Alternative Representation, KCL-KVL, Nodal Analysis

Lecture 2

Course No: CSE 251

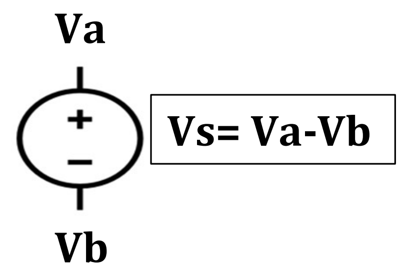
Course Title: Electronic Devices and Circuits

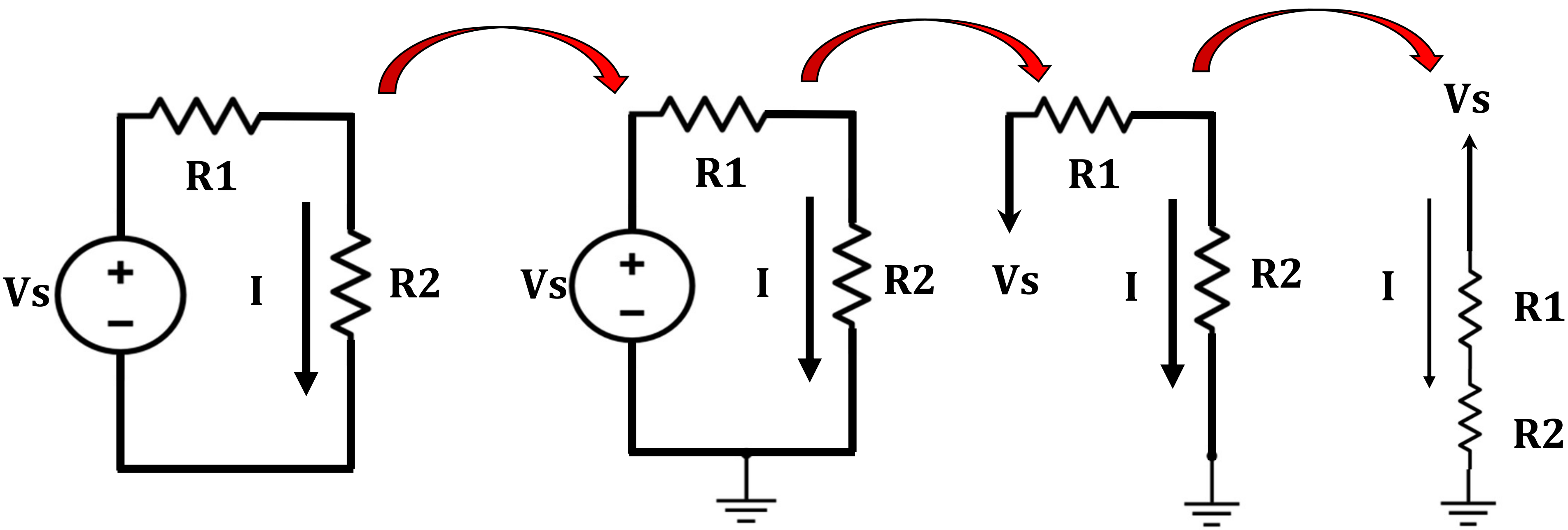
Alternative Circuit Representation: Line diagrams

Goal: representing circuits using Shorthand notations

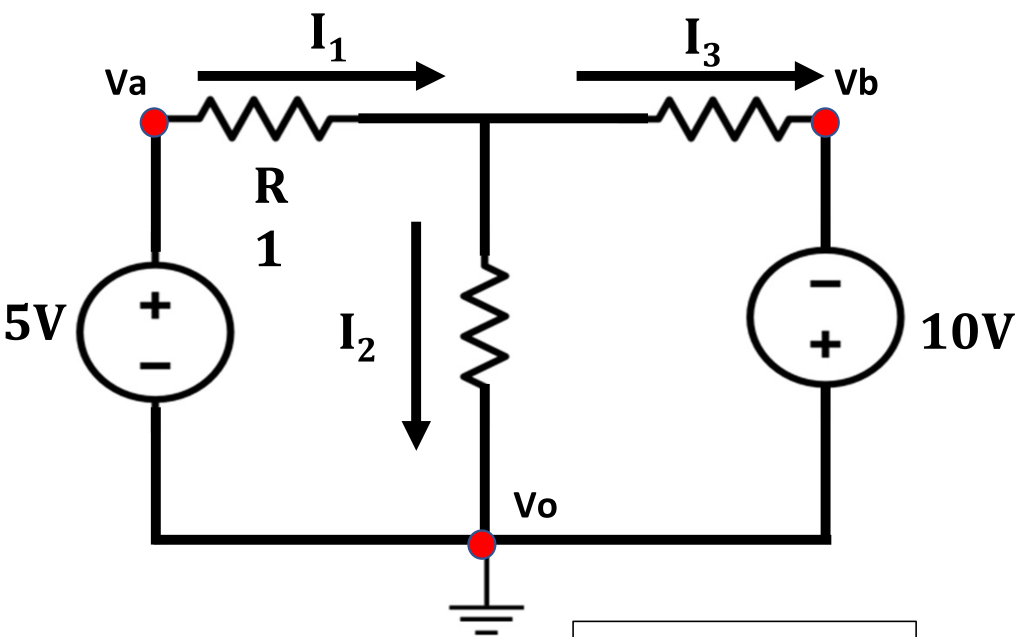
Steps

- Identify the 'Nodes'
- Select one node as 'Ground'
- Replace the other known voltage nodes with an arrow

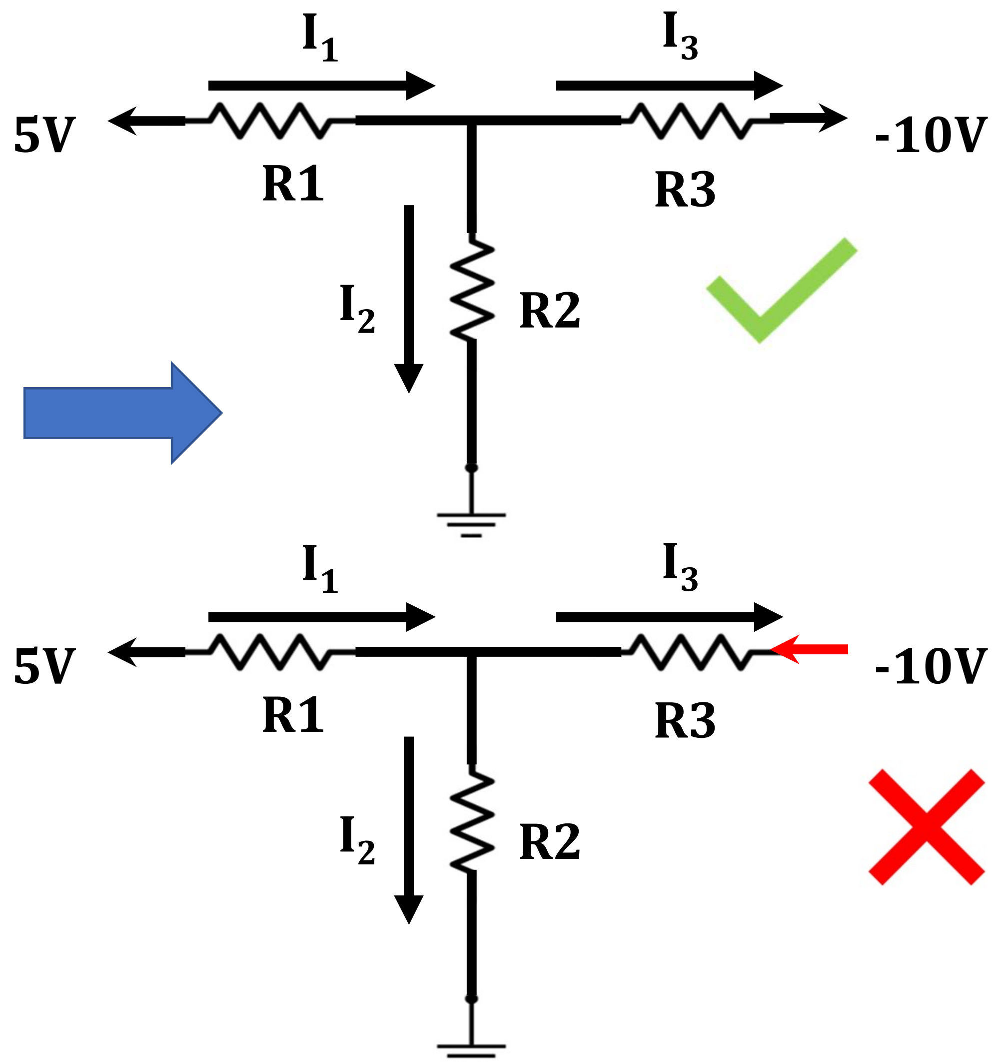




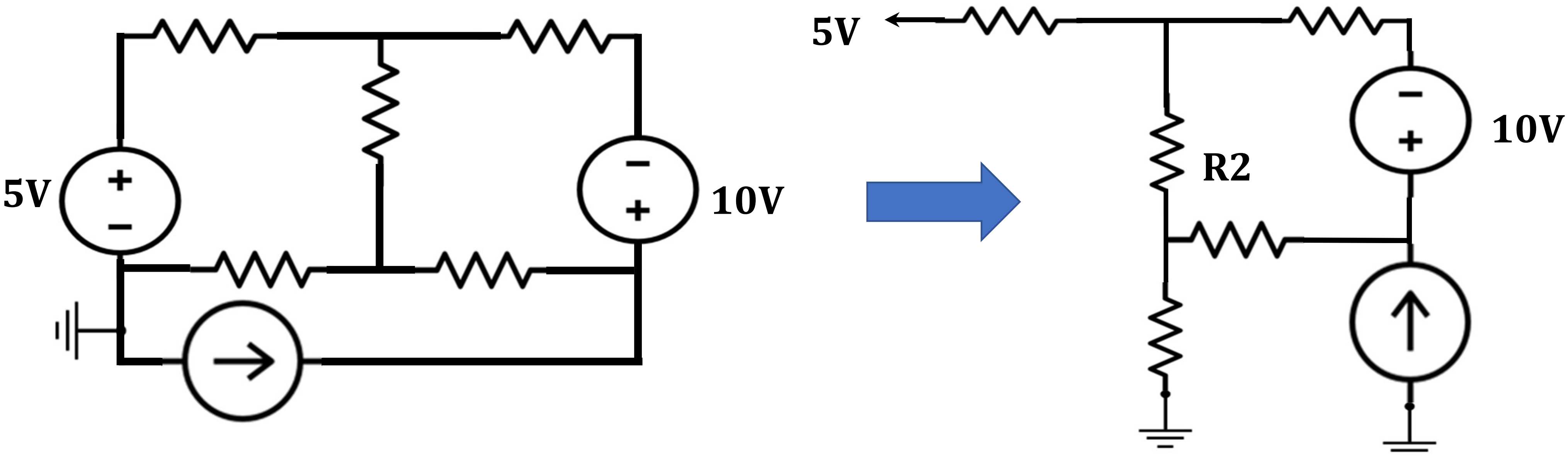
- Circuits with **<u>voltage sources of opposite polarities</u>**



Vo= 0V [Ground]
For 5V :
Va-Vo= (5-0) V
=> Va = 5V
For 10V :
Vo-Vb= (0-10) V
=> Vb = -10 V

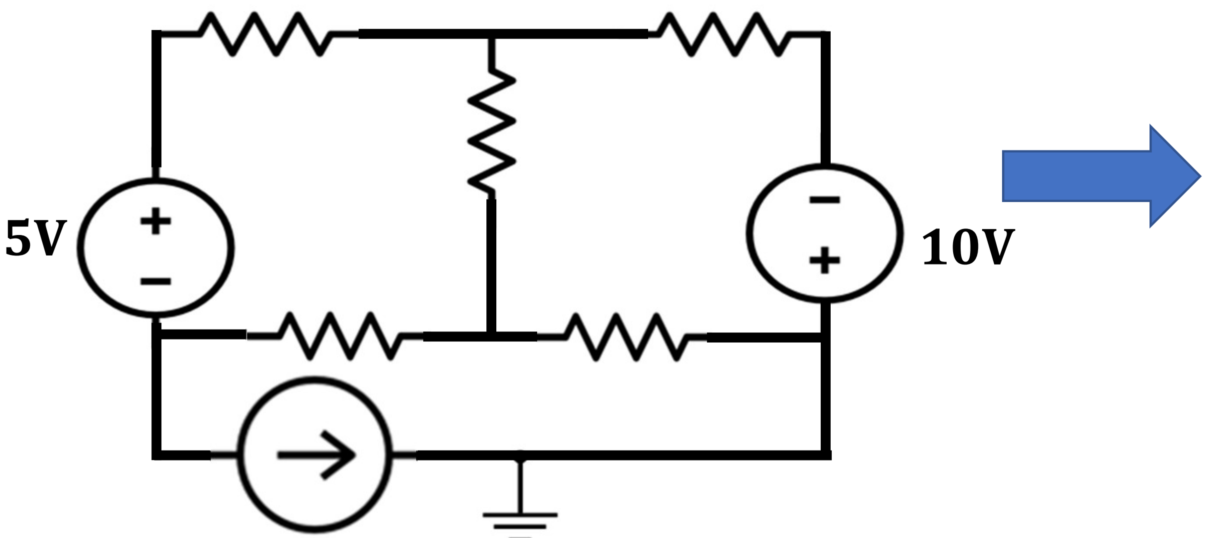


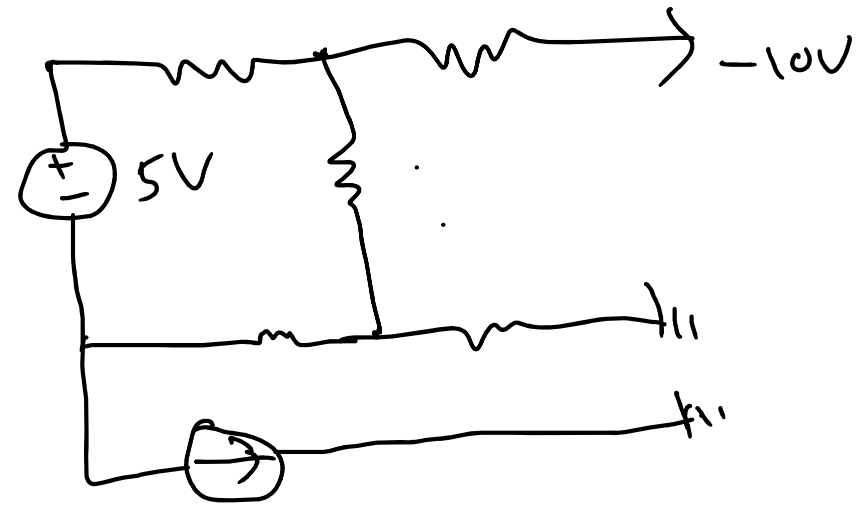
- Circuit with **a current source/ floating voltage source**: Keep them as they are!



- **Floating voltage sources:** None of the terminals of the voltage source is connected to the reference i.e. ground node

Practice Problem



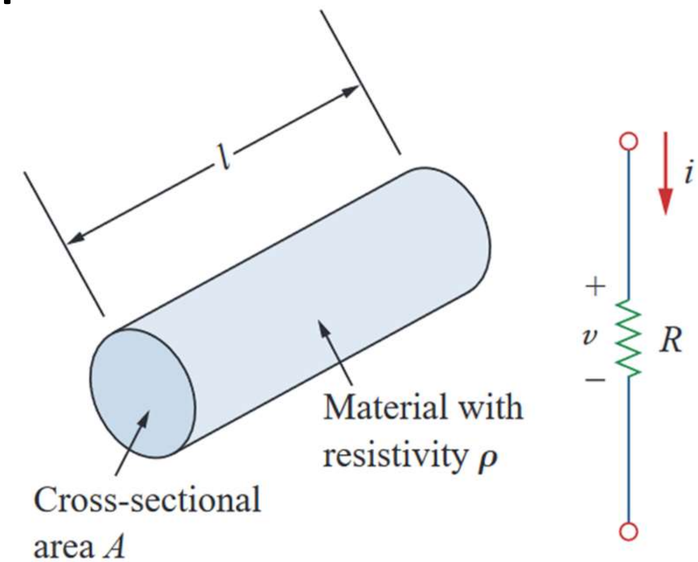


The fundamentals …

Ohm's Law –

- the voltage $\boldsymbol{v}$ across a resistor is **directly proportional** to the current $\boldsymbol{i}$ flowing through the resistor ($\boldsymbol{R}$)

$$\boldsymbol{v} \propto \boldsymbol{i}$$
$$\boldsymbol{v} = \boldsymbol{iR}$$

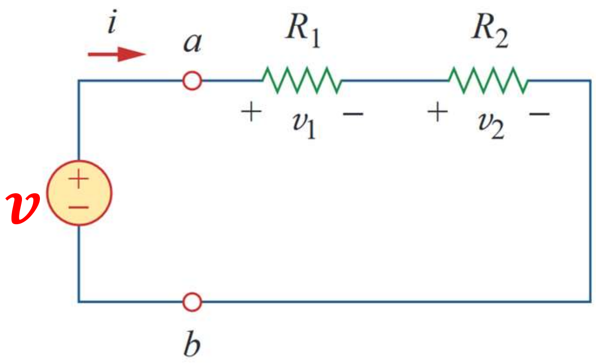


Series Resistors and Voltage Division

The **equivalent resistance** of any number of resistors connected in **series** is the sum of the individual resistances.

Principle of voltage division

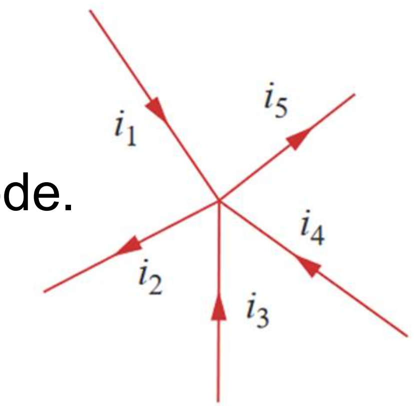
Source voltage v - is divided among the resistors in direct proportion to their resistances; the larger the resistance, the larger the voltage drop.



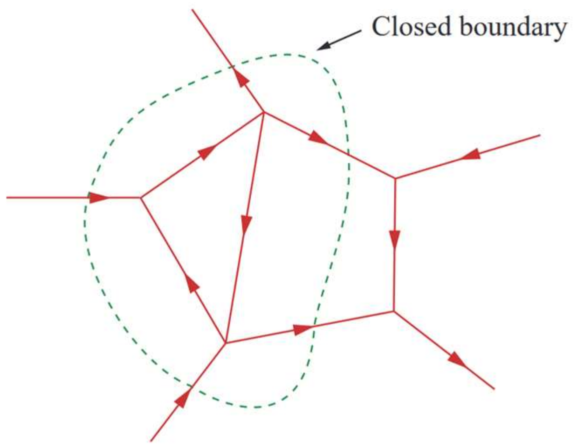
$$v_1 = \frac{R_1}{R_1 + R_2} v \qquad v_2 = \frac{R_2}{R_1 + R_2} v$$

KCL: Kirchhoff's Current Law

The <u>algebraic sum</u> of the **currents** entering a **node (closed boundary)** is equal to the sum of the currents leaving the node.



$$i_1 + (-i_2) + i_3 + i_4 + (-i_5) = 0$$

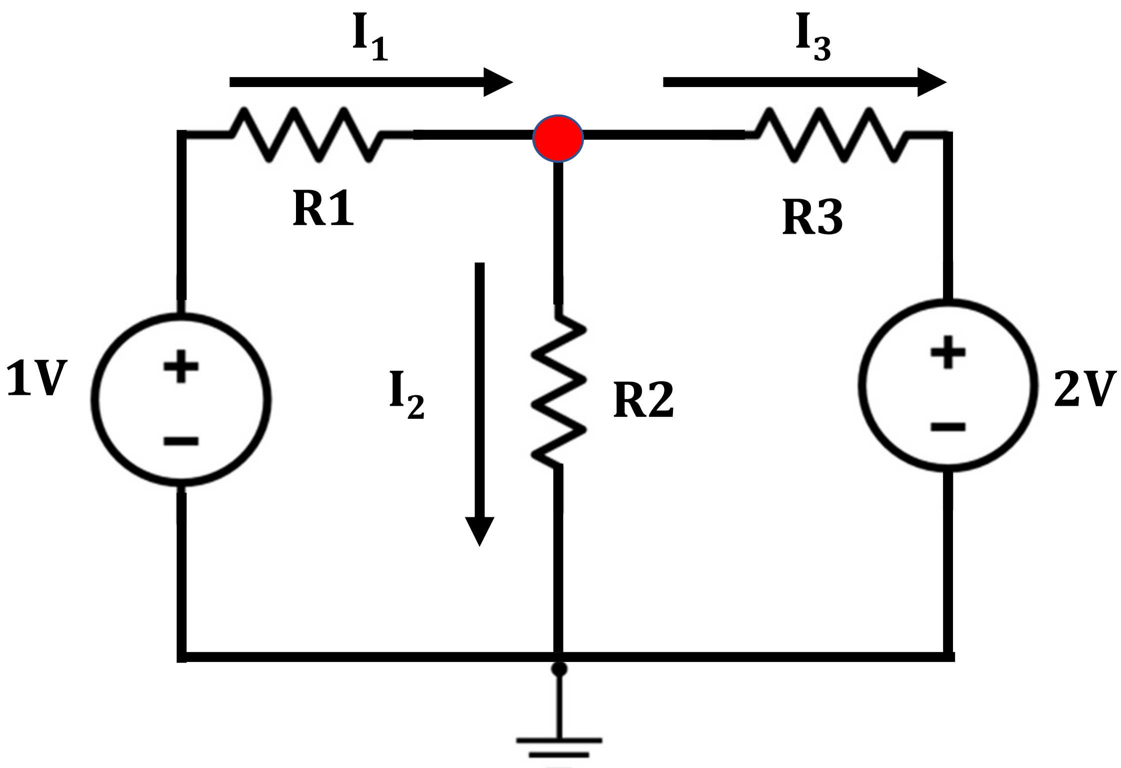


Current Entering node: **Positive**
Current Exiting node: **Negative**

Or vice versa…

Kirchhoff's Current Law (KCL):

- "The algebraic sum of all currents entering and exiting a node must equal zero."
- "Currents flowing into a node (or a junction) must be equal to the currents flowing out of it."



$$I_1 = I_2 + I_3$$

Kirchhoff's Current Law (KCL):

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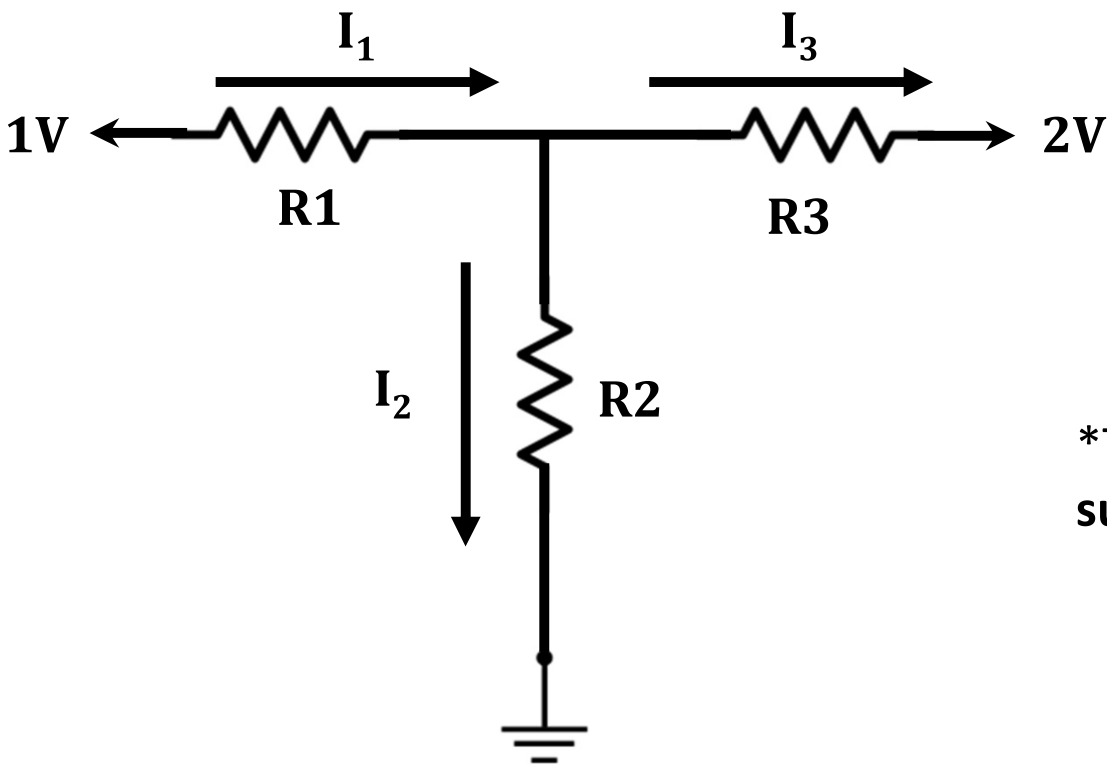
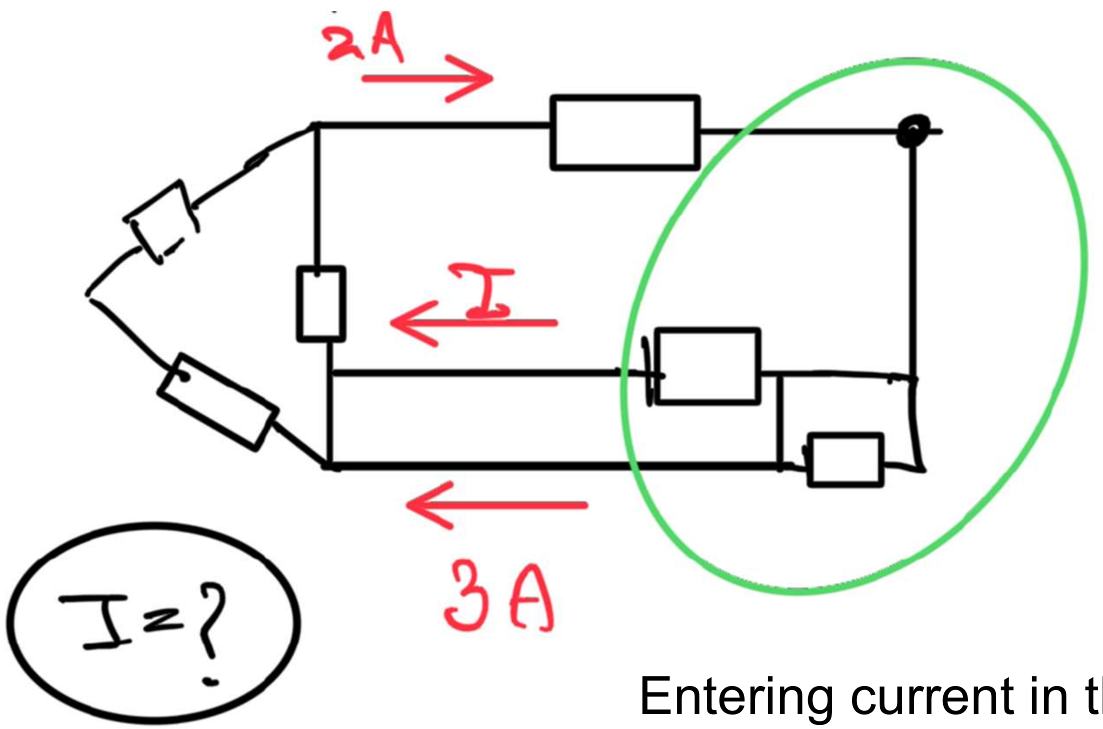


$$\boxed{I_1 = I_2 + I_3}$$

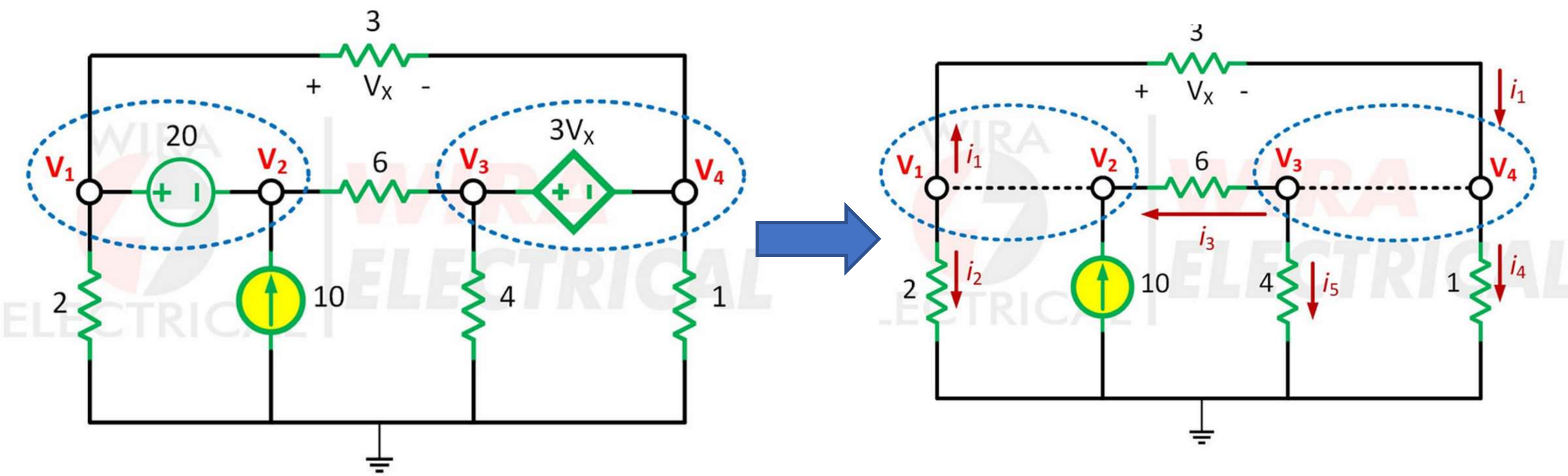
*This is also applicable to **supernodes**!



Entering current in the green closed region= 2A
Leaving current from the closed region= I & 3A

KCL→ I + 3A= 2A

∴ I= -1A



KCL for Super node 1:

$$i_1 + i_2 = i_3 + 10A$$

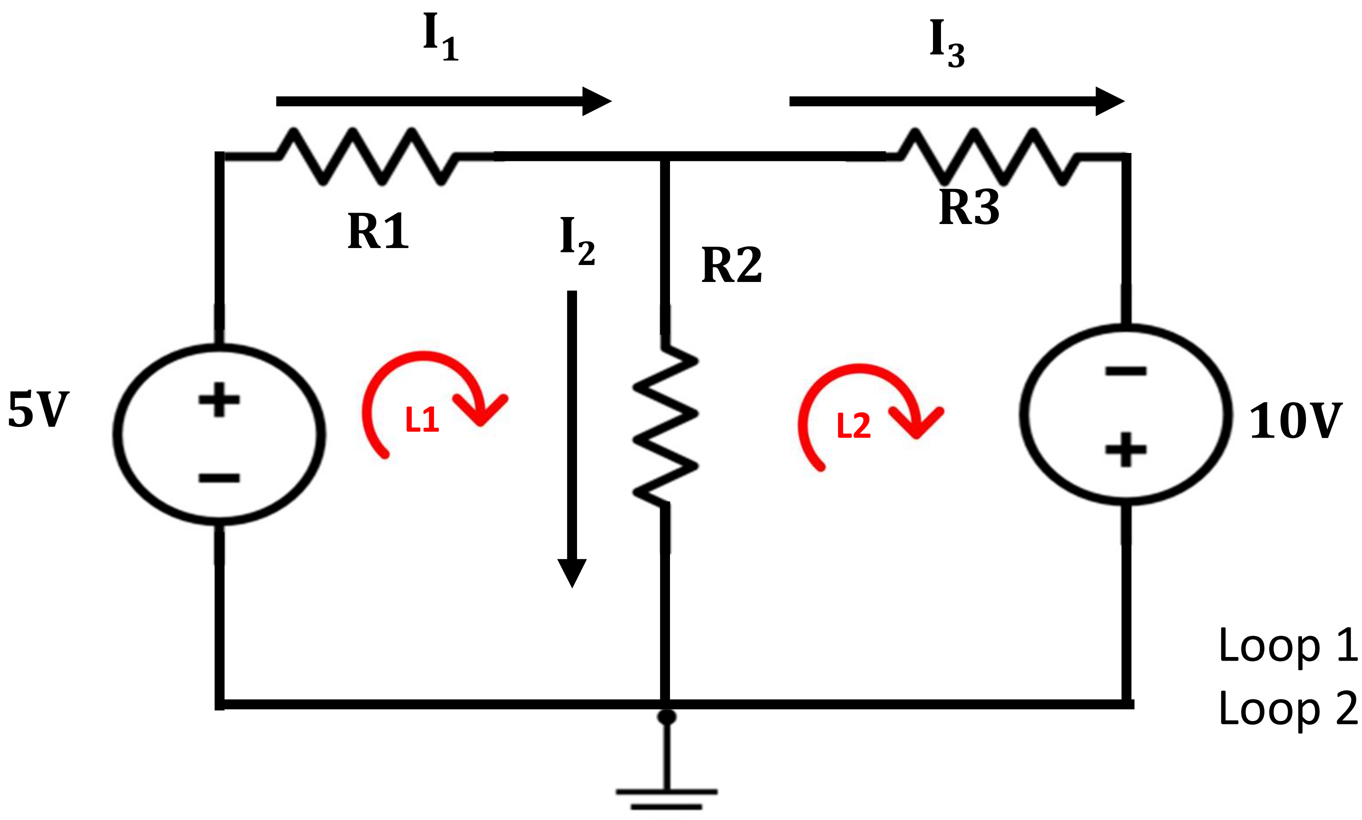
KCL for Super node 2:

$$i_1 = i_3 + i_4 + i_5$$

Kirchhoff's Voltage Law (KVL)

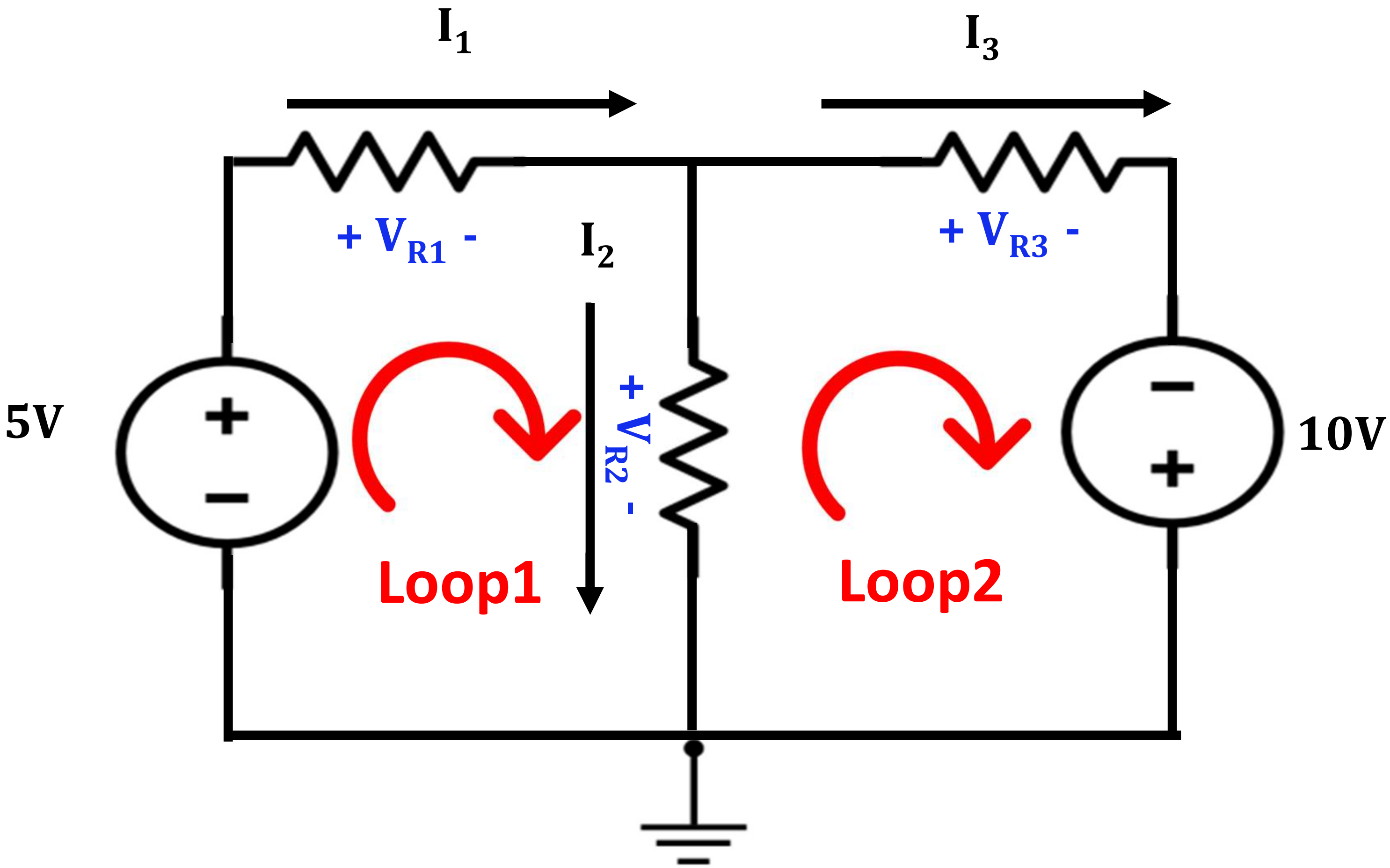
The algebraic sum of all voltages in a loop must equal zero

$$\sum V = 0$$

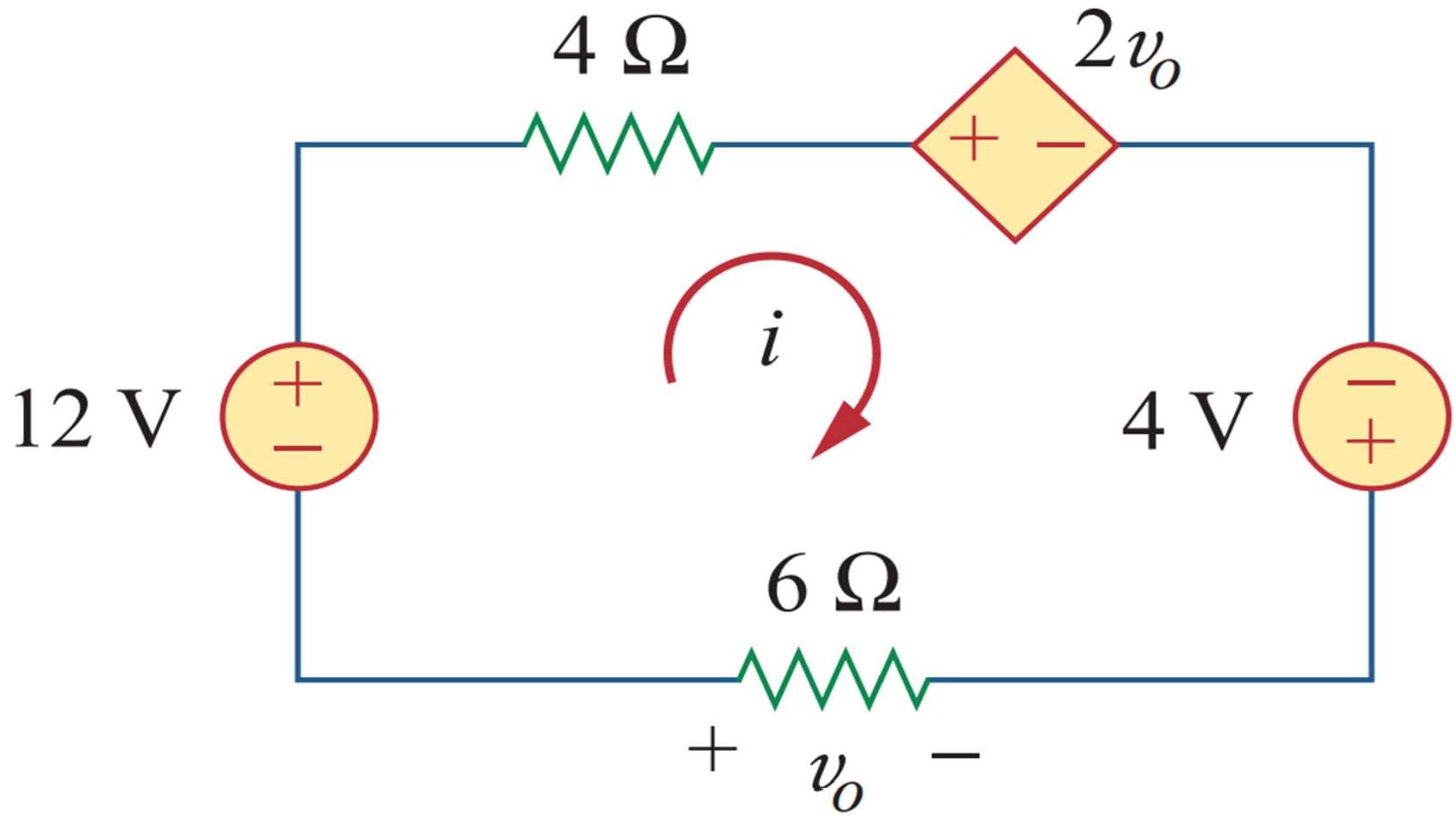


Loop 1: $5 - I_1R_1 - I_2R_2 = 0$

Loop 2: $10 + I_2R_2 - I_3R_3 = 0$



I1
I3
+ VR1 -
I2
+ VR3 -
5V
+ VR2 -
10V
Loop1
Loop2

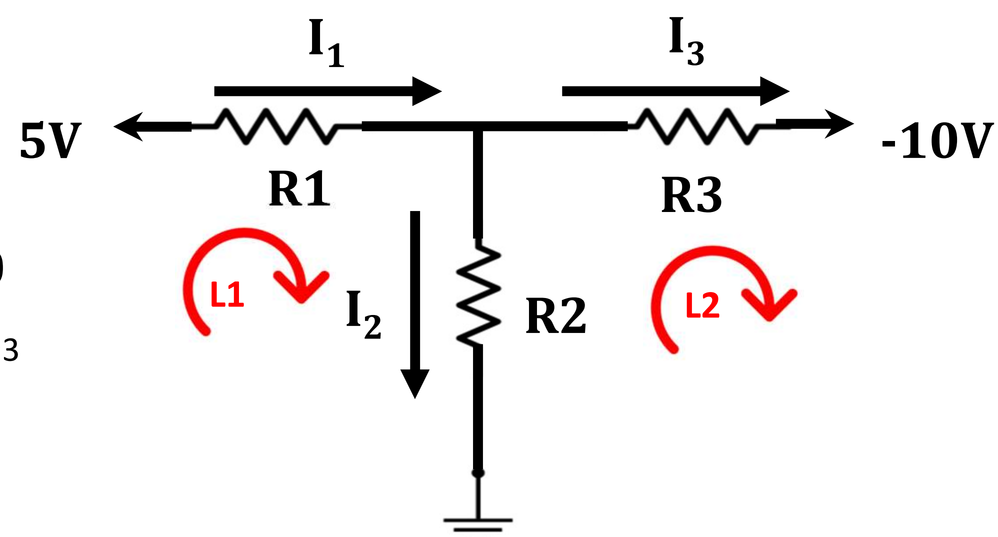


Hint:

KVL: $-12V + 4i + 2v_0 - 4V - v_0 = 0$ --- (1)

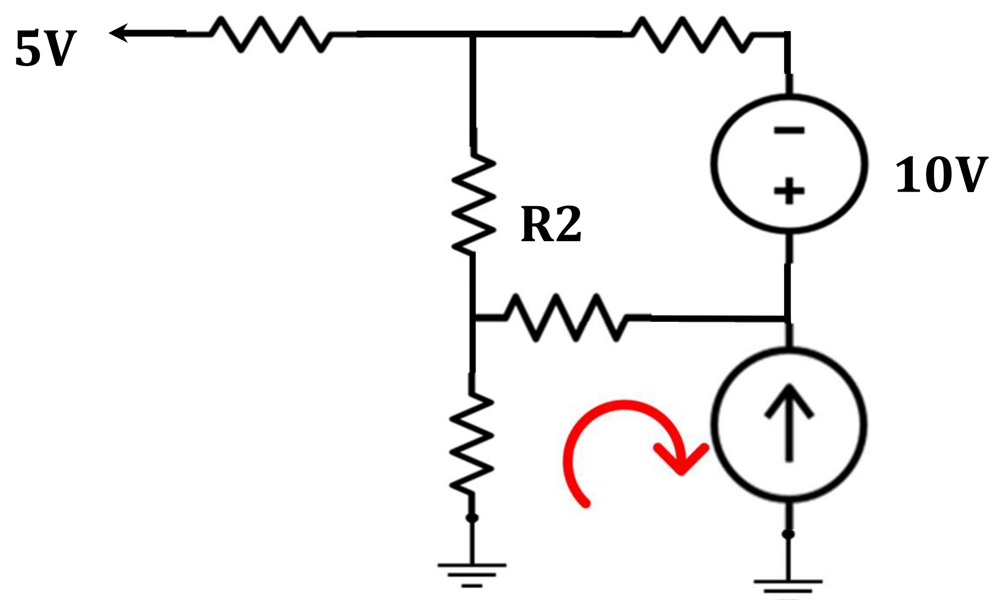
$v_0 = -6i$ --- (2)

$$\sum V\ [along\ line] = Voltage\ at\ the\ starting\ of\ the\ node - Voltage\ at\ the\ ending\ of\ the\ node$$



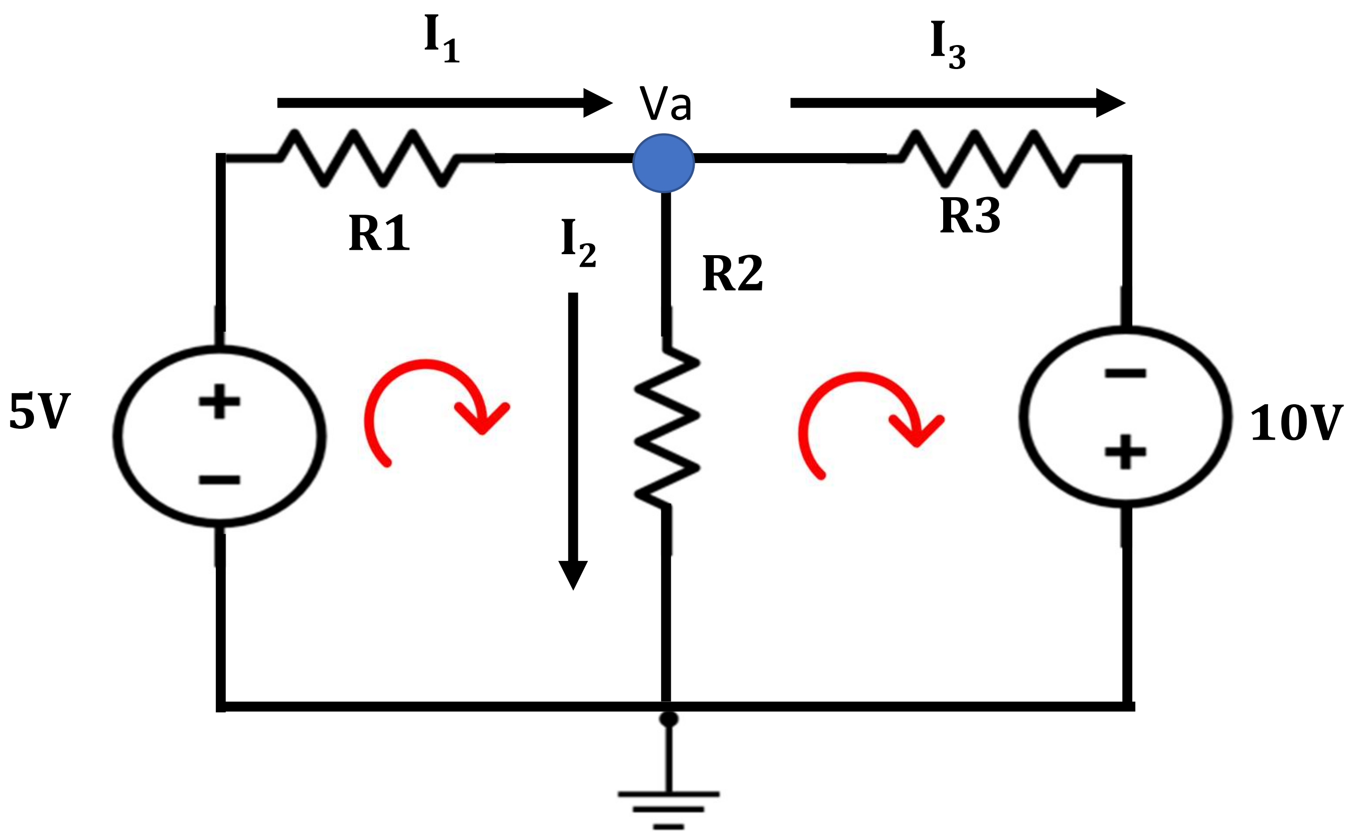
Line 1: $5-0 = I_1R_1+I_2R_2 = 0$

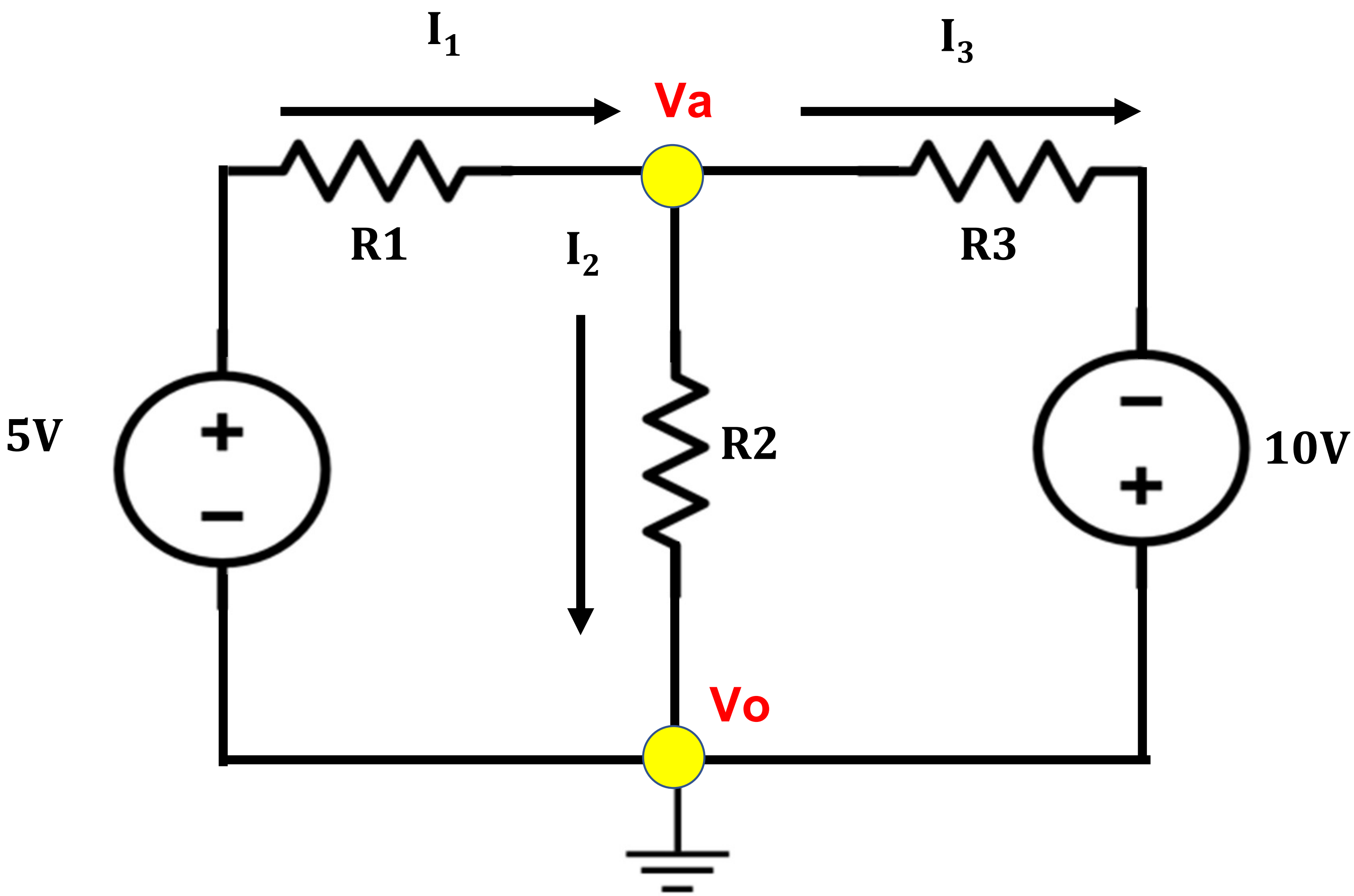
Line 2: $0-(-10) = -I_2R_2+I_3R_3$



Can you write a KVL equation along this line?

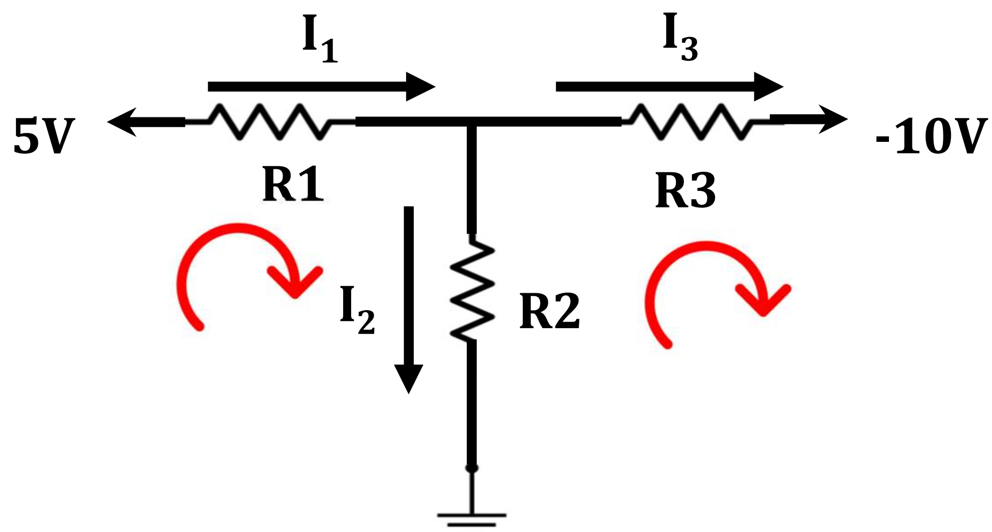
Nodal analysis: $V_a\left(\frac{1}{R1}+\frac{1}{R2}+\frac{1}{R3}\right)-\frac{5}{R1}-\frac{0}{R2}-\frac{-10}{R3}=0\,;\,Derived\ from\ applying\ KCL\ at\ node\ V_a$



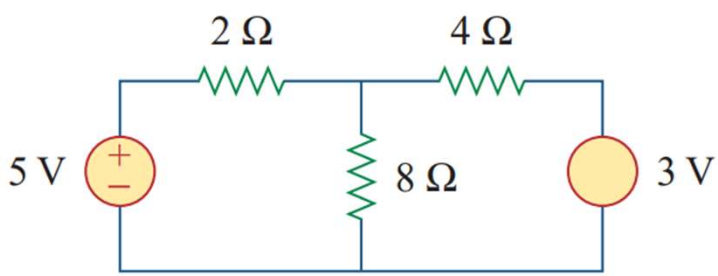

I1
I3
Va
R1
I2
R3
5V
R2
10V
Vo

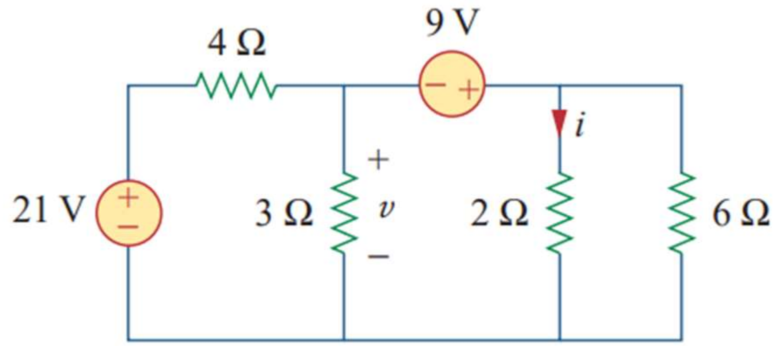
Nodal analysis:

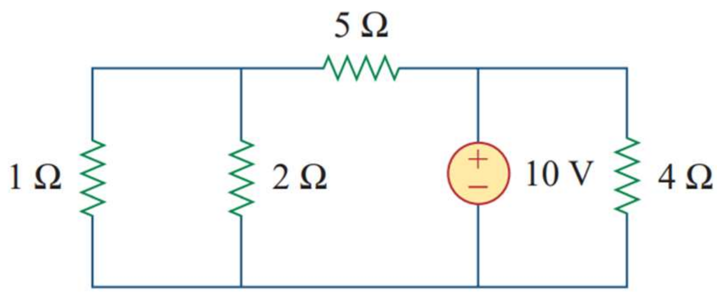
$$V_a\left(\frac{1}{R1}+\frac{1}{R2}+\frac{1}{R3}\right)-\frac{5}{R1}-\frac{0}{R2}-\frac{-10}{R3}=0$$

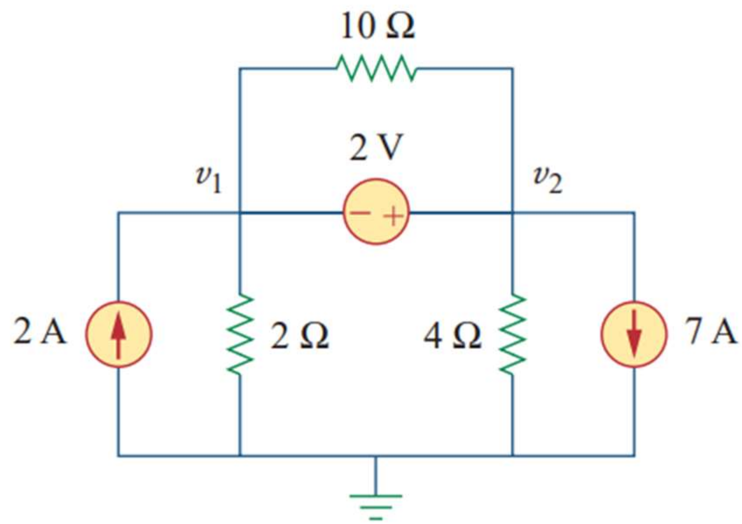


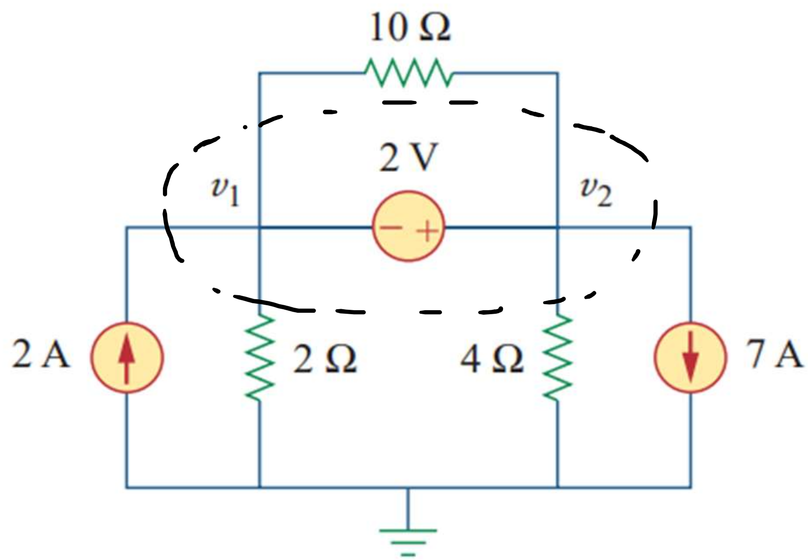
Practice Problems: i) Draw Alternative Circuit Diagrams , ii) Write down KCL equations, iii) Write down KVL equations and iv) Nodal equation











Nodal Analysis:

$$\frac{V1-0}{2} + (-2\,A) + \frac{V2-0}{4} + 7\,A = 0 \text{ ---------(1)}$$

$$V1 - V2 = -2 \text{ --------(2)}$$

Thank You