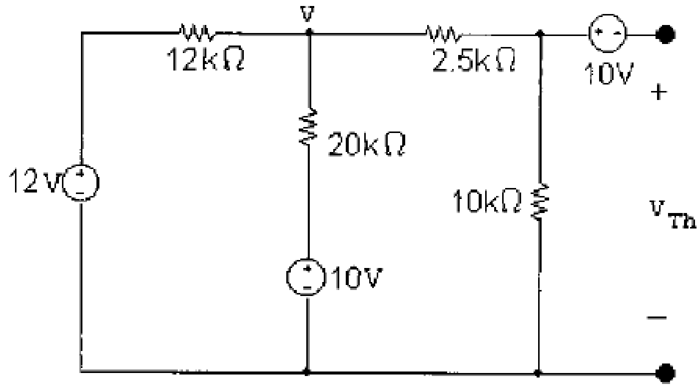
HW#8 Solutions

P 4.77 [a]

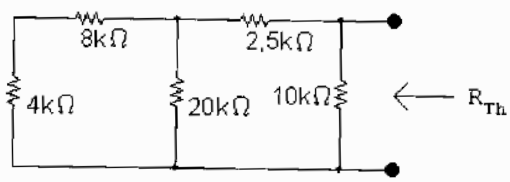


$$\frac{v-12}{12{,}000}+\frac{v-10}{20{,}000}+\frac{v}{12{,}500}=0$$

Solving, $v = 7.03125$ V

$$v_{10k}=\frac{10{,}000}{12{,}500}(7.03125)=5.625\ \text{V}$$

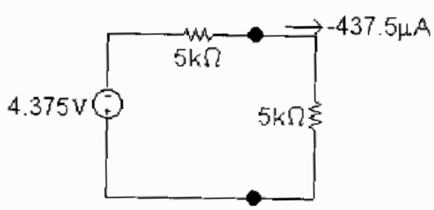
$\therefore\quad V_{Th} = v - 10 = -4.375$ V



$R_{Th} = [(12{,}000\|20{,}000) + 2500] = 5\ \text{k}\Omega$

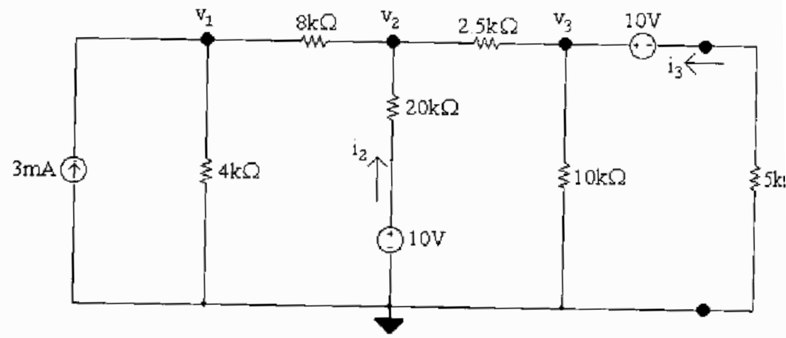
$R_o = R_{Th} = 5\ \text{k}\Omega$

[b]



$p_{max} = (-437.5\times 10^{-6})^2(5000) = 957.03\ \mu\text{W}$

P 4.78 Write KCL equations at each of the labeled nodes, place them in standard form, a
solve:



At v_1: $$-3\times10^{-3}+\frac{v_1}{4000}+\frac{v_1-v_2}{8000}=0$$

At v_2: $$\frac{v_2-v_1}{8000}+\frac{v_2-10}{20{,}000}+\frac{v_2-v_3}{2500}=0$$

At v_3: $$\frac{v_3-v_2}{2500}+\frac{v_3}{10{,}000}+\frac{v_3-10}{5000}=0$$

Standard form:

$$v_1\left(\frac{1}{4000}+\frac{1}{8000}\right)+v_2\left(-\frac{1}{8000}\right)+v_3(0)=0.003$$

$$v_1\left(-\frac{1}{8000}\right)+v_2\left(\frac{1}{8000}+\frac{1}{20{,}000}+\frac{1}{2500}\right)+v_3\left(-\frac{1}{2500}\right)=\frac{10}{20{,}000}$$

$$v_1(0)+v_2\left(-\frac{1}{2500}\right)+v_3\left(\frac{1}{2500}+\frac{1}{10{,}000}+\frac{1}{5000}\right)=\frac{10}{5000}$$

Calculator solution:

$v_1 = 10.890625$ V $\qquad v_2 = 8.671875$ V $\qquad v_3 = 7.8125$ V

Calculate currents:

$$i_2=\frac{10-v_2}{20{,}000}=66.40625\,\mu\text{ A}\qquad i_3=\frac{10-v_3}{5000}=437.5\,\mu\text{ A}$$

Calculate power delivered by the sources:

$$p_{3\text{mA}}=(3\times10^{-3})v_1=(3\times10^{-3})(10.890625)=32.671875\text{ mW}$$

$$p_{10\text{Vmiddle}}=i_2(10)=(66.40625\times10^{-6})(10)=0.6640625\text{ mW}$$

$$p_{10\text{Vtop}}=i_3(10)=(437.5\times10^{-6})(10)=4.375\text{ mW}$$

$$p_{\text{deliveredtotal}}=32.671875+0.6640625+4.375=37.7109375\text{ mW}$$

Calculate power absorbed by the 5 kΩ resistor and the percentage power:

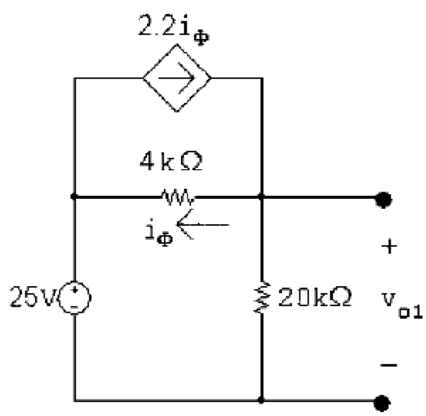
$$p_{5\text{k}}=i_3^2(5000)=(437.5\times10^{-6})^2(5000)=0.95703125\text{ mW}$$

% delivered to R_o: $$\frac{0.95793125}{37.7109375}(100)=2.54\%$$

4.86 [a] Since $0 \leq R_o < \infty$ maximum power will be delivered to the 8 Ω resistor when $R_o = 0$.

[b] $P = \frac{24^2}{8} = 72$ W

P 4.90 Voltage source acting alone:

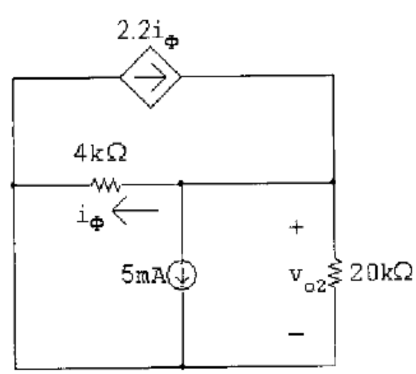


$$\frac{v_{o1} - 25}{4000} + \frac{v_{o1}}{20{,}000} - 2.2\left(\frac{v_{o1} - 25}{4000}\right) = 0$$

Simplifying $\quad 5v_{o1} - 125 + v_{o1} - 11v_{o1} + 275 = 0$

$\therefore \quad v_{o1} = 30$ V

Current source acting alone:



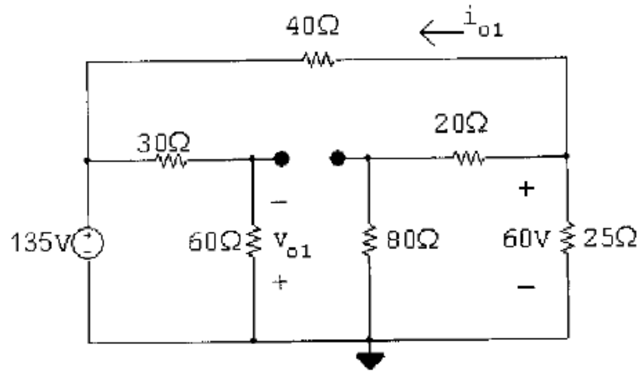
$$\frac{v_{o2}}{4000} + \frac{v_{o2}}{20{,}000} + 0.005 - 2.2\left(\frac{v_{o2}}{4000}\right) = 0$$

Simplifying $\quad 5v_{o2} + v_{o2} + 100 - 11v_{o2} = 0$

$\therefore \quad v_{o2} = 20$ V

$v_o = v_{o1} + v_{o2} = 30 + 20 = 50$ V

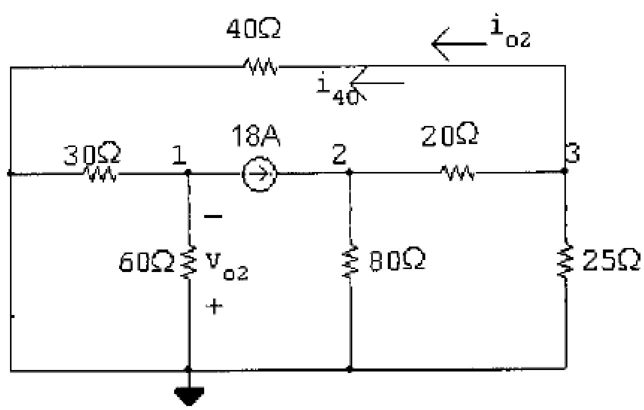
P 4.91 Voltage source acting alone:



$$i_{o1} = \frac{-135}{40 + 100\|25} = -2.25 \text{ A}$$

$$v_{o1} = \frac{60}{90}(-135) = -90 \text{ V}$$

Current source acting alone:



$$\frac{v_1}{30} + \frac{v_1}{60} + 18 = 0 \quad \therefore \quad v_1 = -360 \text{ V}; \quad v_{o2} = 360 \text{ V}$$

$$-18 + \frac{v_2}{80} + \frac{v_2 - v_3}{20} = 0$$

$$\frac{v_3 - v_2}{20} + \frac{v_3}{25} + \frac{v_3}{40} = 0$$

$$\therefore \quad v_2 = 441.6 \text{ V}; \quad v_3 = 192 \text{ V}; \quad i_{o2} = 192/40 = 4.8 \text{ A}$$

$$\therefore \; v_o = v_{o1} + v_{o2} = -90 + 360 = 270 \text{ V}$$

$$i_o = i_{o1} + i_{o2} = -2.25 + 4.8 = 2.55 \text{ A}$$