Electrical Circuit-I

9th Lecture

NORTON'S THEOREM

By:

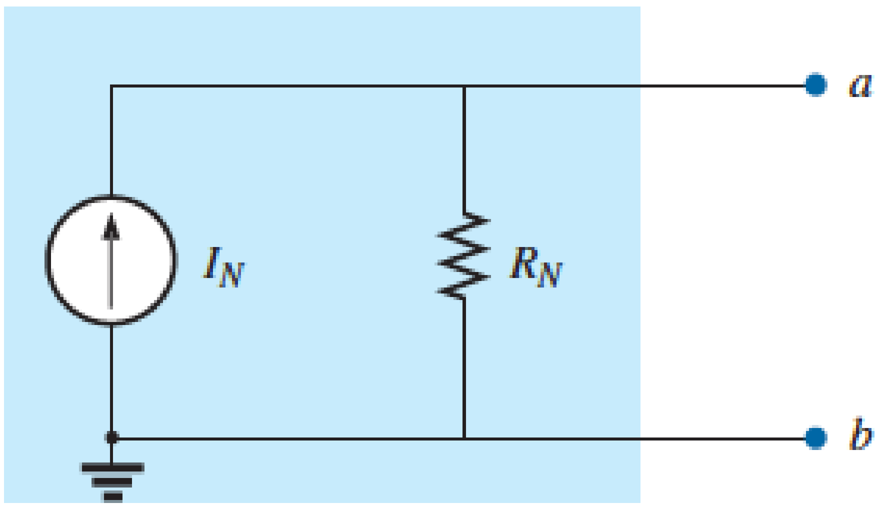
Dr. Ali Albu-Rghaif

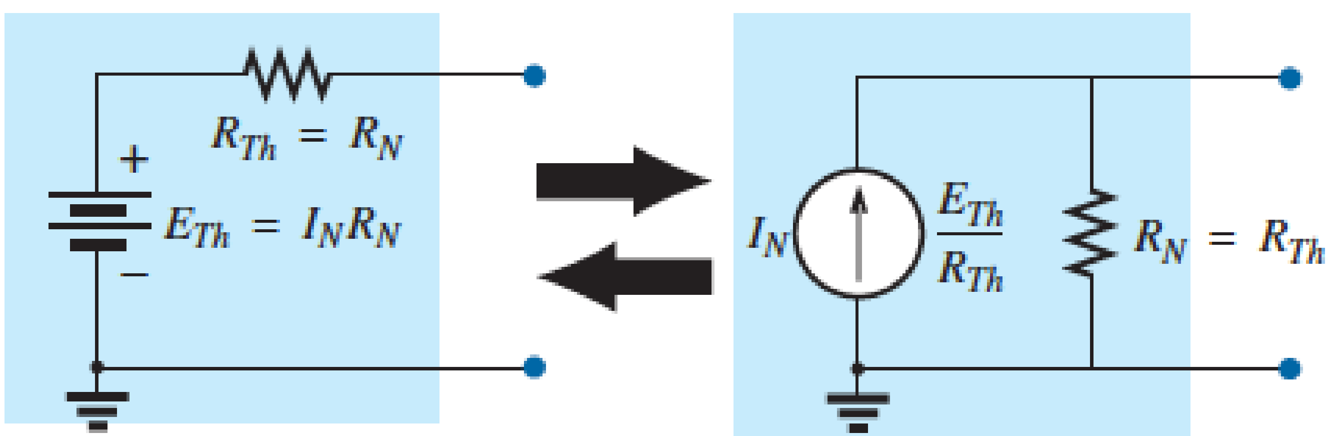
Ref: Robert L. Boylestad, *INTRODUCTORY CIRCUIT ANALYSIS*, Pearson Prentice Hall, Eleventh Edition, 2007

NORTON’S THEOREM

The theorem states the following:

Any two-terminal linear bilateral dc network can be replaced by an equivalent circuit consisting of a current source and a parallel resistor , as shownin below.





Norton's Theorem Procedure

1 Remove that portion of the network across which the Norton equivalent circuit is found.

2 Mark the terminals of the remaining two-terminal network.

R_N

3 Calculate R_N by first setting all sources to zero (voltage sources are replaced with short circuits, and current sources with open circuits) and then finding the resultant resistance between the two marked terminals. (If the internal resistance of the voltage and/or current sources is included in the original network, it must remain when the sources are set to zero). Since $R_N = R_{TH}$, the procedure and value obtained using the approach described for Thévenin's theorem will determine the proper value of R_N.

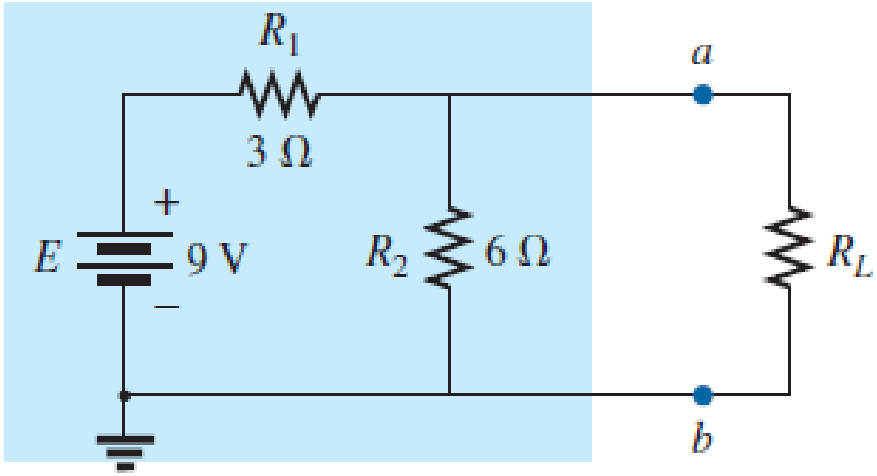
I_N

4 Calculate I_N by first returning all sources to their original position and then finding the short-circuit current between the marked terminals. It is the same current that would be measured by an ammeter placed between the marked terminals.

5 Draw the Norton equivalent circuit with the portion of the circuit previously removed replaced between the terminals of the equivalent circuit.

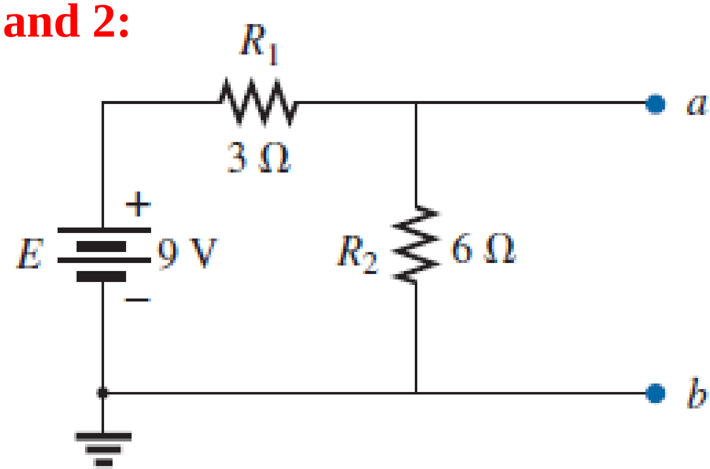
Example (1)

Find the Norton equivalent circuit for the network in the shaded area

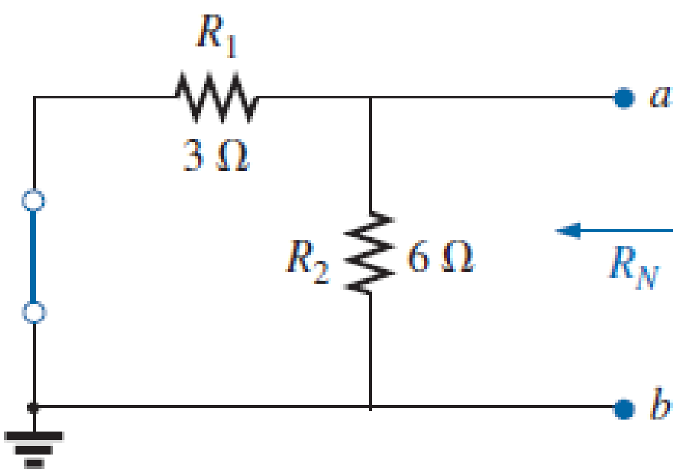


Solution:

Steps 1 and 2:



Steps 3:



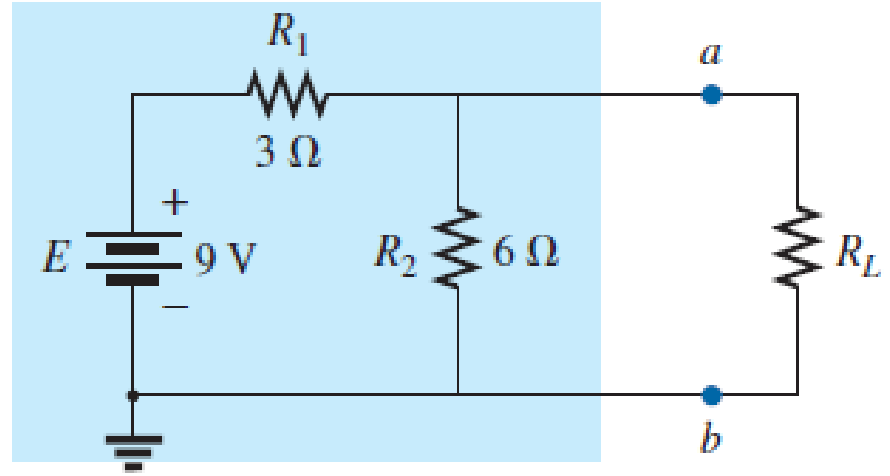
$$R_N = R_1 \| R_2 = 3\ \Omega \| 6\ \Omega$$

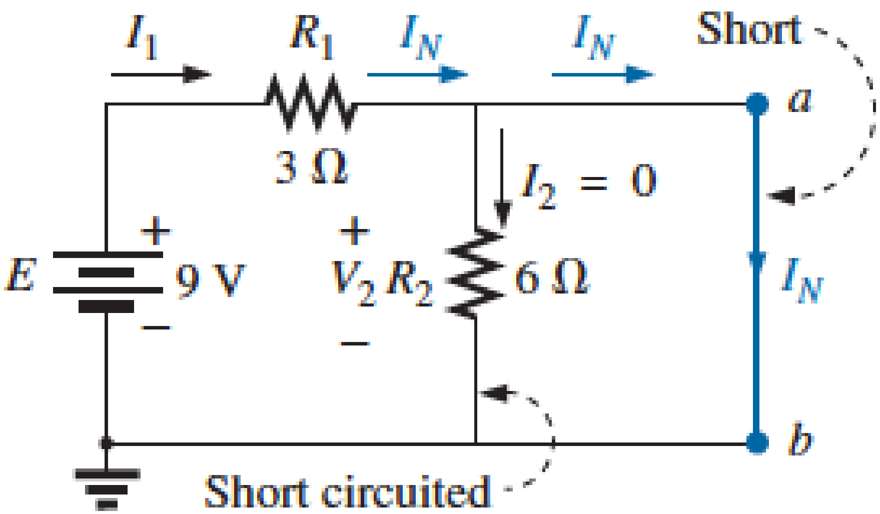
$$= \frac{(3\ \Omega)(6\ \Omega)}{3\ \Omega + 6\ \Omega} = \frac{18\ \Omega}{9} = 2\ \Omega$$

Example (1)

Steps 4:

which clearly indicates that the short-circuit connection between terminals *a* and *b* is in parallel with R_2 and eliminates its effect.



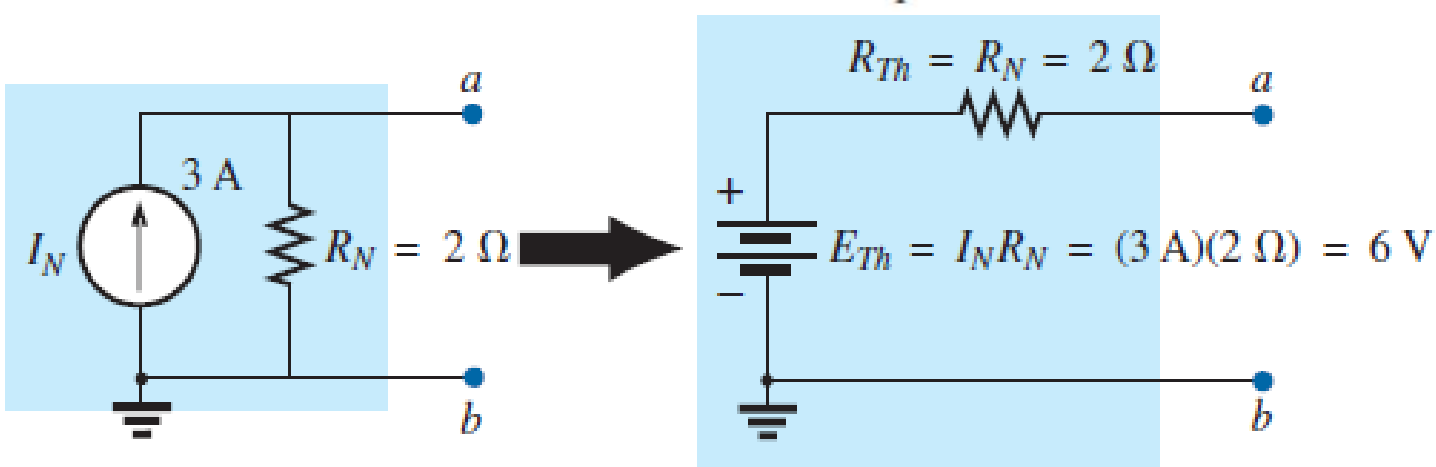


I_N is therefore the same as through R_1, and the full battery voltage

$$V_2 = I_2R_2 = (0)6\ \Omega = 0\ \text{V}$$

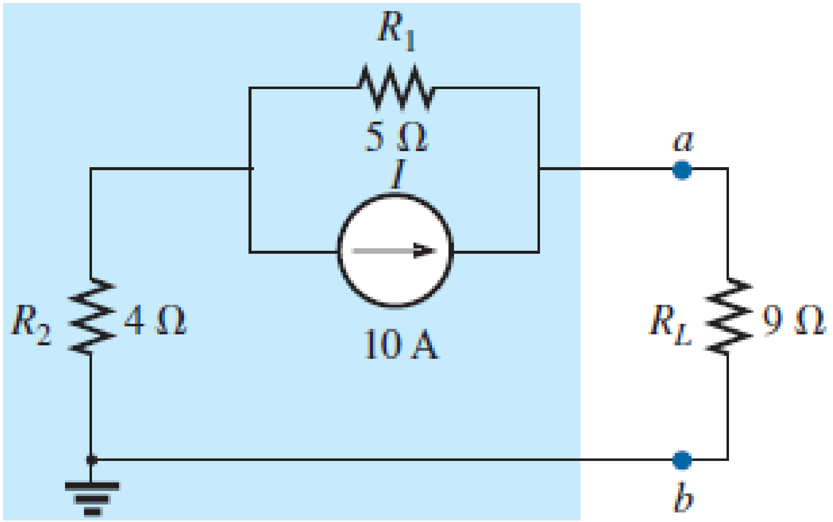
$$I_N = \frac{E}{R_1} = \frac{9\ \text{V}}{3\ \Omega} = 3\ \text{A}$$

Steps 5:



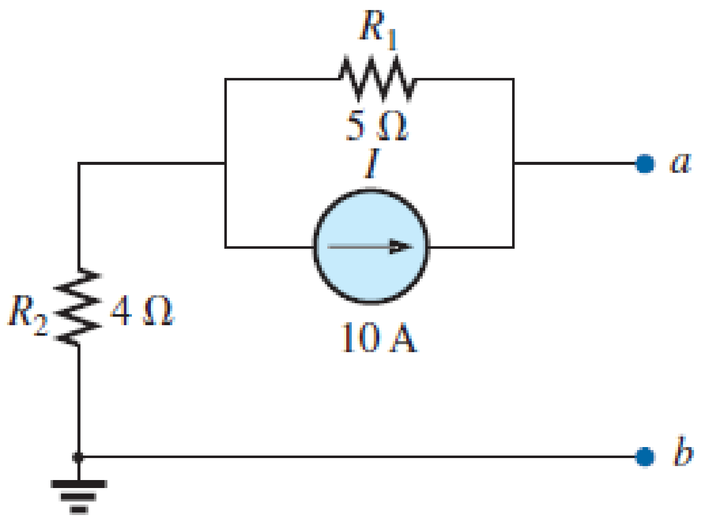
Example (2)

Find the Norton equivalent circuit for the network external to the 9Ω resistor ?

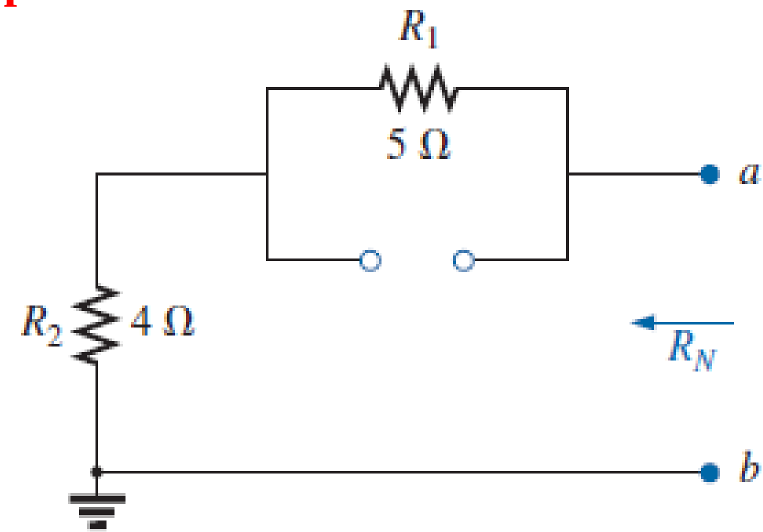


Solution:

Steps 1 and 2:



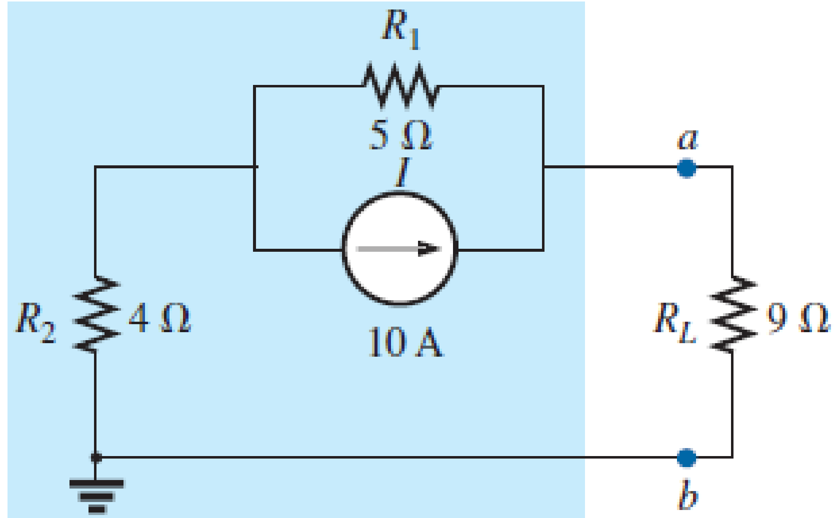
Steps 3:



$$R_N = R_1 + R_2 = 5\ \Omega + 4\ \Omega = 9\ \Omega$$

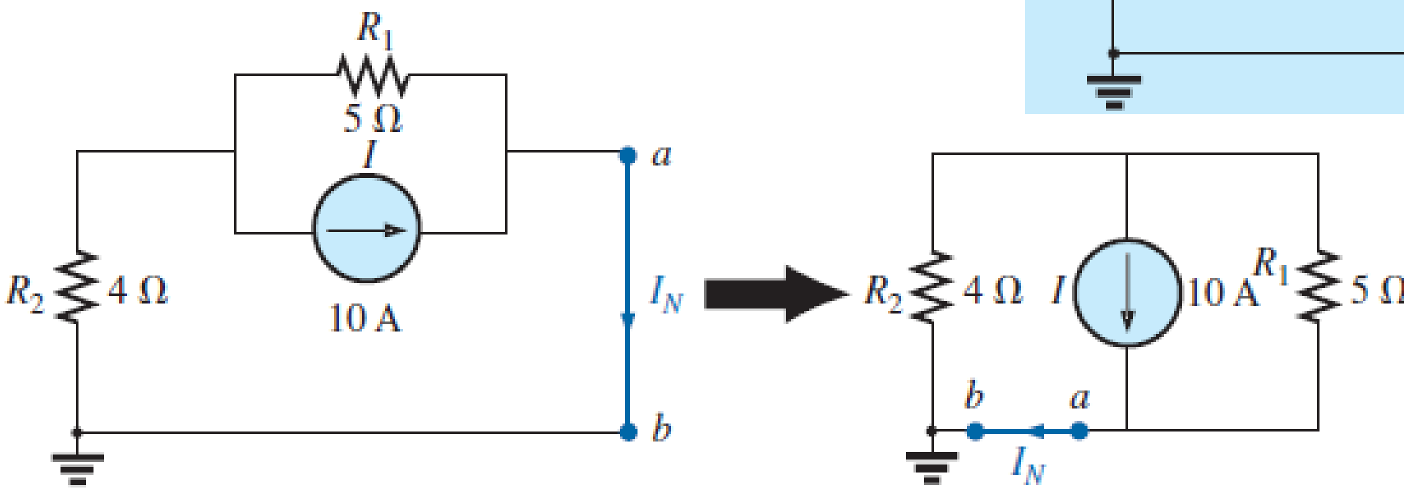
Example (2)

Steps 4:

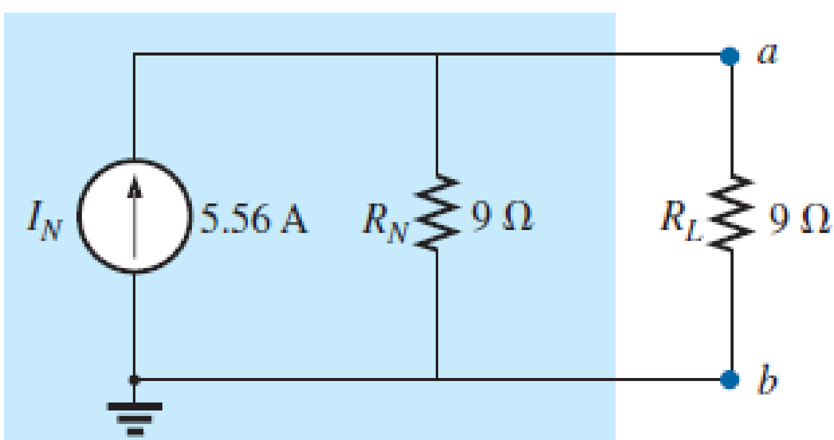


$$I_N = \frac{R_1 I}{R_1 + R_2}$$

$$= \frac{(5\ \Omega)(10\ \text{A})}{5\ \Omega + 4\ \Omega} = \frac{50\ \text{A}}{9} = 5.56\ \text{A}$$

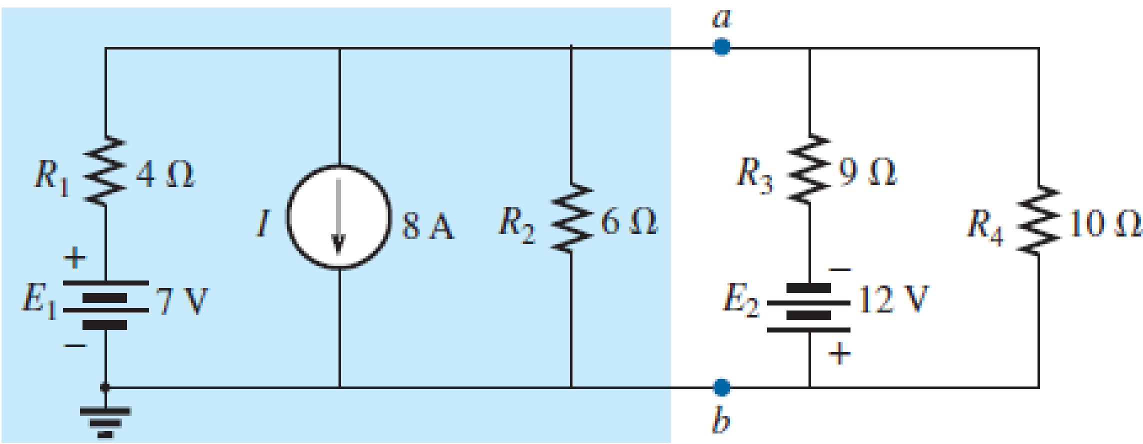


Steps 5:



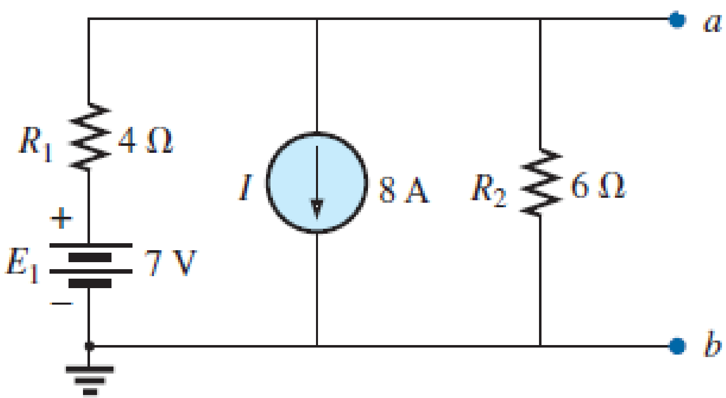
Example (3) (Two sources)

Find the Norton equivalent circuit for the portion of the network to the left of (a-b) ?



Solution:

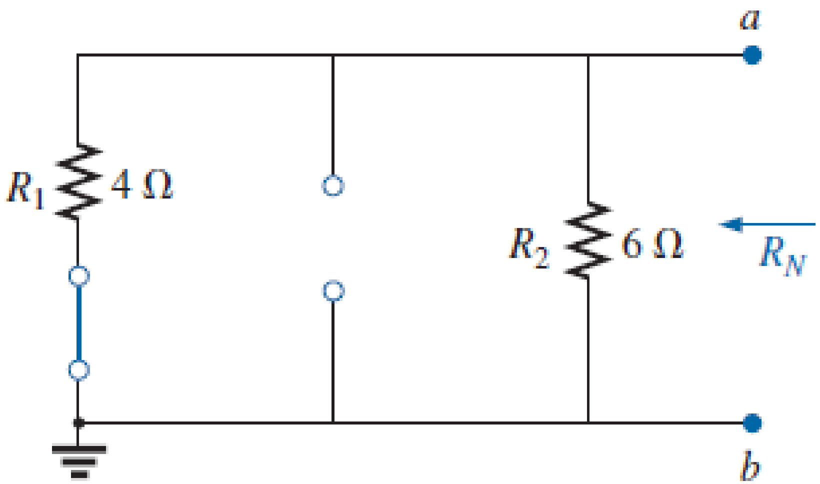
Steps 1 and 2:



Steps 3:

$$R_N = R_1 \| R_2 = 4\ \Omega \| 6\ \Omega =$$

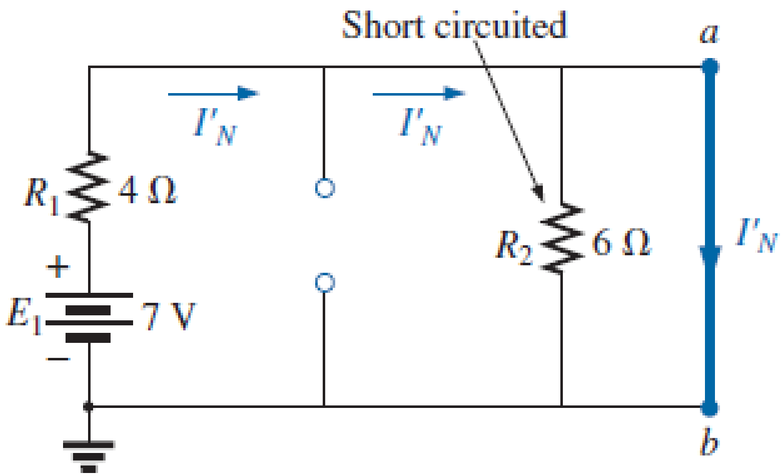
$$= \frac{(4\ \Omega)(6\ \Omega)}{4\ \Omega + 6\ \Omega} = \frac{24\ \Omega}{10} = 2.4\ \Omega$$



Example (3)

Step 4: A

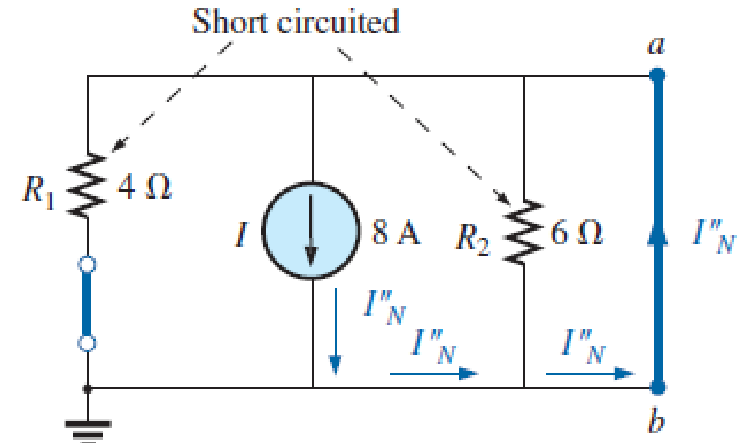
(Using superposition) For the 7 V battery



$$I'_N = \frac{E_1}{R_1} = \frac{7\text{ V}}{4\ \Omega} = 1.75\text{ A}$$

Step 4: B

For the 8 A source , we find that both R1 and R2 have been "short circuit" by the direct connection between a and b,



$$I''_N = I = 8\text{ A}$$

The result is

$$I_N = I''_N - I'_N = 8\text{ A} - 1.75\text{ A} = \mathbf{6.25\text{ A}}$$

Step 5: