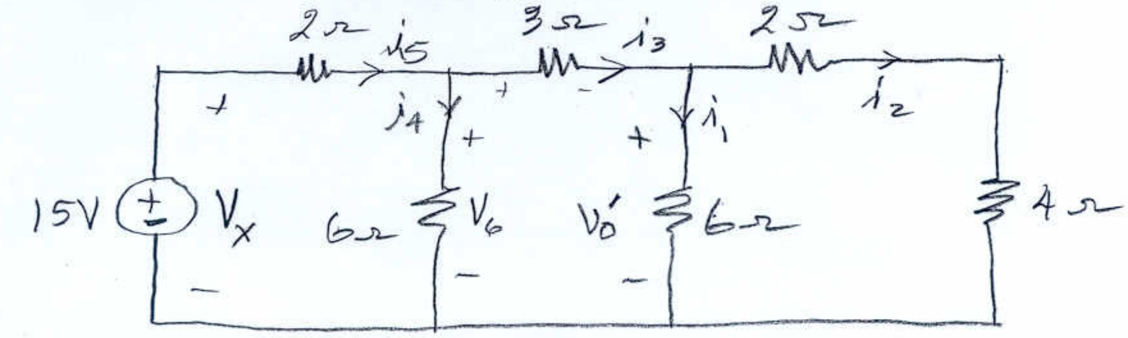
ECE 300 wlg

HW # 3 Spring 2007

4.5 For the circuit below assume $V_o = 1$ and use linearity to find the true V_o



With $V_o = 1$ volt

$$i_1 = \frac{1}{6} \; ; \quad i_2 = \frac{1}{6}$$

$$i_3 = i_1 + i_2 = \frac{1}{3}$$

$$V_6 = i_3 \times 3 + i_1 \times 6 = \frac{1}{3} \times 3 + \frac{1}{6} \times 6 = 2V$$

$$i_4 = \frac{V_6}{6} = \frac{2}{6} = \frac{1}{3}$$

$$i_5 = i_4 + i_3 = \frac{1}{3} + \frac{1}{3} = \frac{2}{3}$$

$$V_x = 2 i_5 + 6 i_4 = 2 \times \frac{2}{3} + 6 \times \frac{1}{3}$$

$$= \frac{4}{3} + \frac{6}{3} = \frac{10}{3}$$

Then $$\frac{V_x}{15} = \frac{V_o'}{V_o} \; ; \quad \frac{\frac{10}{3}}{15} = \frac{1}{V_o}$$

$$\boxed{V_o = \frac{15}{10} \times 3 = 4.5\,V}$$

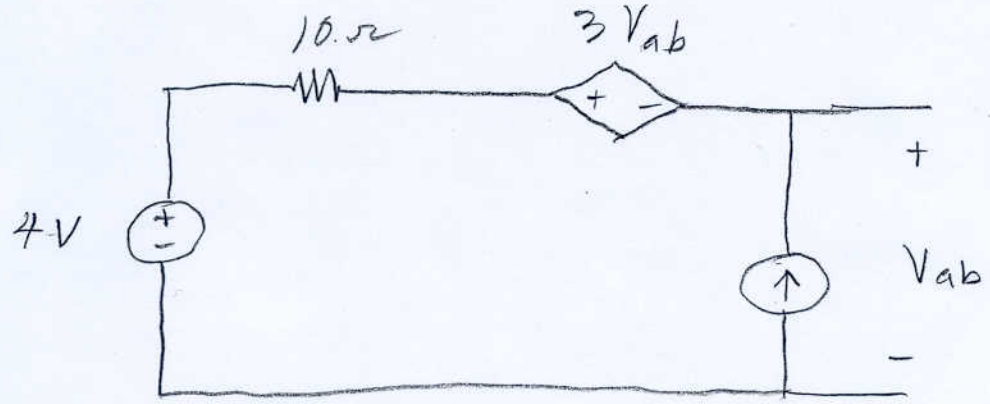
(compare to nodal analysis)

4.10

Find the terminal voltage V_{ab} by

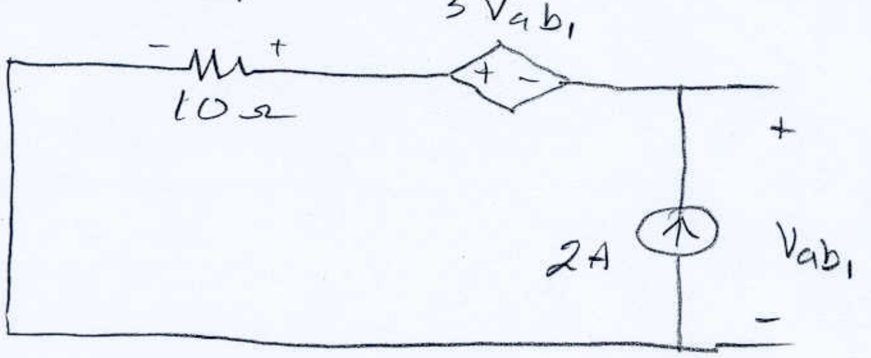
(a) superposition

(b) nodal analysis



(a) superposition

de-energize the 4 volt source and find V_{ab_1}



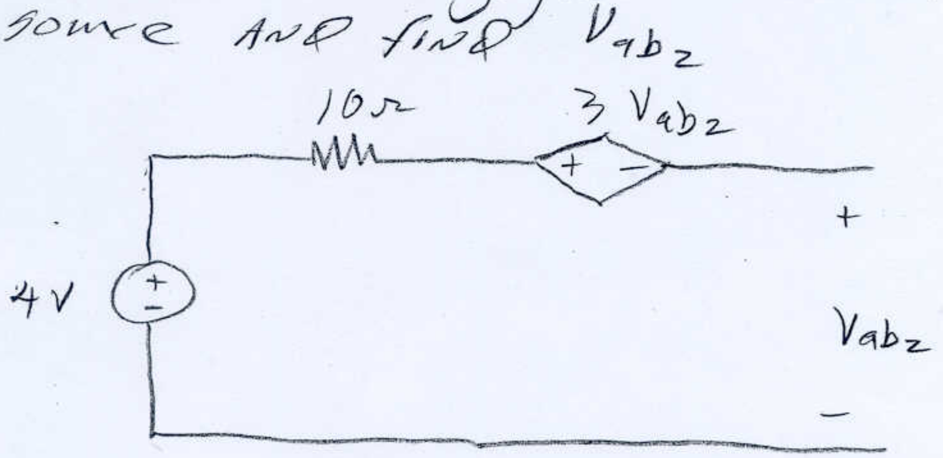
$$-10 \times 2 + 3V_{ab_1} + V_{ab_1} = 0$$

$$4V_{ab_1} = 20$$

$$\boxed{V_{ab_1} = 5V}$$

4.10 continued

Now de-energize the current source and find V_{ab_2}



No current so the voltage drop across the 10Ω resistor is zero.

$$-4 + 3V_{ab_2} + V_{ab_2} = 0$$

$$4V_{ab_2} = 4$$

$$V_{ab_2} = 1\ V$$

Thus, by superposition

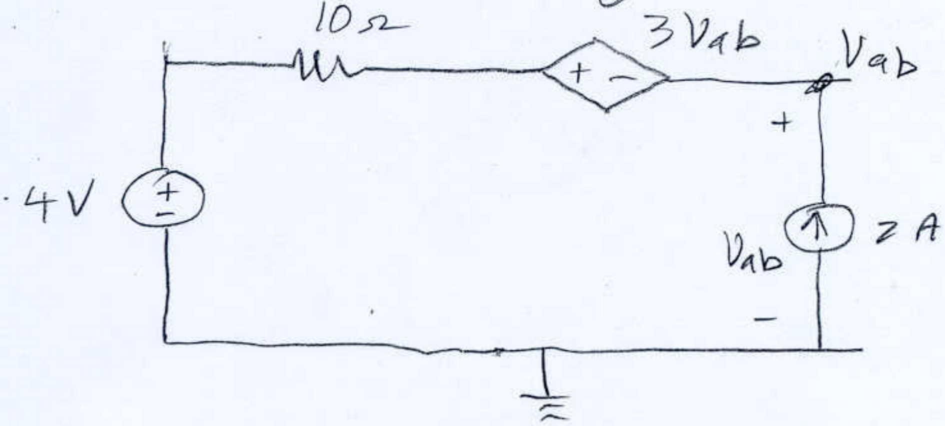
$$V_{ab} = V_{ab_1} + V_{ab_2} = 5 + 1$$

$$\boxed{V_{ab} = 6\ V}$$

Part (b), next page:

4.10 continued

(b) Find V_{ab} by nodal analysis



At node V_{ab}:

$$\frac{V_{ab} + 3V_{ab} - 4}{10} - 2 = 0$$

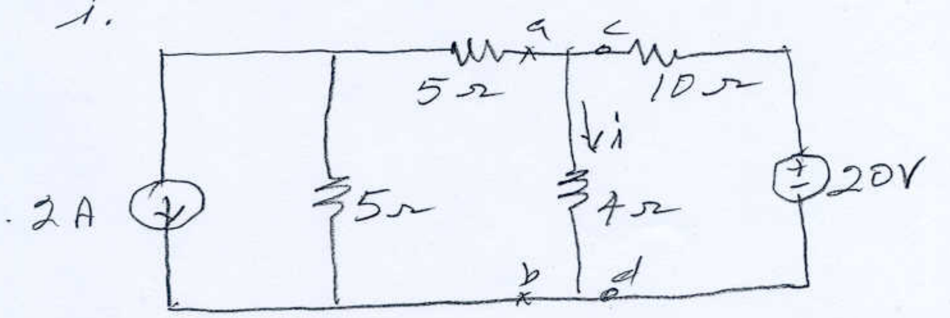
$$V_{ab} + 3V_{ab} - 4 - 20 = 0$$

$$4V_{ab} = 24$$

$$\boxed{V_{ab} = 6\,V}$$ QED

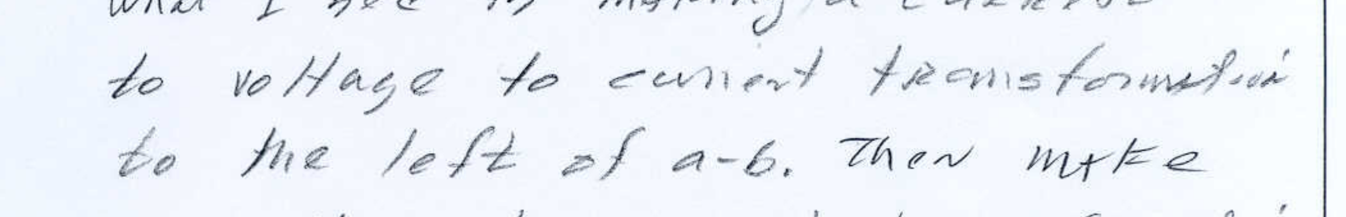
4.22

Use source transformation to find i.

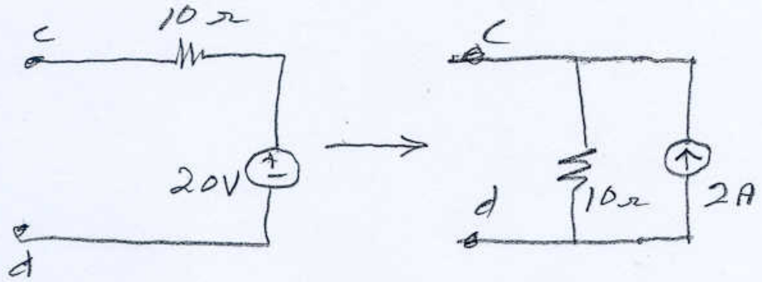


Working circuits using source transformations is a little like a chess or checker game. Different people will make different moves to get to the same end. What I see is making a current to voltage to current transformation to the left of a-b. Then make a voltage to current transformation to the right of c-d. Then combine current sources to one net current source: combine resistors to one resistor - then use the current division to find i.

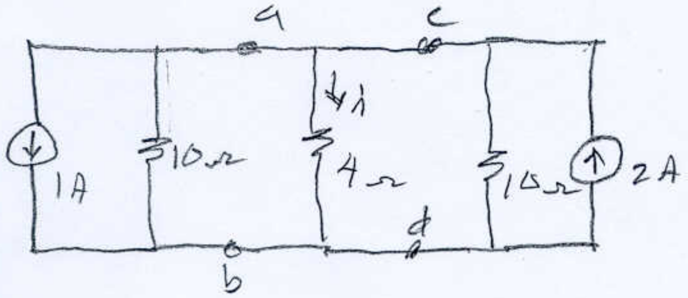
First step, to the left of a-b

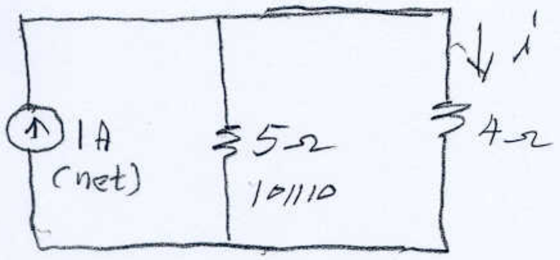


4.22 cont.



Now combine





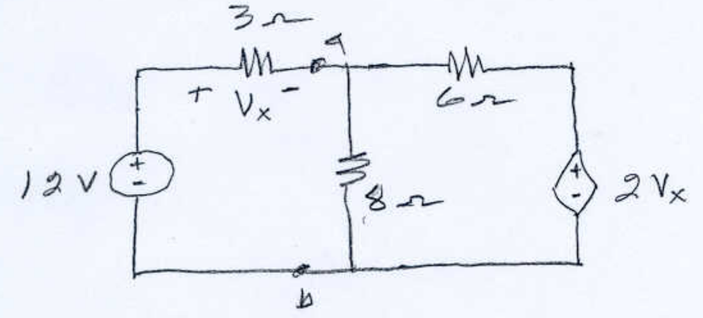
current Division

$$i = \frac{1 \times 5}{5+4}$$

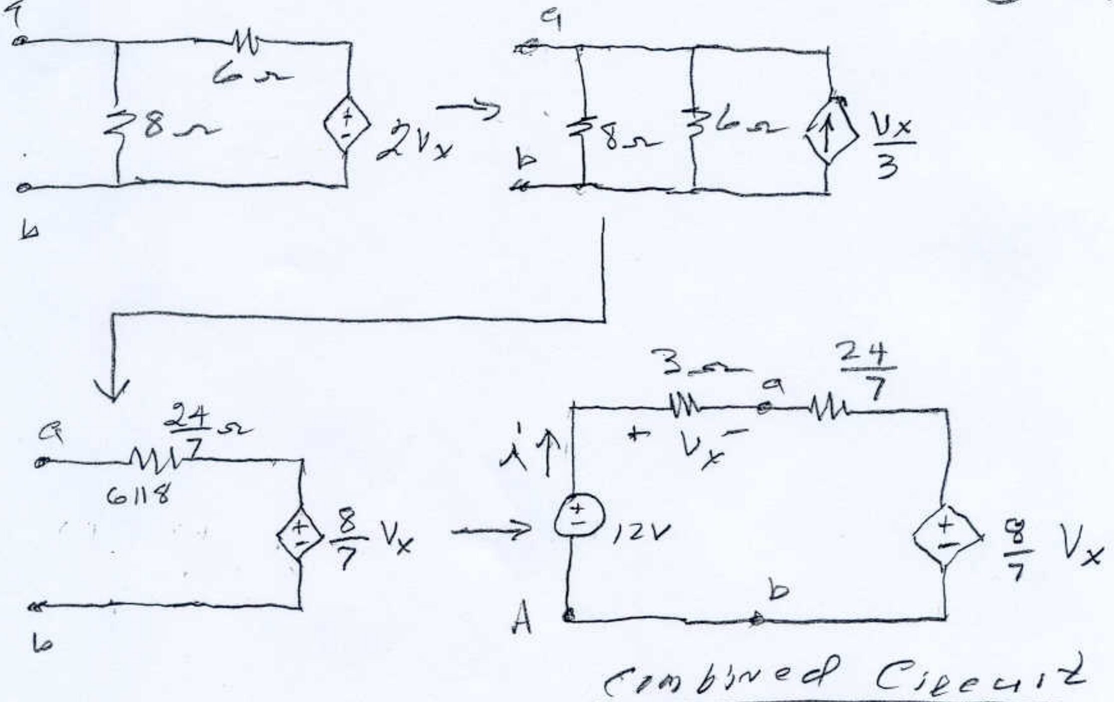
$$\boxed{i = \frac{5}{9} A = 0.555 A}$$

4.31

Determine V_x in the following circuit



My plan: I can do a voltage to current to voltage transformation to the right of a-b. I will then have a series single look circuit for which I can apply KVL to find V_x. Notes: I cannot do a source transformation (left of a-b; voltage to current) because I will loose idenity of V_x.



Combined Circuit

4.31 cont.

From the combined circuit we write KVL, starting at A, go C.W., Σ drops = 0

$$-12 + V_x + \frac{24}{7} i' + \frac{8}{7} V_x = 0$$

but $V_x = 3i'$

so

$$-12 + V_x + \frac{24}{7}\left(\frac{V_x}{3}\right) + \frac{8}{7} V_x = 0$$

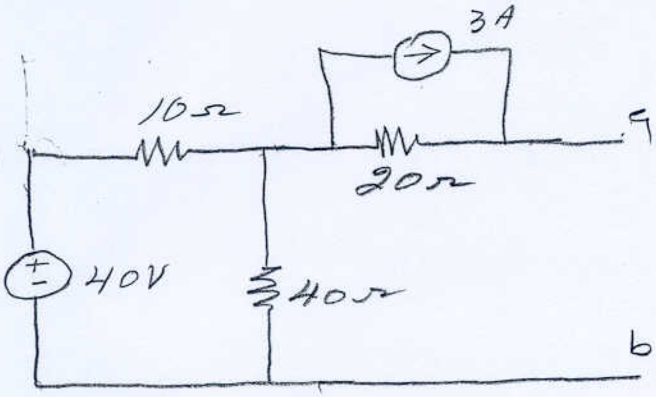
$$-12 + V_x + \frac{16}{7} V_x = 0$$

$$\boxed{V_x = \frac{84}{23} \text{ V}}$$

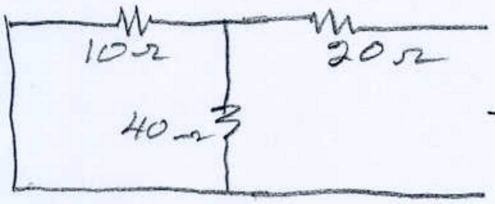
4.34

Find the Thevenin circuit for the following, left of a-b

We worked a problem like this in class - Thur - Feb 8.



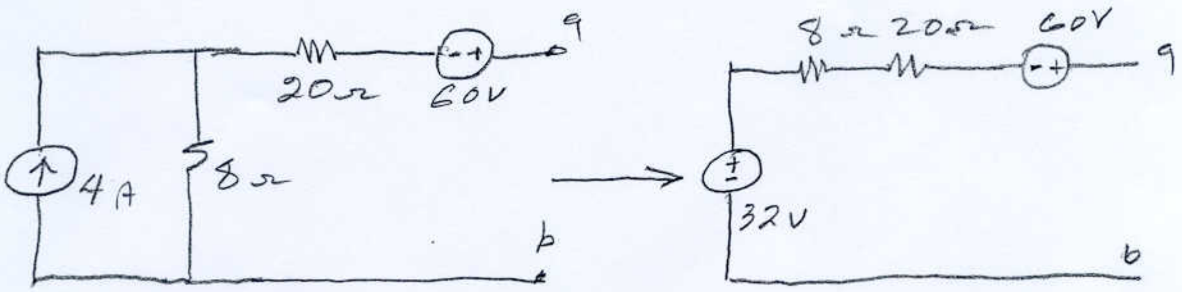
To find R_{TH}, De-energize sources, giving



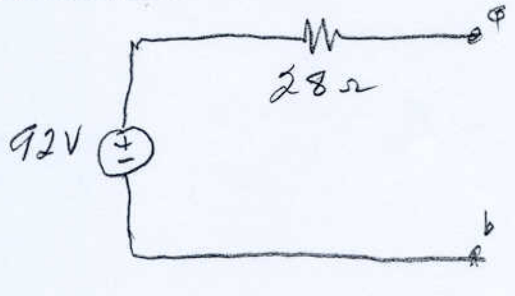
$\longrightarrow R_{TH} = 10 \| 40 + 20$

$R_{TH} = 28\,\Omega$

If we use source transformations we have

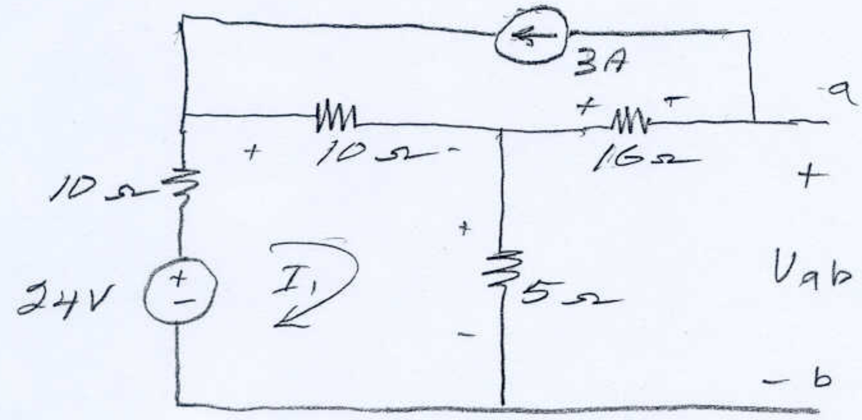


Simplifying:

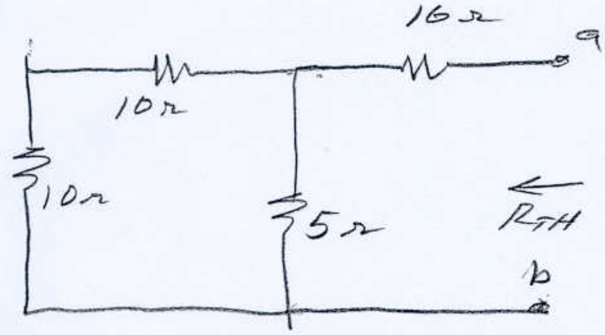


The Thevenin circuit

4.39 Find the Thevenin circuit of the following.



To find R_{TH} de-energize the sources



$R_{TH} = (10+10) \| 5 + 16$

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

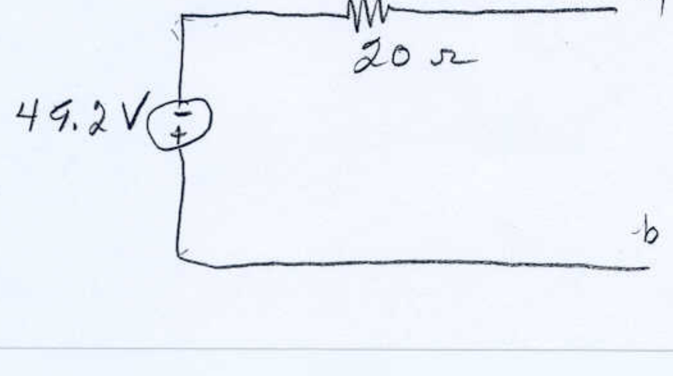
Looks like mesh is the quickest way to solve for $V_{oc} = V_{ab}$. We have

$$-24 + 10 I_1 + 10(I_1 + 3) + 5 I_1 = 0$$

$$I_1 = -\frac{6}{25}$$

then $-V_{ab} - 16 \times 3 + 5\left(-\frac{6}{25}\right) = 0$

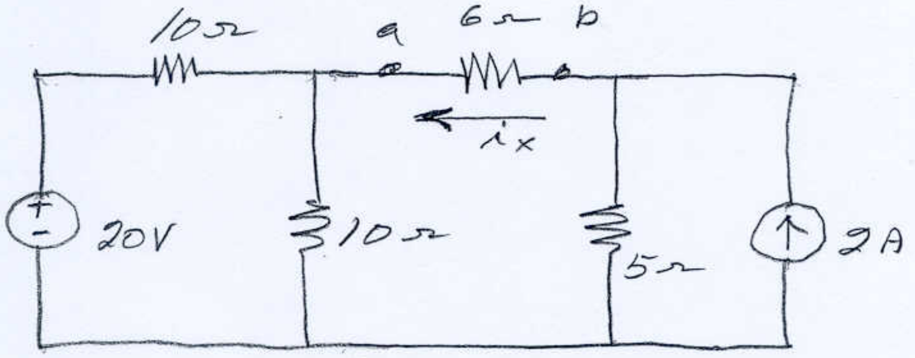
$$V_{ab} = V_{oc} = V_{TH} = -49.2\,V$$



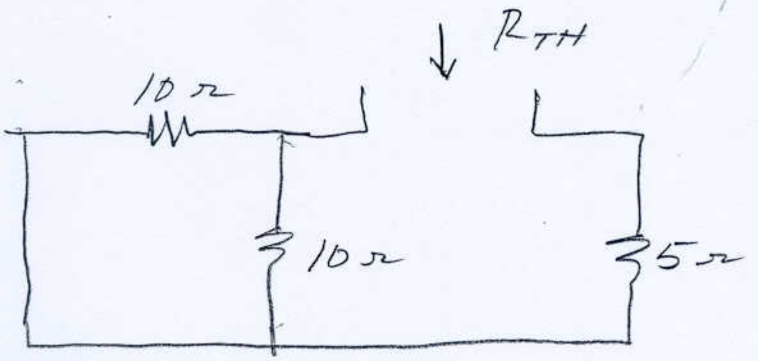
The Thevenin circuit

4.43

Find the Thevenin circuit looking into terminals a-b; the use the Thevenin circuit to find i_x

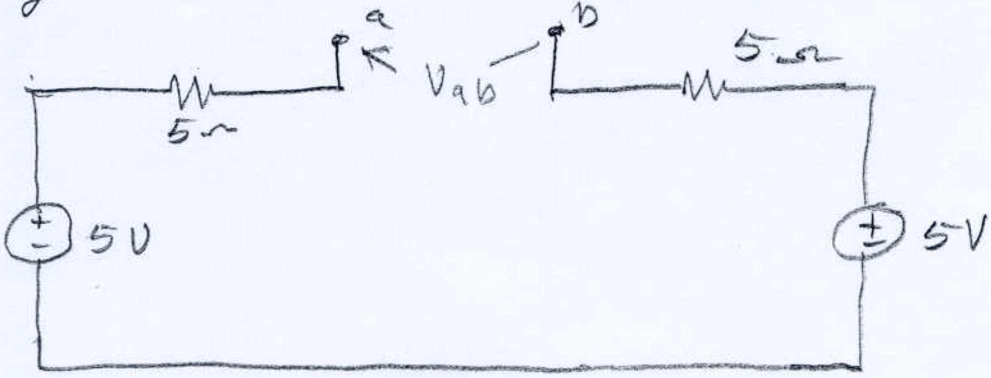


To find R_{TH}, De-energize the sources. This gives



$$\boxed{R_{TH} = 10 \| 10 + 5 = 10\,\Omega}$$

Using source transformations we have



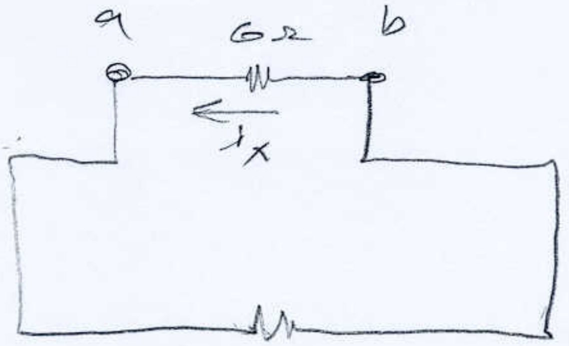
4,43 cont

Writing KVL

$$-V_{ab} + 5 - 5 = 0$$

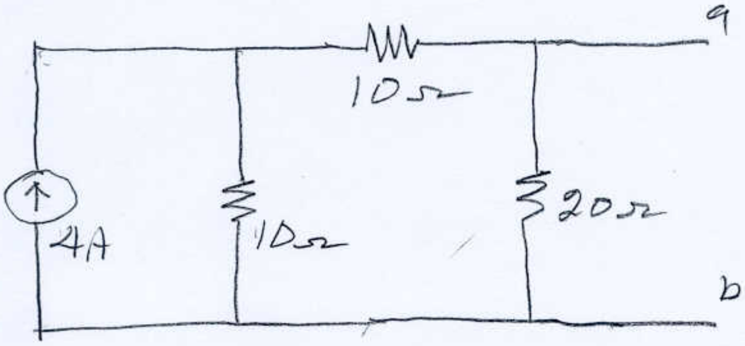
$$V_{ab} = V_{oc} = \boxed{V_{TH} = 0}$$

The Thevenin circuit with the 6Ω connected:

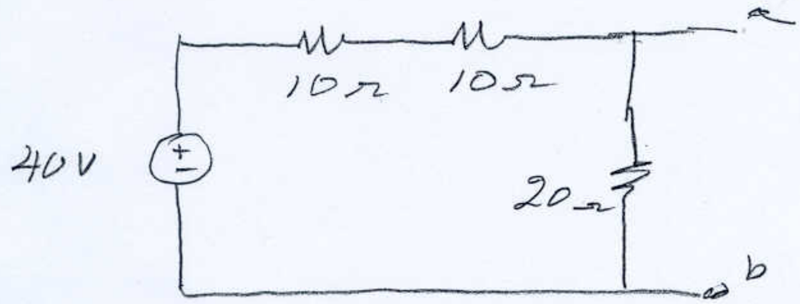


obviously $\boxed{i_x = 0}$

4.46 Given the circuit below
(a) Find the open-circuit voltage
(b) Find the short-circuit current
(c) From (a) & (b) determine I_N & R_{TH}

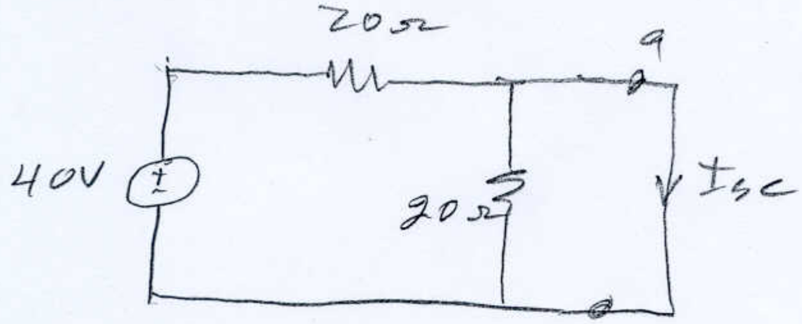


To find the open-circuit voltage use source transformation.



$$V_{ab} = \underline{\underline{V_{oc}}} = V_{TH} = \frac{40 \times 20}{20+20} = 20V = V_{oc}$$

Use the above ckt to find I_{sc}



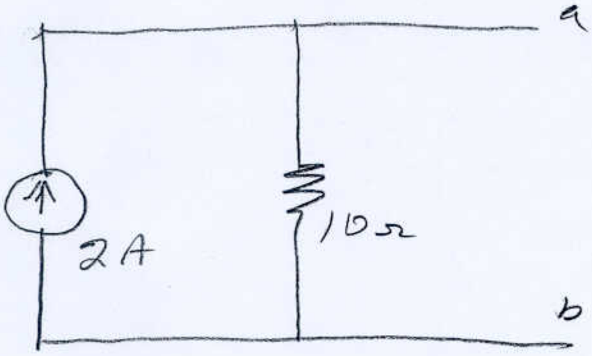
4.46 cont.

$$I_{sc} = \frac{40}{20} = 2A$$

(c) $$R_N = R_{TH} = \frac{V_{oc}}{I_{sc}} = \frac{20}{2} = 10\,\Omega$$

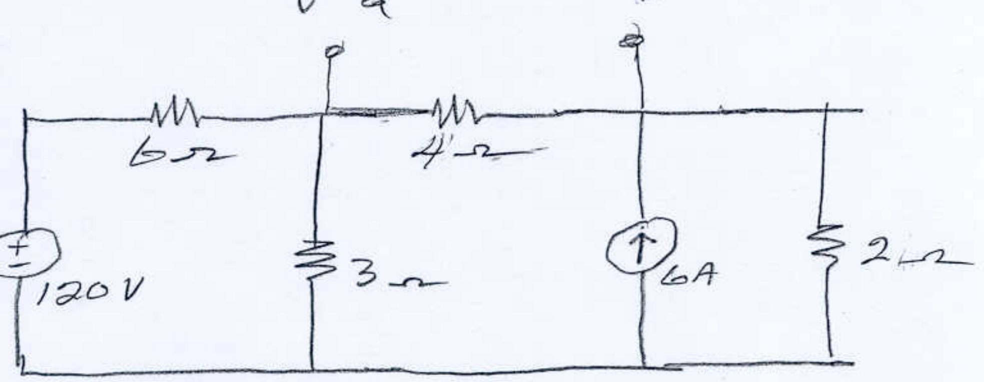
$$I_N = I_{sc} = 2A$$

Norton Ckt

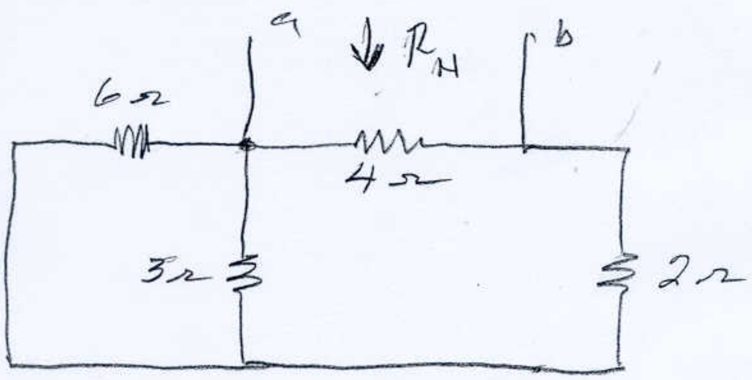


4.51

(a) Obtain the Norton circuit for the following

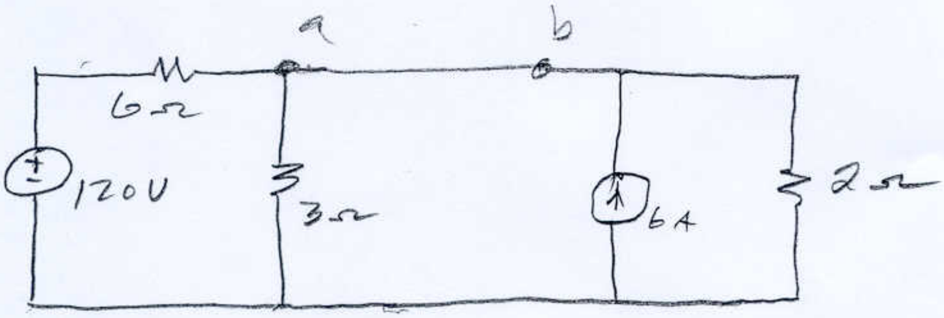


To find $R_N = R_{TH}$ De-energize the independent sources.



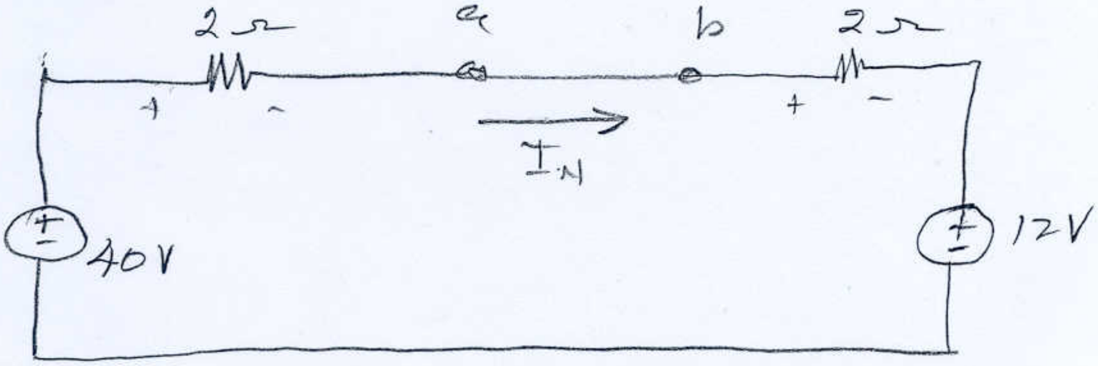
$R_N = 4 \parallel 4 = 2\Omega$

When we place a short across a-b we short out the 4Ω resistor. The circuit becomes as follows;



4.51 cont

Using source transformations we have,



$$-40 + 4I_N + 12 = 0$$

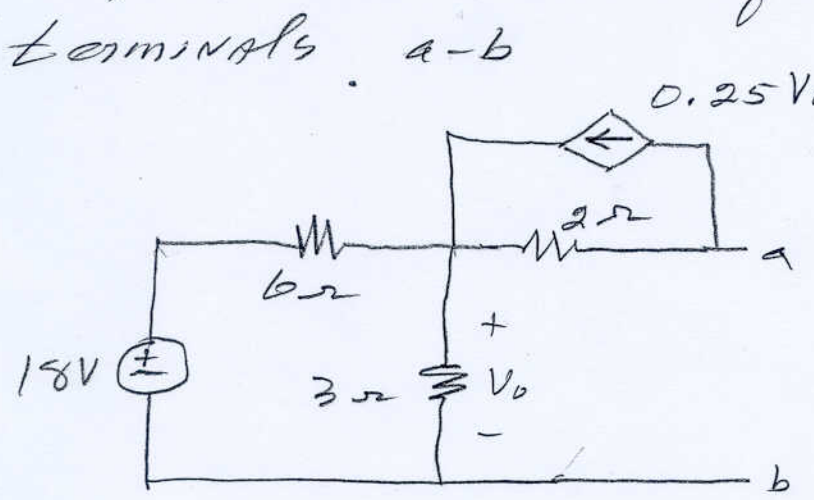
$$I_N = 7A$$

$$R_N = 2\Omega$$

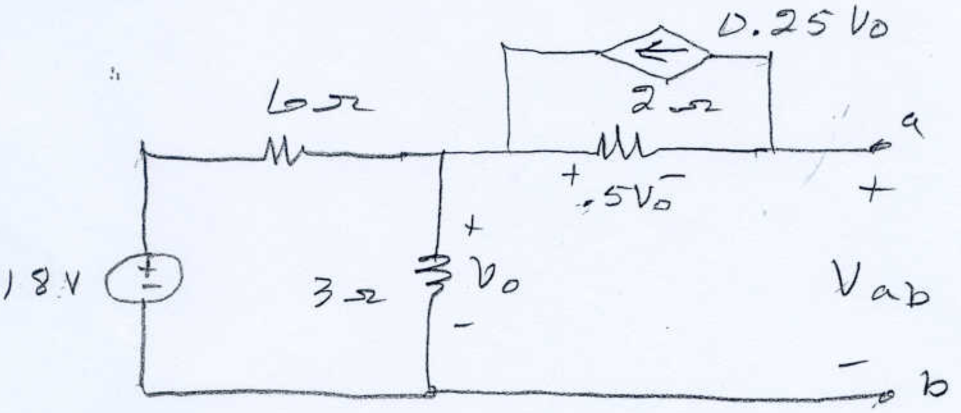
current goes right to left

4.53

Find the Norton equivalent at terminals a-b.



First find the open-circuit voltage.



Using KVL

$$-V_{ab} - .5V_o + V_o = 0$$

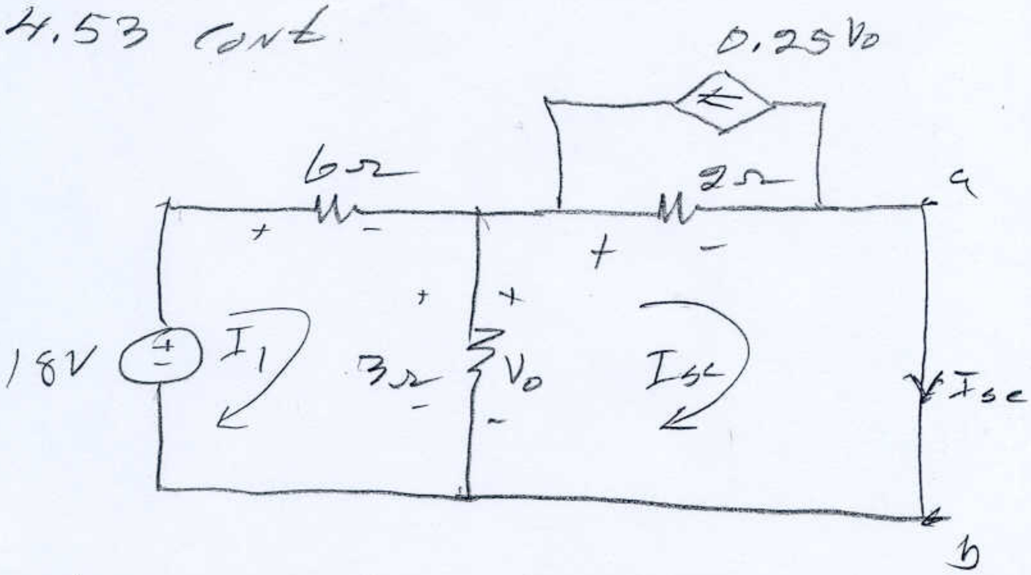
but $V_o = \dfrac{18 \times 3}{3 + 6} = 6\,V$

$\therefore$

$$V_{ab} = 0.5\,V_o = \boxed{3\,V = V_{oc}}$$

Now find I_{sc}

4.53 cont.



Using mesh Analysis

$$-18 + 6I_1 + 3(I_1 - I_{sc}) = 0$$

$$\boxed{9I_1 - 3I_{sc} = 18}$$

$$-3(I_1 - I_{sc}) + 2(I_{sc} + 0.25V_o) = 0$$

but $V_o = 3(I_1 - I_{sc})$

so

$$-3(I_1 - I_{sc}) + 2(I_{sc} + 0.25 \times 3(I_1 - I_{sc}$$

$$-3I_1 + 3I_{sc} + 2I_{sc} + 1.5I_1 - 1.5I_{sc} = 0$$

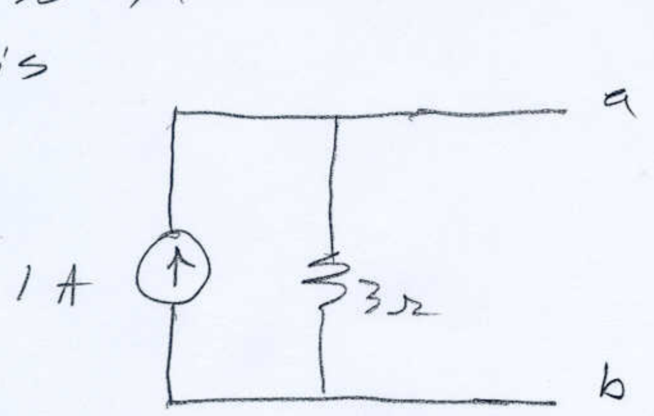
$$\boxed{-1.5I_1 + 3.5I_{sc} = 0}$$

$$\boxed{I_{sc} = 1A} \quad ; \quad V_{oc} = 3V$$

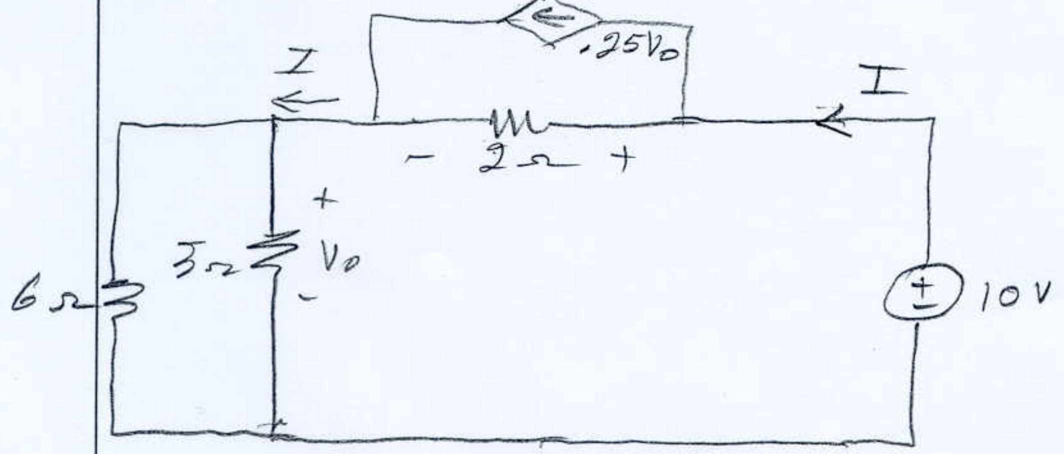
$\therefore \; I_N = 1A \; ; \; R_N = \dfrac{V_{oc}}{I_{sc}} = \dfrac{3}{1} = 3\Omega$

4.53 cont

So the Norton equivalent circuit is



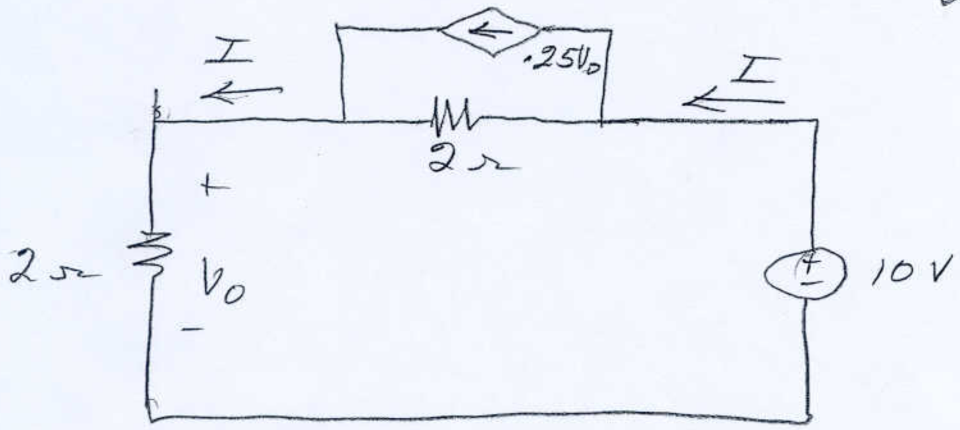
Another way of finding $R_N = R_{TH}$ is given below. We will apply a 10V signal to the circuit and find the resulting current when all independent sources are de-energized, we have



$$R_N = \frac{10}{I}$$

4.53 cont

so we solve the following ckt



Using KVL

$$-10 + 2(I - 0.5V_o) + V_o = 0$$

$$-10 + 2I - 0.5V_o + V_o = 0$$

$$-10 + 2I + 0.5V_o = 0$$

but $V_o = 2I$

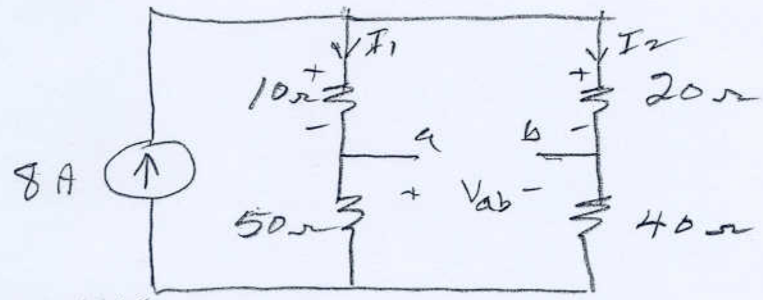
so

$$-10 + 2I + I = 0$$

$$\boxed{\frac{10}{I} = 3 = R_{TH}}$$ QED

4.59

Determine the Thevenin and Norton circuit for the following



Thevenin

With the 8 A source de-energized we have

$$\boxed{R_{TH} = 30 \| 90 = 22.5\,\Omega}$$

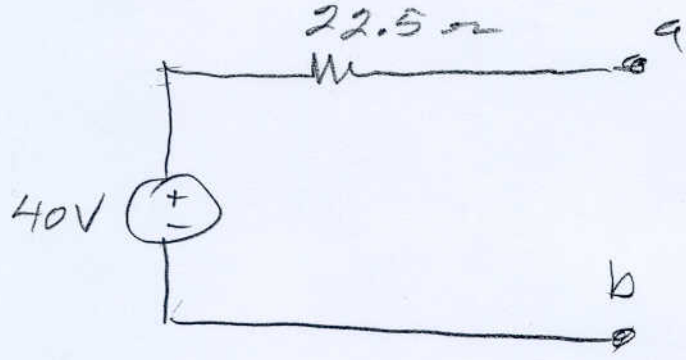
By inspection $I_1 = I_2 = 4$ A

$V_{TH} = V_{ab}$

$$-V_{ab} - 10I_1 + 20I_2 = 0$$

$$V_{ab} = 20 \times 4 - 10 \times 4 = 40\text{ V}$$

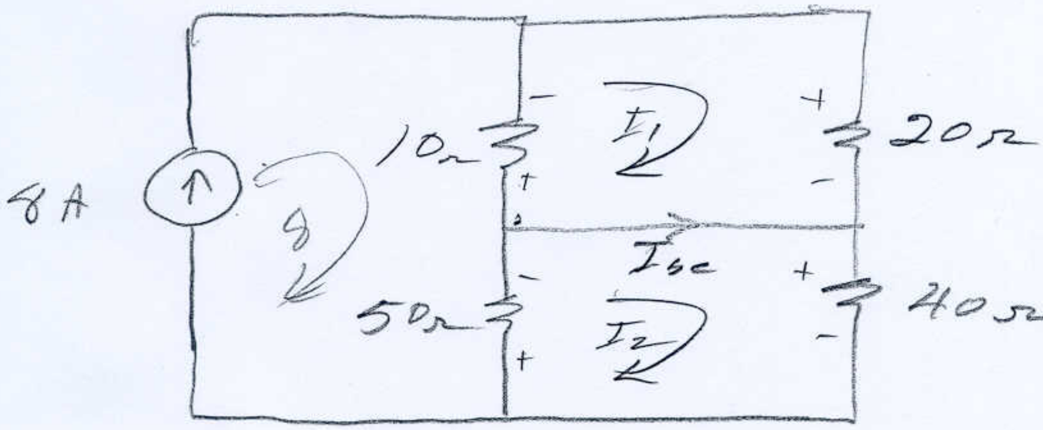
$$V_{TH} = 40\text{ V}$$



Thevenin Circuit

4.59 cont

To find I_{sc}



$$10(I_1 - 8) + 20I_1 = 0$$

$$30I_1 = 80$$

$$I_1 = \frac{8}{3}$$

$$50(I_2 - 8) + 40I_2 = 0$$

$$90I_2 = 400$$

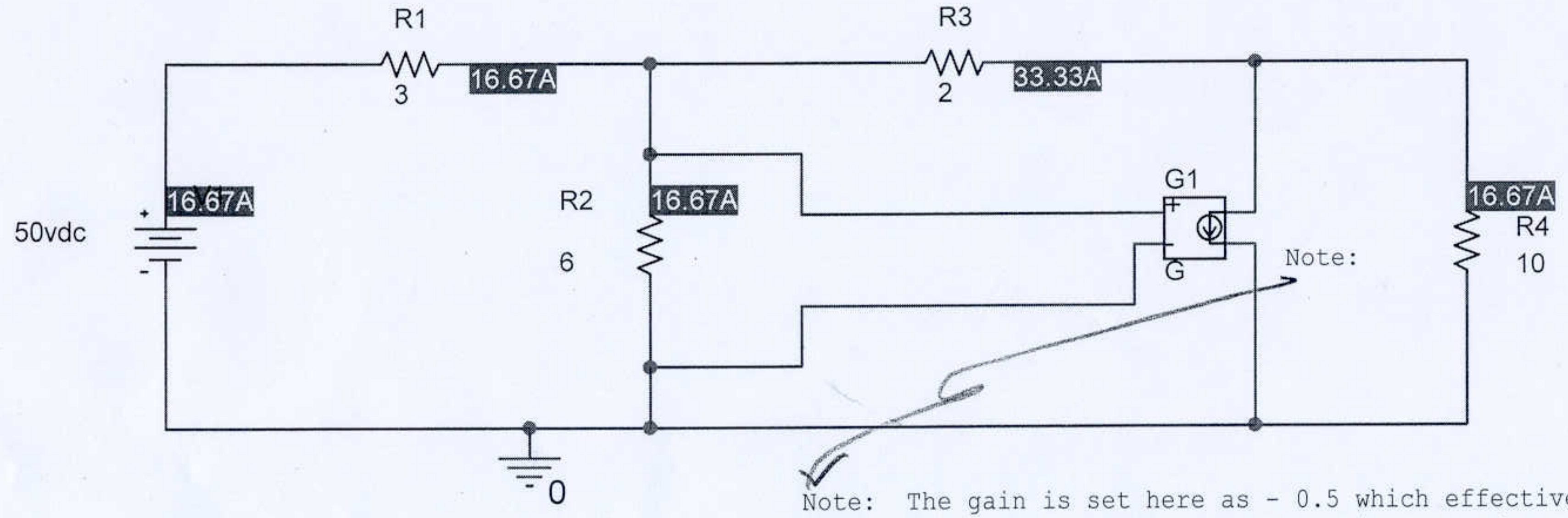
$$I_2 = \frac{40}{9}$$

$$I_{sc} = I_2 - I_1 = \frac{40}{9} - \frac{8}{3} = \frac{16}{9}$$

$$\boxed{I_{sc} = 1.7778 \text{ A}}$$

Also $I_N = \dfrac{V_{TH}}{R_{TH}} = \dfrac{40}{22.5} = 1.778 \text{ A}$

This is problem 4.57 from Alexander 3rd Edition



Note: The gain is set here as - 0.5 which effectively
turns the current arrow to point upward