Exam #2 → Thursday, February 21

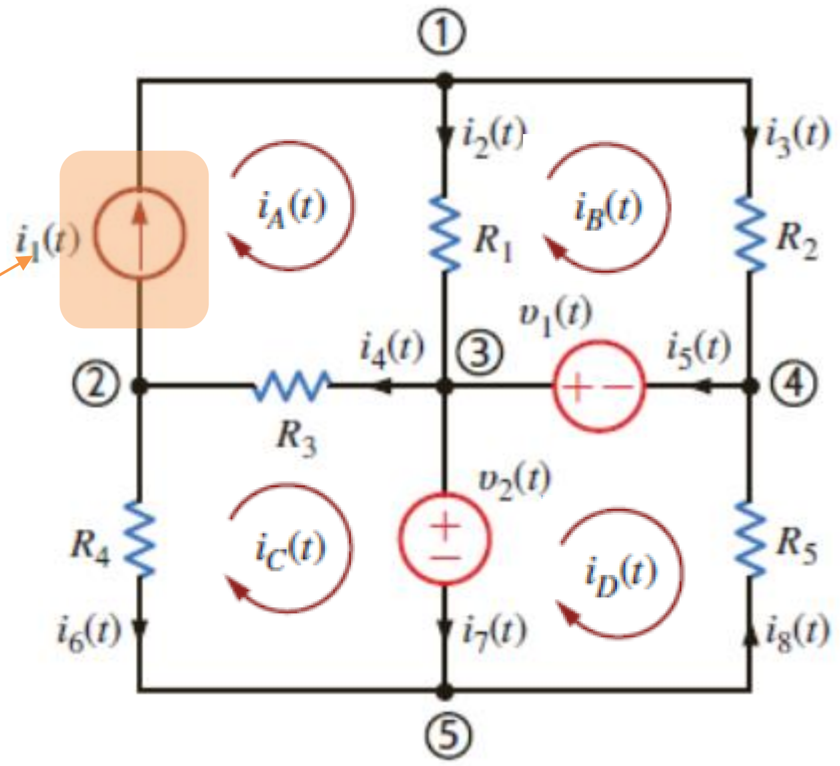
Concepts Chapter #3:

*** "Bate": bring your own set of equations (no problems, photocopies, solutions, etc)… subject to approval by the professor

1) Nodal Analysis
   - Select node as reference
   - # of Eq. = # of nodes – 1
   - variables → voltages
   - KCL → equations
   - voltage source → constraint eq. (express in terms of variables)
   - voltage source between 2 non-reference nodes → supernode
2) Loop Analysis
   - # of Eq. = # of independent loops
   - variables → currents (assign a loop current to each independent loop)
   - KVL → equations
   - current source → constraint eq. (express in terms of variables)

Last Lecture → Mesh Analysis

- *M → # of independent loops in a planar circuit*
- *M → # independent simultaneous equations*



__Analysis Procedure__

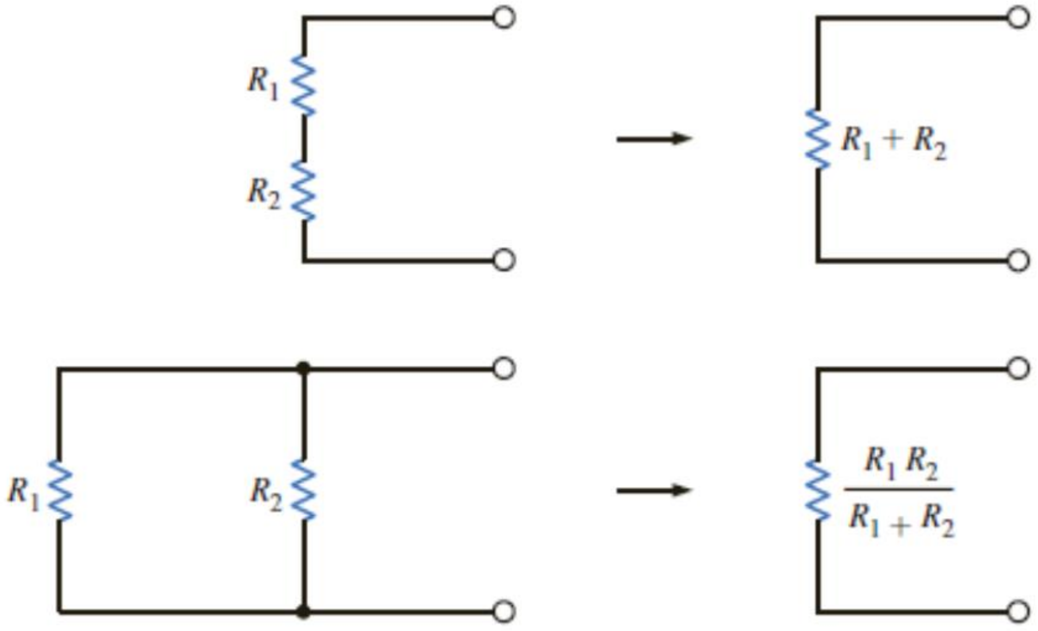
1) Identify #of equations
2) Stablish current around loops
3) Identify voltage drops according currents
4) Identify current sources / dependent sources
5) Apply KVL to loops
6) Write constraint equation – current sources → $I_A = I_1$
7) Write controlling equation – dependent sources
8) Solve equation system

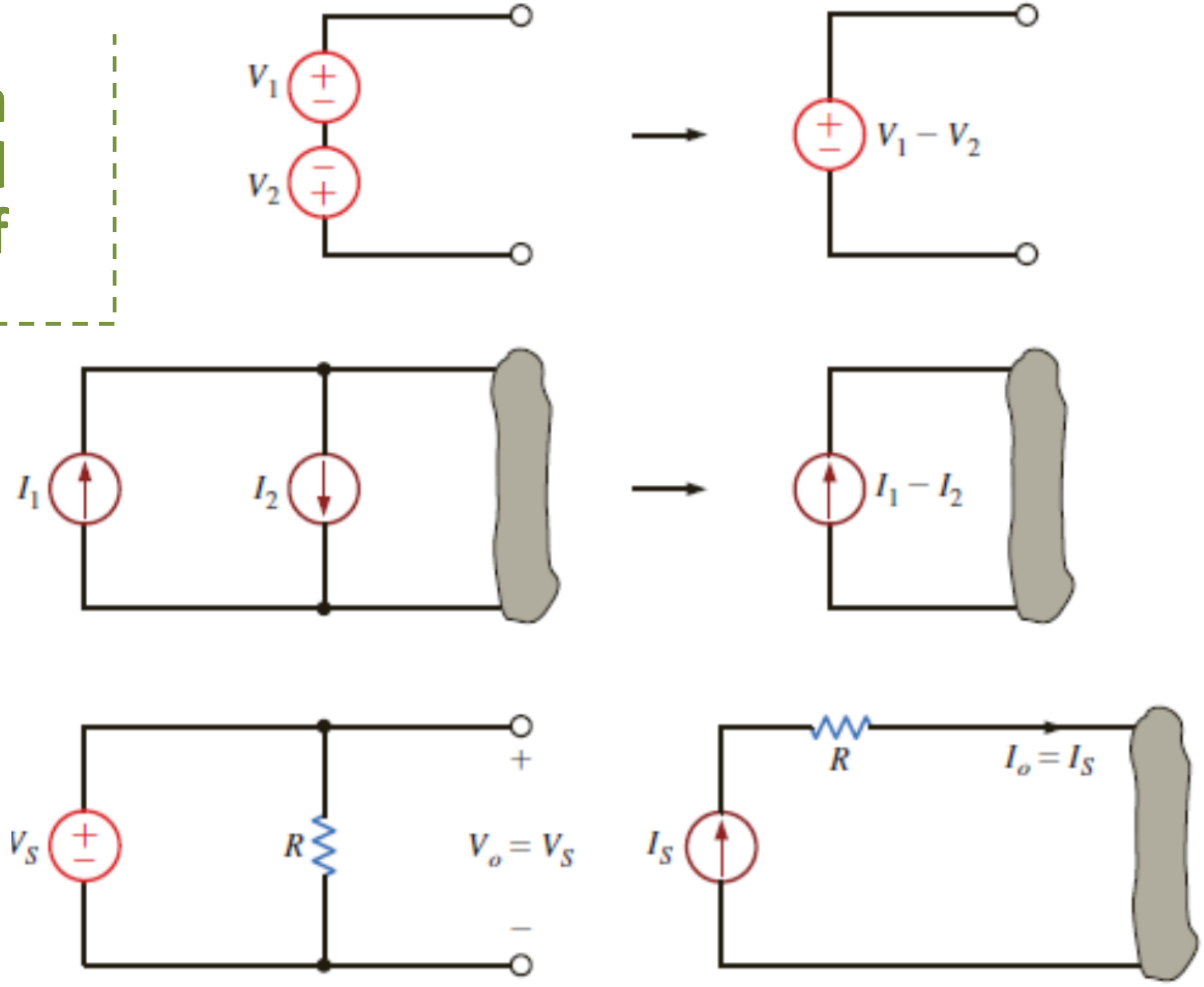
Additional Analysis Techniques → Chapter #5

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

Circuit Equivalence

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

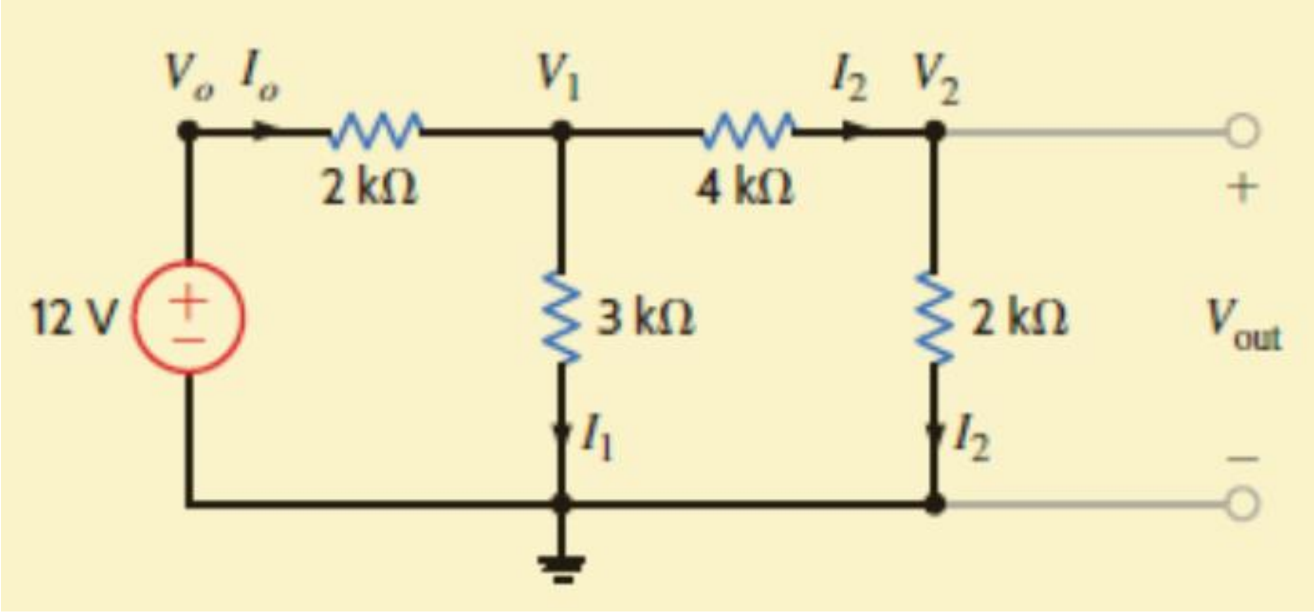




Circuit Linearity

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

Requires both additivity and homogeneity (scaling)



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

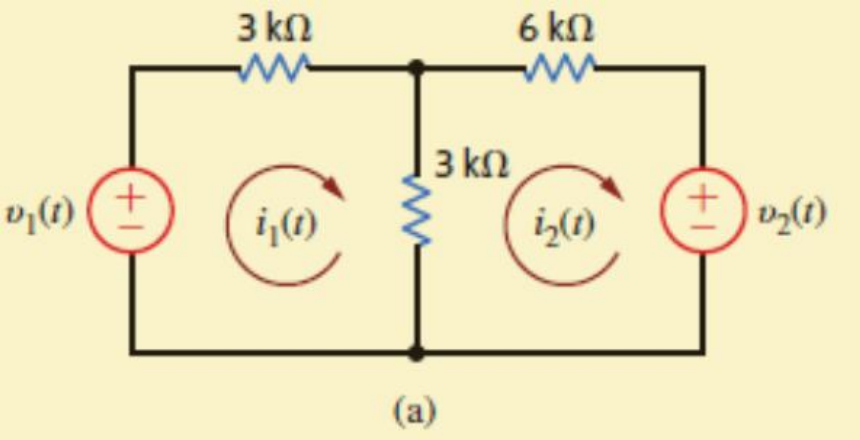
$$\therefore V_{out} = V_0 \cdot \frac{V_{out}'}{V_0'} = V_0 \cdot \frac{1}{6} = 2V$$

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.

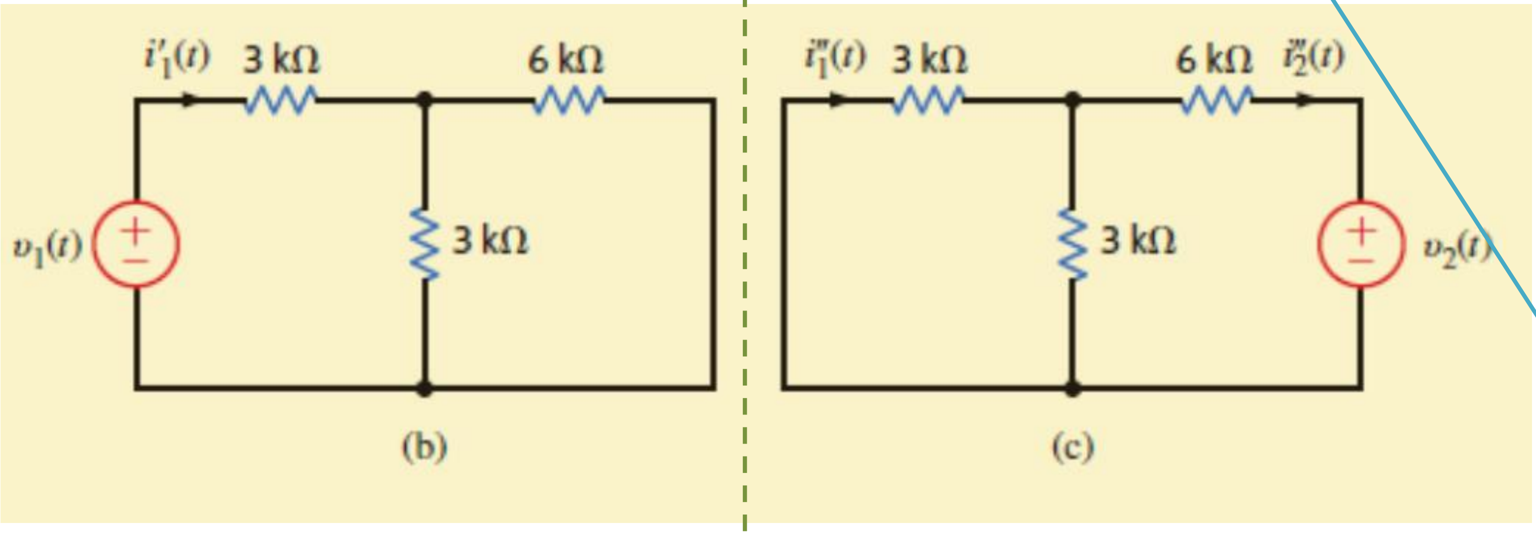
Superposition

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.



$$v_2(t) = 0$$

$$v_1(t) = 0$$



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

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

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

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

Superposition

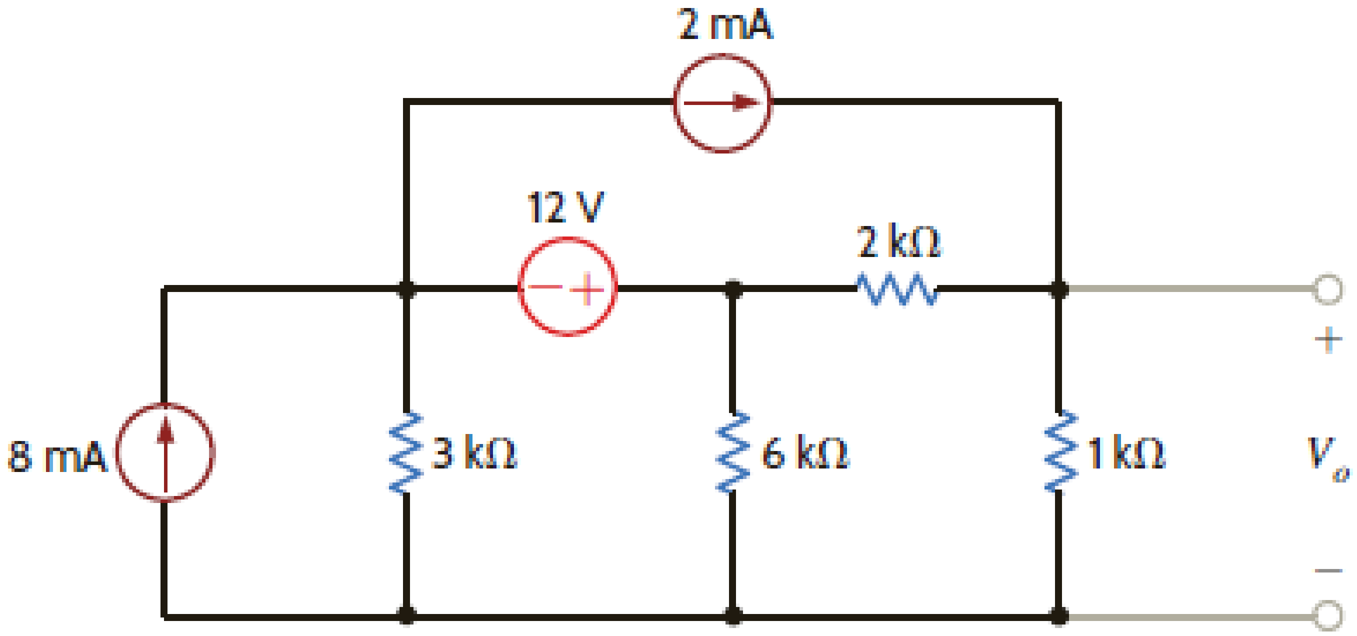
Each independent source can be applied independently with the remaining source turned off:

- ***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.

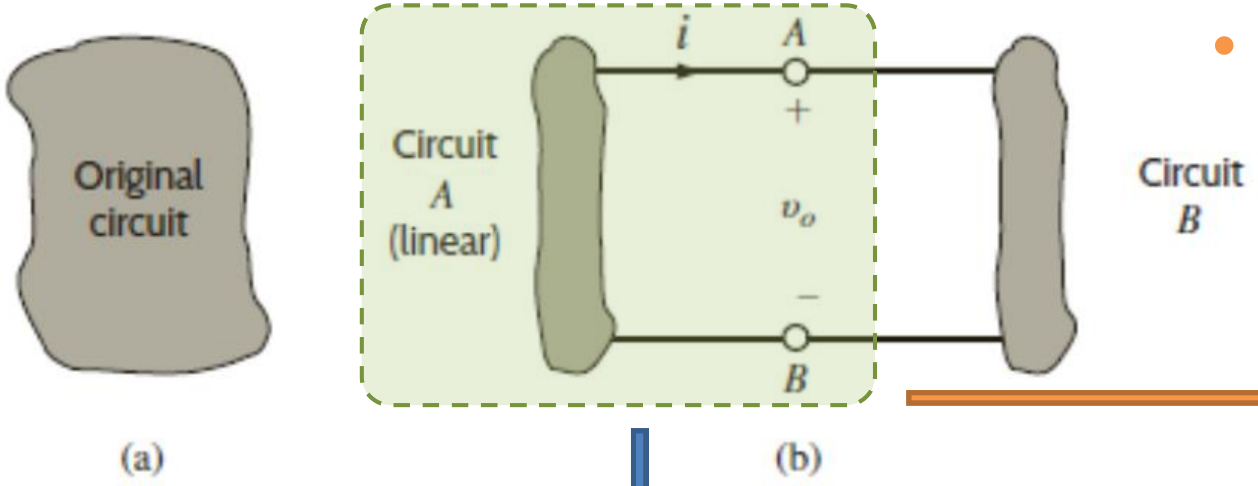


Thevenin’s and Norton’s Theorems

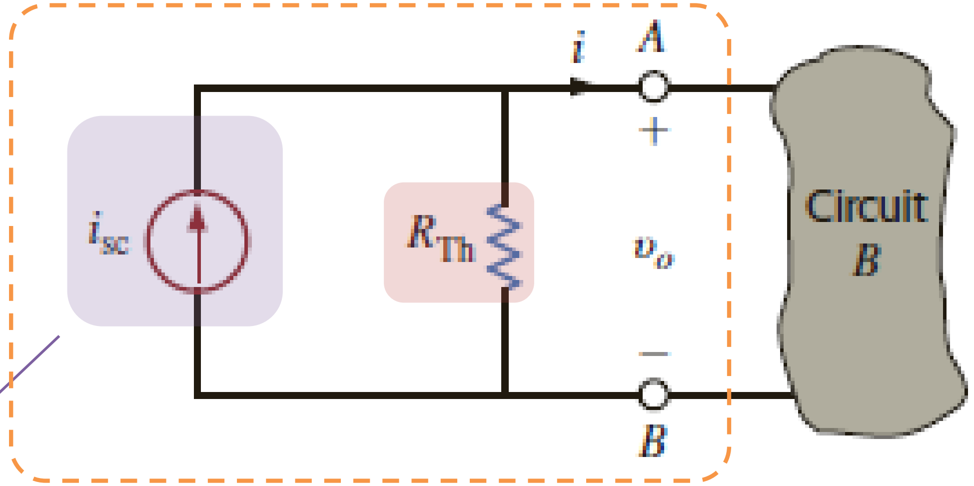
Thevenin’s Theorem: ***an entire circuit or network can be replaced, exclusive of the load, by an equivalent circuit that contains only an* independent voltage source in series with a resistor *in such a way that the current-voltage relationship at the load is unchanged.***

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

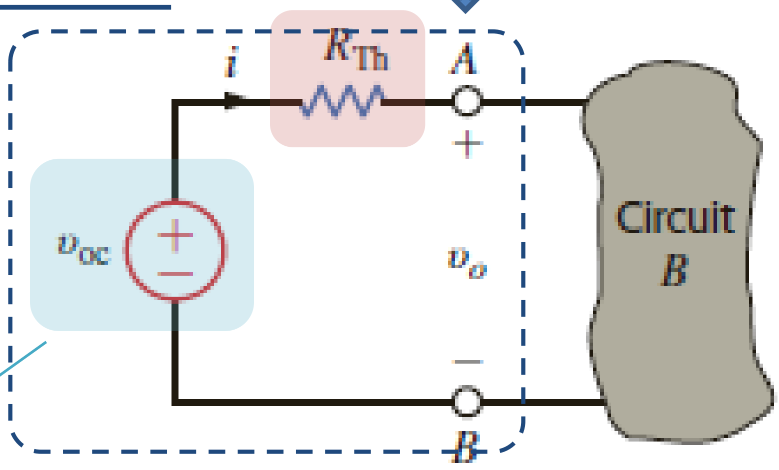


- **Norton**



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

- **Thevenin**



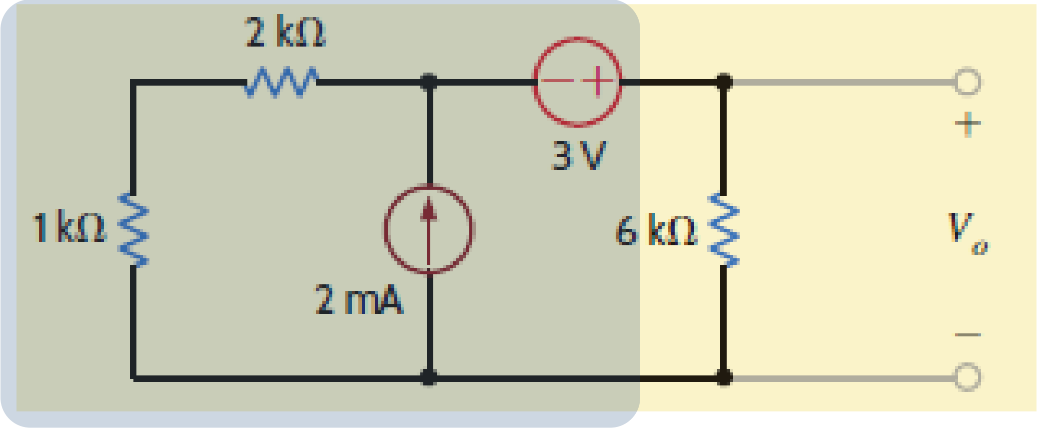
R_{Th}: equivalent resistance looking back into circuit A from A-B with all independent sources in circuit A made zero

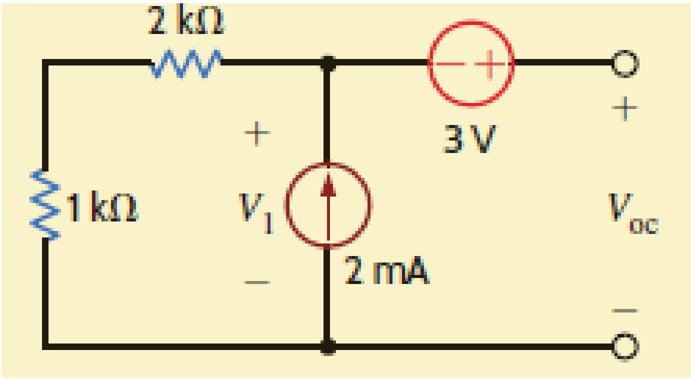
$$v_{oc} = R_{Th} \cdot i_{sc}$$

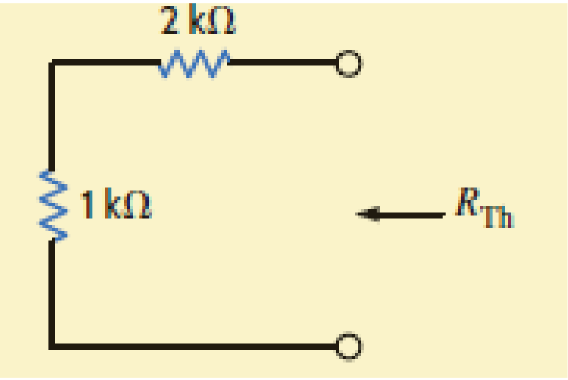
v_{oc}: open circuit voltage from circuit A measured at A-B

Thevenin’s Theorem → Independent Sources Only

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

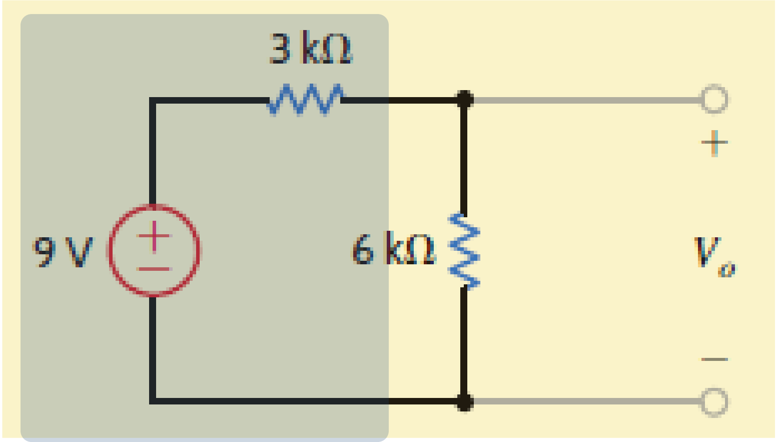






$$V_{OC} = 2m(1k + 2k) + 3 = 9V$$

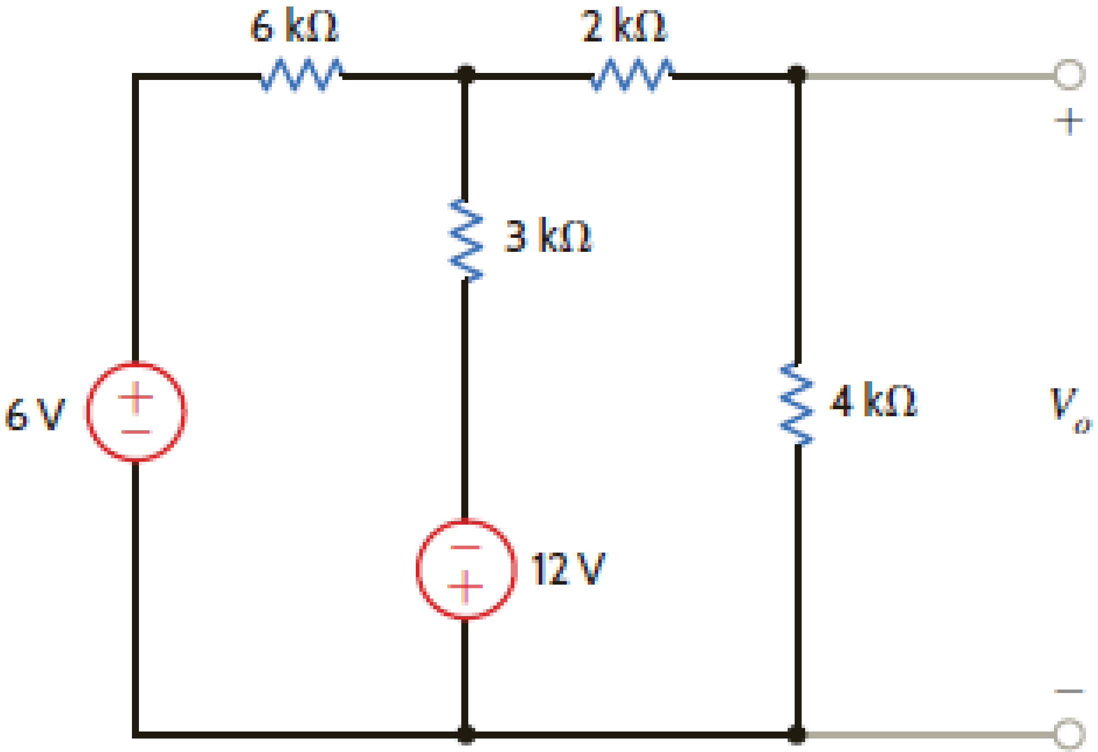
$$R_{th} = 1k + 2k = 3k\Omega$$



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

Learning Assessment → E5.6

Use Thevenin's Theorem to find V_0 in the network provided.



Thevenin and Norton Equivalent Circuits

1) **Independent Sources Only**
   - **Find either V_{oc} or I_{sc}**
   - **R_{Th} can be extrapolated directedly from the network**
2) **Dependent Sources Only**
   - **The equivalent circuit is R_{Th} only**
   - **Find R_{th} through ohms law by placing an voltage/current source and measuring the current/voltage**
3) **Independent and Dependent Sources**
   - **Must calculate both the V_{OC} and I_{SC} to calculate R_{TH}.**
   - **Must not split the dependent source an its controlling variable**

Thevenin's Norton's Theorem → Dependent Sources Only

Example 5.8: Determine the Thevenin equivalent of the network provided at terminals A-B.

Measure R_{th} via a current or voltage source at A-B!