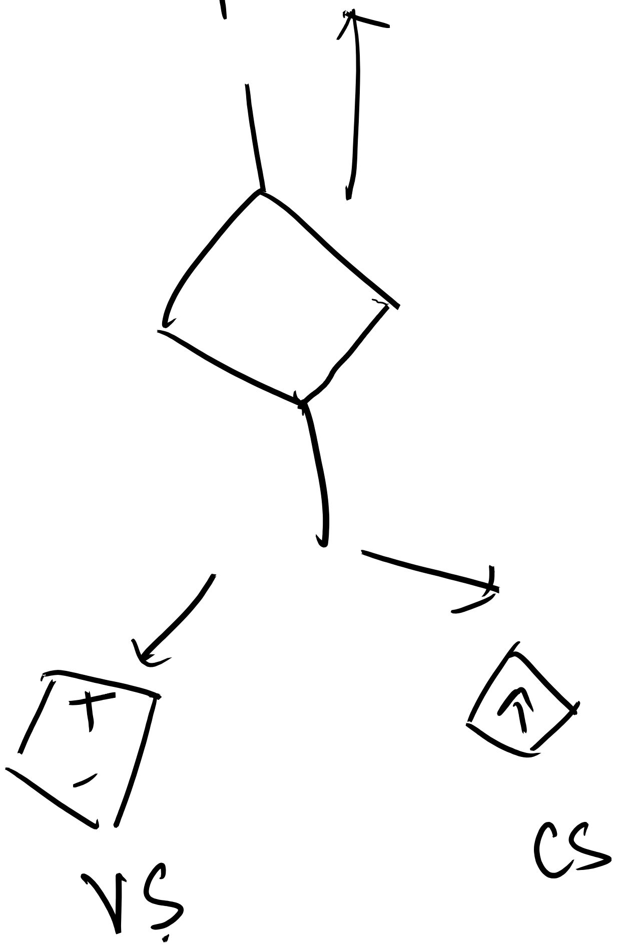
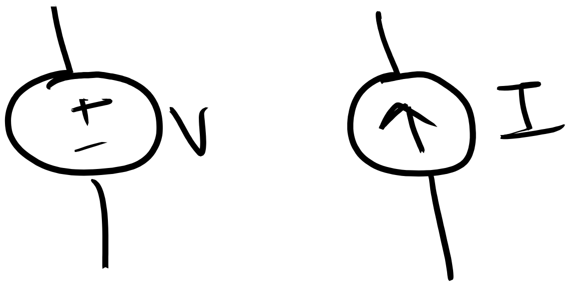
UES013 : Electrical & Elect Science

H3 ← CSE → ✓ → UES013

H1, H2 CWE → → UES001

* Dependent & Independent Sources

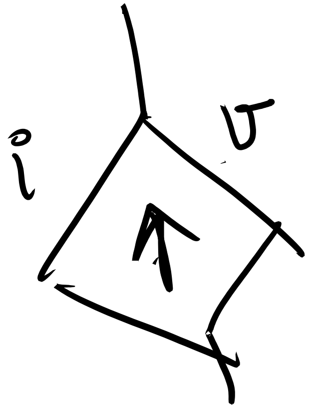




CCVS

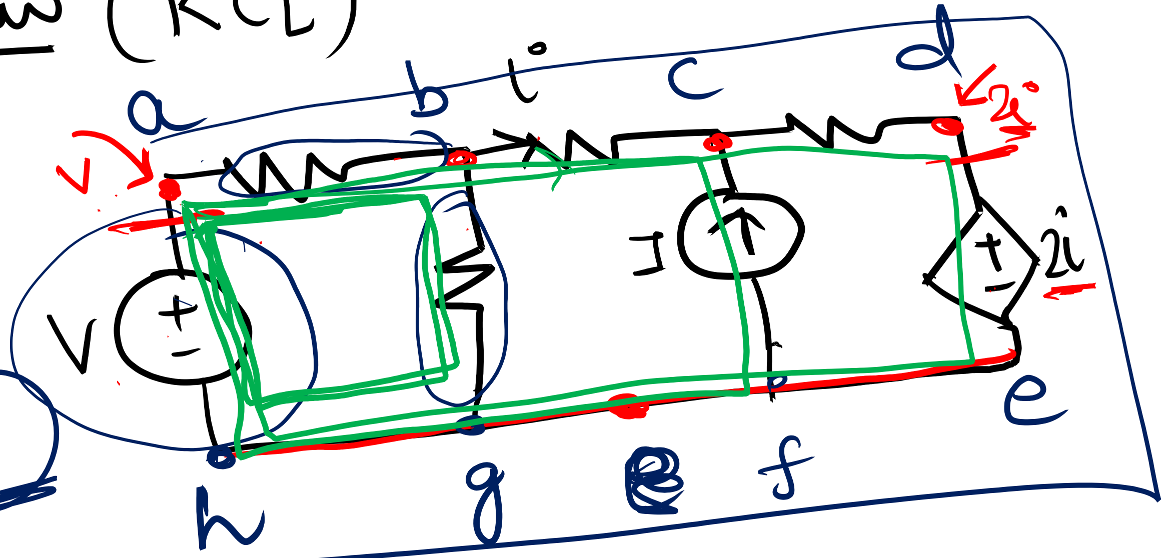
VCVS

CCCS



VCCS

* Kirchoff's Current Law (KCL)



CCVS

$\boxed{b\,c\,f\,g\,b}$

→ Nodes

→ Branches

→ Loops (ab gha) – L1

→ Mesh

→ Path → abgh

abcd

abcdefgh

abcfgha – loop2

abcdefgha – loop3

Mesh → loop which does not have any other loops within it.

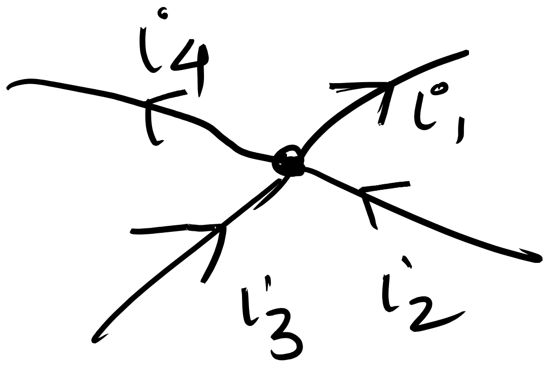
(i) KCL:

Algebraic sum of all currents at a node is zero

'or'

Alg. sum of all currents entering a node =

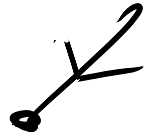
'' '' '' '' '' leaving a node.

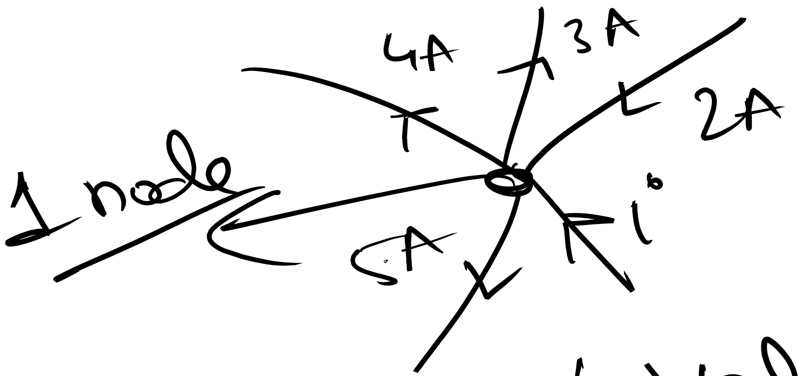


KCL at node; (leaving the node as +)

$$\boxed{i_1 + i_4 - i_3 - i_2 = 0}$$

$i_1 = -2A$



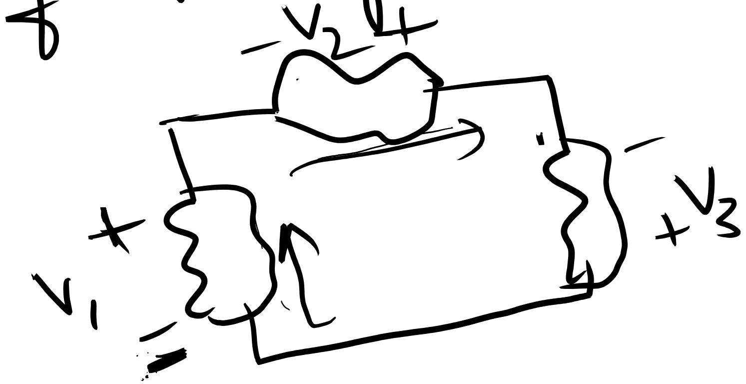


$i = ?$

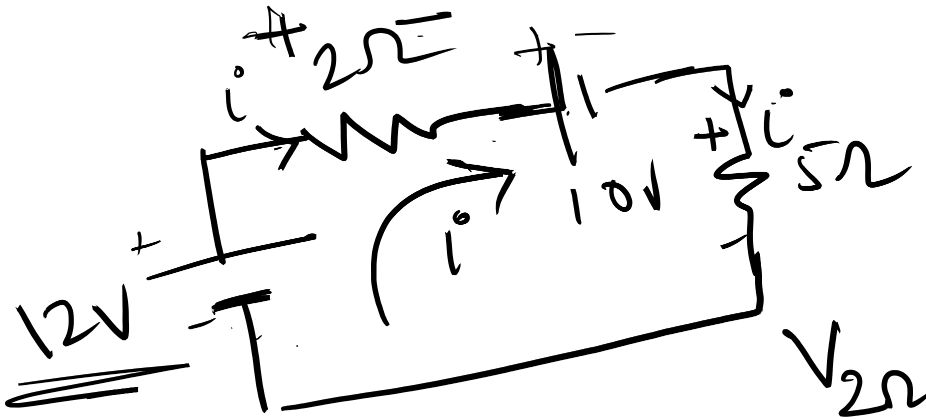
$3 + 4 + 5 - 2 - i = 0$

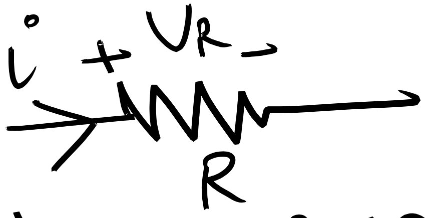
② Kirchoff's Voltage law (KVL)

Algebraic sum of voltage drops in a loop is zero



$$\boxed{-V_1 - V_2 - V_3 = 0}$$





$V_{2\Omega} = \frac{4}{7}V$; $V_{5\Omega} \Rightarrow \frac{10}{7}V$

$P_{absorbed}$

$P_{delivered}$

Applying KVL: →

$$\boxed{-12 + (i.2) + 10 + 5i = 0} \Rightarrow \boxed{i = \frac{2}{7}A}$$

$V = iR \Rightarrow \boxed{P = i^2R} \rightarrow$ loss

12V → deliver

Power ⇒ $\boxed{P = v.i}$

$P_{12V} = vi = 12 \times \frac{2}{7} = \frac{24}{7}$ W (delivery)

$P_{5\Omega} = \frac{10}{7} \times \frac{2}{7} = \frac{20}{49}$ W (absorbing)

$P_{2\Omega} = \frac{4}{7} * \frac{2}{7} = \frac{8}{49}$ W (absorbing)

$P_{10V} = 10 \times \frac{2}{7} = \frac{20}{7}$ W (absorbing)

* Note:

$\left.\begin{array}{l} 2\Omega \\ 5\Omega \\ 10V \end{array}\right\}$ Absr

VCVS

$V = iR$

$= 15 \times i$

1 loop or 1 mesh

Applying KVL.

$$-120 + 30i + 2V_a + 15i = 0 \quad (1)$$

$$V_a = -15i \quad (2)$$

$i = ?$

$V_a = ?$

Physical World

Mechanics

Electrical

Model

Mathematical functions

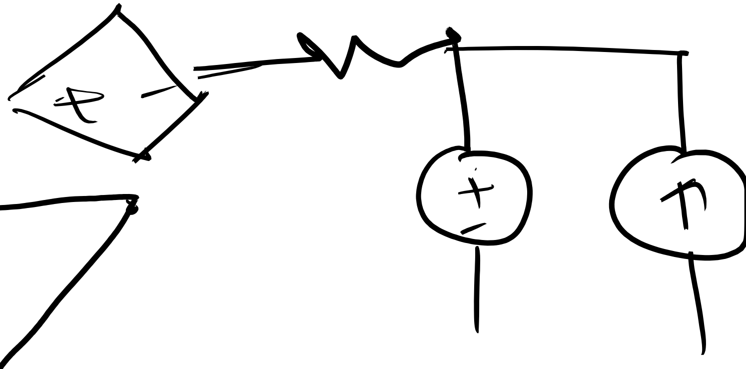
Electr.

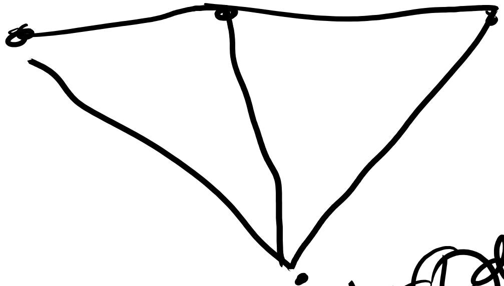
Analysis

→ KVL ; KCL ; Ohm's Law

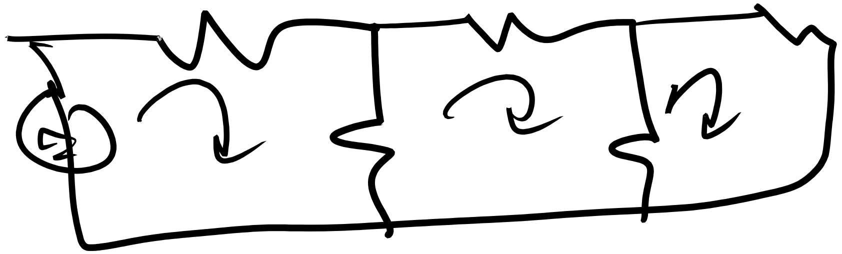
* KVL → Mesh Analysis

KCL → Nodal Analysis





$V = L\frac{di}{dt}$ $\qquad$ $V = iR$

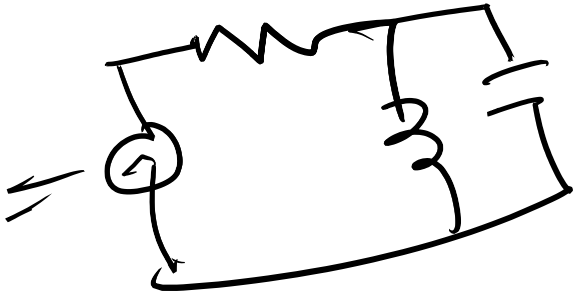


2Ω

→ Analysis

i/p → system → o/p = ?

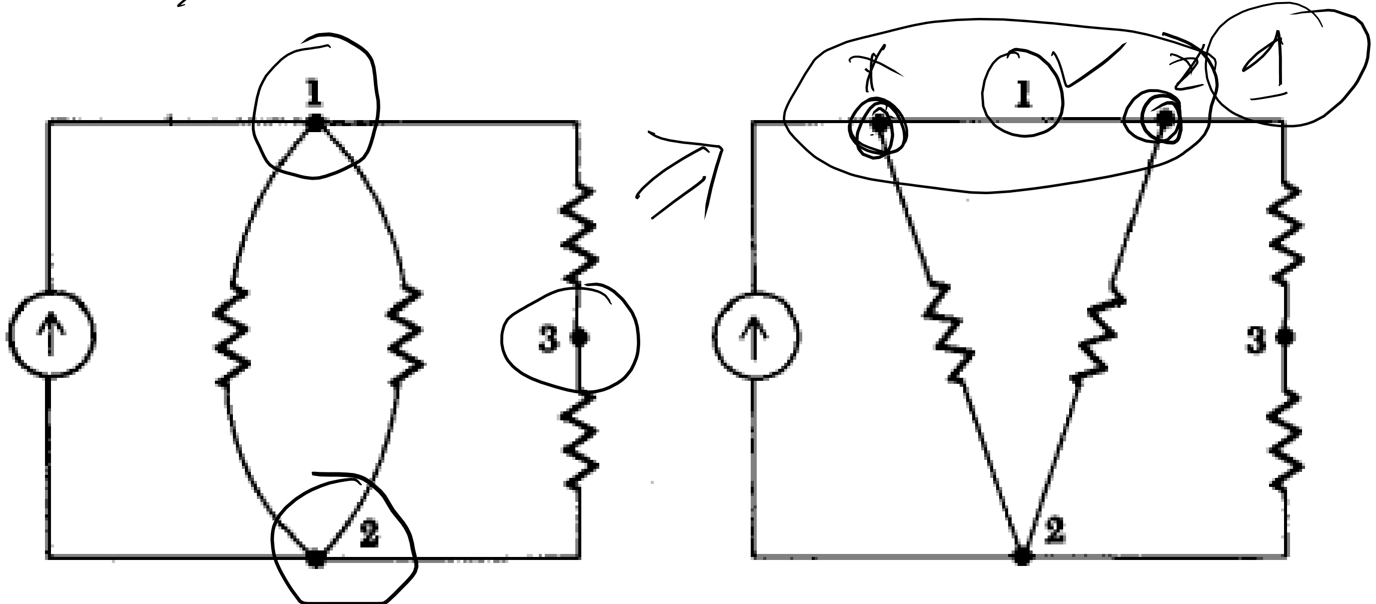
→ KX



Node

- A point at which two or more elements have a common connection is called a node.
- Two points connected through a zero resistance line will be considered as a same node.
- NODE Vs Junction: Node-Minimum 2 Branches

  Junction - Minimum 3 Branches

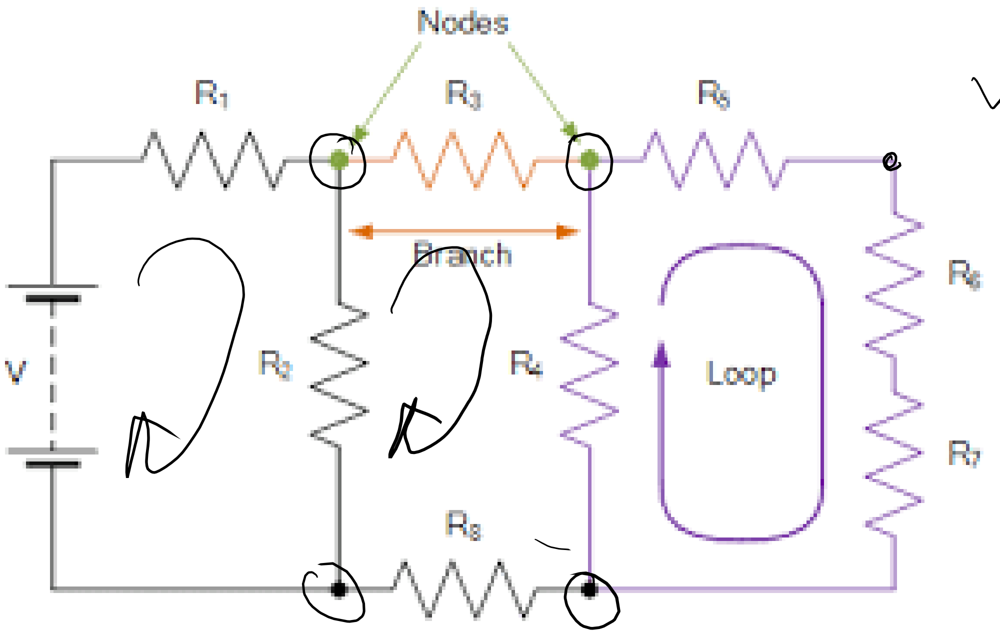


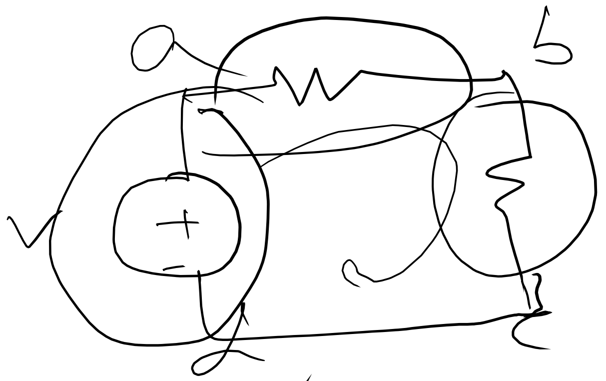
the nodes are represented with numbers.

Loop, Node and Branch

closed path

- A branch is a single path in a network composed of simple element and one node at each end.



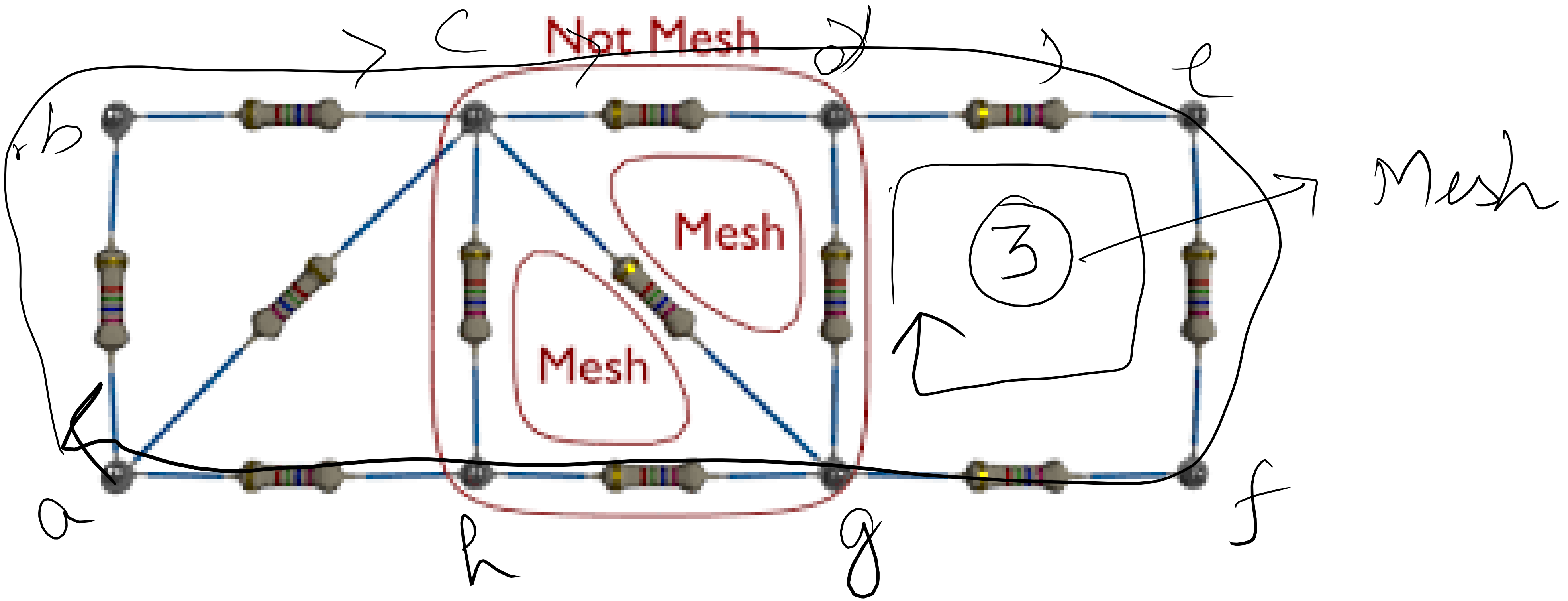


abcda → loop

abcd → path

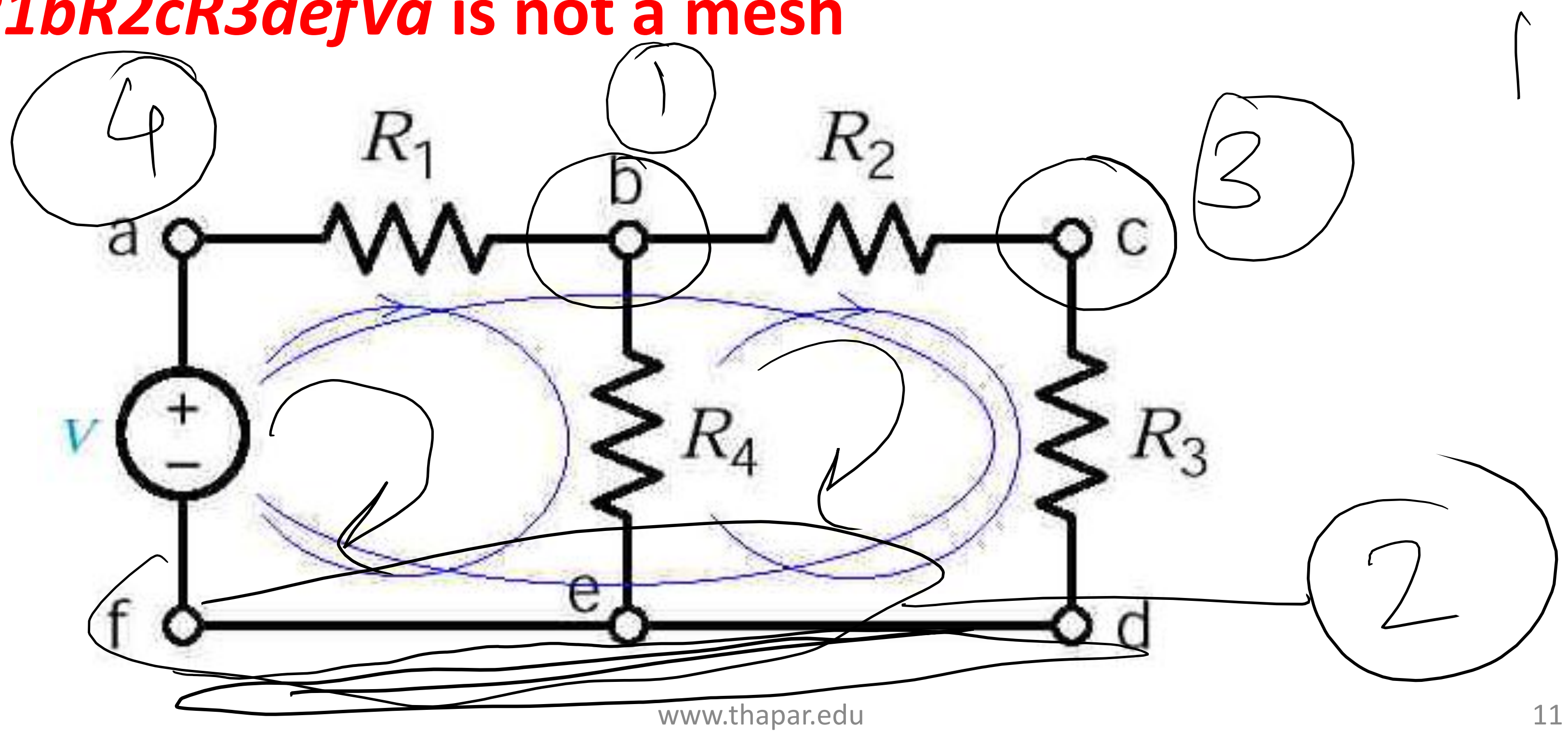
Mesh

- Mesh is a loop which does not contain any other loop within it.



Mesh

- The circuit below has 4 nodes.
- The loops *aR1bR4efVa* and *bR2cR3deR4b* are mesh.
- **Loop *aR1bR2cR3defVa* is not a mesh**

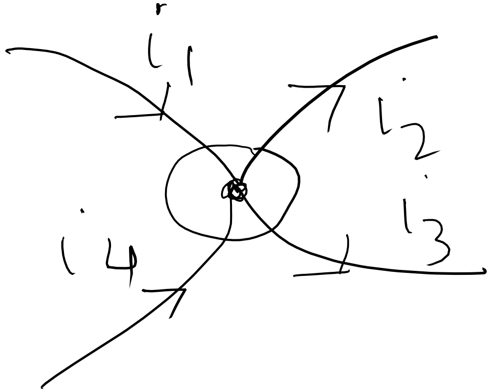


Branch, Loop and Nodes

- Relationship between branches, nodes and loops.

$$b = l + n - 1$$

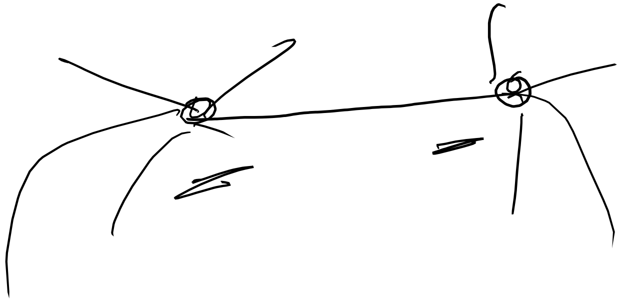
- *b – branches*
- *n - nodes*
- *l – independent loops*



Apply KCL at Node:

* Convention → outgoing (+)

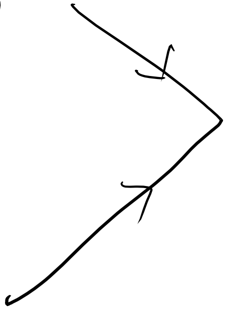
→ Uniform throughout



$$i_3 + i_2 - i_1 - i_4 = 0$$

→ ~~(or)~~ incoming (+)

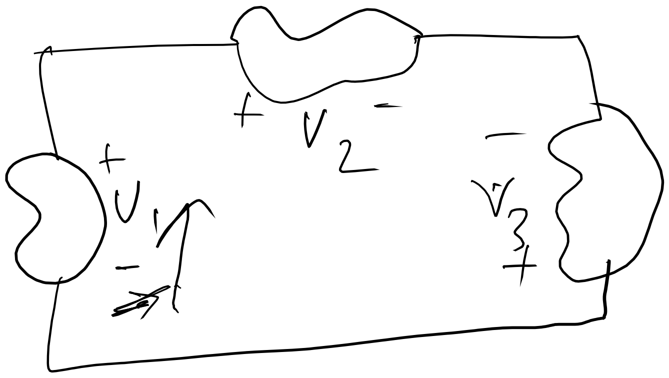
$$i_1 + i_4 - i_3 - i_2 = 0$$



* Conservation of charge?

KVL : The algebraic sum of voltages around any closed path in a circuit is zero.

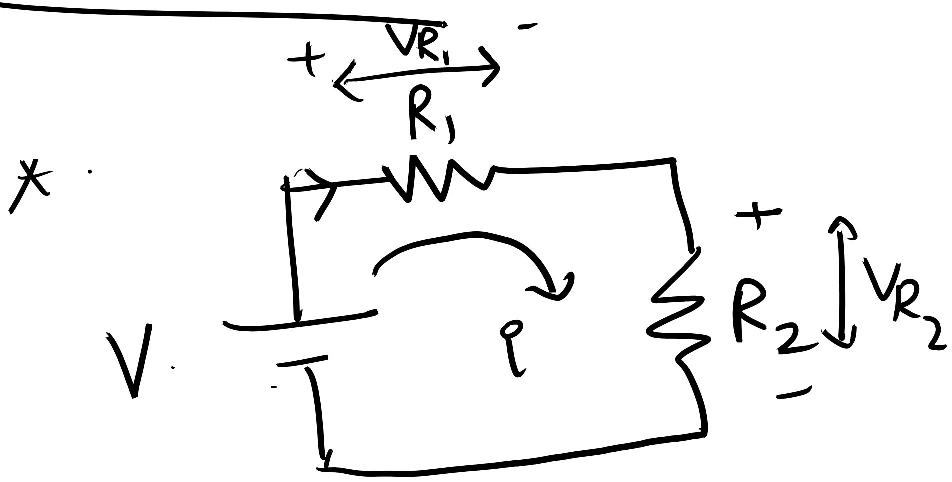
Convention



$$-V_1 + V_2 - V_3 = 0$$

* KVL + KCL

KVL ; KCL



Apply KVL;

$$-V + iR_1 + iR_2 = 0$$

$$i(R_1 + R_2) = V$$

$$i = \frac{V}{R_1 + R_2} \quad \text{— ①}$$

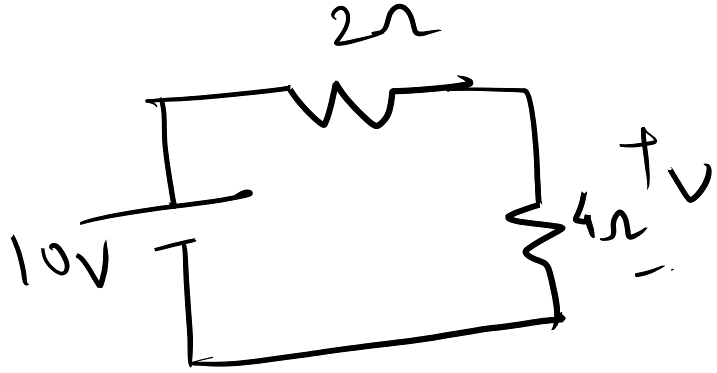
$$V_{R_1} = \underline{IR} = i \cdot R_1 = \frac{R_1 V}{R_1 + R_2} \quad \text{— ②}$$

$$V_{R_2} = IR = iR_2 = \frac{R_2 V}{R_1 + R_2} \quad \text{— ③}$$

Eq ② & ③ $\Longrightarrow$ <u>Voltage Division</u>

$$V_{R_1} = R_1 \frac{V}{(R_1 + R_2)}$$

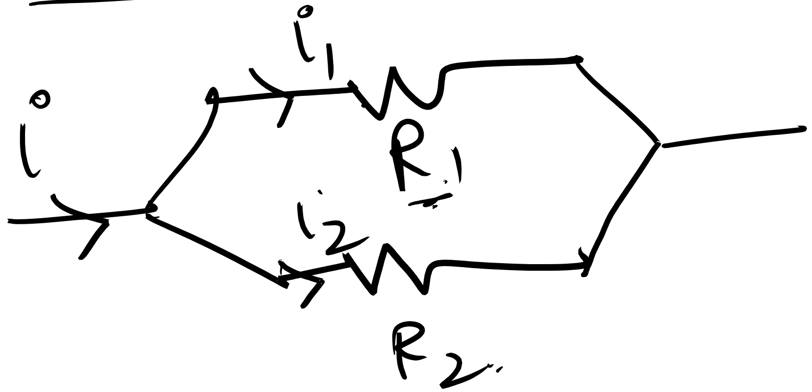
$$V_{R_2} = R_2 \frac{V}{(R_1 + R_2)}$$



$$V = 4 * \frac{10}{4+2} = \frac{40}{6} \text{ Volts}$$

Voltage Div. $\Rightarrow R \cdot \dfrac{V}{\text{Sum of } R.}$

* Current Division

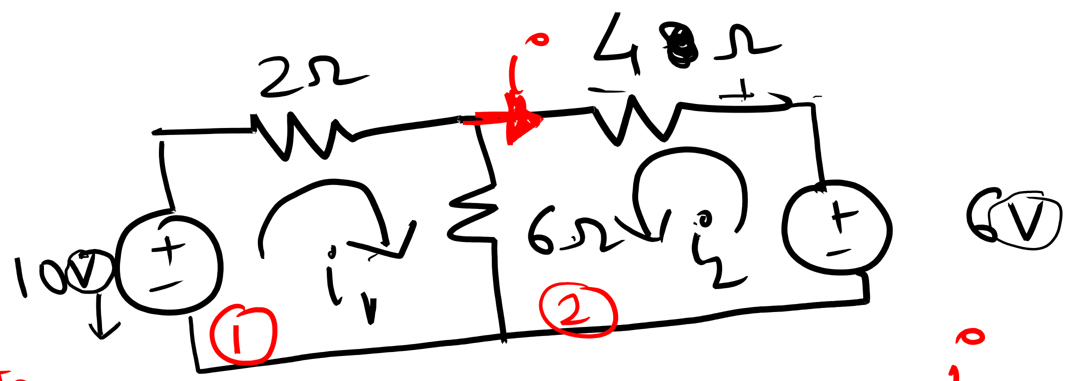


$$i_1 = \frac{i \cdot R_2}{R_1 + R_2}$$

$$i_2 = \frac{i\, R_1}{R_1 + R_2}$$

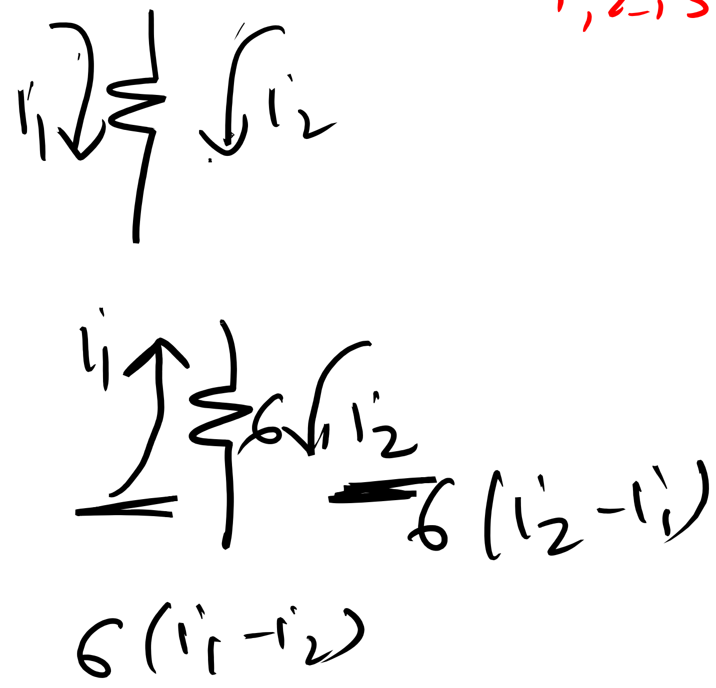
* Mesh Analysis

→ Identify Meshes & take some variables for mesh currents



$i_{1,2,3---n}$

→ Apply KVL in individual meshes.



Mesh 1

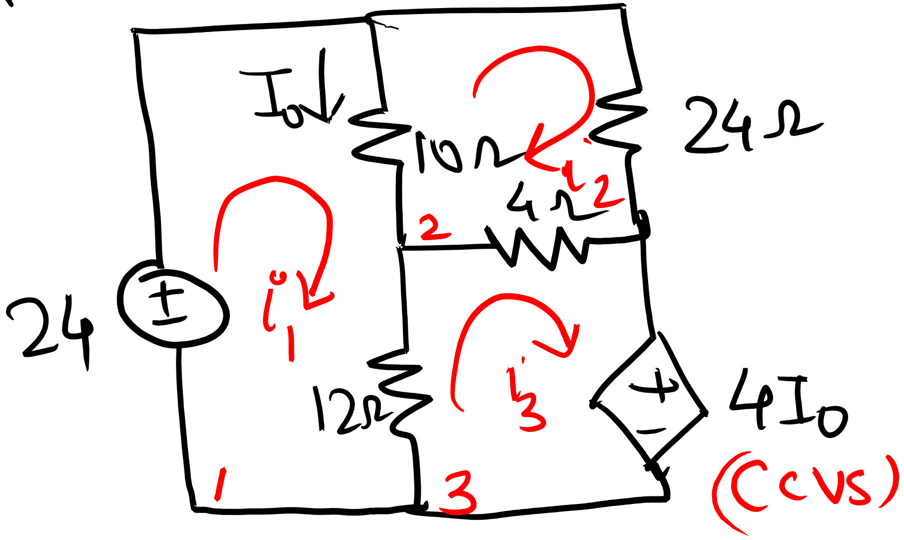
$$-10+2i_1+6(i_1+i_2)=0 \quad —(1)$$

mesh 2

$$+4i_2-6+6(i_1+i_2)=0 \quad —(2)$$

$$i_1=\frac{16}{11}\,A \; ; \; i_2=-\frac{3}{11}\,A$$

*



* **Mesh 1**

$$-24 + 10(i_1 - i_2) + 12(i_1 - i_3) = 0 \quad \text{—} \quad (1)$$

* **Mesh 2**

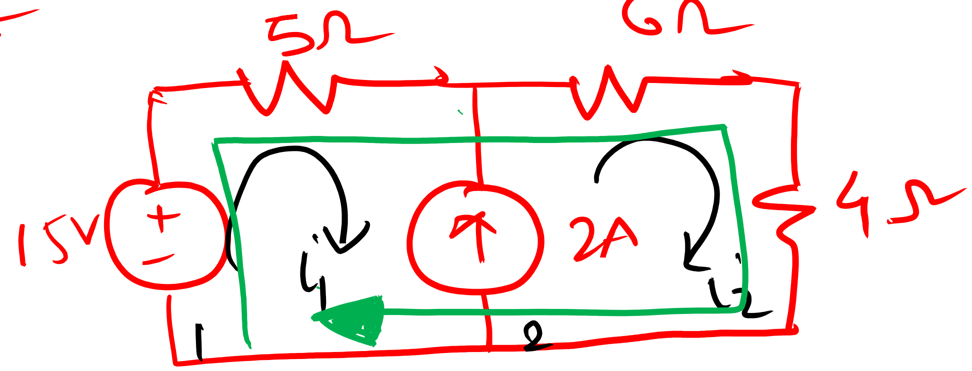
$$24 i_2 + 4(i_2 - i_3) + 10(i_2 - i_1) = 0 \quad \text{—} \quad (2)$$

* **Mesh 3**

$$4(i_3 - i_2) + 4I_o + 12(i_3 - i_1) = 0 \quad \text{—} \quad (3)$$

$$I_o = i_1 - i_2 \quad \text{—} \quad (4)$$

*

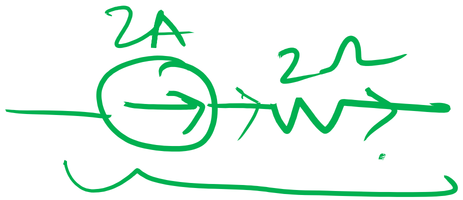


Mesh 1:

$-15 + 5i_1 + ? = 0$

Mesh 2:

$6i_2 + 4i_2 + ? = 0$

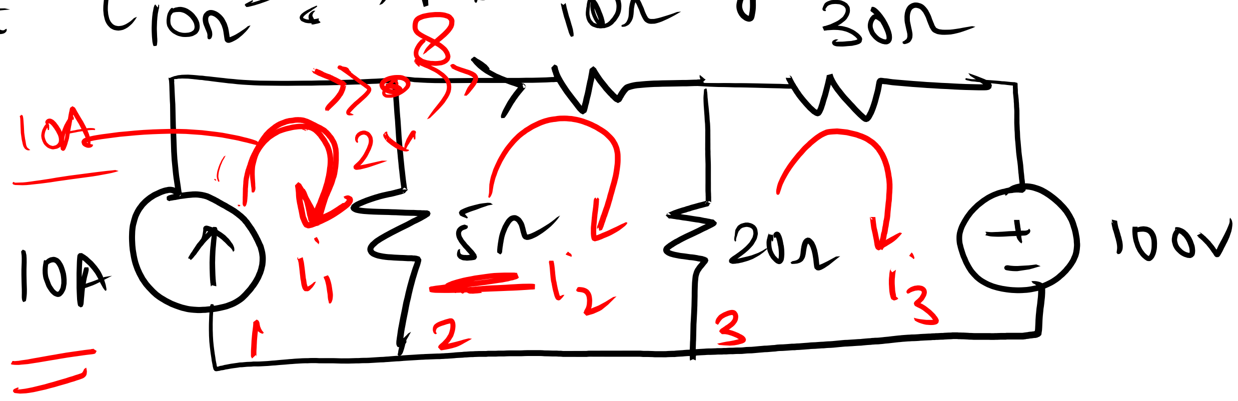


→ Super Mesh

$-15 + 5i_1 + 6i_2 + 4i_2 = 0$ —— ①

$i_2 - i_1 = 2$ —— ②

* $i_{10\Omega} = ?$ → Mesh Analysis



$$5(i_2 - i_1)$$

$$5(12 - 10) = \boxed{2A}$$

Mesh 1: → $i_1 = 10$ → (1)

Mesh 2: $10 i_2 + 20(i_2 - i_3) + 5(i_2 - i_1) = 0$

$$i_1 - 7 i_2 + 4 i_3 = 0 \rightarrow (2)$$

Mesh 3:

$$30 i_3 + 100 + 20(i_3 - i_2) = 0 \rightarrow (3)$$

→ Mesh Analysis + SuperMesh

→ Nodal Analysis : (KCL)

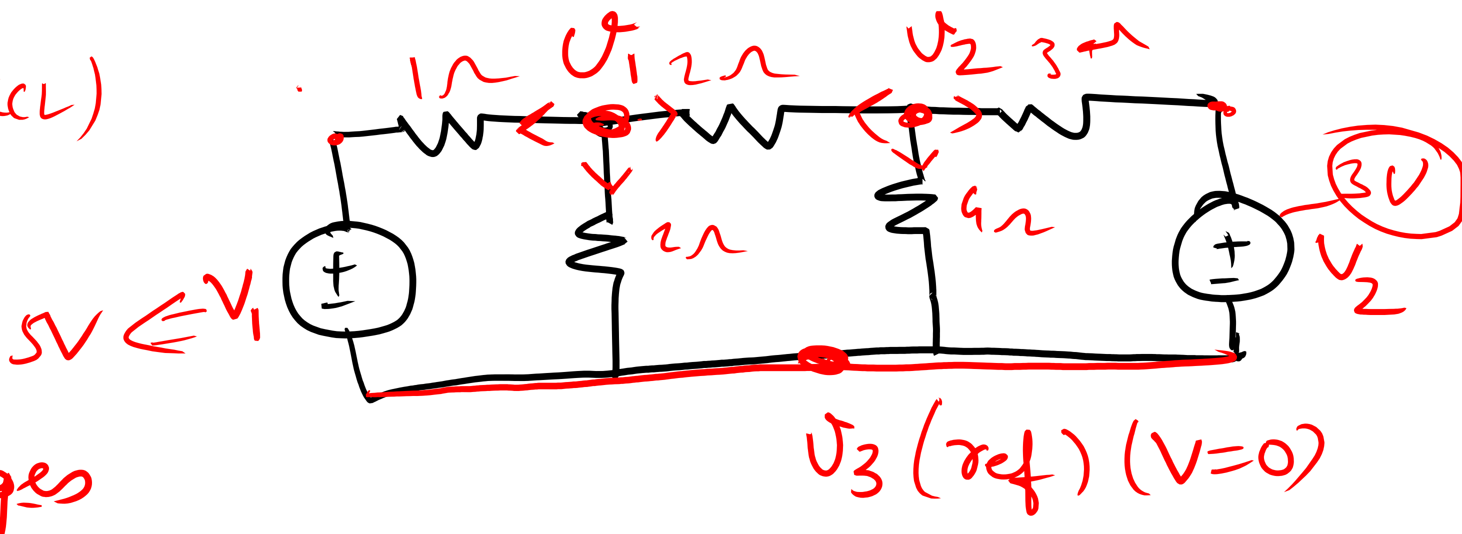
① Identify Nodes

② Mark the nodes with unknown voltages

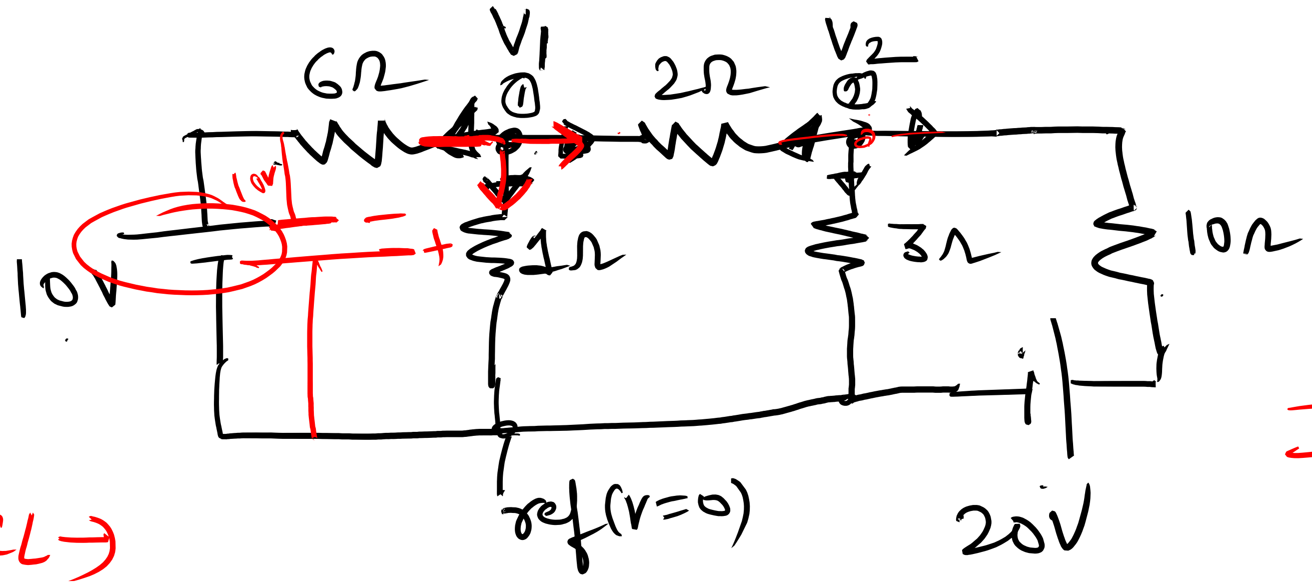
③ Take one node as a ref with (V=0)

④ Take currents on all node (outgoing current → +ive)

⑤ Finally write KCL eq. on each node



Q



$$i = \frac{V}{R} = \frac{V_1 - V_2}{R}$$

$\Rightarrow$ Nodal Analysis

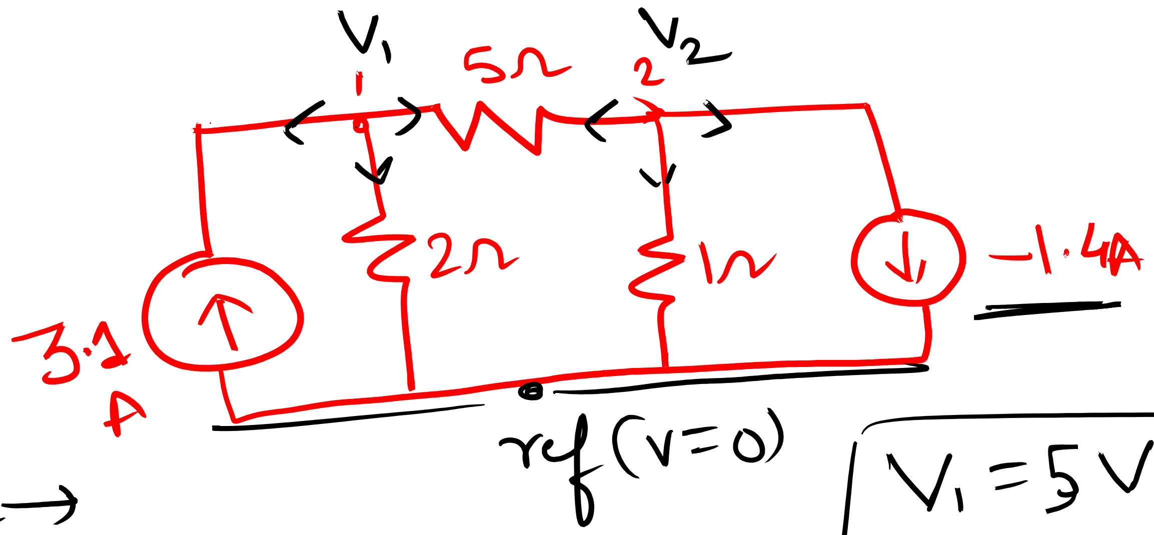
KCL →

At node 1

$$\frac{V_1 - 10}{6} + \frac{V_1 - 0}{1} + \frac{V_1 - V_2}{2} = 0$$

KCL at Node 2

$$\frac{V_2 - V_1}{2} + \frac{V_2 - 0}{3} + \frac{V_2 - 20}{10} = 0$$



$$\boxed{\begin{aligned} V_1 &= 5V \\ V_2 &= 2V \end{aligned}}$$

KCL →

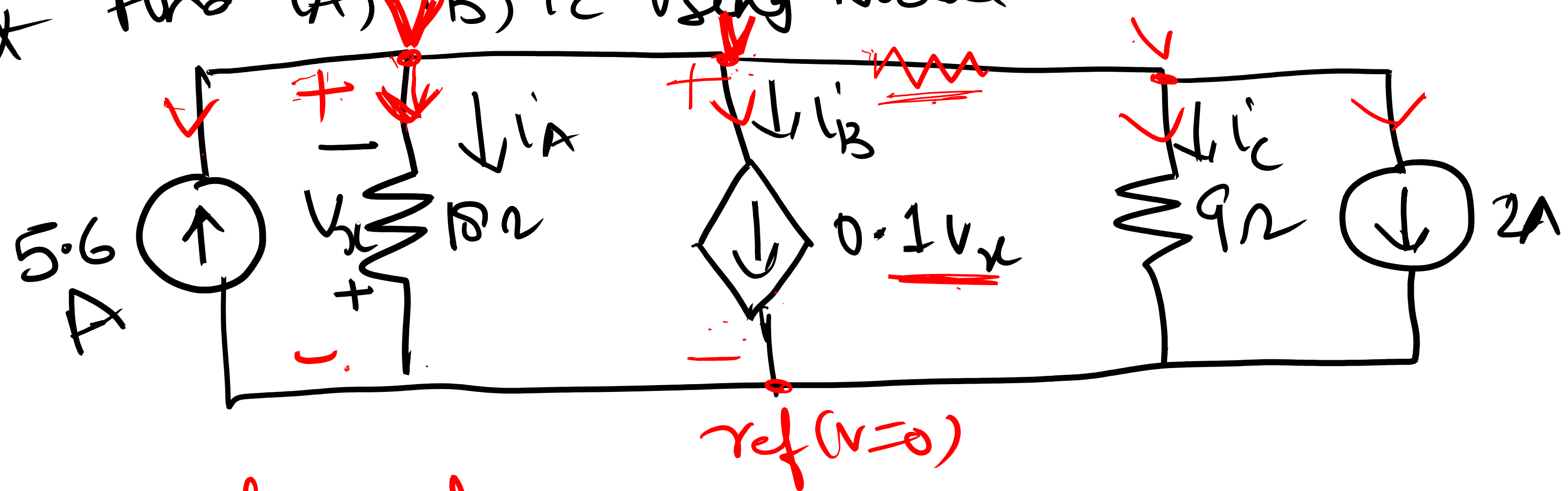
At node 1

$$-3.1 + \frac{V_1-0}{2} + \frac{V_1-V_2}{5} = 0$$

KCL at node 2

$$\frac{V_2-V_1}{5} + \frac{V_2-0}{1} + (-1.4) = 0$$

* Find i_A, i_B, i_C using Nodal



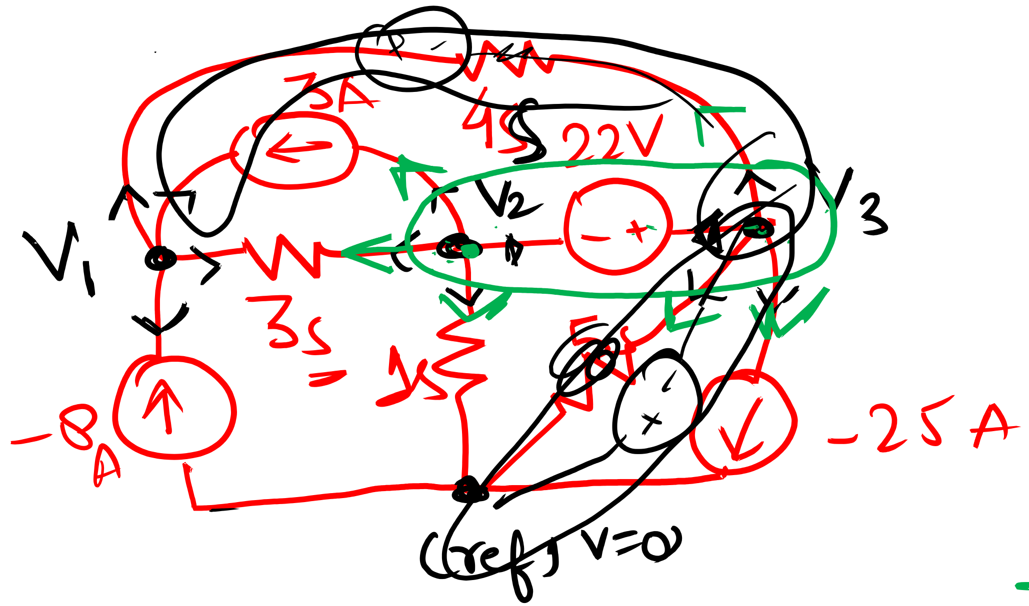
KCL eq for Node:

$$-5.6 + \frac{V}{18} + 0.1V_x + \frac{V}{9} + 2 = 0 \quad \text{— (1)}$$

$$V_x = -18 i_A \quad \text{— (2)}$$

$$\boxed{V_x = -V}$$

*



$R \to \frac{1}{R}$ = Conduct (Ω^{-1}) (S)

3

$$\boxed{V_3 - V_2 = 22}$$

V_1 — 2S — V_2

$(V_1 - V_2)\,2S$

KCL at Node 1

$$(V_1 - V_3)4 + (V_1 - V_2)3 - 3 - (-8) = 0 \quad \text{—(1)}$$

$\Rightarrow$ **SuperNode**

KCL at Node 2

$$(V_2 - V_1)3 + 3 + (V_2 - 0)1 + ? = 0$$

KCL at Node 3

$$\_ \quad \_ \quad \_ \quad + \; ? = 0$$

$$(V_2 - V_1)3 + 3 + V_2 \cdot 1 + (V_3 - V_1)4 + (V_3 - 0)5 + (-25) = 0 \quad \text{—(2)}$$