Desk Copy

ECE 300
Spring Semester, 2008
HW Set #3

Due: February 11, 2008   **Name** wlg
wlg   Print (last, first)

Use engineering paper. Work only on one side of the paper. Use this sheet as your cover sheet, placed on top of your work and stapled in the top left-hand corner. Number the problems at the top of the page, in the center of the sheet. **Do neat work. Underline your answers. Show how you got your equations. Be sure to show how you got your answers.** Each problem counts 10 points.

PP means Practice Problem:

PP 4.2 p. 130: linearity

PP 4.3 p. 132: superposition

4.26 source transformation: Ans: $i_o = 636$ mA

PP 4.8 p. 142: Thevenin:

PP 4.9 p. 143: Thevenin: Also use **P-spice** to simulate this circuit and actually find V_{TH} from the open circuit voltage. Also, find I_N as the short circuit current from the simulation. Verify R_{TH} from your simulation. Submit diagrams to verify your P-spice work.

PP 4.10 p. 145: Thevenin:

4.45 Thevenin and Norton: Work by both Norton and Thevenin. Actually find I_N by find the Short circuit current and find V_{TH} by actually find the open circuit voltage.
Ans: $I_N = 2$ A, $R_{TH} = 3\ \Omega$, V_{TH} on your own.

4.46 Thevenin and Norton: Work this by both Norton and Thevenin: Ans: $I_N = 2$ A, $R_{TH} = 10\ \Omega$ V_{TH} on your own.

4.50 Norton: Find I_N as the short circuit current, directly, by using circuit theory. Find V_{TH} by actually find the open circuit voltage. Verify that $I_N = V_{TH}/R_{TH}$. Ans: $I_N = -0.4$ A $R_{TH} = 10\ \Omega$.

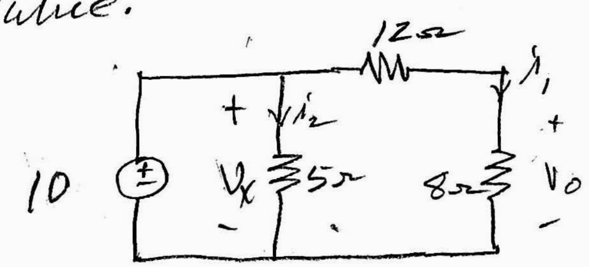
4.72 Thevenin: Ans: (a) $V_{TH} = 40$ V, $R_{TH} = 12\ \Omega$, (b) $I = 2$ A, (c) $R_{TH} = 12\ \Omega$, (d) $P = 33.3$ W

4.85 Thevenin: Ans: (a) $V_{TH} = 24$ V, $R_{TH} = 30\ k\Omega$; (b) $V_{ab} = 9.6$ V

ECE 300
H.W. # 4

P.P. 4.2

For the following circuit, assume $V_o = 1V$ and use linearity to calculate the actual value.



With $V_o = 1V$,

by voltage division

$$V_o = 1V = \frac{V_x 8}{8+12} = \frac{V_x 8}{20} = 0.4V_x$$

so $$V_x = \frac{1}{0.4} = 2.5$$

$$\frac{10}{V_x} = \frac{V_o}{1}$$

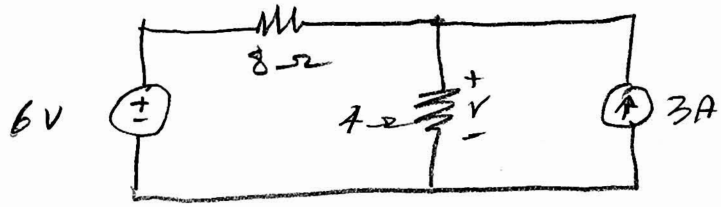
or $$V_o = \frac{10}{V_x} = \frac{10}{2.5} = 4V$$

$$\boxed{V_o = 4V}$$

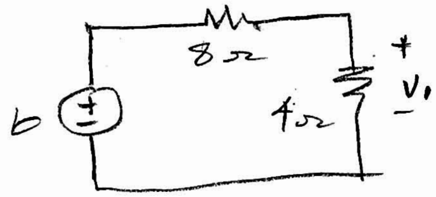
There are other ways to do the problem.

P.P. 4.3

In the following circuit, use superposition to find V.

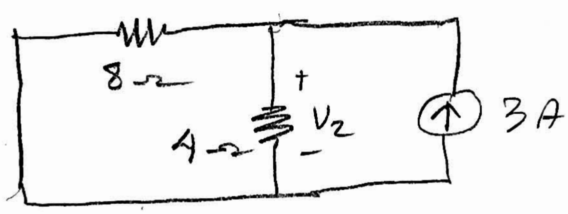


Suppress the 3A source



$$V_1 = \frac{6 \times 4}{4+8} = 2\,V$$

Suppress the 6V source



Using current division;

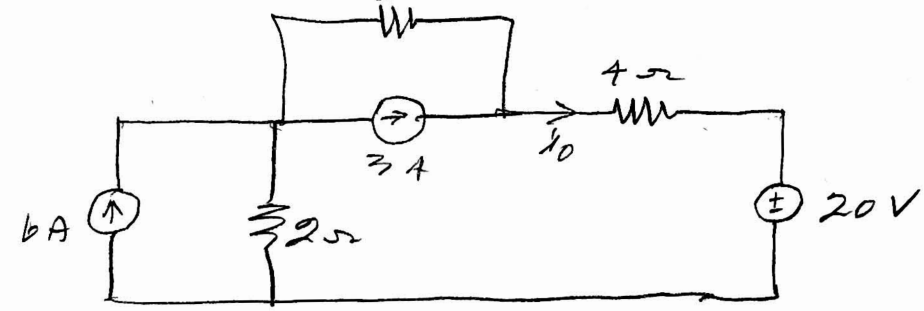
$$V_2 = \left(\frac{3 \times 8}{4+8}\right) \times 4 = \frac{24}{12} \times 4 = 8\,V$$

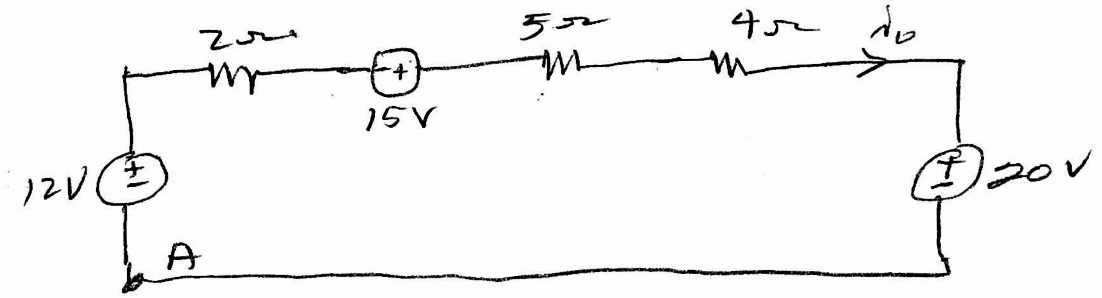
$$V = V_1 + V_2 = 2 + 8 = 10\,V$$

$$\boxed{V = 10\,V}$$

4,26

Use source transformation to find i_o in the following circuit.





Start at A, CW, Σ drops = 0

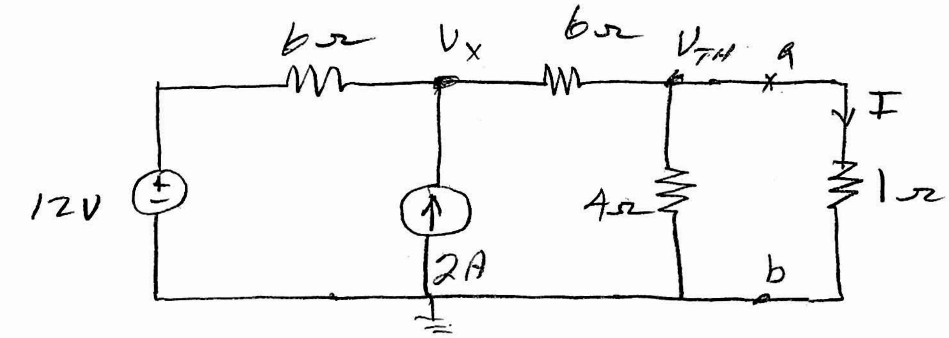
$$-12 + 2i_o - 15 + 5i_o + 4i_o + 20 = 0$$

$$11 i_o = 7$$

$$\boxed{i_o = 636.4 \text{ mA}}$$

PP 4.8

For the circuit below, find the Thevenin equivalent circuit to the left of a-b the use the circuit to find I.



Practically by inspection,

$$R_{TH} = 4 \parallel 12 = 3\,\Omega$$

To find V_{TH},
with 1Ω removed, we have

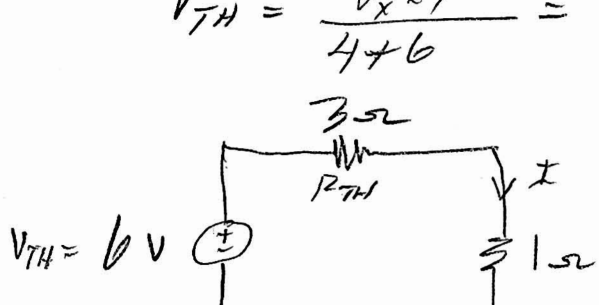
$$30 / \quad \frac{V_X - 12}{6} + \frac{V_X}{10} - 2 = 0$$

$$5V_X - 60 + 3V_X - 60 = 0$$

$$8V_X = 120$$

$$V_X = 15\text{ V}$$

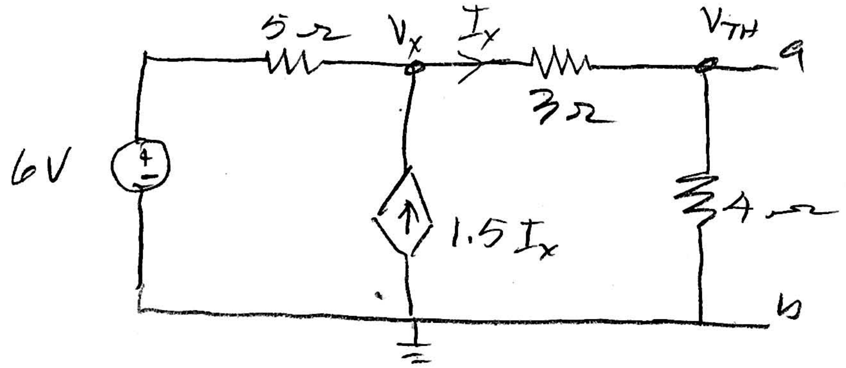
$$V_{TH} = \frac{V_X \times 4}{4+6} = \frac{15 \times 4}{10} = 6\text{ V}$$



$$\boxed{I = \frac{6}{4} = 1.5\text{ A}}$$

PP 4.9

Find the Thevenin equivalent circuit to the left of terminals a-b.



$$\frac{V_x-6}{5} + \frac{V_x}{7} - 1.5 I_x = 0$$

$$I_x = \frac{V_x}{7}$$

$$35\left(\frac{V_x-6}{5} + \frac{V_x}{7} - \frac{1.5 V_x}{7}\right) = 0$$

$$7V_x - 42 + 5V_x - 7.5V_x = 0$$

$$4.5 V_x = 42$$

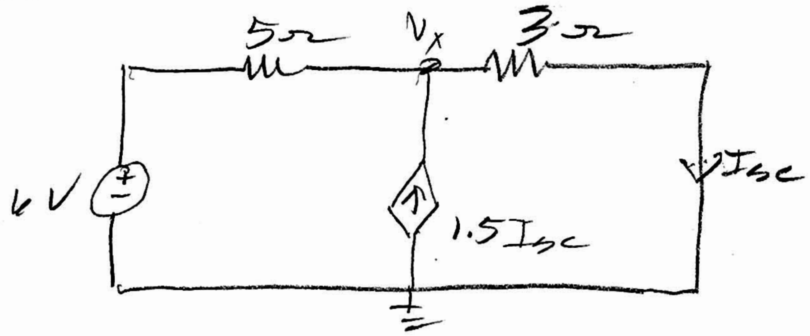
$$V_x = 9.33 V$$

$$V_{TH} = \frac{4 \times V_x}{3+4} = 5.33 V$$

To find R_{TH}, find I_{sc} and use

$$R_{TH} = \frac{V_{TH}}{I_{sc}}$$

PP 4.9 continued



$$\frac{V_x-6}{5}+\frac{V_x}{3}-1.5I_{sc}=0$$

$$I_{sc}=\frac{V_x}{3}$$

$$15\left(\frac{V_x-6}{5}+\frac{V_x}{3}-\frac{1.5V_x}{3}\right)=0$$

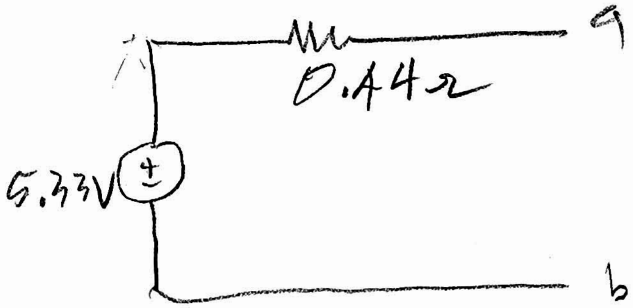
$$3V_x-18+5V_x-7.5V_x=0$$

$$0.5V_x=18$$

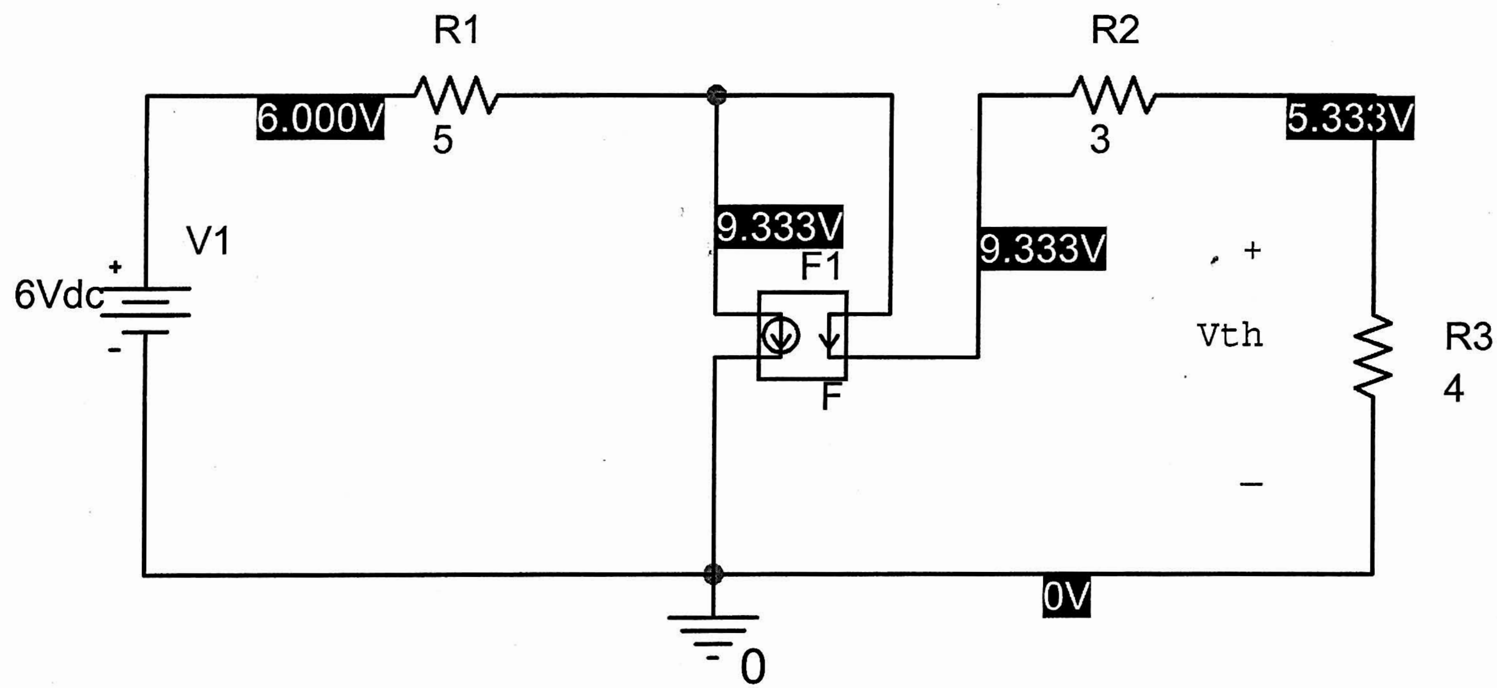
$$V_x=36V$$

$$\boxed{I_{sc}=\frac{V_x}{3}=12A}$$

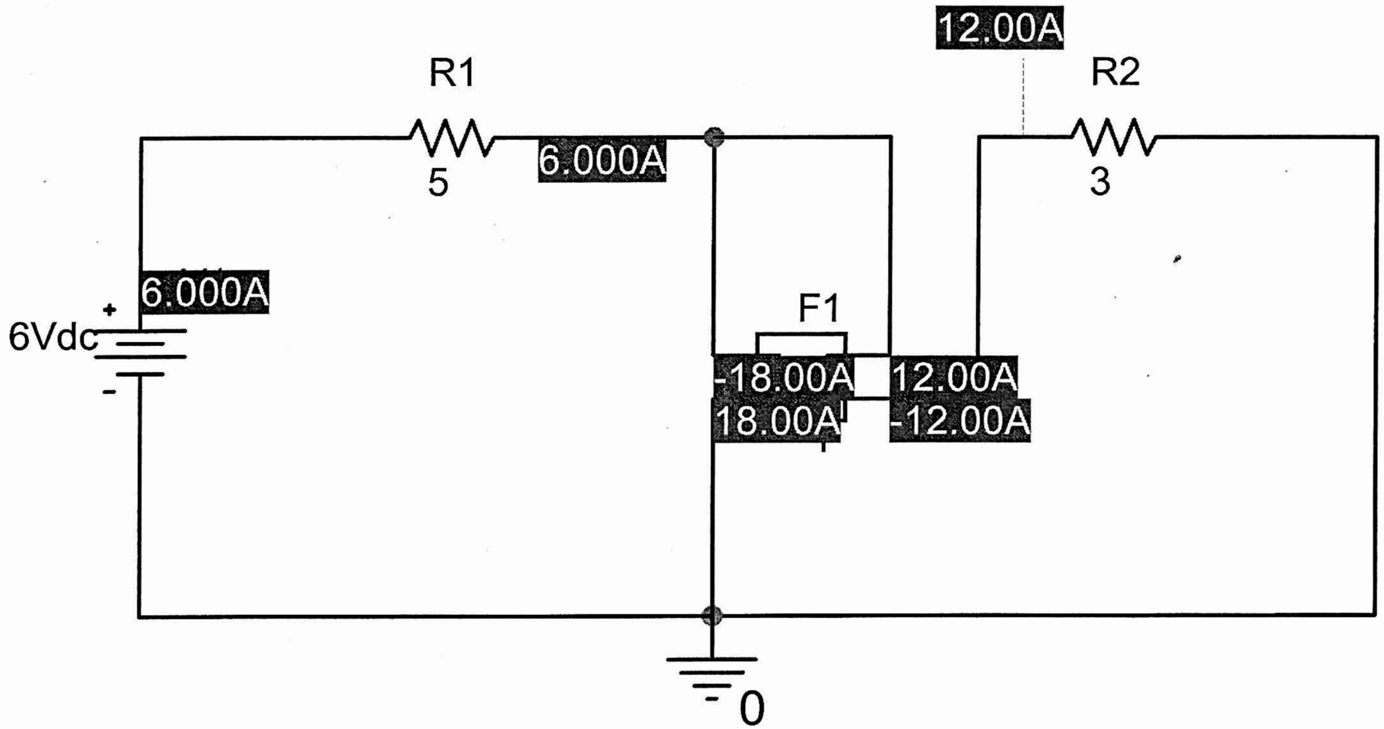
$$R_{TH}=\frac{V_{TH}}{I_{sc}}=\frac{5.33V}{12A}=0.44\Omega$$



Theven equivalent circuit



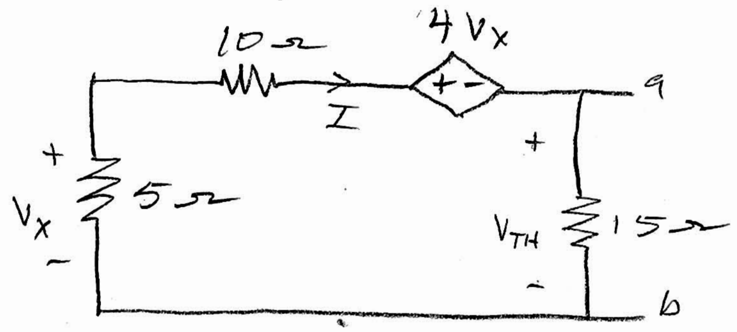
Circuit for finding Vth



Circuit for getting I short circuit

PP 4.10

Find the Thevenin equivalent for the following.



First find V_{TH}

$$5I + 10I + 4V_x + 15I = 0$$

$$V_x = -5I$$

so,

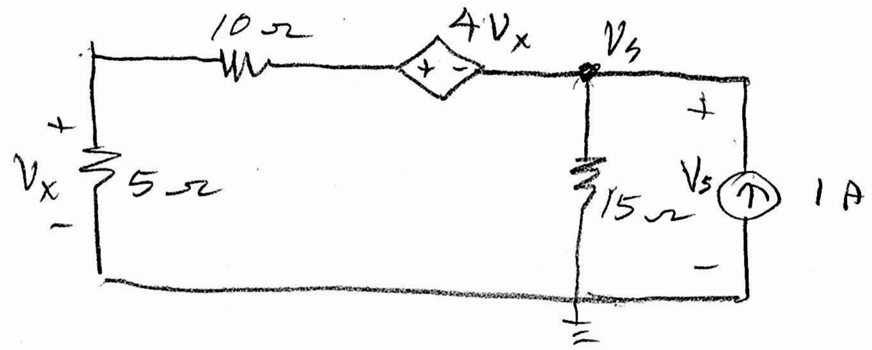
$$5I + 10I - 20I + 15I = 0$$

As expected, $10I = 0$ (No juice!)

$$I = 0$$

$\therefore V_{TH} = 0$

Use the following circuit to find R_{TH}.



$R_{TH} = \dfrac{V_s}{1}$, find V_s

PP 4.10 cont.

Using nodal analysis:

$$\left(\frac{V_s + 4V_x}{15} + \frac{V_s}{15} - 1 = 0\right) \quad \#1$$

$$V_x = \left(\frac{V_s + 4V_x}{15}\right) \times 5 = \frac{V_s + 4V_x}{3}$$

$$3V_x = V_s + 4V_x$$

$$V_x = -V_s$$

Back to #1

$$15\left(\frac{V_s - 4V_s}{15} + \frac{V_s}{15} - 1 = 0\right)$$

$$V_s - 4V_s + V_s - 15 = 0$$

$$-2V_s = 15$$

$$V_s = -7.5\,V$$

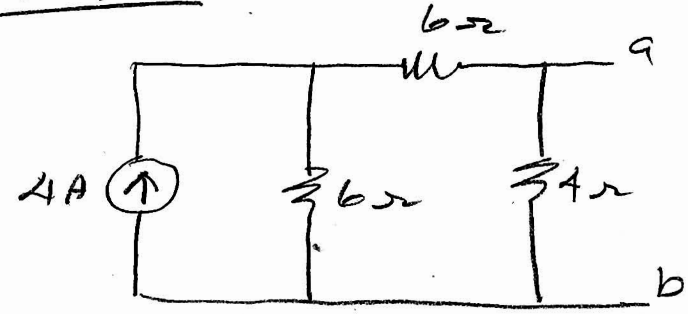
$$\therefore R_{TH} = \frac{V_s}{1} = \frac{-7.5}{1} = -7.5\,\Omega$$

$$\boxed{R_{TH} = -7.5\,\Omega}$$

4.45

Find the Norton equivalent circuit for the following. Find both V_{TH} & I_{N} circuits.

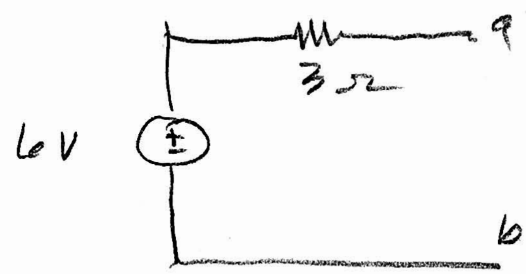
Thevenin



Using current division;

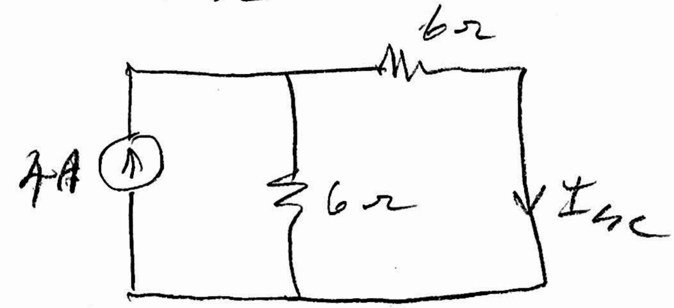
$$V_{ab} = \left(\frac{4 \times 6}{10+6}\right) \times 4 = \frac{24 \times 4}{16} = 6V = V_{TH}$$

$$R_{TH} = 4 \parallel 12 = 3\Omega$$



Norton

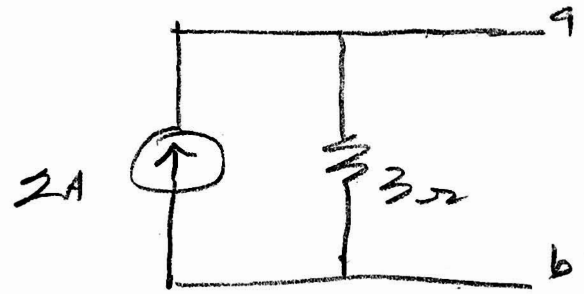
Find I_{sc}



4.45 cont

$I_{sc} = 2A$ (inspection)

Norton Circuit

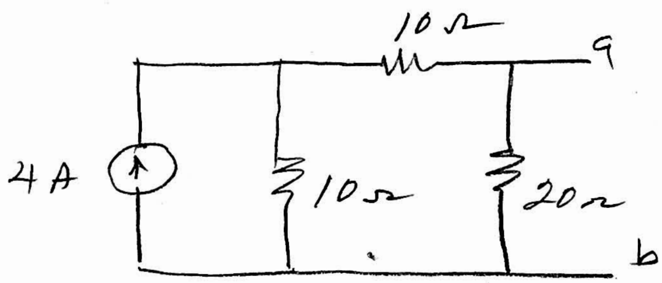


source transformations shows we can go from Norton ⟷ Thevenin

4.46

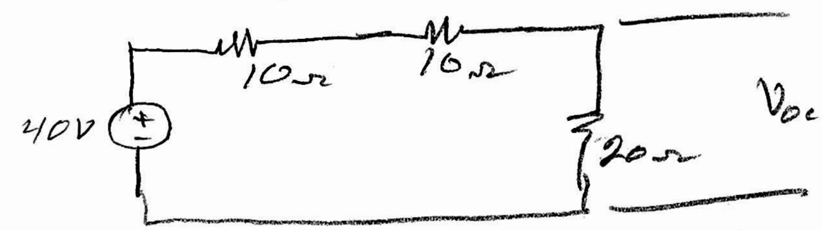
Find the Norton and Thevenin equivalent for the following circuit.

Thevenin



circuit X

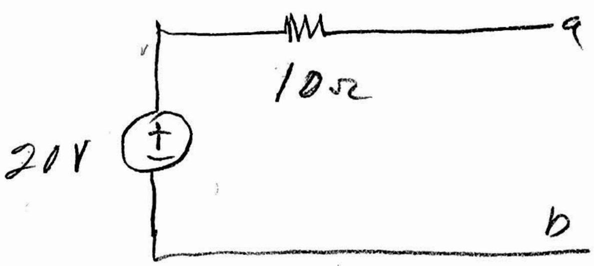
Almost the same problem as 4.45
Mentally doing a source transformation and applying.



$V_{oc} = V_{TH}$

$V_{TH} = 20\,V$ (inspection)

$R_{TH} = 20 \| 20 = 10\,\Omega$



Thevenin equivalent circuit

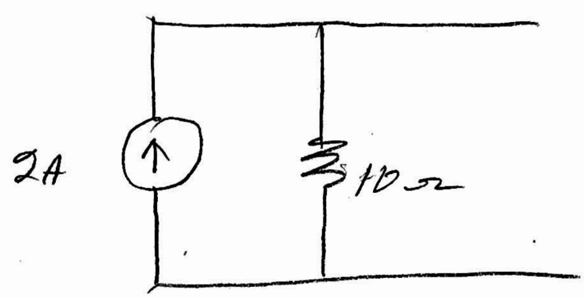
4.46 cont

Norton:

Back to circuit X; use current division to get I_{sc}.
Putting a short across a-b, shorts out the 20Ω resistor. So,

$$I_{sc} = \frac{4 \times 10}{20} = 2A = I_N$$

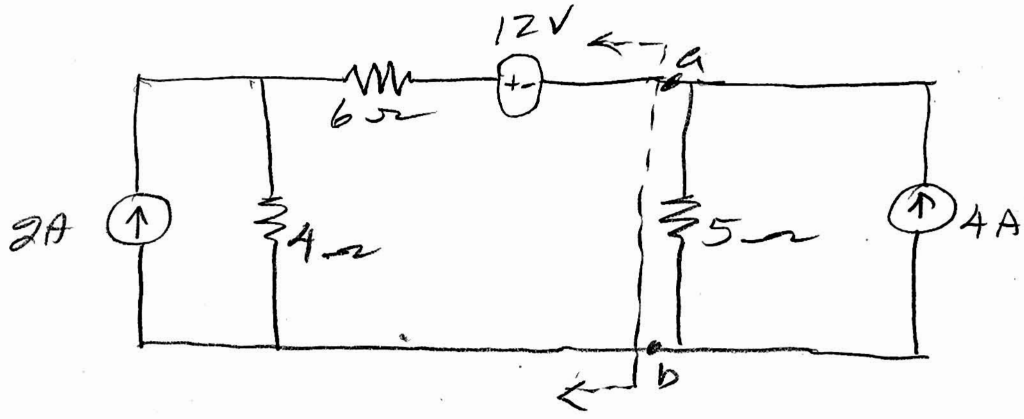
We already found R_{TH}.



Norton equivalent circuit

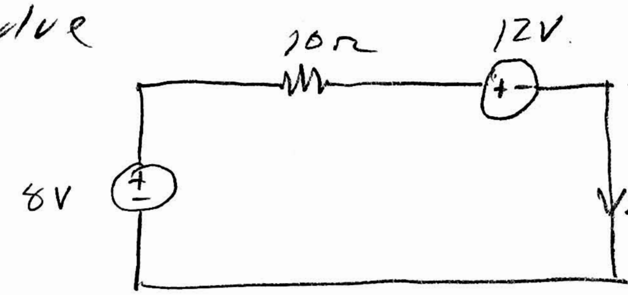
4.50

Obtain the Norton equivalent circuit for the following, as shown, then find i



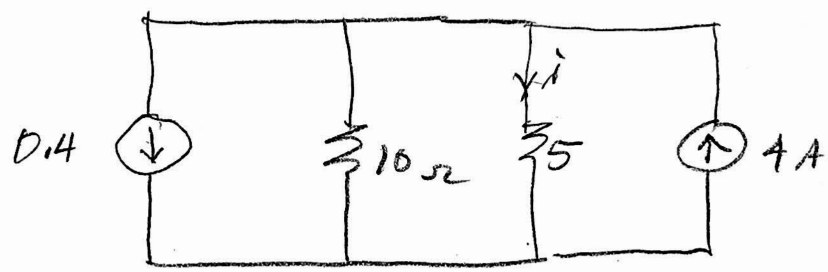
$R_{TH} = 10\ \Omega$ (inspection)

To find I_{sc}, make a transformation, solve



Circuit X

$$I_{sc} = \frac{-4}{10} = -0.4$$

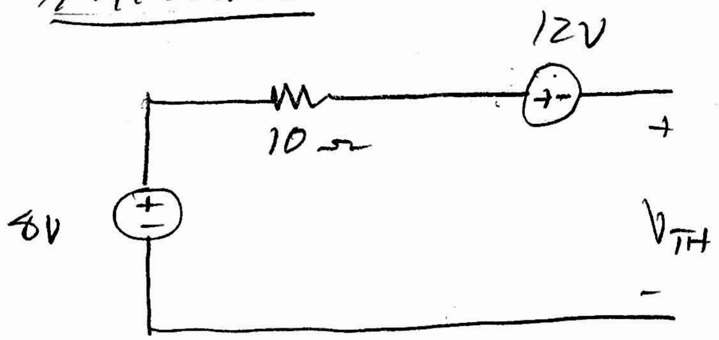


By current division

$$i = \frac{(4-0.4)\times 10}{15} = \frac{36}{15} = 2.4\ A$$

4.50

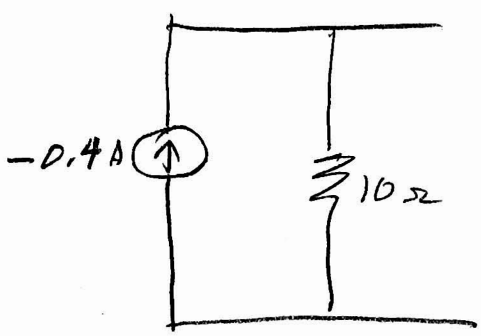
Thevenin



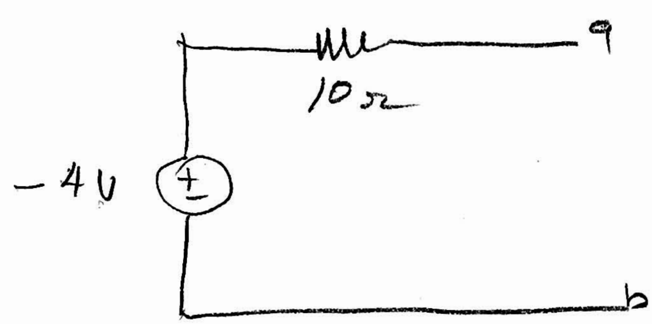
$$V_{TH} = 8 - 12 = -4V$$

$$\therefore \quad I_N = \frac{V_{TH}}{R_{TH}} = \frac{-4}{10} = -0.4A$$

Norton Circuit



Thevenin Circuit



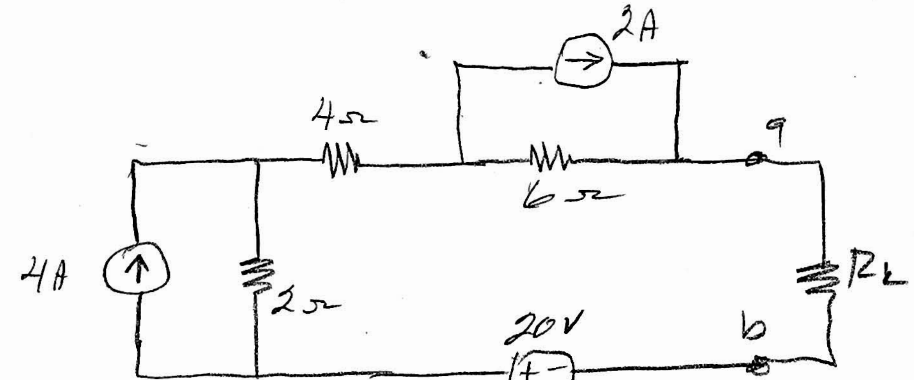
4.72

(a) For the following circuit obtain the Thevenin equivalent circuit at terminals a-b.

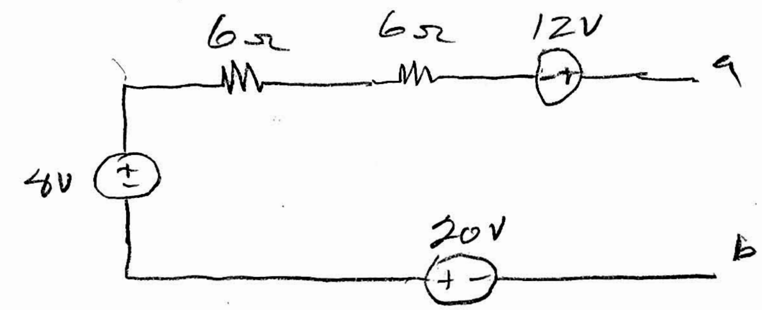
(b) Calculate the current in $R_L = 8\,\Omega$

(c) Find R_L for maximum power transfer.

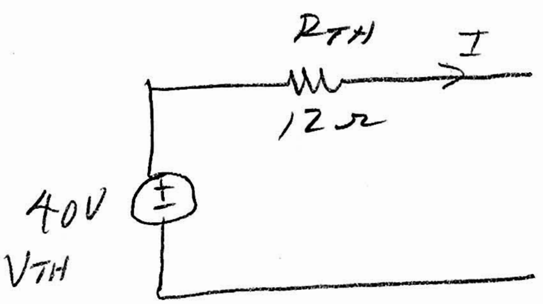
(d) Determine the maximum power.



(a)
With source transformation,



$V_{OC} = V_{TH} = 40V$; $R_{TH} = 12\,\Omega$



Thevenin equivalent circuit.

4.72 cont.

(b) With 8 Ω attached to the Thevenin circuit, between terminals a-b,

$$I = \frac{40}{20} = 2A$$

(c) Find R_L for maximum power transfer.

$$R_L = R_{TH} = 12\,\Omega$$

(d) Find this power.

A general expression for this is

$$P_L = \left(\frac{V_{TH}}{R_{TH} + R_{TH}}\right)^2 \times R_{TH} = \left(\frac{V_{TH}}{2R_{TH}}\right)^2$$

$$P_L = \frac{V_{TH}^2}{4R_{TH}}$$

$$P_L = \frac{40^2}{4 \times 12} = \frac{40^2}{48} = 33.33W$$

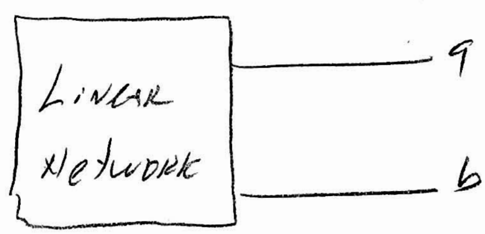
$$\boxed{P_L = 33.33\ W}$$

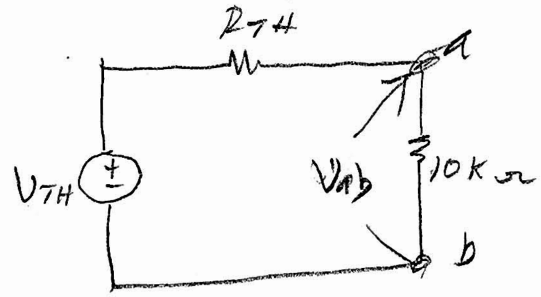
4.85

The Thevenin equivalent circuit at terminals a-b of the linear network shown below is to be determined by measurement.
When 10-kΩ is connected to terminals a-b the voltage V_{ab} is measured as 6V.
When 30 kΩ is connected to terminals a-b then V_{ab} is measured as $V_{ab} = 12V$.
Determine.

(a) the Thevenin equivalent at terminals a-b

(b) V_{ab} when a 20 kΩ resistor is connected to terminals a-b.

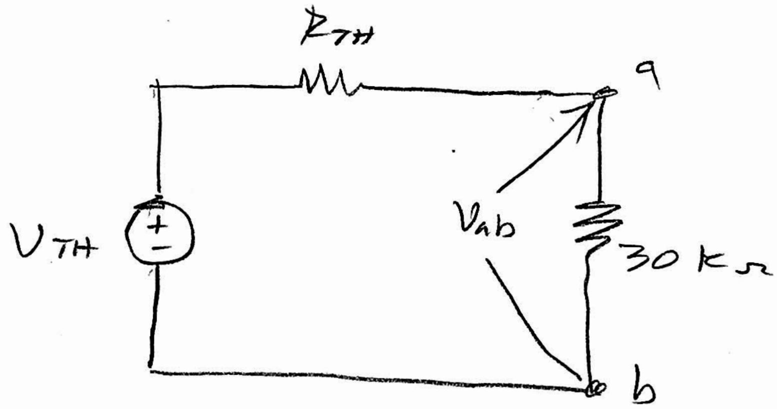




$$V_{ab} = \frac{V_{TH} \times 10K}{10K + R_{TH}} = 6V$$

$$10K\, V_{TH} - 6\, R_{TH} = 60K \qquad \text{Eq. (1)}$$

4.85 cont



$$V_{ab} = \frac{V_{TH} \times 30k}{R_{TH} + 30k} = 12V$$

OR

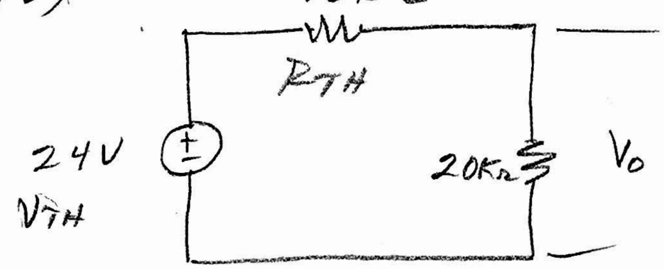
$$30k\,V_{TH} - 12\,R_{TH} = 360\,k \qquad Eq\ (2)$$

from Equations (1) and (2)

$$\begin{bmatrix} 10k & -6 \\ 30k & -12 \end{bmatrix} \begin{bmatrix} V_{TH} \\ R_{TH} \end{bmatrix} = \begin{bmatrix} 60k \\ 360k \end{bmatrix}$$

$\boxed{V_{TH} = 24V}$; $\boxed{R_{TH} = 30\,k\Omega}$

(b)



$$\boxed{V_o = \frac{24 \times 20k}{50k} = 9.6\,V}$$