CSE 251: Electronic Devices & Circuits

Lecture 2:

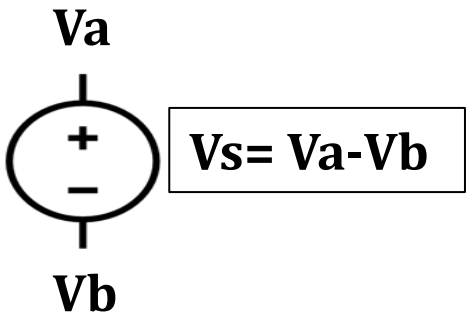
KCL, KVL, Nodal Analysis & Line diagram

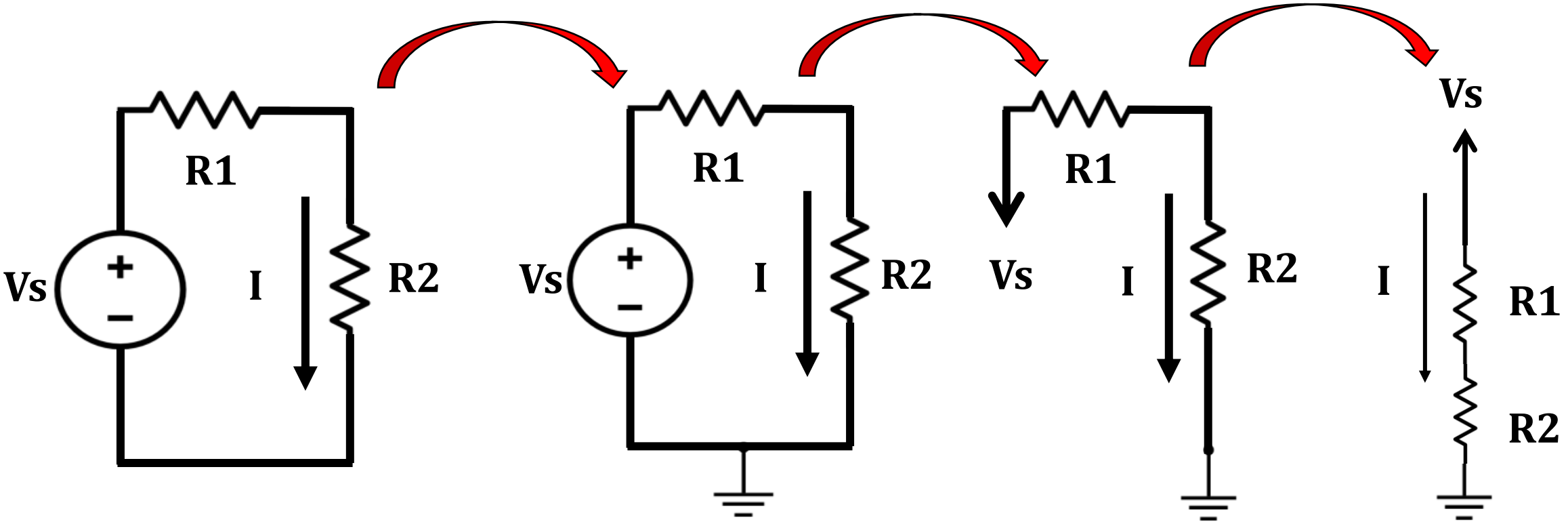
Alternative Circuit Representation: Line diagrams

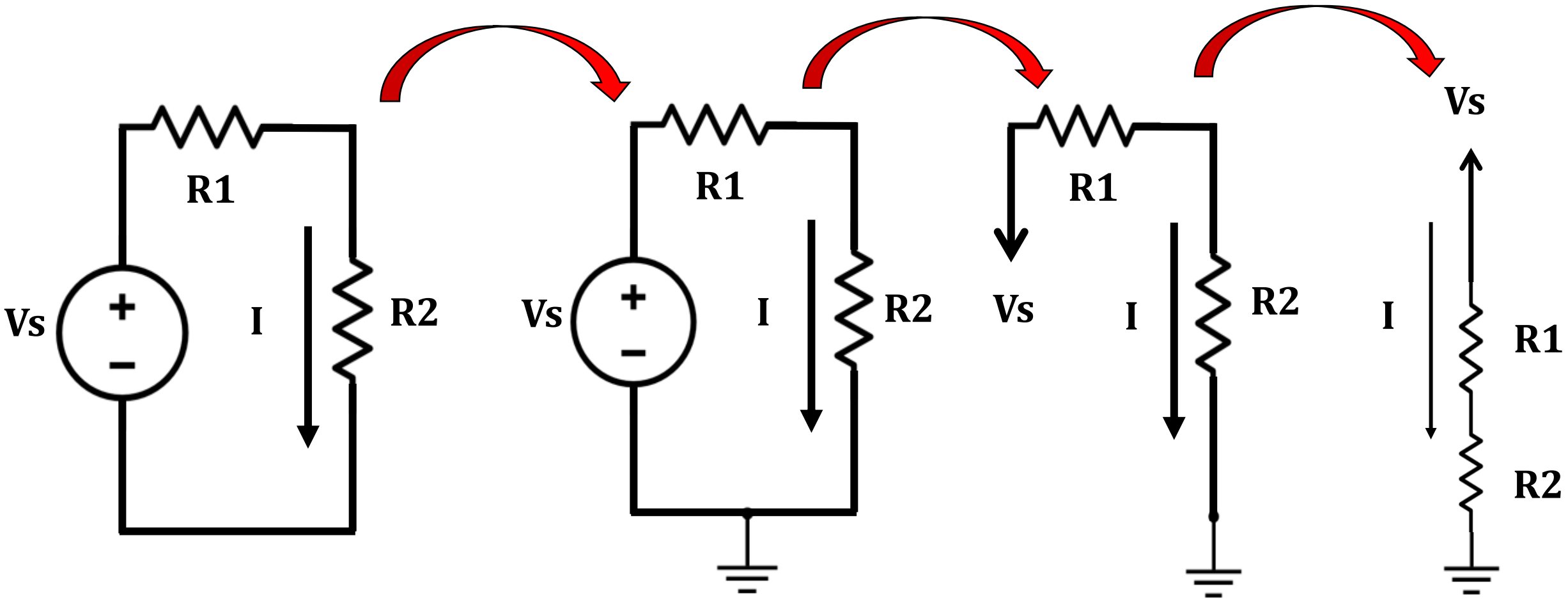
Goal: representing circuits using Short hand notations

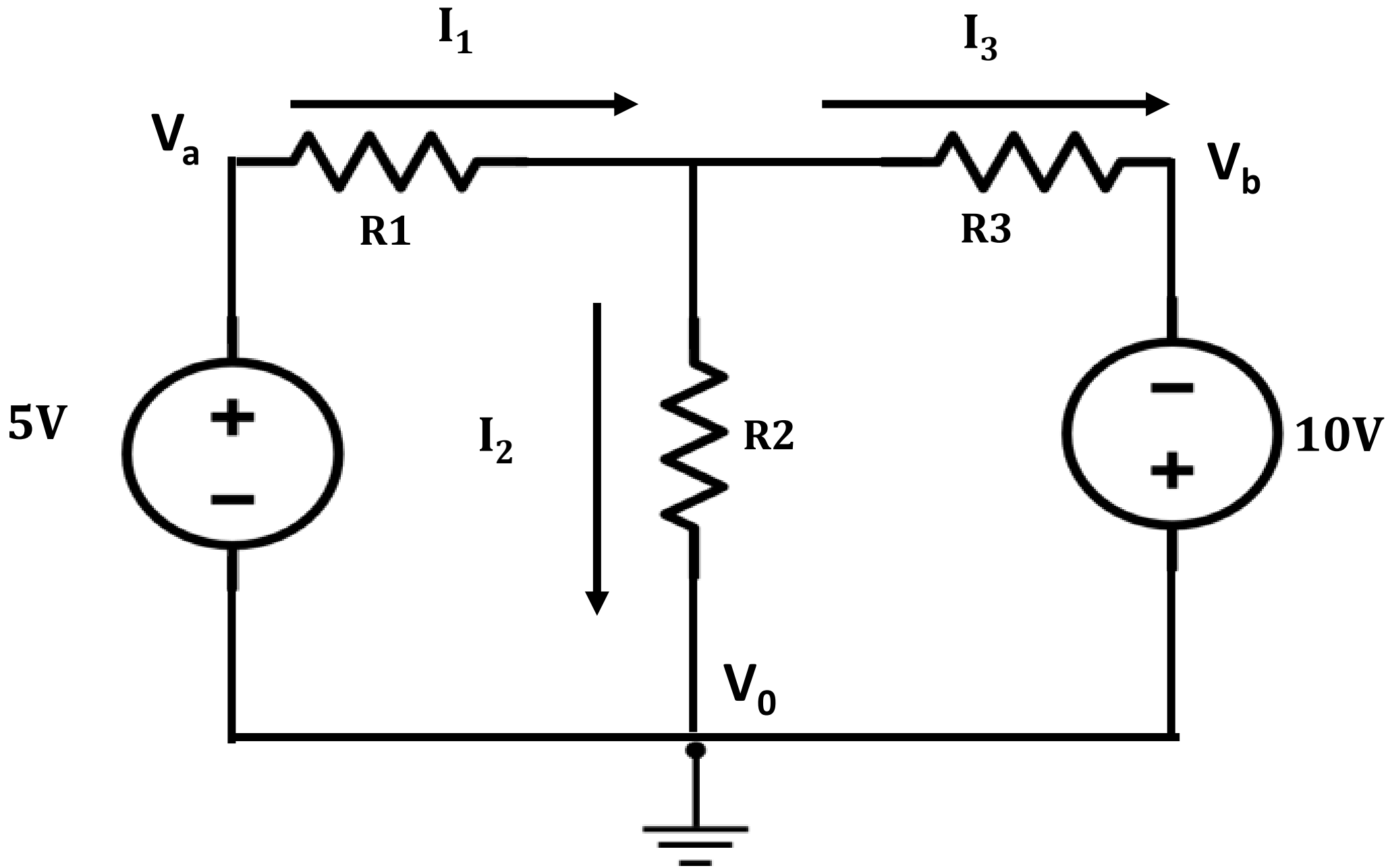
Steps

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

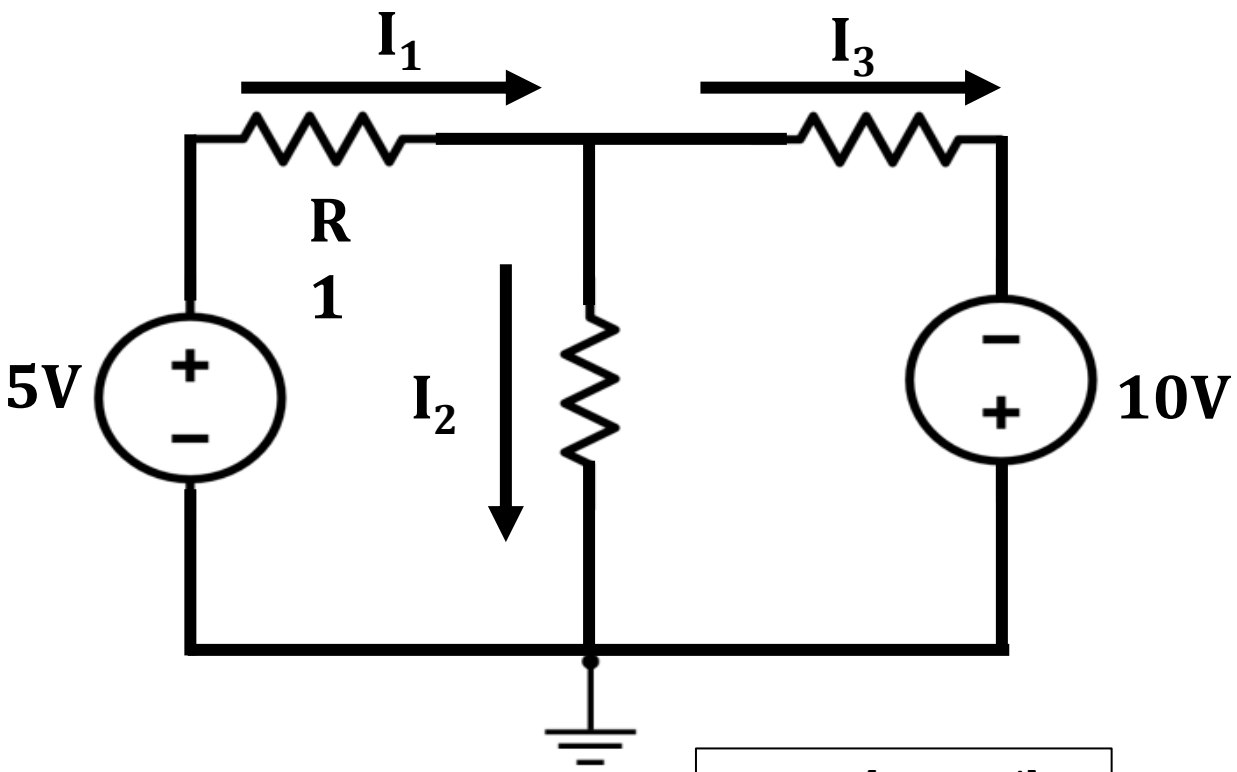





R1
Vs
I
R2
R1
Vs
I
R2
R1
Vs
I
R2
Vs
I
R1
R2


I1
I3
Va
R1
R3
Vb
5V
I2
R2
10V
V0

- Circuits with voltage sources of opposite polarities



Vo= 0V [Ground]

For 5V :

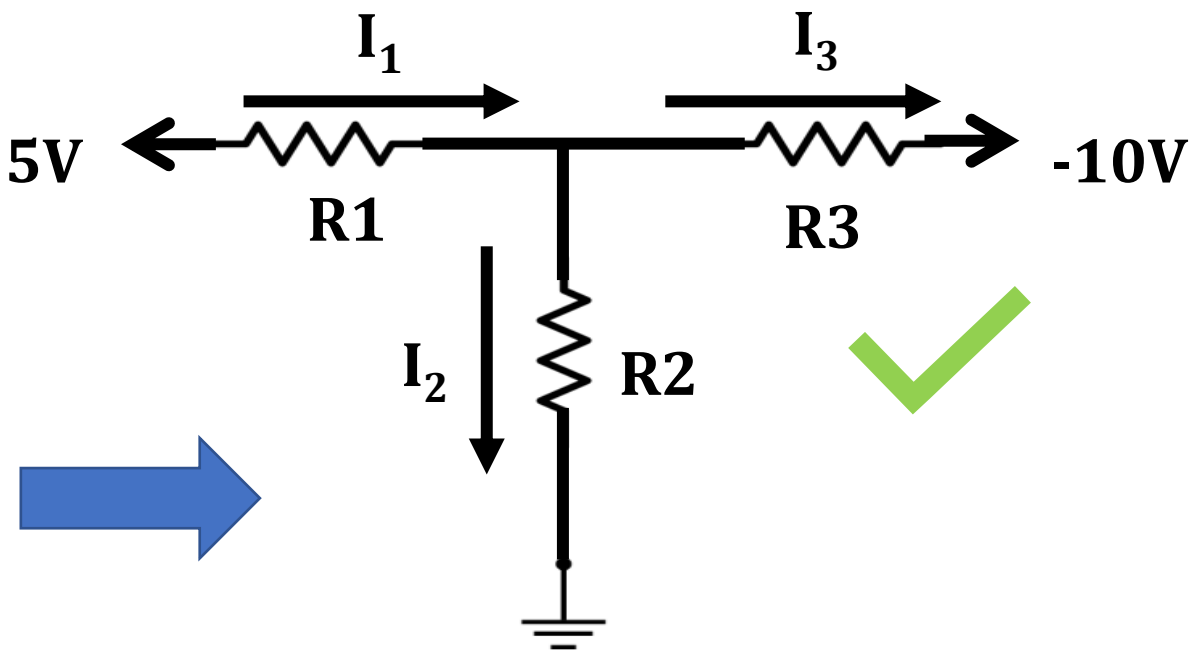
Va-Vo= (5-0) V

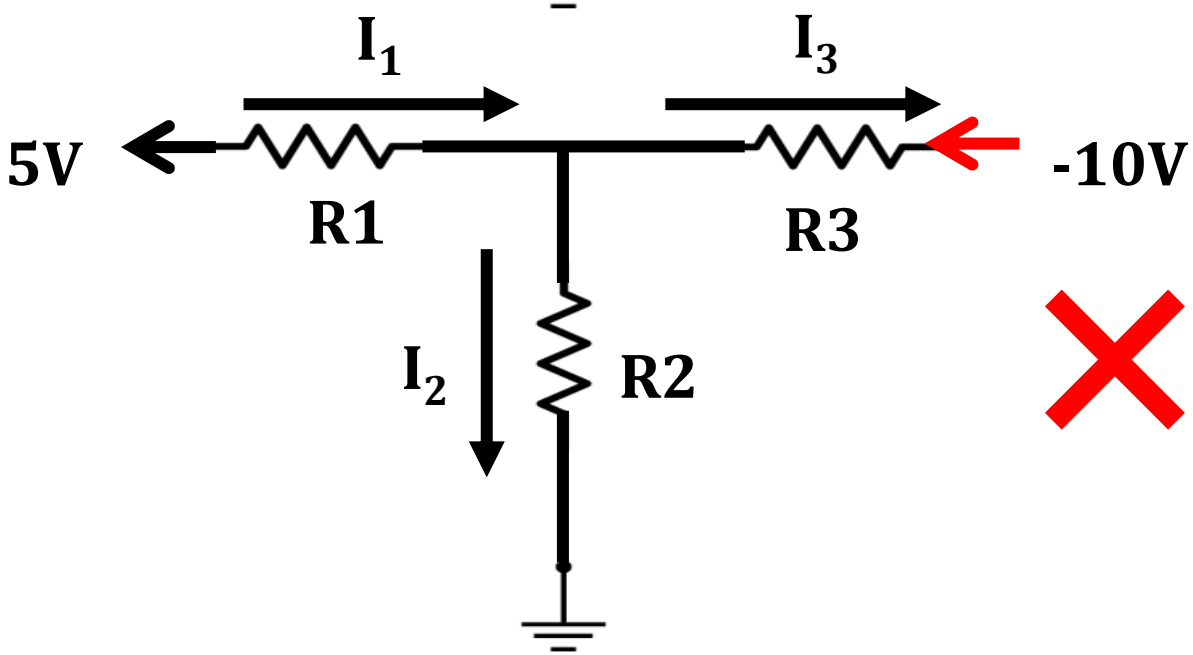
=> Va = 5V

For 10V :

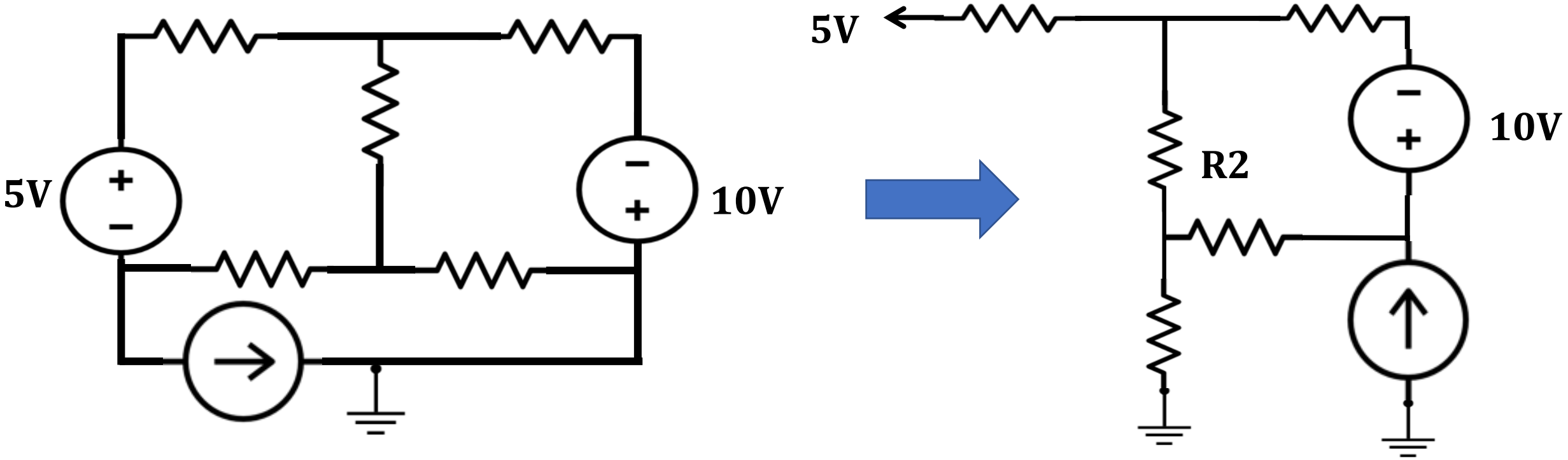
Vo-Vb= (0-10) V

=> Vb = -10 V



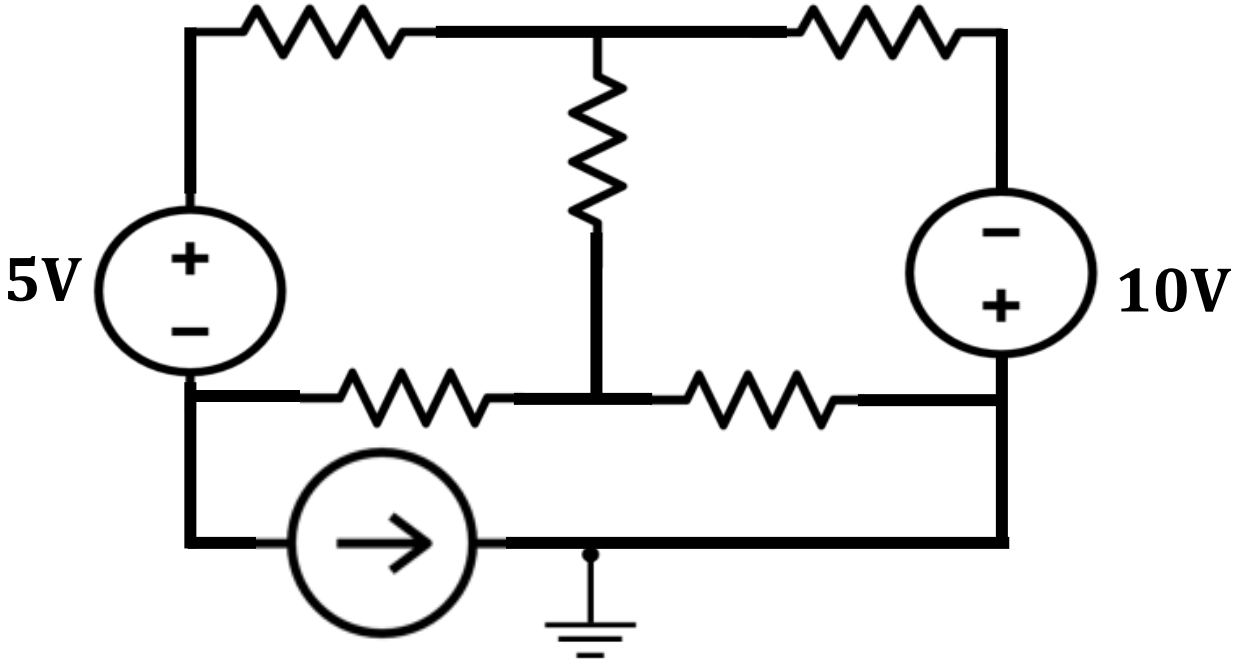


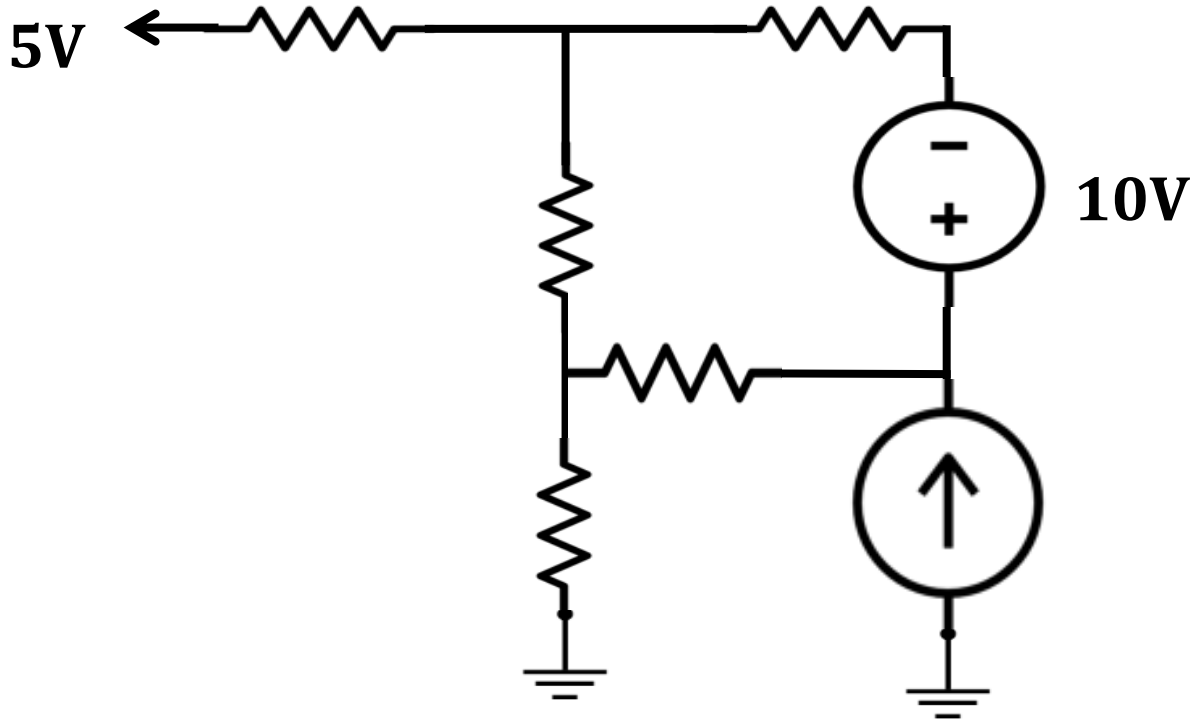
- Circuit with a current source/ floating voltage source: Keep them as they are!



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

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

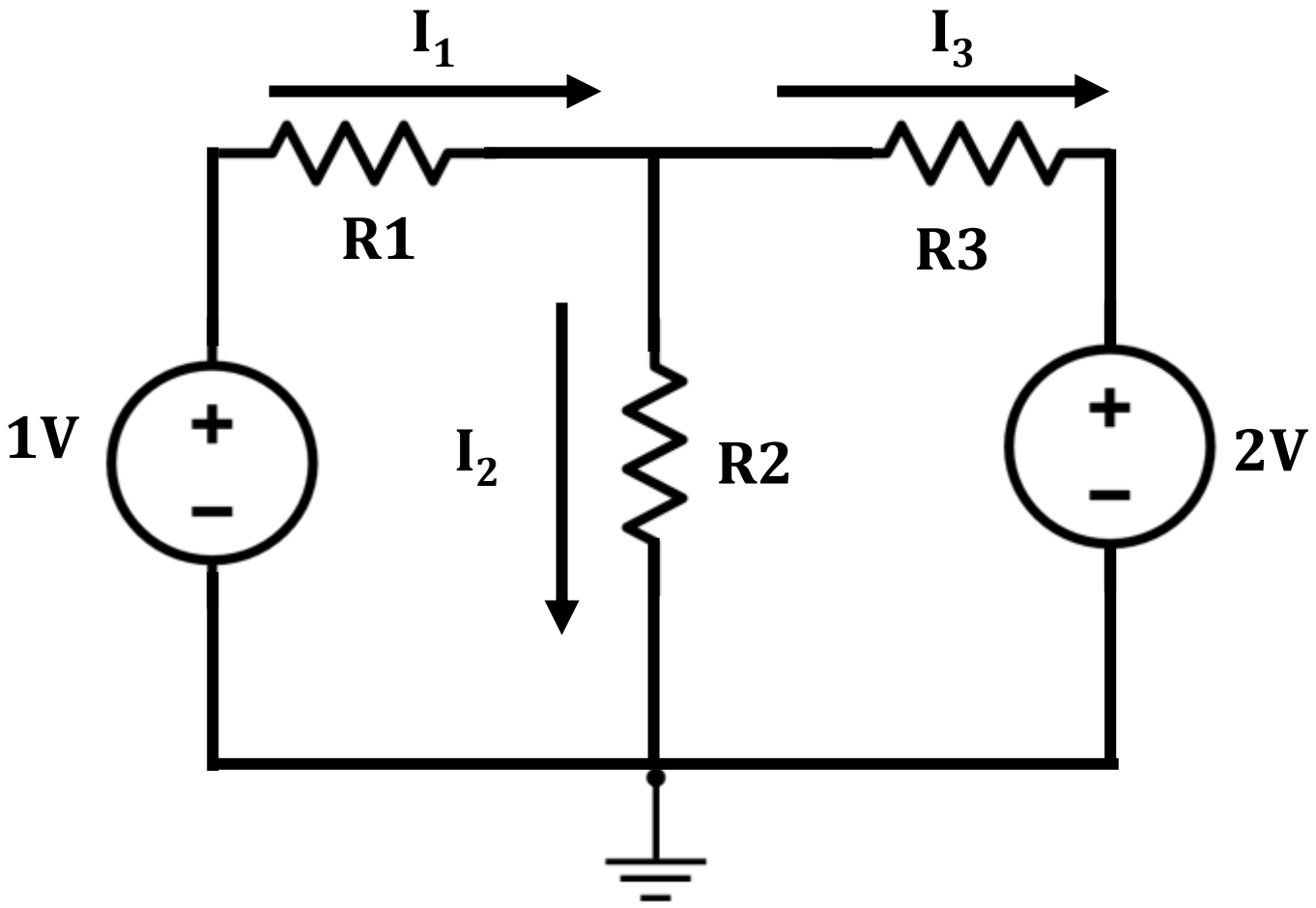




- **Floating voltage sources:** None of the terminals of the voltage source is connected to the reference i.e. ground node

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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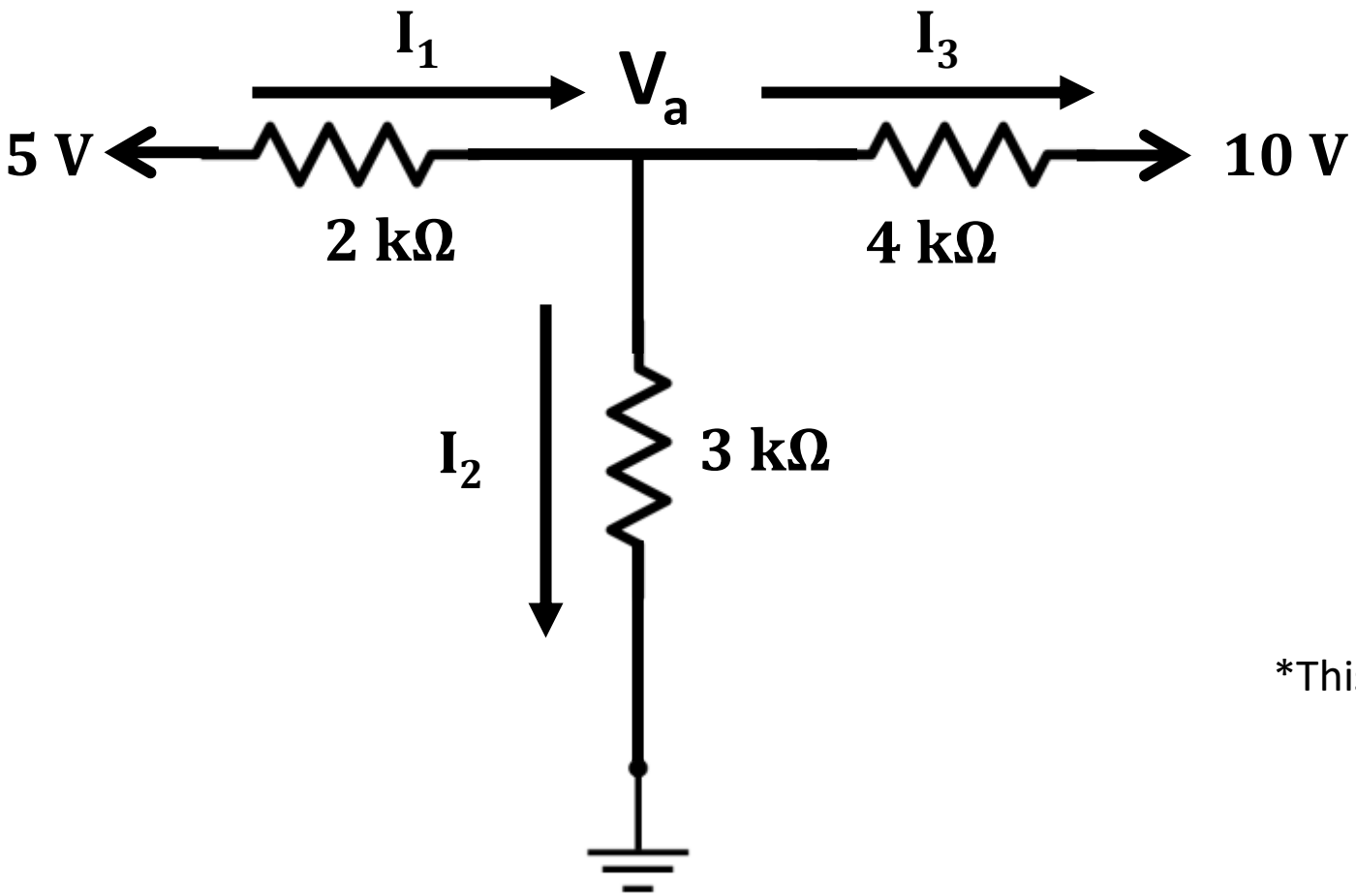


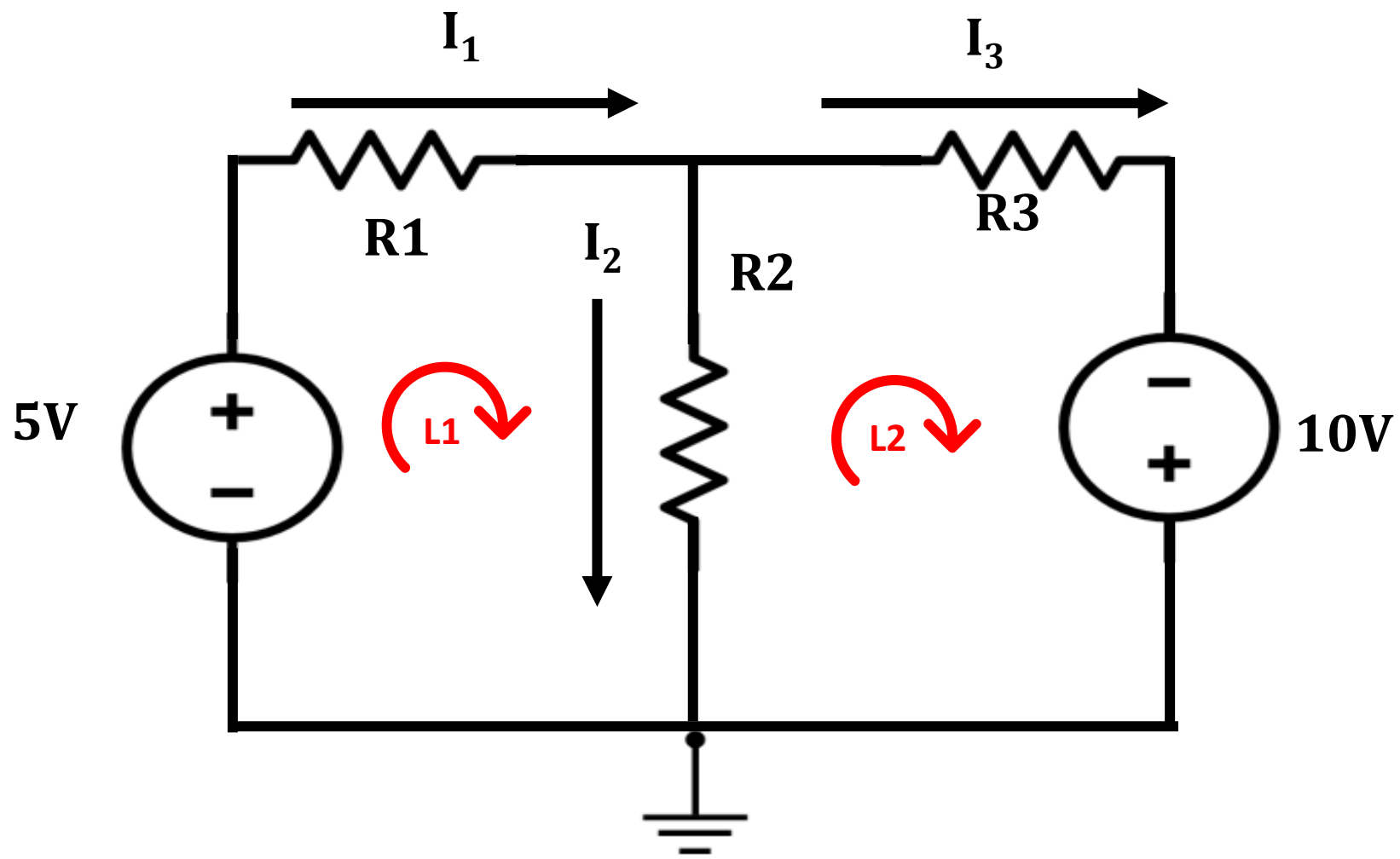
$$I_1 = I_2 + I_3$$

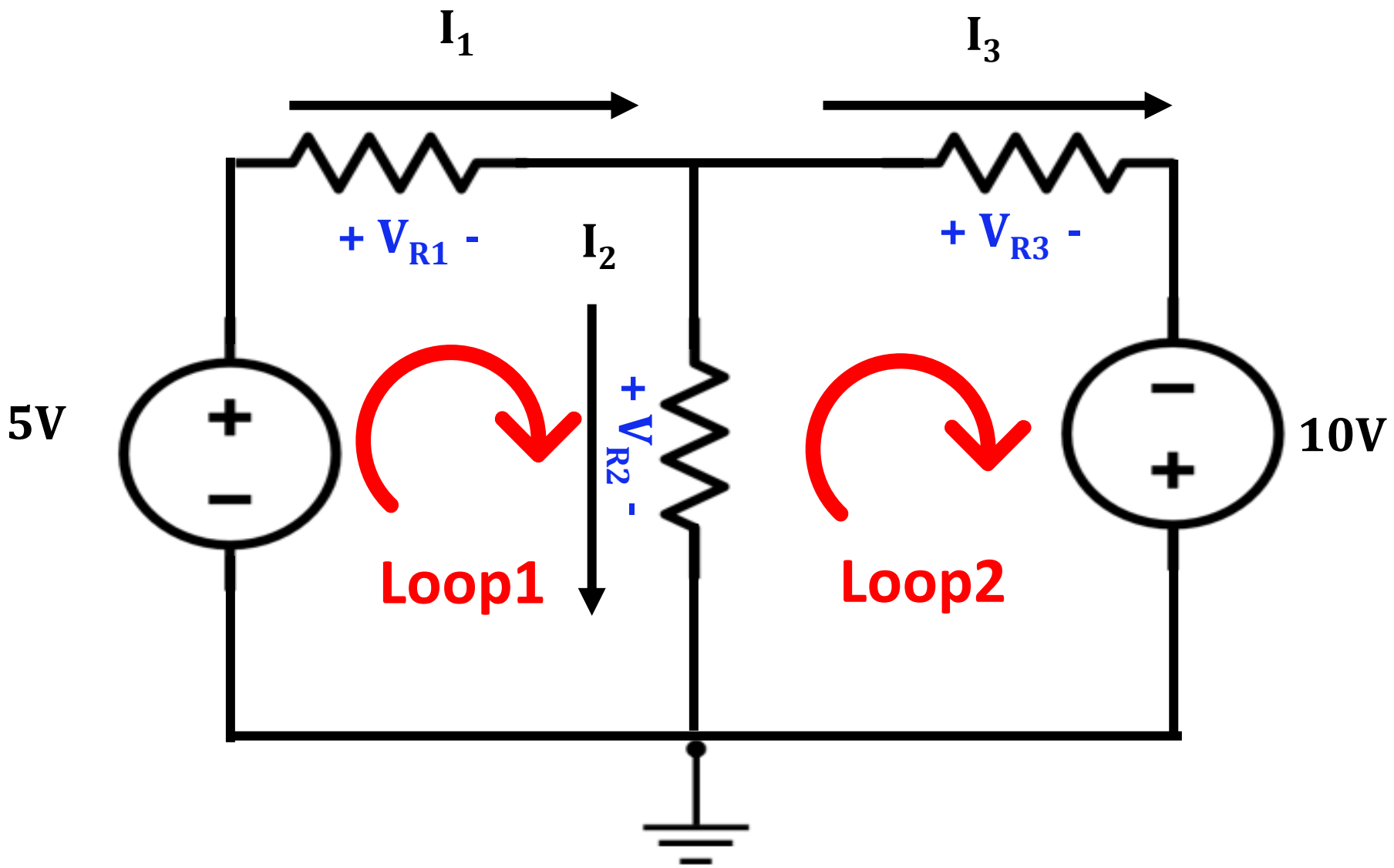
*This is also applicable for supernodes!

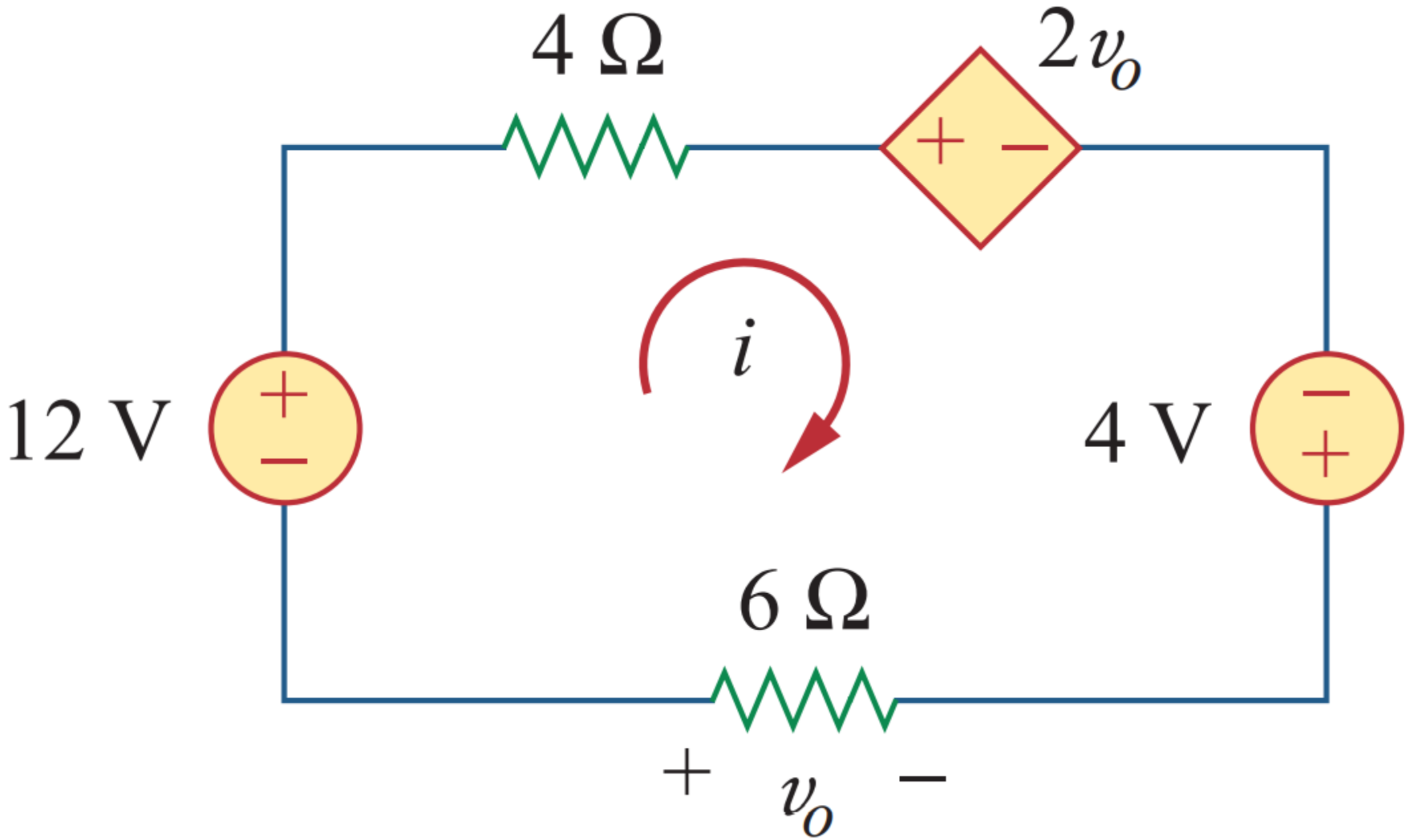
Kirchhoff's Voltage Law (KVL): The algebraic sum of all voltages in a loop must equal zero

Loop 1: $5-I_1R_1-I_2R_2=0$
Loop 2: $10+I_2R_2-I_3R_3=0$

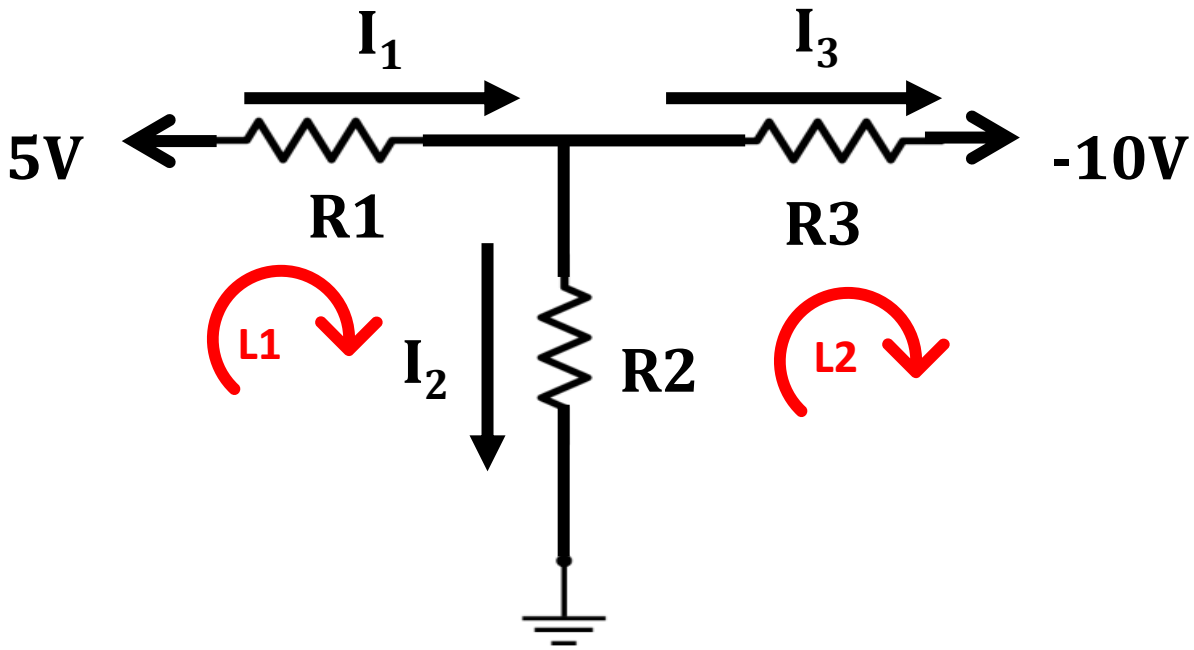
$$\sum V = 0$$




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

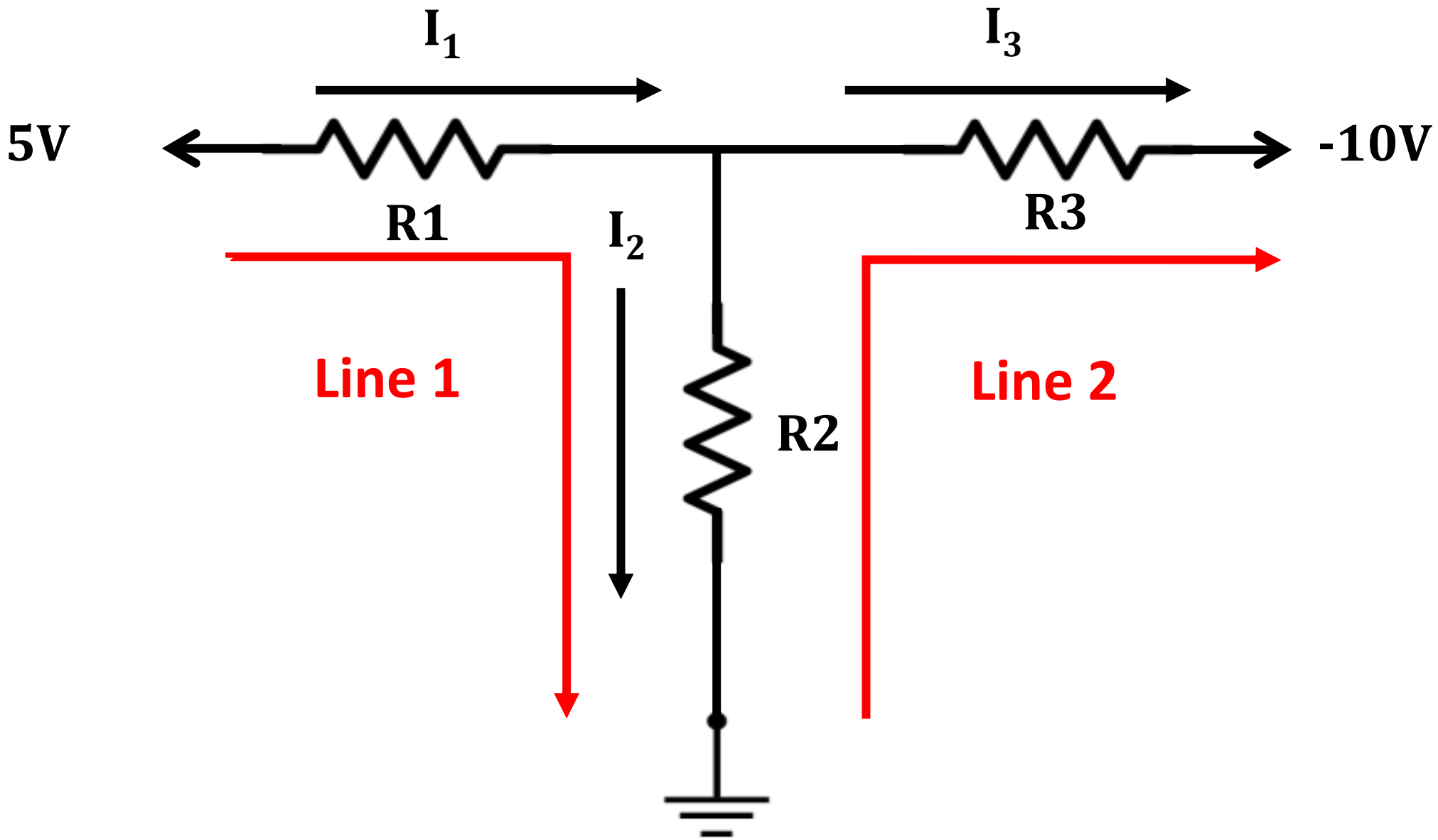

4 Ω
2v_o
12 V
i
4 V
6 Ω
+ v_o −

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

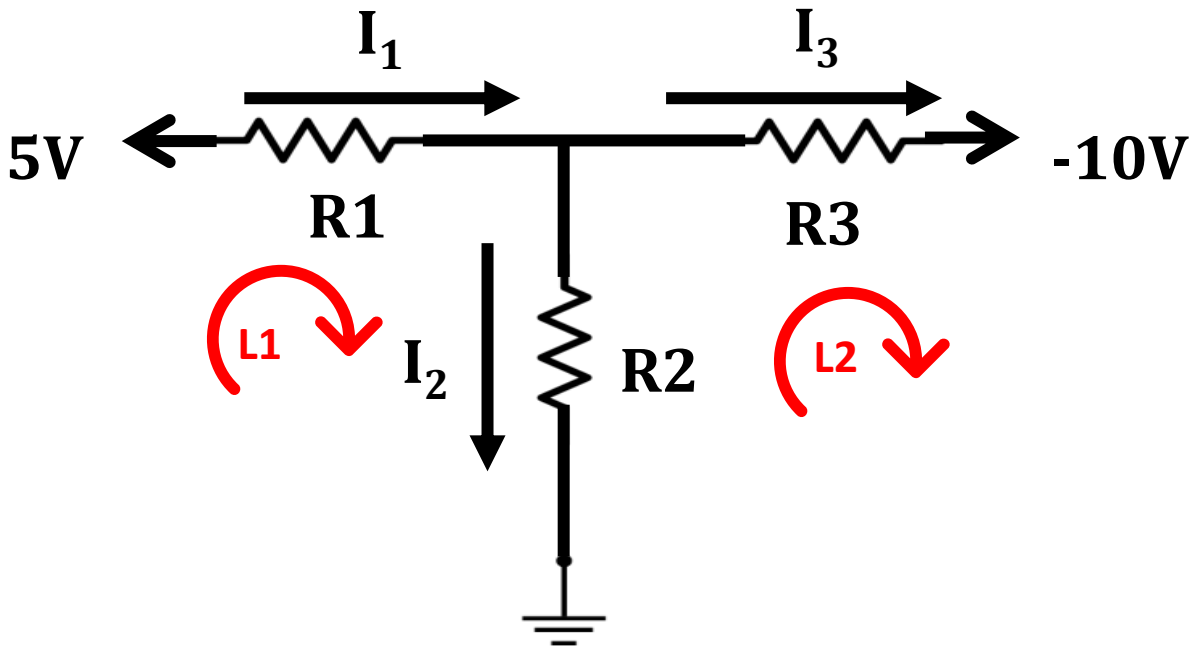


Line 1: 5-0 =$I_1R_1+I_2R_2$ =0

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

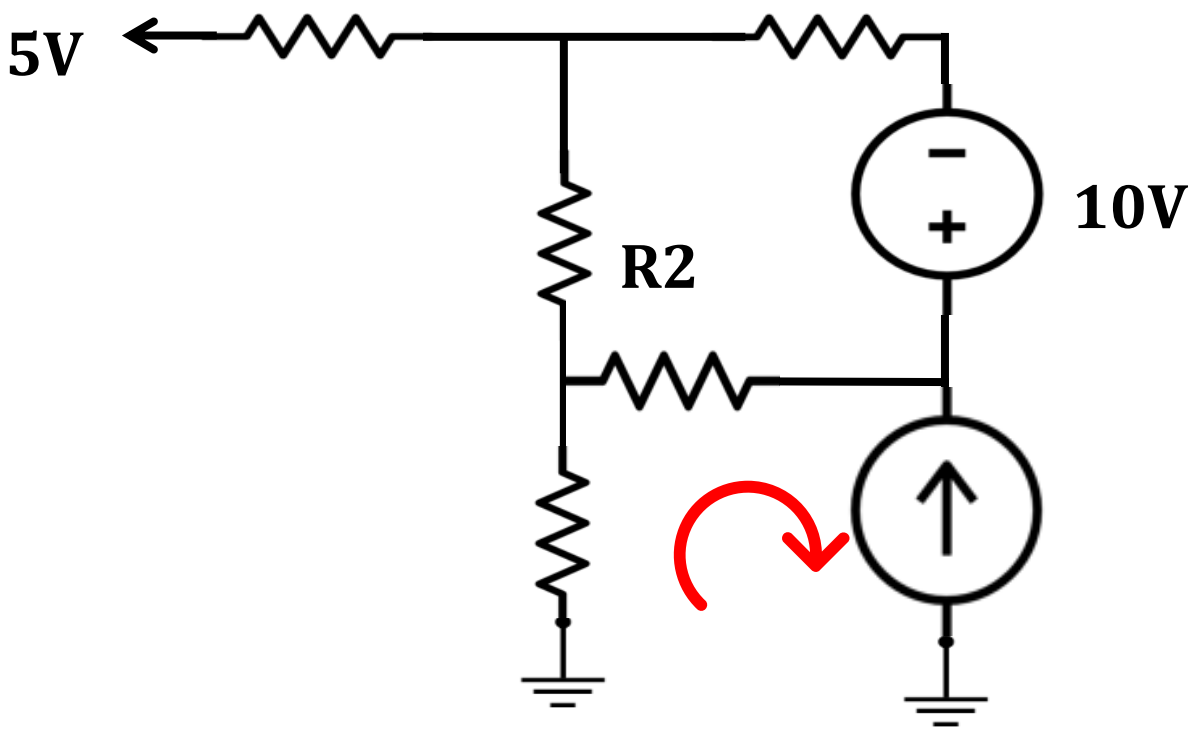

I1
I3
5V
-10V
R1
R3
I2
Line 1
Line 2
R2

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



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

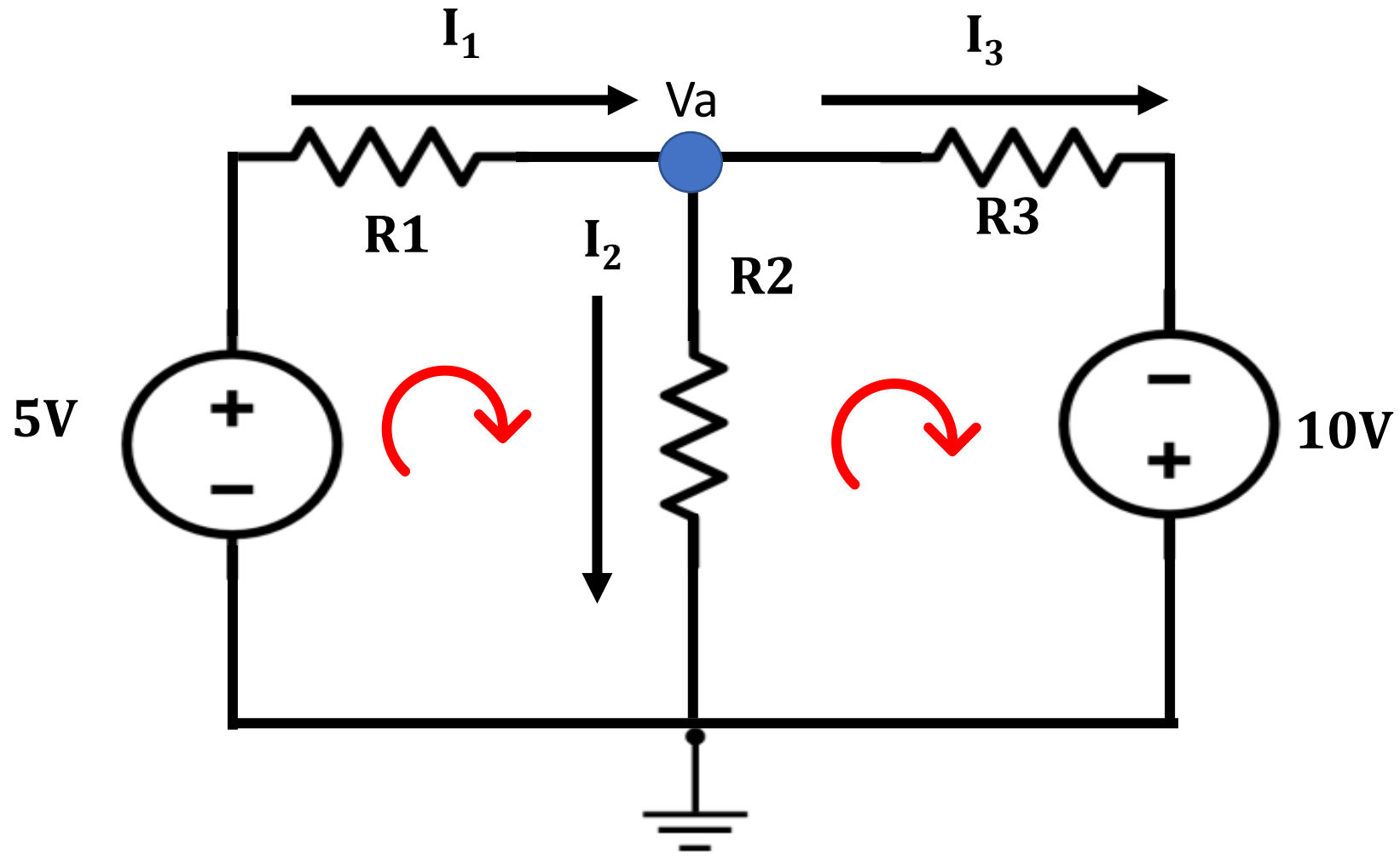
Line 2: 0+10=-$I_2R_2+I_3R_3$

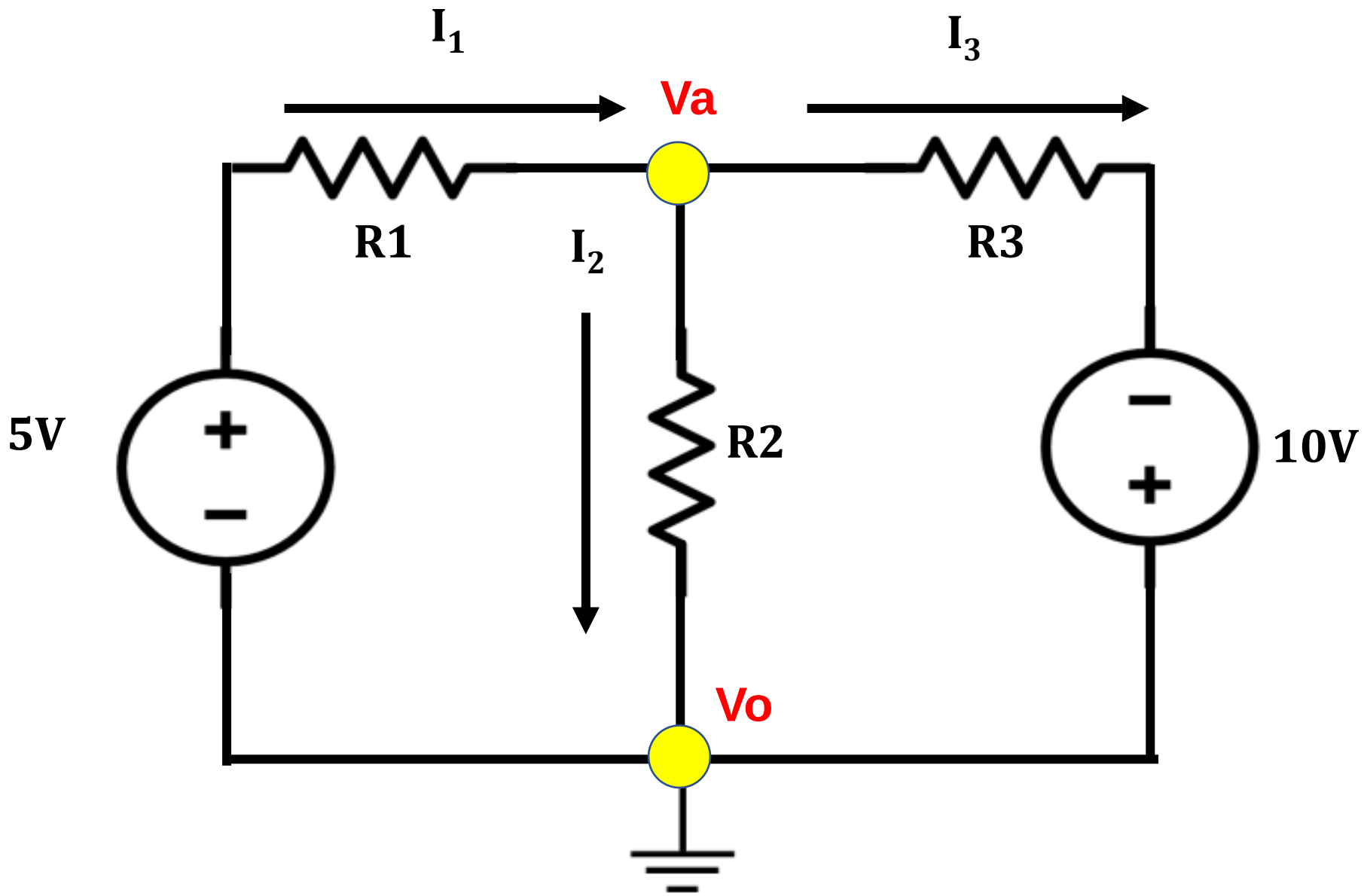


Can you write a KVL equation along this line?

Nodal analysis:

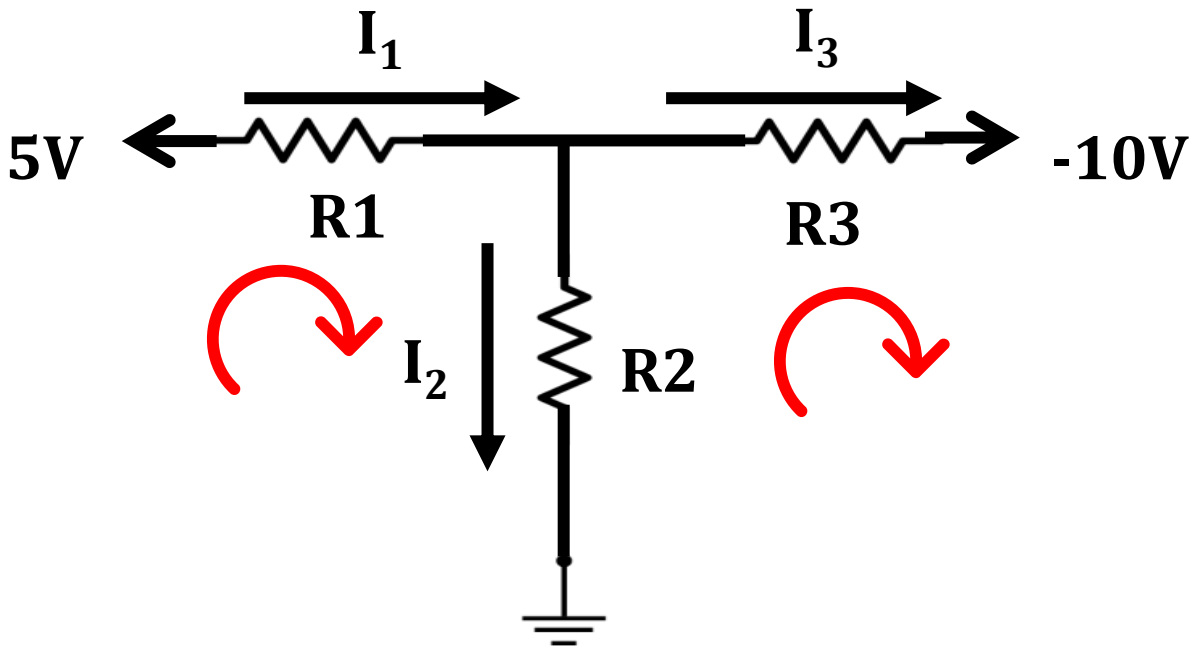
$$V_a\left(\frac{1}{R1}+\frac{1}{R2}+\frac{1}{R3}\right)-\frac{5}{R1}-\frac{0}{R2}-\frac{-10}{R3}=0\ ;Derived\ from\ applying\ KCL\ at\ node\ V_a$$




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