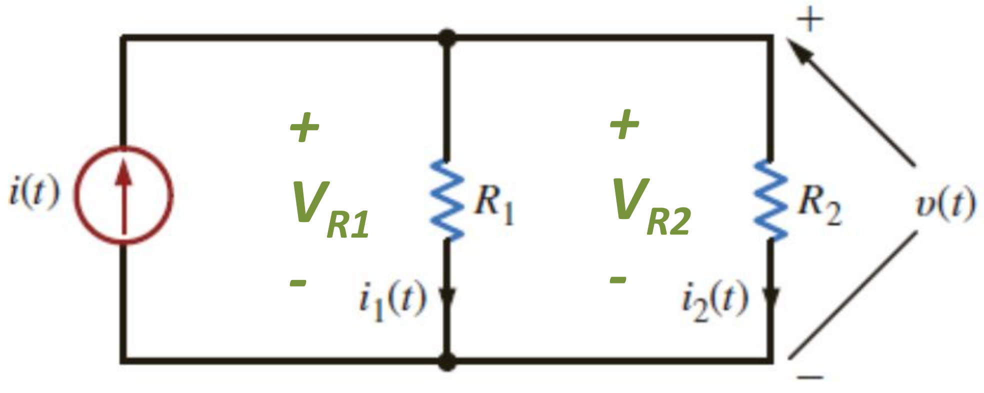
Last Lecture → Current / Voltage Division

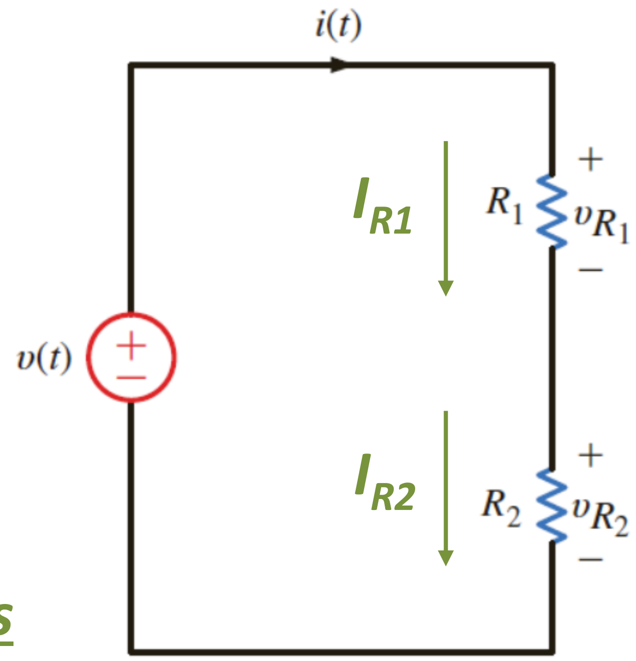


* $V_{R1}=V_{R2}=v(t)$

∴ R_1 and R_2 are in <u>parallel</u>

$$\therefore i_1(t) = \frac{R_2}{R_1 + R_2} \cdot i(t)$$

$$i_2(t) = \frac{R_1}{R_1 + R_2} \cdot i(t)$$



* $I_{R1} = I_{R2} = i(t)$

∴ R_1 and R_2 are in <u>series</u>

$$\therefore v_{R1} = \frac{R_1}{R_1 + R_2} \cdot v(t)$$

$$v_{R2} = \frac{R_2}{R_1 + R_2} \cdot v(t)$$

Last Lecture → Multiple Source/Resistor Networks

- **Series**

The sum of several voltage source in series can be replaced by one source whose value is the algebraic sum of the individual source

The equivalent resistance of N resistors in series is simply the sum of the individual resistances.

$$R_s = R_1 + R_2 + \cdots + R_N$$

- **Parallel**

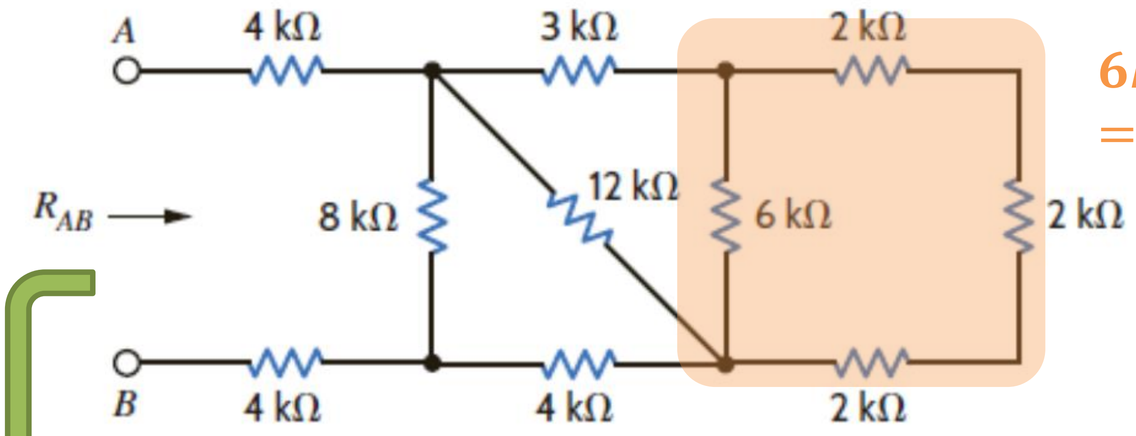
The sum of several current source in series can be replaced by one source whose value is the algebraic sum of the individual source

The reciprocal of the equivalent resistance of N resistors in parallel is equal to the sum of the reciprocal of the individual resistances.

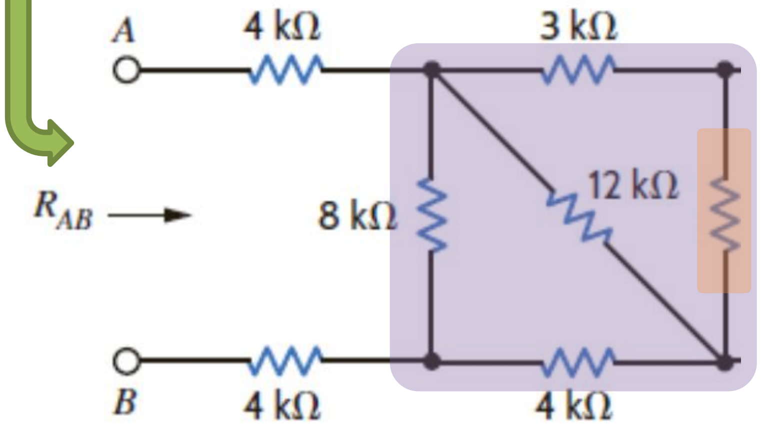
$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N}$$

Series/Parallel Resistor Combinations

E2.16: Find R_{AB} in the provided network.

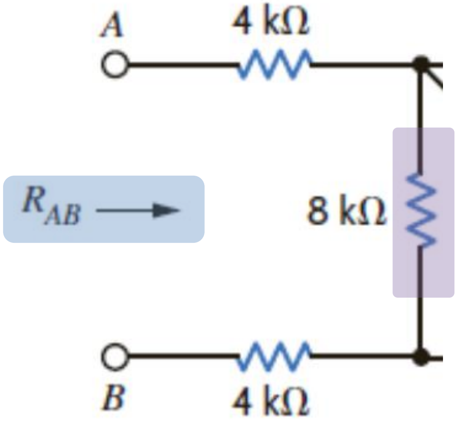


$6k \| (2k + 2k + 2k)$
$= 3k$



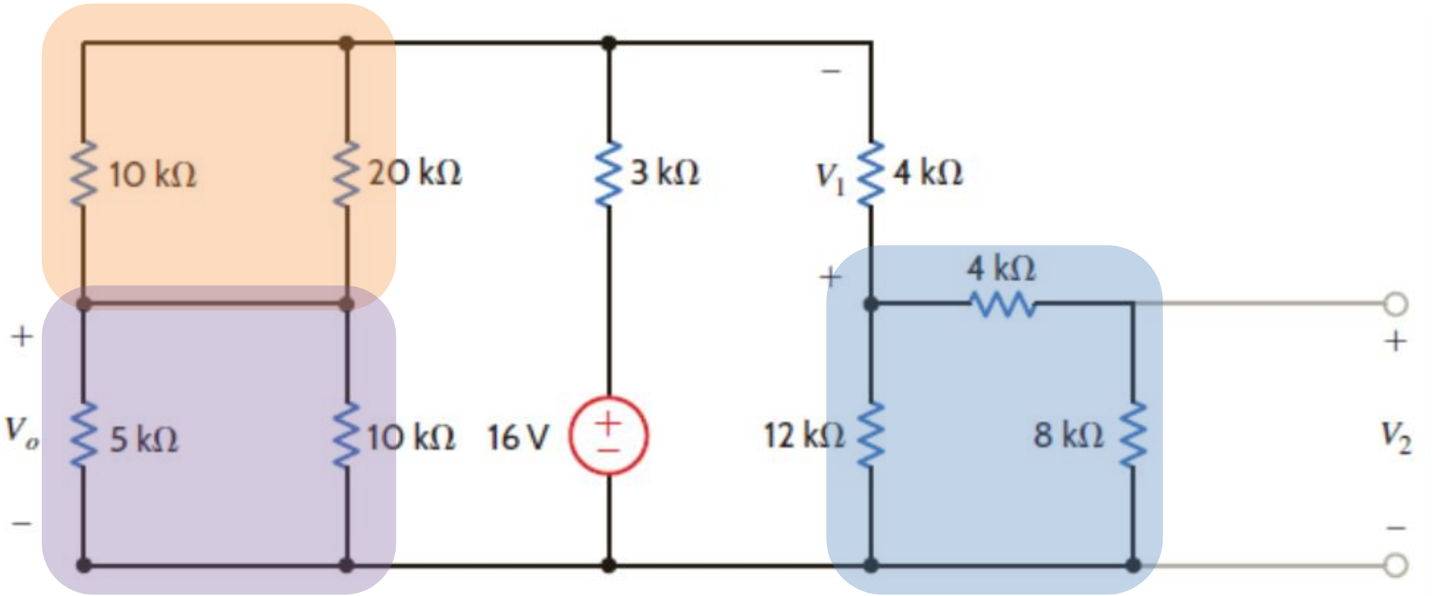
$8k \| (12k \| (3k + 3k) + 4k)$
$= 4k$

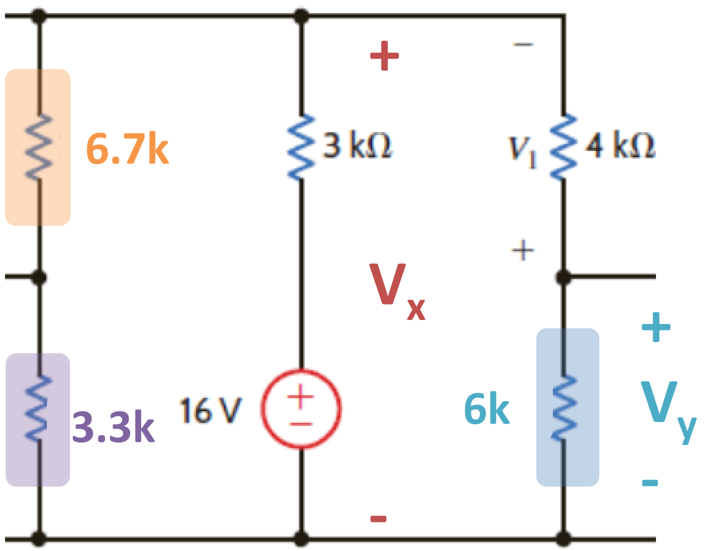
$\therefore R_{AB} = 4k + 4k + 4k$



Learning Assessment E2.22

Find V_0, V_1, and V_2 in the network provided.





$$V_x = 16\left[\frac{10k \| 10k}{3k + 10k \| 10k}\right] = 10V$$

$$V_0 = V_x\left[\frac{3.3k}{6.7k + 3.3k}\right] = 3.3V$$

$$V_1 = -V_x\left[\frac{4k}{6k + 4k}\right] = -4V$$

$$V_2 = 6\left[\frac{8k}{4k + 8k}\right] = 4V$$

$$V_y = V_x + V_1 = 10 - 4 = 6V$$

Wye ⇆ Delta Transformations

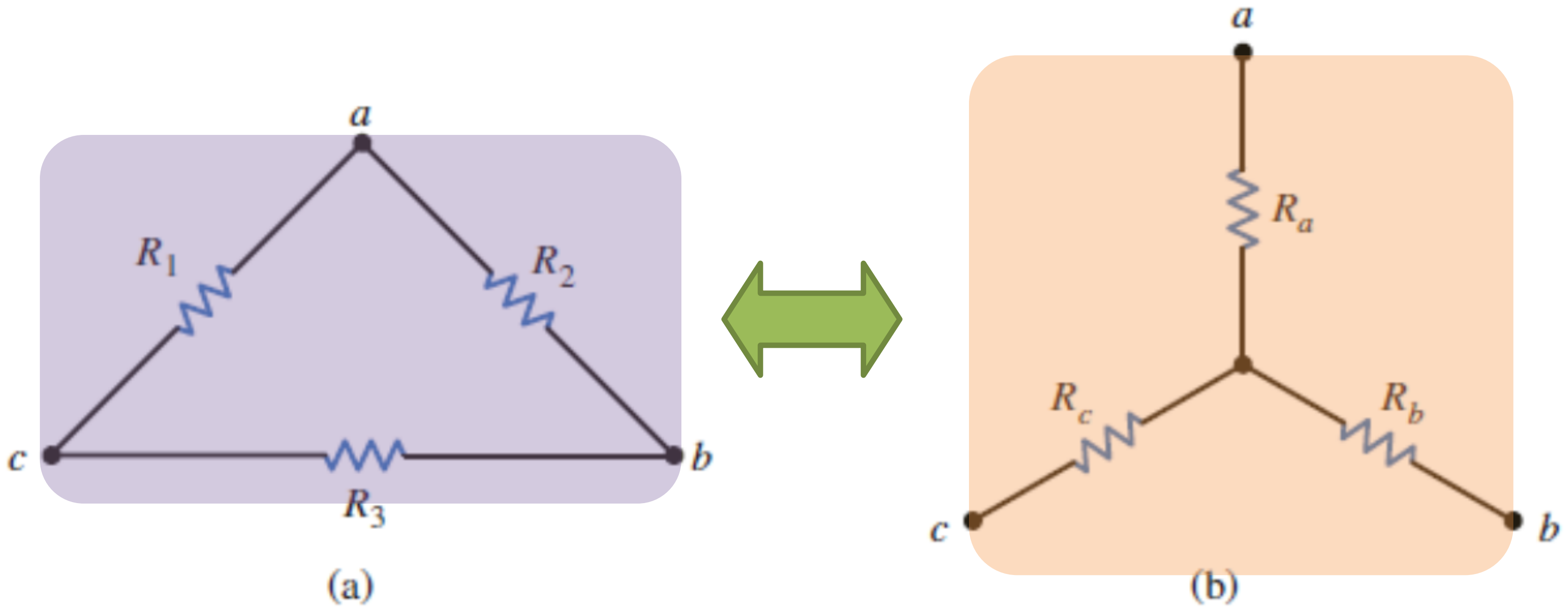
For the two networks to be equivalent at each corresponding pair of terminals, it is necessary that the resistance at the corresponding terminals be equal (e.g., the resistance at terminals a and b with c open-circuited must be the same for both networks.

$\Delta \leftarrow Y$

$$R_1 = \frac{R_aR_b + R_bR_c + R_aR_c}{R_b}$$

$$R_2 = \frac{R_aR_b + R_bR_c + R_aR_c}{R_c}$$

$$R_3 = \frac{R_aR_b + R_bR_c + R_aR_c}{R_a}$$



$Y \leftarrow \Delta$

$$R_a = \frac{R_1R_2}{R_1 + R_2 + R_3}$$

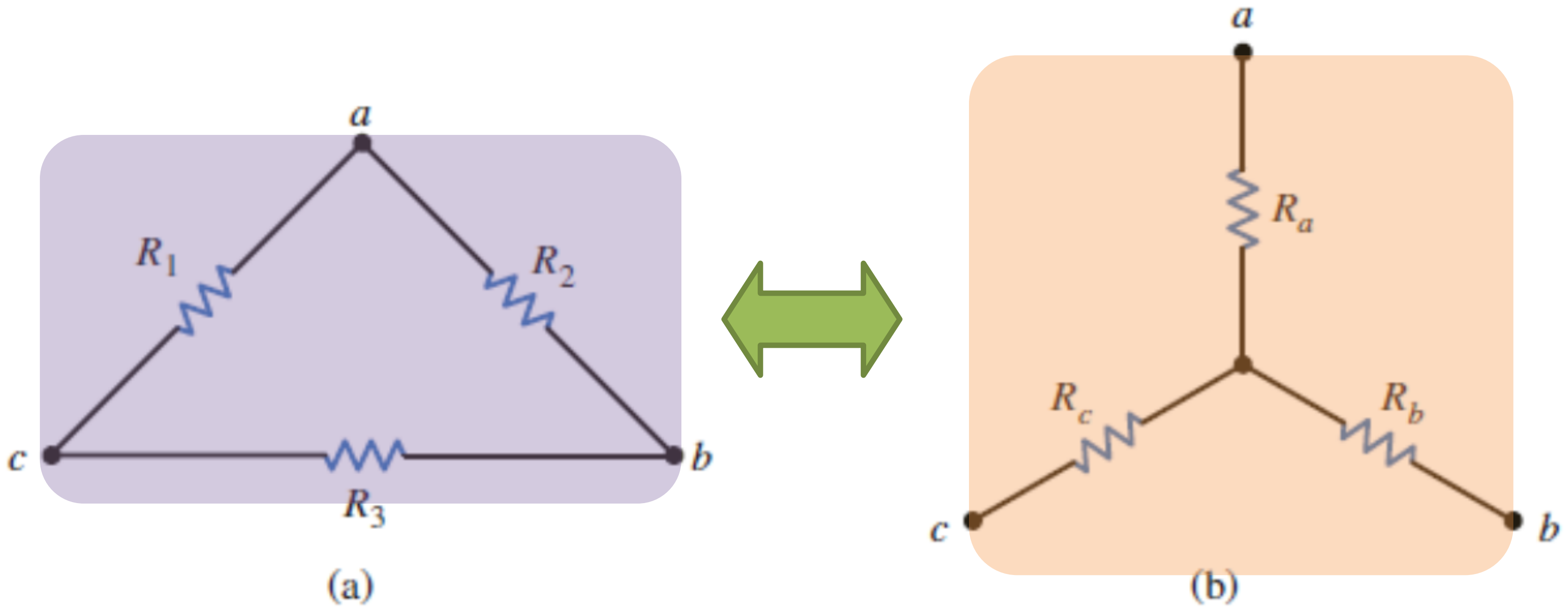
$$R_b = \frac{R_2R_3}{R_1 + R_2 + R_3}$$

$$R_c = \frac{R_1R_3}{R_1 + R_2 + R_3}$$

Wye ⇆ Delta Transformations

For the two networks to be equivalent at each corresponding pair of terminals, it is necessary that the resistance at the corresponding terminals be equal (e.g., the resistance at terminals a and b with c open-circuited must be the same for both networks.

… for $R_a = R_b = R_c = R_Y$
$R_1 = R_2 = R_3 = R_\Delta$

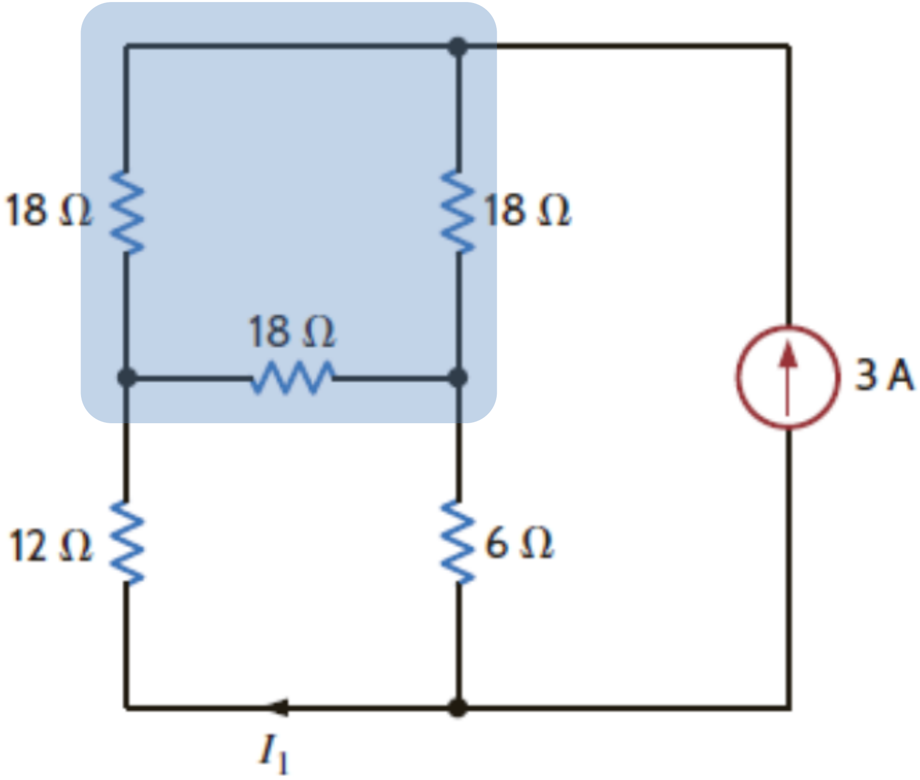


$\Delta \leftarrow Y$ $\quad \left\{ R_\Delta = 3R_Y \right.$

$Y \leftarrow \Delta$ $\quad \left\{ R_Y = \frac{1}{3} R_\Delta \right.$

Learning Assessment E2.26

Find I_1 in the network provided.



Circuits with Dependent Sources

1) **Write KVL and/or KCL equations for the network**

   → treat the dependent CS as an independent CS

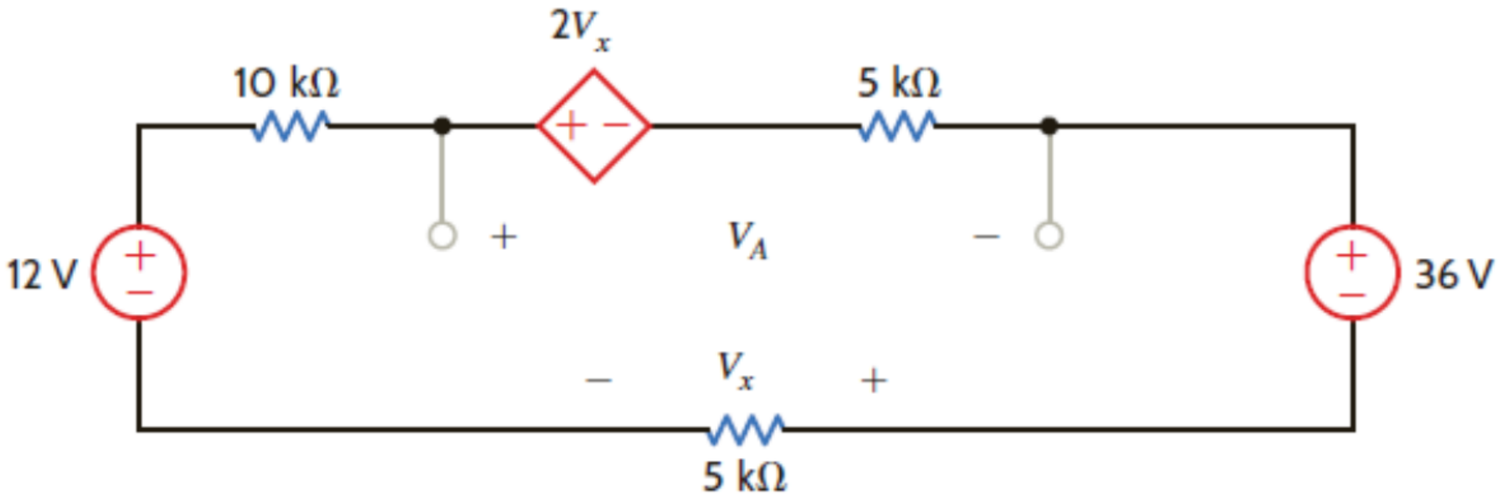
2) **Write the equation that specifies the relationship of the dependent source to the controlling parameter.**

3) **Solve the equations for the unknowns.**

   → Be sure the number of linearly independent equations matches the number of unknowns.

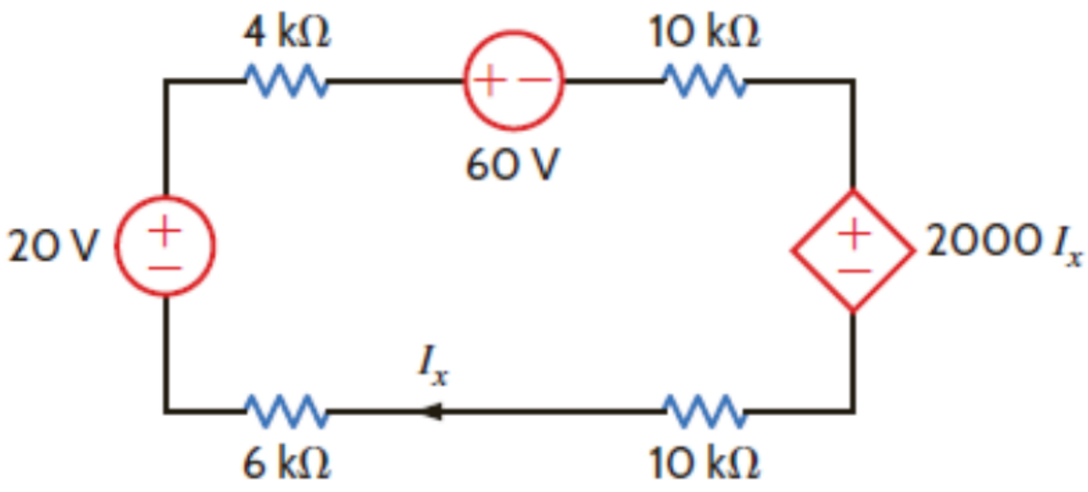
Learning Assessment E2.29

Find V_A in the network provided.



Problem 2.35

Find the power absorbed by the dependent source in the circuit provided.

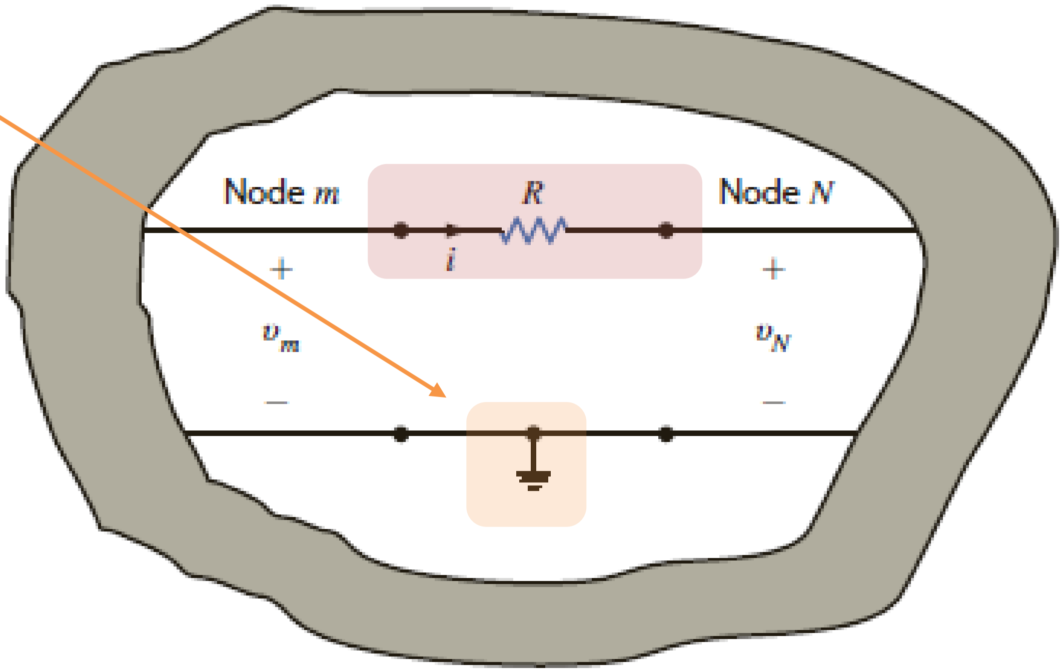


Nodal and Loop Analysis → Chapter #3

- **Solve circuits with multiple nodes using nodal analysis**
- **Solve circuits with multiple loops using loop analysis**
- **Identify the most appropriate analysis technique that should be utilized to solve a particular problem**

Nodal Analysis

- One node is selected as the reference node
- *KCL is applied to the remaining N-1 nodes*



Ohm's Law:

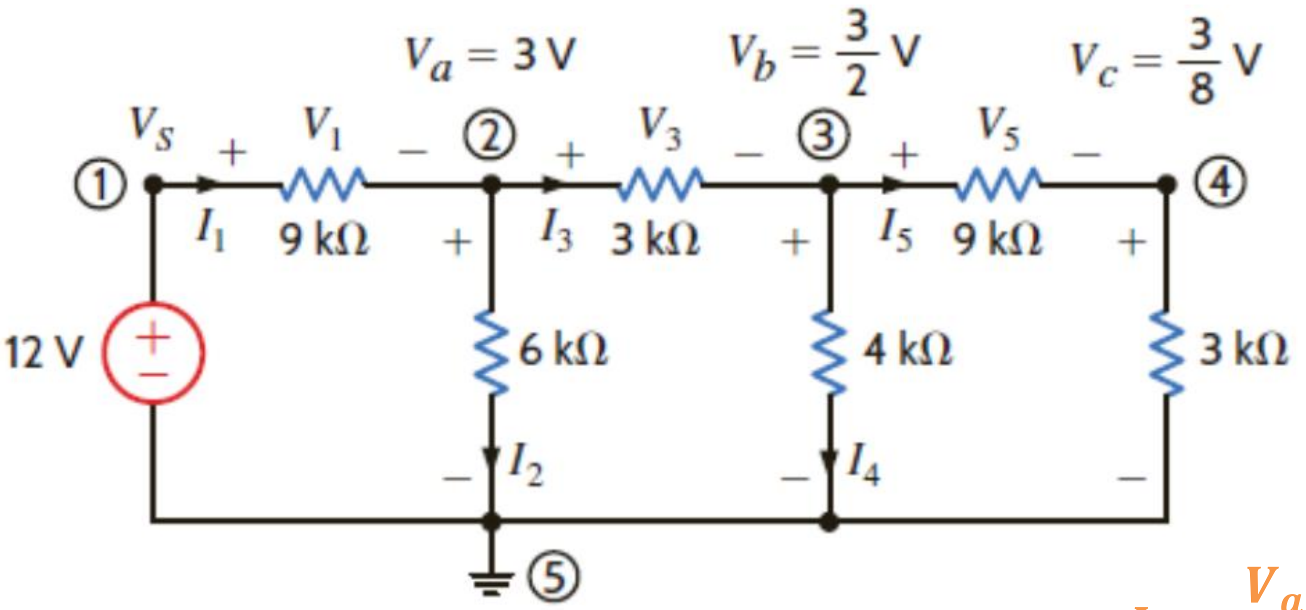
$$i = \frac{v_m - v_n}{R}$$

- Current defined by Ohm's law
- Variables are node voltages
- Voltages are defined with respect to a common point (the reference)

N-1 independent simultaneous equations!

Nodal Analysis → Known Node Voltages

- Define node voltages to be positive with respect to the reference node
- Define currents with respect to node voltages



- Voltage across resistors

$$V_1 = V_S - V_a = 9V$$
$$V_3 = V_a - V_b = {}^{3}/_{2}\,V$$
$$V_5 = V_b - V_c = {}^{9}/_{8}\,V$$

- Current in resistors

$$I_1 = \frac{V_1}{9k} = \frac{V_S - V_a}{9k} = 1mA$$
$$I_3 = \frac{V_3}{3k} = \frac{V_a - V_b}{3k} = {}^{1}/_{2}\,mA$$
$$I_5 = \frac{V_5}{9k} = \frac{V_b - V_c}{9k} = {}^{1}/_{8}\,mA$$

$$I_2 = \frac{V_a - 0}{6k} = {}^{1}/_{2}\,mA$$
$$I_4 = \frac{V_b - 0}{4k} = {}^{3}/_{8}\,mA$$

Nodal Analysis → with Independent CS

1) **Identify #of nodes:** 3 node circuit
2) **Select reference node:** bottom node, 3
3) **Label other node voltages:** v_1, v_2
4) **Identify branch currents:** i_1, i_2, i_3
5) **Apply KCL to nodes:** 1, 2 → 2 independent equations

assume:

$I_A = 1mA \quad R_1 = 12k\Omega$

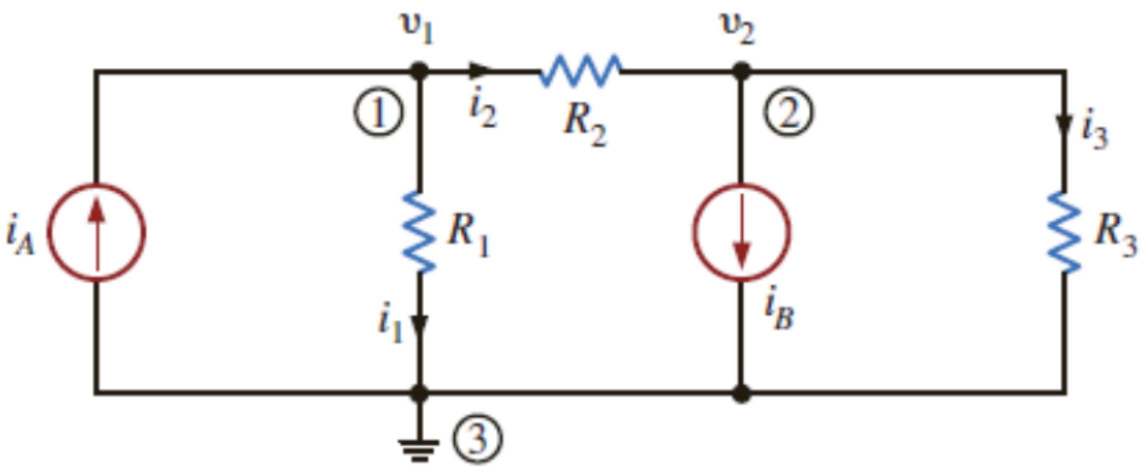
$I_B = 4mA \quad R_2 = 6k\Omega$

$R_3 = 6k\Omega$

KCLs:

$$I_A = I_1 + I_2 = \frac{V_1}{R_1} + \frac{V_1 - V_2}{R_2} = V_1\left[\frac{1}{R_1} + \frac{1}{R_2}\right] - V_2\left[\frac{1}{R_2}\right]$$

$$I_B = I_2 + I_3 = \frac{V_1 - V_2}{R_2} - \frac{V_2}{R_3} = V_1\left[\frac{1}{R_2}\right] - V_2\left[\frac{1}{R_2} + \frac{1}{R_3}\right]$$



matrix eq.

$$\begin{bmatrix} I_A \\ I_B \end{bmatrix} = \begin{bmatrix} \frac{1}{R_1 \| R_2} & -\frac{1}{R_2} \\ \frac{1}{R_2} & -\frac{1}{R_2 \| R_3} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$