EECS16 DIS 3A (First Circuits Discussion!)

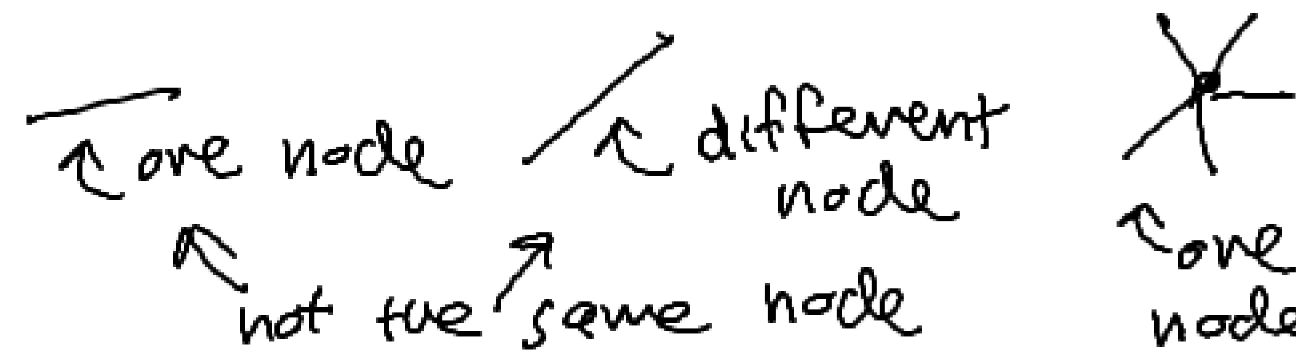
What is a circuit made of?

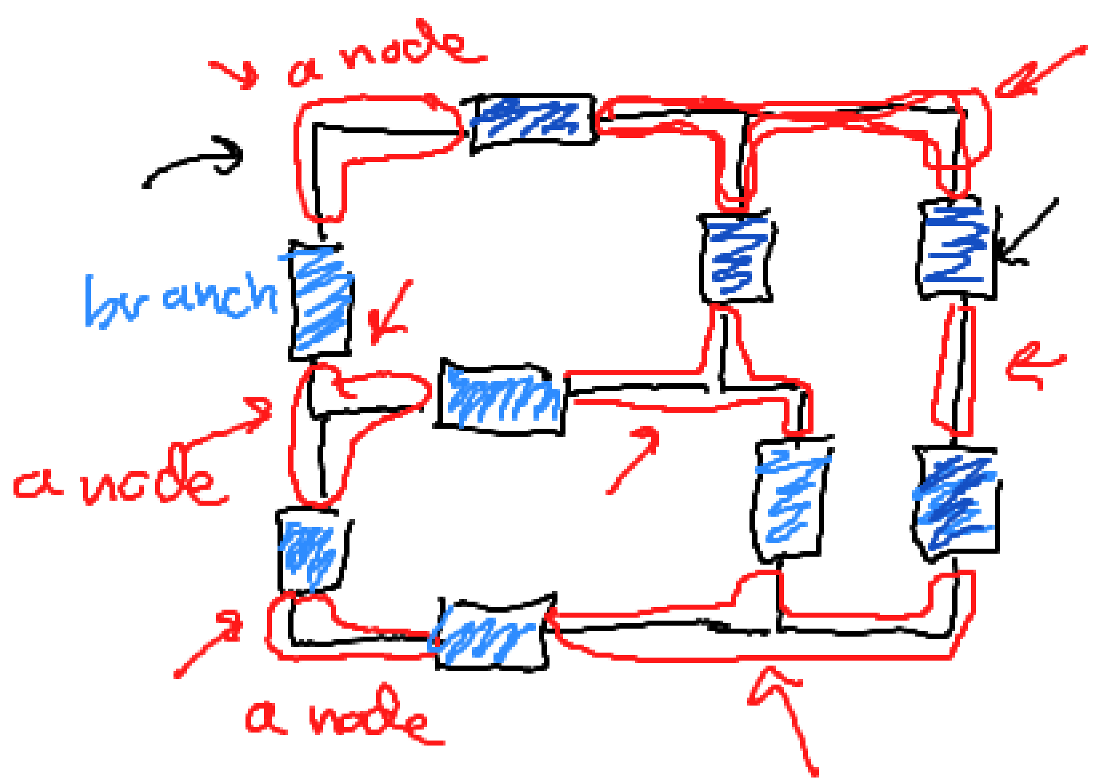
Nodes – junction of connections between "highways" for charge

Branches – highways for charge (electrical elements wires/opens)
(paths/links between nodes)

Charge – (+) (voltages & currents are a result of charge)

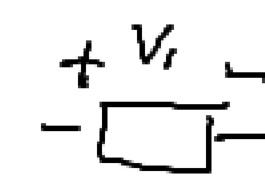
Node – connected/continuous piece of wire



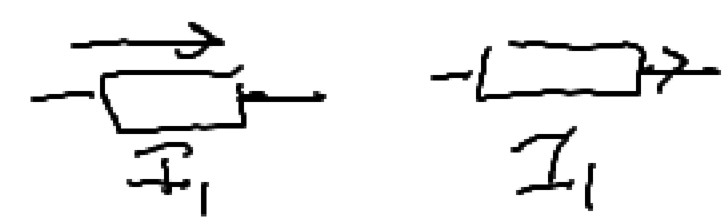


Branch Quantities:

Branch Voltages
label on a branch



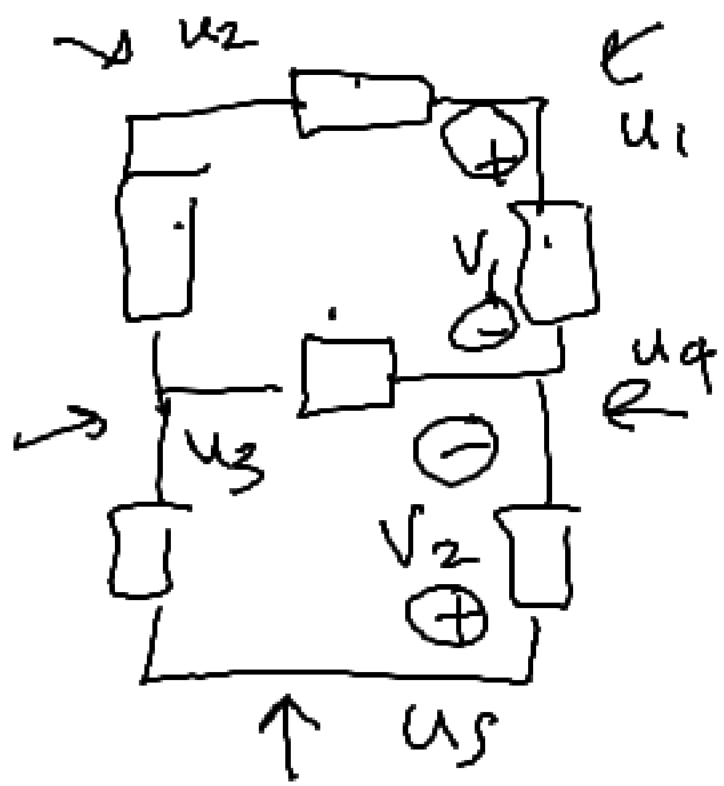
Branch currents
amount of charge flowing/time through a branch



Nodes

Node voltage ~~Node current~~

"Elevation" relative to some reference height

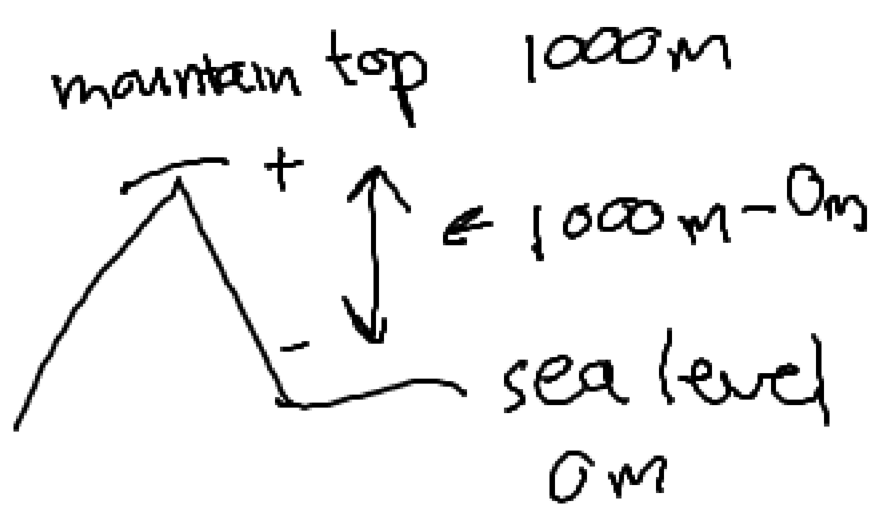


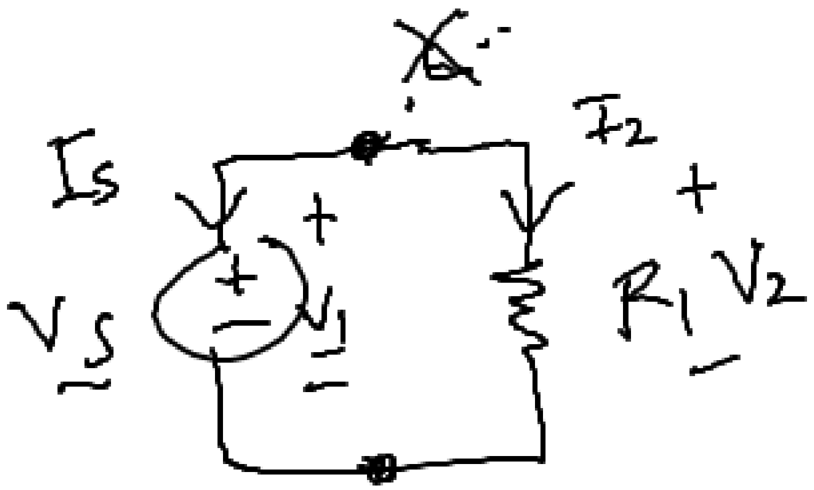
A relationship between branch voltages & node voltages

$$V_1 = u_1 - u_4$$

branch voltage = node voltage on ⊕ terminal − node voltage on ⊖ terminal

$$V_2 = u_5 - u_4 \quad \checkmark$$



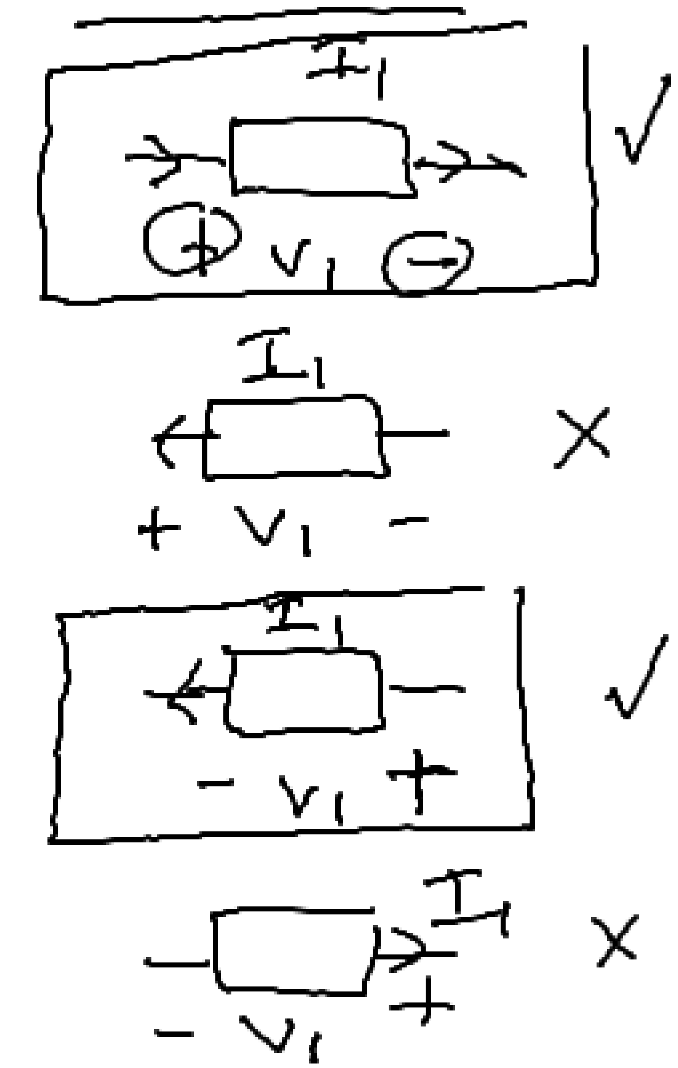


Find I_S

given $V_S = 1V$, $R_1 = \ \Omega$

Convention regarding branch voltages & branch currents

: Passive sign convention



$V_1 = V_S \Leftarrow$

Using KCL, KVL, Ohm's law

KCL: at a node, the currents coming in from branches is the same as currents going out on branches

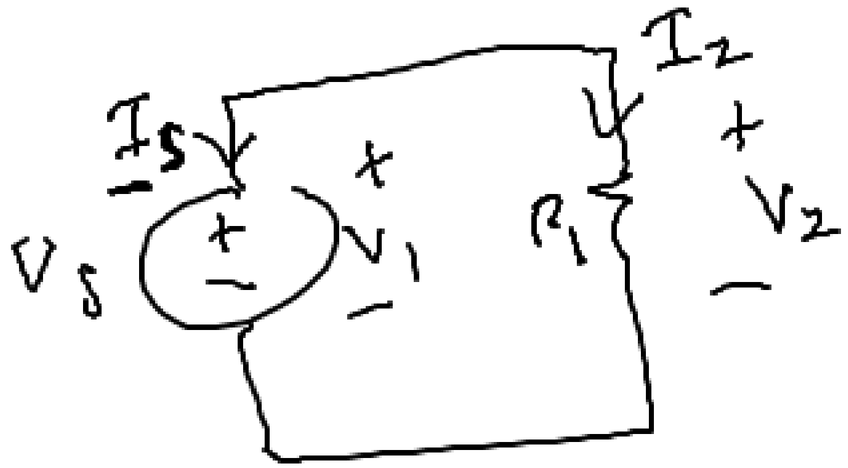
$$\boxed{0 = I_S + I_2}$$ ✓

KVL: for a loop of branches the sum of branch voltages will be zero

$$-V_S + V_2 = 0$$

$$\boxed{V_2 = V_1 = V_S}$$ ✓

Ohm's law: relates branch current + branch voltage for a resistor



① $0 = I_S + I_2$

② $V_1 = V_2 = V_S$ ⇐

③ $V_2 = R_1 I_2$

$V_S = 1V$

$R_1 = 1k\Omega$

Ohm's law:

$V_B = R I_B$

V_B : branch voltage of R

I_B : branch current of R

$$\boxed{V_2 = R_1 I_2}$$

① → ① $I_S = -I_2$

② + ③ → $V_S = R_1 I_2$

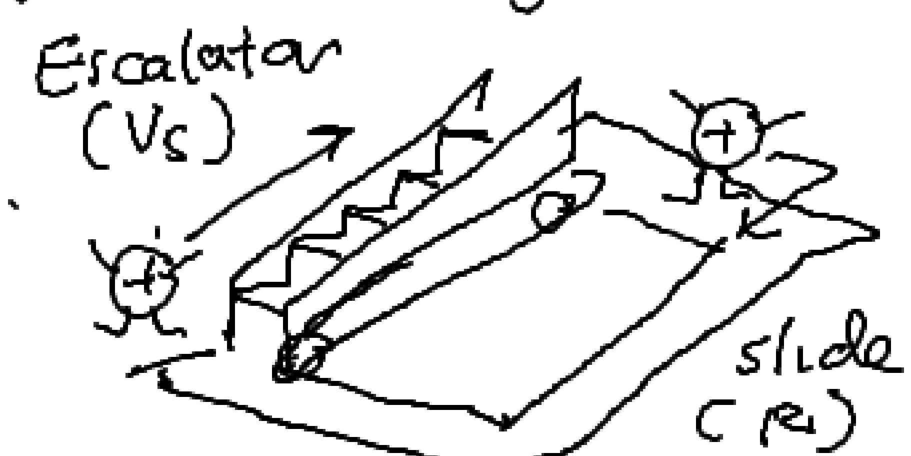
$\frac{V_S}{R_1} = I_2$

→ $I_S = -\frac{V_S}{R_1} = \frac{-1V}{1k\Omega} = \boxed{-1\,mA}$

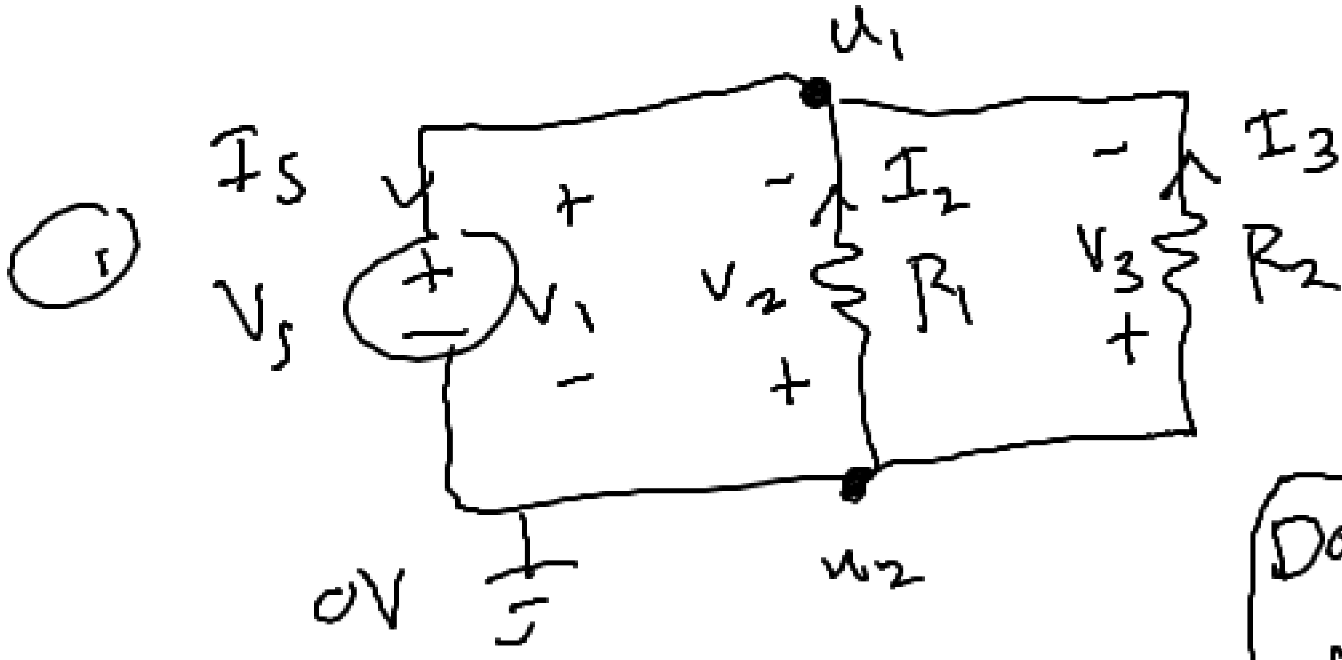
kilo $= \times 1000$

milli $= \times \frac{1}{1000}$

What do negative currents mean?



↳ Our assumed direction of movement for positive charges was wrong, they move the opposite way.



$V_s = 1V$

$R_1 = 2k\Omega$

$R_2 = 2k\Omega$

Don't write KCL for nodes w/ voltage sources if using NVA

Node voltage analysis (NVA)

(aka Nodal analysis)

① Labeling circuit

② Write KCL eqns

③ Substitute ohm's law in terms of node voltages

④ Solve for node voltages (couldn't apply)

$u_2 = 0V \leftarrow$

$V_1 = V_S$

② KCL @ u_1 node:

take your pick

$$I_S = I_2 + I_3$$

$$I_S - I_2 - I_3 = 0$$

$$-I_S + I_2 + I_3 = 0$$

③ Ohm's law:

$V_2 = I_2 R_1$

~~$V_1 =$~~

$V_3 = I_3 R_2$

Node voltages

$V_2 = 0 - u_1$

$V_1 = V_S = u_1 - 0$

$V_3 = 0 - u_1$

Substitute into KCL

$\frac{-u_1}{R_1} = I_2$

$V_S = u_1 \leftarrow$

$I_3 = \frac{-u_1}{R_2}$

$$I_S = -\frac{u_1}{R_1} + \left(\frac{-u_1}{R_2}\right)$$

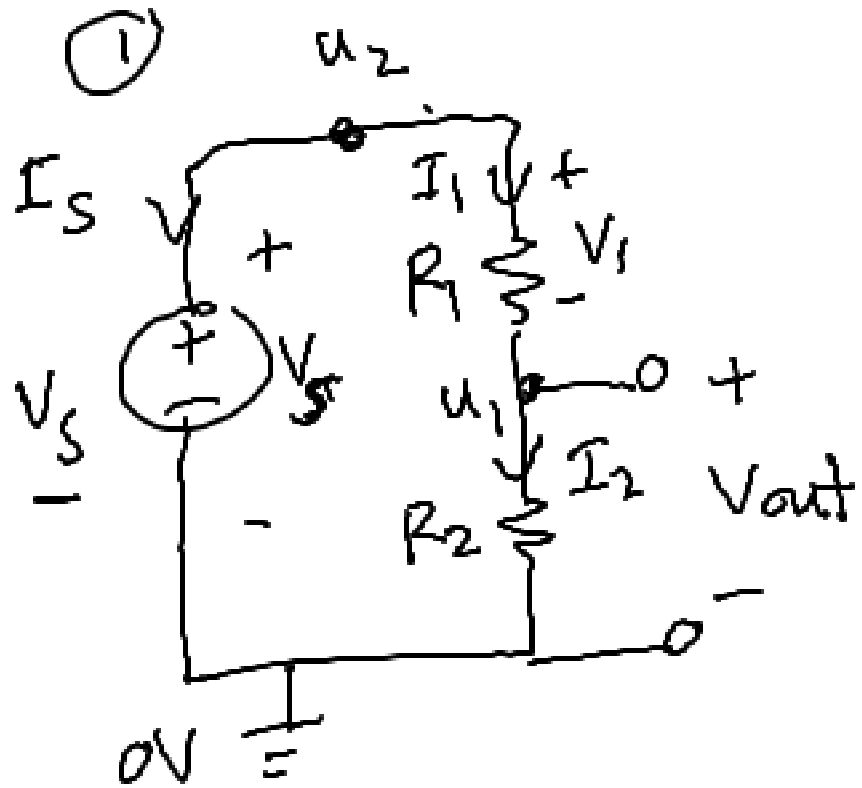
$$= -\left(\frac{V_S}{R_1} + \frac{V_S}{R_2}\right)$$

$$= -\left(\frac{1V}{2k\Omega} + \frac{1V}{2k\Omega}\right)$$

$$= \boxed{-1mA}$$

Goal of NVA: a system of eqns in terms of node voltage

①



Find V_{out} in terms of R_1, R_2, V_S

② KCL @ non V_S nodes

@ u_1 $\quad I_1 = I_2$

(in) $\quad$ (out)

③ Sub. Ohm's law

$$V_1 = R_1 I_1 = u_2 - u_1$$

$$\rightarrow V_{out} = R_2 I_2 = u_1 - 0V$$

$$V_S = u_2 - 0V$$

$$\Rightarrow \begin{cases} I_1 = \dfrac{V_S - u_1}{R_1} \\ I_2 = \dfrac{u_1}{R_2} \end{cases} \Rightarrow \boxed{\dfrac{V_S - u_1}{R_1} = \dfrac{u_1}{R_2}}$$

④ Solve for u_1 (node voltages)

$$\frac{V_S}{R_1} = \frac{u_1}{R_1} + \frac{u_1}{R_2} \Rightarrow u_1 = \frac{V_S}{R_1} \cdot \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$$

$$u_1 = \frac{R_2}{R_1 + R_2} V_S$$

* ⑤ What are solving for? $\boxed{V_{out} = \dfrac{R_2}{R_1 + R_2} V_S}$