MALVINO & BATES

Electronic PRINCIPLES

SEVENTH EDITION

Chapter 1

Introduction

Topics Covered in Chapter 1

- Three kinds of formulas
- Approximations
- Voltage sources
- Current sources
- Thevenin's Theorem
- Norton's Theorem
- Troubleshooting

Three kinds of formulas

The definition: Invented for a new concept

$$C = \frac{Q}{V}$$

{defines what capacitance is}

{does not require verification}

The law: Summarizes a relationship that exists in nature

$$f = K\frac{Q_1 Q_2}{d^2}$$

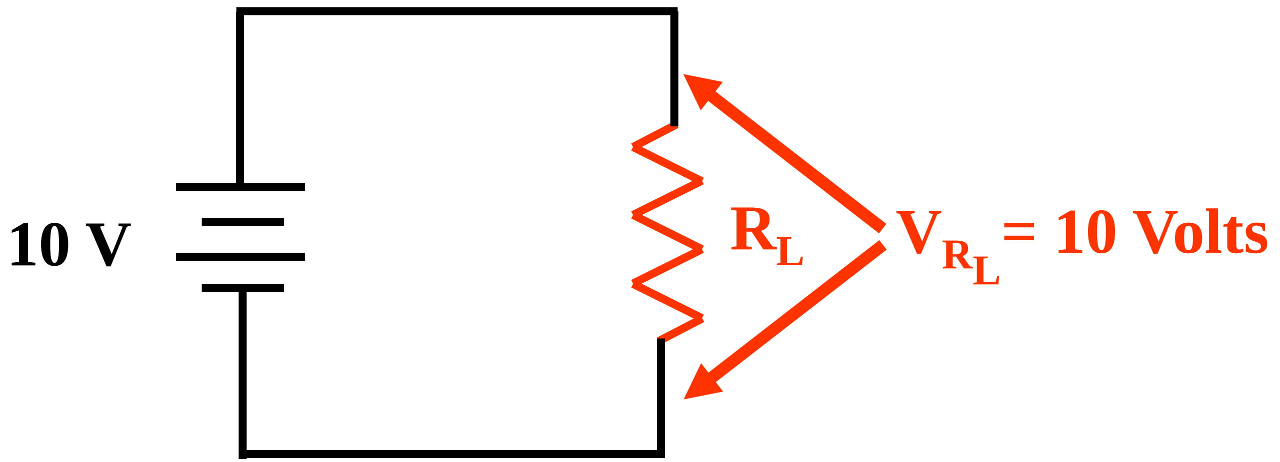
{verified by experiment}

The derivation: Obtained by manipulating other formulas using mathematics

$$Q = CV$$

Ideal voltage source

Maintains a constant output voltage, regardless of the value of R_L.



The ideal model can be called *the first approximation*.

Approximations

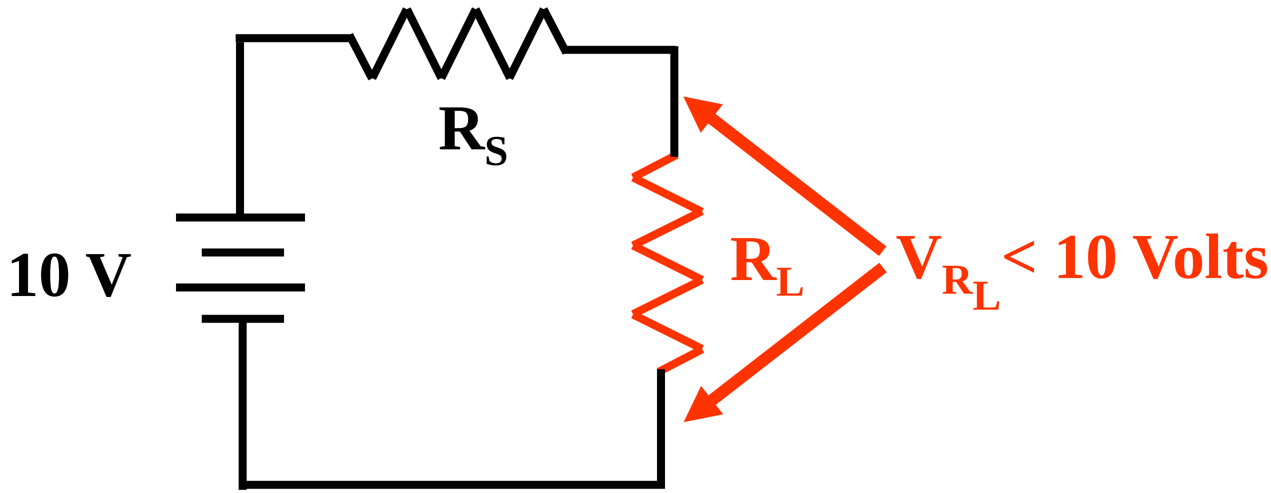
- Widely used in industry
- Useful for troubleshooting
- Useful for circuit calculations

Voltage Sources

- An ideal source has no internal resistance
- The second approximation of a voltage source has internal resistance
- A stiff voltage source has an internal resistance that is 1/100 of load resistance

Real Voltage Source

Has an internal resistance in series with the source

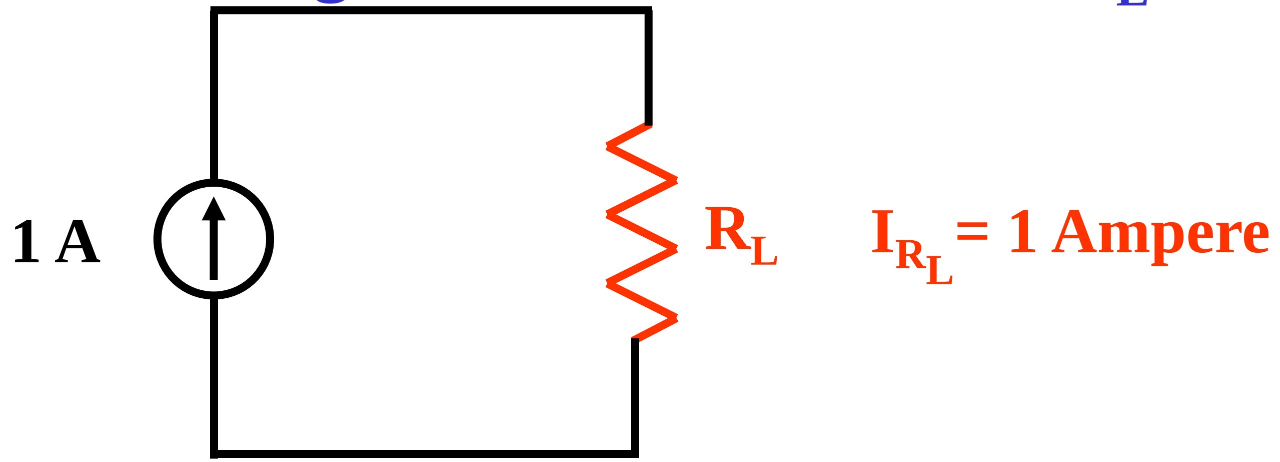


This model is called the *the second approximation*.

When R_L is equal to or greater than 100 times R_S, a real voltage source is *stiff* and the first approximation can be used.

Ideal current source

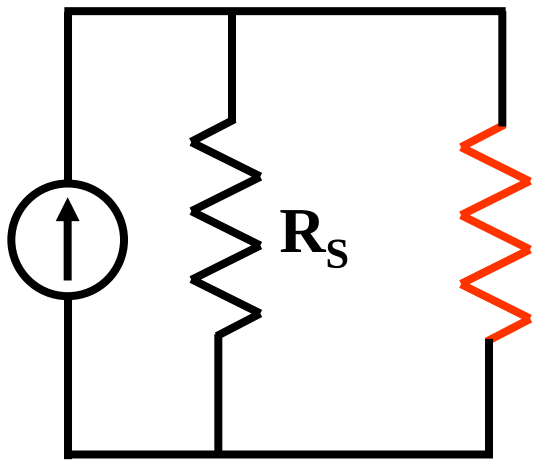
Maintains a constant output current, regardless of the value of R_L.



The ideal model can be called *the first approximation*.

Real current source

Has a large internal resistance in parallel with the source



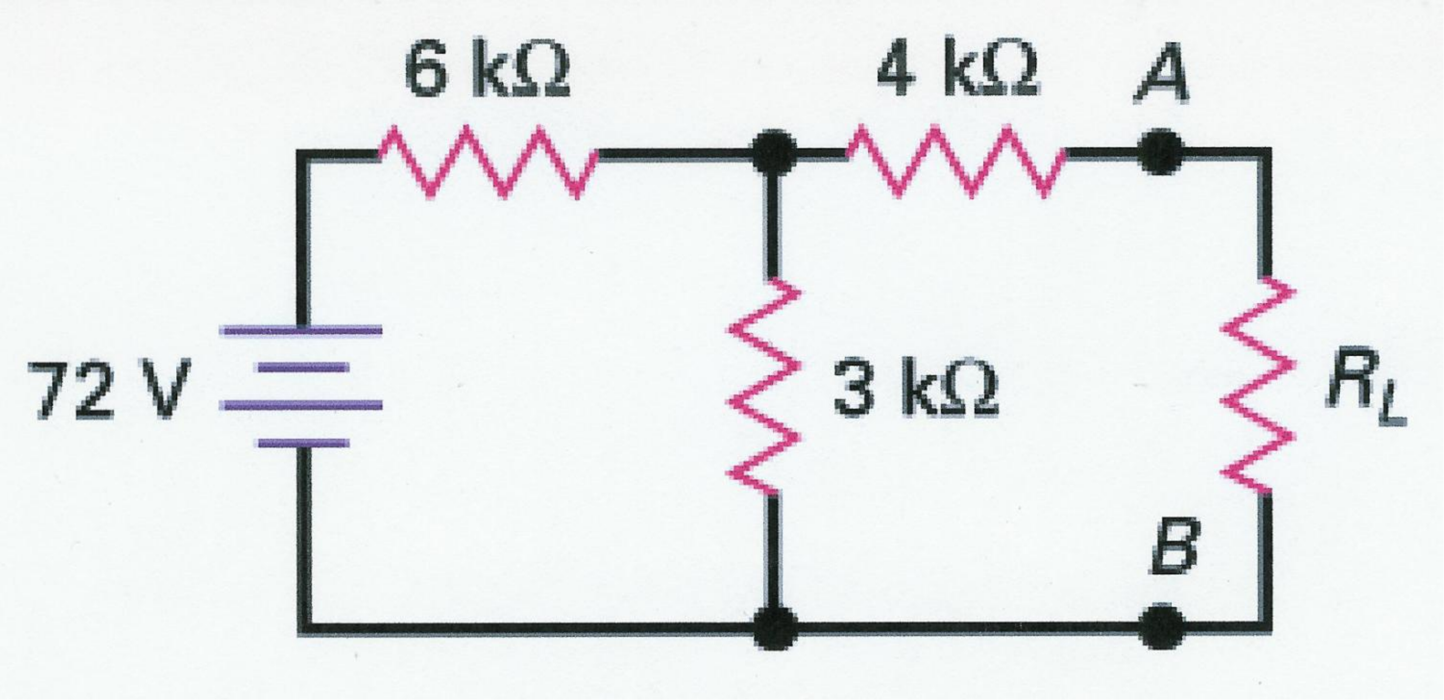
This model is called the *the second approximation*.

When R_S is equal to or greater than 100 times R_L, a real current source is *stiff* and the first approximation can be used.

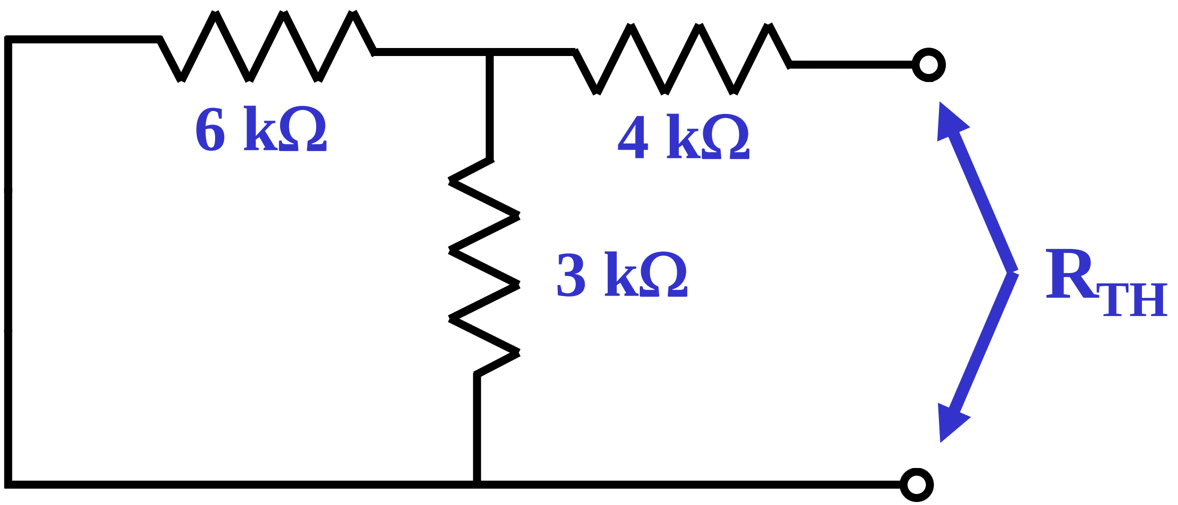
Thevenin's Theorem

- **Used to replace any linear circuit with an equivalent voltage source called V_{TH} and an equivalent resistance called R_{TH}**

Thevenin Example
Original Circuit

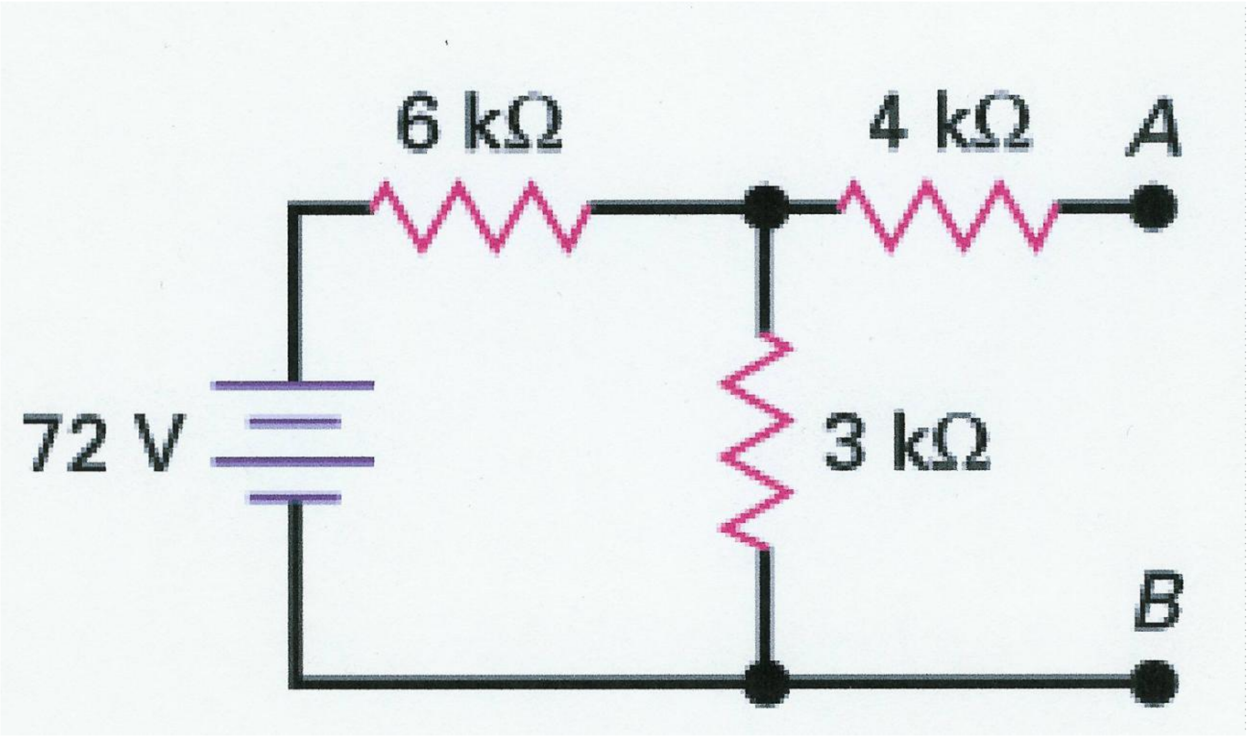


Thevenin's theorem can be used to replace any linear circuit with an equivalent voltage source called V_{TH} and an equivalent resistance called R_{TH}.



Calculate or measure Thevenin's resistance (R_{TH})

Thevenin's Voltage



Voltmeter Tip

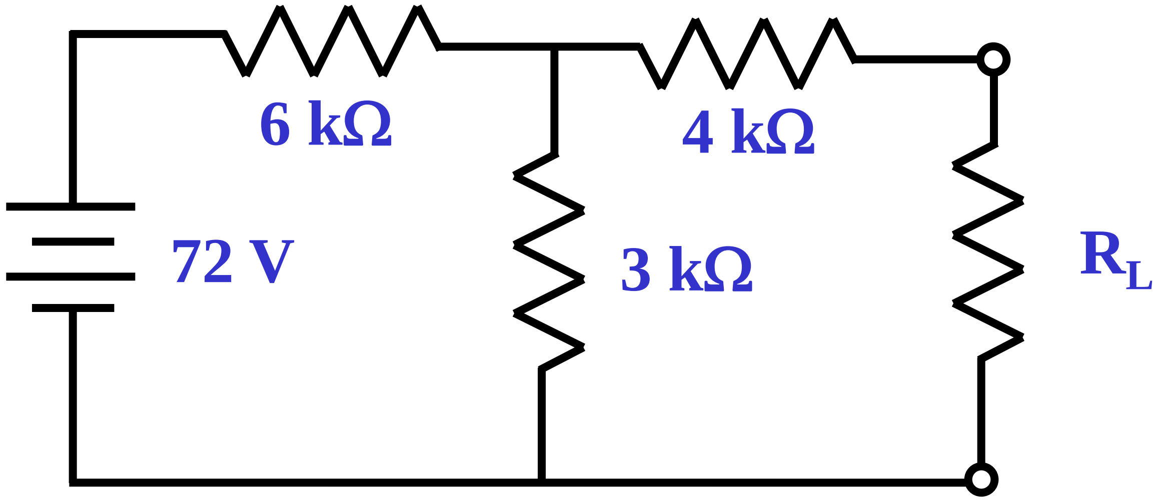
The input impedance of a voltmeter should be at least 100 times greater than the Thevenin resistance to avoid meter loading.

Meter loading errors cause inaccurate measurements.

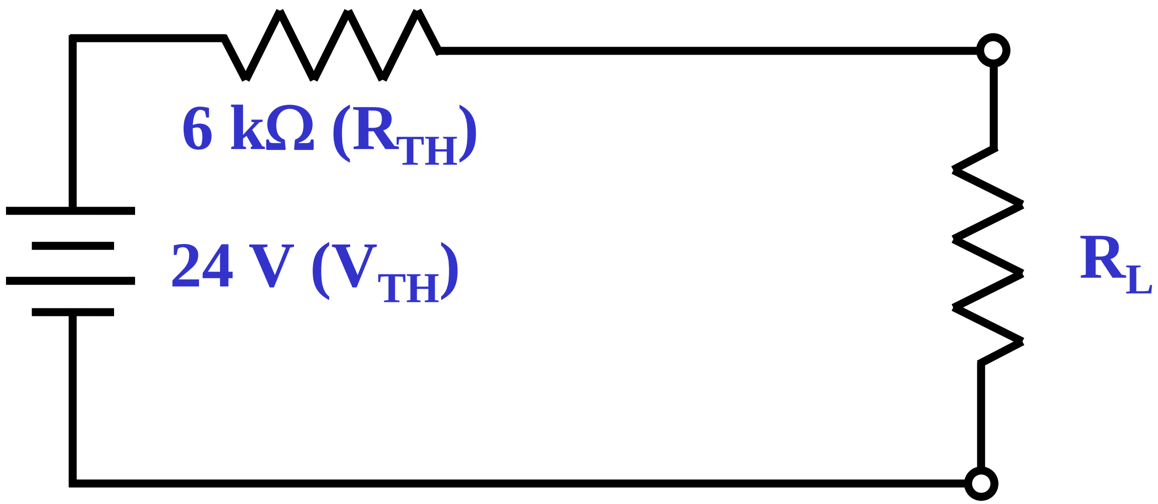
DMMs are usually not a problem since they typically have an input impedance of 10 MΩ.

Thevenin Equivalent Circuit

Original circuit



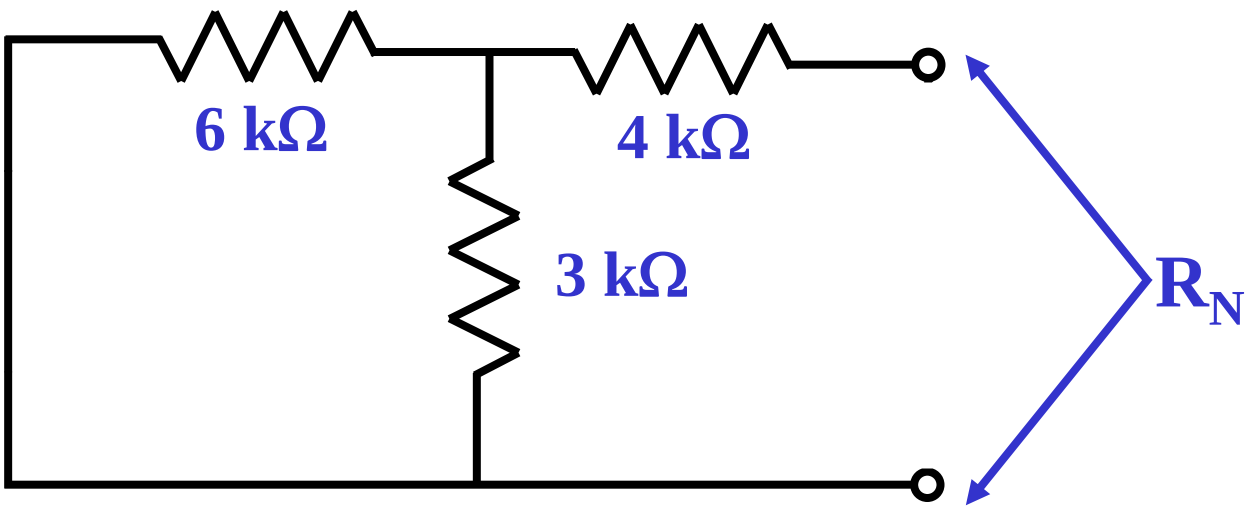
Thevenin equivalent circuit



Norton's Theorem

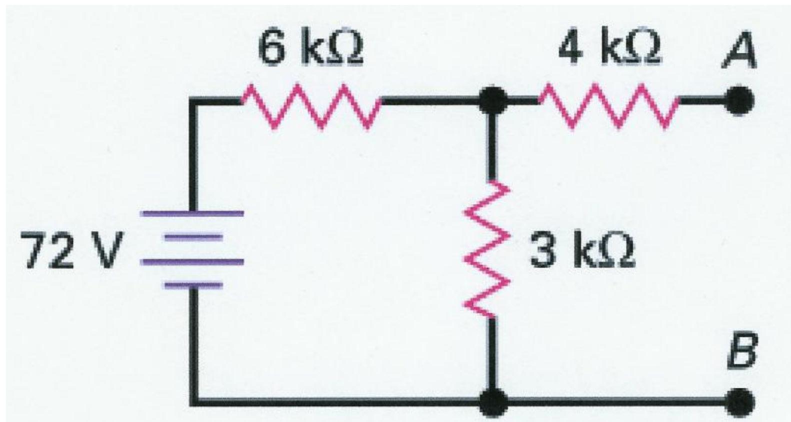
Used to replace any linear circuit with an equivalent current source called I_N and an equivalent resistance called R_N

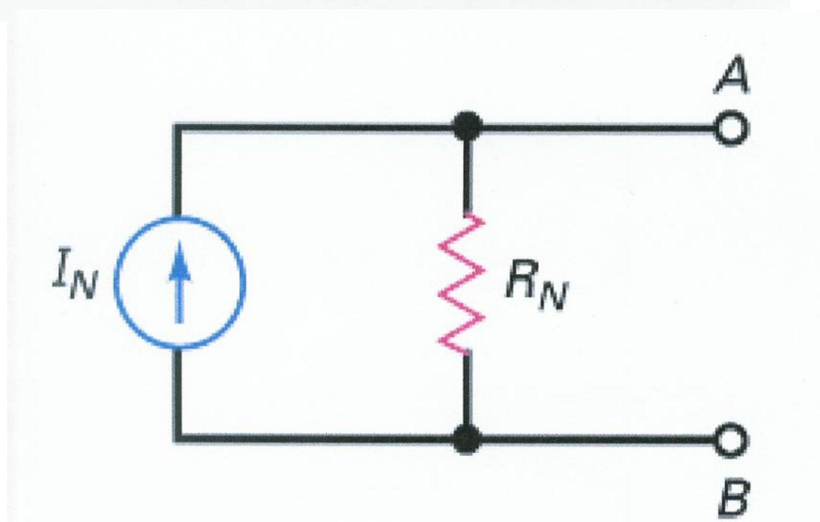
Norton's Resistance



R_N is the same as R_{TH}.

Norton’s Current



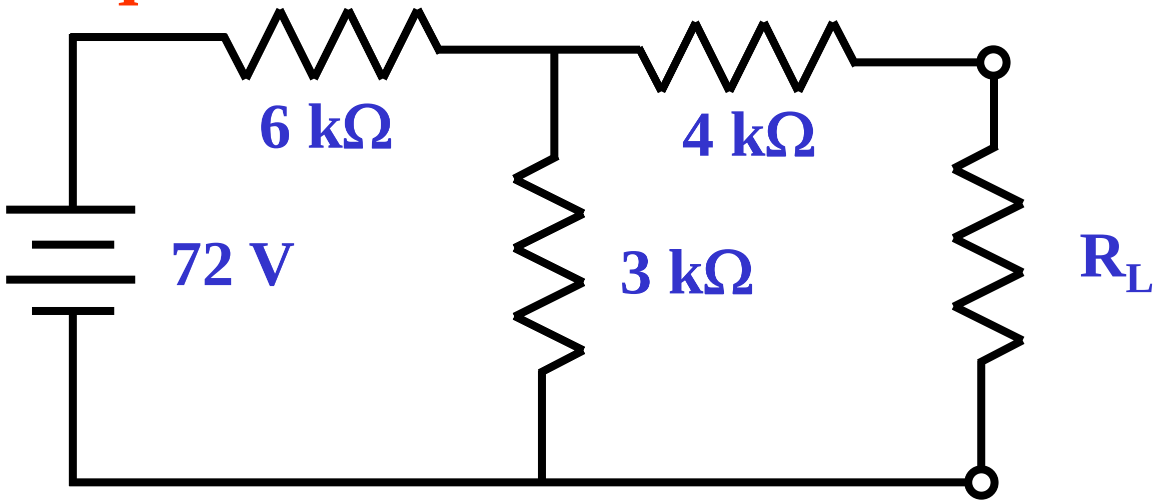


I_N = 4 mA

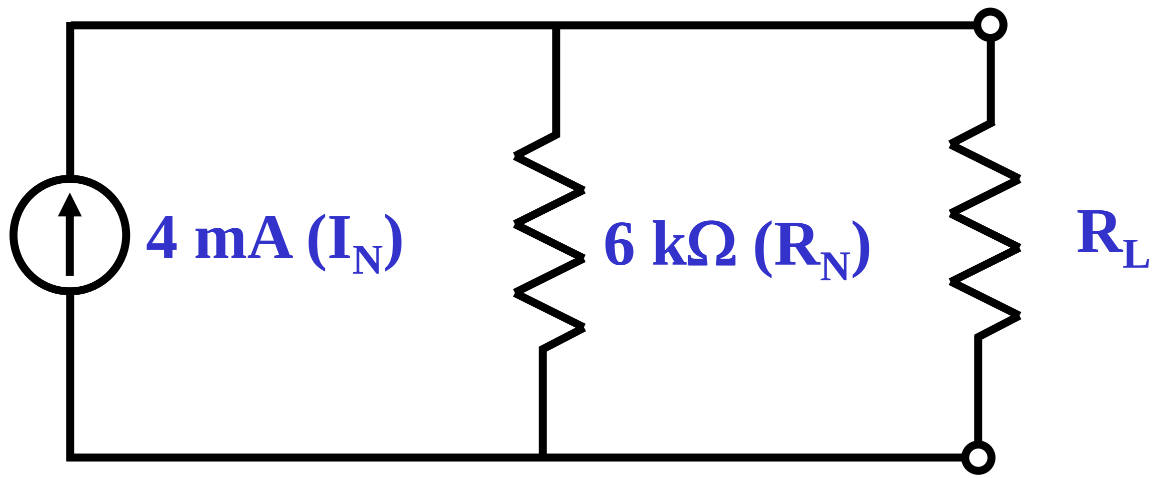
R_N = 6 KΩ

Norton Equivalent Circuit

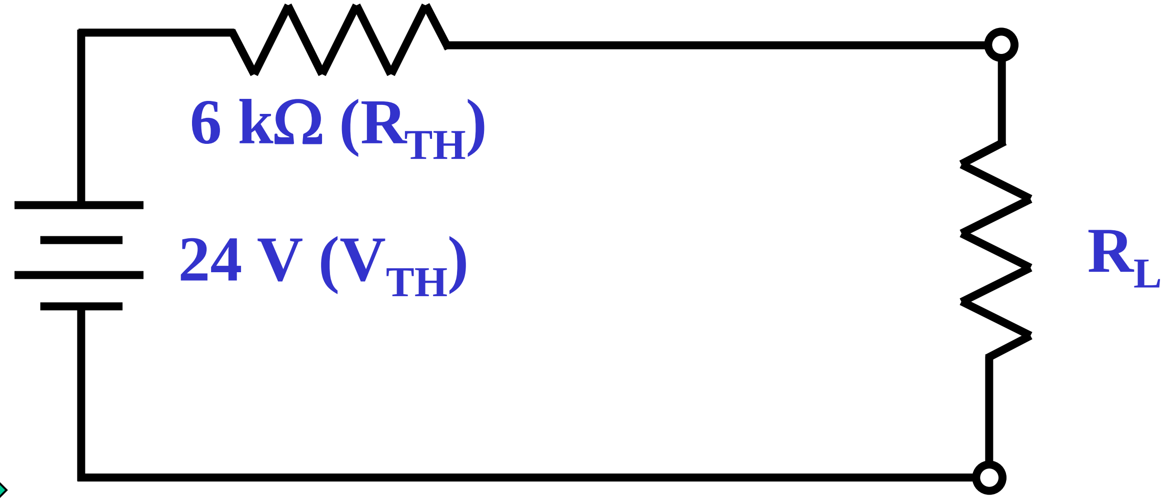
The original circuit



The Norton equivalent circuit



A Thevenin equivalent circuit

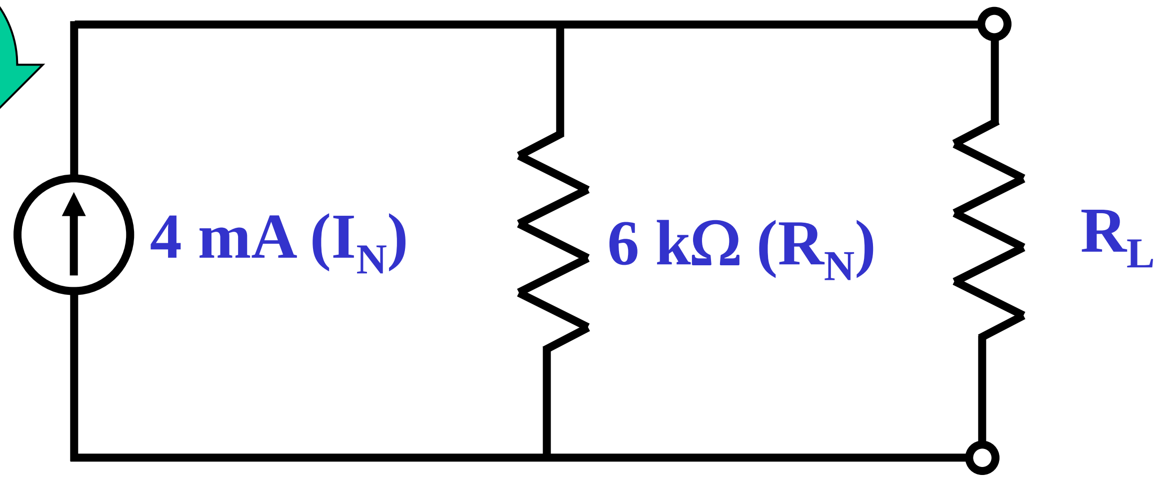


Circuit Conversion

$$R_N = R_{TH}$$

$$I_N = \frac{V_{TH}}{R_{TH}}$$

The Norton *dual*



Solder and Connector Problems

- A solder bridge between two lines effectively shorts them together.
- A cold solder joint is effectively an open circuit.
- An intermittent trouble is one that appears and disappears (could be a cold solder joint or a loose connection).

Troubleshooting

- Finding out why a circuit is not doing what it is supposed to do
- Common problems are opens and shorts

An open device

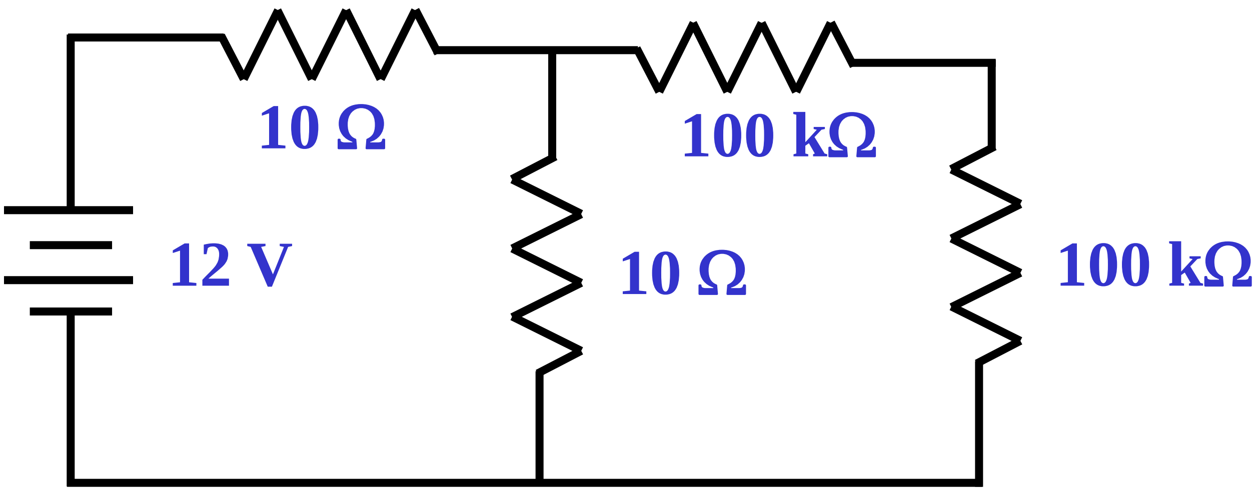
- The current through it is zero.
- The voltage across it is unknown.
- V = zero x infinity {indeterminate}

A shorted device

- The voltage across it is zero.
- The current through it is unknown.
- I = 0/infinity {indeterminate}

A troubleshooting example:

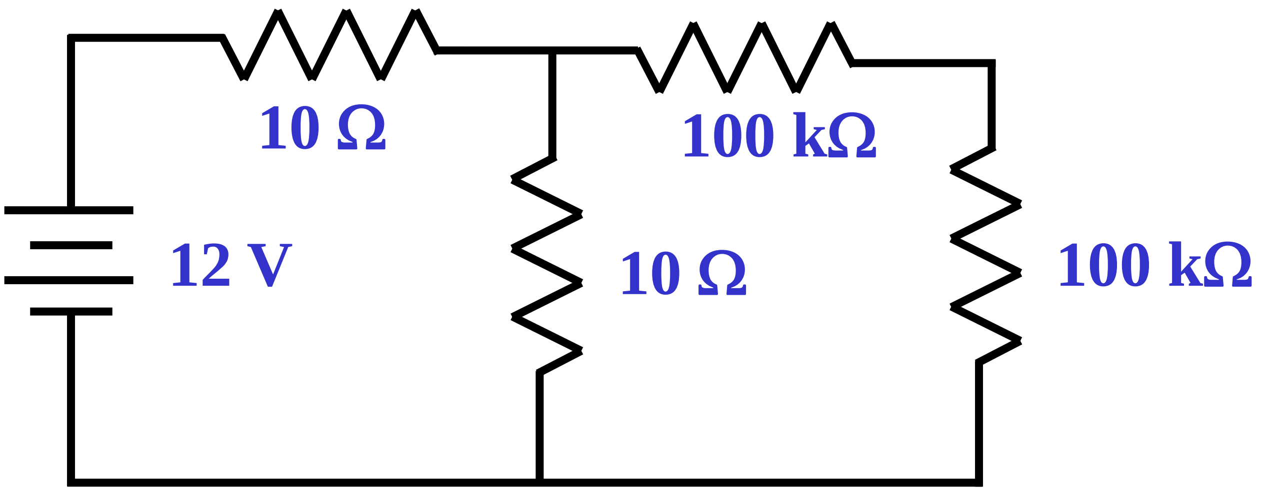
Do the two 10 Ω resistors form a *stiff* voltage divider?



Why?

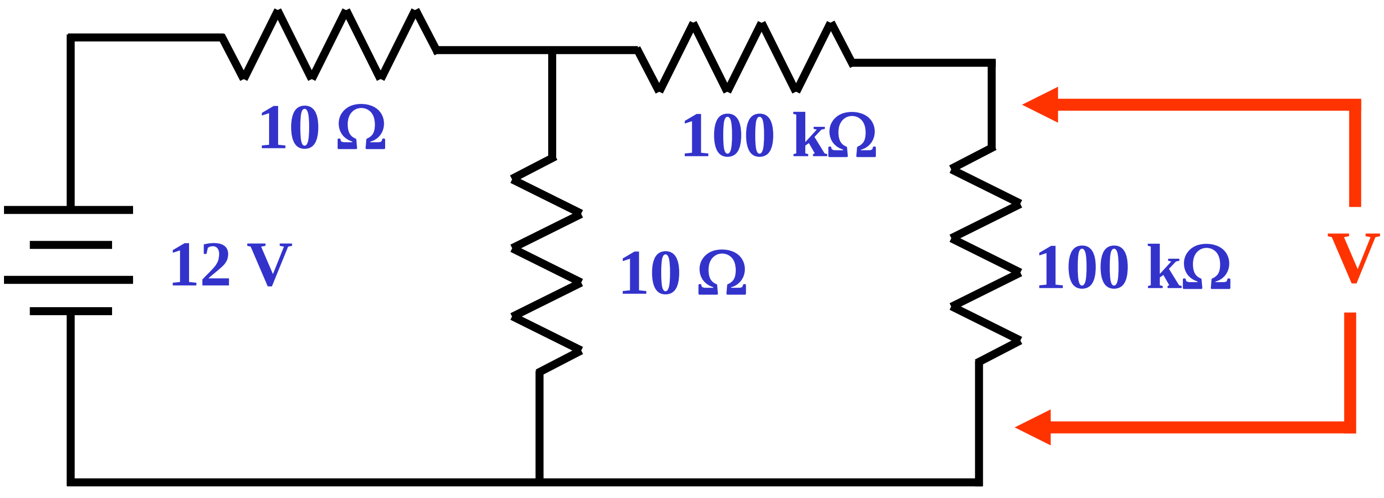
A troubleshooting example:

What are the expected voltages in this circuit?



A troubleshooting example:

What are some causes for this voltage (V) being too high?



A troubleshooting example:

What are some causes for this voltage (V) being too low?