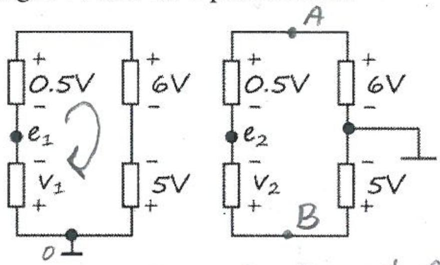
Solution

National Taiwan Normal University
Department of Computer Science and Information Engineering
CSU0007 - Basic Electronics
Homework 2

Seven questions. 100 points total. Due on 10PM, Tuesday, 3/31/2020. Submit your answer via Moodle
Clearly state each step of your calculation to receive full score.

1. (20 points) Find the node voltages e_1 and e_2 and the branch voltages v_1 and v_2. 5 points each.



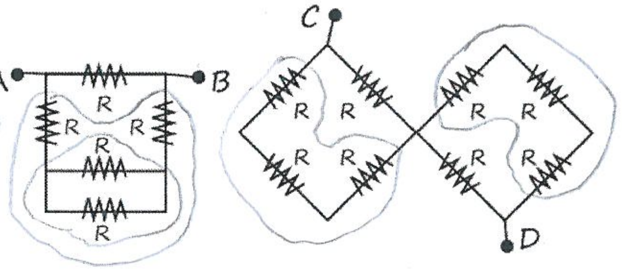
Using KVL we see that $v_1 = v_2$, and it must be, since the two circuits are the same (grounding point is just an artificial way to aid our analysis).

KVL: $0.5-6+5-v_1=0 \Rightarrow v_1 = -0.5\text{ V}$ $\quad v_2 = v_1$

$e_1 = 0 - v_1 = 0.5\text{ V}$

Via either node A or node B we may see $e_2 = 5.5\text{ V}$. For example, node voltage at A is $0+6=6\text{ V}$ thus $e_2 = 6-0.5 = 5.5$ ※

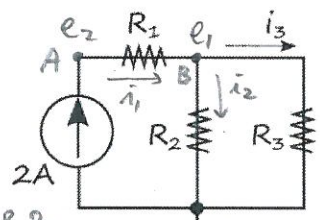
2. (10 points) Find the equivalent resistance from the viewpoint of A-B and from that of C-D. 5 points each.



$R_{AB} = R /\!/ (R + (R/\!/R) + R)$
$= R /\!/ (\frac{5}{2}R)$
$= (\frac{1\times\frac{5}{2}}{1+\frac{5}{2}})R = \frac{5}{7}R$ ※

$R_{CD} = R/\!/(3R) + R/\!/(3R)$
$= 2\times(\frac{1\times3}{1+3})R$
$= \frac{3}{2}R$ ※

3. (10 points) Find the current i_3.



Way ① current divider:

$i_3 = 2 \times \frac{R_2}{R_2+R_3} = \frac{2R_2}{R_2+R_3}$ A

since 2A flows through R_1

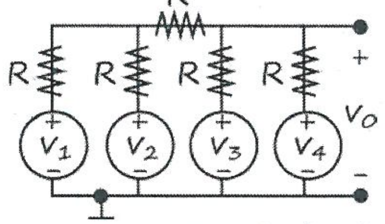
Way ② node method:

KCL at node A $\Rightarrow i_1 = 2A$

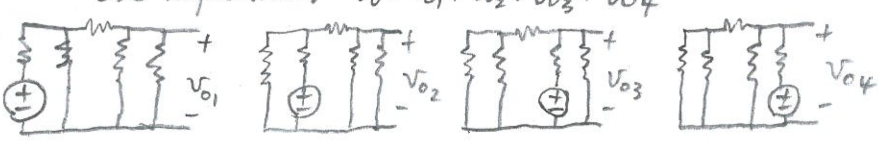
KCL at node B $\Rightarrow i_1 = i_2 + i_3$

$\Rightarrow 2 = \frac{e_1-0}{R_2} + \frac{e_1-0}{R_3} \Rightarrow e_1 = \frac{2R_2R_3}{R_2+R_3} \Rightarrow i_3 = \frac{e_1}{R_3} = \frac{2R_2}{R_2+R_3}$ A ※

4. (10 points) Find the voltage v_0.

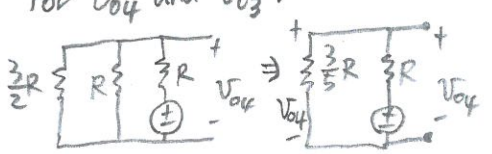


Use suposition. $V_o = V_{o_1} + V_{o_2} + V_{o_3} + V_{o_4}$



we see $V_{o_1} = V_{o_2}$ if $V_1 = V_2$, and $V_{o_3} = V_{o4}$ if $V_3 = V_4$

For V_{o4} and V_{o3}:

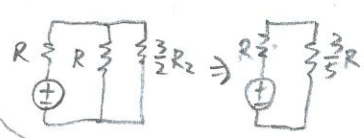


$\frac{\frac{3}{2}\times1}{\frac{3}{2}+1} = \frac{3}{5}$

Using voltage divider,

$V_{o4} = V_4 \times \frac{\frac{3}{5}}{\frac{3}{5}+1} = \frac{3}{8}V_4 \Rightarrow V_{o_3} = \frac{3}{8}V_3$

For V_{o_1} and V_{o2}:



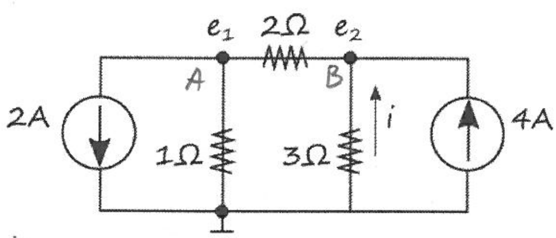
apply voltage divider twice

$V_{o_1} = (V_1 \times \frac{1\times\frac{3}{5}}{1+\frac{3}{5}}) \times \frac{1\times\frac{1}{2}}{1+\frac{1}{2}} = \frac{1}{8}V_1$

$\Rightarrow V_{o_2} = \frac{1}{8}V_2$

$\Rightarrow V_o = \frac{1}{8}(V_1+V_2) + \frac{3}{8}(V_3+V_4)$ ※

5. (15 points) Find node voltage e_1 and e_2, and then find the current i. 5 points each.



Way ① node method:

KCL at A: $2+\frac{e_1-0}{1}+\frac{e_1-e_2}{2}=0$

KCL at B: $\frac{e_1-e_2}{2}+\frac{0-e_2}{3}+4=0$

$\Rightarrow \begin{cases} 4+2e_1+e_1-e_2=0 \\ 3e_1-3e_2-2e_2+24=0 \end{cases}$

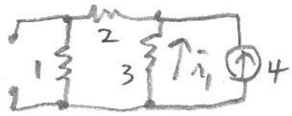
$\Rightarrow \begin{cases} 3e_1-e_2=-4 \\ 3e_1-5e_2=-24 \end{cases}$

$\Rightarrow \begin{cases} e_2=5 \\ e_1=\frac{1}{3} \end{cases}$

$i=\frac{0-e_2}{3}=\frac{-5}{3}A$ #

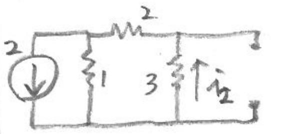
Way ② suposition:

$i=i_1+i_2$



for i_1, using current divider

$i_1=-4\times\frac{(1+2)}{(1+2)+3}=-2$

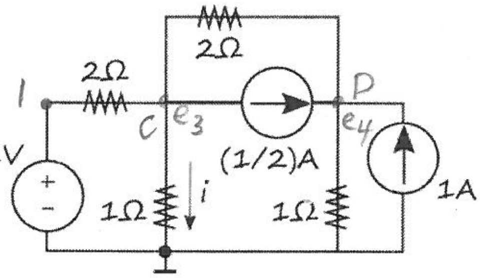


for i_2, using current divider

$i_2=2\times\frac{1}{1+(2+3)}=\frac{1}{3}$

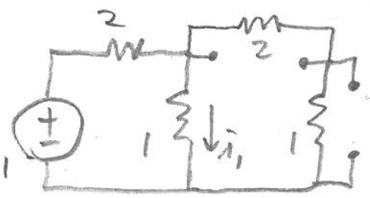
then $i=i_1+i_2=-2+\frac{1}{3}=\frac{-5}{3}A$ #

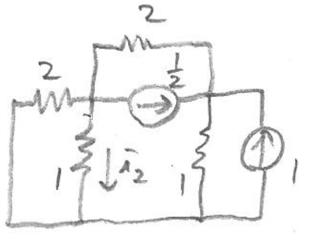
6. (10 points) Find the current i. --



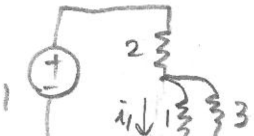
Let's use superposition in a bit fancy way:

$i=i_1+i_2$





⇓



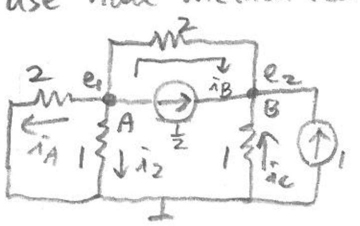
using voltage divider and element law

$i_1=\left(1\times\frac{\frac{1\times3}{1+3}}{2+\frac{1\times3}{1+3}}\right)\times1^{-1}$

$=\frac{3}{11}$

⇓

use node method here then



KCL at A: $\frac{e_1-0}{2}+\frac{e_1-0}{1}+\frac{1}{2}+\frac{e_1-e_2}{2}=0$

KCL at B: $\frac{1}{2}+\frac{e_1-e_2}{2}+\frac{0-e_2}{1}+1=0$

$\Rightarrow \begin{cases} 4e_1-e_2=-1 \\ e_1-3e_2=-3 \end{cases} \Rightarrow \begin{cases} 12e_1-3e_2=-3 \\ e_1-3e_2=-3 \end{cases}$

$\Rightarrow e_1=0 \Rightarrow i_2=\frac{e_1-0}{1}=0$

$\Rightarrow i=i_1+i_2=\frac{3}{11}A$ #

Alternatively, we can directly use the node method

KCL at e_3: $\frac{1-e_3}{2}+\frac{0-e_3}{1}+\frac{e_4-e_3}{2}+\frac{-1}{2}=0$

KCL at e_4: $\frac{e_3-e_4}{2}+\frac{1}{2}+\frac{0-e_4}{1}+1=0$

$\Rightarrow \begin{cases} -4e_3+e_4=0 \\ e_3-3e_4=-3 \end{cases}$

$\Rightarrow \begin{cases} -12e_3+3e_4=0 \\ e_3-3e_4=-3 \end{cases}$

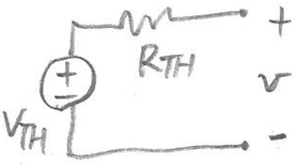
$\Rightarrow e_3=\frac{3}{11}$

$\Rightarrow i=\frac{e_3-0}{1}=\frac{3}{11}A$

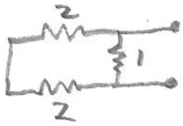
#

7. (25 points) Thévenin's Theorem and its application:

7a. (10 points) Find R_{TH} and V_{TH} of the following circuit:



for R_{TH} :



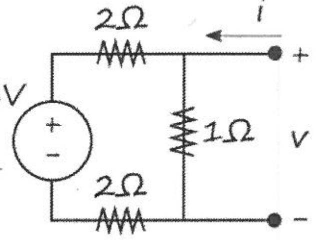
$\Rightarrow$

$\Rightarrow R_{TH} = \frac{1\times4}{1+4} = \frac{4}{5}$

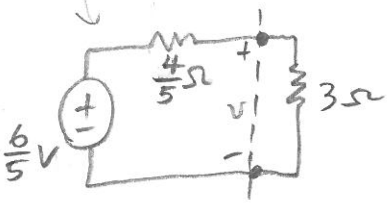
for V_{TH} : $V_{TH} = v$

use voltage divider

$V_{TH} = v = 6 \times \frac{1}{2+1+2} = \frac{6}{5}$ V #



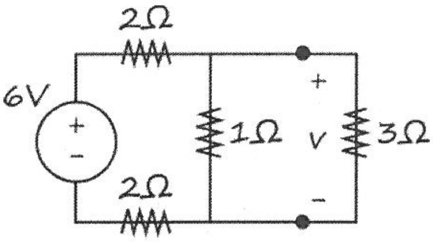
7b. (5 points) Use the result from 7a to find the voltage v here.



voltage divider

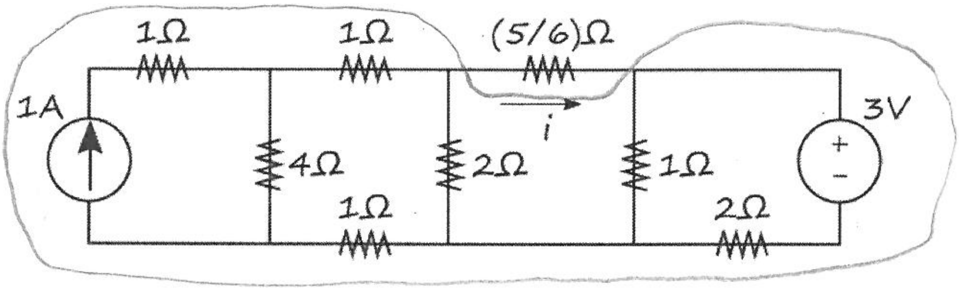
$v = \frac{6}{5} \times \frac{3}{\frac{4}{5}+3}$

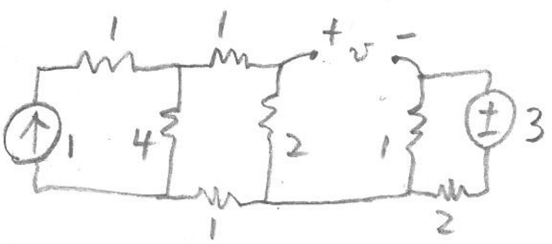
$= \frac{6}{5} \times \frac{15}{19} = \frac{18}{19}$ V #



7c. (10 points) In the following circuit, find the current i. (Hint: study Example 3.22 in the textbook)

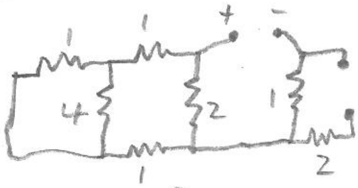
Besides textbooks' method, we may consider one single equivalent circuit:





⇓

for R_{TH} :



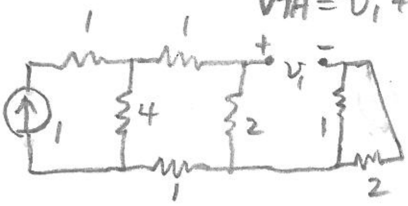
$R_{TH} = \left[\left(1+(1 /\!/ 4)+1\right) /\!/ 2\right]+1$

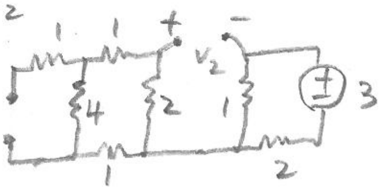
$= \left[\frac{14}{5} /\!/ 2\right]+1$

$= \frac{\frac{14}{5}\times2}{\frac{14}{5}+2}+1 = \frac{28}{24}+1 = \frac{13}{6}$

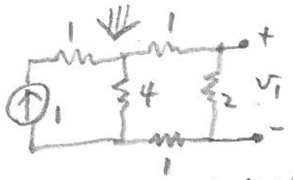
for V_{TH}, we may use superposition

$V_{TH} = v_1 + v_2$





⇓



use current divider and element law

$v_1 = \left[1 \times \frac{4}{4+(1+2+1)}\right] \times 2$

$= 1$

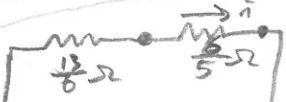
⇓

use voltage divider

$v_2 = -3 \times \frac{1}{1+2} = -1$

Therefore $V_{TH} = v_1 + v_2$

$= 0$



$i = 0$ #