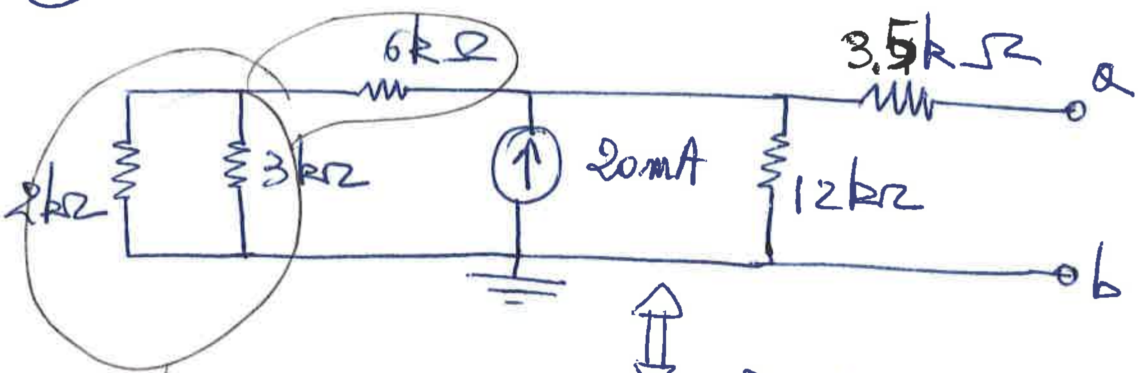
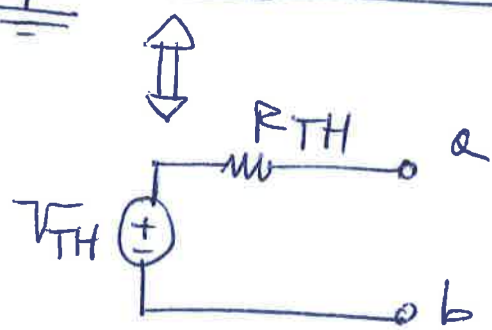
R_{TH}, V_{TH} Calculation

(Extra credit)

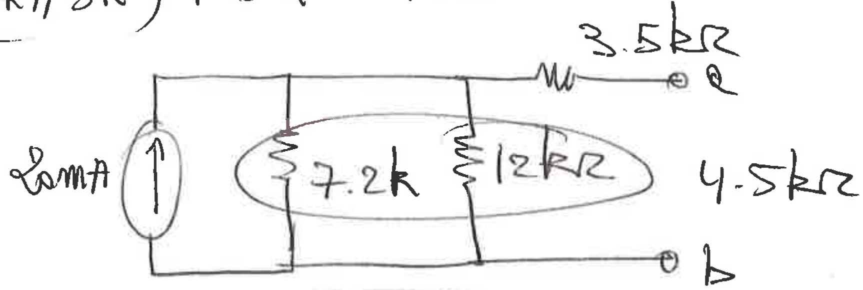
Due: Friday Nov. 6, '09 <u>in class</u>

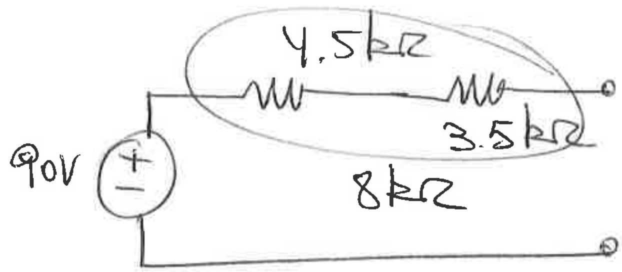
① For the network shown below, calculate V_{TH} & R_{TH}





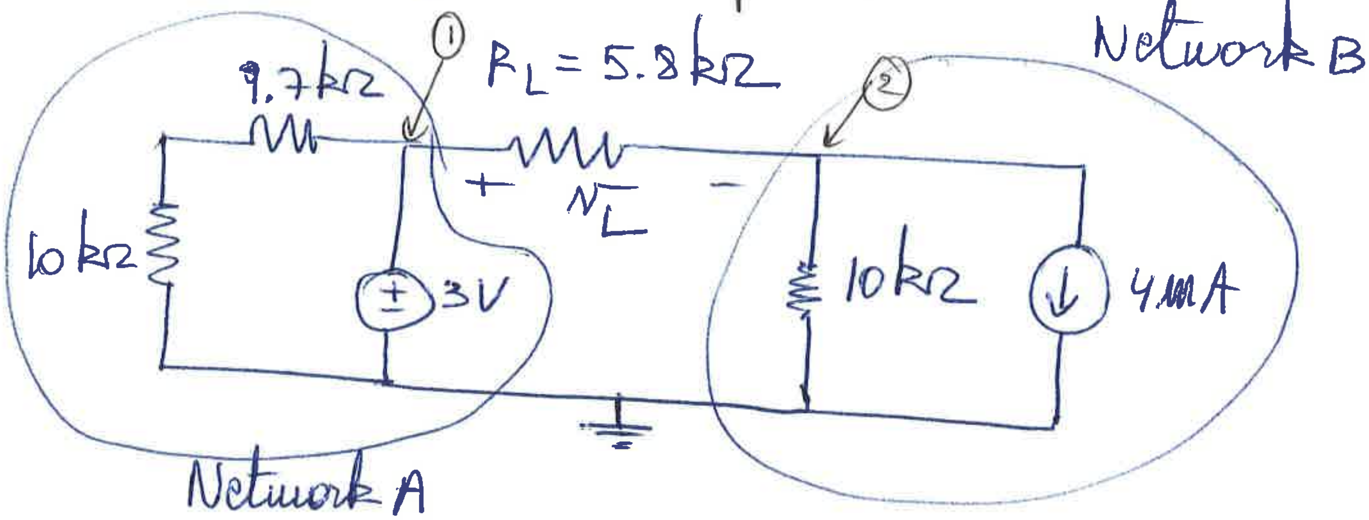
$(2k // 3k) + 6k = 7.2k\Omega$

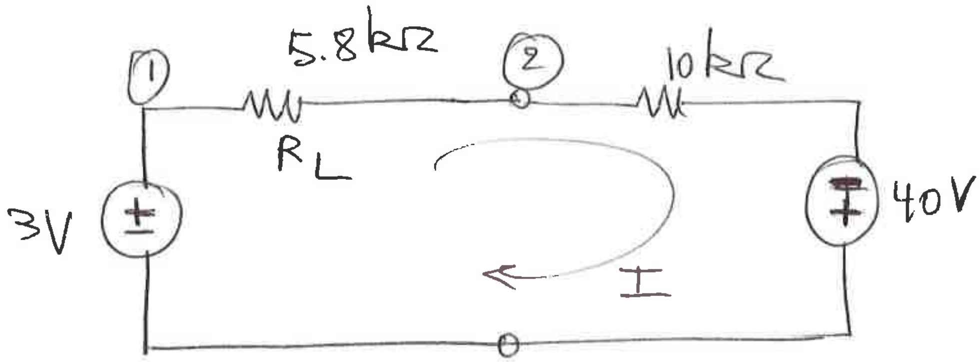




$$\boxed{\begin{aligned} V_{TH} &= 90V \\ R_{TH} &= 8k\Omega \end{aligned}}$$

② For the network shown below, consider the 5.8 kΩ to be a load. Replace networks Ⓐ and Ⓑ by their Thevenin equivalents and calculate the voltage V_L across the load, Power dissipated in 5.8 kΩ.





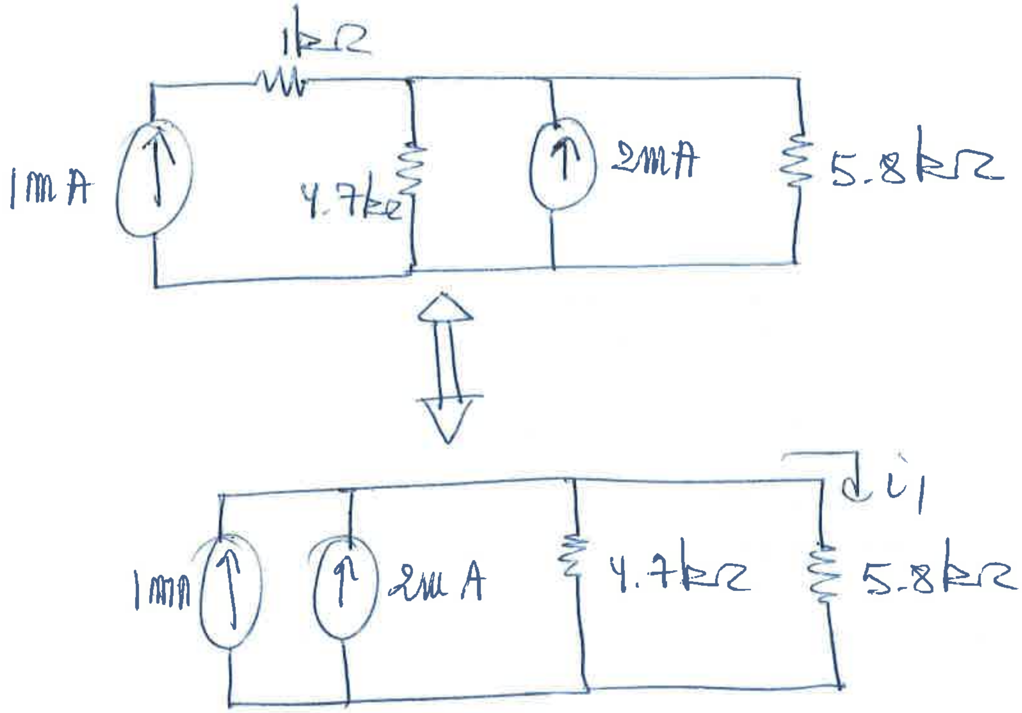
$$I = \frac{43}{15.8}\ mA$$

$$\boxed{P_{5.8k\Omega} = I^2\, 5.8\, 10^3 = 42.97\, mW}$$

Voltage across load.

$$V_{12} = V_L = 5.8\,k\Omega\ \frac{43}{15.8}\ mA = \frac{5.8\,(43)}{15.8}\ V$$

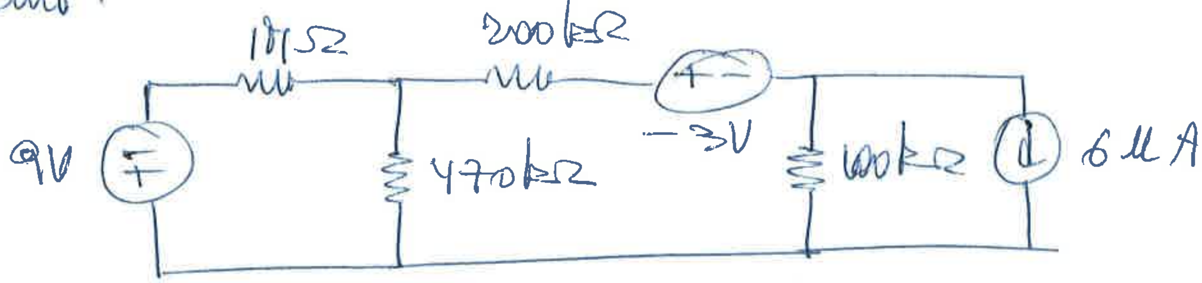
Using source transformation to first simplify the circuit, determine the power dissipated by 5.8 kΩ resistor

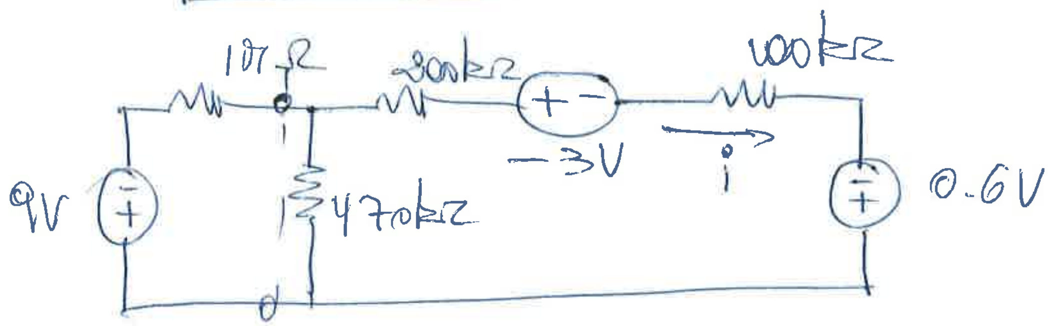


$$i_1 = \frac{4.7}{4.7+5.8}\, 3\,mA = 1.343\,mA$$

$$\boxed{P_{5.8k\Omega} = 5.8\,10^3\, i^2 = 10.46\,mW}$$

Determine power dissipated by 101 Ω resistor using source transformation to simplify circuit.

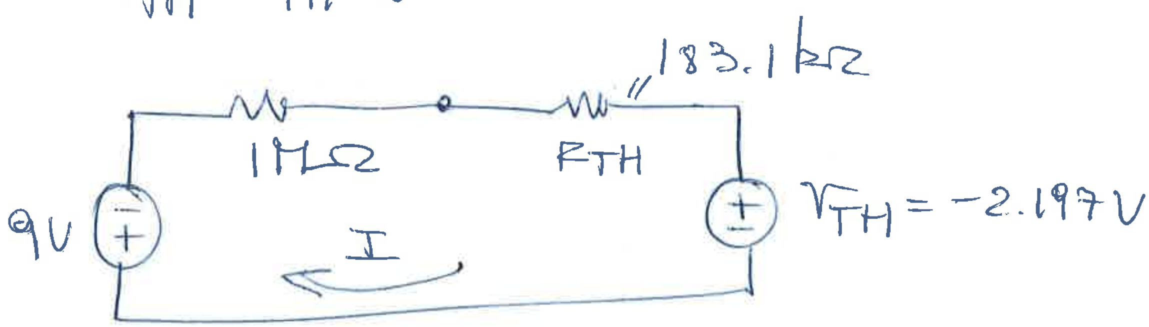




$R_{TH} = (470k // 300k) = 183.1\,k\Omega$

$i_N = -3.6V / 300k\Omega = -12\,\mu A$

$V_{TH} = R_{TH}\, i_N = -2.197\,V$



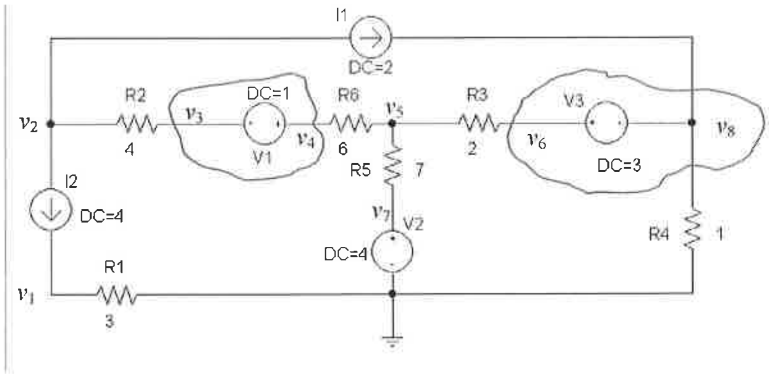
$9 + 1183.1 \times 10^3 I - 2.197 = 0$

$\boxed{I = -5.750\,\mu A}$

$\boxed{P_{101\Omega} = I^2 10^6 = 33.06\,\mu W}$

Hwk #3

24. We begin by selecting the bottom node as the reference, naming each node as shown below, and forming two different supernodes as indicated.



Voltages in volts. Currents in amperes. Resistances in ohms.

By inspection, $v_7 = 4$ V and $v_1 = (3)(4) = 12$ V.

At node 2: $-4 - 2 = (v_2 - v_3)/4$ or $v_2 - v_3 = -24$ [1]

At the 3-4 supernode:
$0 = (v_3 - v_2)/4 + (v_4 - v_5)/6$ or $-6v_2 + 6v_3 + 4v_4 - 4v_5 = 0$ [2]

At node 5:
$0 = (v_5 - v_4)/6 + (v_5 - 4)/7 + (v_5 - v_6)/2$ or $-14v_4 + 68v_5 - 42v_6 = 48$ [3]

At the 6-8 supernode: $2 = (v_6 - v_5)/2 + v_8/1$ or $-v_5 + v_6 + 2v_8 = 4$ [4]

3-4 supernode KVL equation: $v_3 - v_4 = -1$ [5]
6-8 supernode KVL equation: $v_6 - v_8 = 3$ [6]

Rewriting Eqs. [1] to [6] in matrix form,

$$\begin{bmatrix} 1 & -1 & 0 & 0 & 0 & 0 \\ -6 & 6 & 4 & -4 & 0 & 0 \\ 0 & 0 & -14 & 68 & -42 & 0 \\ 0 & 0 & 0 & -1 & 1 & 2 \\ 0 & 1 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & -1 \end{bmatrix} \begin{bmatrix} v_2 \\ v_3 \\ v_4 \\ v_5 \\ v_6 \\ v_8 \end{bmatrix} = \begin{bmatrix} -24 \\ 0 \\ 48 \\ 4 \\ -1 \\ 3 \end{bmatrix}$$

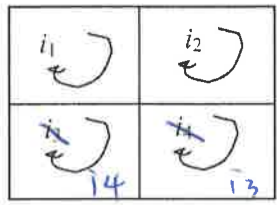
Solving, we find that
$v_2 = -68.9$ V, $v_3 = -44.9$ V, $v_4 = -43.9$ V, $v_5 = -7.9$ V, $v_6 = 700$ mV, $v_8 = -2.3$ V.

The power generated by the 2-A source is therefore $(v_8 - v_6)(2) = \boxed{133.2 \text{ W.}}$

Should be V_2

V_2

43. Define four mesh currents



By inspection, i_1 = -4.5 A. 5 points

We form a supermesh with meshes 3 and 4 as defined above.

MESH 2: $2.2 + 3\,i_2 + 4\,i_2 + 5 - 4\,i_3 = 0$ [1] 30 points

SUPERMESH: $3\,i_4 + 9\,i_4 - 9\,i_1 + 4\,i_3 - 4\,i_2 + 6\,i_3 + i_3 - 3 = 0$ [2] 35 points

Supermesh KCL equation: $i_4 - i_3 = 2$ [3] 20 points

Simplifying and combining terms, we may rewrite these three equations as:

$$\begin{aligned} 7\,i_2 - 4\,i_3 &= -7.2 && [1] \\ -4\,i_2 + 11\,i_3 + 12\,i_4 &= -37.5 && [2] \\ -\,i_3 + i_4 &= 2 && [3] \end{aligned}$$

Solving, we find that i_2 = -2.839 A, i_3 = -3.168 A, and i_4 = -1.168 A.

The power supplied by the 2.2-V source is then $2.2\,(i_1 - i_2) = \boxed{-3.654\text{ W.}}$ 10 points

10

47. (a) Select terminal **b** as the reference terminal, and define a nodal voltage V_1 at the top of the 200-Ω resistor. Then,

$$0 = \frac{V_1 - 20}{40} + \frac{V_1 - V_{TH}}{100} + \frac{V_1}{200} \qquad [1]$$

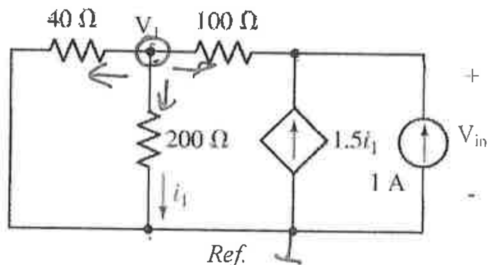
$$1.5\, i_1 = (V_{TH} - V_1)/\, 100 \qquad [2]$$

where $i_1 = V_1/\,200$, so Eq. [2] becomes $\quad 150\, V_1/\,200 + V_1 - V_{TH} = 0 \quad$ [2]

Simplifying and collecting terms, these equations may be re-written as:

$$(0.25 + 0.1 + 0.05)\, V_1 - 0.1\, V_{TH} = 5 \qquad [1]$$
$$(1 + 15/\,20)\, V_1 - V_{TH} = 0 \qquad [2]$$

Solving, we find that $\boxed{V_{TH} = 38.89\text{ V}}$. To find R_{TH}, we short the voltage source and inject 1 A into the port:



$$0 = \frac{V_1 - V_{in}}{100} + \frac{V_1}{40} + \frac{V_1}{200} \qquad [1]$$

$$1.5\, i_1 + 1 = \frac{V_{in} - V_1}{100} \qquad [2]$$

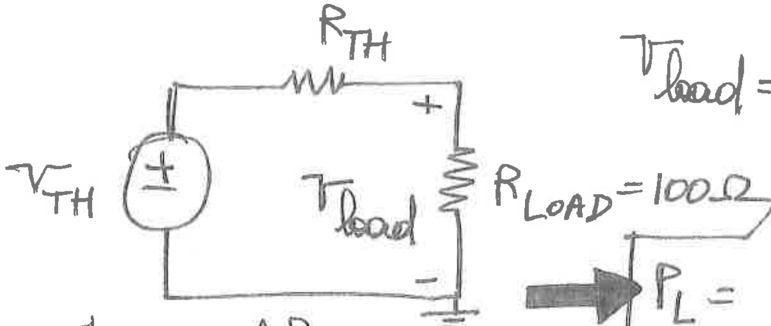
$$i_1 = V_1/\,200 \qquad [3]$$

Combining Eqs. [2] and [3] yields $\quad 1.75\, V_1 - V_{in} = -100 \quad$ [4]

Solving Eqs. [1] & [4] then results in $V_{in} = 177.8$ V, so that $R_{TH} = V_{in}/\, 1\text{ A} = \boxed{177.8\ \Omega.}$

(b) Adding a 100-Ω load to the original circuit or our Thévenin equivalent, the voltage across the load is

$$V_{100\Omega} = V_{TH}\left(\frac{100}{100 + 177.8}\right) = 14.00\text{ V}, \text{ and so } P_{100\Omega} = (V_{100\Omega})^2 / 100 = \boxed{1.96\text{ W.}}$$



$$V_{load} = \frac{V_{TH}\ R_{load}}{R_{load} + R_{TH}}$$

$$\boxed{P_L = \frac{V_L^2}{R_{load}} = 1.96W}$$

Original circuit