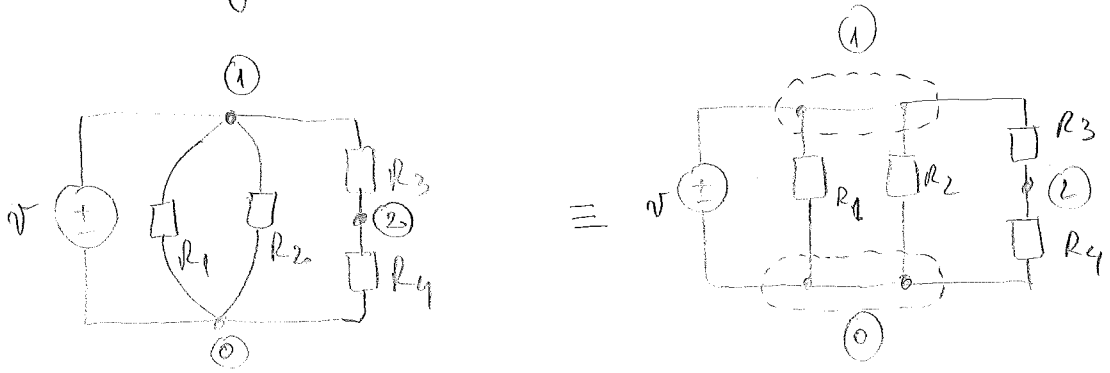
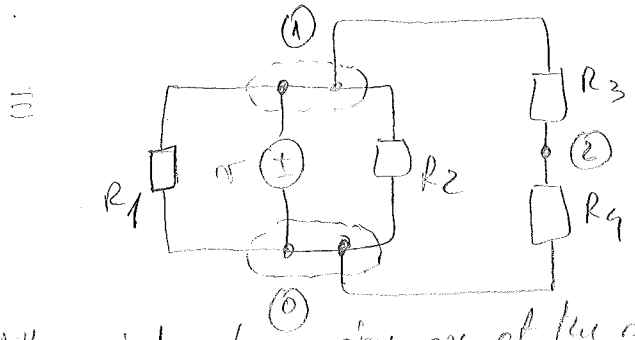
Nodes and branches in electric circuits

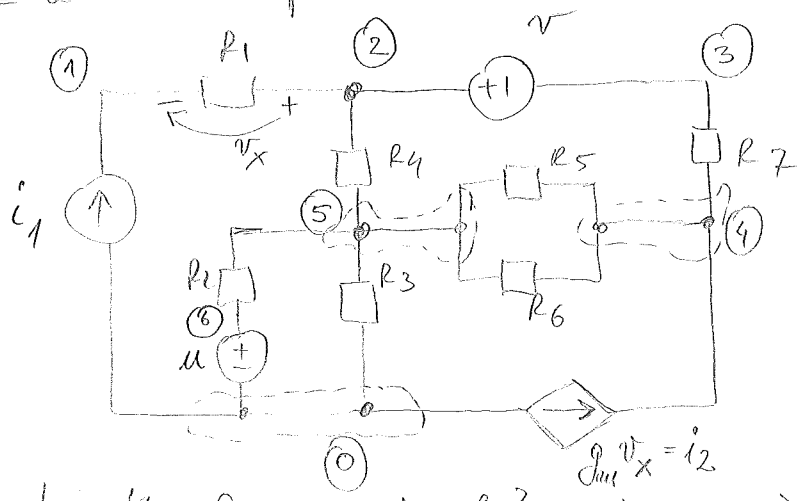
- A node $\triangleq$ a point at which 2 or more elements have a common connection.
- A branch $\triangleq$ a single element and its 2 terminals.





Note: All points of a wire are at the same potential. Also, all current entering one end of a wire exits at the other end.

- A path $\triangleq$ a sequence of branches.
- A loop $\triangleq$ a closed path.

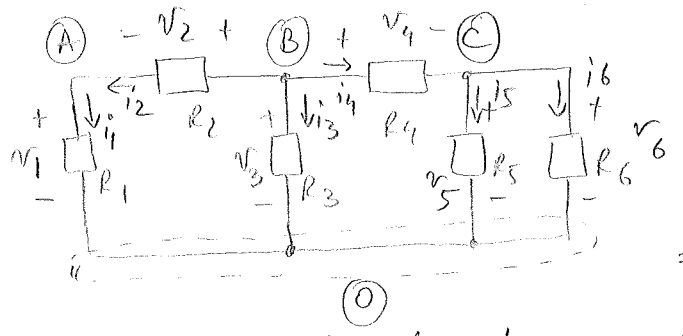


Example paths: $\{v, R_7, i_2, i_1\}$, $\{R_4, R_3\}$

Example loops: $\{v, R_7, i_2, R_3, R_4\}$, $\{i_1, u, R_2, R_4, R_1\}$

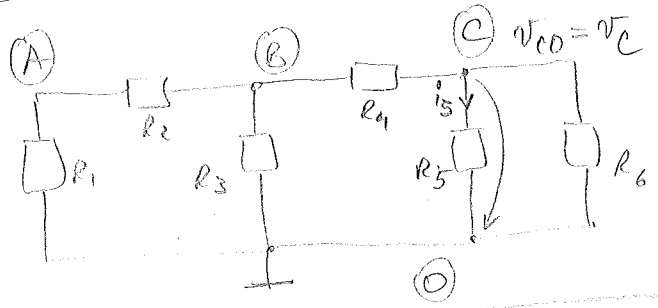
Question: how many loops do we have?

- Branch current ≜ the current through a branch.
- Branch voltage ≜ the voltage across a branch.



≜ the reference node.

- To keep schematic diagram simple and neat we'll explicitly show only voltages and current of interest.
- When referenced with respect to the reference node, node potentials are simply referred to as node voltages.

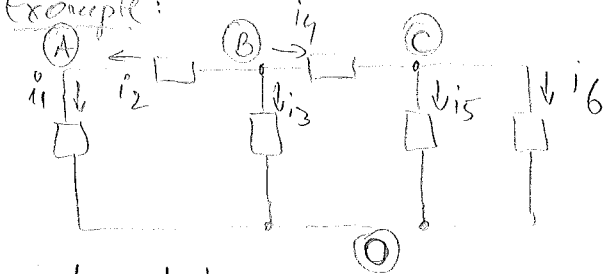


Kirchhoff's Current Law (KCL)

- At any instant the sum of all current entering a node must equal the sum of all current leaving that node.
(In other words, the algebraic sum of all current entering a node is zero)
- Mathematically

$$(1)\quad \sum_{\text{IN}} i = \sum_{\text{OUT}} i \quad \text{or} \quad \sum_{n} i_n = 0 \quad (2)$$

Example:

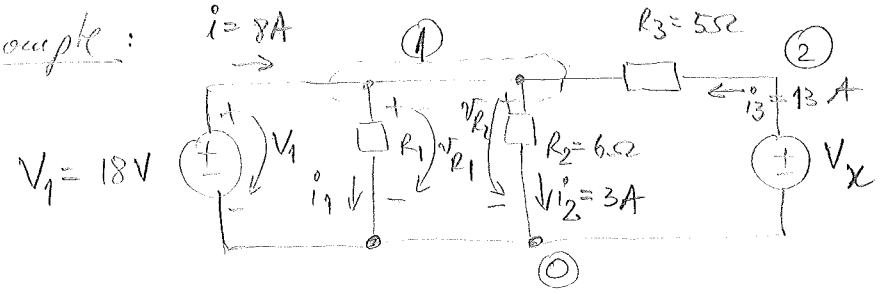


Node A: $i_2 = i_1$
Node B: $0 = i_2 + i_3 + i_4$
Node C: $i_4 = i_5 + i_6$
Node 0: $i_1 + i_3 + i_5 + i_6 = 0$

Using the algebraic sums:

Node A: $i_2 - i_1 = 0$
Node B: $i_2 + i_3 + i_4 = 0$
Node C: $i_4 - i_5 - i_6 = 0$
Node 0: $i_1 + i_2 + i_3 + i_5 + i_6 = 0$

Example:



a) How many nodes, branches, loops?

3 , 5 , 6

b) $i = 8A$, $i_2 = 3A$, $i_3 = 13A$ $\quad R_1 = ?$

KCL: $i + i_3 = i_1 + i_2 \Leftrightarrow 8A + 13A = i_1 + 3A$

$\Leftrightarrow i_1 = 18A$

Note that $V_1 = v_{R_1} = v_{R_2} = 18V$

Use Ohm's law: $i_1 = \frac{v_{R_1}}{R_1} \Leftrightarrow R_1 = \frac{v_{R_1}}{i_1} = \frac{18V}{18A} = 1\Omega$

Example 2

How many loops?