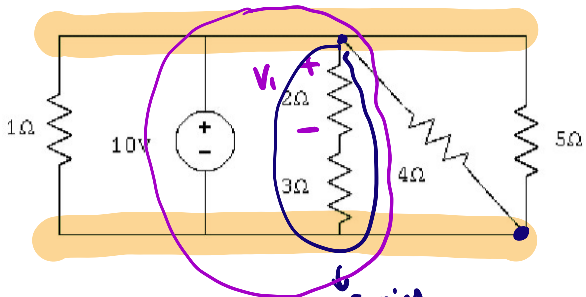
• Example #1:

- Simplify the following circuit into a voltage source in parallel with a single resistor, Req. What is the value of Req?
- Determine the voltage at the 2Ω resistor.



series

$2+3=5\,\Omega$

Req - ?

a) $\frac{45}{59}\,\Omega$

b) $33/13\,\Omega$

c) $10/7\,\Omega$

d) $\frac{20}{33}\,\Omega$

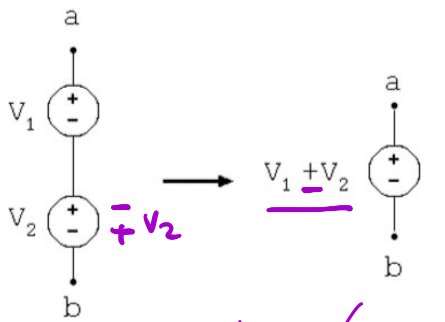
e) None

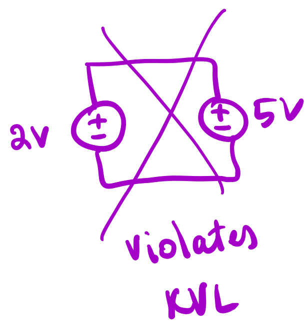
$$\frac{1}{R_{eq}} = 1 + \frac{1}{5} + \frac{1}{4} + \frac{1}{5} = \frac{33}{20} \Rightarrow R_{eq} = \frac{20}{33}\,\Omega$$

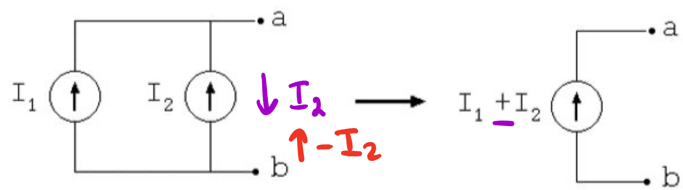
Voltage division:

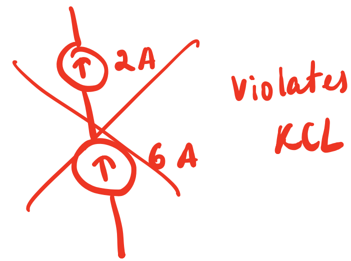
$$V_1 = V\,\frac{2}{2+3} = 4V$$

- Source combinations

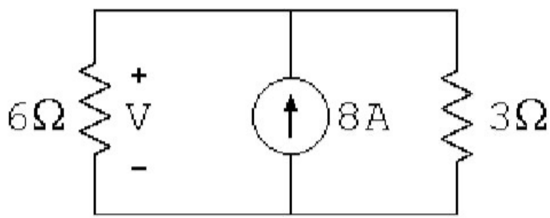


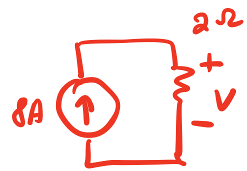






• Example #2: Determine the voltage V in the following circuit



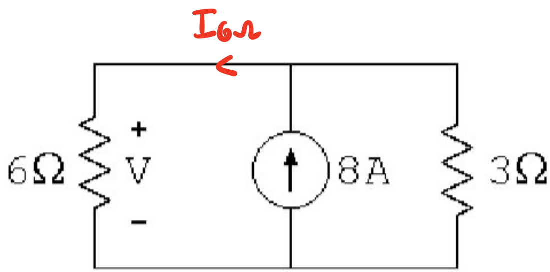


- Approach 1:

• $R_p = \frac{6 \cdot 3}{6+3} = \frac{18}{9} = 2\,\Omega$

• $V = R \cdot I = 2 \cdot 8 = 16\,V$

- Example #2-cont: Determine the voltage V in the following circuit

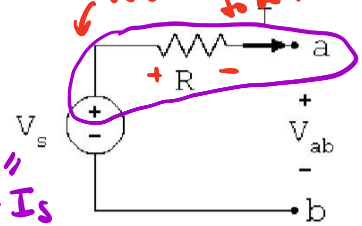


– Appoach 2: current division

- $I_{6\Omega} = I\left(\frac{3}{3+6}\right) = 8\left(\frac{3}{9}\right) = \frac{8}{3}\,A$
- $V = I_{6\Omega} \cdot R = \frac{8}{3} \cdot 6 = 16\,V$

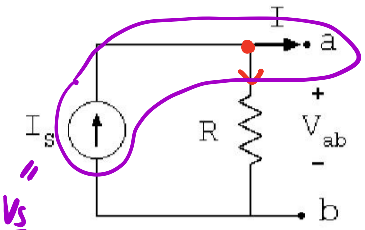
- Source transformations

Vs and R has to be in series!



$= R\cdot I_s$

want



$= \frac{V_s}{R}$

KVL: $-V_s + I\cdot R + V_{ab} = 0$

KCL: $I_s = I + \frac{V_{ab}}{R}$

$V_s = \underbrace{V_{ab} + I\cdot R}$

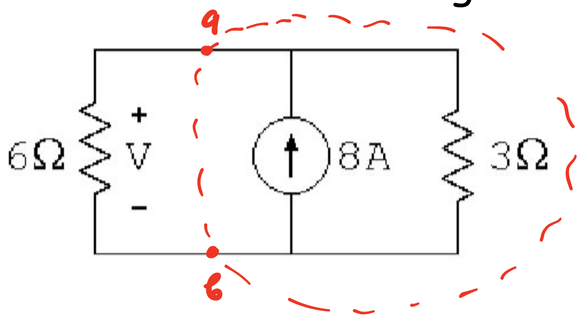
$R I_s = \underbrace{I\cdot R + V_{ab}}$

$$V_s = R\cdot I_s$$

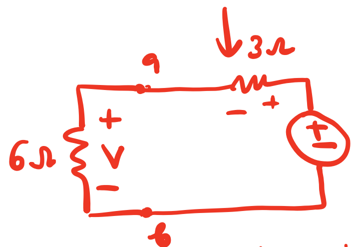
or

$$I_s = \frac{V_s}{R}$$

• Example #2-cont: Determine the voltage V in the following circuit using source transformations



Note: don't transform parts of the circuit you are interested in !

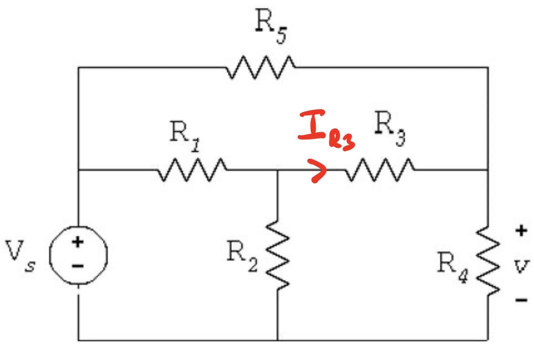


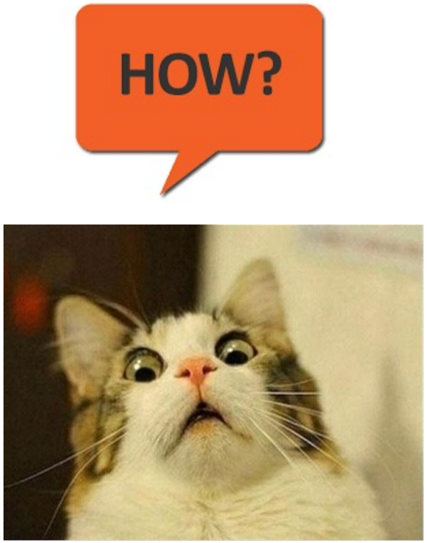
$V_s = 3 \cdot 8 = 24V$

⇓ voltage division:

$$V = 24\left(\frac{6}{6+3}\right) = 16V$$

• Example #4: Determine V_{R4} and I_{R3} in the following circuit

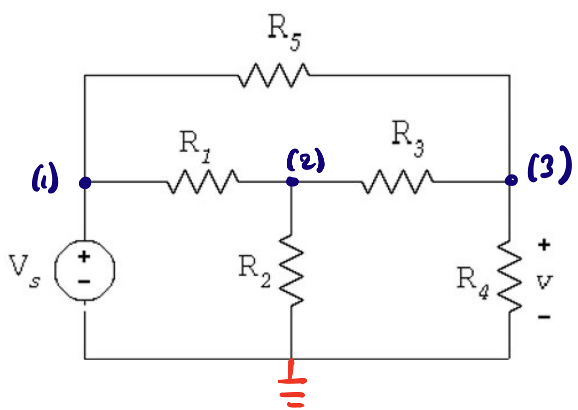




- Node-voltage method

- Step #1:

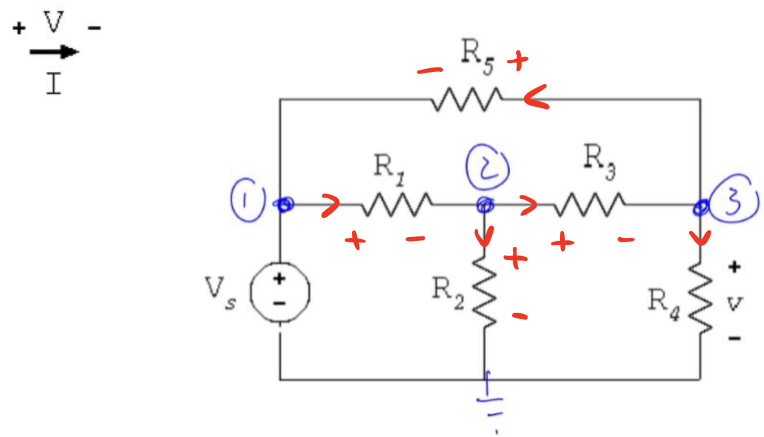
Identify all nodes and label their node voltages V_1, V_2,..., V_n plus a reference.



- Node-voltage method

- Step #2:

Assign current directions and polarities to all elements (use SRS for simplicity).

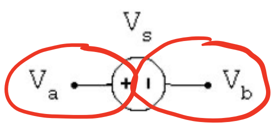


• Node-voltage method

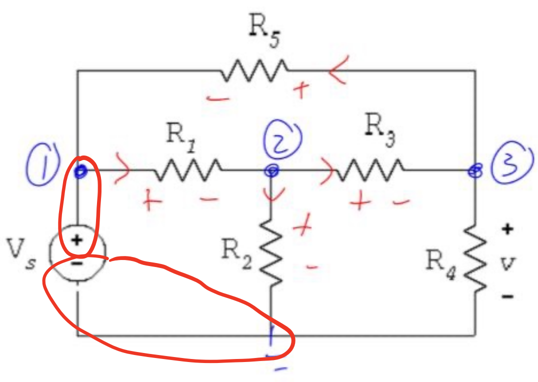
• Step #3:

simple

Use voltage sources to obtain equations between their node voltages



$V_s = V_a - V_b$



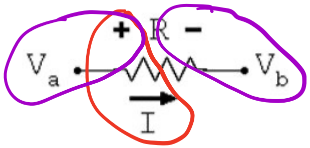
$V_s = V_1 - 0 \quad (1)$

- Node-voltage method

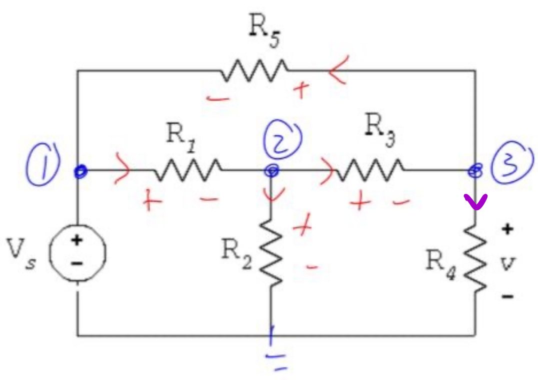
- Step #4:

Use KCL on remaining nodes to get a total of n equations in terms of the node voltages.

→ total number of nodes − reference.



$$I = \frac{V_a - V_b}{R}$$



$V_s = V_1$ (1)

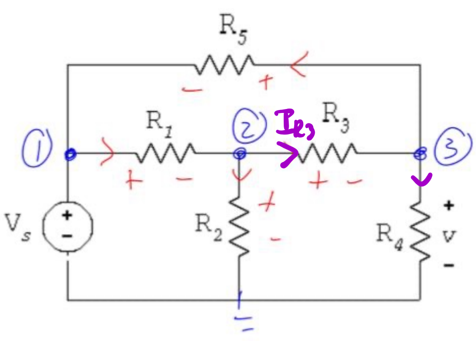
KCL @ (2): $\dfrac{V_1 - V_2}{R_1} = \dfrac{V_2 - 0}{R_2} + \dfrac{V_2 - V_3}{R_3}$ (2)

KCL @ (3): $\dfrac{V_2 - V_3}{R_3} = \dfrac{V_3 - 0}{R_4} + \dfrac{V_3 - V_1}{R_5}$ (3)

- Node-voltage method

- Step #5:
  Solve equations

V_{R_4} and I_{R_3} - ?



Assume : $R_i = 2\Omega$ for all i

$V_s = 1V$

$$1 = V_1 \quad (1)$$

$$\frac{V_1 - V_2}{R_1} = \frac{V_2}{R_2} + \frac{V_2 - V_3}{R_3}$$

$$\Downarrow$$

$$0 = -\frac{1}{2}V_1 + \frac{3}{2}V_2 - \frac{1}{2}V_3 \quad (2) \quad (\times 2)$$

$$\frac{V_2 - V_3}{R_3} = \frac{V_3}{R_4} + \frac{V_3 - V_1}{R_5}$$

$$\Downarrow$$

$$0 = -\frac{1}{2}V_1 - \frac{1}{2}V_2 + \frac{3}{2}V_3 \quad (3) \quad (\times 2)$$

$$1 = 3V_2 - V_3 \Rightarrow V_3 = 3V_2 - 1$$

$$1 = -V_2 + 3V_3$$

$$\vdots$$

$$V_2 = \frac{1}{2}V$$

$$V_3 = \frac{1}{2}V$$

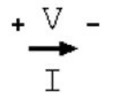
$$V = V_3 - 0 =$$

$$= \frac{1}{2}V$$

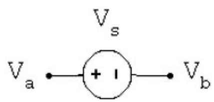
$$I_{R_3} = \frac{V_2 - V_3}{R_3} = 0\ A$$

- Node-voltage method: summary

1. Identify all nodes and label their node voltages $V_1, V_2, \ldots, V_n$ plus a reference
2. Assign current directions and polarities to all elements (use SRS for simplicity)

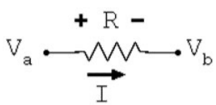


3. Use voltage sources to obtain equations between their node voltage



$$V_s = V_a - V_b$$

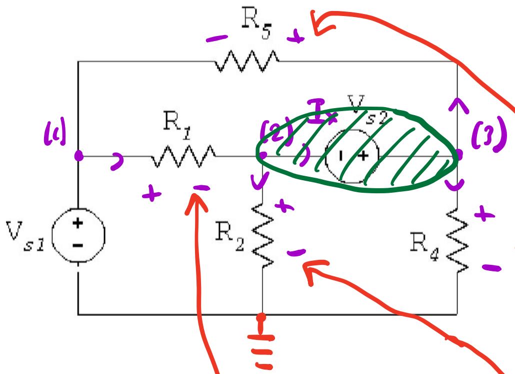
4. Use KCL on remaining nodes to get a total of n equations in terms of the node voltages



$$I = \frac{V_a - V_b}{R}$$

5. Solve equations

- Example #5: Use the node-voltage method to determine all node voltages in this circuit



$$V_{s_1} = V_1 - 0 \quad (1)$$

$$V_{s_2} = V_3 - V_2 \quad (2)$$

$$\text{KCL @ (2)}: \frac{V_1 - V_2}{R_1} = \frac{V_2 - 0}{R_2} + I_x \quad (3)$$

$$\text{KCL @ (3)}: I_x = \frac{V_3 - 0}{R_4} + \frac{V_3 - V_1}{R_5} \quad (4)$$

$$\frac{V_1 - V_2}{R_1} = \frac{V_2 - 0}{R_2} + \frac{V_3 - 0}{R_4} + \frac{V_3 - V_1}{R_5}$$

Supernode (2-3): combine KCL @ (2) and (3).

Works only with voltage sources between 2 nodes.