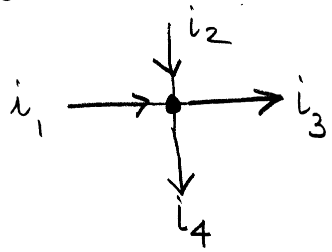
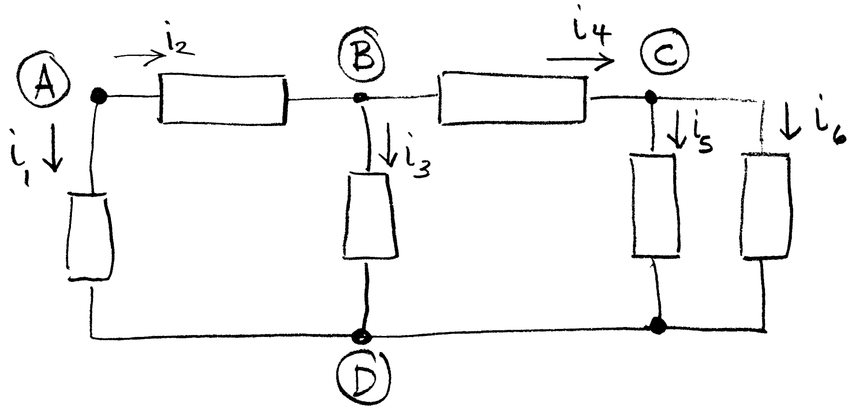
Kirchoff's Current Law

the algebraic sum of currents entering a node is zero



$$\sum_{+in} i_j = 0$$

This is nothing more than conservation of electrons, i.e., what enters the node is equal to what leaves the node.



At node A $\quad \sum_{+out} i_j = i_1 + i_2 = 0$

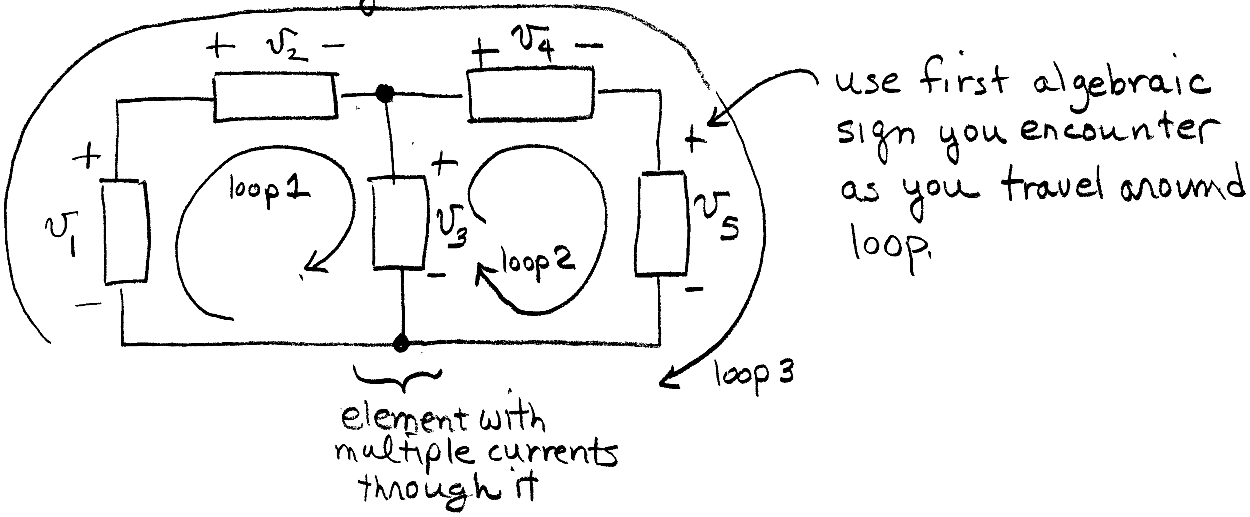
At node B $\quad \sum_{+out} i_j = -i_2 + i_3 + i_4 = 0$

A circuit with N nodes will have N-1 independent equations from Kirchoff's Current Law.

Kirchoff's Voltage Law

The algebraic sum of all the voltages around a loop is zero.

IMPORTANT: identify every element by passive sign convention

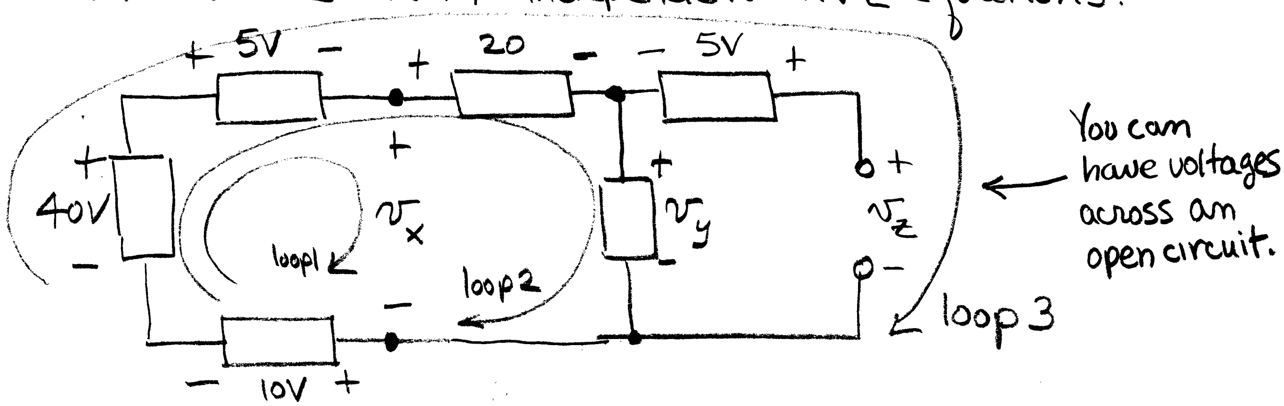


loop 1: $-v_1 + v_2 + v_3 = 0$

loop 2: $-v_3 + v_4 + v_5 = 0$

loop 3: $-v_1 + v_2 + v_4 + v_5 = 0$

If a circuit has N nodes and E elements you can write E − N + 1 independent KVL equations.



loop 1 gives v_x: $-40 + 5 + v_x + 10 = 0$ $\quad v_x = +25$ Volts

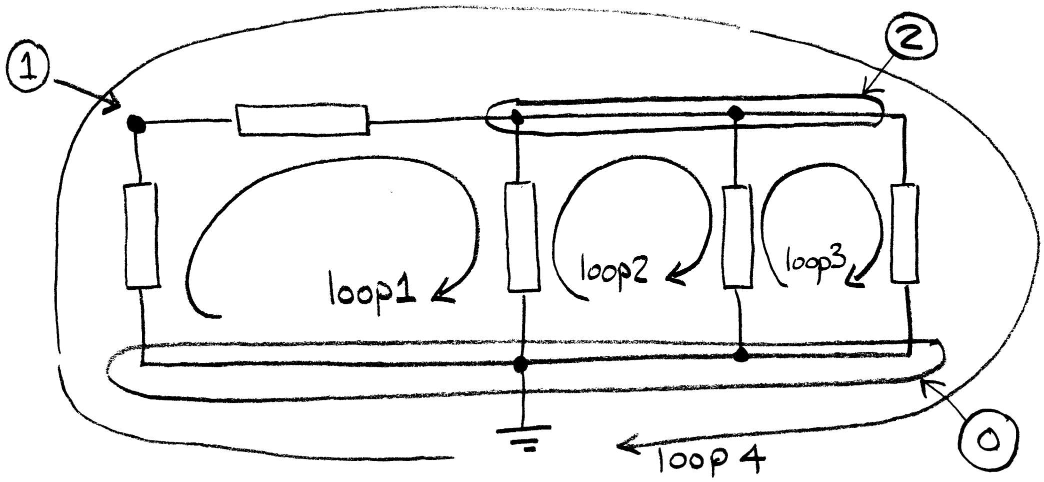
loop 2 gives v_y: $-40 + 5 + 20 + v_y + 10 = 0$ $\quad v_y = +5$ volts

loop 3 gives v_z: $-40 + 5 + 20 - 5 + v_z + 10 = 0$ $\quad v_z = +10$ volts

NOTE: You can use many other loops.

2-2 Connection constraints

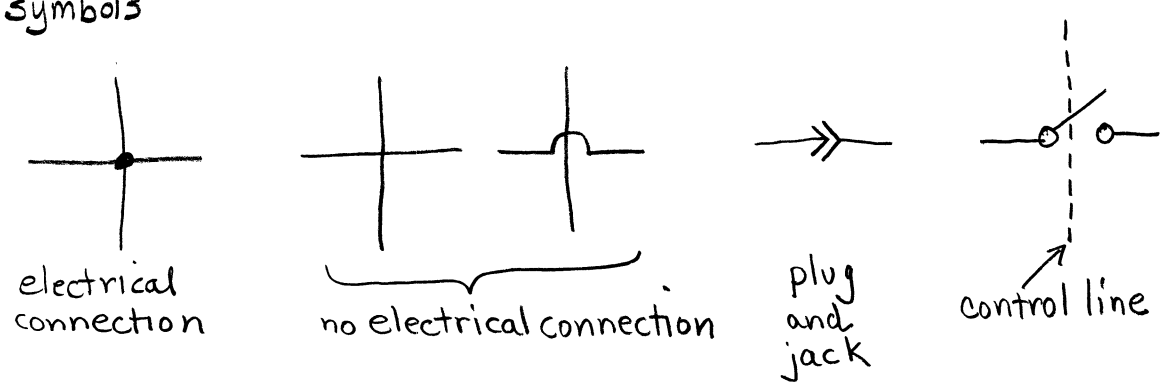
- circuit – interconnection of electrical devices
- node – electrical junction of two or more devices
- loop – closed path formed by tracing through an ordered sequence of nodes without passing through any node more than once



This circuit has three nodes. We always number the ground node ∅.

There are many possible loops. Four are shown.

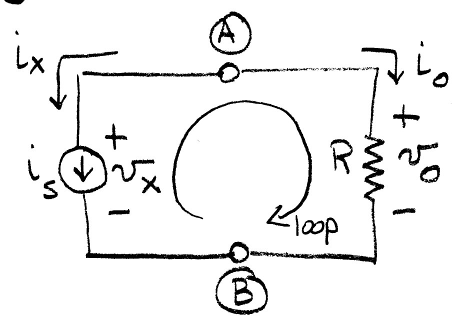
symbols



2-3 Combined Constraints

Goal is to determine voltages or currents at various places in a circuit.

Initially all circuits will come with reference marks.



We want to know (i_x, v_x) and (i_o, v_o)

4 unknowns $\Rightarrow$ 4 eqns

I. Start with element equations

$i_s = i_x$ since current through current source must always be i_s (1)

$v_o = i_o R$ Ohm's Law for resistor (2)

II. Then do connection equations

KCL at node A: $\sum_{+in} i = 0$ $-i_x - i_o = 0$ (3)

KVL around loop $\sum_{\circlearrowleft} v = 0$ $-v_x + v_o = 0$ (4)

This is four equations in four unknowns

From (1) and (3) $i_o = -i_x$ (3)

$i_o = -i_s$ substituting (1) into (3)

Since i_s is known i_x and i_o are now known.

Substituting these results into (2) gives

$$v_o = -i_s R$$

Using (4) now gives v_x as

$$v_x = v_o = -i_s R$$

The - sign simply means that for the given direction of i_s v_o is in the opposite polarity to that shown in the drawing