Additional Analysis Techniques → Chapter #5

9/16/2019

- **Linearity and Equivalence**
- **Superposition**
- **Thevenin Equivalent Circuit**
- **Norton Equivalent Circuit**
- **Source Transformation**
- **Maximum Power Transfer**

Circuit Equivalence

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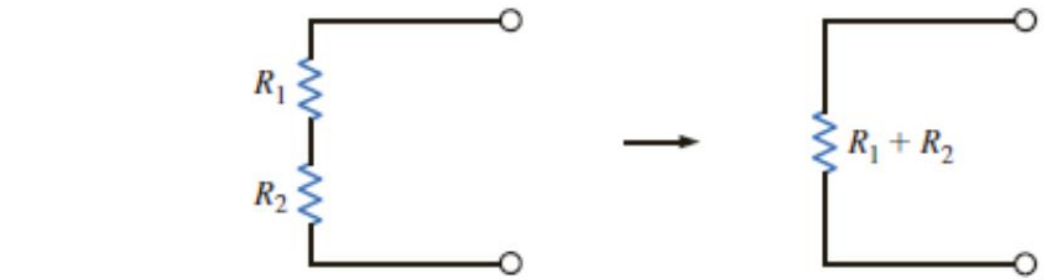
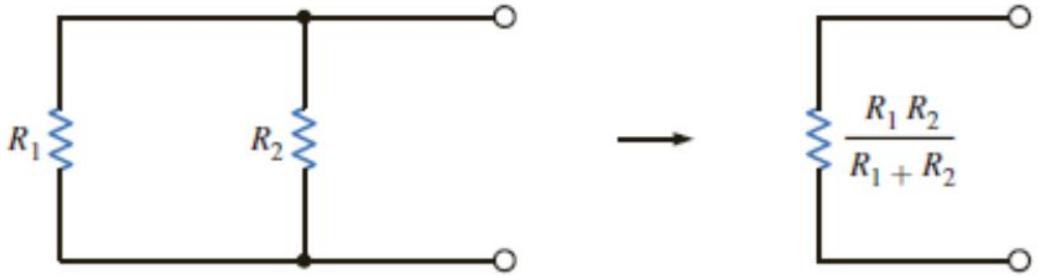
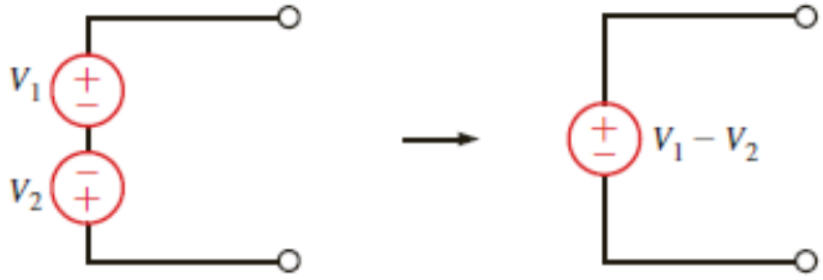
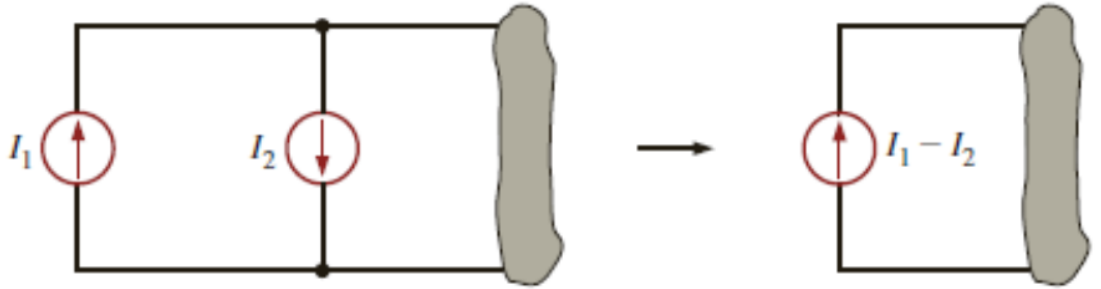
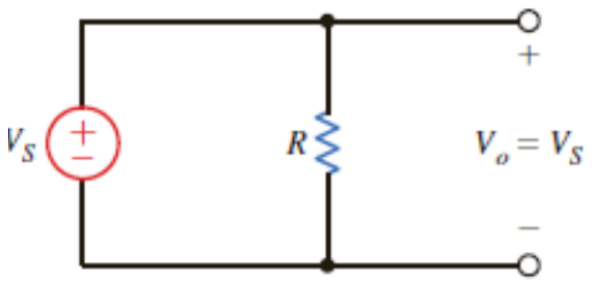
An equivalent circuit refers to a theoretical circuit that retains all of the electrical characteristics of a given circuit.

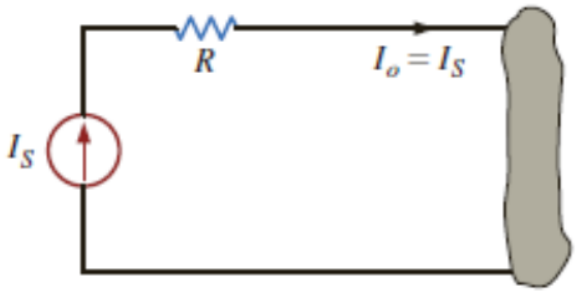






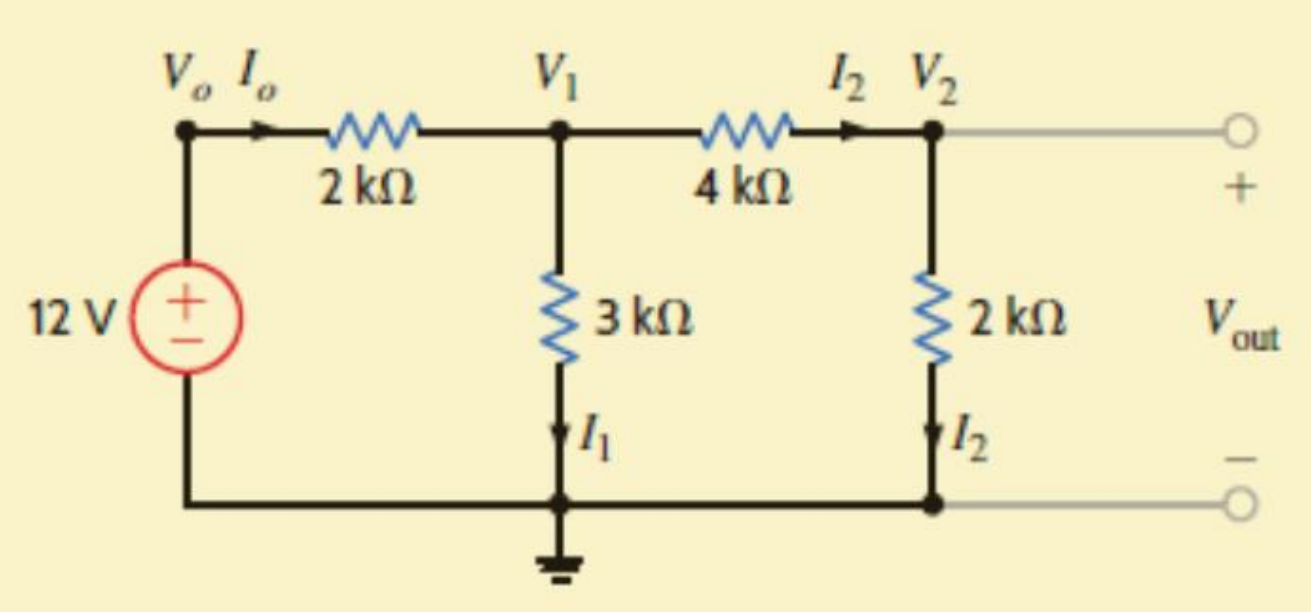






Circuit Linearity

Requires both additivity and homogeneity (scaling)



$$\frac{V_{out}}{V_0} = \frac{V_{out}{}'}{V_0{}'}$$

$$V_{out}{}' = 1V \rightarrow V_o{}' = 6V$$

$$\therefore V_{out} = V_0 \cdot \frac{V_{out}{}'}{V_0{}'} = V_0 \cdot \frac{1}{6} = 2V$$

Example 5.1: Find V_{out} …

assuming V_{out} =1, find V_o and then use linearity to obtain V_{out} for V_o= 12V.

Superposition

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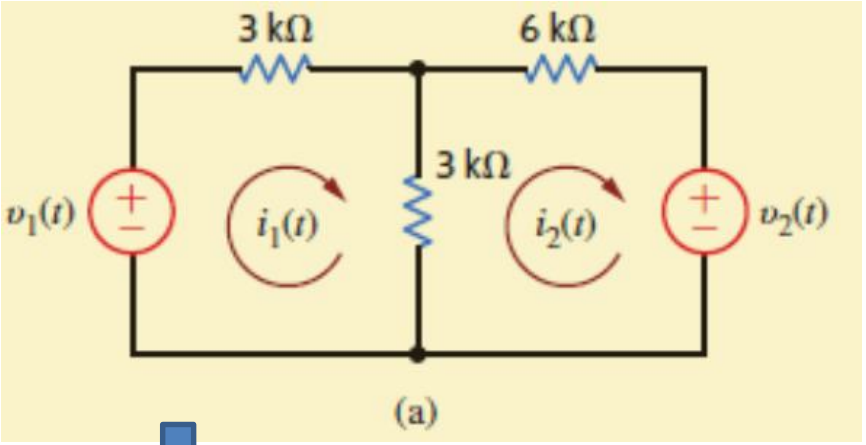
In any linear circuit containing multiple independent sources, the current or voltage at any point in the network may be calculated as the algebraic sum of the individual contributions of each source acting alone.



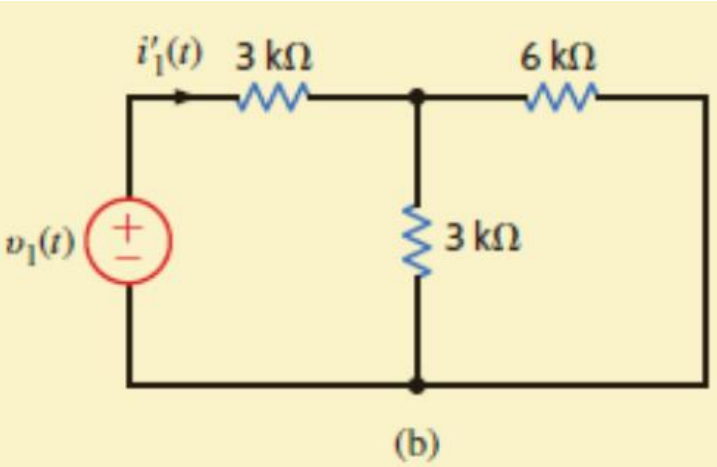
$$i_1(t) = \frac{v_1(t)}{5k} - \frac{v_2(t)}{15k}$$

$$i_1'(t) = \frac{v_1(t)}{5k}$$

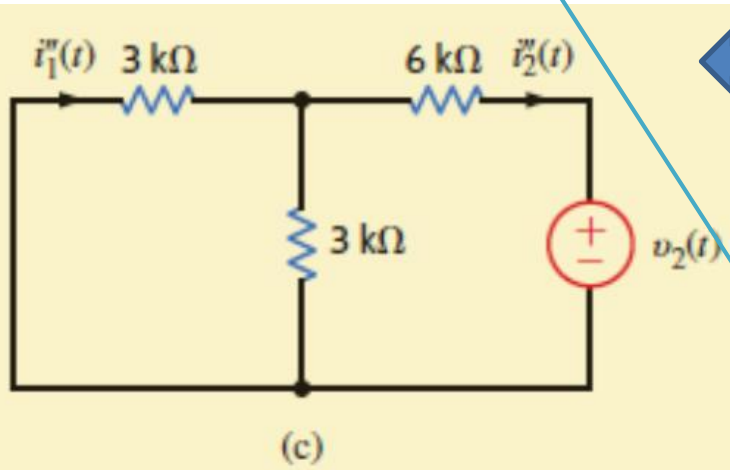
$$i_1''(t) = -\frac{v_2(t)}{15k}$$

$$i_1(t) = i_1'(t) + i_1''(t)$$

$v_2(t) = 0$

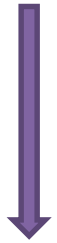


$v_1(t) = 0$



Superposition

Each independent source can be applied independently with the remaining source turned off:

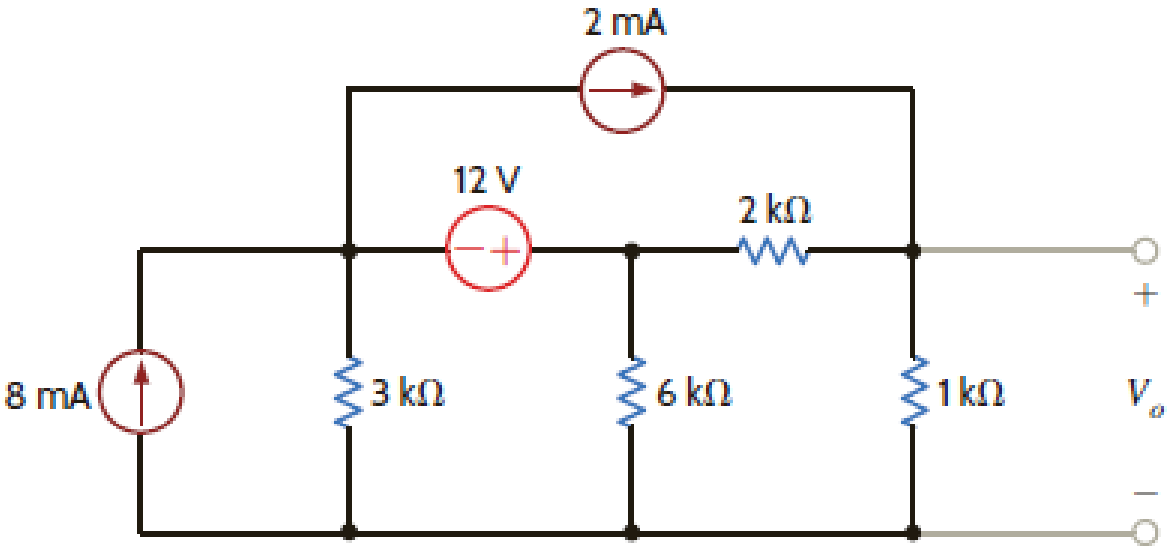


- ***Turn off a voltage source*** → *short circuit*
- ***Turn off a current source*** → *open circuit*

The final solution is the algebraic sum of the independent results!

Learning Assessment E.5.4

Find V_0 using superposition.



Thevenin's and Norton's Theorems

Thevenin's Theorem: *an entire circuit or network can be replaced, exclusive of the load, by an equivalent circuit that contains only an* ***independent voltage source in series with a resistor*** *in such a way that the current-voltage relationship at the load is unchanged.*

Nortons's Theorem: *an entire circuit or network can be replaced, exclusive of the load, by an equivalent circuit that contains only an* ***independent current source in parallel with a resistor*** *in such a way that the current-voltage relationship at the load is unchanged.*

Thevenin's and Norton's Theorems

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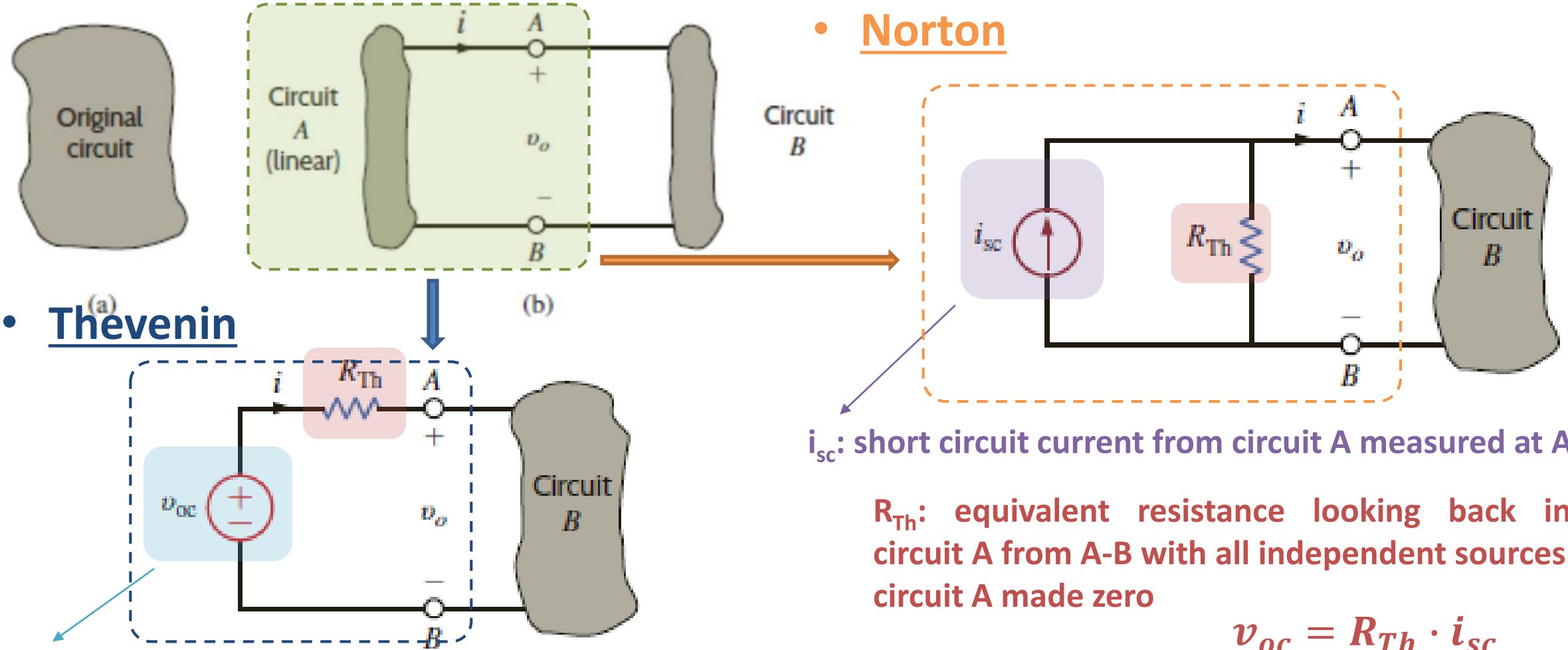

- **Norton**

- **Thevenin**

i_{sc}: short circuit current from circuit A measured at A-B

R_{Th}: equivalent resistance looking back into circuit A from A-B with all independent sources in circuit A made zero

v_{oc}: open circuit voltage from circuit A measured at A-B

$$v_{oc} = R_{Th} \cdot i_{sc}$$

Thevenin's Theorem → Independent Sources Only

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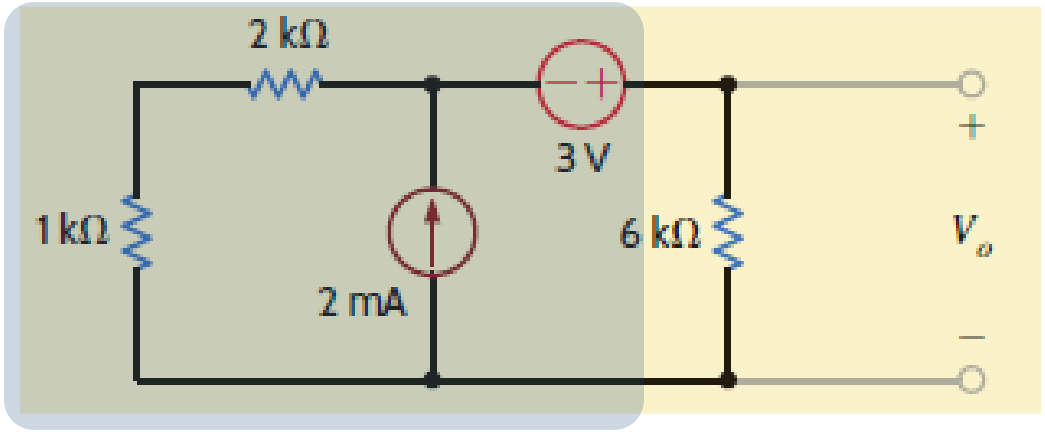
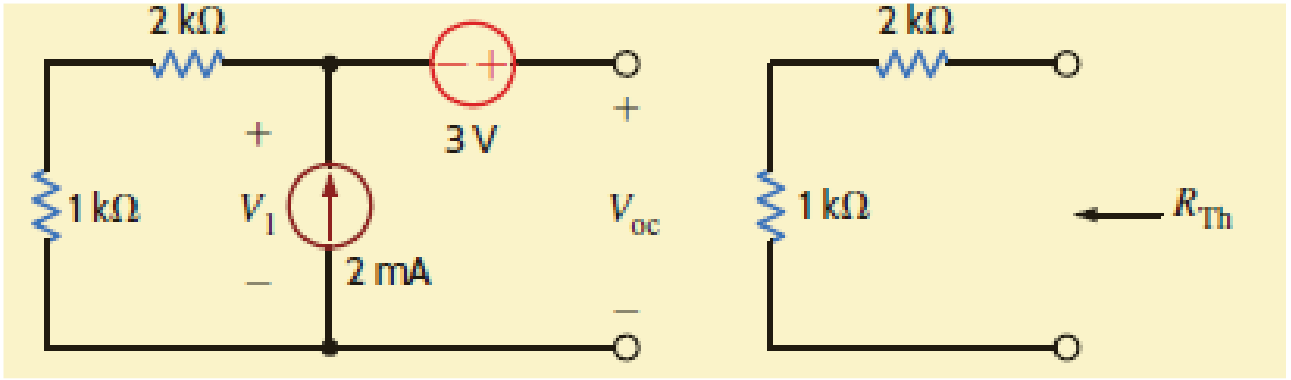
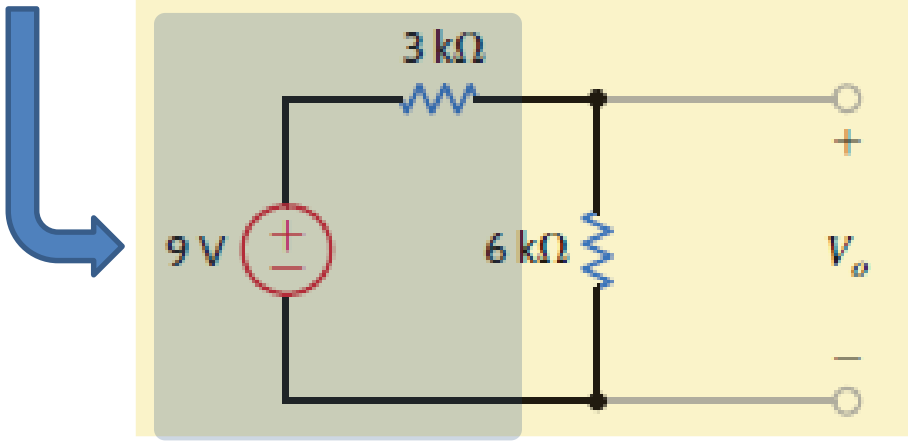
Example 5.5: Use Thevenin's and Norton's theorems to find V_0 in the network provided.







$$V_{OC} = 2m(1k + 2k) + 3 = 9V$$

$$R_{th} = 1k + 2k = 3k\Omega$$

$$V_O = 9\frac{6k}{3k + 6k} = 6V$$