ in the 6 Ω resistor.