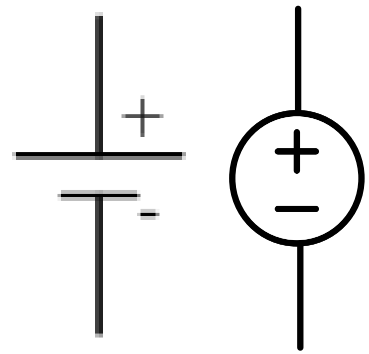
Energy Sources

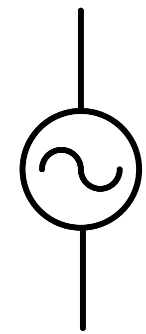
- ILO – Day4
  - Classify energy sources
    - Voltage source
    - Current source
  - Identify the properties & differences between ideal and practical voltage and current sources
  - Convert voltage source to equivalent current source and vice versa

Energy sources

- In electrical engineering, we mainly concern about two types of energy sources:
  - Voltage sources

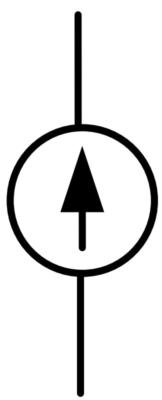


DC source



AC source

  - Current sources



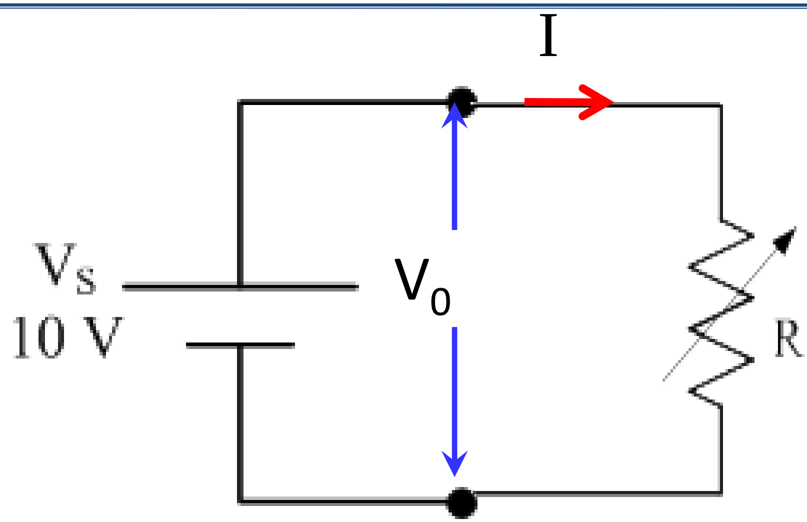
Voltage sources

- Ideal voltage source
- Practical voltage source

<u>Ideal voltage source</u>

- An ideal voltage source can give constant voltage across its output terminals independent of the amount of current flowing out of it.

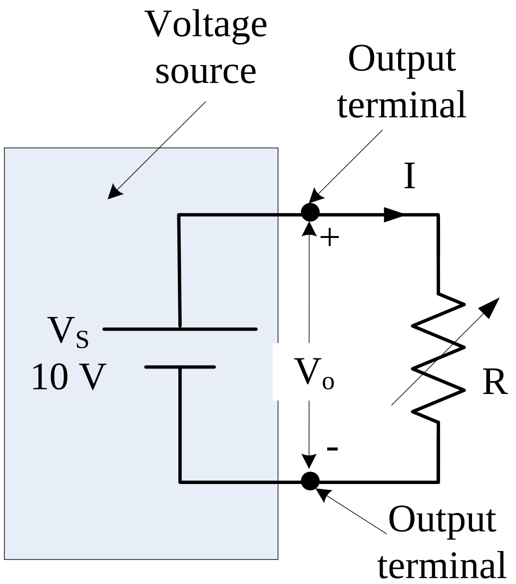
Ideal voltage source



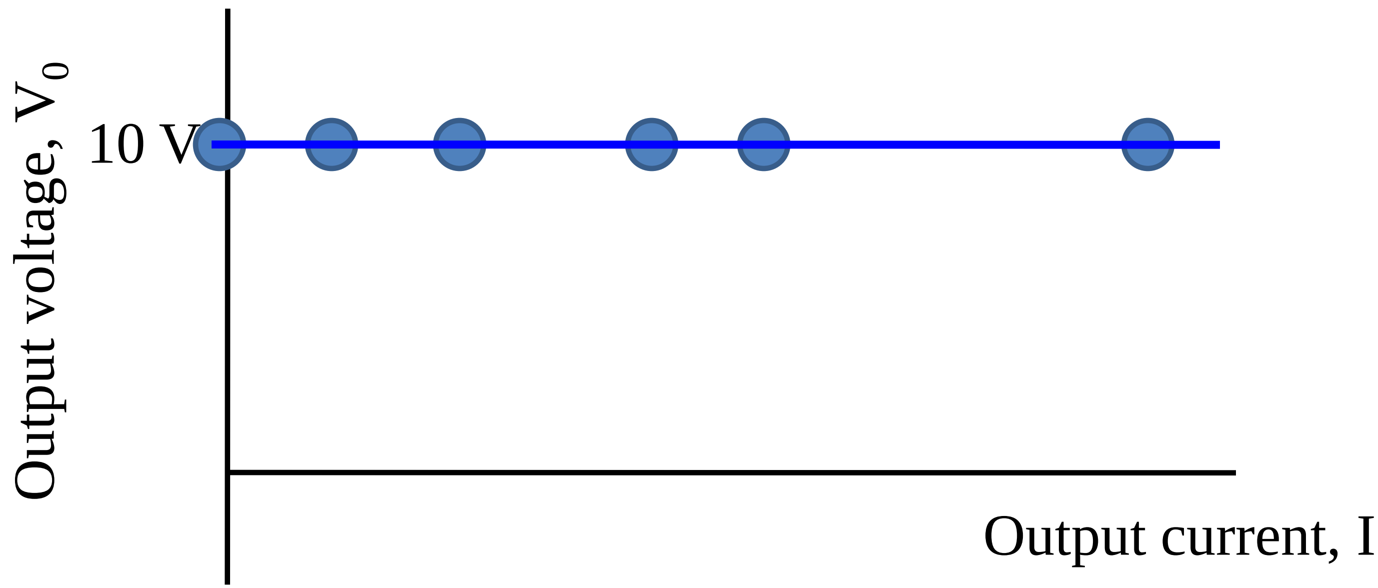
An ideal voltage source can give constant voltage across its output terminals independent of the amount of current flowing out of it.

R (Ω)	I (A)	V_o (V)
Open	0	10
10	1	1x10=10
5	2	2x5=10
2.5	4	4x2.5=10
2	5	5x2=10
1	10	10x1=10

Ideal voltage source



R (Ω)	I (A)	V_o (V)
Open	0	10
10	1	1x10 = 10
5	2	2x5 = 10
2.5	4	4x2.5 = 10
2	5	2x5 = 10
1	10	10x1 = 10



Practical voltage source

- In real world, when voltage sources are used in practice, they are never ideal

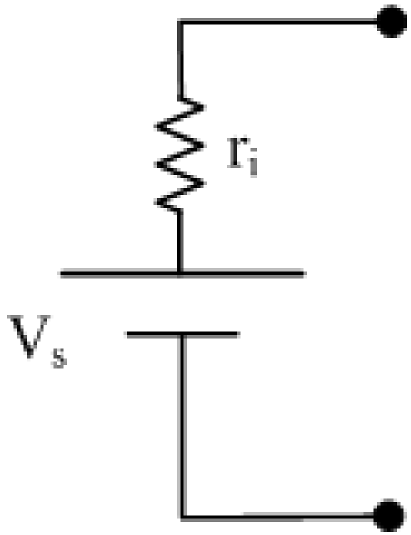
- Such a voltage source cannot provide constant voltage across its output terminals when the current flowing out of the source changes

- This is due to some voltage drop that takes place inside the voltage source due to its internal resistance

- Internal resistance cannot be avoided in practical sources.

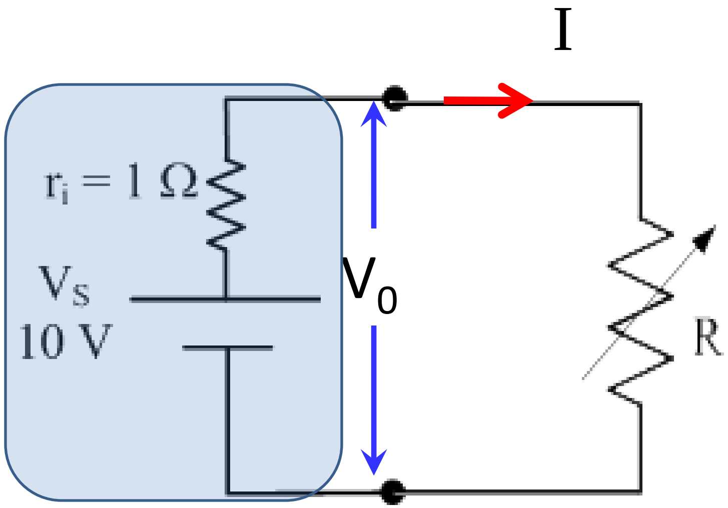
Practical voltage source

- A practical voltage thus is represented by an ideal voltage source, in **series** with its internal resistance
  - (which is shown as external to the source)



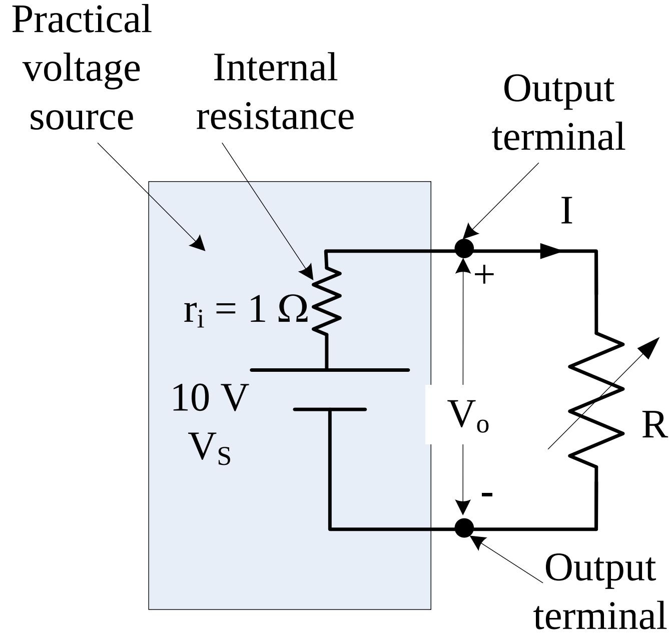
- A practical voltage source has its output terminal voltage reduced as the current flowing out of it is increased
- This drop is due to voltage that is lost in its internal resistance

Practical voltage source



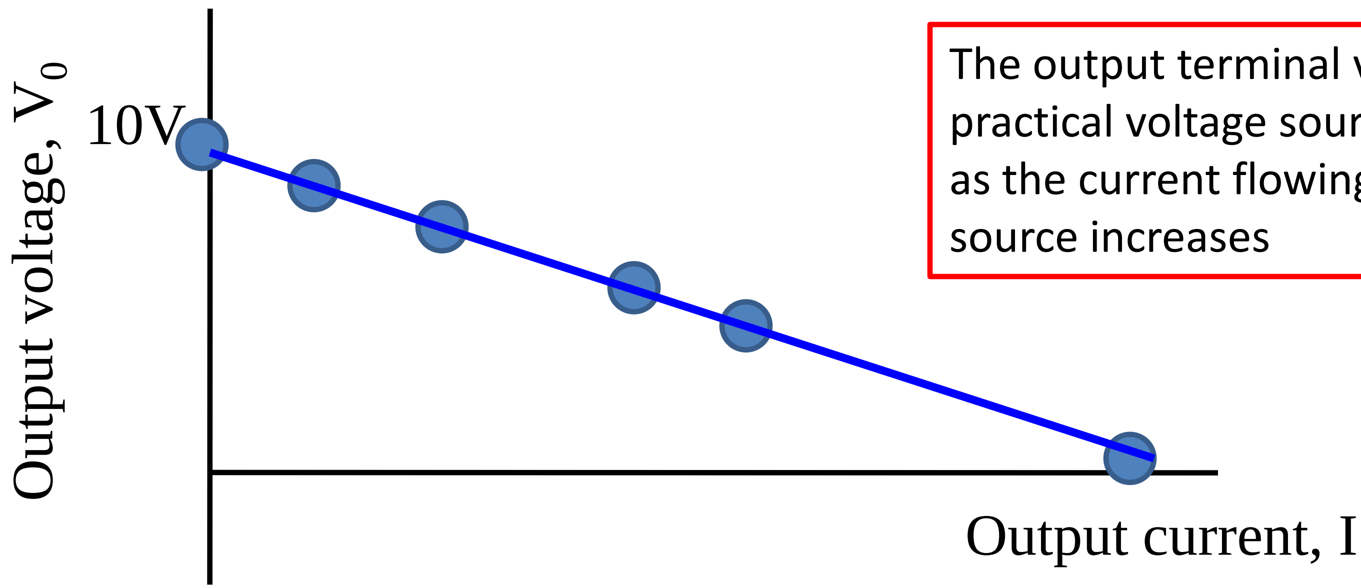
As current flows out of the source, there is always a voltage drop across the internal resistance r_i before the voltage is available across the output terminals.

R (Ω)	I (A)	V_o (V)
Open	0	10
9	1	1x9=9
4	2	2x4=8
1.5	4	4x1.5=6
1	5	5x1=5
0	10	10x0=0



Practical voltage source

R (Ω)	I (A)	V_o (V)
Open	0	10
9	1	1x9 = 9
4	2	2x4 = 8
1.5	4	4x1.5 = 6
1	5	5x1 = 5
0	10	10x0 = 0



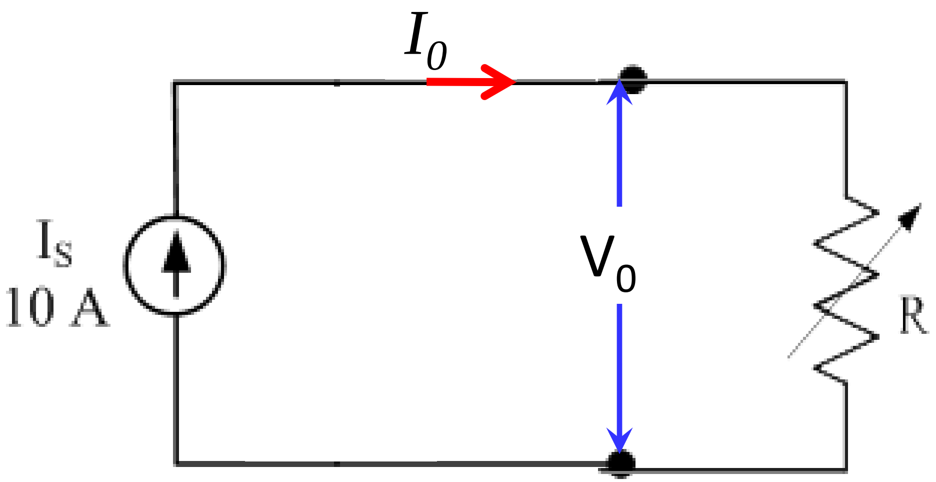
The output terminal voltage of a practical voltage source thus **drops** as the current flowing out of the source increases

Current sources

- Ideal current source
- Practical current source

<u>Ideal current source</u>

- An ideal current source can give constant current at its output independent of the output voltage.

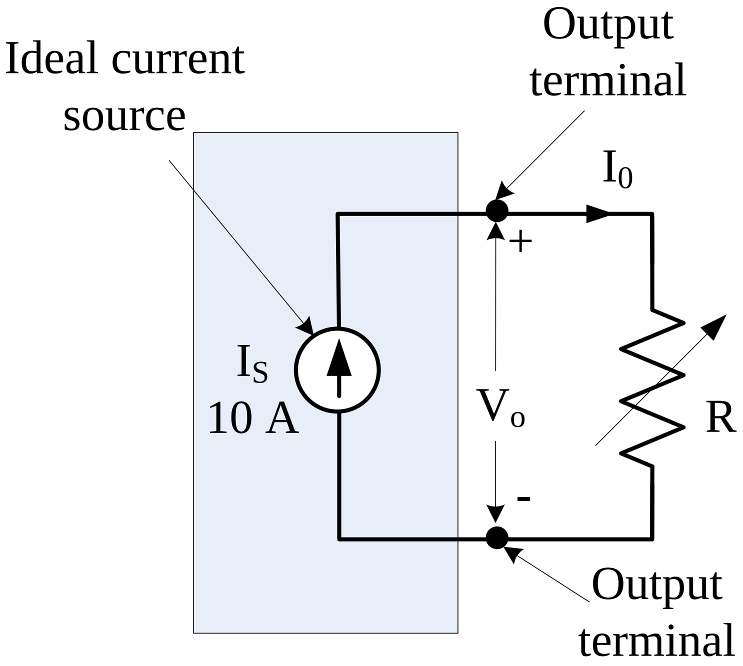


Ideal current source

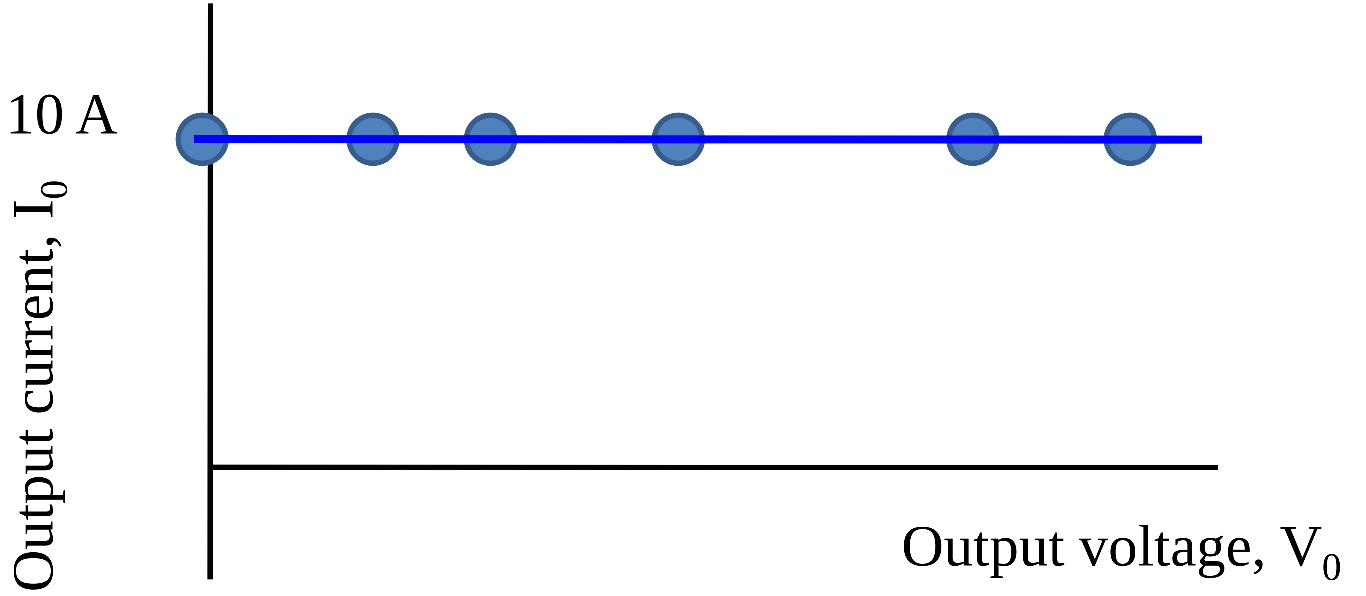
An ideal current source can give constant current at its output independent of the output voltage

R (Ω)	I_0 (A)	V_o (V)
0	10	0
2	10	20
3	10	30
5	10	50
8	10	80
10	10	100

Ideal current source



R (Ω)	V_o (V)	I_0(A)
0	0	10
2	20	10
3	30	10
5	50	10
8	80	10
10	100	10

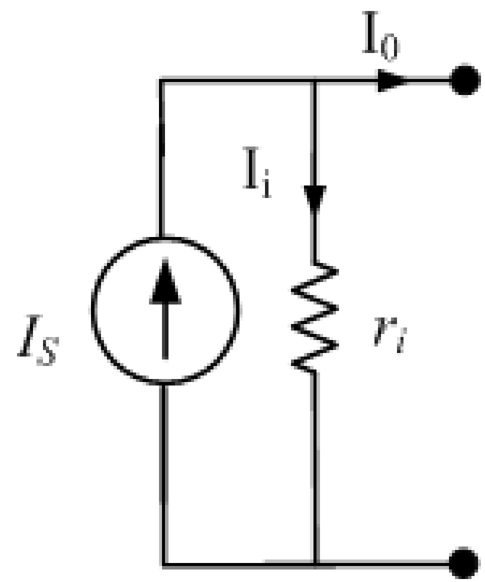


Practical current source

- Practical current sources that are used in real world are seldom ideal
- Such a current source cannot provide constant current at its output when its output terminal voltage changes
- This is due to presence of some internal resistance within the current source
- The internal resistance absorbs some portion of the source current before the current can flow out to the external load.

Practical current source

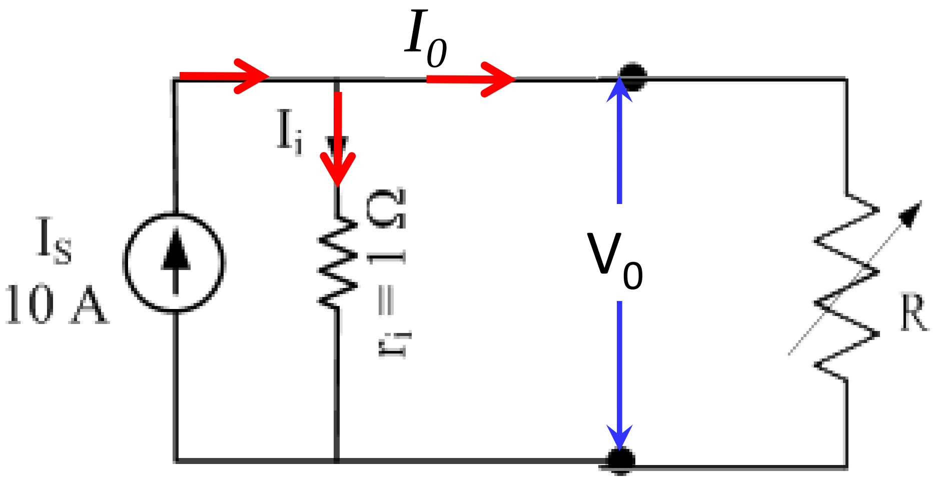
- A practical current is represented by an ideal current source, in **parallel** with its internal resistance
  - (which is shown as external to the source)



$$I_0 = I_S - I_i$$

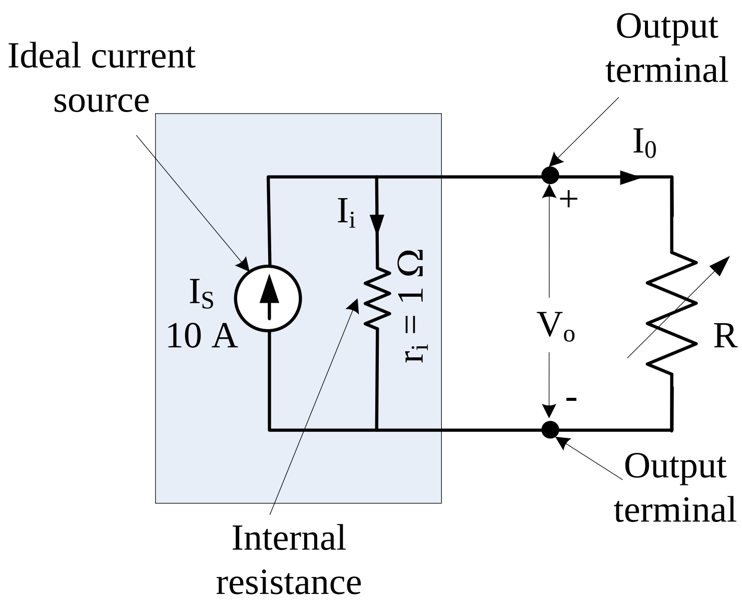
- A practical current source has its output load current I_0 reduced as its terminal voltage is increased
- This is due to a current component I_i that branches out through its internal resistance.

Practical voltage source



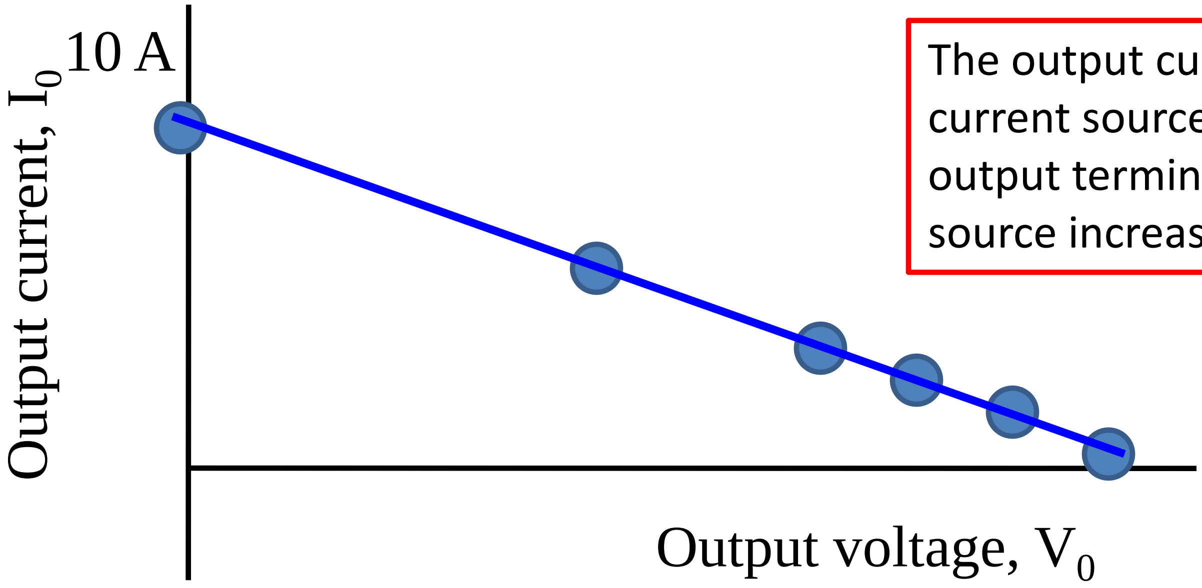
As current flows out of the source, there is always a component that is bypassed through the internal resistance

R (Ω)	I_i (A)	I_0(A)	V_o (V)
0	0	10	0
1	5	5	5
3	7.5	2.5	7.5
4	8	2	8
9	9	1	9
Open	10	0	10



Practical current source

R (Ω)	V_o (V)	I_0(A)
0	0	10
1	5	5
3	7.5	2.5
4	8	2
9	9	1
Open	10	0



The output current of a practical current source thus **drops** as the output terminal voltage of the source increases

Source conversion

Relation between current and voltage sources

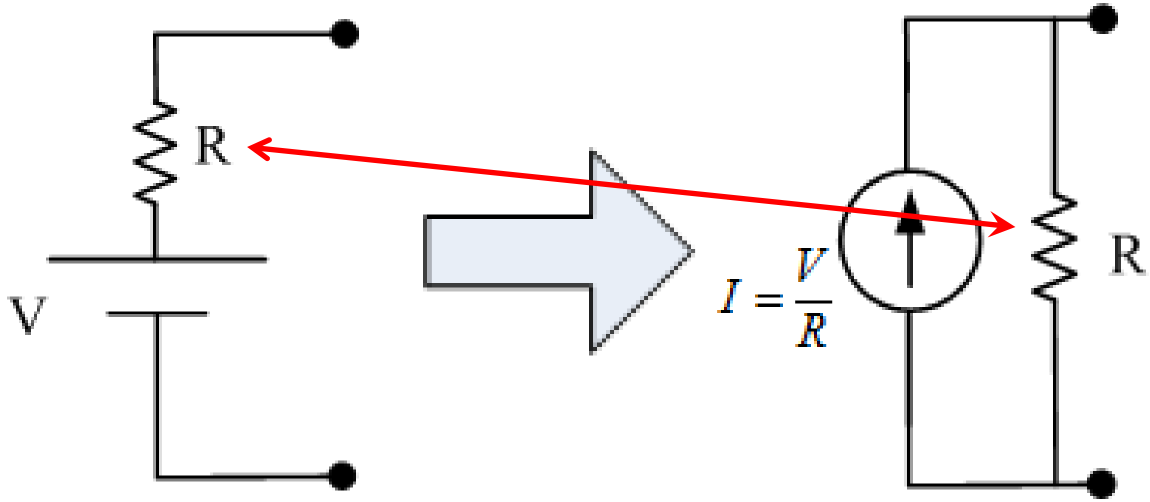
- A practical voltage source with certain internal resistance can be equivalently represented by a practical current source with internal resistance, and vice versa.

- When such source conversions are done, there is practically no effect on the external part of the circuit.

- This means that by converting a voltage source to a current source, or a current source to a voltage source, the output voltage and current of the source as applied to the external circuit remains same.

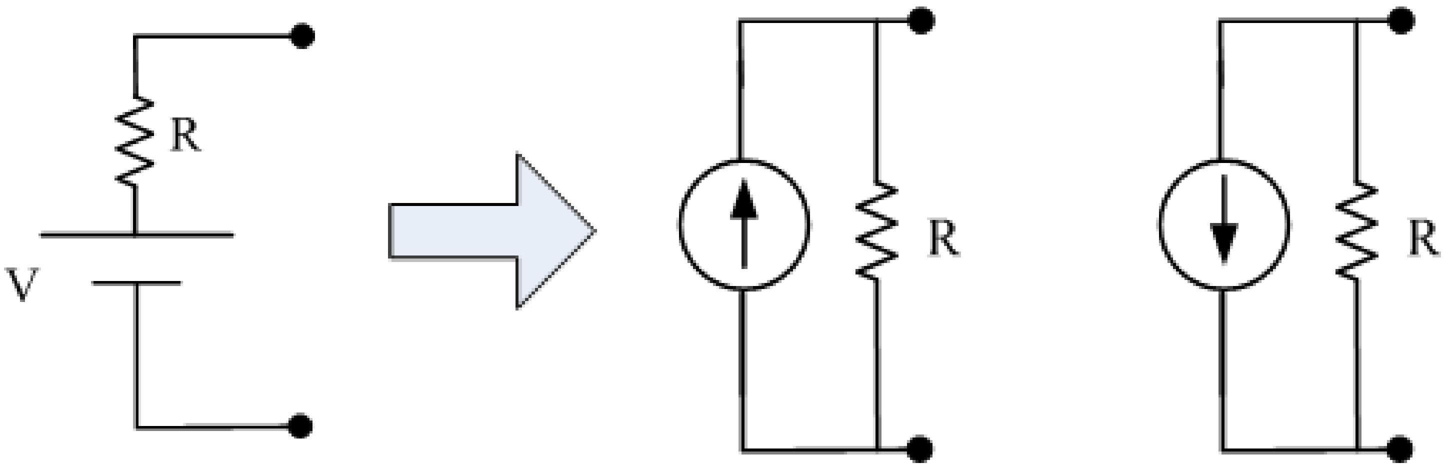
Source conversion

- A voltage source of
  - Value *V*
  - in series with a resistance *R*
- Can be equivalently converted to a current source of
  - Value $I = \frac{V}{R}$
  - in parallel with the same resistance *R*



$$\boxed{V = IR \Rightarrow I = \frac{V}{R}}$$

Source conversion



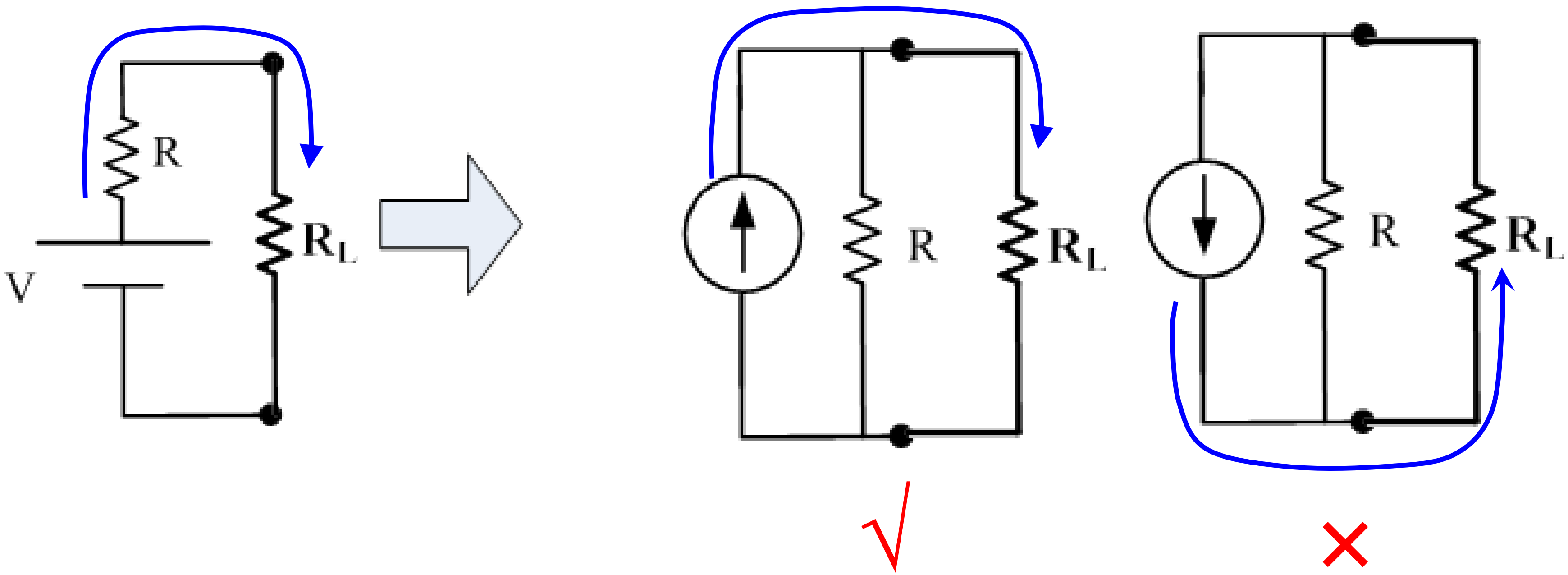
Value of the current source?

$$I = \frac{V}{R}$$

Direction of the current source?

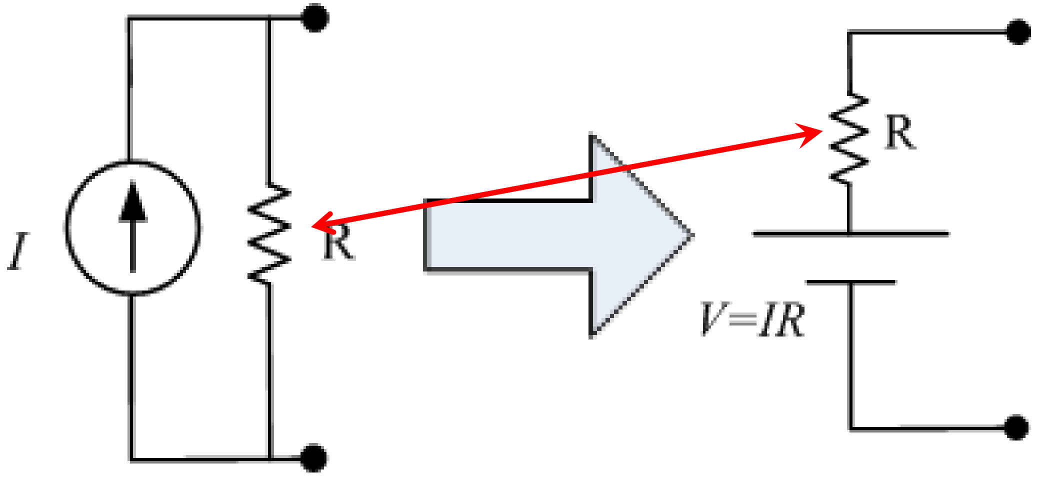
Source conversion

Direction of the equivalent current source should be such that it sends current to the external in a direction that is same as the direction in which current was being sent by the original voltage source.



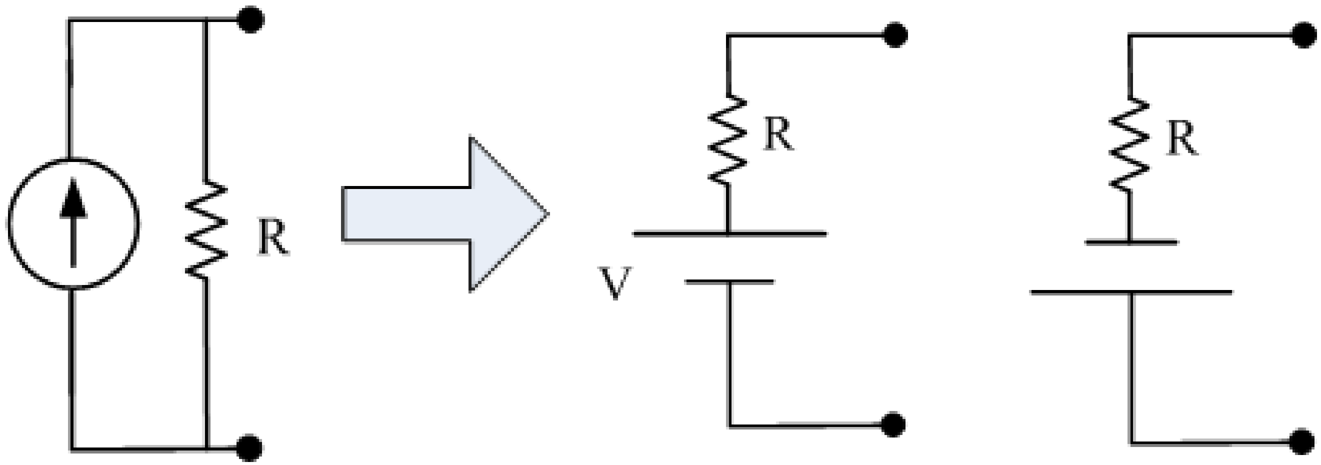
Source conversion

- A current source of
  - Value *I*
  - in parallel with a resistance *R*
- Can be equivalently converted to a voltage source of
  - Value $V = IR$
  - in series with the same resistance *R*



$\boxed{V = IR}$

Source conversion



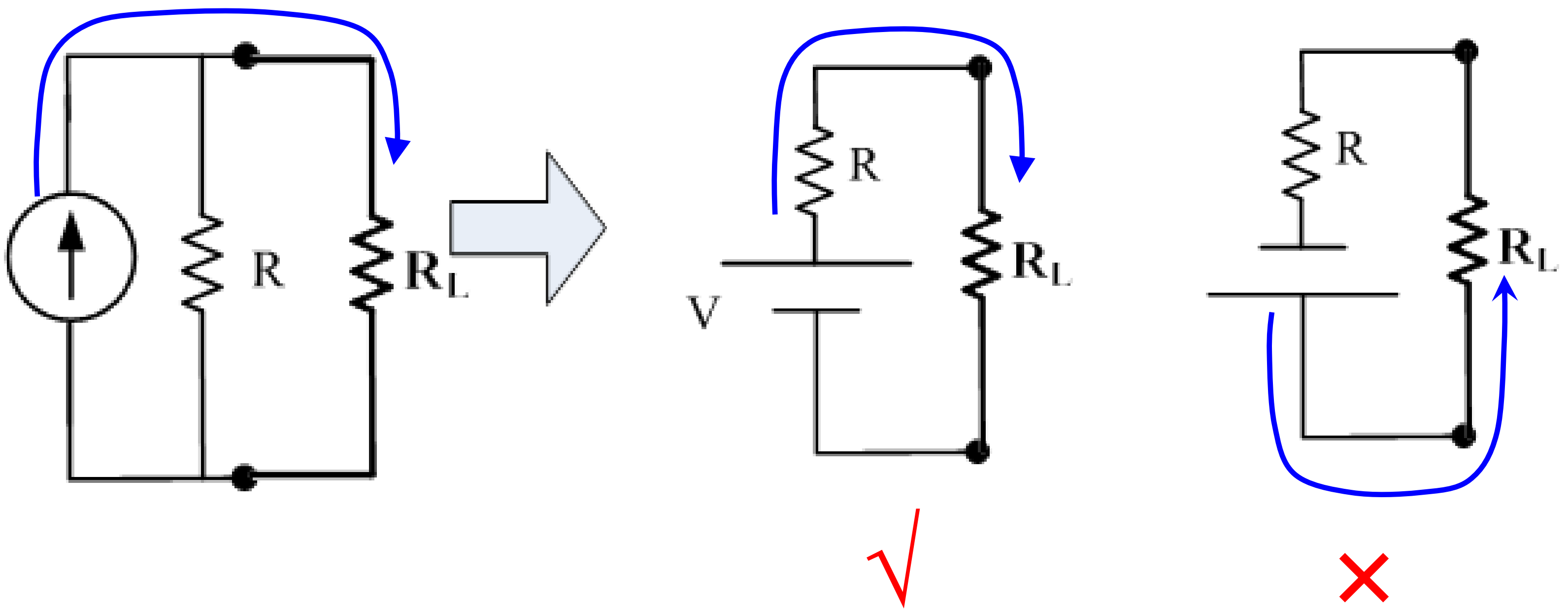
Value of the voltage source?

$$V = IR$$

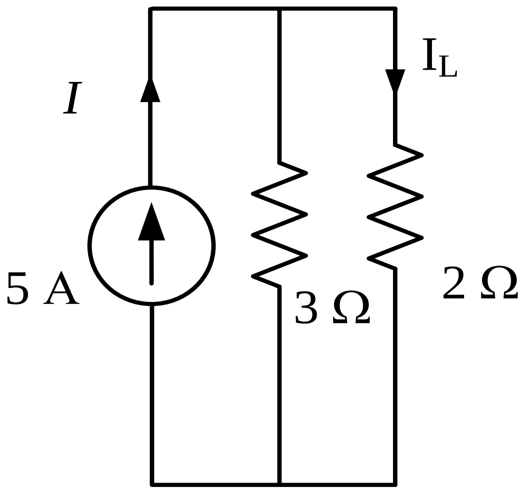
Direction (polarity) of the voltage source?

Source conversion

Polarity of the equivalent voltage source should be such that it sends current to the external in a direction that is same as the direction in which current was being sent by the original current source.

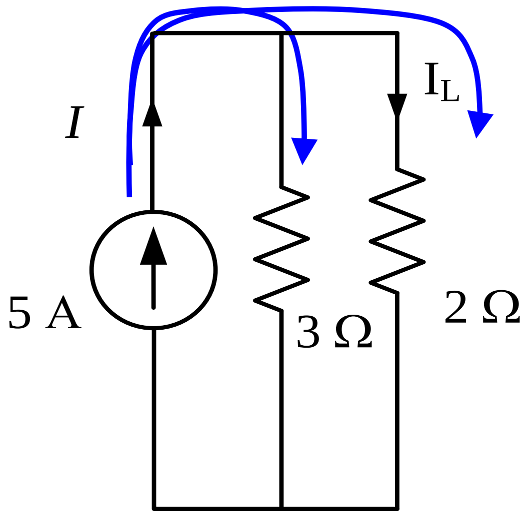


Find current in the 2Ω resistance. Verify the result using source transformation



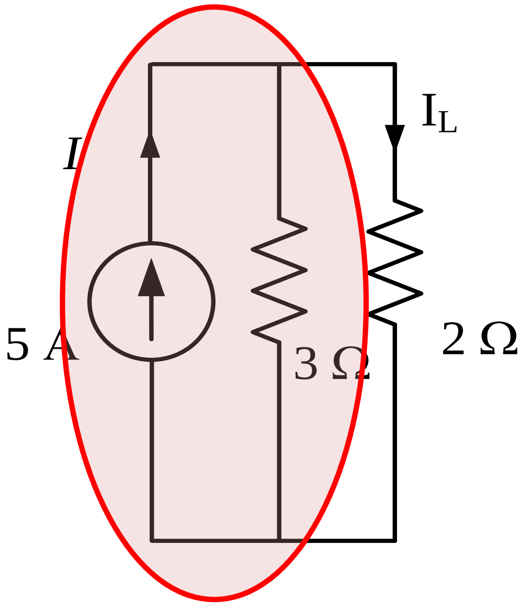
Find current in the 2Ω resistance. Verify the result using source transformation

Using current division rule, value of the current passing through the 2 Ω load resistance is calculated as:



$$I_L = 5 \times \frac{3}{2+3} = \frac{15}{5} = 3\ A$$

Find current in the 2Ω resistance. Verify the result using source transformation



Now we convert the 5 A current source with 3 Ω resistance in parallel, into an equivalent voltage source of value:

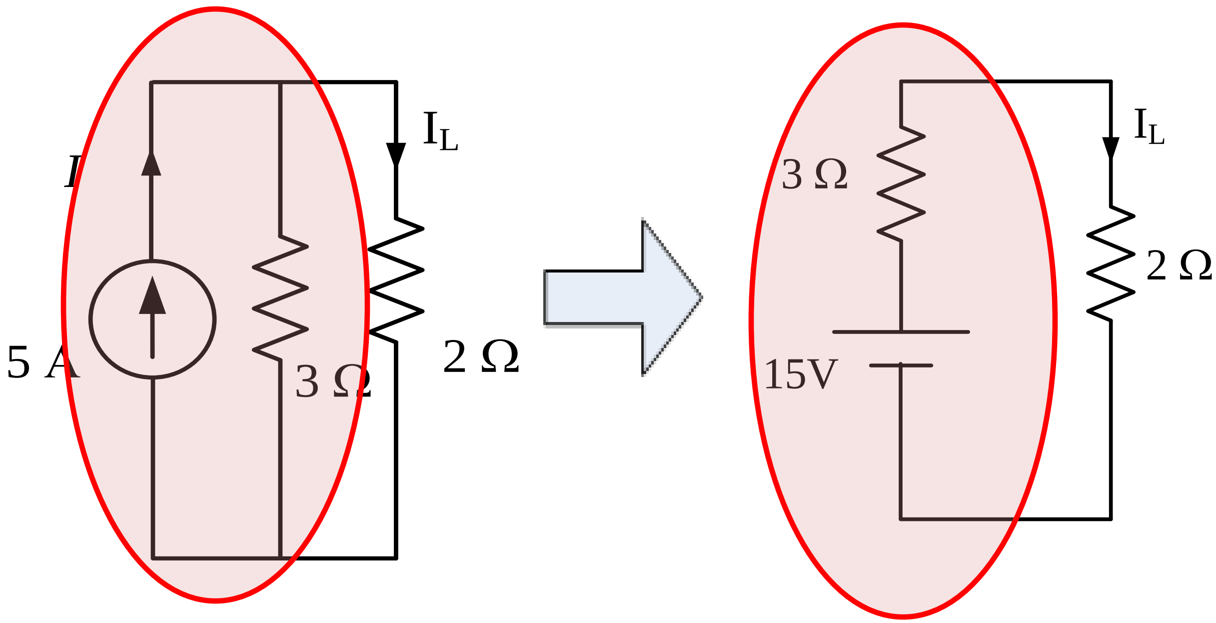
V = IR = 5 x 3 = 15 V

In series with the same resistance 3 Ω

Don't do anything with the load resistance (2 Ω)

Find current in the 2Ω resistance. Verify the result using source transformation

Converting current source to voltage source:



$\therefore$ Current in the 2 Ω resistance: $I_L = \dfrac{15}{3+2} = \dfrac{15}{5} = 3\,A$

Thus, result is verified.