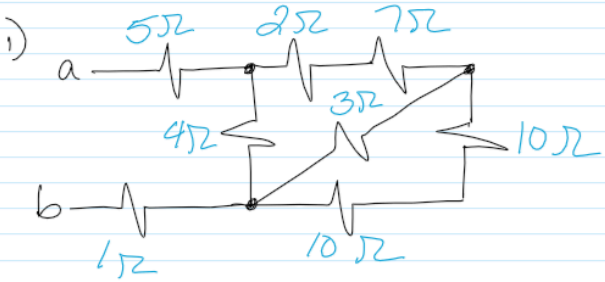
Sample Problems for ESE 271

Finding Equivalent Resistance

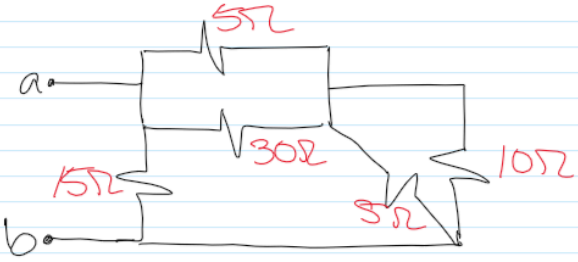
Problem Set 1: Equivalent Resistances

Find $R_{eq} = R_{ab}$ in the following circuits:

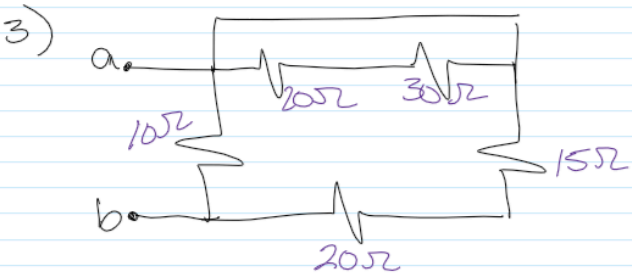
1)



2)

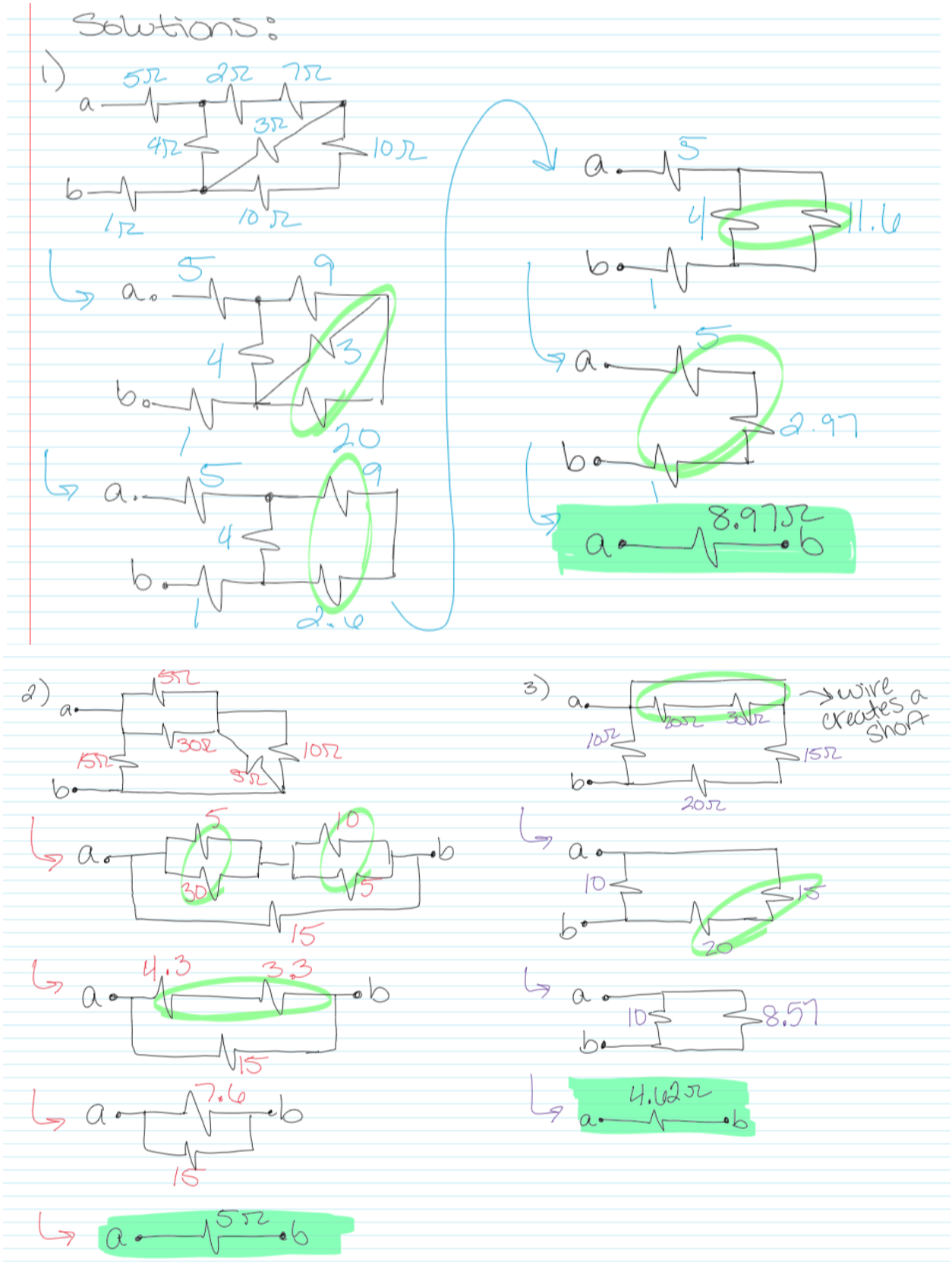


3)



Sample Problems for ESE 271

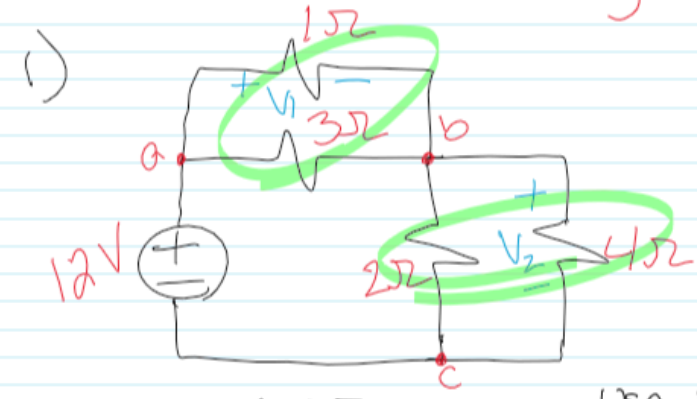
Solutions

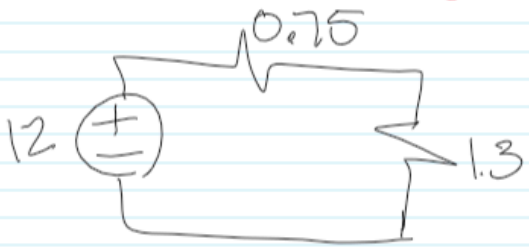


Finding Voltages

Problem Set 2: Finding Voltages

1)





Use KVL:

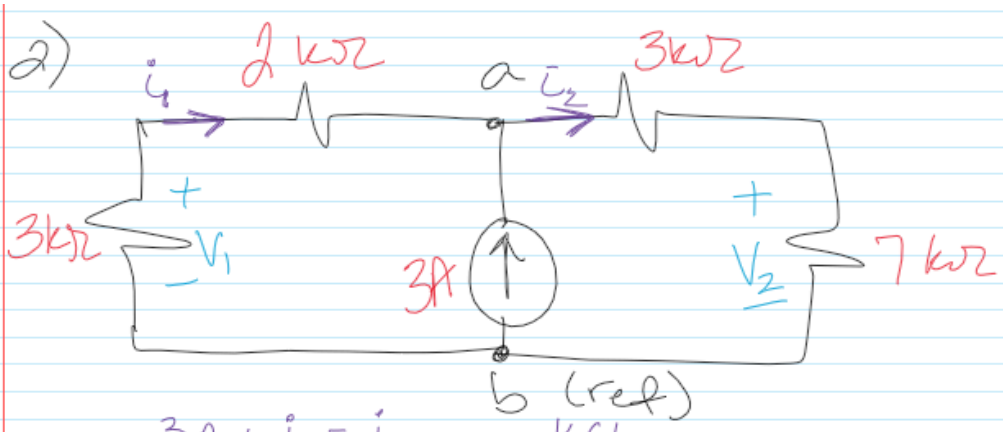
$-12 + 0.75i + 1.3i = 0$

$i \approx 5.9\,A$

$V_{ab} = i \cdot 0.75 = 4.4\,V = V_1$

$V_{bc} = i \cdot 1.3 = 7.7\,V = V_2$

2)



$3A + i_1 = i_2$ KCL

$$i_1 = \frac{V_b - V_A}{5k\Omega} = \frac{-V_a}{5k\Omega} \; ; \; i_2 = \frac{V_a - V_b}{10\,k\Omega} = \frac{V_a}{10k\Omega}$$

$$3 - \frac{V_a}{5k} = \frac{V_a}{10k}$$

$$30k - 2V_a = V_a$$

$$30k = 3V_a$$

$$V_a = 10\,kV$$

$$i_1 = \frac{-10\,kV}{5k\Omega} = -2A$$

$$i_2 = \frac{10kV}{10k\Omega} = 1A$$

$$V_1 = -i_1 \cdot 3k\Omega = -(-2)(3k)$$

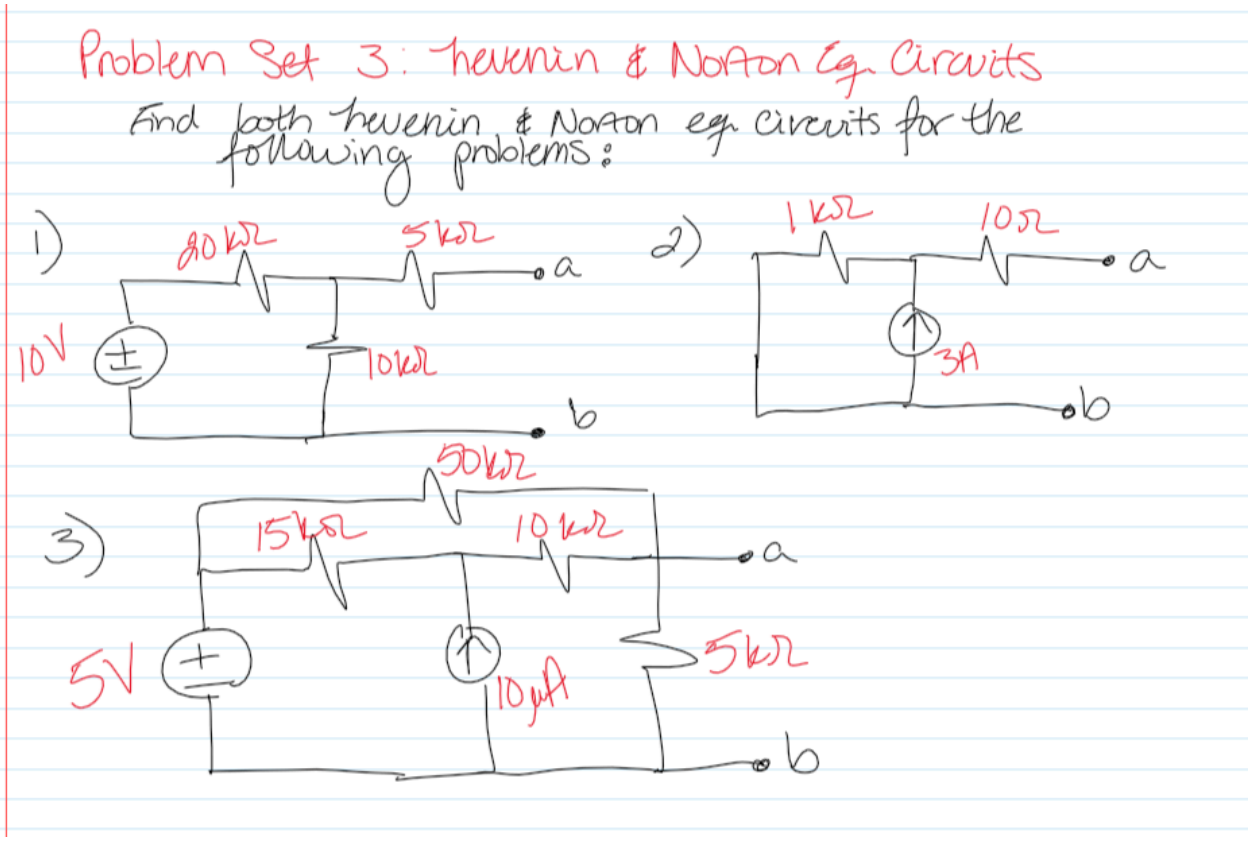
$$V_1 = 6kV$$

$$V_2 = i_2 \cdot 7k\Omega = 1 \cdot 7k$$

$$V_2 = 7kV$$

Sample Problems for ESE 271

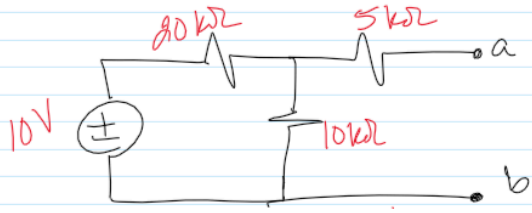
Finding Thevenin and Norton Equivalent Voltages/Currents



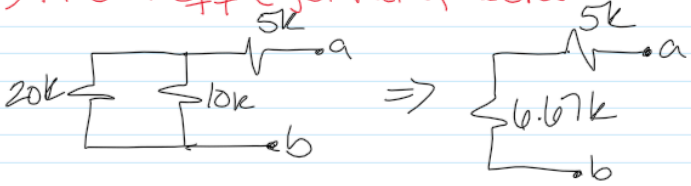
Solution for Problem #1

Solutions:

1)

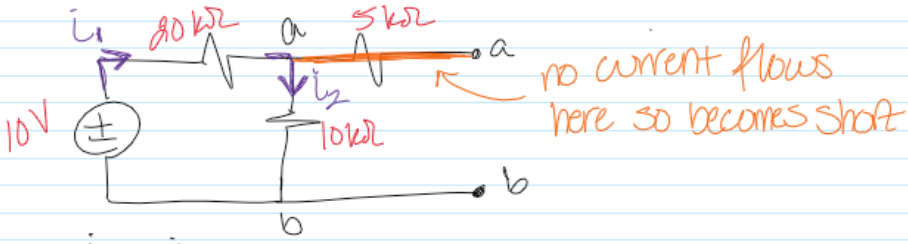


1) Find R_{eq} (get rid of sources: V → SC / I → OC)

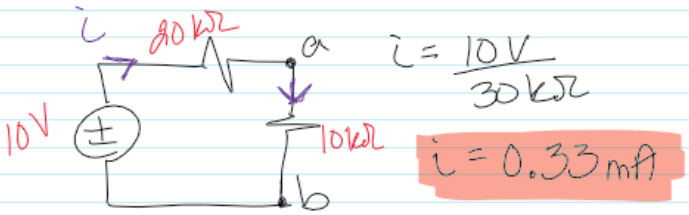


$R_{th} = 11.67\ k\Omega$

2) Find V_{th}



$i_1 = i_2$



$i = \frac{10\ V}{30\ k\Omega}$

$i = 0.33\ mA$

$V_{th} = V_{ab} = i \cdot 10k\Omega$

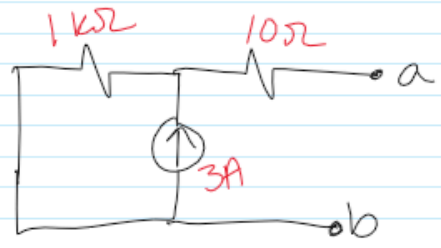
$V_{th} = 3.3\ V$

3) Find I_N

$$I_N = \frac{V_{th}}{R_{eq}} = \frac{3.3V}{11.67\ k\Omega} = 0.283\ mA = I_N$$

Solution for Problem #2

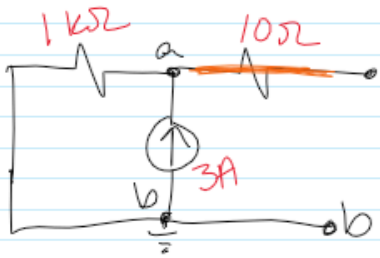
2)



1) Find R_{th} ($I \to 0C$)

$R_{th} = 11\ k\Omega$

2) Find V_{th}



$i = 3A$

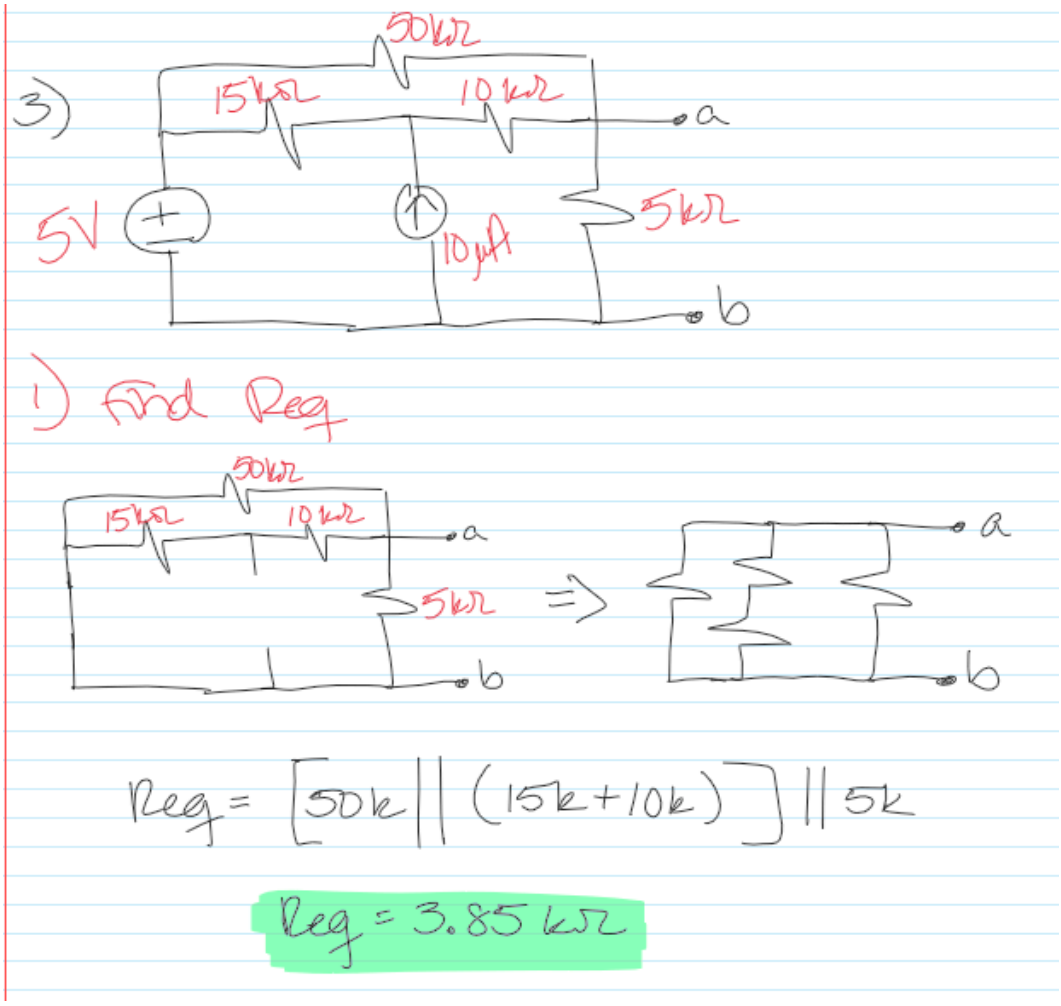
$V_{ab} = i \cdot 1k\Omega = 3kV$

& $V_{ab} = V_{th} = 3kV$

3) Find I_N

$$I_N = \frac{V_{th}}{R_{eq}} = \frac{3kV}{11k\Omega} = 0.27A = I_N$$

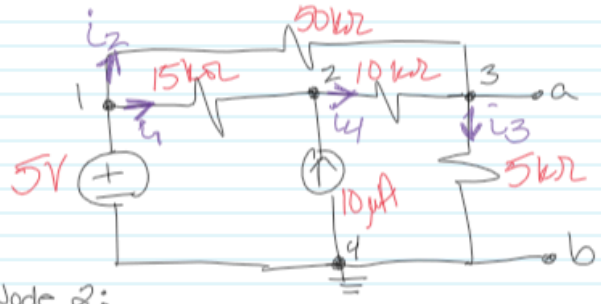
Solution for Problem #3



$$R_{eq} = [50k \,||\, (15k + 10k)] \,||\, 5k$$

$$R_{eq} = 3.85\ k\Omega$$

2) Find V_{th}



Node 2:

$V_1 = 5V$, $i_1 + 10\mu A = i_4$

$i_1 = \frac{5 - V_2}{15k}$, $i_4 = \frac{V_2 - V_3}{10k}$

$\therefore \left(\frac{5 - V_2}{15k} + 10\mu = \frac{V_2 - V_3}{10k}\right) \cdot 15k$

$5 - V_2 + 0.15 = 1.5V_2 - 1.5V_3$

$5.15 = 2.5V_2 - 1.5V_3$

Node 3:

$i_2 + i_4 = i_3$

$i_2 = \frac{5 - V_3}{50k}$, $i_3 = \frac{V_3}{5k}$

$\therefore \left(\frac{5 - V_3}{50k} + \frac{V_2 - V_3}{10k} = \frac{V_3}{5k}\right) \cdot 50k$

$5 - V_3 + 5V_2 - 5V_3 = 10V_3$

$5 + 5V_2 - 6V_3 = 10V_3$

$5 = 16V_3 - 5V_2$

System of equations:

$5.15 = 2.5V_2 - 1.5V_3$

$5 = -5V_2 + 16V_3$

$V_2 = 2.77\ V$ $V_3 = 1.18\ V$

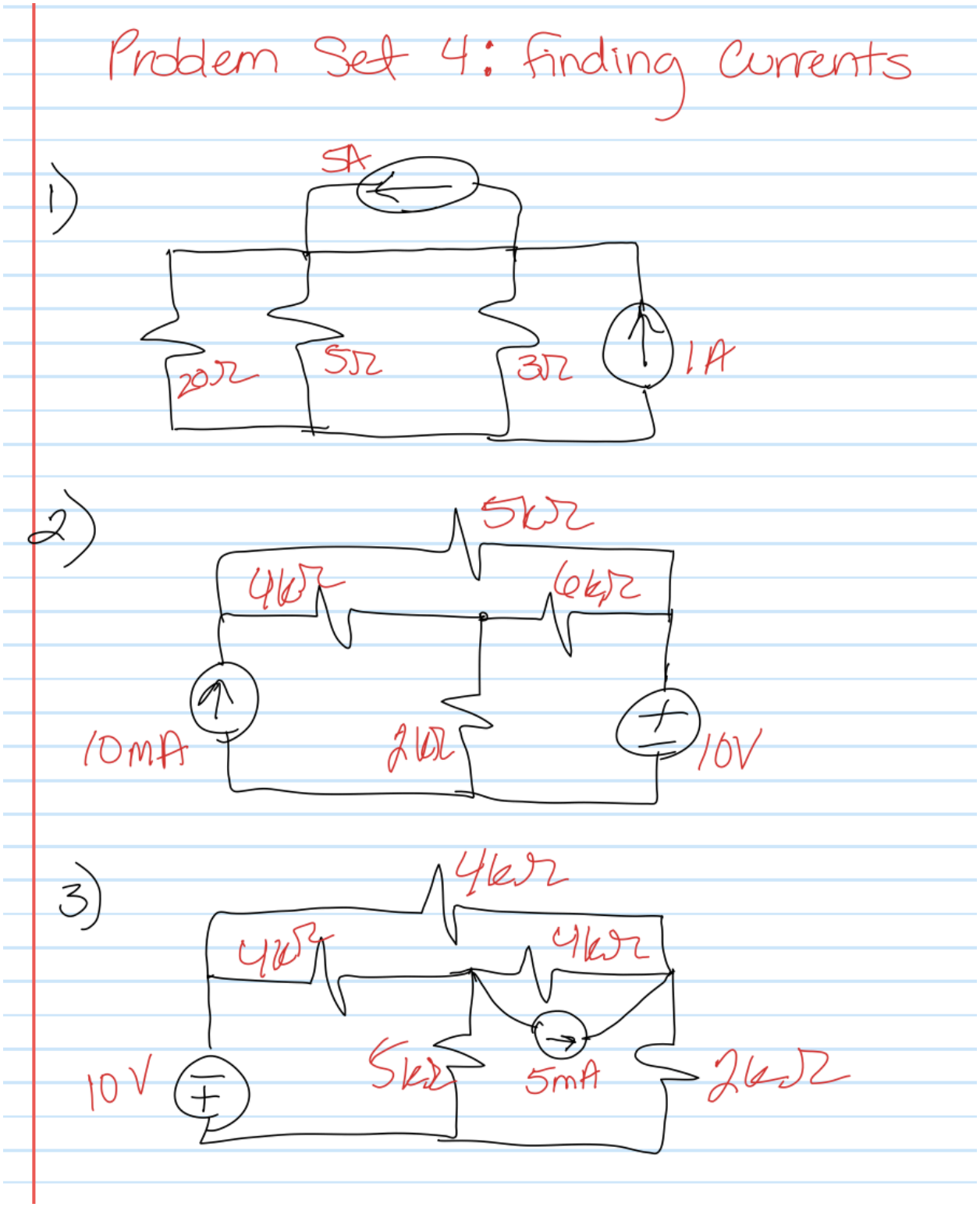
$V_3 = V_{ab} = V_{th} = 1.18\ V$

3) Find I_N

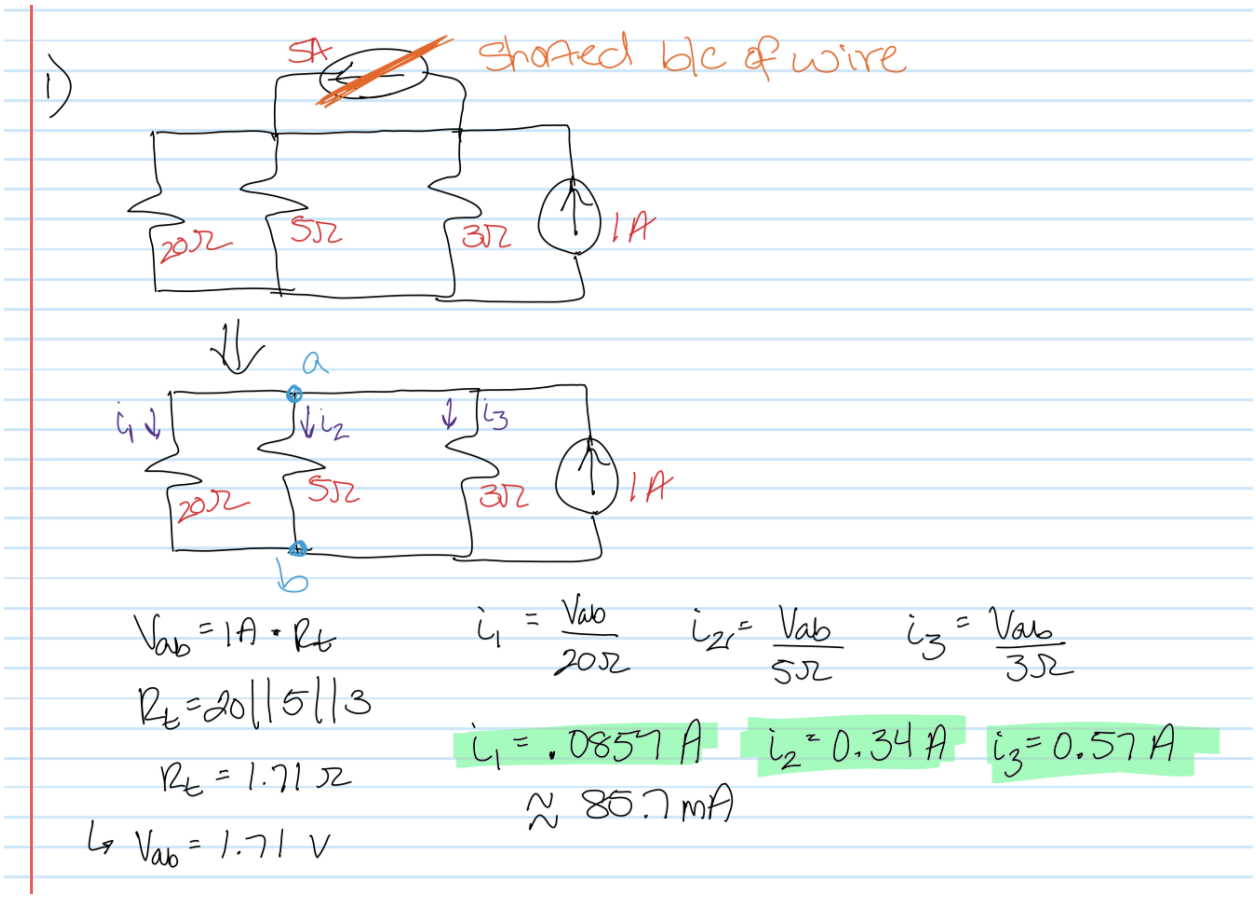
$I_N = \frac{V_{th}}{R_{eq}} = \frac{1.18\ V}{3.85k\Omega} = 0.306\ mA = I_N$

Sample Problems for ESE 271

Finding Currents in a Circuit

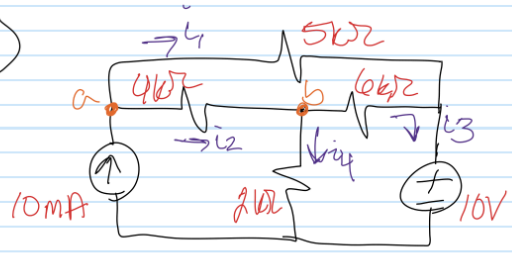


Solution for Problem #1



Solution for Problem #2

2)



node 1: $10\cdot10^{-3} - i_1 - i_2 = 0$

$$\left[10\cdot10^{-3} - \left(\frac{V_a-10}{5k}\right) - \left(\frac{V_a-V_b}{4k}\right) = 0\right] 20k$$

$$200 - 4V_a + 40 - 5V_a + 5V_b = 0$$

$$9V_a - 5V_b = 240$$

node 2: $i_2 - i_3 - i_4 = 0$

$$\left[\left(\frac{V_a-V_b}{4k}\right) - \left(\frac{V_b-10}{6k}\right) - \left(\frac{V_b}{2k}\right) = 0\right] 12k$$

$$3V_a - 3V_b - 2V_b + 20 - 6V_b = 0$$

$$3V_a - 11V_b = -20$$

System: $\begin{cases} 9V_a - 5V_b = 240 \\ 3V_a - 11V_b = -20 \end{cases}$

$$V_a = 32.62\ V$$
$$V_b = 10.7\ V$$

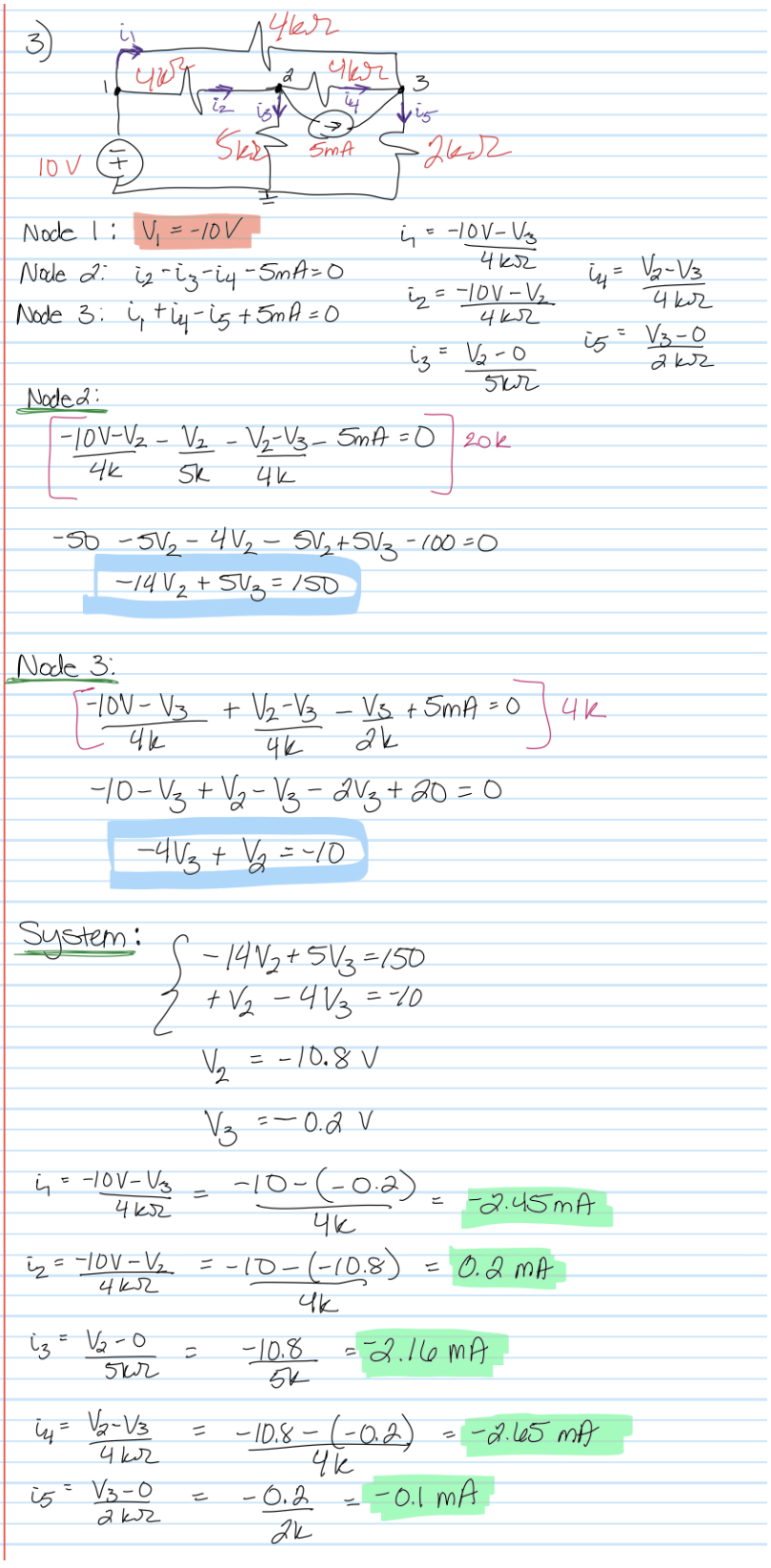
$$i_1 = \frac{V_a-10}{5k} = 4.52\ mA$$

$$i_2 = \frac{V_a-V_b}{4k} = 5.48\ mA$$

$$i_3 = \frac{V_b-10}{6k} = 0.12\ mA$$

$$i_4 = \frac{V_b}{2k} = 5.35\ mA$$

Solution for Problem #3



Node 1: $V_1 = -10V$

Node 2: $i_2 - i_3 - i_4 - 5mA = 0$

Node 3: $i_1 + i_4 - i_5 + 5mA = 0$

$i_1 = \frac{-10V - V_3}{4k\Omega}$

$i_2 = \frac{-10V - V_2}{4k\Omega}$

$i_3 = \frac{V_2 - 0}{5k\Omega}$

$i_4 = \frac{V_2 - V_3}{4k\Omega}$

$i_5 = \frac{V_3 - 0}{2k\Omega}$

Node 2:

$$\left[\frac{-10V - V_2}{4k} - \frac{V_2}{5k} - \frac{V_2 - V_3}{4k} - 5mA = 0\right] 20k$$

$$-50 - 5V_2 - 4V_2 - 5V_2 + 5V_3 - 100 = 0$$

$$-14V_2 + 5V_3 = 150$$

Node 3:

$$\left[\frac{-10V - V_3}{4k} + \frac{V_2 - V_3}{4k} - \frac{V_3}{2k} + 5mA = 0\right] 4k$$

$$-10 - V_3 + V_2 - V_3 - 2V_3 + 20 = 0$$

$$-4V_3 + V_2 = -10$$

System:

$$\begin{cases} -14V_2 + 5V_3 = 150 \\ +V_2 - 4V_3 = -10 \end{cases}$$

$V_2 = -10.8\ V$

$V_3 = -0.2\ V$

$i_1 = \frac{-10V - V_3}{4k\Omega} = \frac{-10 - (-0.2)}{4k} = -2.45mA$

$i_2 = \frac{-10V - V_2}{4k\Omega} = \frac{-10 - (-10.8)}{4k} = 0.2\ mA$

$i_3 = \frac{V_2 - 0}{5k\Omega} = \frac{-10.8}{5k} = -2.16\ mA$

$i_4 = \frac{V_2 - V_3}{4k\Omega} = \frac{-10.8 - (-0.2)}{4k} = -2.65\ mA$

$i_5 = \frac{V_3 - 0}{2k\Omega} = \frac{-0.2}{2k} = -0.1\ mA$