

Electrical Science - I

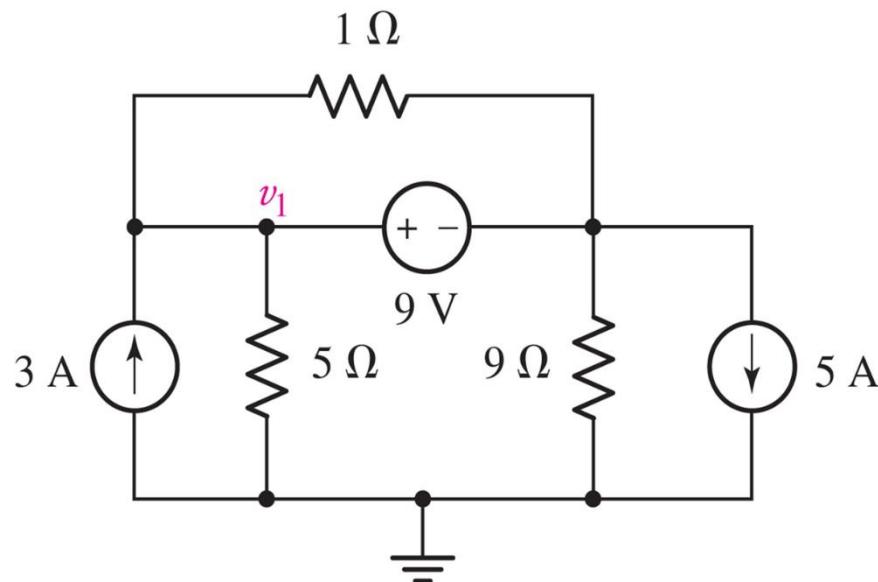
(IEC-102)

Lecture-04

Nodal & Mesh Analysis

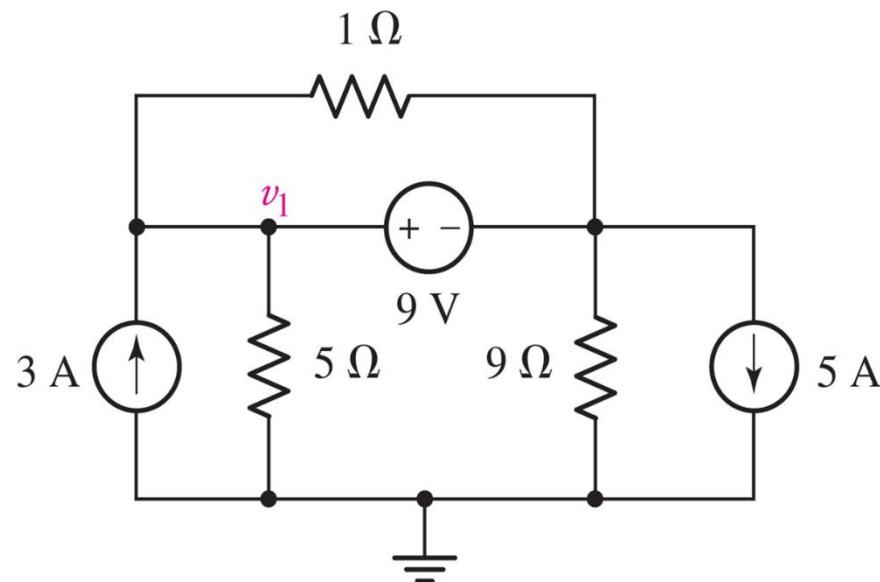
Example

Use both Nodal and Mesh Analysis to find v_1



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Answer: $v_1 = -45/14$

Handy Circuit Analysis Techniques

- Both Nodal Analysis and Mesh Analysis require that we develop a complete set of equations to describe a circuit.

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- If only one particular current, voltage, or power quantity is of interest to us, then there is no need to solve for all the other variables.

Handy Circuit Analysis Techniques

- Both Nodal Analysis and Mesh Analysis require that we develop a complete set of equations to describe a circuit.
- If only one particular current, voltage, or power quantity is of interest to us, then there is no need to solve for all the other variables.
- There are several other techniques for isolating specific parts of a circuit to simplify the analysis.

Super Position

The Superposition Theorem

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all other independent sources disabled

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- If it is an independent current source replace it with a open circuit.

Applying Superposition

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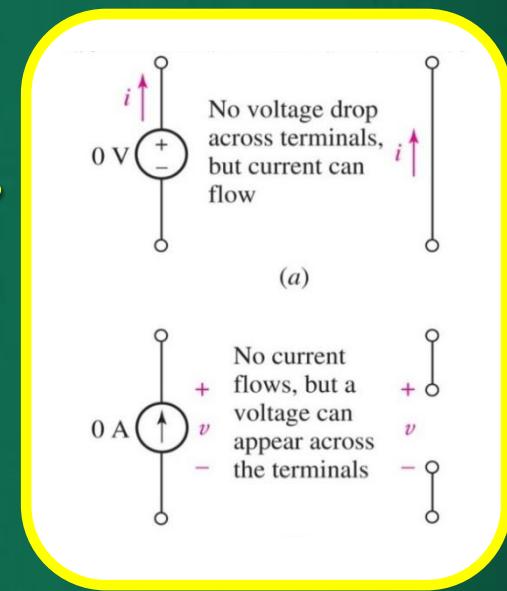
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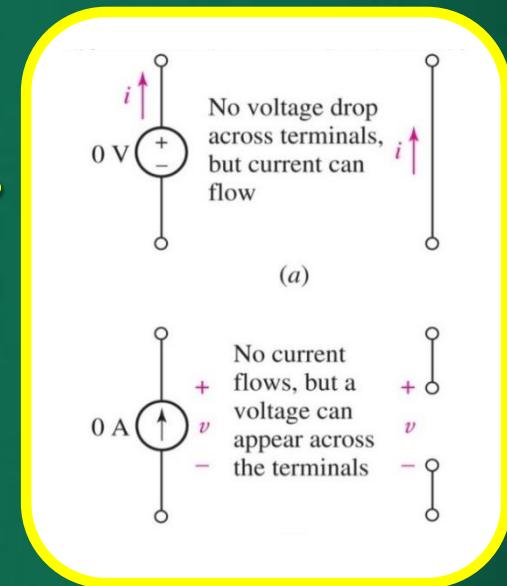
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c) Find the response due to this source acting alone.



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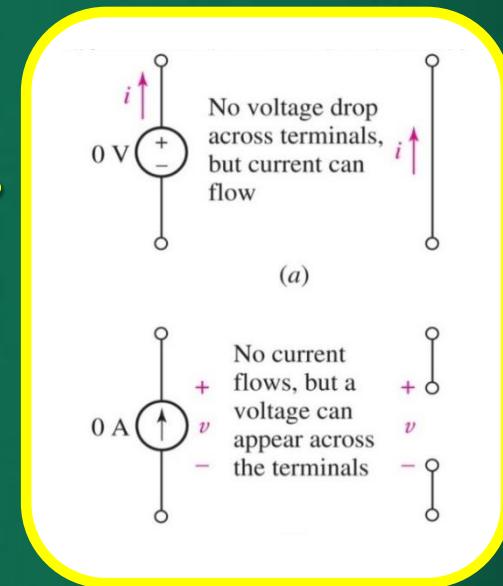
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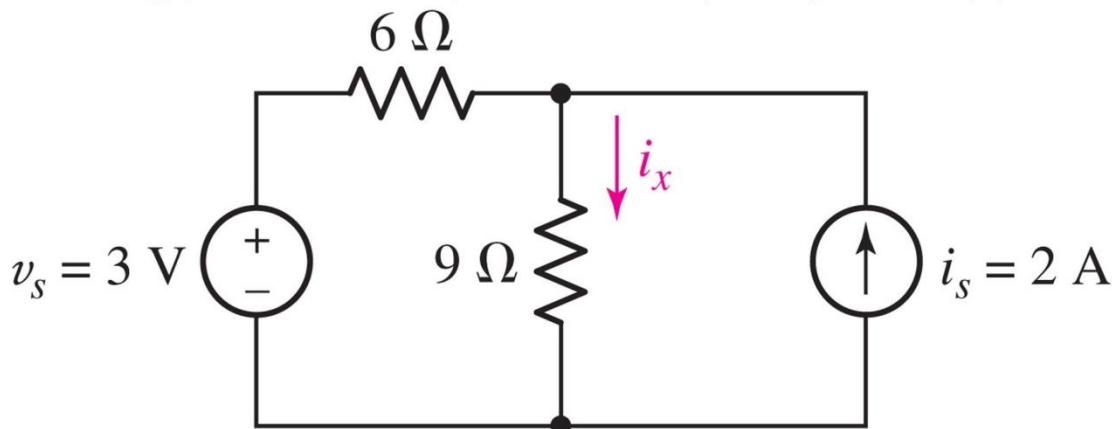
c) Find the response due to this source acting alone.

2. Add the resulting responses due to all independent sources to find the total response.

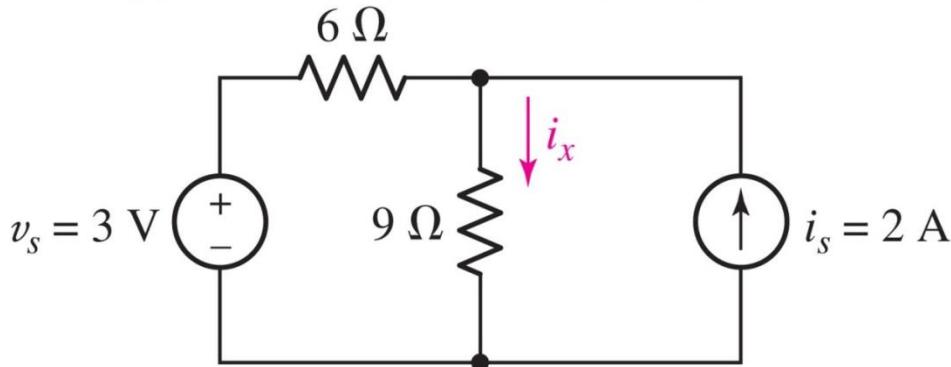


Application of Superposition

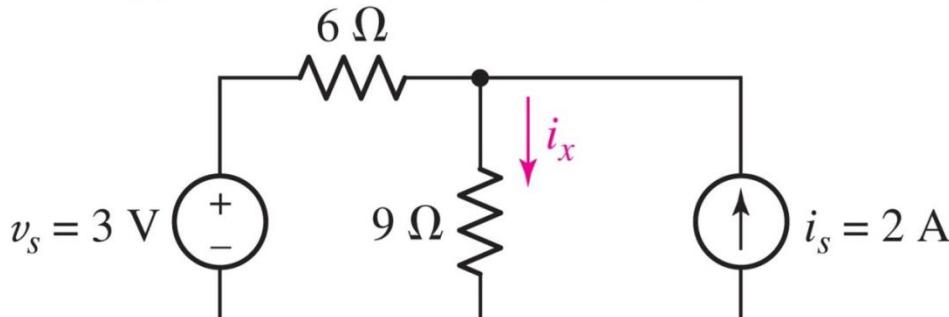
Use superposition to solve for the current i_x .



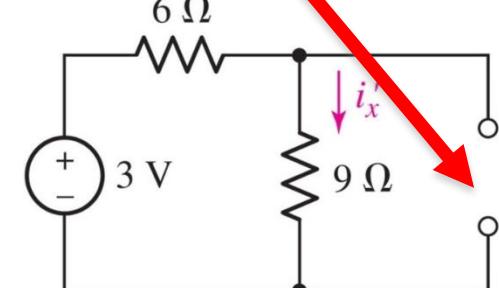
Response due to Voltage Source



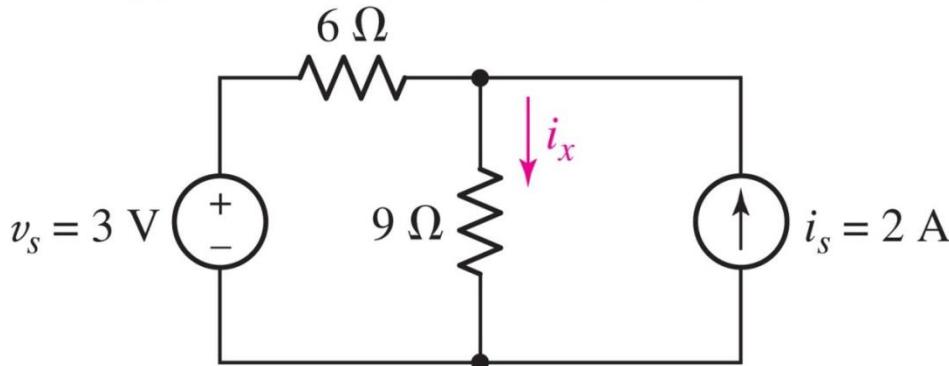
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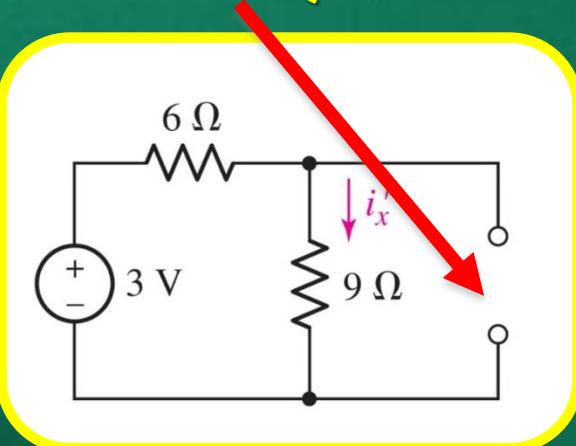
First, turn off (or disable) the current source.



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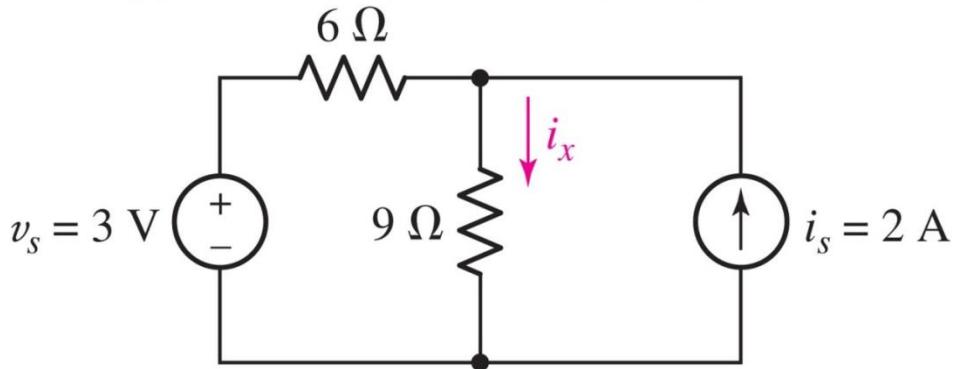


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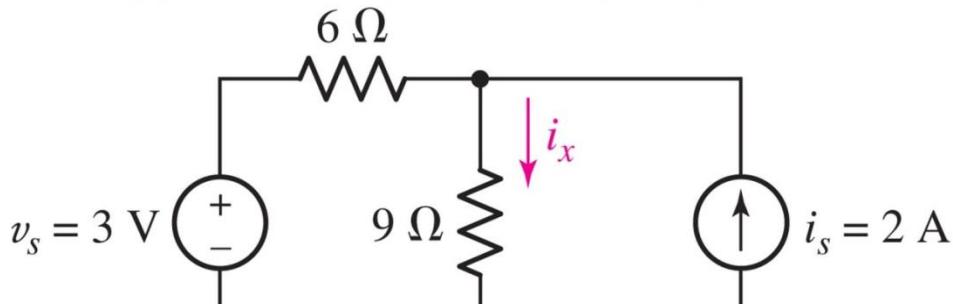


$$i'_x = \frac{3}{6+9} = 0.2$$

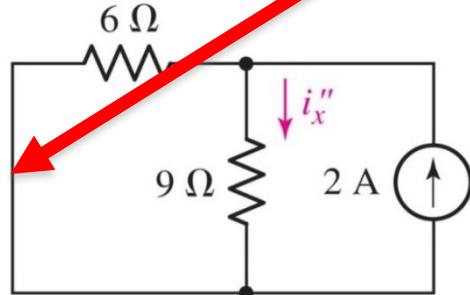
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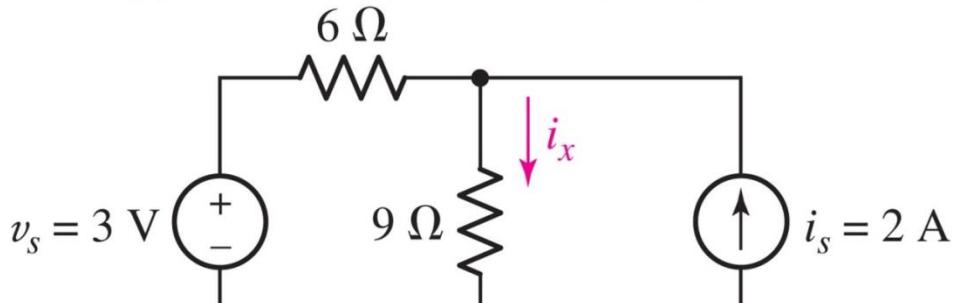
Response due to Current Source



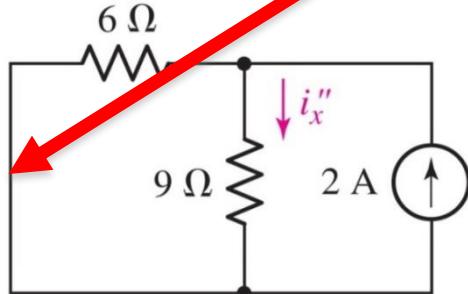
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Response due to Current Source

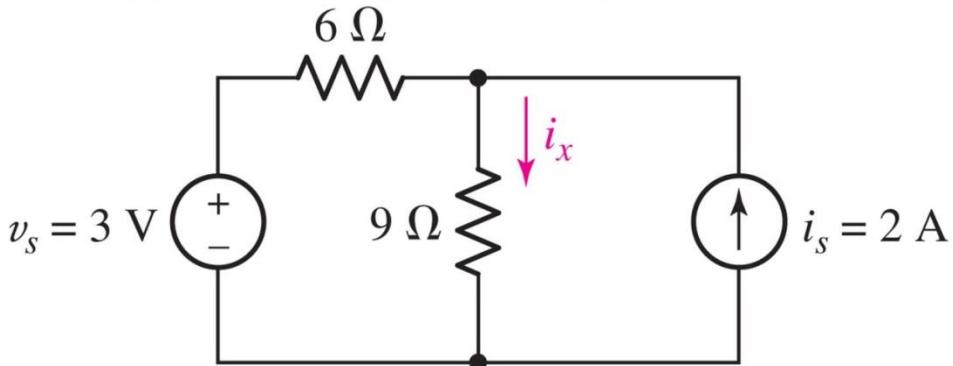


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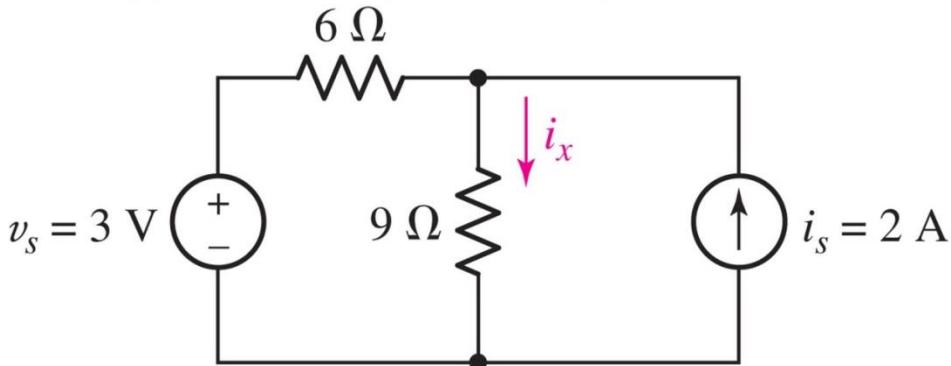
$$i_x'' = \frac{6}{6+9}(2) = 0.8$$

Total Response



Finally, add the responses due to independent sources acting alone to get the total response.

Total Response

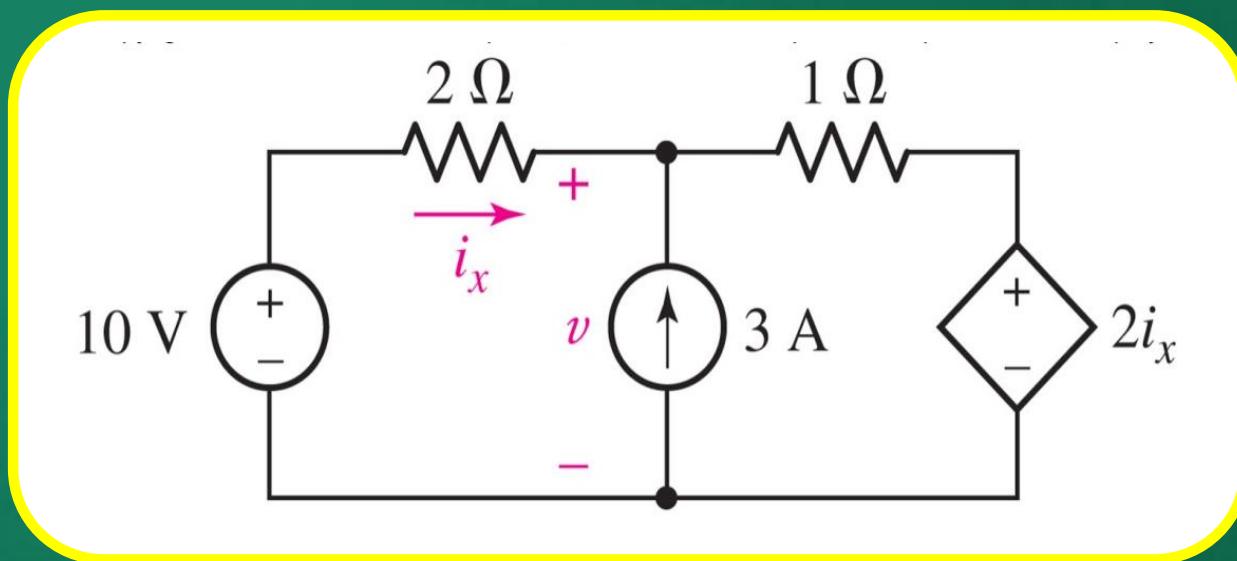


Finally, add the responses due to independent sources acting alone to get the total response.

$$i_x = i_x' + i_x'' = 0.2 + 0.8 = 1.0$$

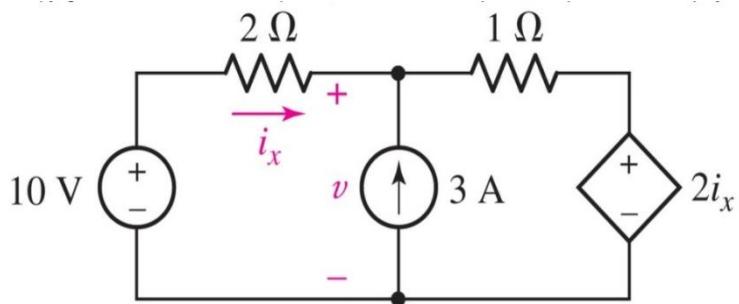
Superposition with a Dependent Source

Use superposition to compute i_x

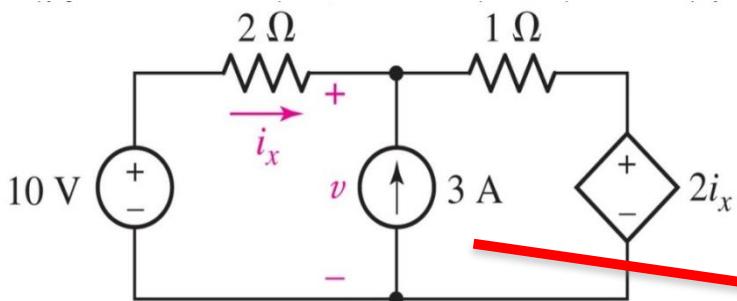


When applying superposition to circuits with dependent sources, these dependent sources are never turned off.

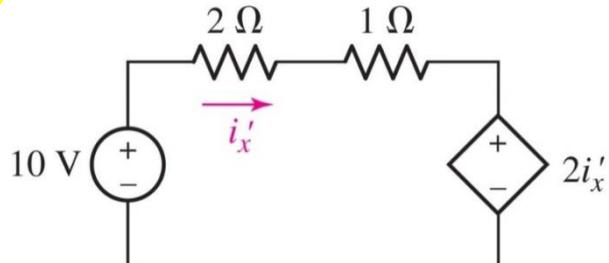
Superposition with a Dependent Source



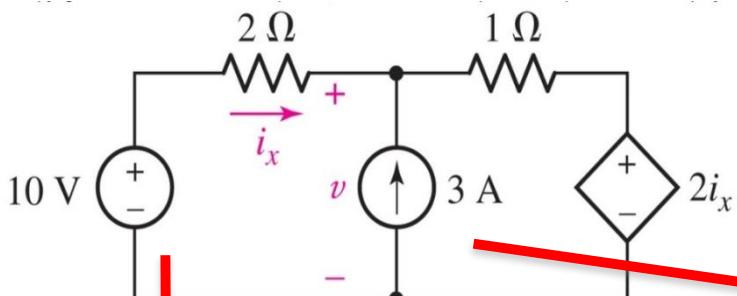
Superposition with a Dependent Source



current source off

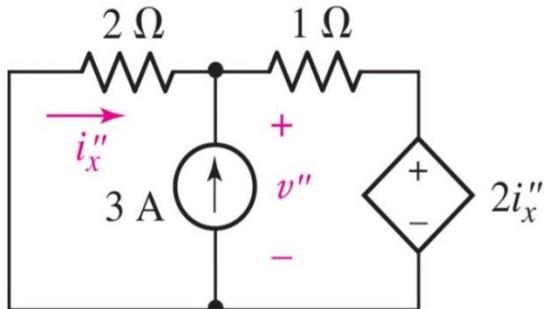
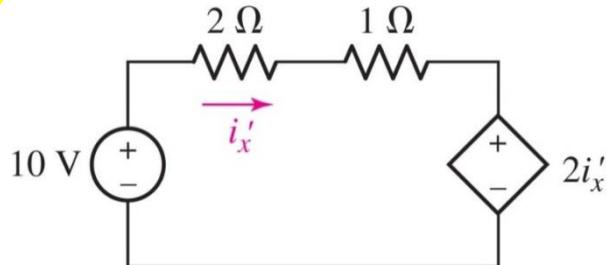


Superposition with a Dependent Source

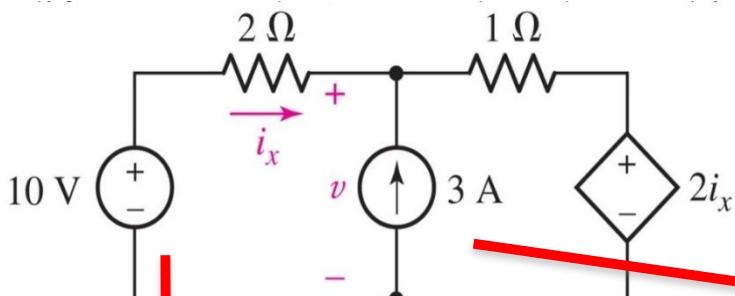


voltage source off

current source off

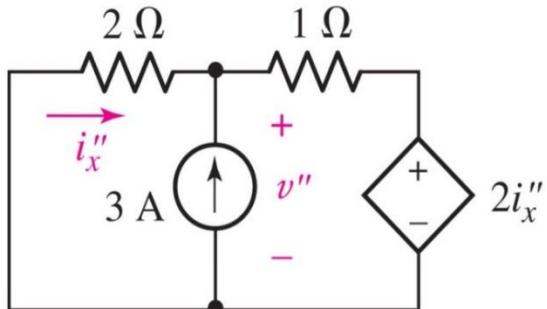
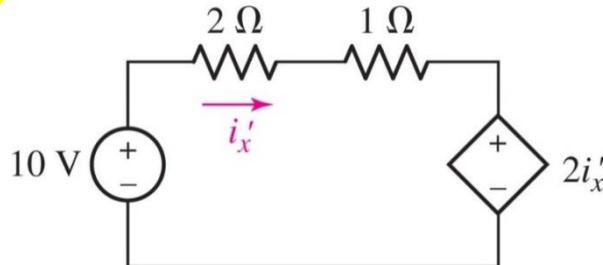


Superposition with a Dependent Source



voltage source off

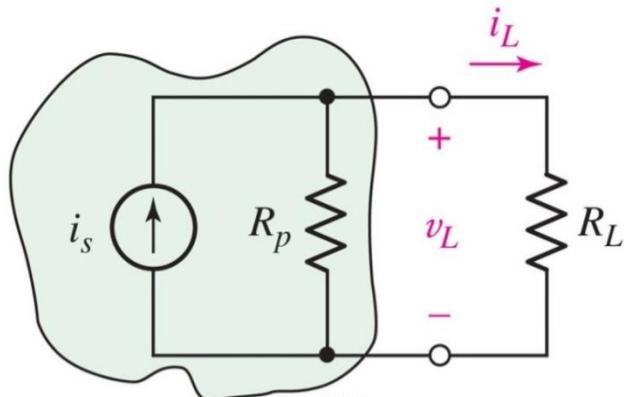
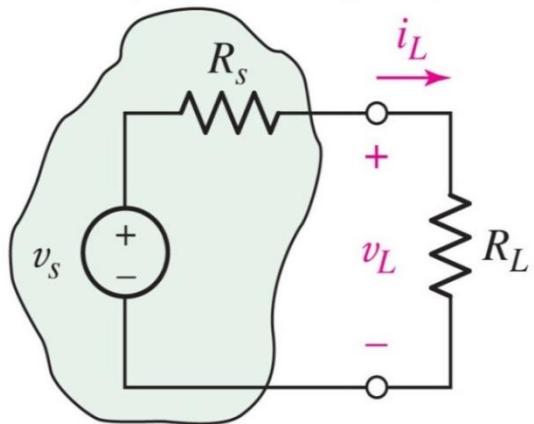
current source off



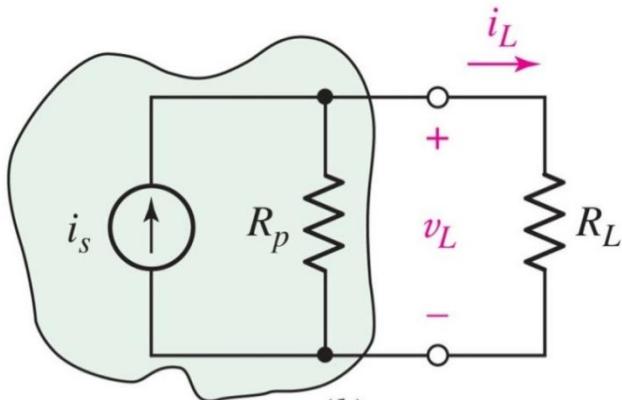
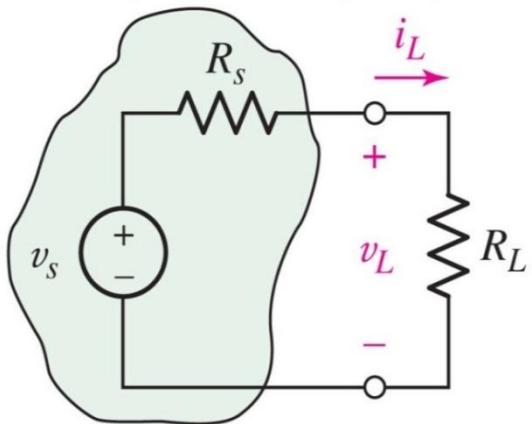
$$i_x = i'_x + i''_x = 2 + (-0.6) = 1.4 \text{ A}$$

Source Transformation

Source Transformation and Equivalent Sources



Source Transformation and Equivalent Sources

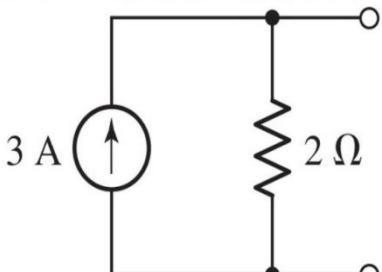


The sources are equivalent if

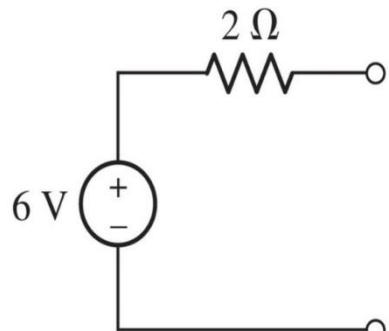
$$R_s = R_p \text{ and } v_s = i_s R_s$$

Source Transformation

- The circuits (a) and (b) are equivalent at the terminals.
- If given circuit (a), but circuit (b) is more convenient, switch them!
- This process is called source transformation.



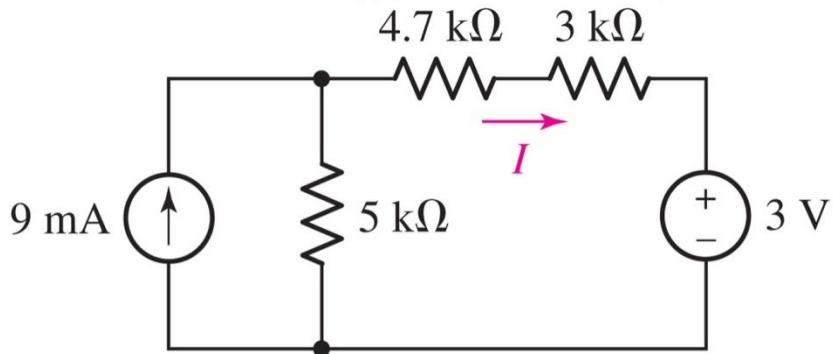
(a)



(b)

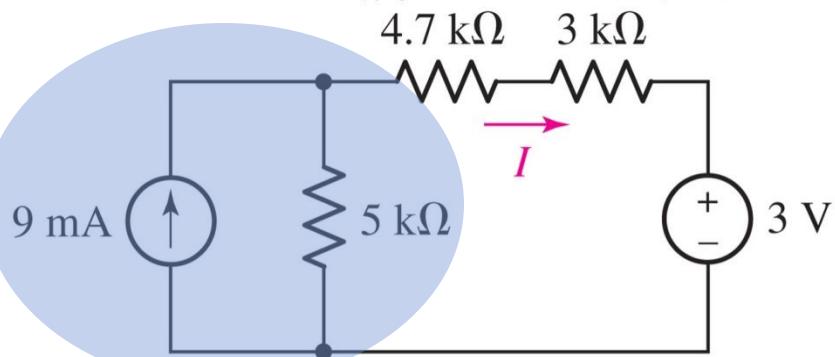
Example: Source Transformation

Find the current I in the circuit below using source transformation.



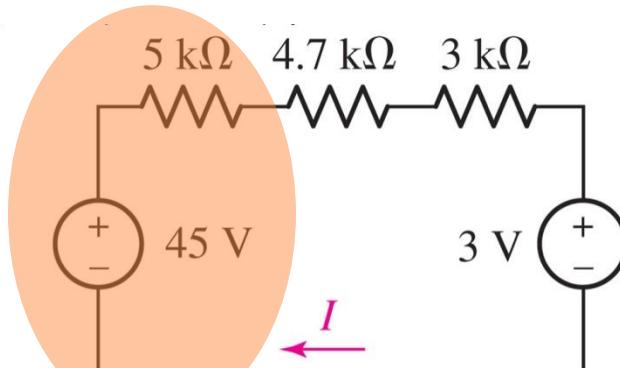
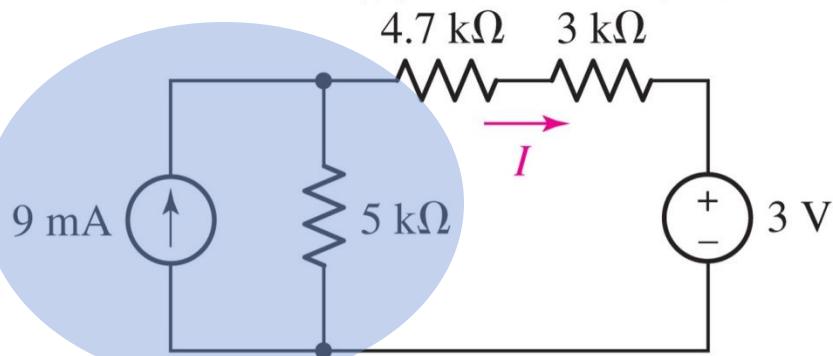
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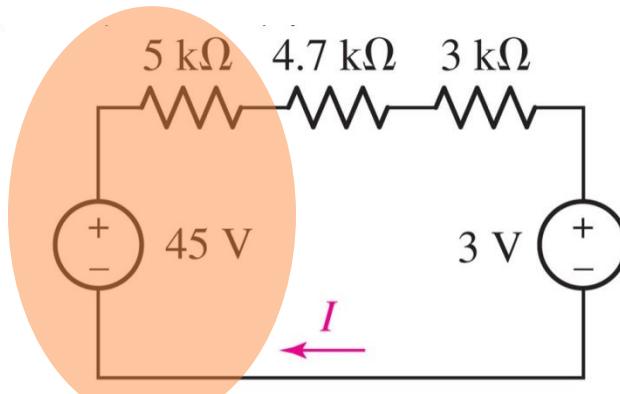
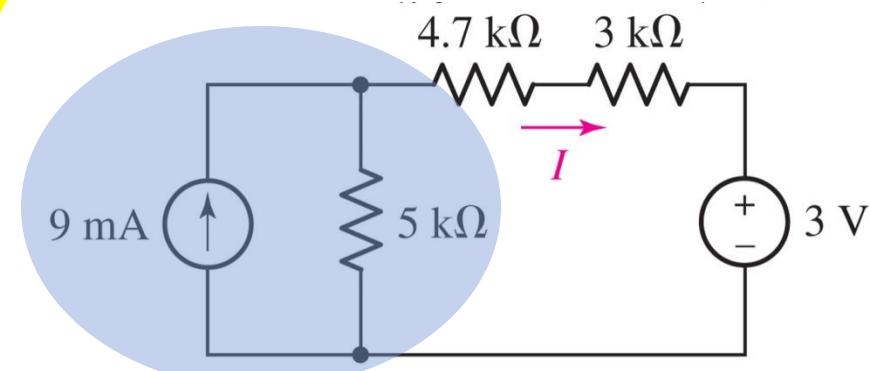
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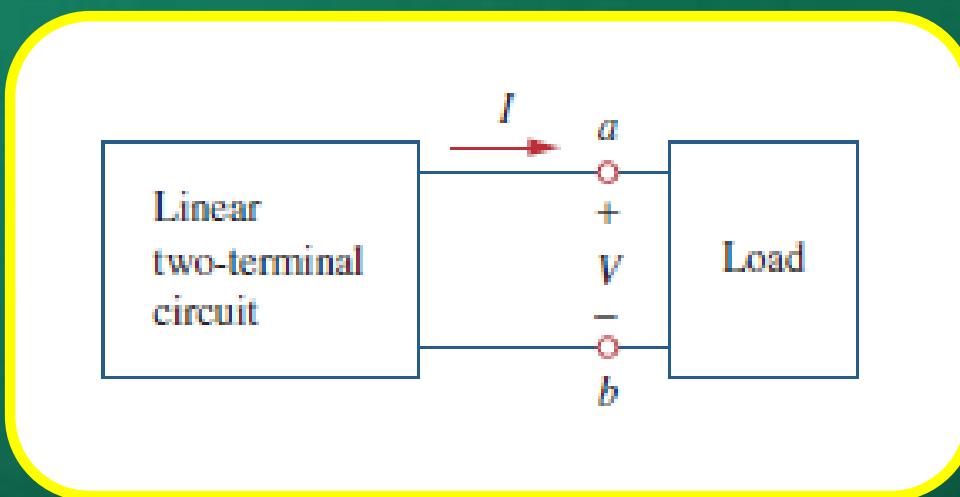


$$\text{Answer: } I = (45 - 3) / (5 + 4.7 + 3) = 3.307 \text{ mA}$$

Thevenin and Norton Equivalent Circuits

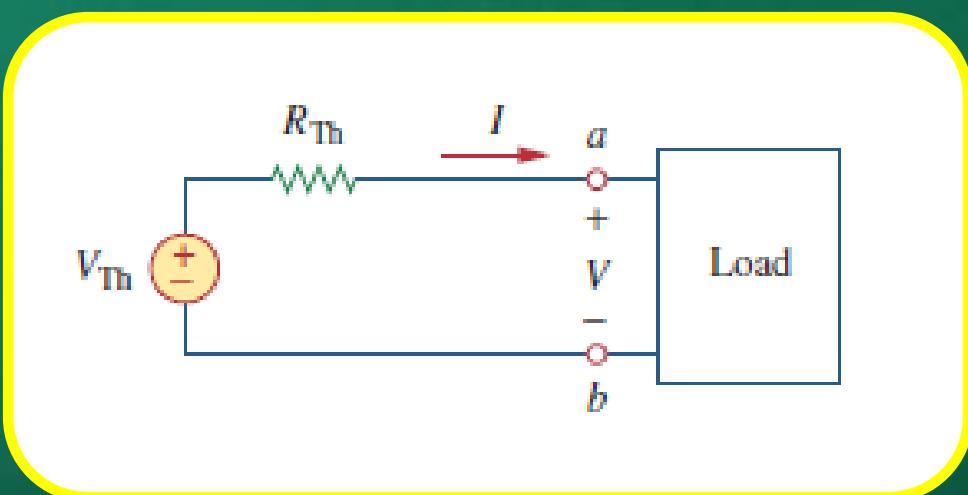
Thévenin Equivalent Circuit

Thévenin's theorem: It states that a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a voltage source V_{Th} in series with a resistor R_{Th} , where V_{Th} is the open-circuit voltage at the terminals and R_{Th} is the input or equivalent resistance at the terminals when the independent sources are turned off.



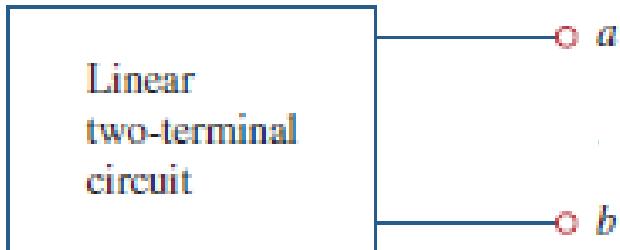
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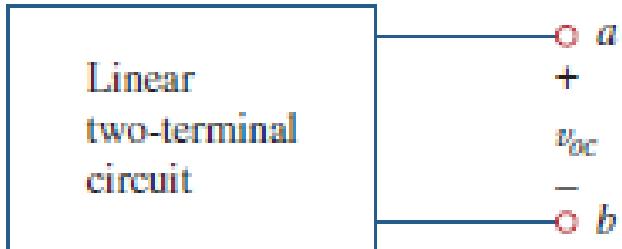
Finding Thévenin Equivalent Circuit

- Disconnect the load.



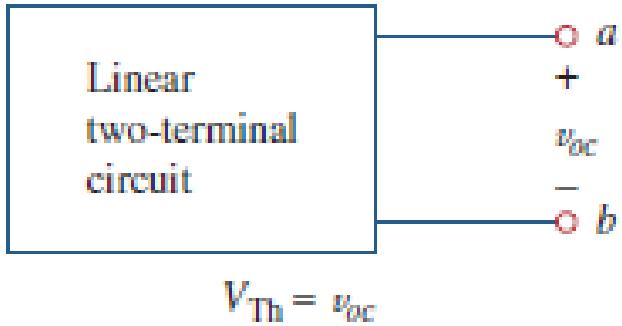
Finding Thévenin Equivalent Circuit

- Disconnect the load.
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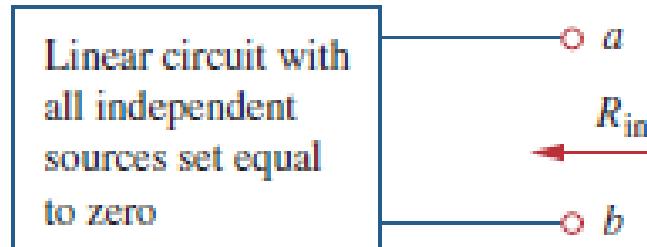
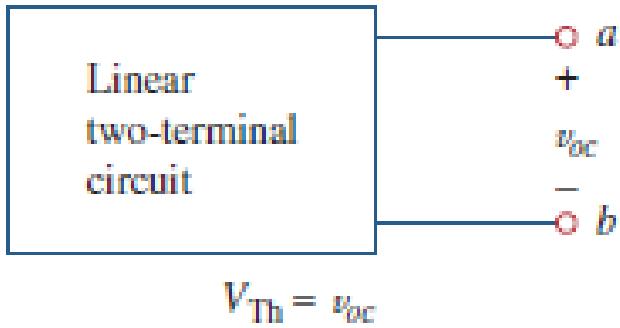
Finding Thévenin Equivalent Circuit

- Disconnect the load.
- Find the open circuit voltage v_{oc} ($v_{oc} = V_{Th}$)



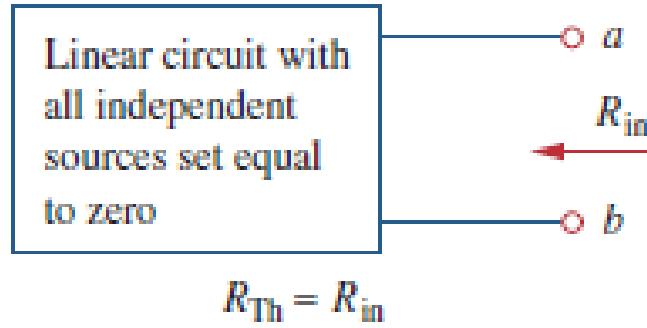
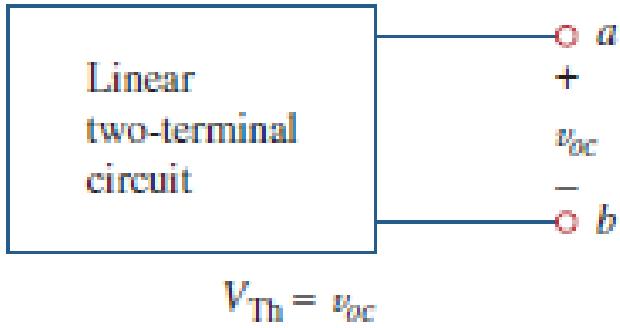
Finding Thévenin Equivalent Circuit

- Disconnect the load.
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- Find the equivalent resistance R_{eq} of the network with all independent sources turned off.

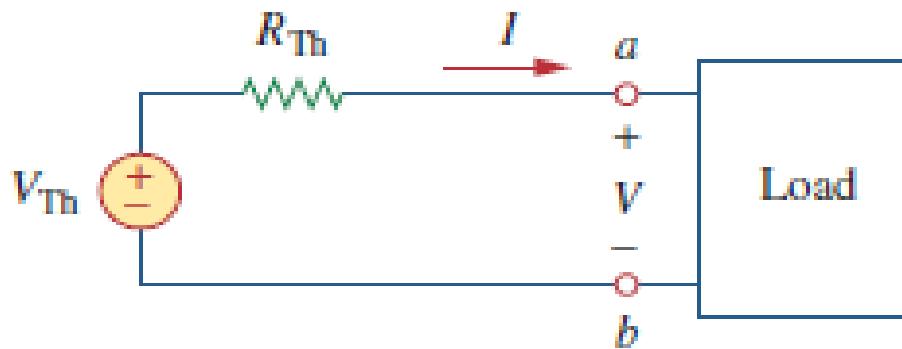


Finding Thévenin Equivalent Circuit

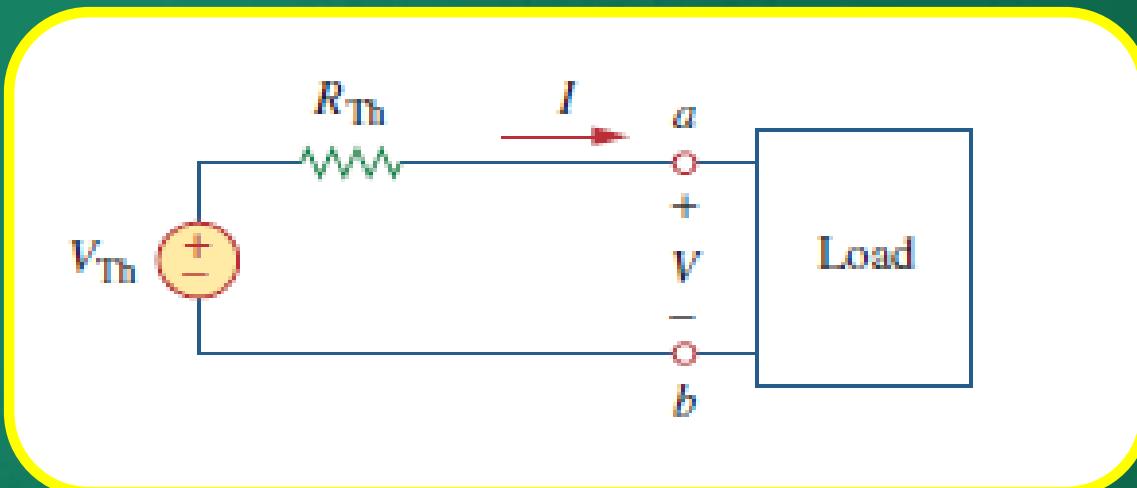
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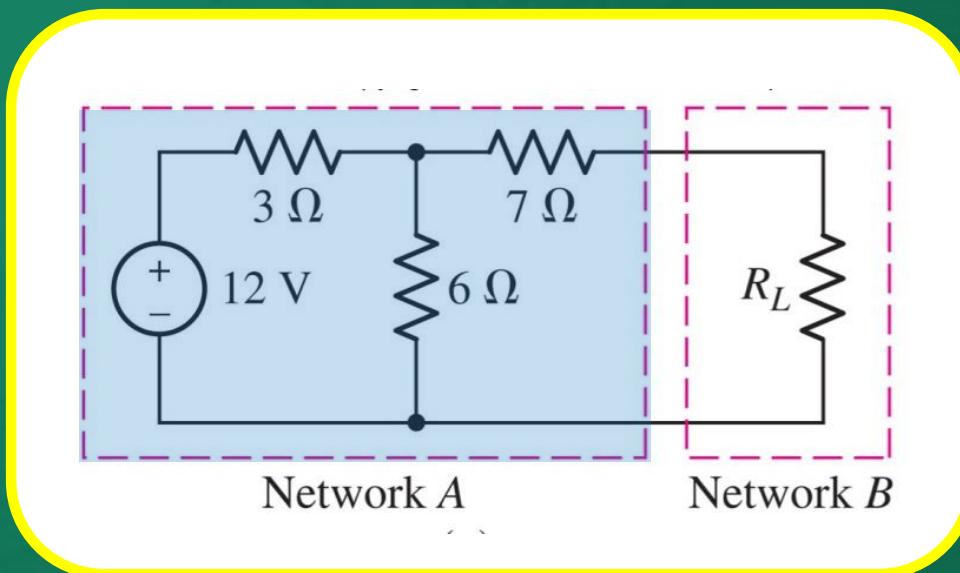


$$V_{TH} = v_{oc}$$

$$R_{TH} = R_{eq}$$

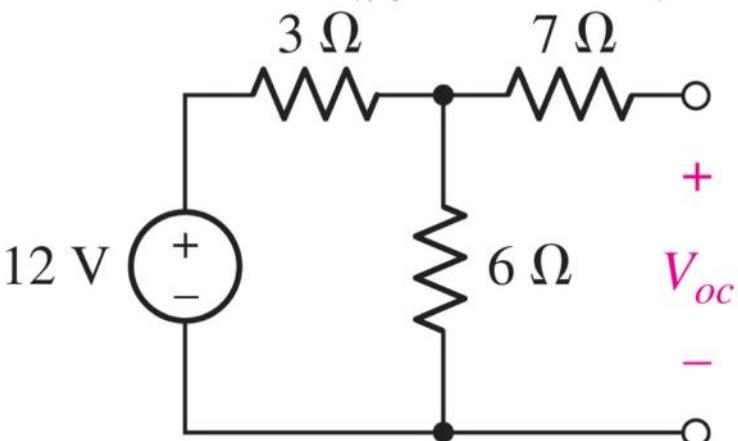
Thévenin Example (1 of 6)

Find the Thevenin equivalent of Network A



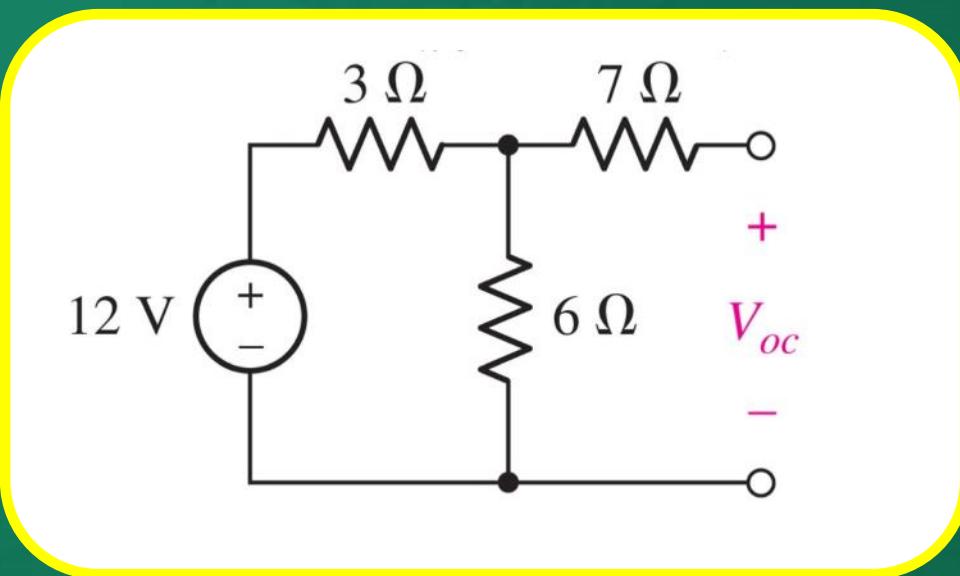
Thévenin Example (2 of 6)

Thevenin Voltage (V_{Th})



Thévenin Example (3 of 6)

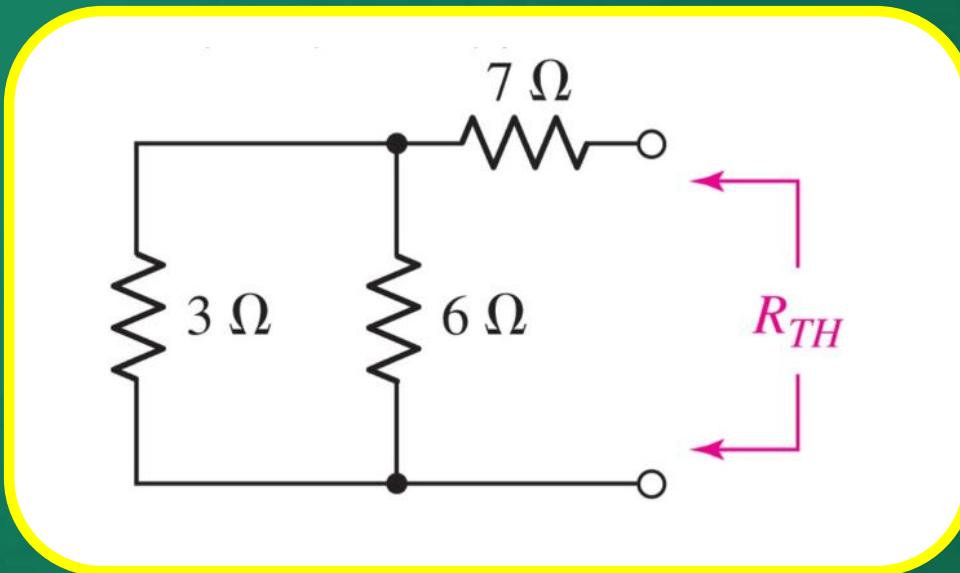
Thevenin Voltage (V_{Th})



$$V_{Th} = V_{oc} = 8 \text{ V}$$

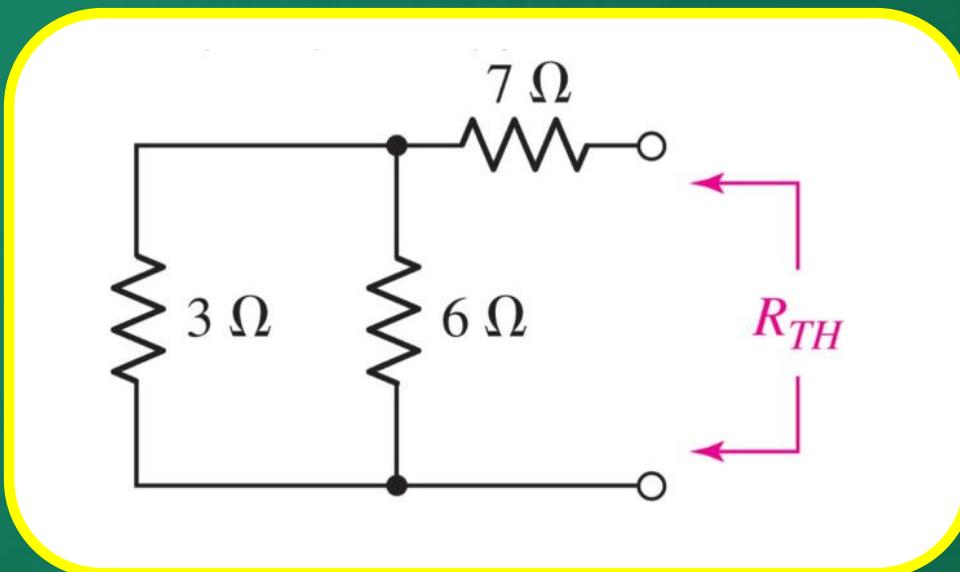
Thévenin Example (4 of 6)

Thevenin Resistance (R_{Th})



Thévenin Example (5 of 6)

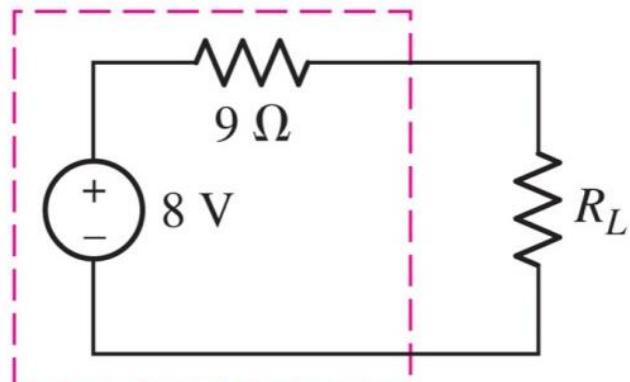
Thevenin Resistance (R_{Th})



$$R_{Th} = 9 \Omega$$

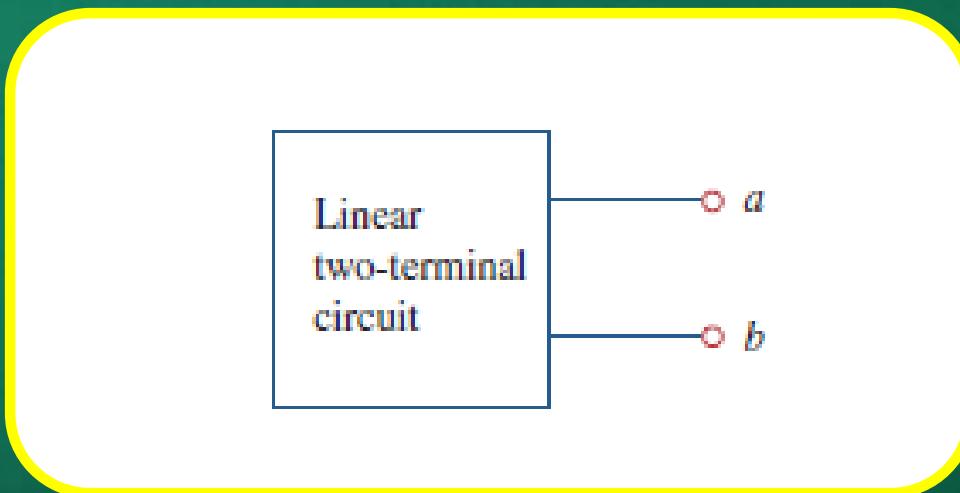
Thévenin Example (6 of 6)

Thevenin Equivalent of Network A



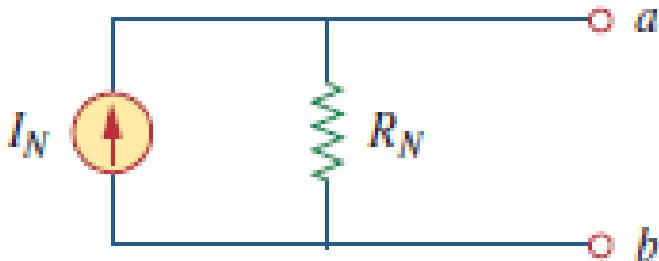
Norton Equivalent Circuit

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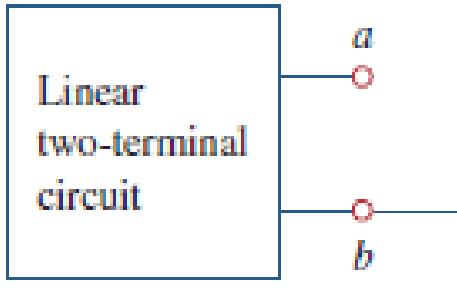
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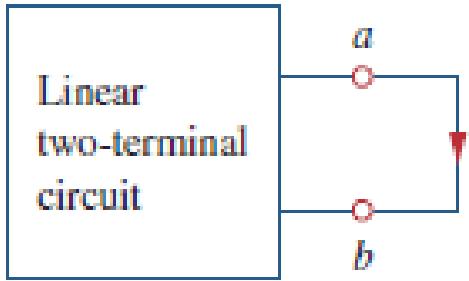
Finding Norton Equivalent Circuit

- Disconnect the load (if any).



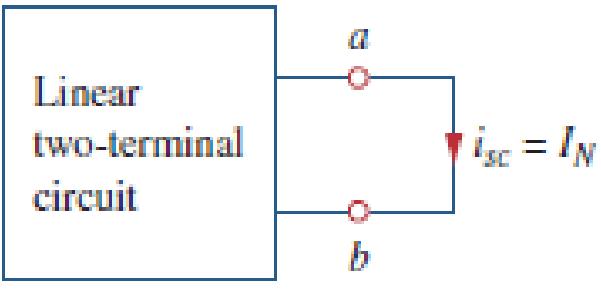
Finding Norton Equivalent Circuit

- Disconnect the load (if any).
- Short the terminals and find the short circuit current i_{sc}



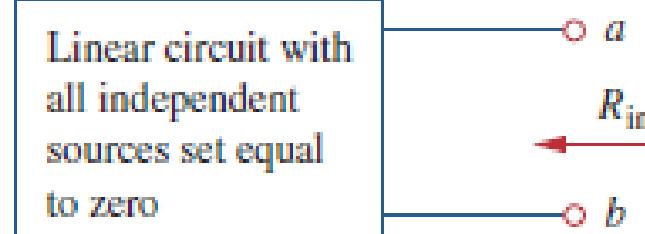
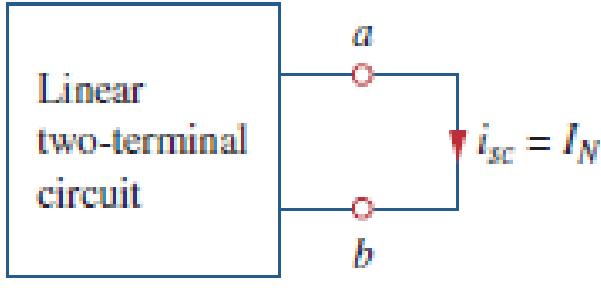
Finding Norton Equivalent Circuit

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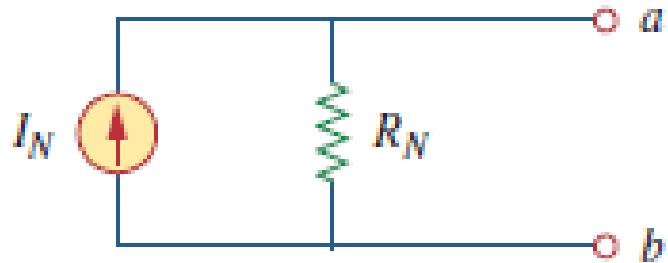


Finding Norton Equivalent Circuit

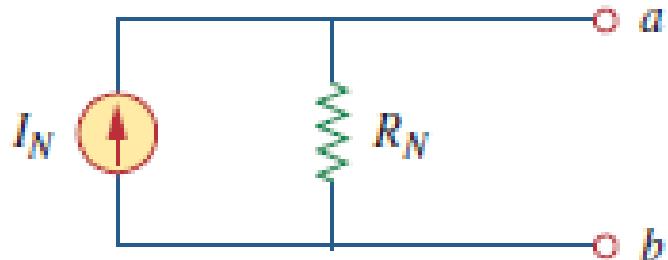
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Thévenin Equivalent Circuit



Thévenin Equivalent Circuit

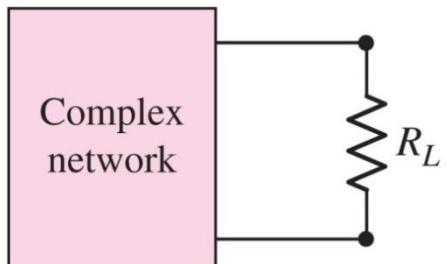


$$I_N = i_{sc}$$

$$R_N = R_{eq}$$

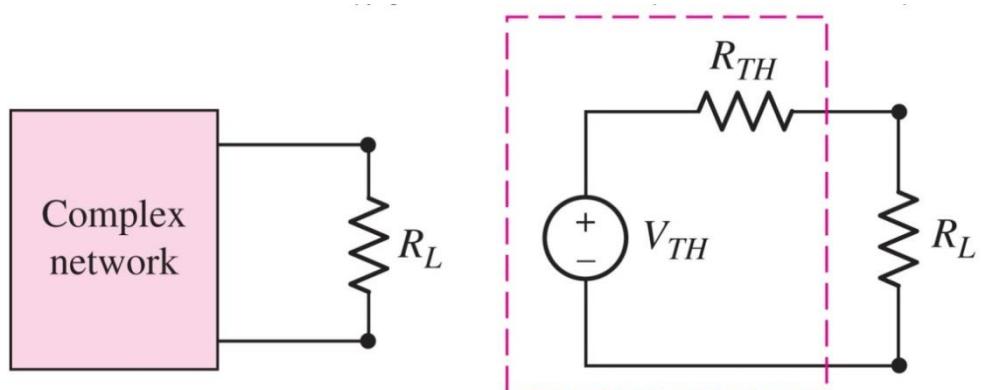
Source Transformation: Norton and Thevenin

The Thévenin and Norton equivalents are source transformations of each other!



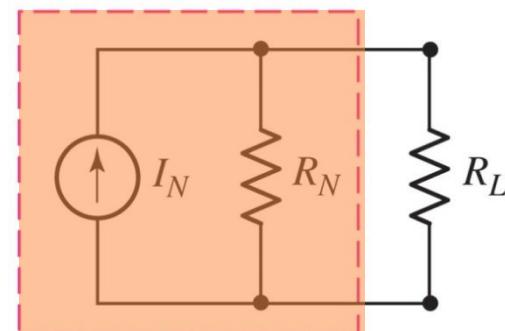
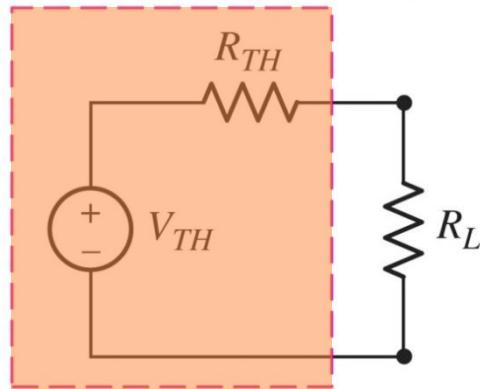
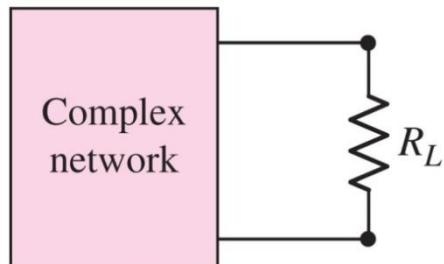
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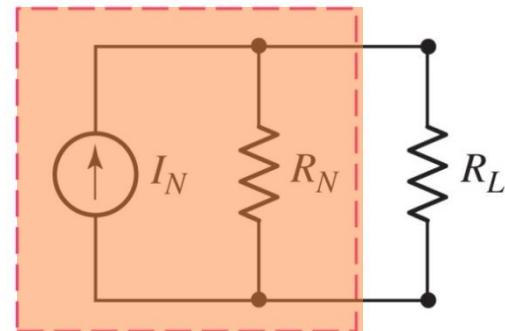
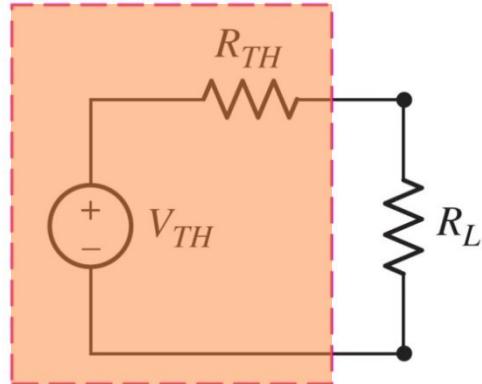
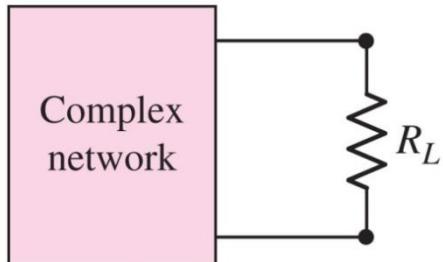
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Source Transformation: Norton and Thevenin

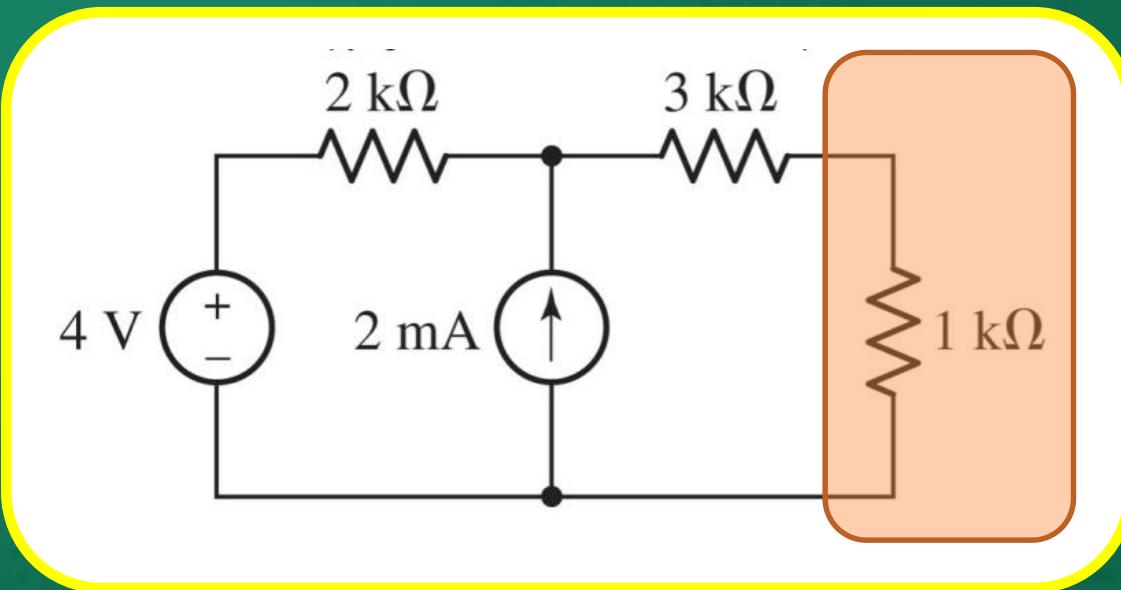
The Thévenin and Norton equivalents are source transformations of each other!



$$R_{TH} = R_N = R_{eq} \text{ and } V_{TH} = i_N R_{eq}$$

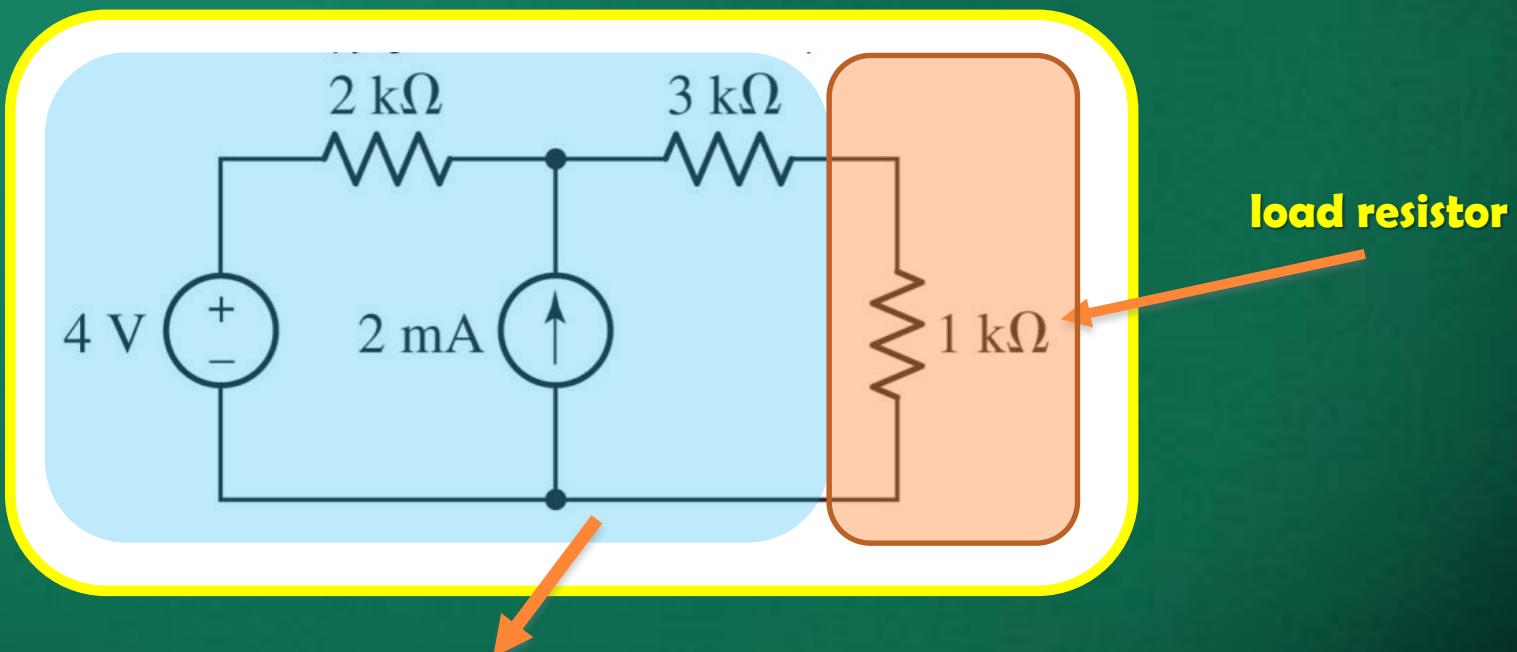
Example: Norton and Thévenin

Find the Thévenin and Norton equivalents for the network faced by the $1\text{ k}\Omega$ resistor.



Example: Norton and Thévenin

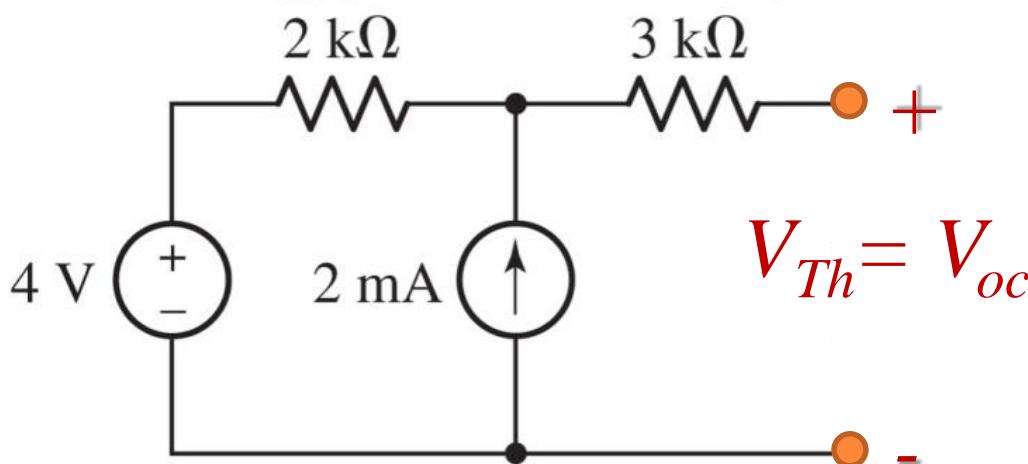
Find the Thévenin and Norton equivalents for the network faced by the $1\text{ k}\Omega$ resistor.



this is the circuit to be simplified

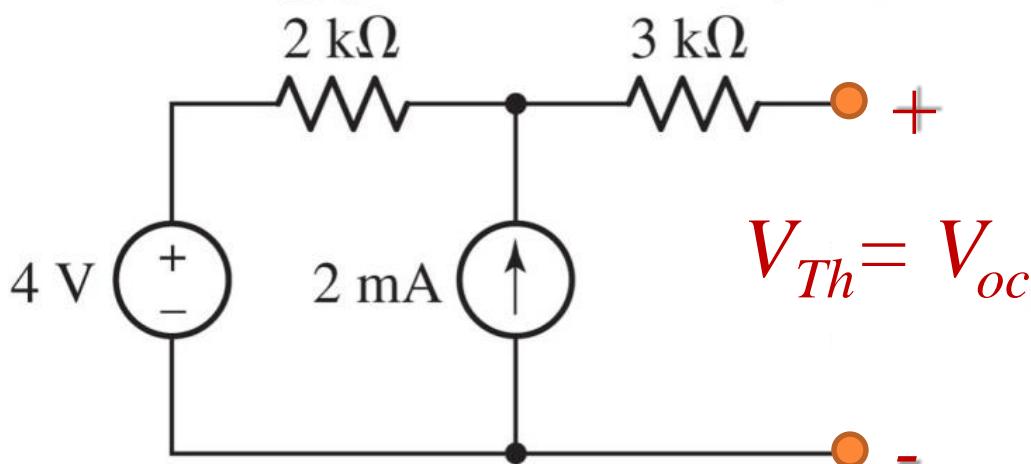
Example: Thévenin Equivalent

Finding the Thévenin voltage (V_{Th})



Example: Thévenin Equivalent

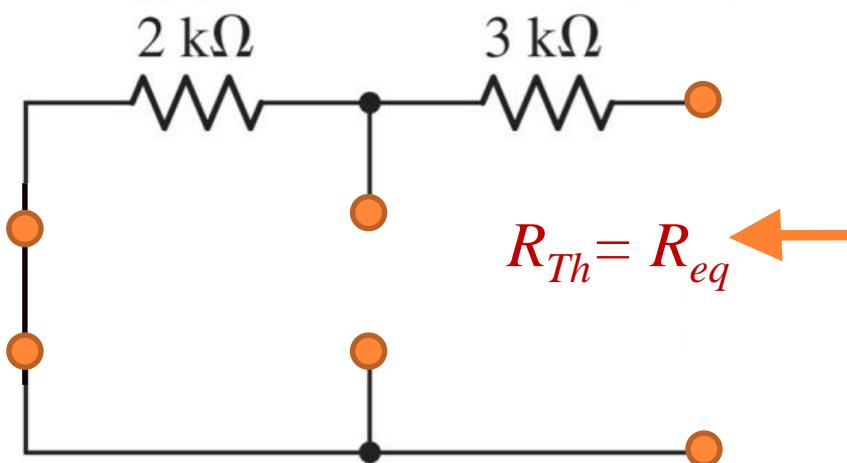
Finding the Thévenin voltage (V_{Th})



$$V_{Th} = V_{oc} = 8 \text{ V}$$

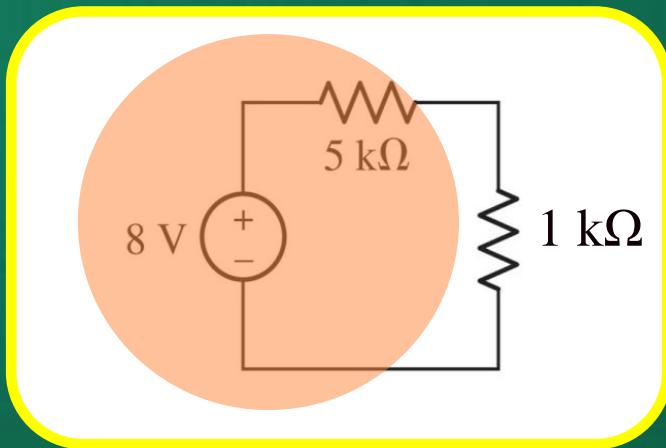
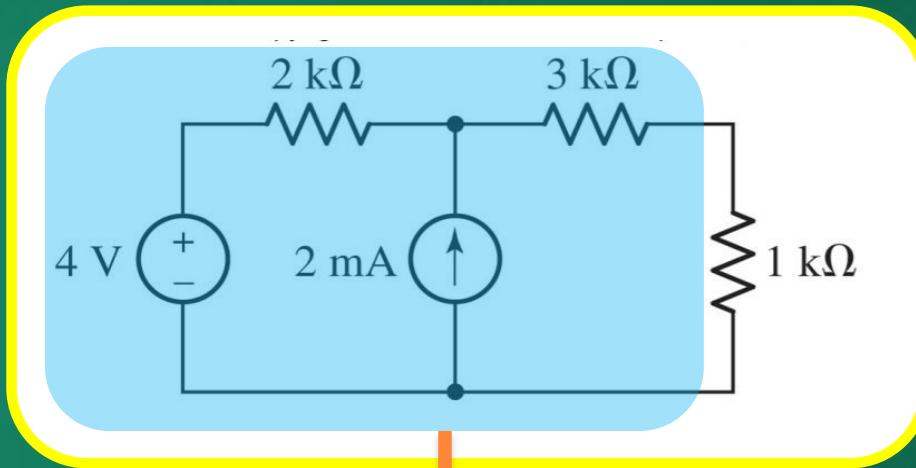
Example: Thévenin Equivalent

Finding the Thévenin resistance (R_{Th})



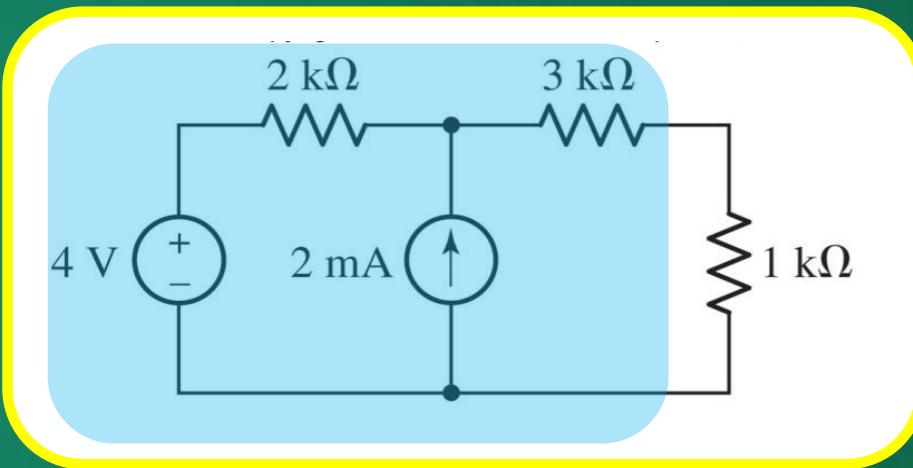
$$R_{Th} = R_{eq} = 5\text{ k}\Omega$$

Example: Thévenin Equivalent

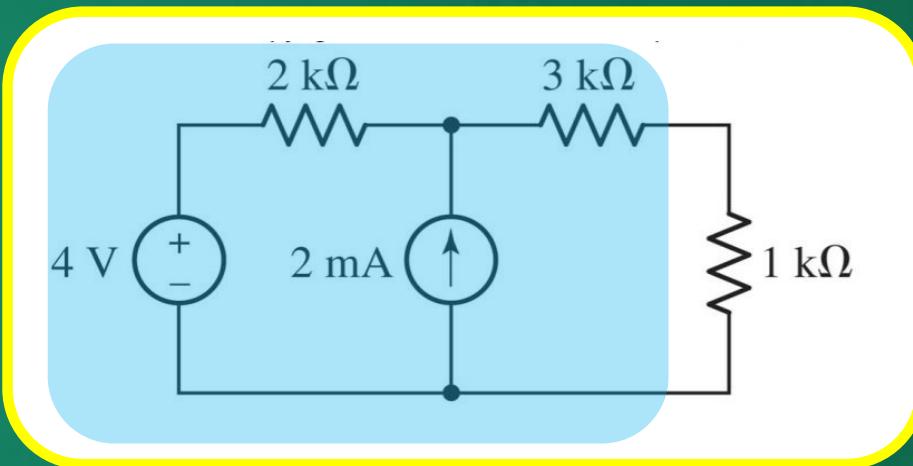


**Thévenin
Equivalent**

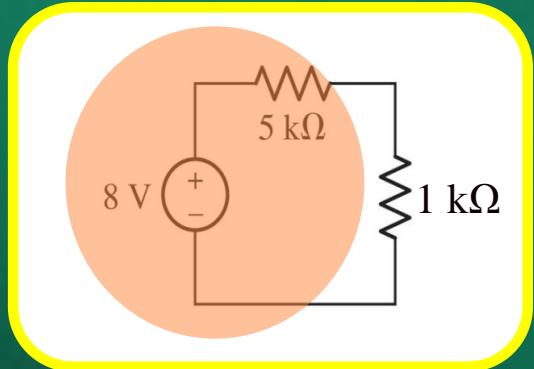
Example: Norton and Thévenin



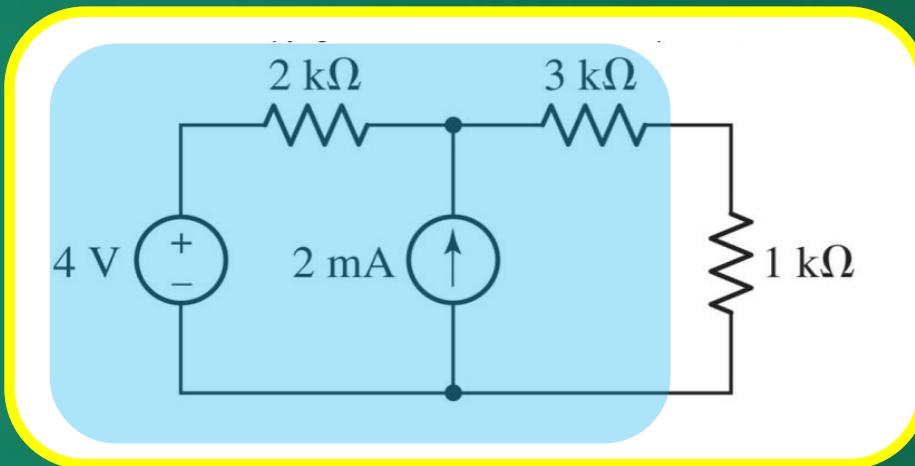
Example: Norton and Thévenin



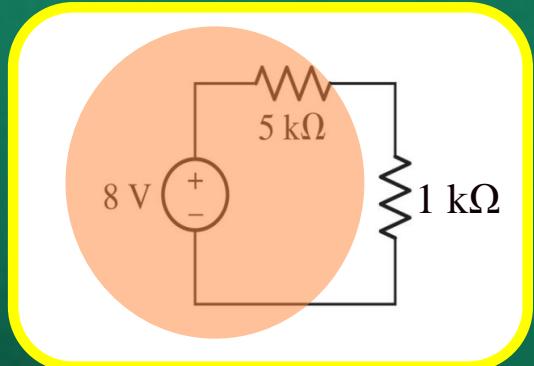
Thévenin Equivalent



Example: Norton and Thévenin



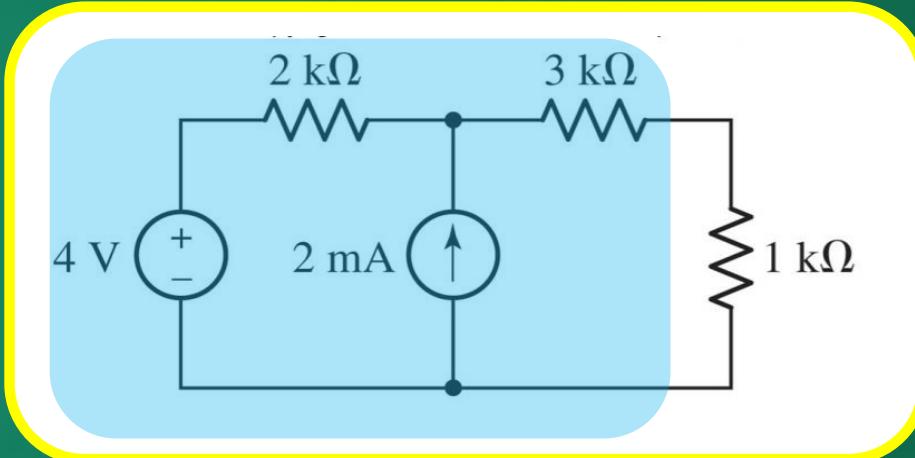
Thévenin Equivalent



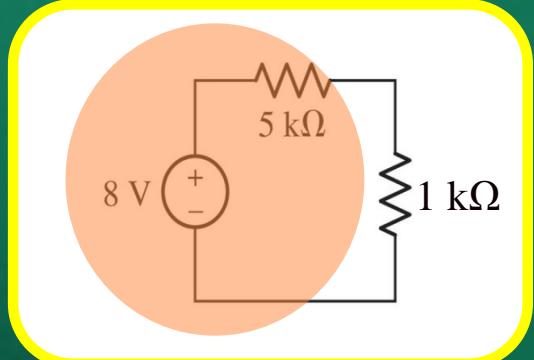
Source Transformation



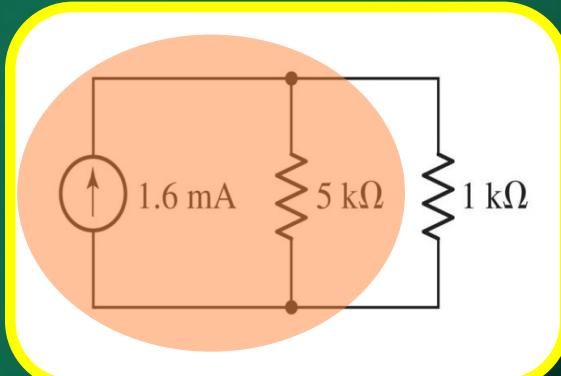
Example: Norton and Thévenin



Thévenin Equivalent



Norton Equivalent



Source Transformation