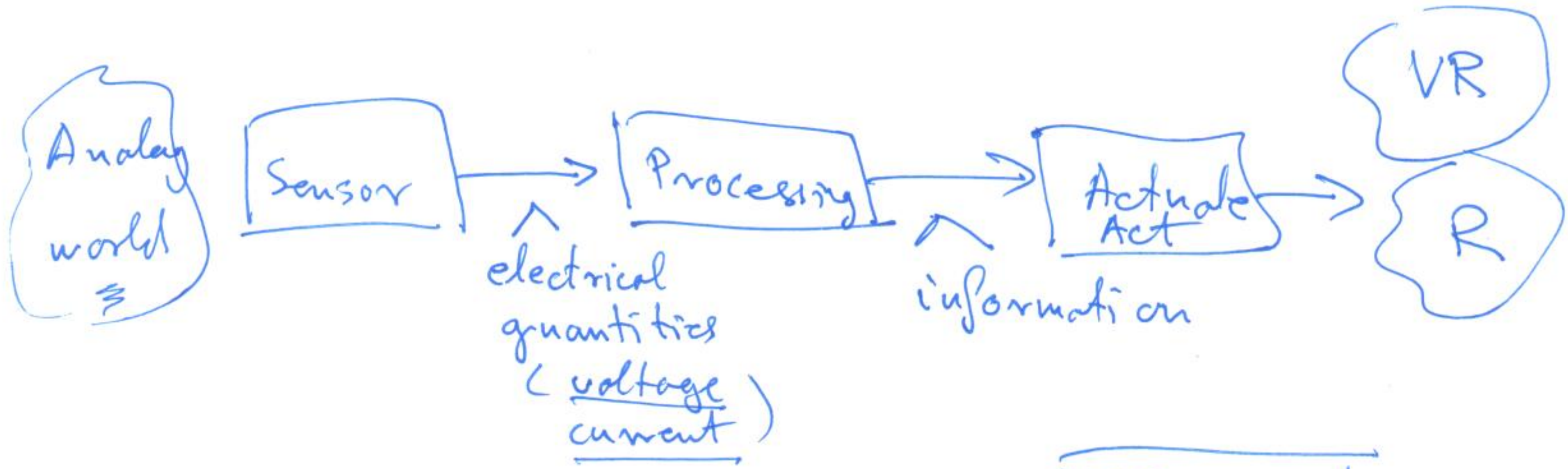
(1) 2/20/18 (in Lecture) EE16A

EE16A Module 2 - Lecture 1



SPICE

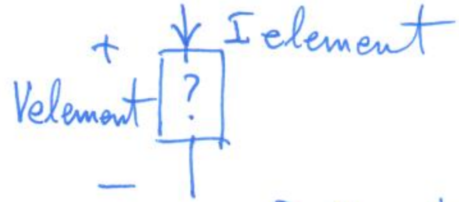
Electrical circuit analysis (tool)

Quantities	Analytical Symbol	Units
Voltage	V	Volts [V]
Current	I	Amps [A]
Resistance	R	Ohms [Ω]

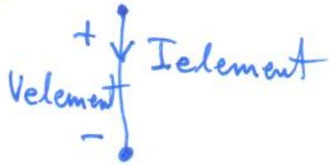
Circuit diagram (collection of elements, where each element has some voltage accross it and some current through it)

(2)

Key circuit elements:

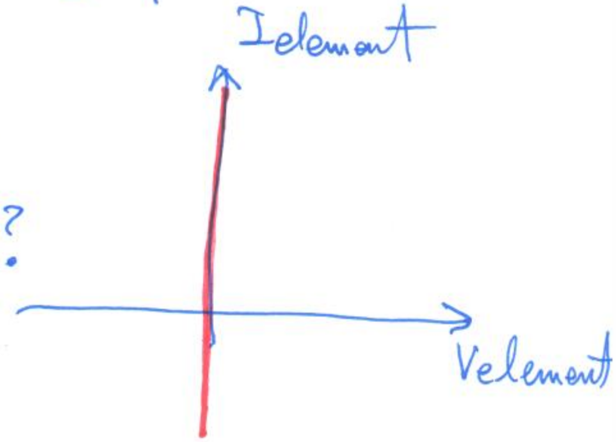


(1) wire

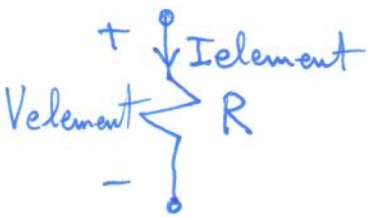


$V_{element} = 0$

$I_{element} = ?$

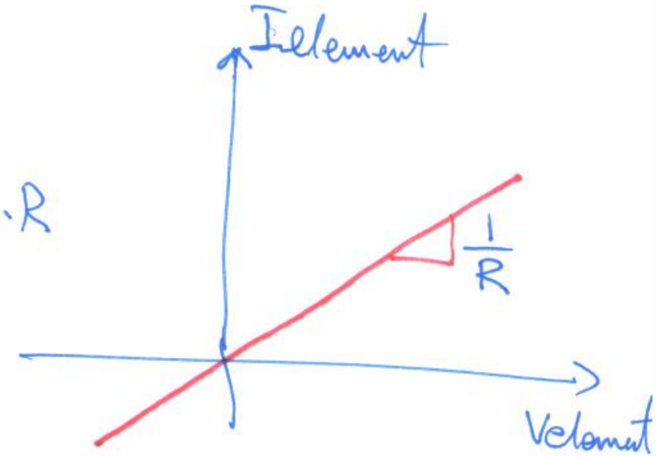


(2) Resistor

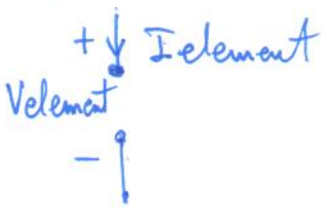


Ohm's Law

$V_{element} = I_{element} \cdot R$



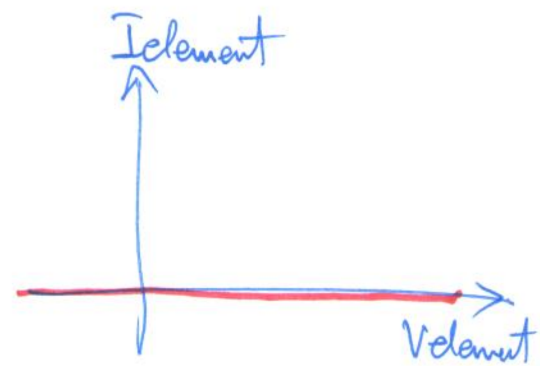
(3) "open" circuit



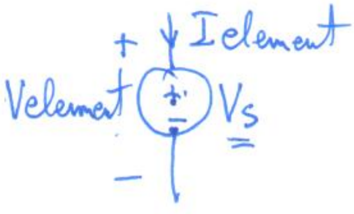
$I_{element} = 0$

$V_{element} = ?$

(set by the rest of the circuitry)

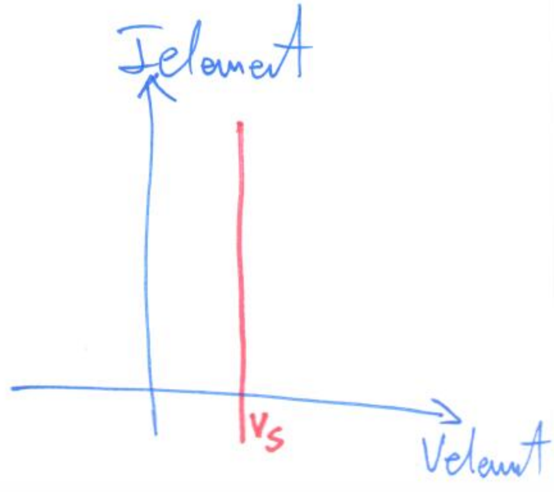


(4) Voltage source:

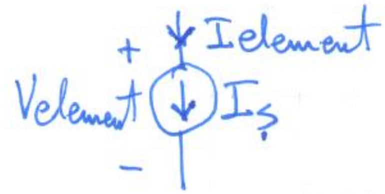


$V_{element} = V_s$

$I_{element} = ?$

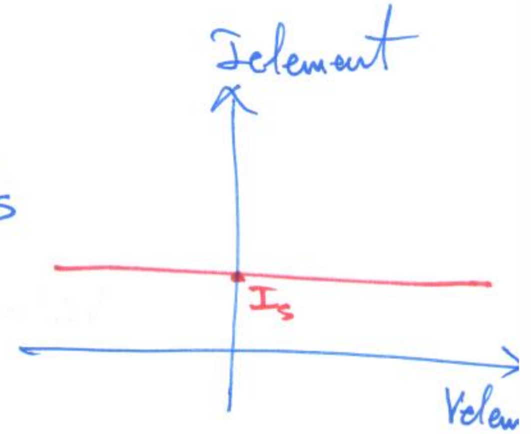


(5) Current source:



$I_{element} = I_S$

$V_{element} = ?$

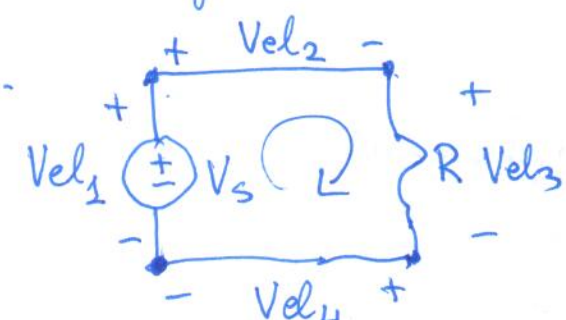


Velement and Ielement can be positive or negative

Rules for circuit analysis:

(1) KVL: sum of voltages across the elements in a loop = 0

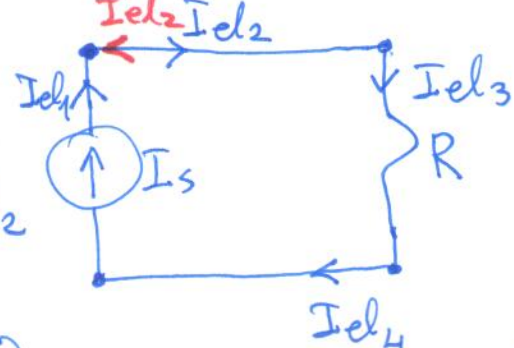
e.g.



$Vel_1 - Vel_2 - Vel_3 - Vel_4 = 0$

(2) KCL: The current flowing into any junction must equal the current flowing out.

e.g.



$Iel_1 = -I'el_2$

$Iel_1 + Iel'_2 = 0$

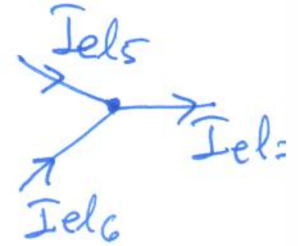
$Iel_1 = Iel_2$

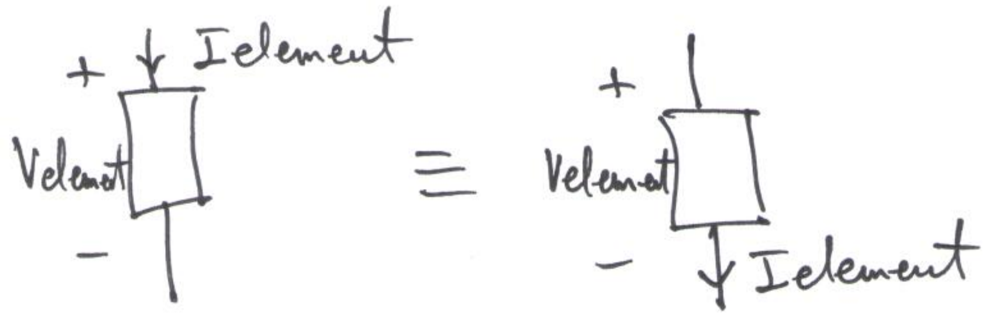
$Iel_2 = Iel_3$

$Iel_3 = Iel_4$

$\rightarrow Iel_1 = Iel_4$

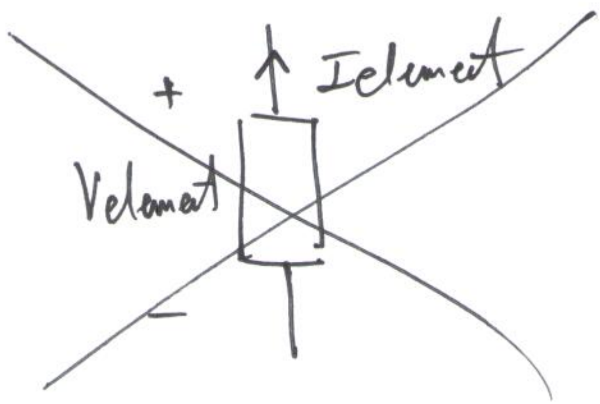
$Iel_5 + Iel_6 = Ie$





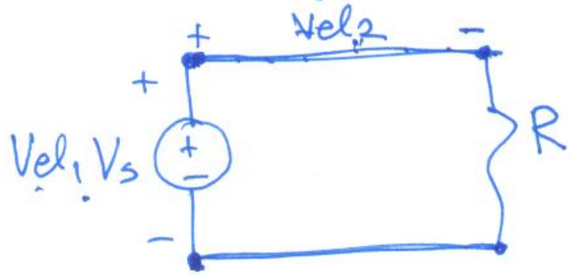
- passive sign convention

Ielement goes into a +
or out of a − terminal



Circuit analysis algorithm : "nodal analysis"

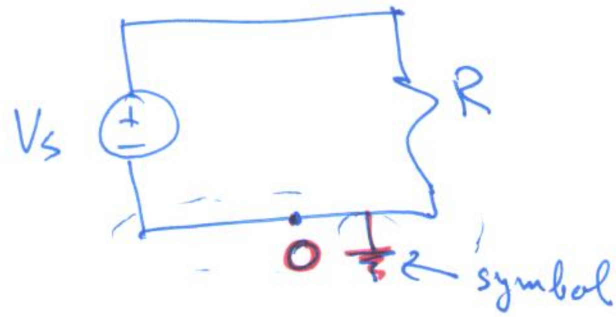
e.g. circuit (given)



node has the same "potential"

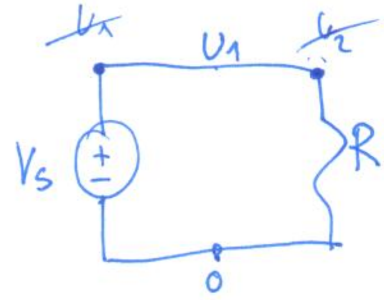
Note 11 has a 4-element example

Step 1: Pick a "reference" node and label it as "0".
All voltages measured relative to this node.



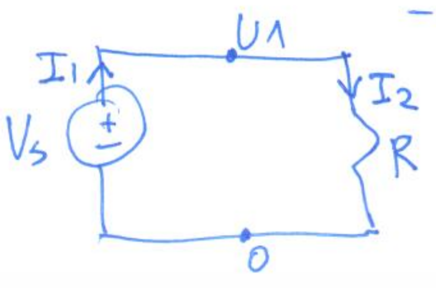
"ground"

Step 2: Label all remaining nodes as U_i's $[U_1, \dots U_n]$

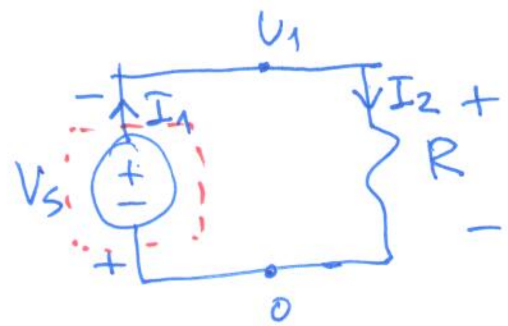


$U_1 - 0 = U_1$ ↑ unknowns

Step 3: Label all branch currents with I_m $[I_1, \dots, I_k]$
– Arbitrarily pick direction of I_m ↑ unknowns



step 4: Add ± labels on each element following the "passive sign" convention.

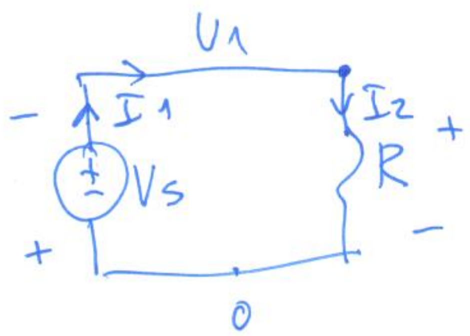


(independent of what is in the element)

step 5: $A\vec{x} = \vec{b}$ $\vec{x} = \begin{bmatrix} I_1 \\ \vdots \\ I_k \\ V_1 \\ \vdots \\ V_n \end{bmatrix}$ $\vec{b} = \begin{bmatrix} b_1 \\ \vdots \\ b_{k+n} \end{bmatrix}$, $A_{k+n \times k+n}$

$$\vec{x} = \begin{bmatrix} I_1 \\ I_2 \\ V_1 \end{bmatrix}$$

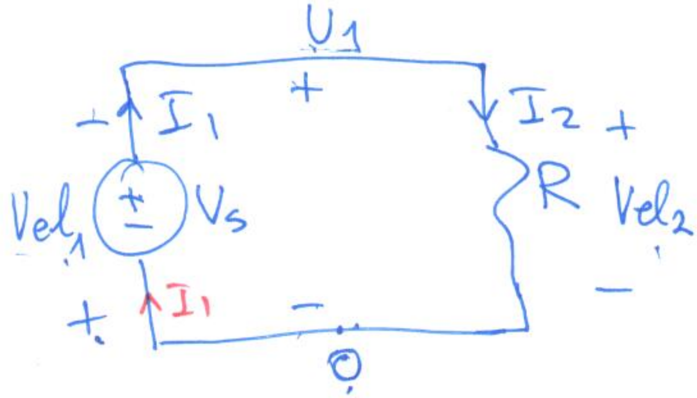
step 6: Use KCL to fill as many rows of A as possible (lin indep) #nodes − 1



$$I_1 = I_2$$

$$\begin{bmatrix} 1 & -1 & 0 \\ & & \\ & & \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ V_1 \end{bmatrix} = \begin{bmatrix} 0 \\ \\ \end{bmatrix}$$

Step 7: Use I-V relationships for each element to fill the rest of the A matrix



Voltage source:

$Vel_1 = -V_s$

$-U_1 = -V_s$

$U_1 = V_s$

~~$Vel_1 =$~~ $U_1 = -Vel_1$

Resistor:

$Vel_2 = I_2 \cdot R$ Ohm's law

$U_1 = Vel_2$

$\Rightarrow U_1 = I_2 \cdot R$

$U_1 - I_2 R = 0$

$1 \cdot U_1 - R I_2 = 0$

$$\begin{bmatrix} 1 & -1 & 0 \\ 0 & 0 & 1 \\ 0 & -R & 1 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ U_1 \end{bmatrix} = \begin{bmatrix} 0 \\ V_s \\ 0 \end{bmatrix}$$

$U_1 = V_s$, $I_2 = \frac{V_s}{R}$ $I_1 = \frac{V_s}{R}$

Note 11