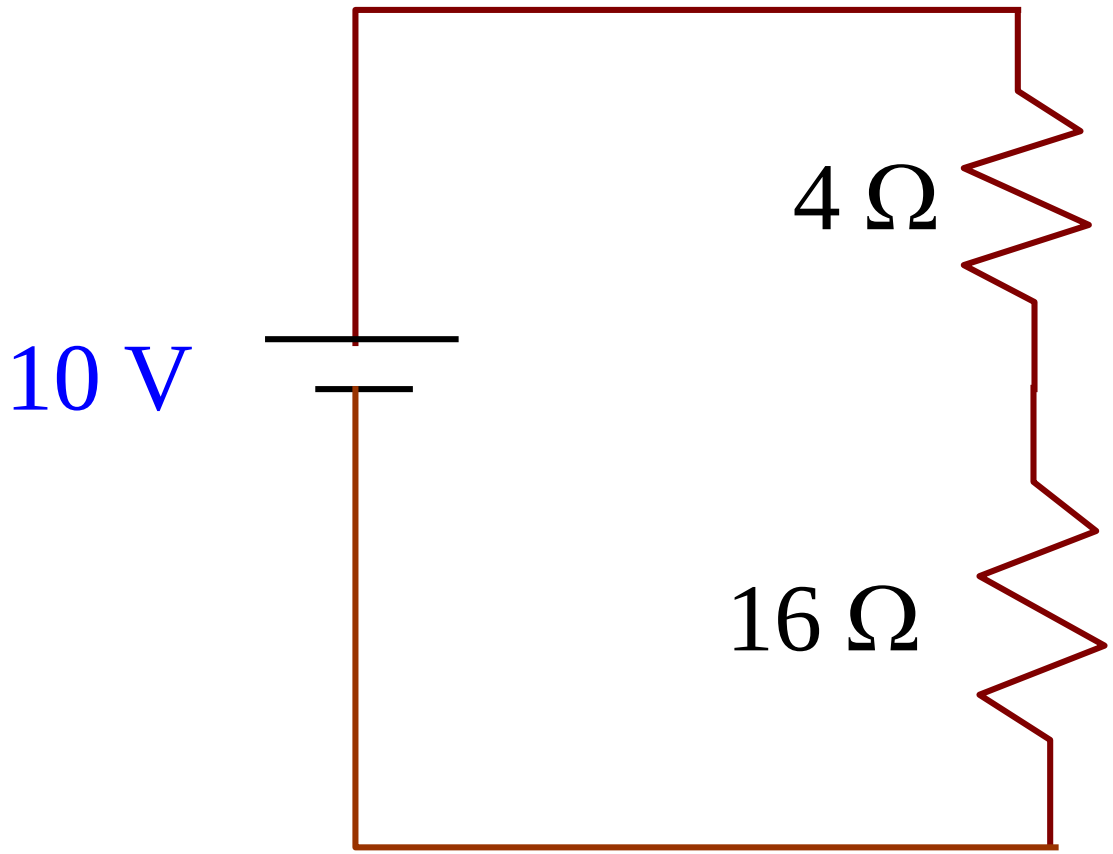
Circuit Analysis

Voltage and Current Sources

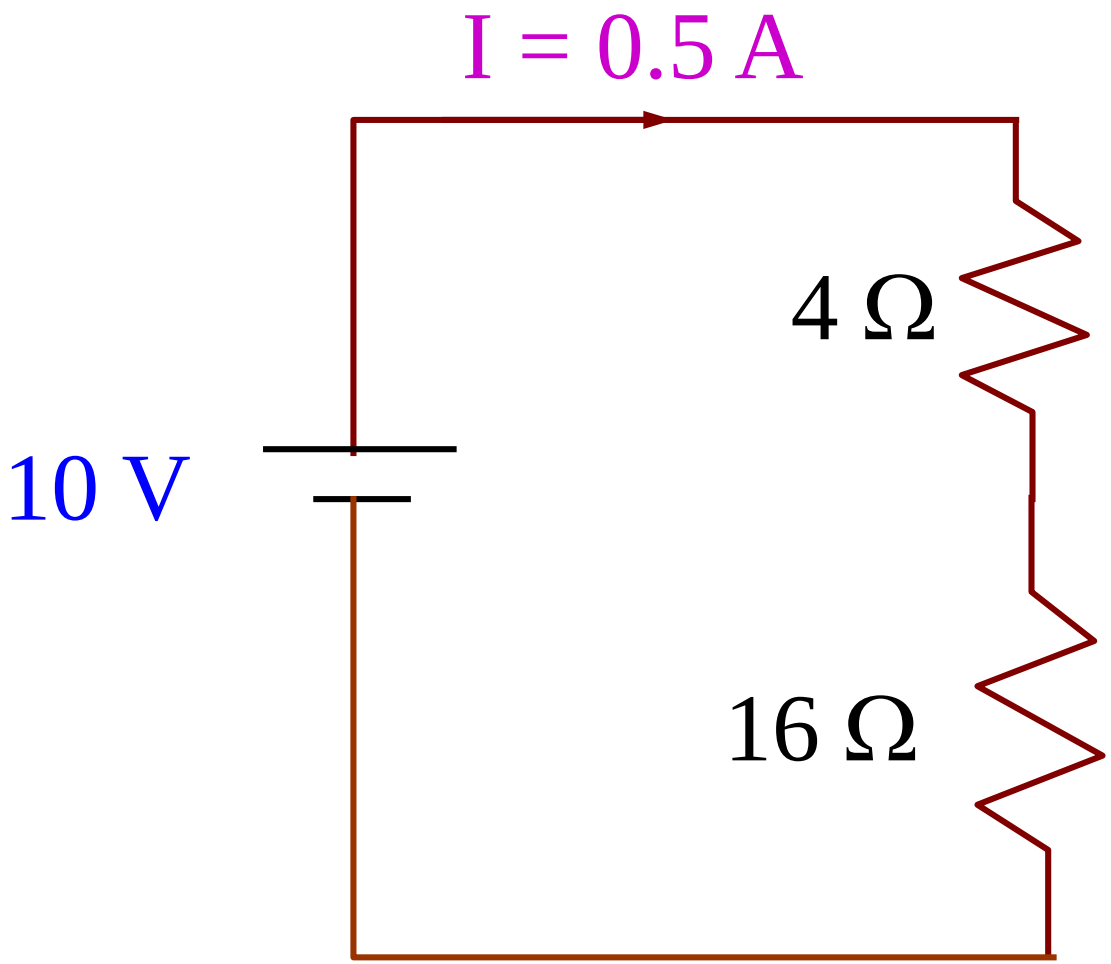
Objective

- Understand the characteristics of voltage and current sources
- Understand the principle of source conversion
- Operate voltage sources and current sources in series and parallel combination and find equivalent circuit.

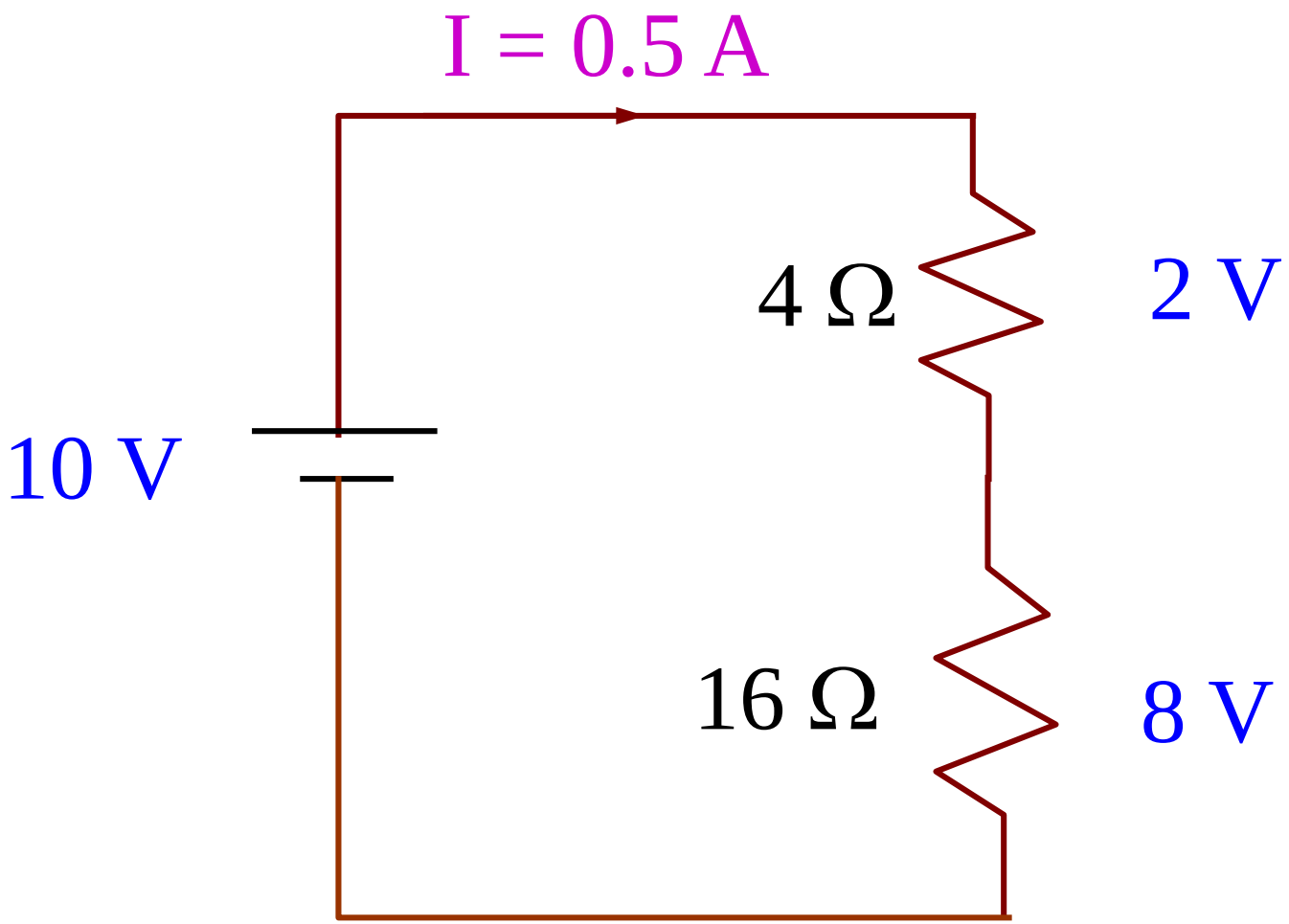
The use of arrow to represent potential difference



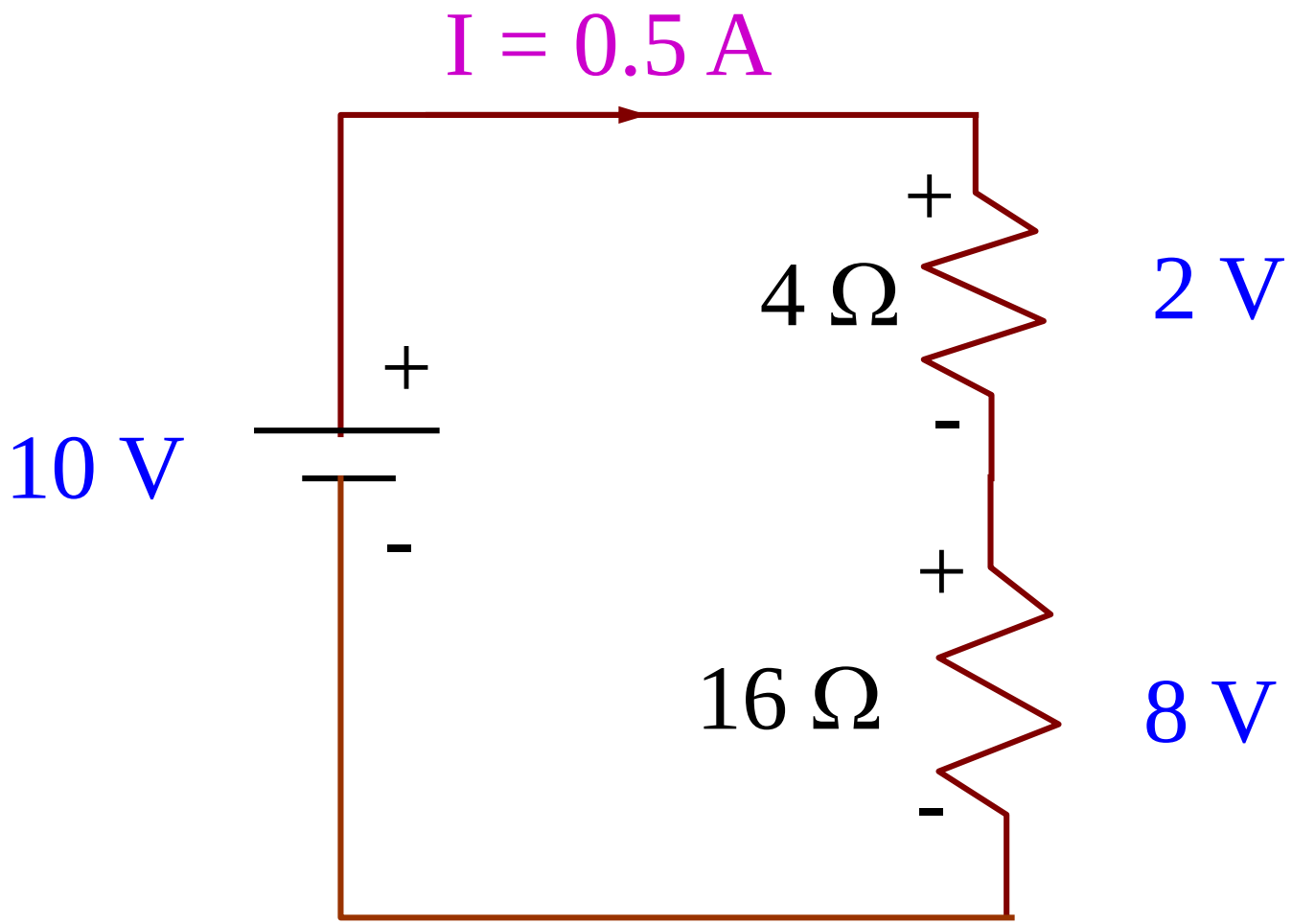
The use of arrow to represent potential difference



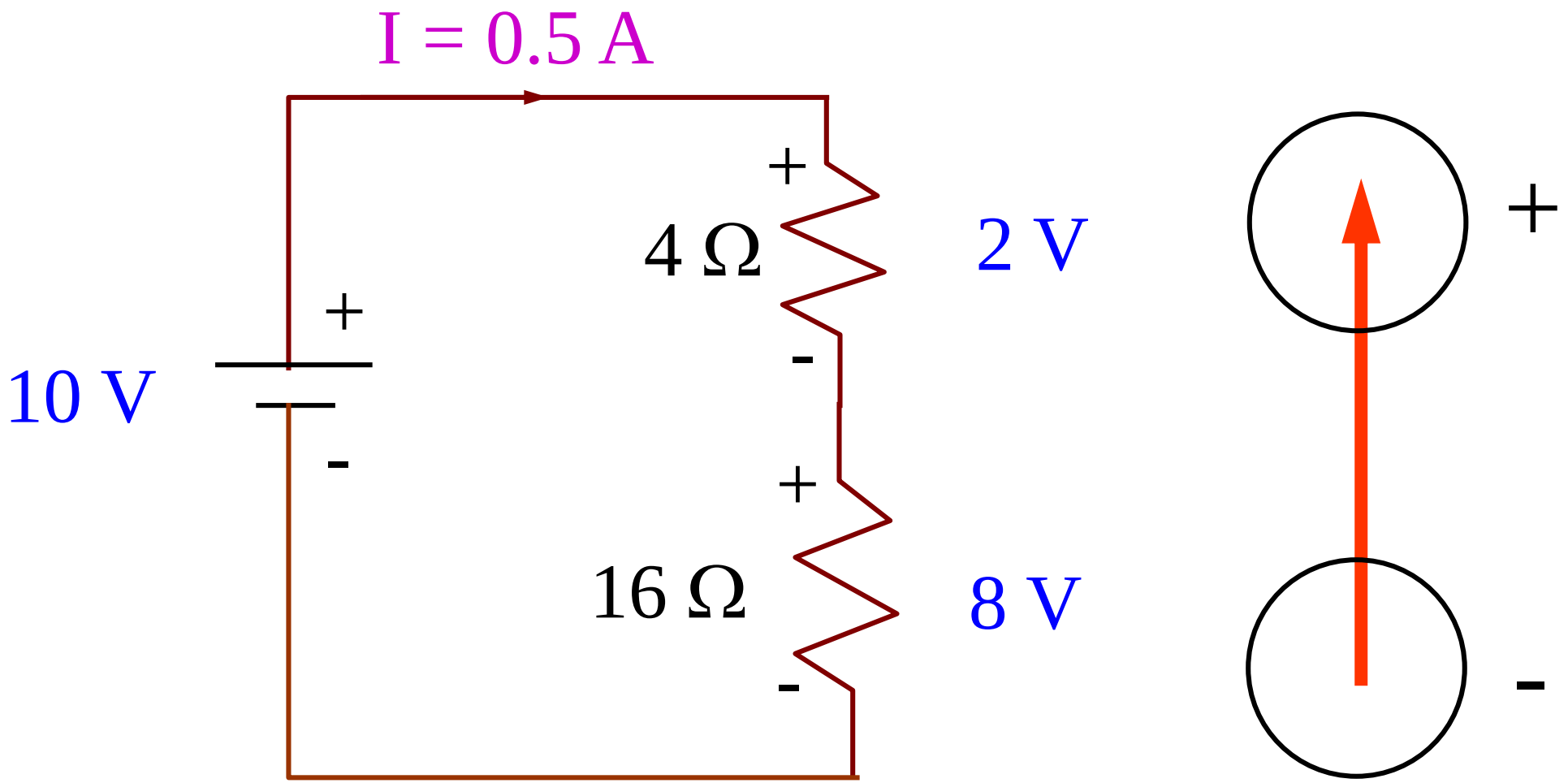
The use of arrow to represent potential difference



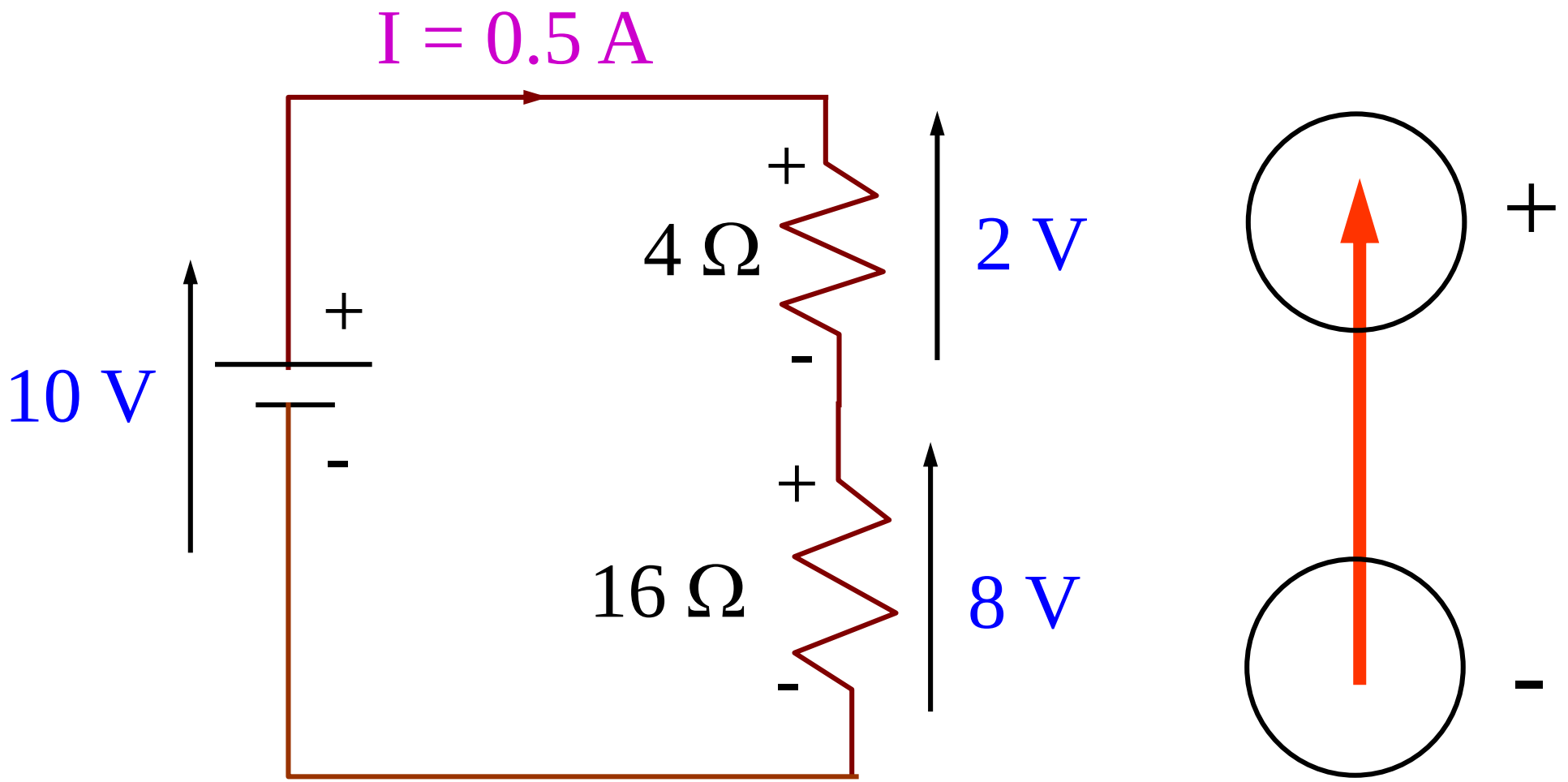
The use of arrow to represent potential difference



The use of arrow to represent potential difference

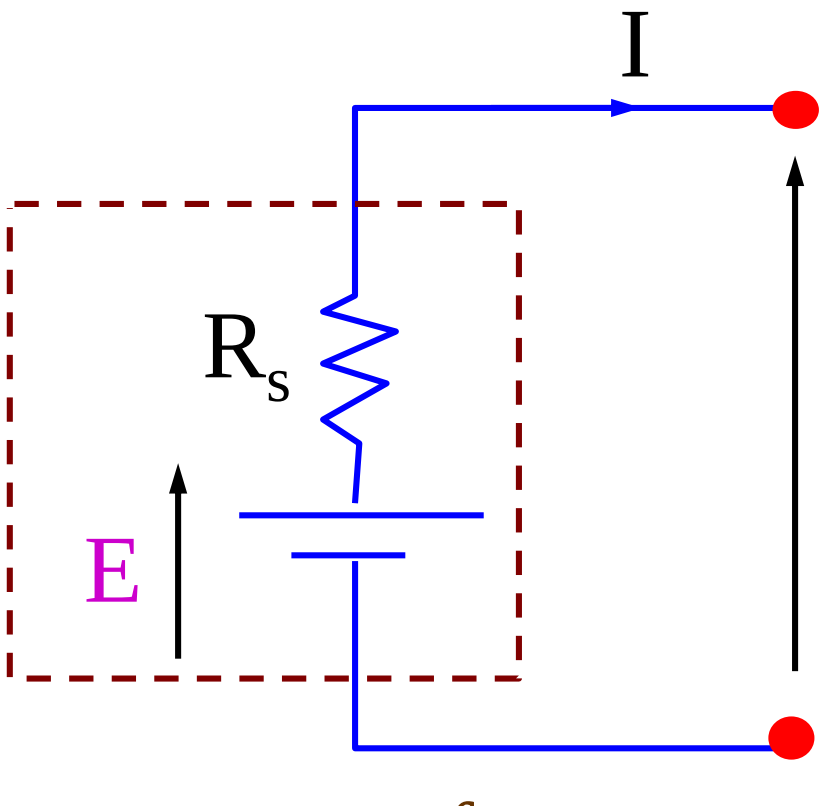


The use of arrow to represent potential difference



Constant Voltage Source

Voltage source



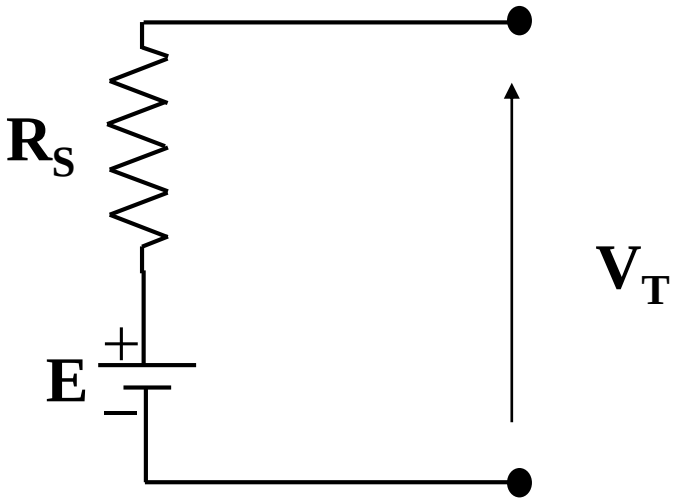
V_T - terminal voltage
This voltage depends on the amount of current being drawn from the supply

E - the constant emf

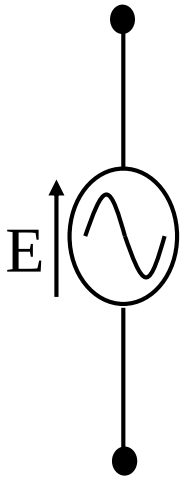
R_s - the source internal resistance

Constant Voltage Source

- **Representation of voltage source**



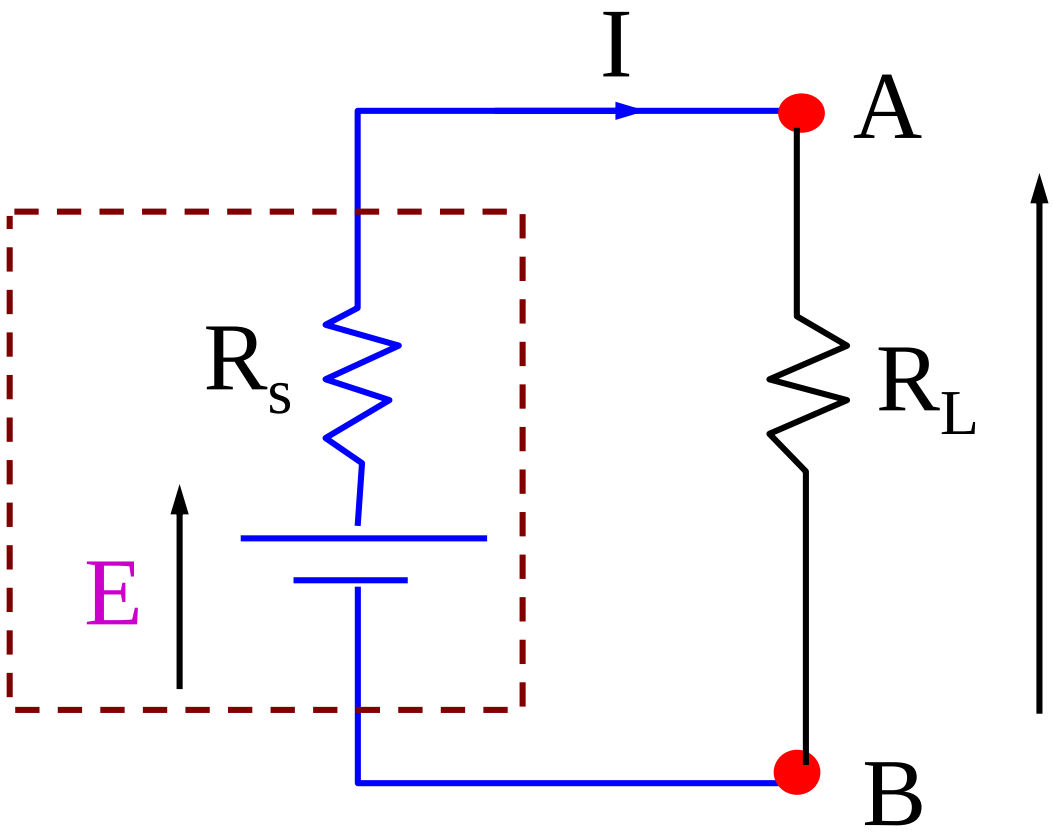
(a) Voltage source



(b)Other symbol

Constant Voltage Source

voltage source

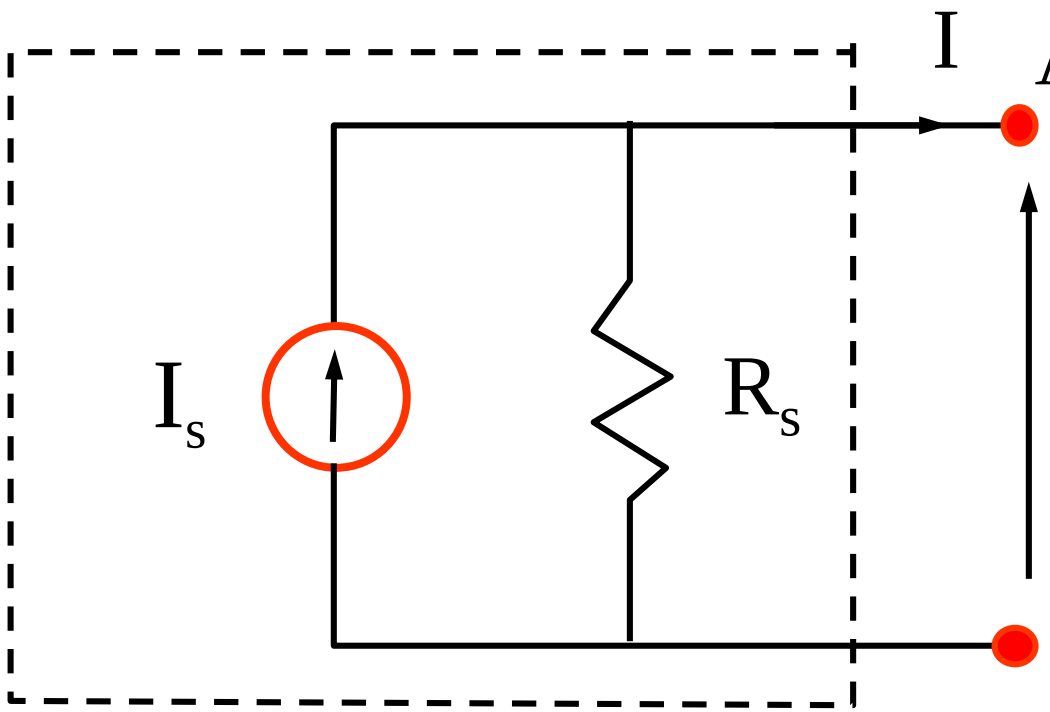


$V_T = I R_L$

By KVL, $E = I R_s + V_T = I R_s + I R_L$

Constant Current Source

Current Source



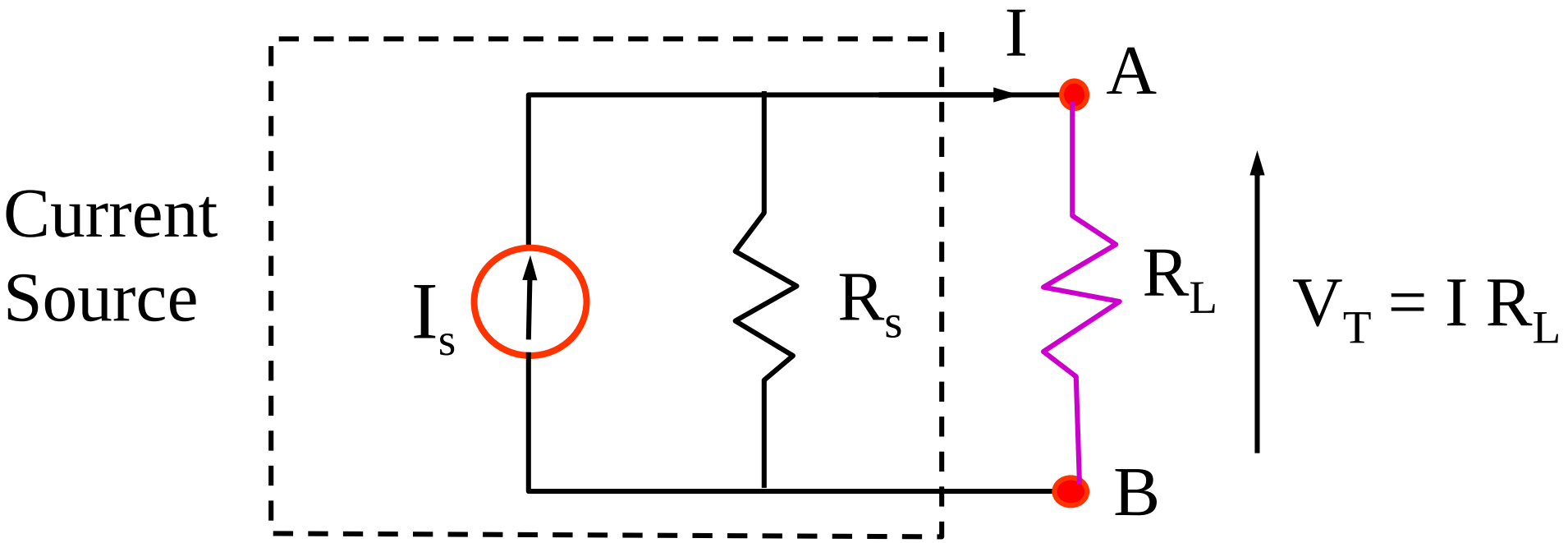
V_T - terminal voltage
This voltage depends on the amount of current being drawn from the supply

I_s = constant current, independent of the load

R_s = internal resistance

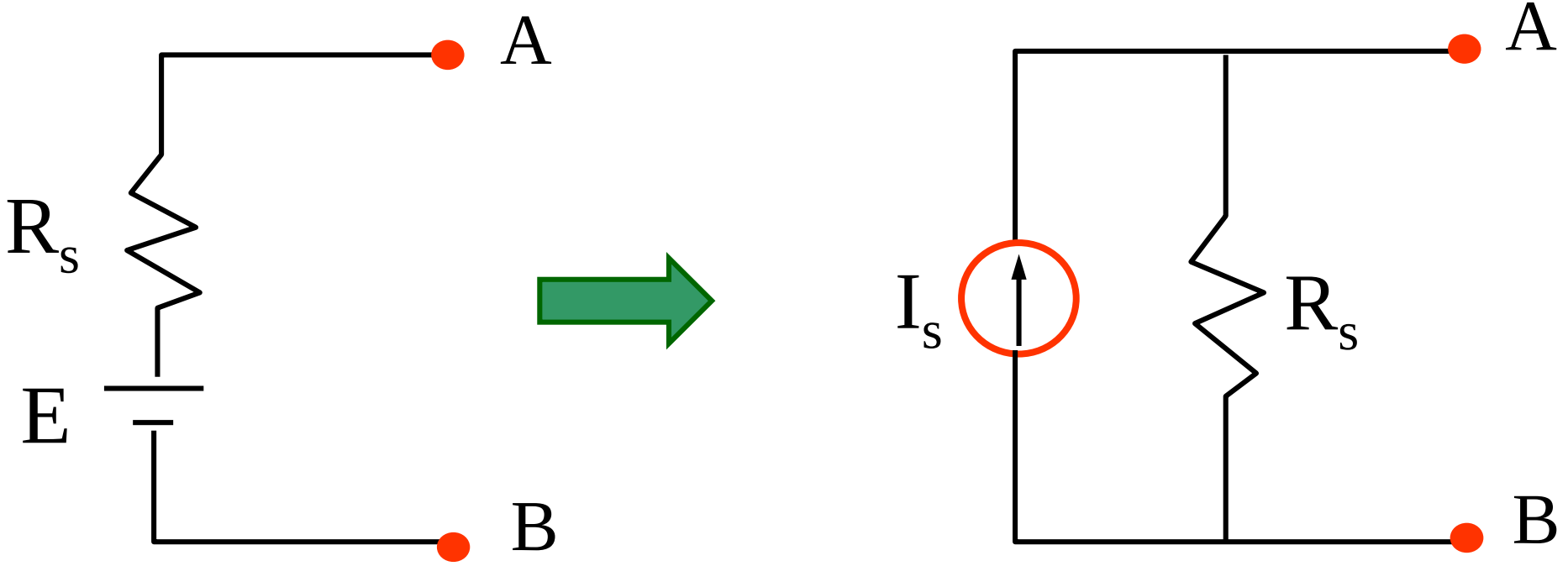
I = load current

Constant Current Source



Assume that a resistor R_L is connected across the terminals A & B such that $V_T = I R_L$
and $I = I_s \times [R_s / (R_s + R_L)]$ (current divider)

Source Conversion

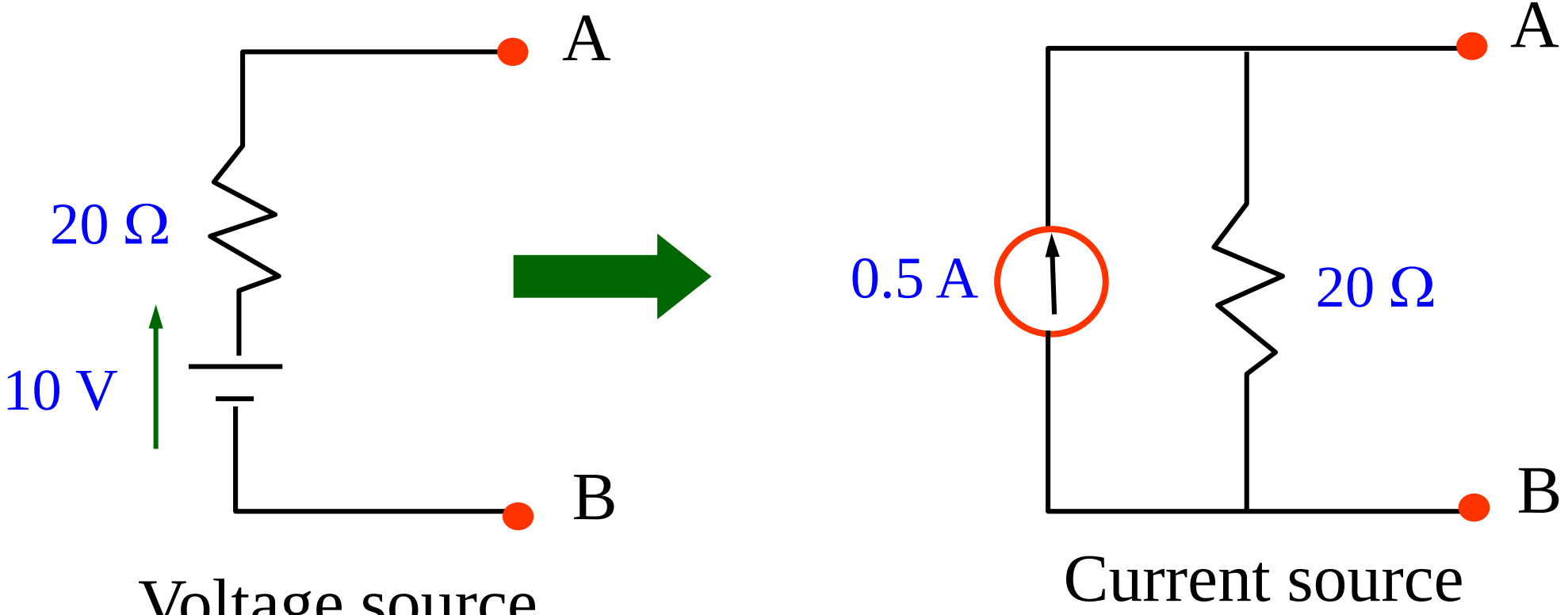


Voltage source

Current source

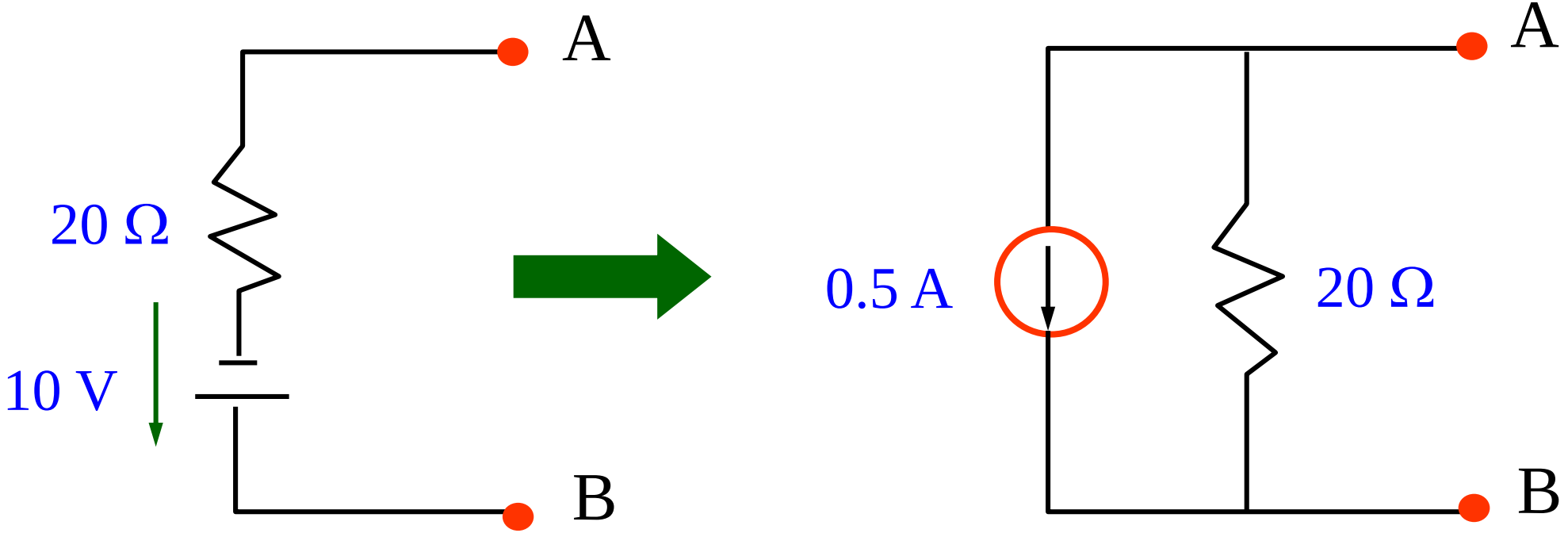
$$I_s = E / R_s$$

Source Conversion



$I_s = 10/20 = 0.5$ A

Source Conversion

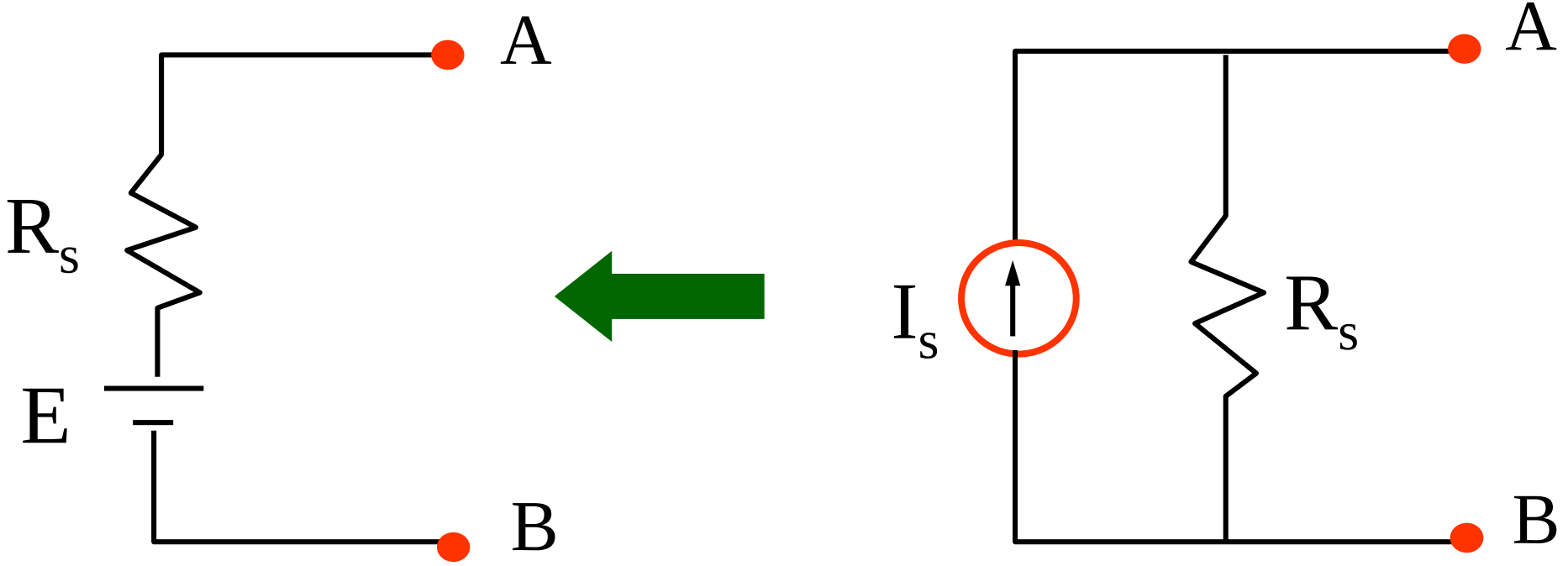


Voltage source

Current source

$I_s = 10/20 = 0.5$ A

Source Conversion

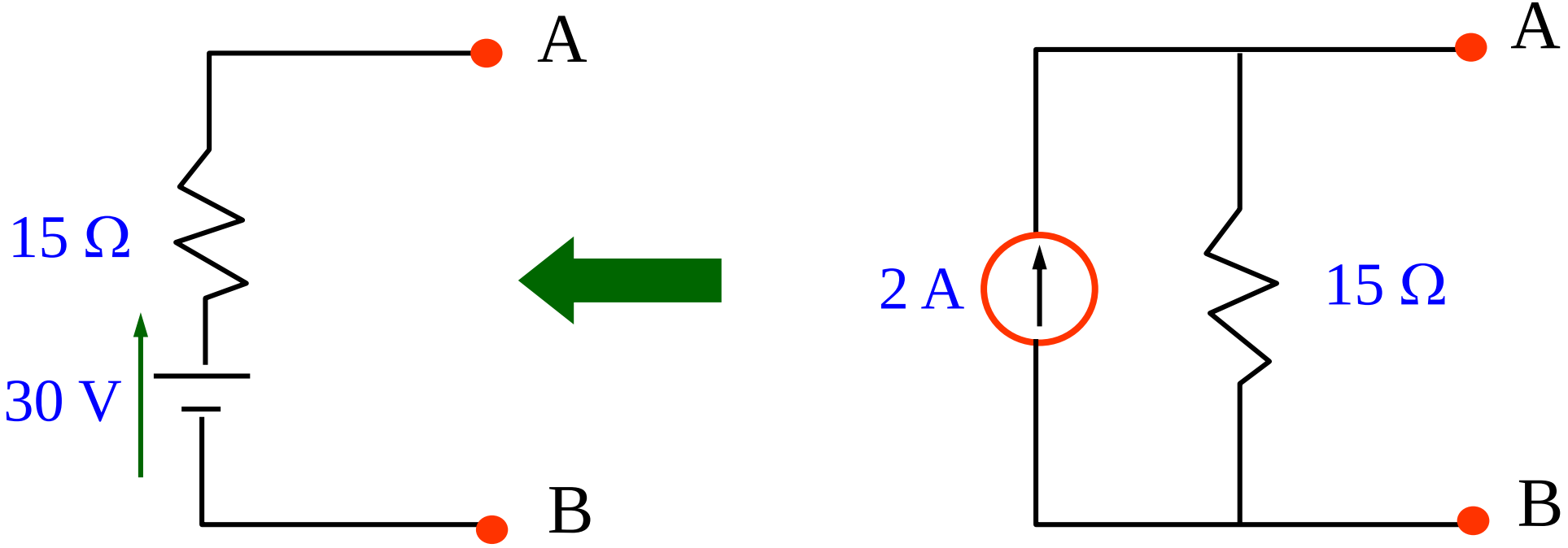


Voltage source

Current source

$E = I_s \; R_s$

Source Conversion

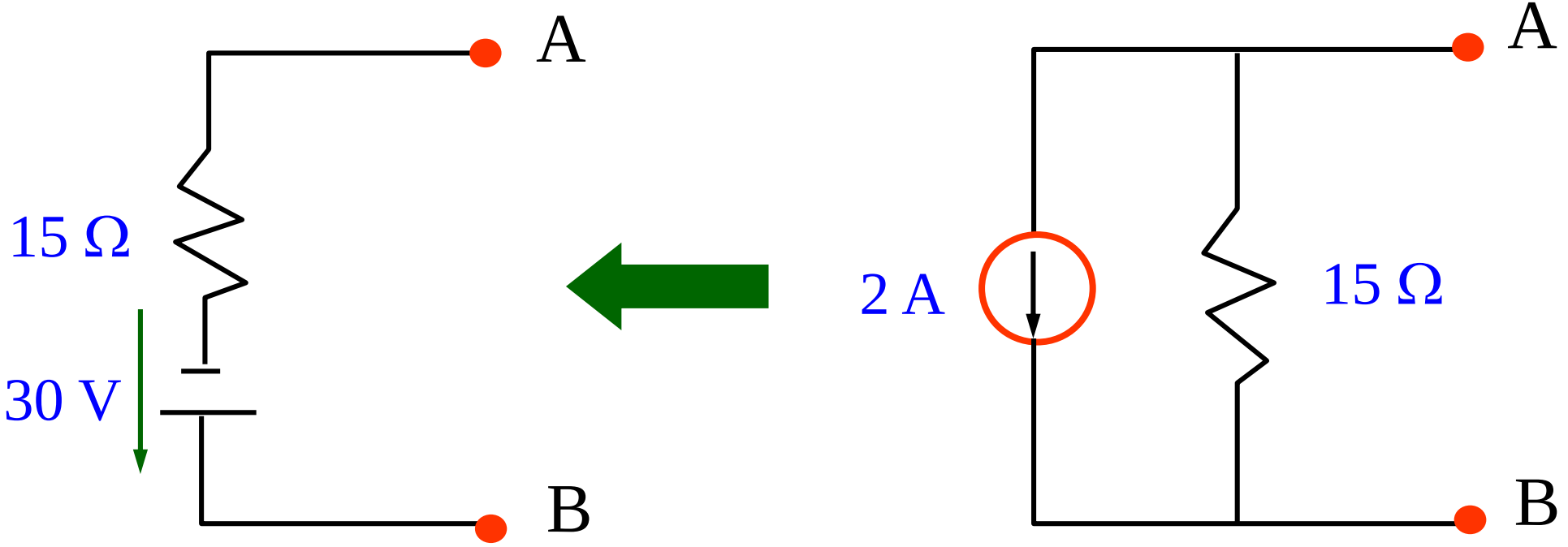


Voltage source

Current source

E = 2 x15 = 30 V

Source Conversion

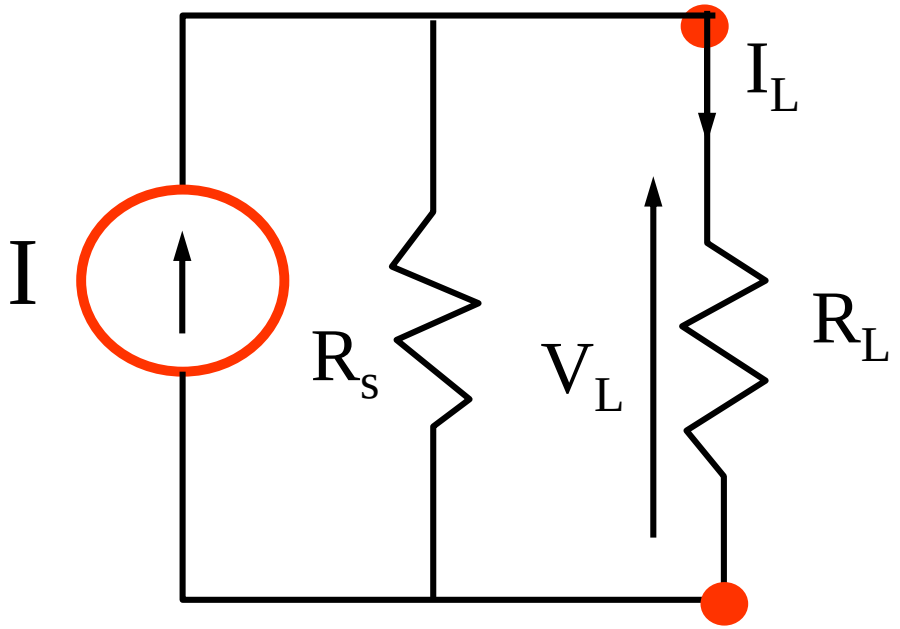


Voltage source

Current source

E = 2 x15 = 30 V

Tutorial 1, Question 1



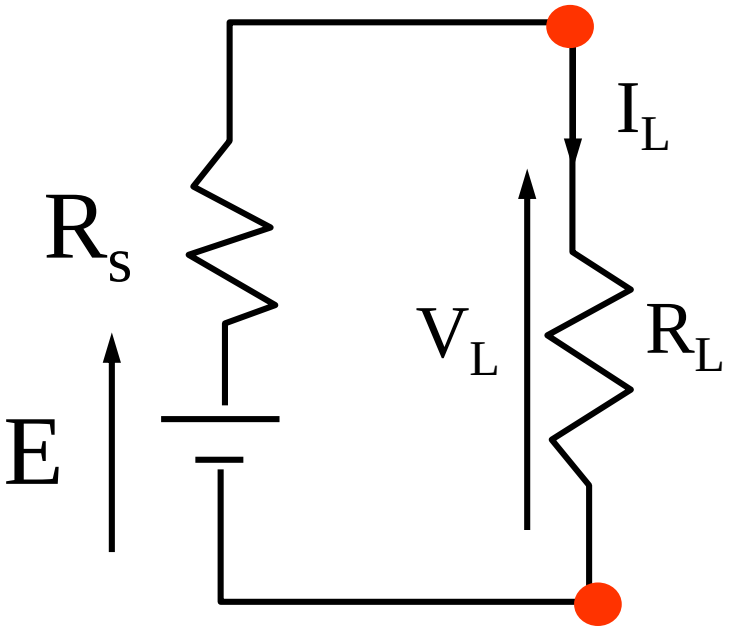
Constant current source

I = 12 A, R_s = 2 Ω and R_L = 6 Ω

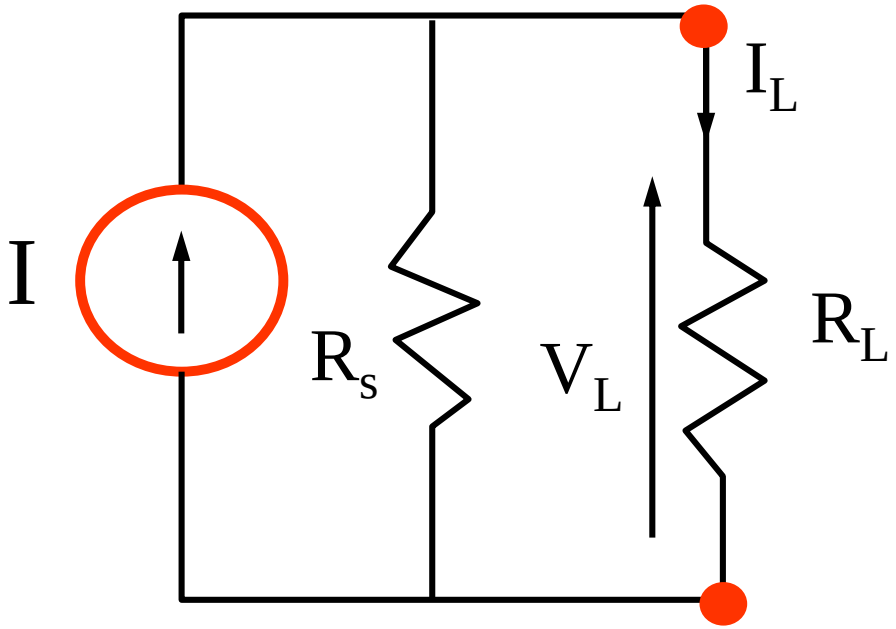
I_L = 12 x[2 / (2+6)] = 3 A and

V_L = 3 x 6 = 18 V

Tutorial 1, Question 1



Constant voltage source

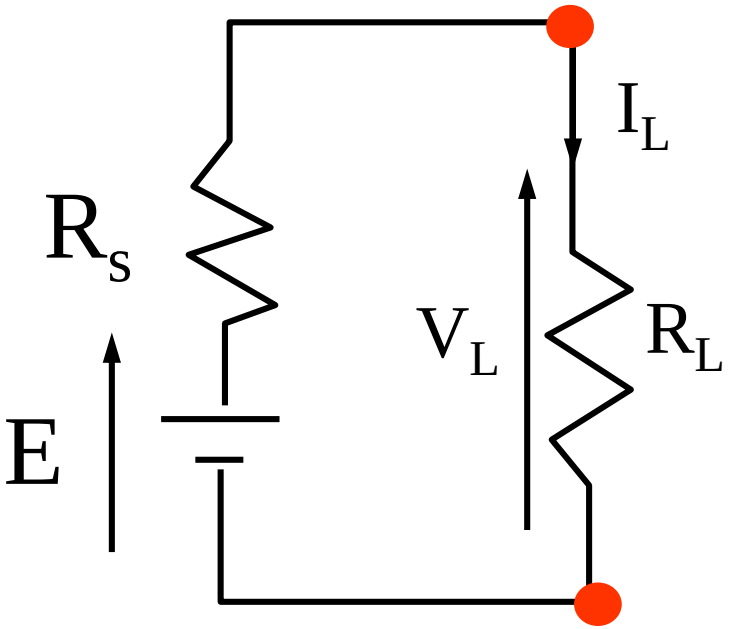


Constant current source

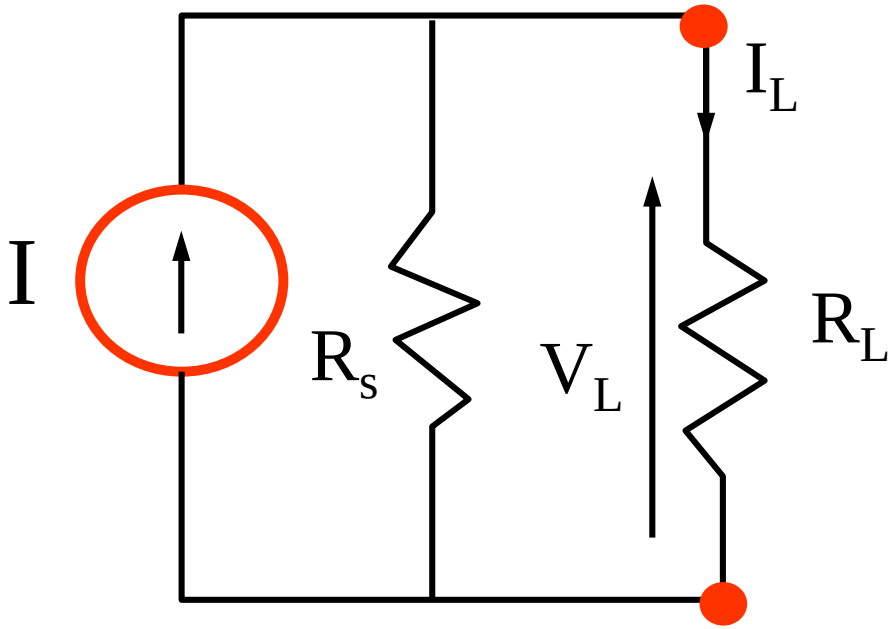
$E = I \times R_s = 12 \times 2 = 24$ V

$I = 12$ A, $R_s = 2\ \Omega$ and $R_L = 6\ \Omega$

Tutorial 1, Question 1



Constant voltage source



Constant current source

$E = I \times R_s = 12 \times 2 = 24$ V

$I_L = 24 / (2 + 6) = 3$ A and

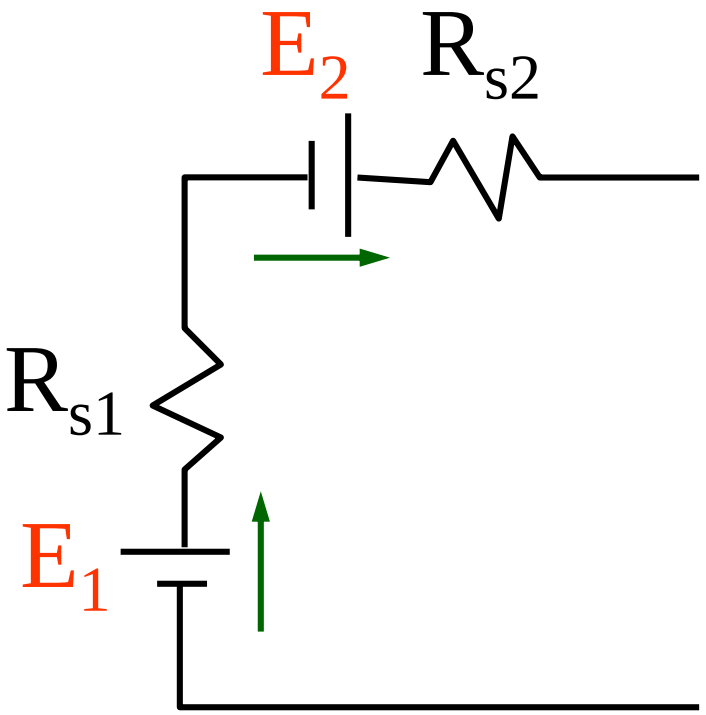
$V_L = 3 \times 6 = 18$ V

$I = 12$ A, $R_s = 2\ \Omega$ and $R_L = 6\ \Omega$

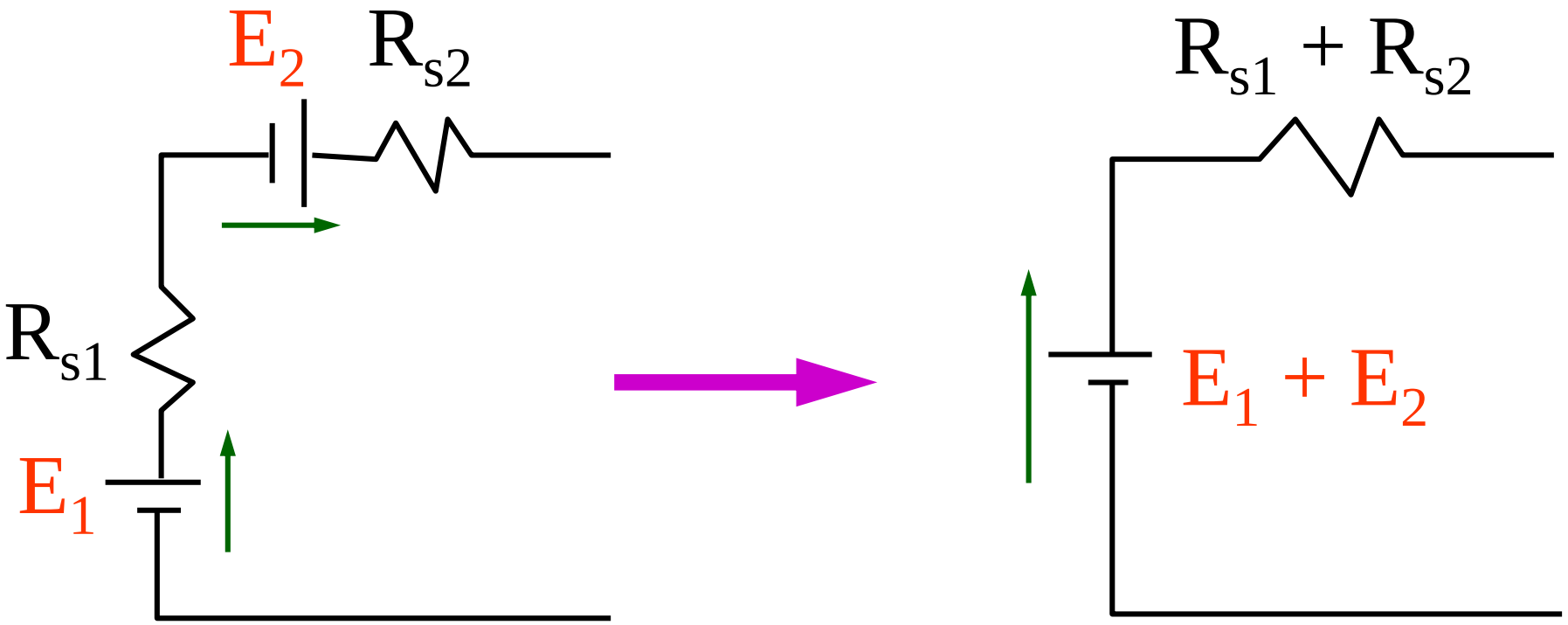
$I_L = 12 \times 2 / (2 + 6) = 3$ A and

$V_L = 3 \times 6 = 18$ V

Voltage sources in series

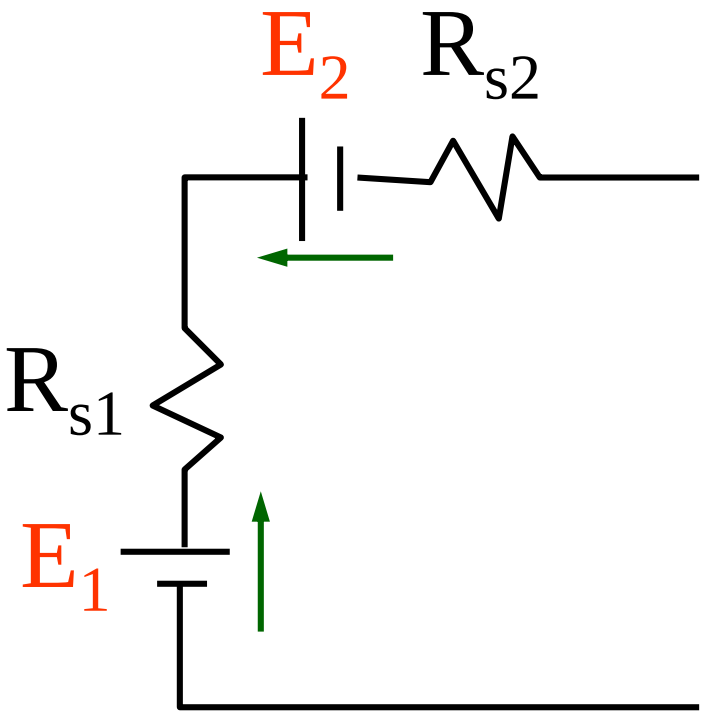


Voltage sources in series

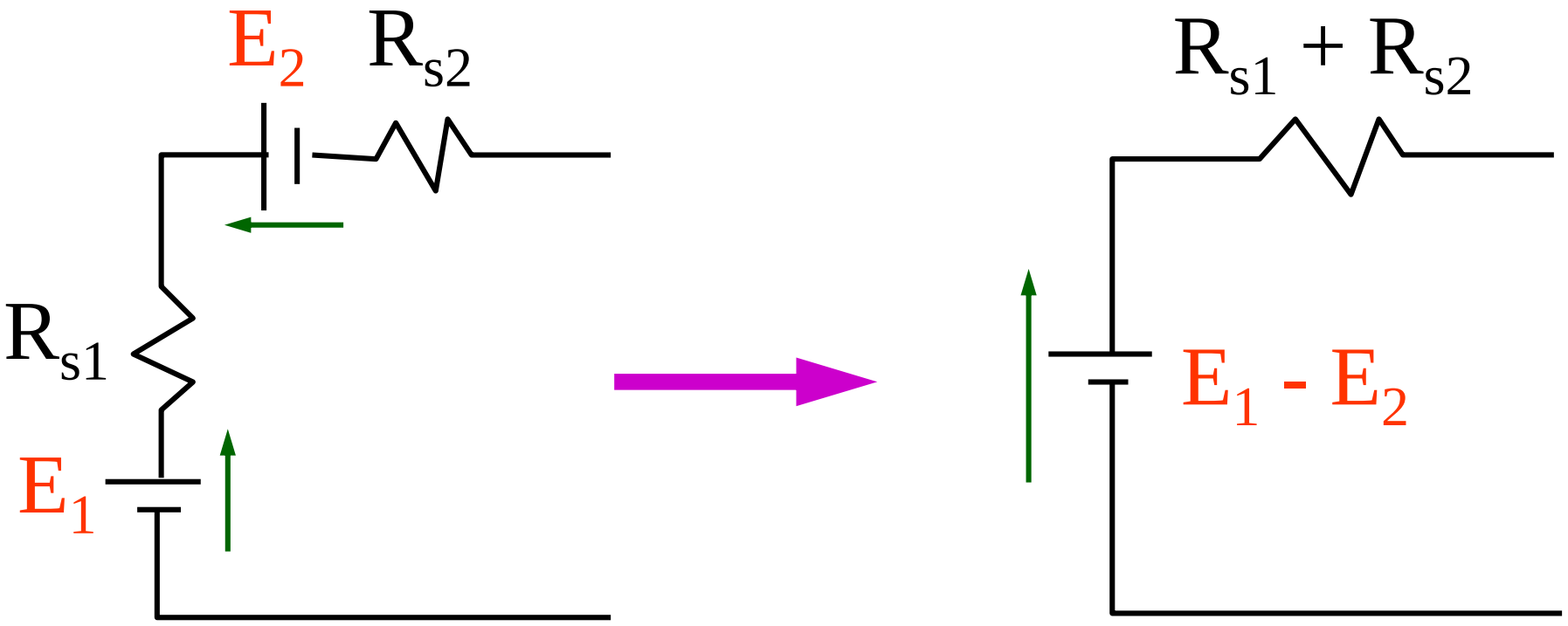


Series-aiding voltage sources

Voltage sources in series



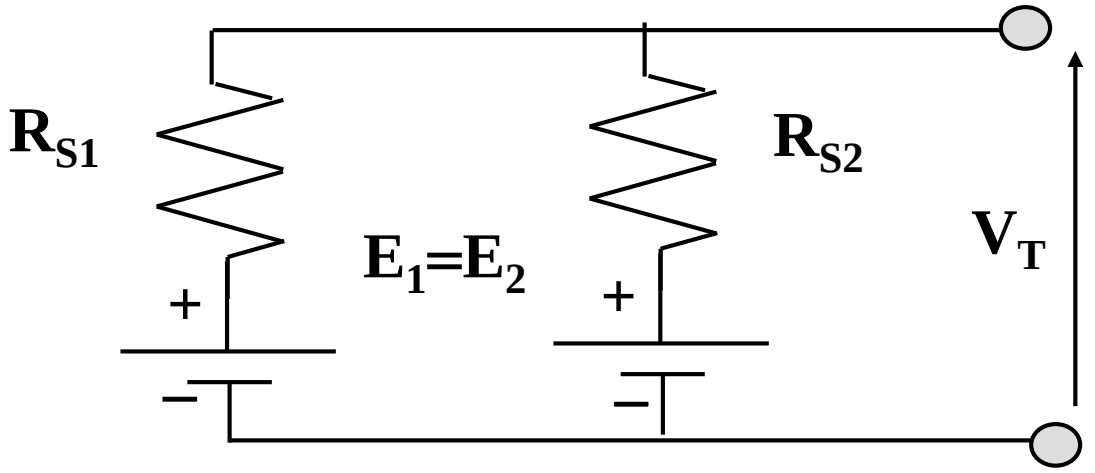
Voltage sources in series



Series-opposing voltage sources

Voltage sources in parallel

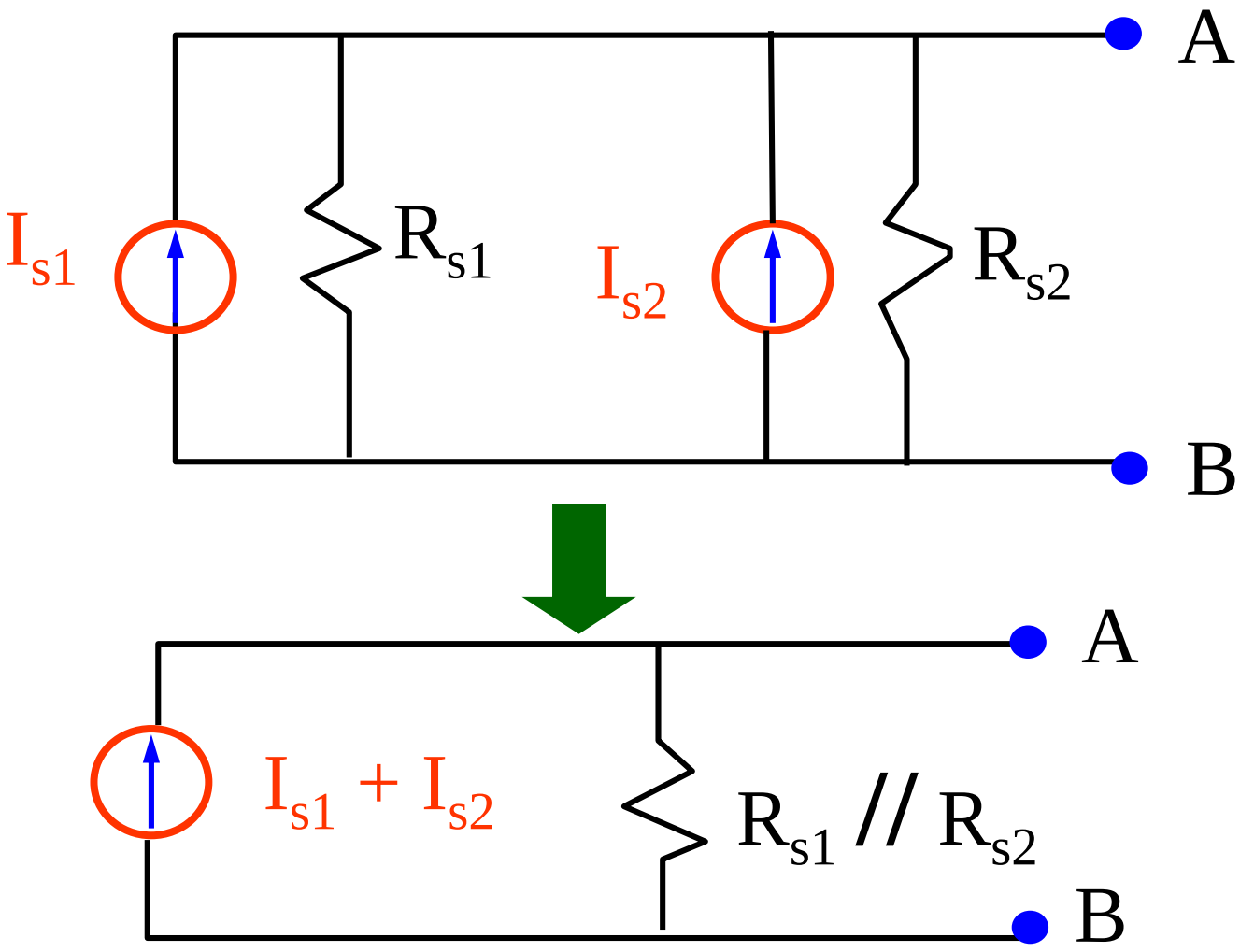
- Parallel operation of voltage sources with different voltages not possible.
- Parallel operation of identical voltage sources for higher output current.



Current sources in series

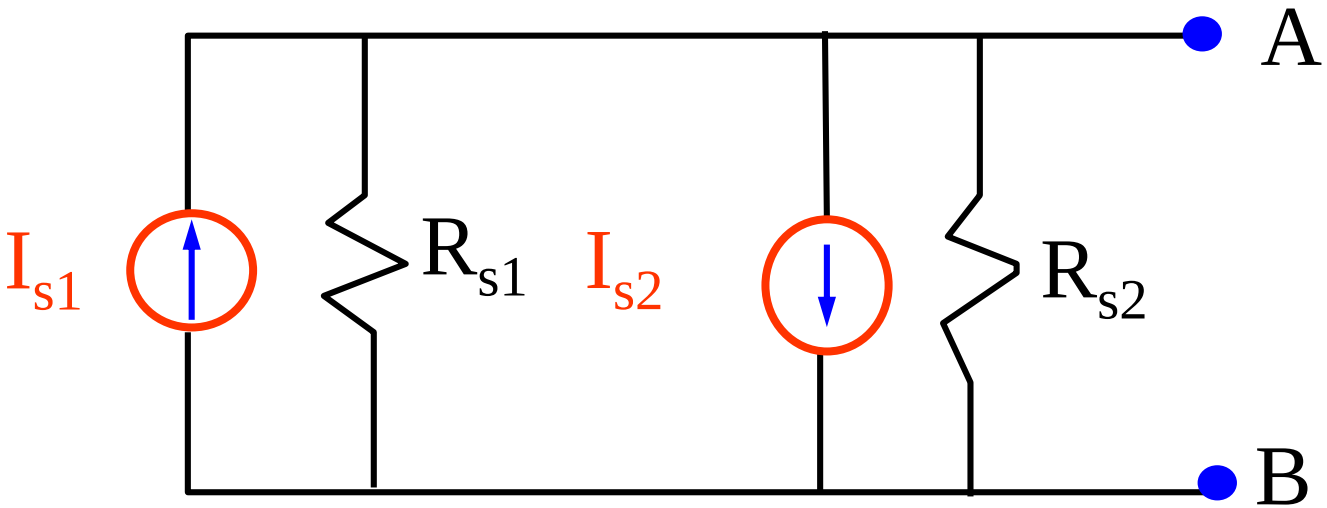
- Series operation of different current sources are not practical

Current sources in parallel

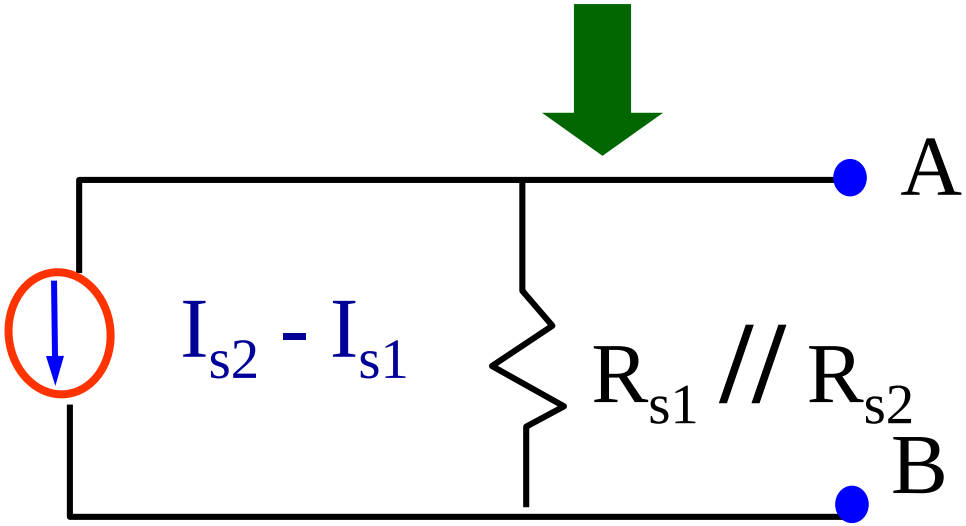


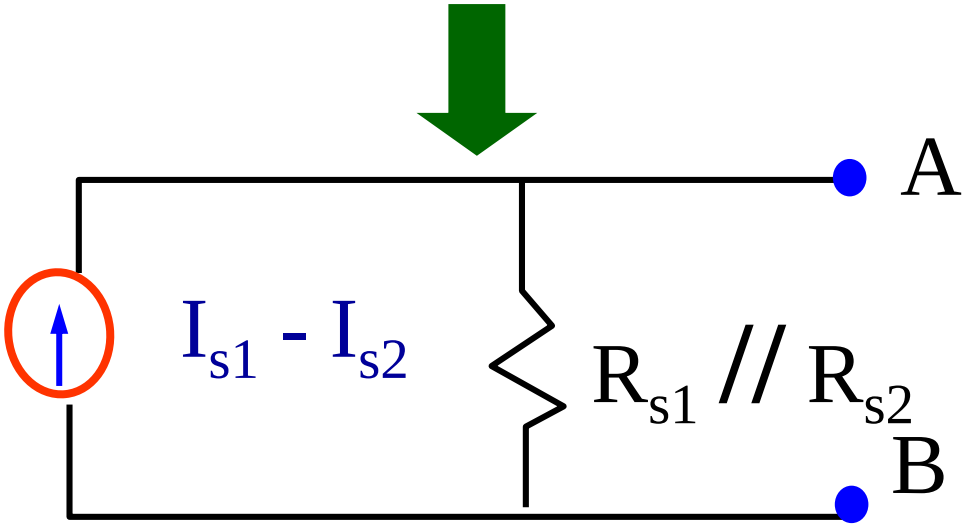
Parallel-aiding current sources

Current sources in parallel



Parallel-opposing current sources





Procedure for finding the equivalent current source or voltage source

- *When two voltage sources are in parallel or when a voltage source is in parallel with a current source.*
  - *Always first convert the voltage source to its equivalent current sources with appropriate current direction.*

Procedure for finding the equivalent current source or voltage source

- *Identify the type of parallel connection as either*
  - ***Parallel aiding current sources or***
  - ***Parallel opposing current sources.***
- *Simplify the circuit to find the single equivalent current source with appropriate current direction.*

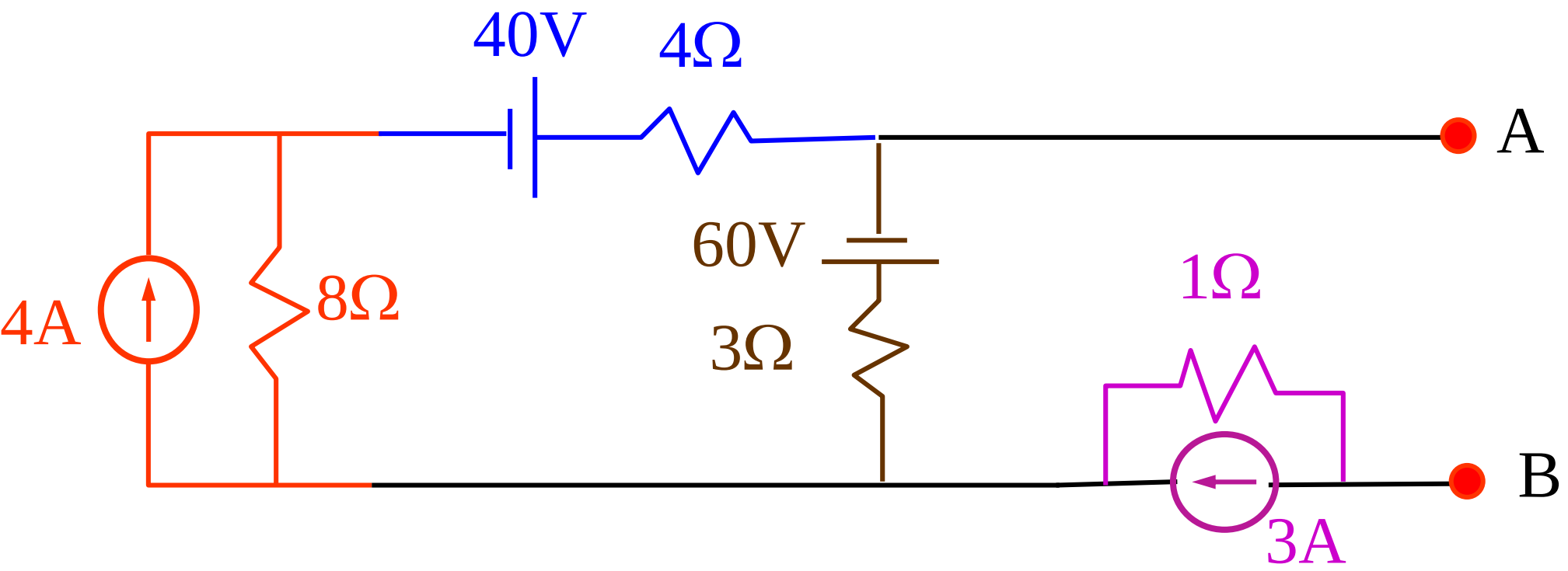
Procedure for finding the equivalent current source or voltage source

- *When two current sources are in series or when a current source is in series with a voltage source.*
  - *Always first convert the current source to its equivalent voltage sources with appropriate voltage direction.*

Procedure for finding the equivalent current source or voltage source

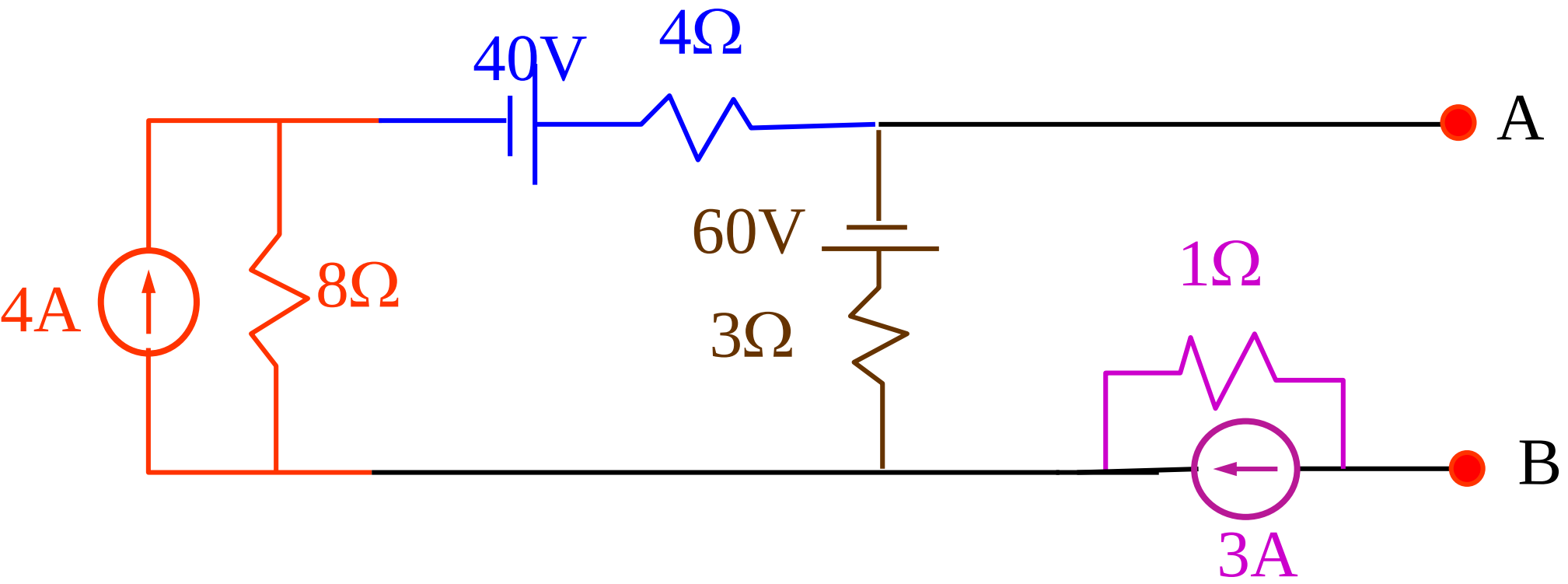
- *Identify the type of series connection as either*
  - ***Series aiding voltage sources or***
  - ***Series opposing voltage sources.***
- *Simplify the circuit to find the single equivalent voltage source with appropriate voltage direction.*

Example 1.2



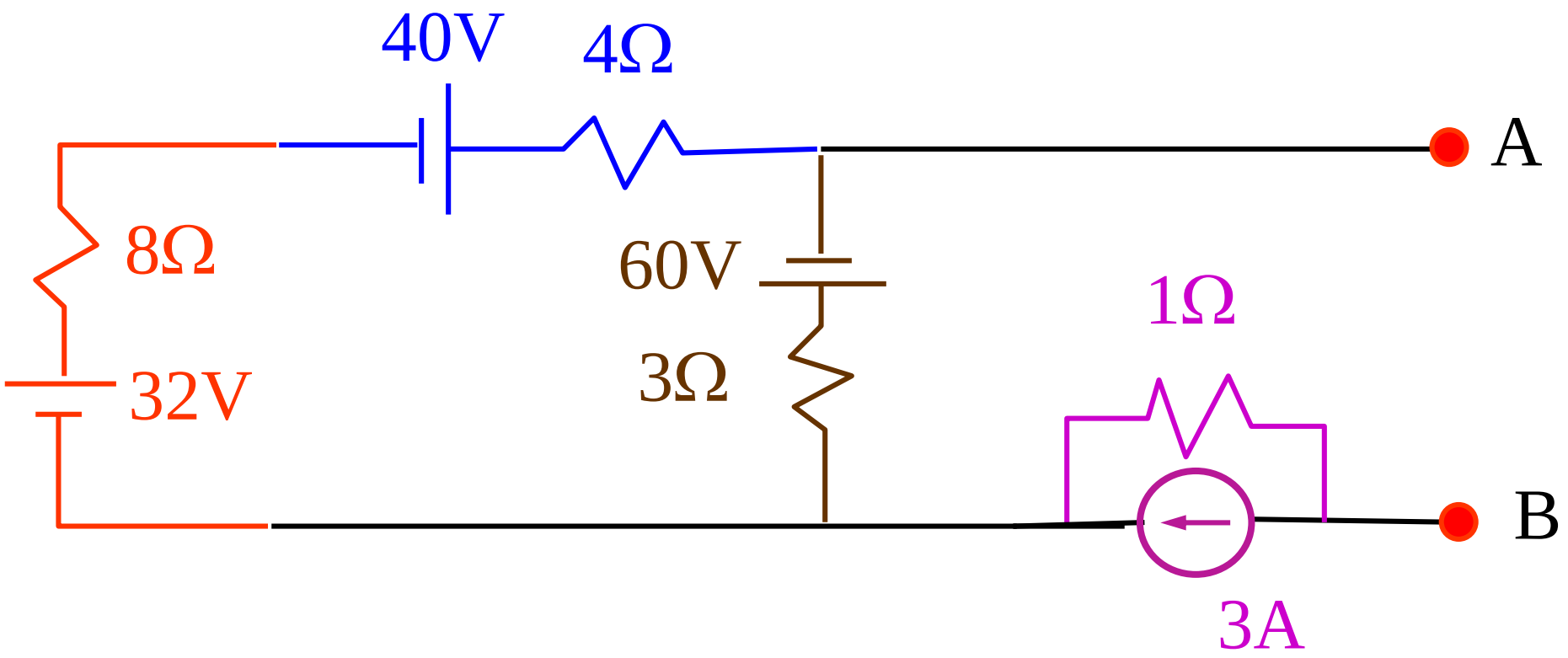
Simplify the above into an equivalent current source

Example 1.2

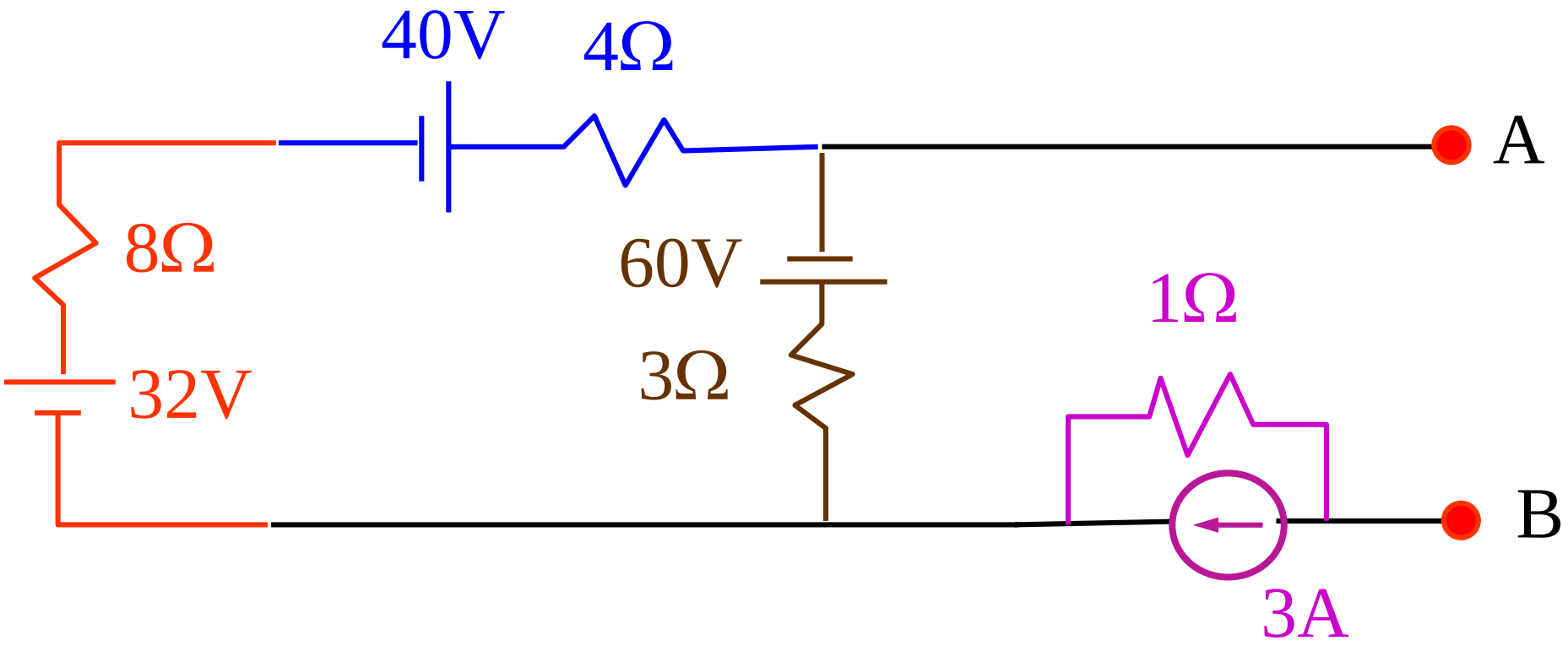


Convert the parallel 4A, 8Ω into series voltage source of 4 x 8 = 32 volts with 8Ω as the series resistor

Example 1.2

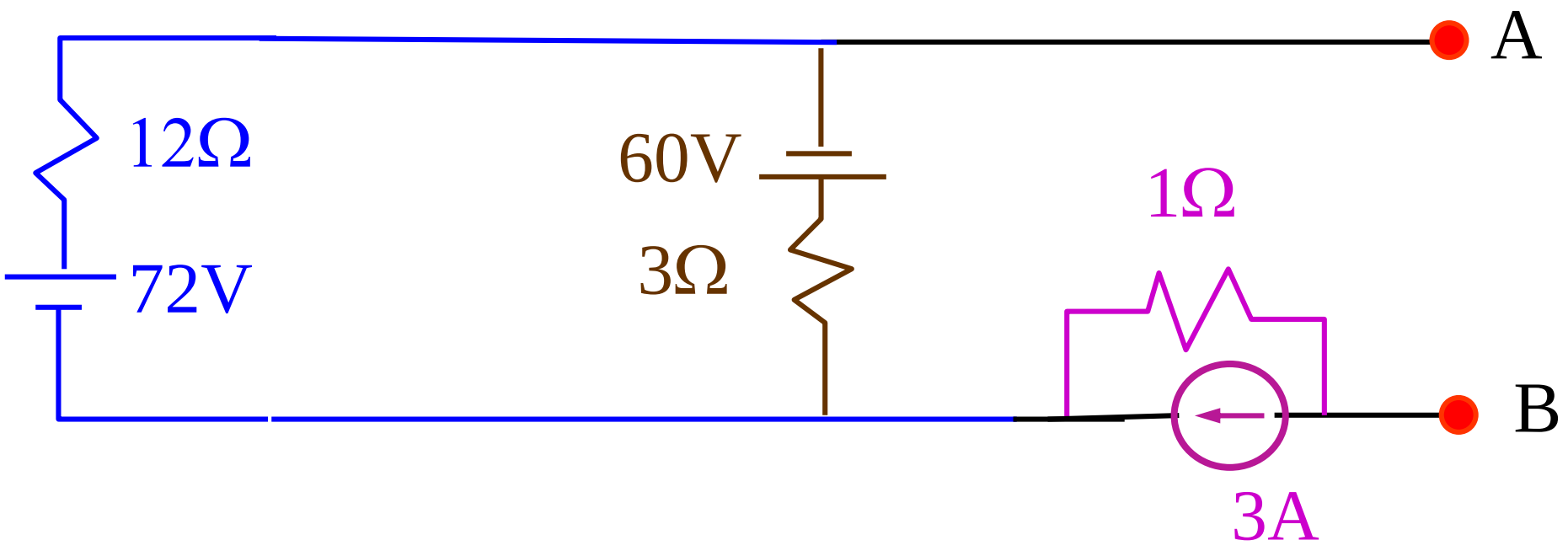


Example 1.2

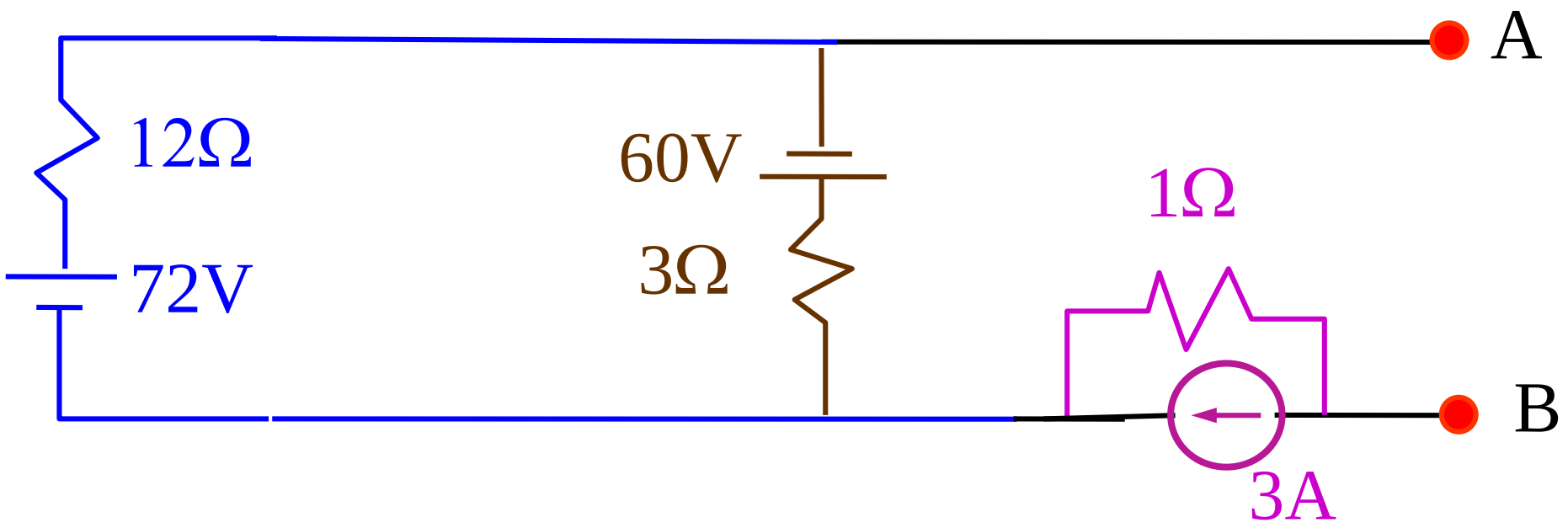


Now combine the 32V and 8Ω with the 40V and 4Ω to form a total of 72V and 12Ω series circuit

Example 1.2

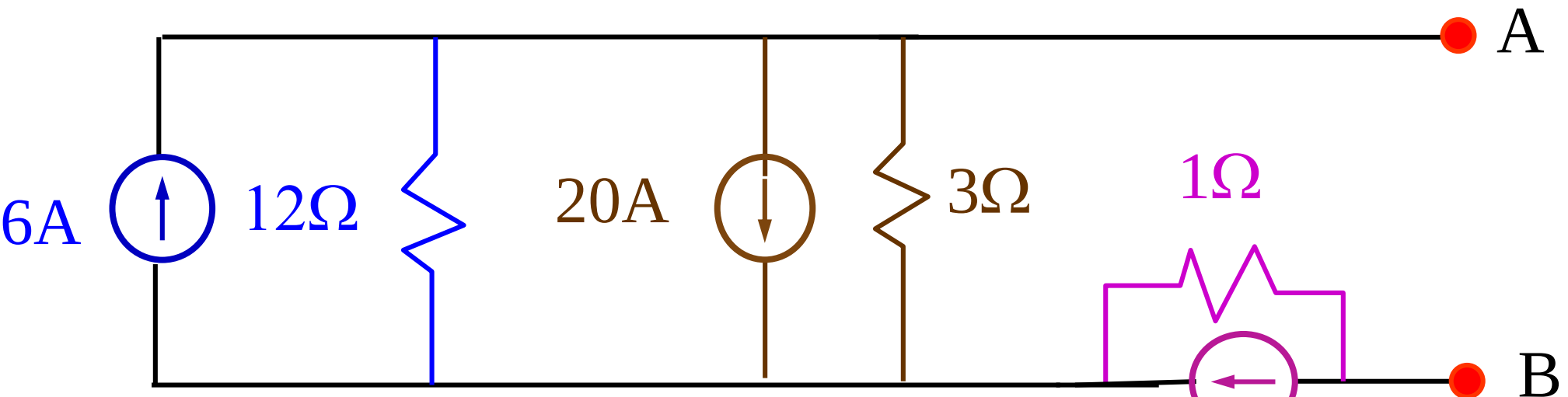


Example 1.2



The 72V, 12Ω and 60V, 3Ω must both be converted into current sources before they can be combined

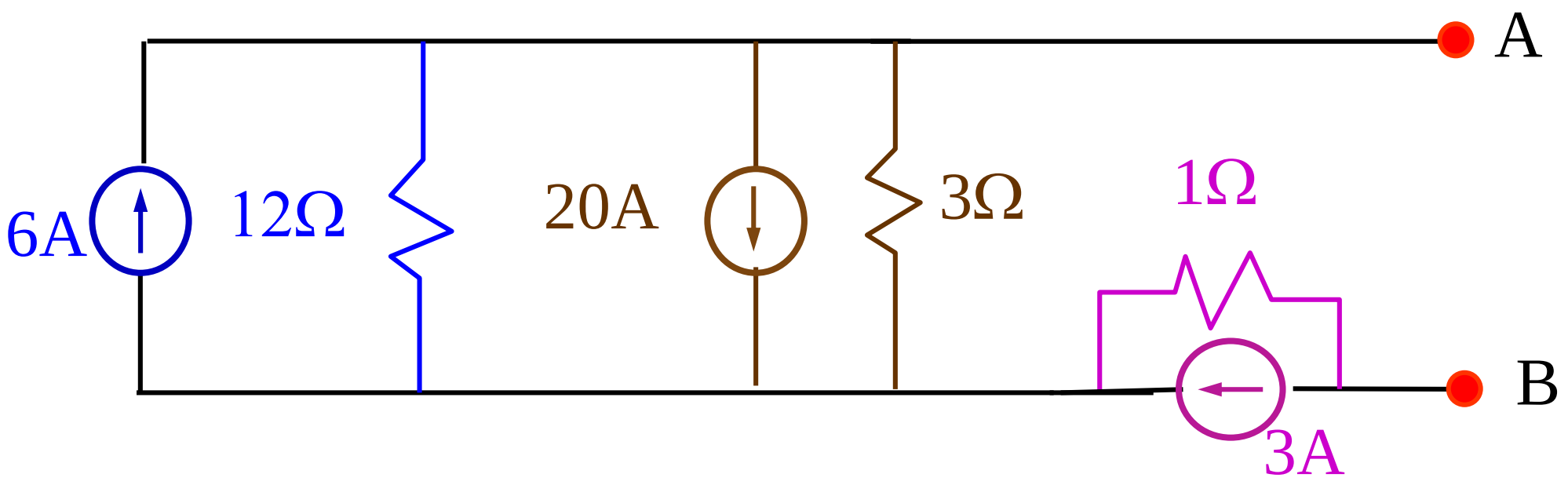
Example 1.2



I_{S1} =72/12 = 6A

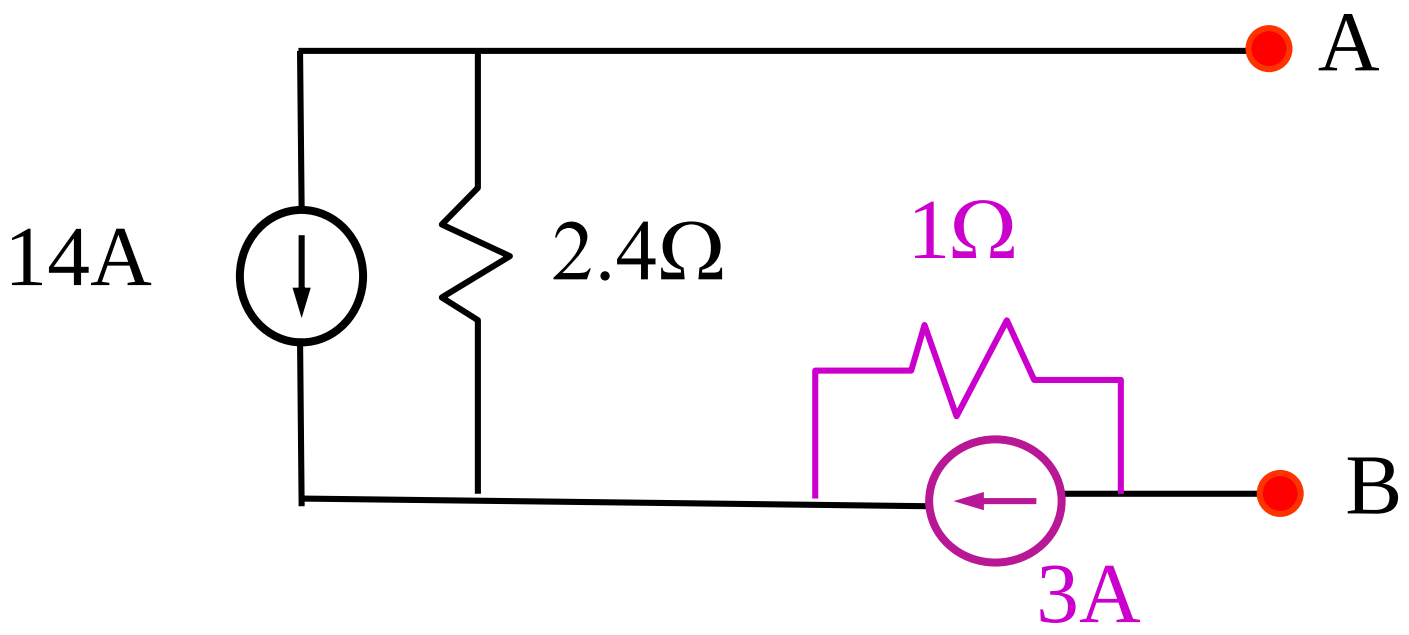
I_{S2} =60/3 = 20A

Example 1.2

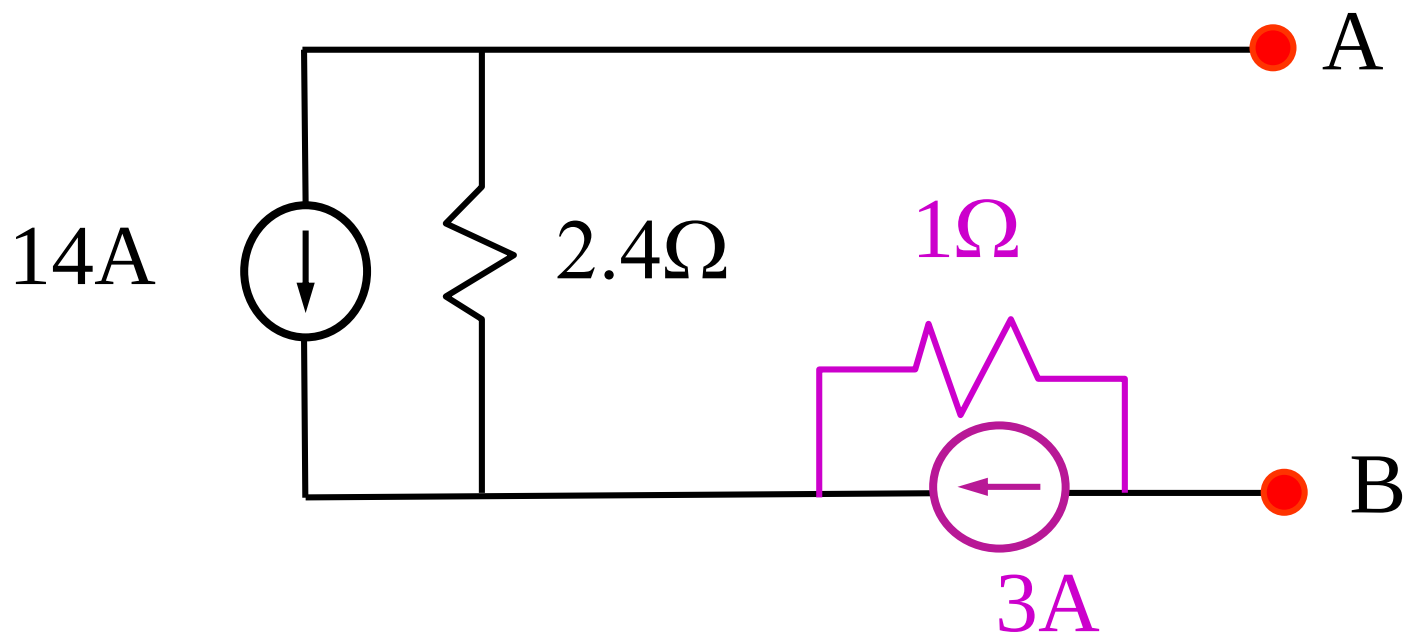


Now combine the 6A, 12Ω with the 20A, 3Ω into one single current source with a parallel resistor equals to 12//3 = 2.4Ω

Example 1.2

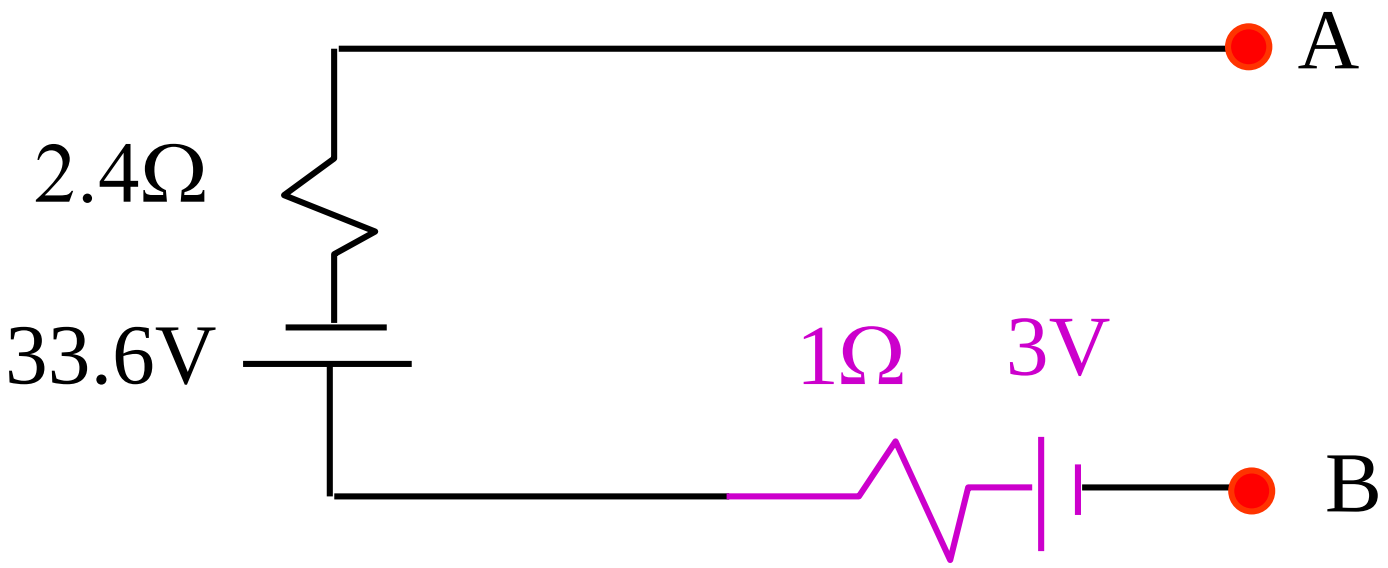


Example 1.2



To combine these two current sources, both must first be converted into voltage sources.

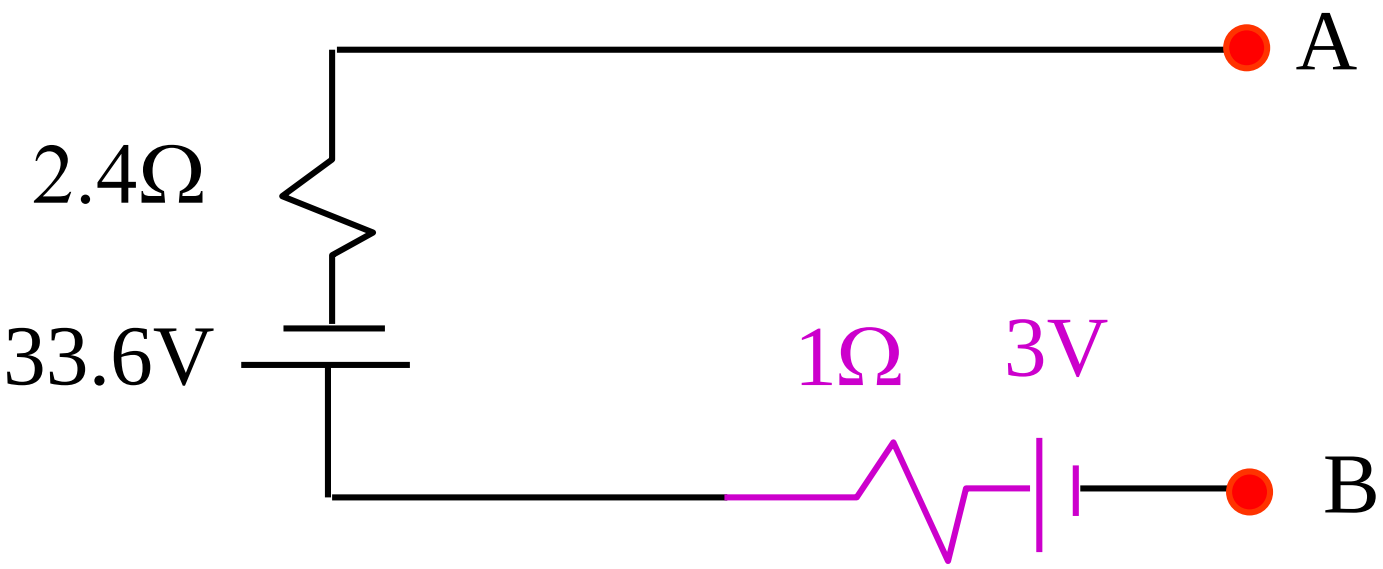
Example 1.2



E =14x2.4 =33.6 V

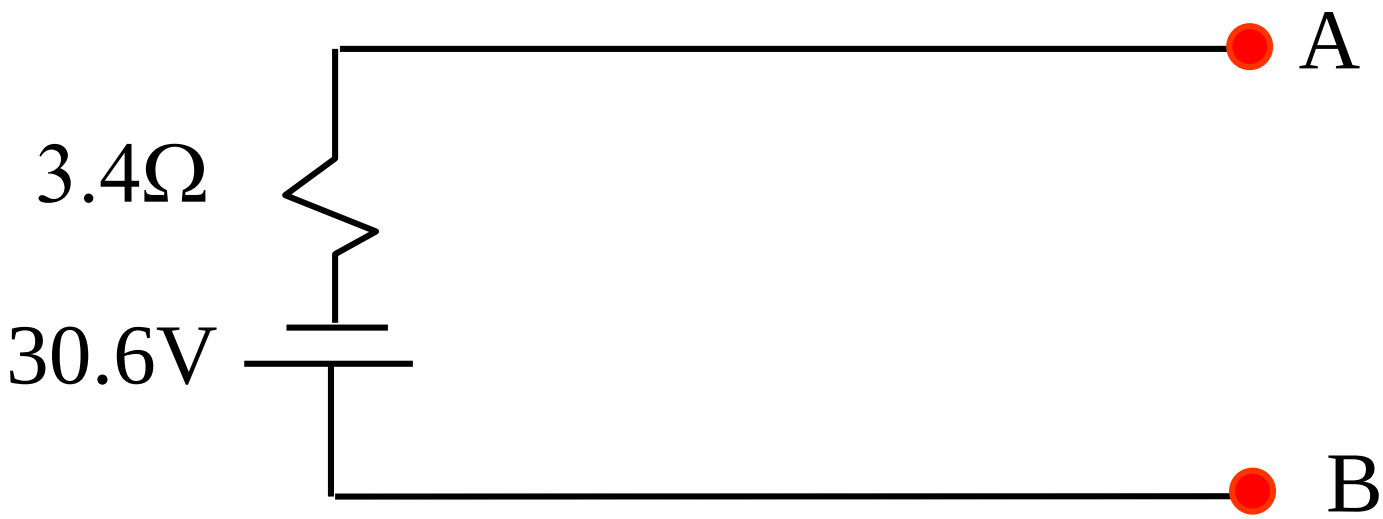
E =1x3 =3 V

Example 1.2



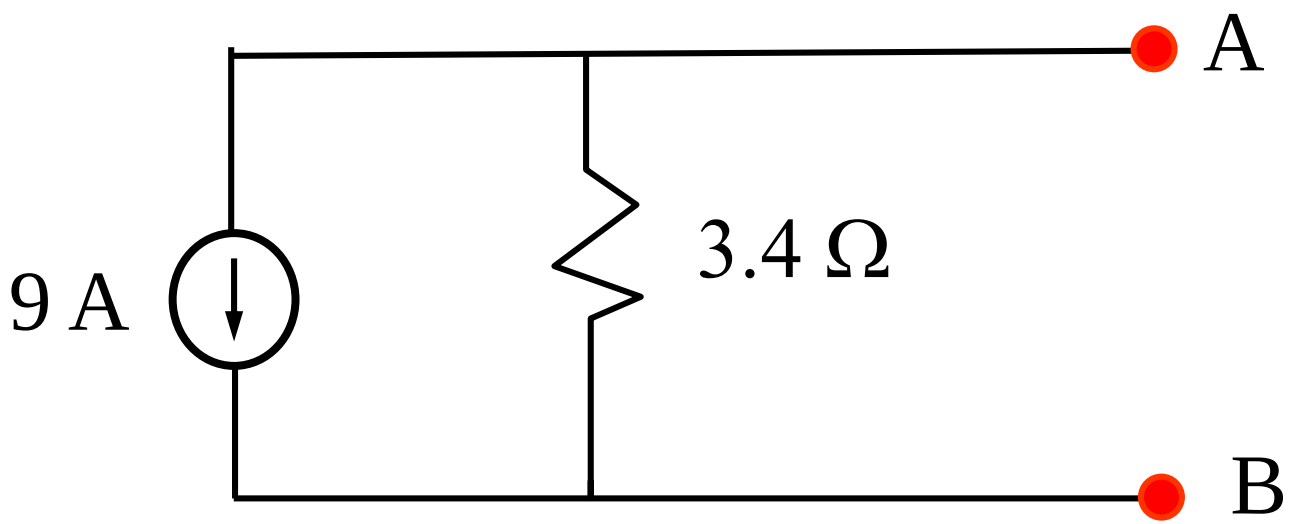
Now these two voltage sources can be combined to form a voltage source of 30.6 V & 3.4 Ω

Example 1.2



This can be the answer if an equivalent voltage source is required.

Example 1.2



This is the final required equivalent current source

…next topic

Mesh/Loop Analysis

Nurturing Curious Minds, Producing Passionate Engineers

Lee M L
Office: T12A522
School of EEE
Tel: 6879-0657