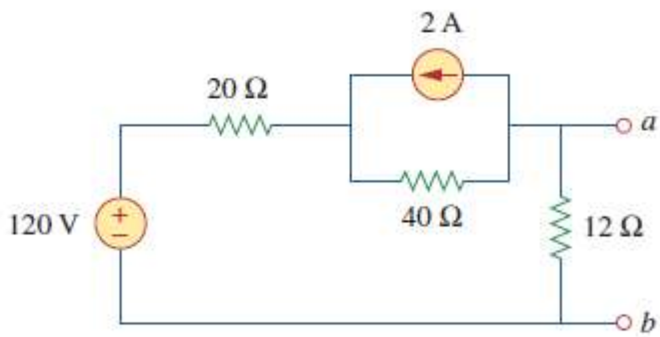
Circuits I – Tutorial 07

Thevenin and Norton

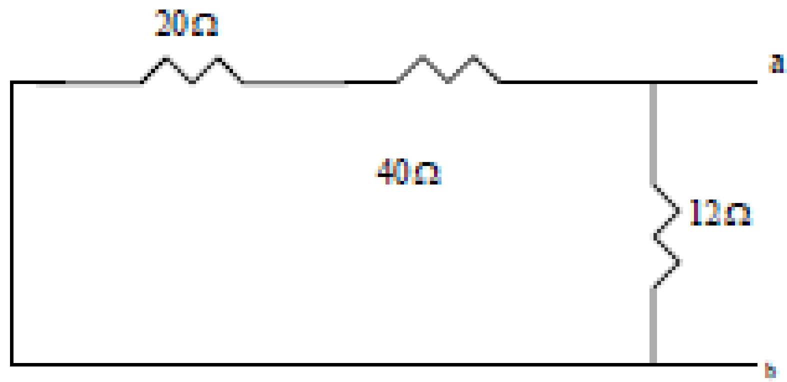
Q1

4.37 Find the Norton equivalent with respect to terminals *a-b* in the circuit shown in Fig. 4.104.



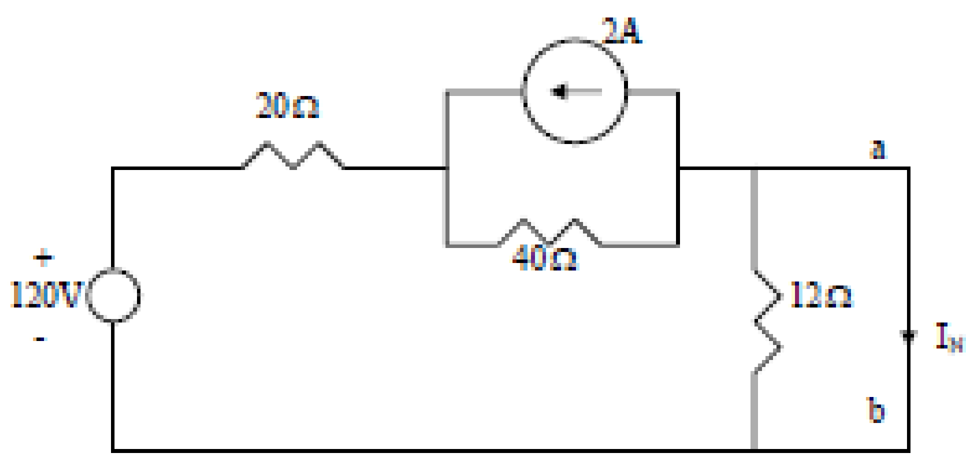
Sol 1

R_N is found from the circuit below.

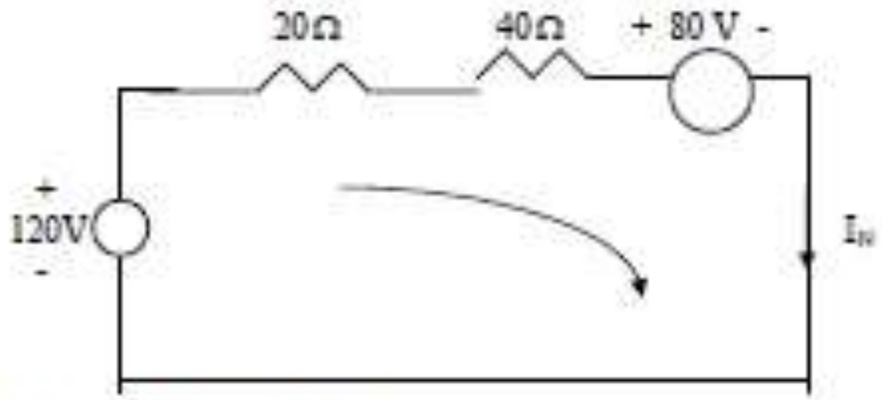


$R_N = 12 // (20 + 40) = 10\ \Omega.$

I_N is found from the circuit below.



Applying source transformation to the current source yields the circuit below.

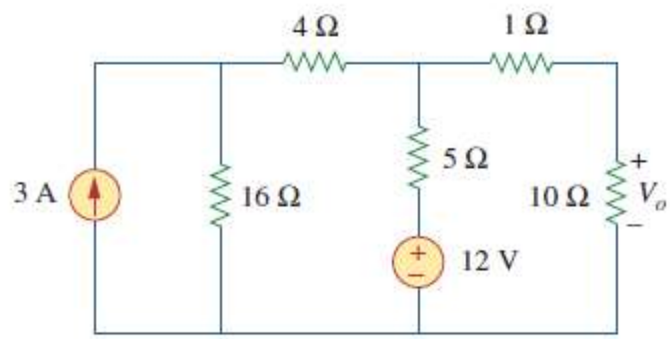


Applying KVL to the loop yields

$$-120 + 80 + 60I_N = 0 \longrightarrow I_N = 40/60 = \mathbf{666.7\ mA}.$$

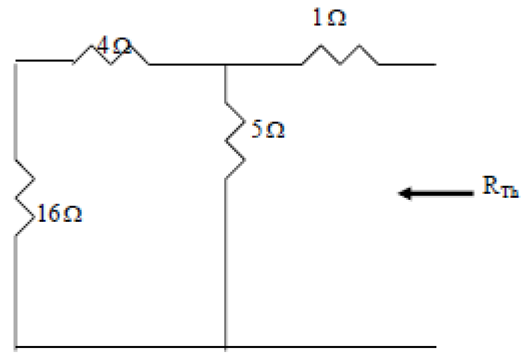
Q2

4.38 Apply Thevenin's theorem to find V_o in the circuit of Fig. 4.105.



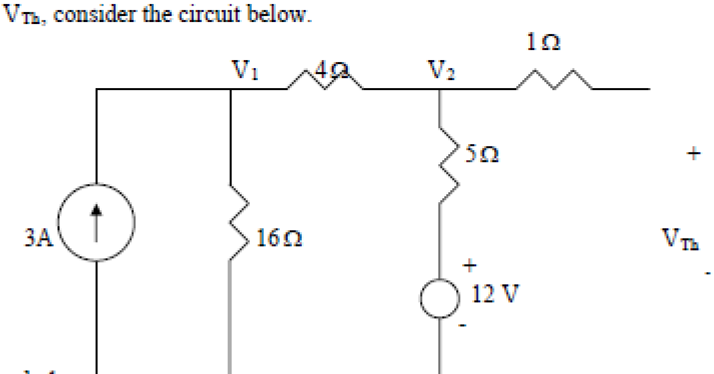
Sol 2

We find Thevenin equivalent at the terminals of the 10-ohm resistor. For R_{Th}, consider the circuit below.



$$R_{Th} = 1 + 5//(4+16) = 1 + 4 = 5\Omega$$

For V_{Th}, consider the circuit below.



At node 1,

$$3 = \frac{V_1}{16} + \frac{V_1 - V_2}{4} \longrightarrow 48 = 5V_1 - 4V_2 \qquad (1)$$

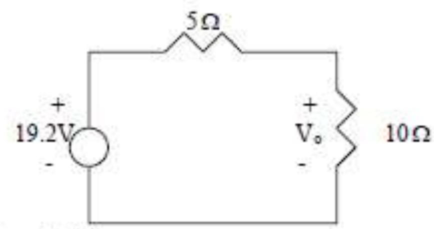
At node 2,

$$\frac{V_1 - V_2}{4} + \frac{12 - V_2}{5} = 0 \longrightarrow 48 = -5V_1 + 9V_2 \qquad (2)$$

Solving (1) and (2) leads to

$$V_{Th} = V_2 = 19.2$$

Thus, the given circuit can be replaced as shown below.

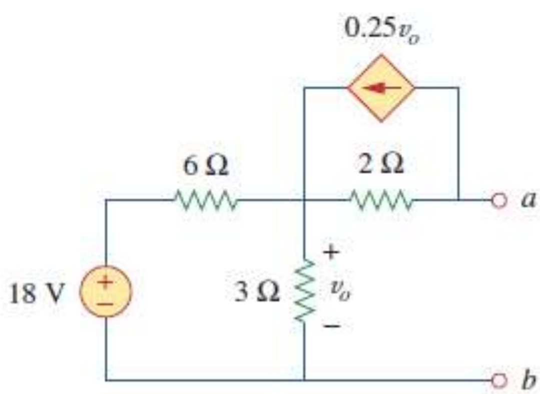


Using voltage division,

$$V_o = \frac{10}{10+5}(19.2) = 12.8\ \text{V}.$$

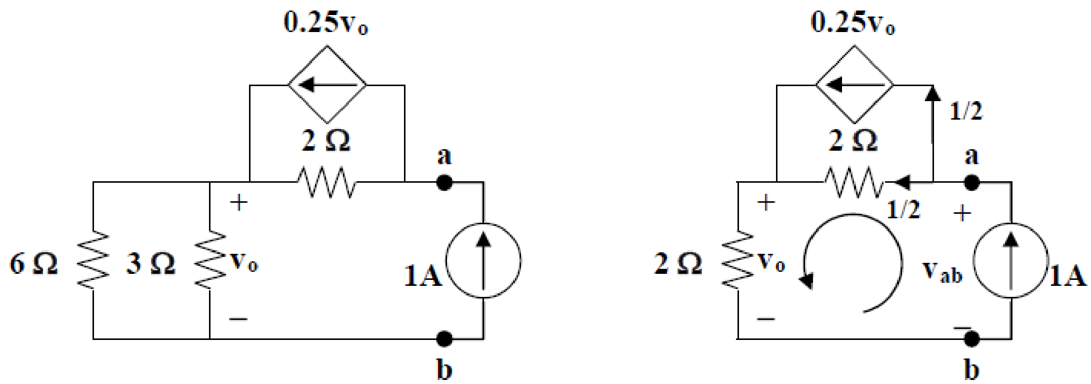
Q3

4.53 Find the Norton equivalent at terminals *a*-*b* of the circuit in Fig. 4.119.



Sol 3

To get R_{Th}, consider the circuit in Fig. (a).



(a) (b)

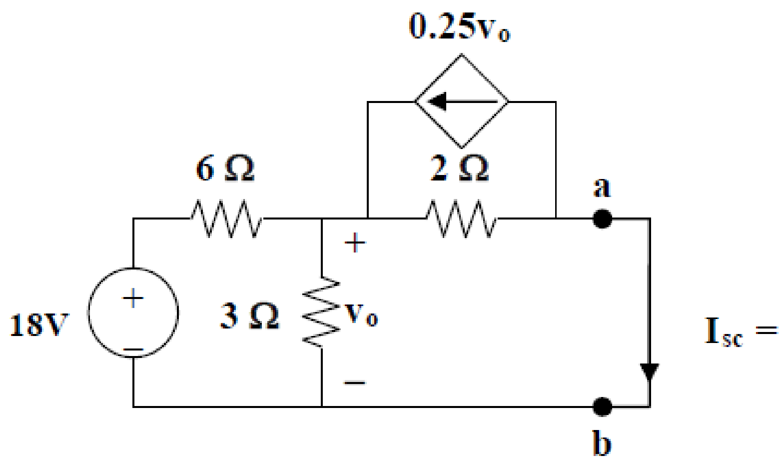
From Fig. (b),

$$v_o = 2x1 = 2V, \; -v_{ab} + 2x(1/2) + v_o = 0$$

$$v_{ab} = 3V$$

$$R_N = v_{ab}/1 = \mathbf{3\ ohms}$$

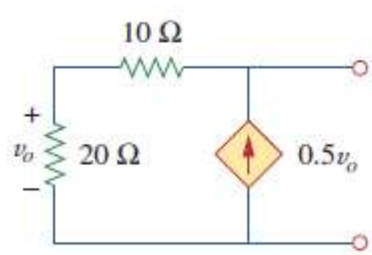
To get I_N, consider the circuit in Fig. (c).



(c)

$$[(18 - v_o)/6] + 0.25v_o = (v_o/2) + (v_o/3) \text{ or } v_o = 4V$$

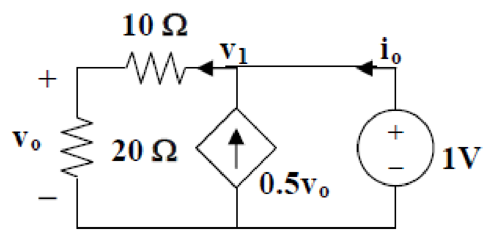
But, $(v_o/2) = 0.25v_o + I_N$, which leads to I_N = **1 A**

Q4	**4.63** Find the Norton equivalent for the circuit in Fig. 4.129. 

Sol 4

Because there are no independent sources, $I_N = I_{sc} = \mathbf{0\ A}$

R_N can be found using the circuit below.



Applying KCL at node 1, $v_1 = 1$, and $v_o = (20/30)v_1 = 2/3$

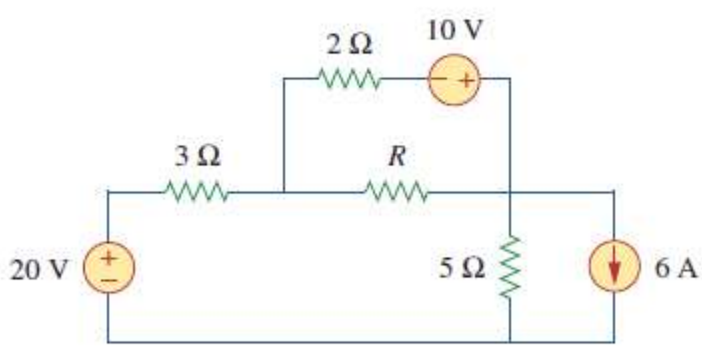
$i_o = (v_1/30) - 0.5v_o = (1/30) - 0.5x2/3 = 0.03333 - 0.33333 = -0.3$ A.

Hence,

$R_N = 1/(-0.3) = \mathbf{-3.333\ ohms}$

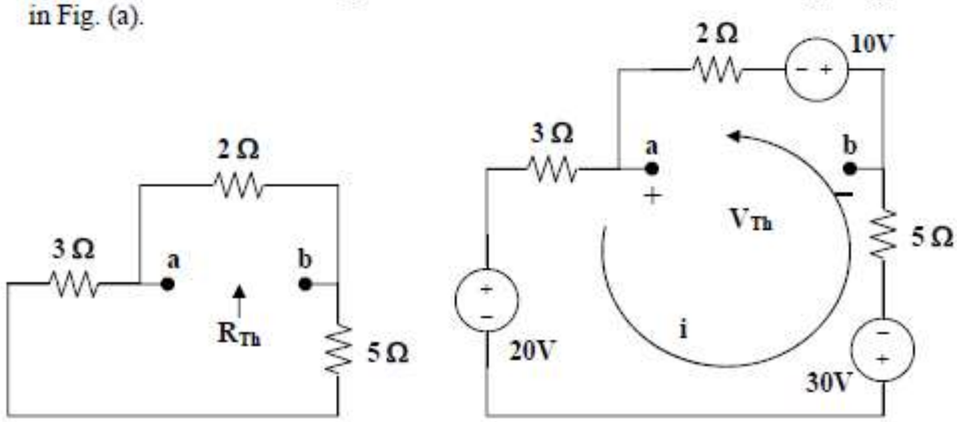
Q5

4.66 Find the maximum power that can be delivered tc the resistor R in the circuit of Fig. 4.132.



Sol 5

We first find the Thevenin equivalent at terminals a and b. We find R_{Th} using the circuit in Fig. (a).



(a) (b)

$$R_{Th} = 2||(3+5) = 2||8 = \mathbf{1.6\ ohms}$$

By performing source transformation on the given circuit, we obatin the circuit in (b). We now use this to find V_{Th}.

$$10i + 30 + 20 + 10 = 0, \text{ or } i = -6$$

$$V_{Th} + 10 + 2i = 0, \text{ or } V_{Th} = 2\text{ V}$$

$$p = V_{Th}^2/(4R_{Th}) = (2)^2/[4(1.6)] = \mathbf{625\ m\ watts}$$