EE301 – Lesson 12
Section 9.3

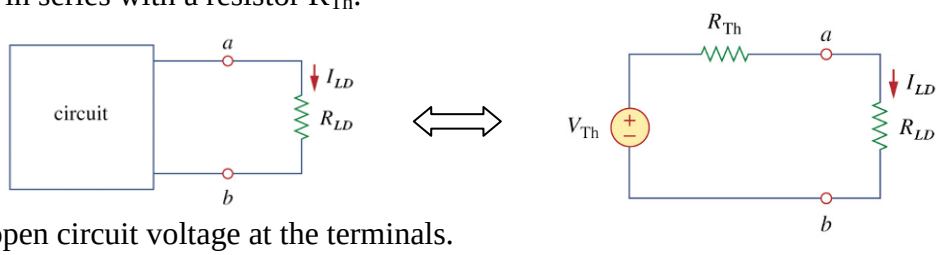
THÉVENIN'S THEOREM

Learning Objectives

a. State and explain Thévenin's theorem.
b. List the procedure for determining the Thévenin equivalence of an actual circuit from the standpoint of two terminals.
c. Apply Thévenin's Theorem to simplify a circuit for analysis.

Thévenin's Theorem Thévenin's theorem greatly simplifies analysis of complex circuits by allowing us to replace all of the elements with a combination of just one resistor and one voltage source.

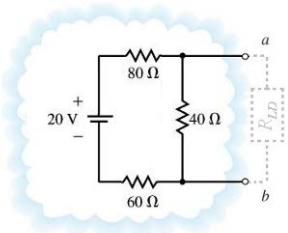
So, a complex two-terminal circuit can be replaced by an equivalent circuit consisting of a voltage source V_{Th} in series with a resistor R_{Th}.



E_{Th} is the open circuit voltage at the terminals.

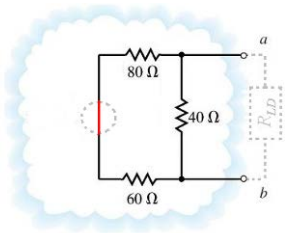
R_{Th} is the input or equivalent resistance at the terminals when the sources are turned off.

Determining E_{Th}: Remove the load (open-circuit) and measure the resulting voltage.



$$E_{th} = \text{ the open circuit voltage } = 20\left(\frac{40}{180}\right) = 4.44 \text{ V}$$

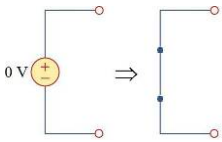
Determining R_{Th}: With the load disconnected, turn off all sources. R_{Th} is the equivalent resistance looking into the "dead" circuit through terminals a-b. To make a circuit dead we have to kill all the sources.



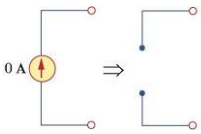
$$R_{th} = (80+60) \parallel 40 = 31.1 \ \Omega.$$

"Killing" a source means setting its value equal to zero:

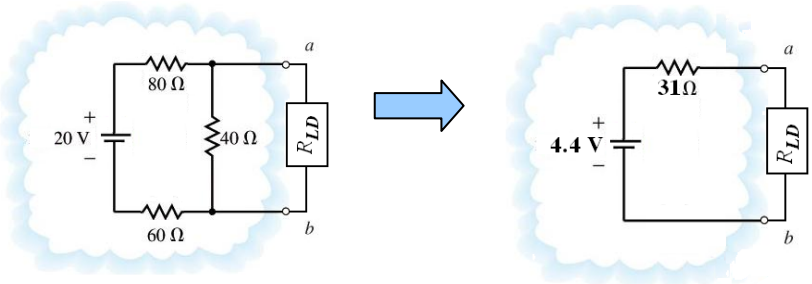
Voltage sources – 0 V is equivalent to a short circuit.



Current sources – 0 A is equivalent to an open circuit.

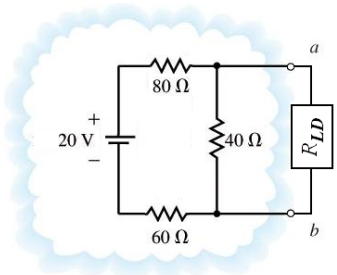


Now we can redraw the circuit showing the Thévenin equivalent with the load installed.

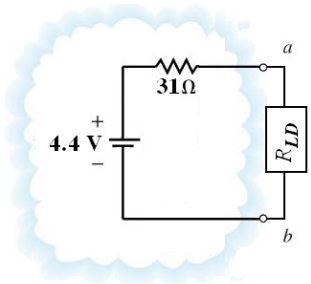


Now, you're probably thinking to yourselves: "Who cares. Big whoop. Another thing to study for the six-week exam. I wonder what's for lunch. And … and … and … *zzzzzz* (sleeping)"

Well, consider this problem. Suppose you had to find the current and voltage across the load resistor R_{LD} in the circuit shown below:



BUT… you need to find the current and voltage across the load resistor R_{LD} for 20 different values of R_{LD}! That would not be fun for the original circuit, but would not be so bad for the Thevenin equivalent circuit:



Repetitive solutions for various load resistances now becomes easy with the transformed circuit.

$$I_{LD} = \frac{E_{Th}}{R_{Th} + R_{LD}} \qquad V_{LD} = \frac{R_{LD}}{R_{Th} + R_{LD}} E_{Th}$$

That's why studies have shown that all midshipmen love Thevenin's Theorem.

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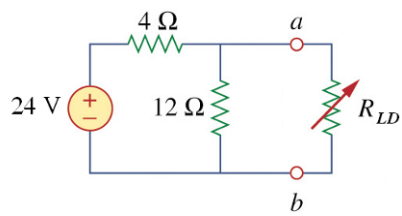
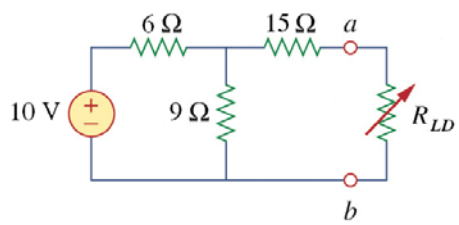
Example. Find the Thévenin equivalent circuit external to R_{LD}. Determine I_{LD} when $R_{LD} = 6\Omega$.



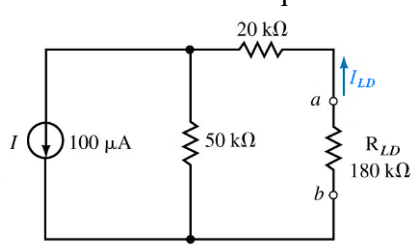
Solution:

Example. Find the Thévenin equivalent circuit external to R_{LD}. Determine I_{LD} when $R_{LD} = 2.5\Omega$.



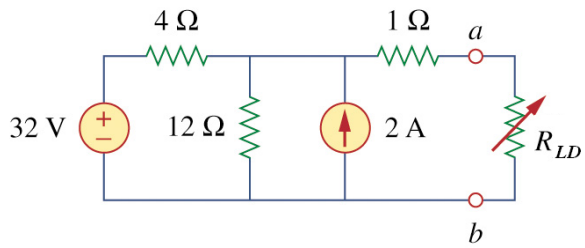
Solution:

Example: Find the Thévenin equivalent circuit external to R_{LD}. Determine I_{LD}.



Solution:

Example: Find the Thévenin equivalent circuit to the left of terminals a-b. Then find the current through R_L with R_{LD} = 2, 4, and 6 Ω. Determine the power dissipated by R_{LD} for each resistance.



Solution:

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Example: Find the Thevenin equivalent circuit for the shaded area of the circuit below (i.e., the Thevenin equivalent circuit "seen by" the 3 Ω resistor.

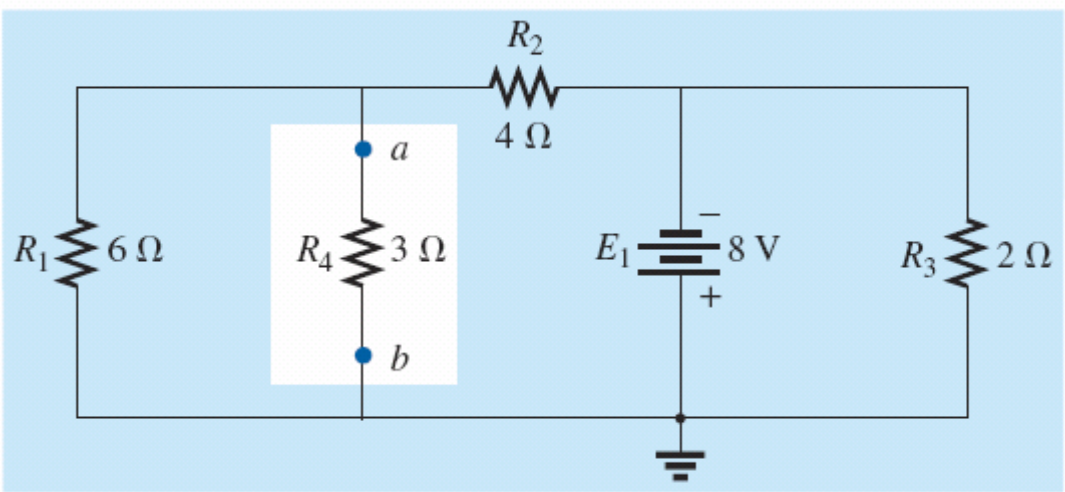

Figure taken from Boylestad, *Introductory Circuit Analysis*, 12th ed., Prentice Hall, 2010

Solution: