Desk Copy

ECE 300
Spring Semester, 2005
HW Set #5

Due: February 24, 2005 **Name** Green
wlg **AM** **PM** **Print(last, first)**

Use Engineering Paper. Work only on one side of the paper. Use this sheet as your cover sheet, placed on top of your work and stapled in the top left-hand corner. Number the problems at the top of the page, in the center of the sheet. **Do neat work. Underline your answers. Show how you got your equations. Be sure to show how you got your answers. Each problem counts 5 points.**

Work the following problems from the text. Answers to the problems, except 4.68, are in the Appendix of the text. You should visit my web site and review the power point slides on op-amps before attempting this homework.

4.68 $P_L = 1.6W$, $V_{TH} = 4V$, $R_{TH} = 0\Omega$

4.69 -1.187 kW

4.75 1 kΩ

5.9 (a) 2V, (b) 2V

5.11 $-2V$, -1 mA

5.13 2.7V, 288 μA

5.15 (a) $-\left(R_1 + R_3 + \frac{R_1 R_3}{R_2}\right)$ (b) -92 kΩ

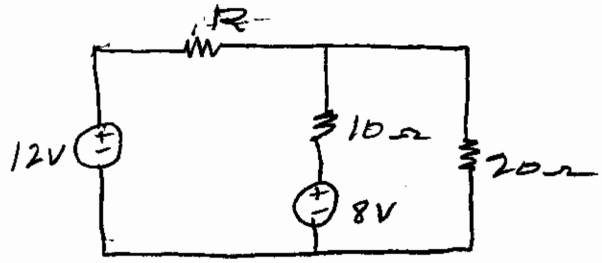
5.19 -0.375 mA

5.27 (a) 10.2, (b) $1.471\cos 120\pi t$

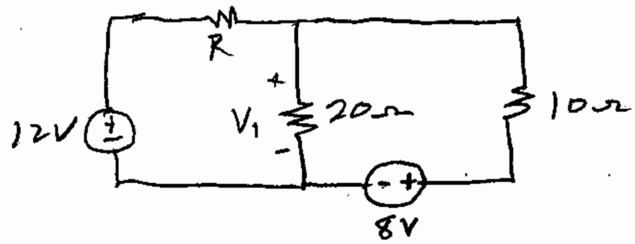
5.31 0.7272 mA

ECE 300
HW #5

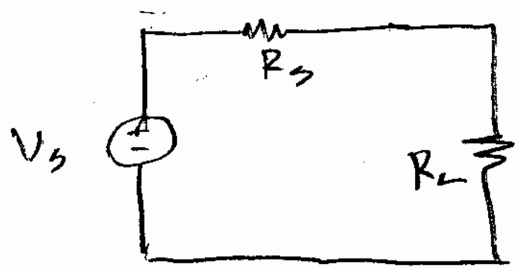
4.68 Find the value of R that results in maximum power transfer to the 10Ω resistor. Find the maximum power.



Redrawn



$$R_{TH} = \frac{20R}{20+R}$$



Consider R_s is the variable resistor; R_L is fixed

At the load

$$P_L = \left(\frac{V_s R_L}{R_s+R_L}\right)^2 \times \frac{1}{R_L} = \frac{V_s^2 R_L}{(R_s+R_L)^2}$$

We see that for

$$P_L = \frac{V_s^2 R_L}{(R_s+R_L)^2}$$

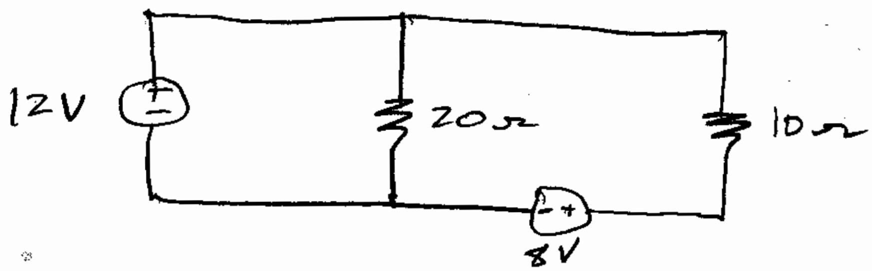
to have the largest value for fixed V_s and R_L; $R_s = 0$.

4.68

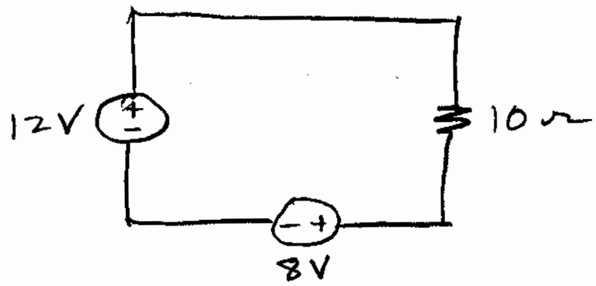
$R_s = 0 = R_{TH} = \dfrac{20R}{20+R}$

Requires $R = 0$

With $R=0$ we have the following;



OR



$P_L = \dfrac{V_L^2}{10} = \dfrac{4^2}{10} = \dfrac{16}{10}$

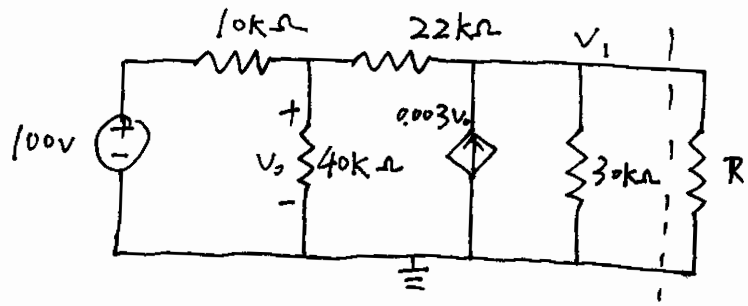
$P_L = 1.6\,V$

$V_{TH} = 4\,V$

$R_{TH} = 0\,\Omega$

4.69

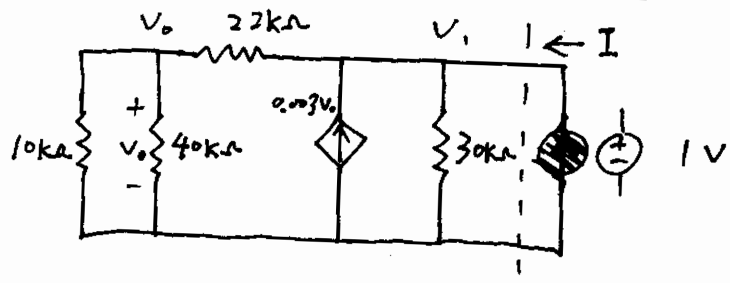
By Pengfei Xi



with R removed,

$$\begin{cases} \frac{V_0 - 100}{10K} + \frac{V_0}{40K} + \frac{V_0 - V_1}{22K} = 0 \\ \frac{V_1 - V_0}{22K} + \frac{V_1}{30K} = 0.003V_0 \end{cases}$$

$$\Rightarrow V_1 = -243.6\text{ V} = V_{TH}$$



$$\begin{cases} \frac{V_0}{10K} + \frac{V_0}{40K} + \frac{V_0 - V_1}{22K} = 0 \\ \frac{V_1 - V_0}{22K} + \frac{V_1}{30K} = 0.003V_0 + I \end{cases}$$

$V_1 = 1\text{ V}$

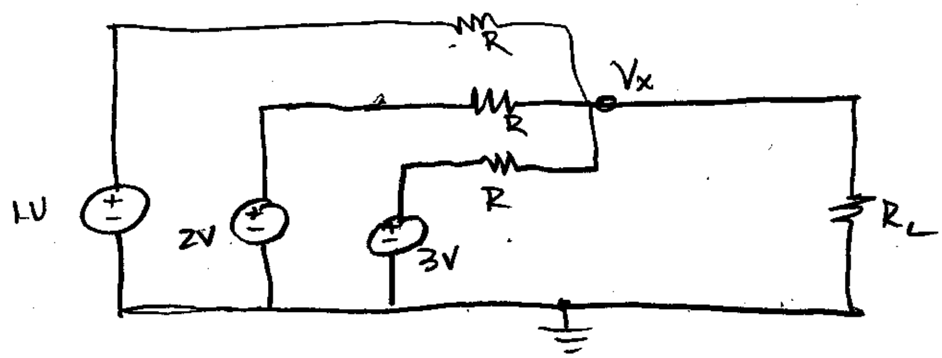
$$\Rightarrow V_0 = 0.267\text{ V}$$

$$I = -0.733\text{ mA}$$

$$R_{TH} = \frac{1}{I} = \frac{1}{-0.733m} = -1.36\text{ k}\Omega$$

$$P_{max} = \frac{V_{TH}^2}{4R_{TH}} = \frac{(-243.6)^2}{4\times(-1.36K)} = -10.9\text{ W}$$

4.75 Determine the value of R such that the maximum power delivered to the load is 3 mW.



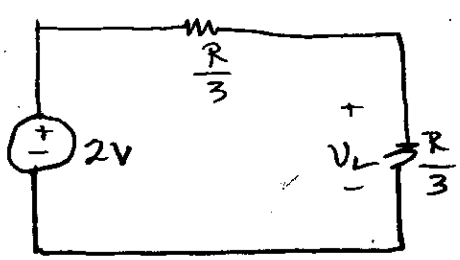
The Thevenin resistance is $\frac{R}{3}$.

With R_L removed we can write a node equation at Vx.

$$\frac{V_x - 1}{R} + \frac{V_x - 2}{R} + \frac{V_x - 3}{R} = 0$$

$$3V_x = 6$$

$$V_x = 2 = V_{TH}$$



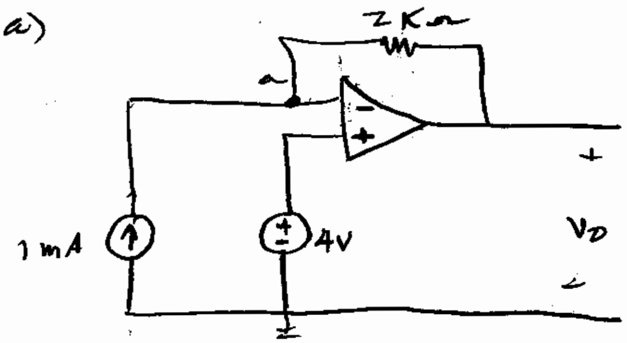
$$V_L = \frac{2 \times \frac{R}{3}}{\frac{R}{3} + \frac{R}{3}} = \frac{2}{2} = 1\,V$$ as expected

$$P_L = \frac{V_L^2}{R/3} = 3\,mW = \frac{3}{R}$$

$R = 1\,K\Omega$

5.9 Determine V_o for each of the following op-amp circuits.

(a)



At a:

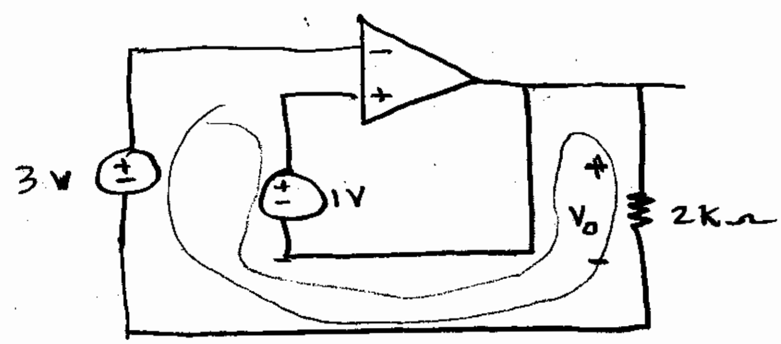
$$1\,mA = \frac{4 - V_o}{2K}$$

or

$$2 = 4 - V_o$$

$$\boxed{V_o = 2V}$$

(b)



Writing KVL around the indicated path gives

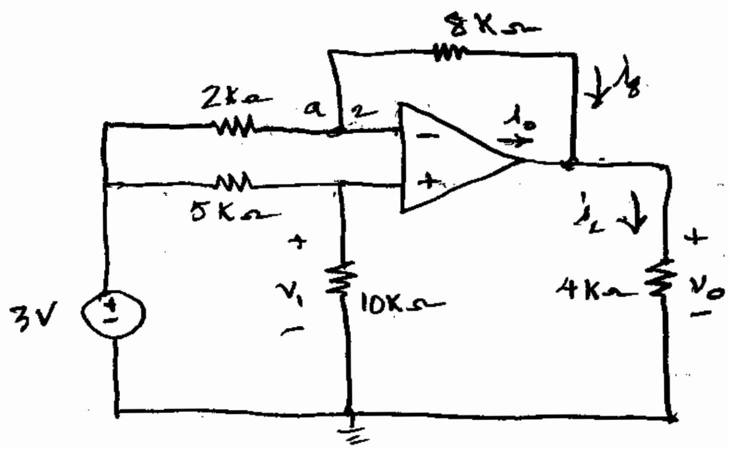
$$-3 + 1 + V_o = 0$$

or

$$\boxed{V_o = 2V}$$

5.11

Find V_o and i_o in the following ckt.



$$V_1 = \frac{3 \times 10K}{15K} = 2V$$

The voltage at node "a" is 2V. Writing a node equation at a gives

$$\frac{2-3}{2K} + \frac{2-V_o}{8K} = 0$$

$$-4 + 2 - V_o = 0$$

$$\boxed{V_o = -2V}$$

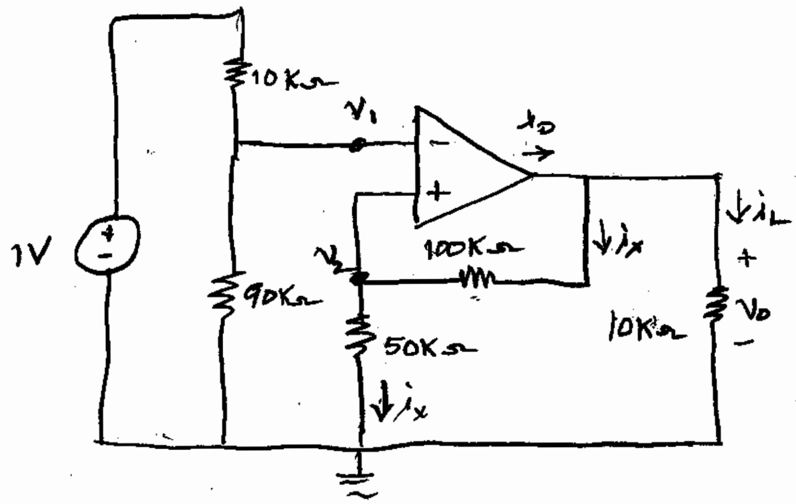
$$i_8 = \frac{2-V_o}{8K} = \frac{4}{8K} = 0.5mA$$

$$i_o + i_8 = i_L = \frac{V_o}{4K} = \frac{-2}{4K} = -0.5mA$$

$$i_o = i_L - i_8 = -0.5mA - 0.5mA$$

$$\boxed{i_o = -1mA}$$

5.13 Find V_o and i_o.



$$V_1 = \frac{1 \times 90}{100} = 0.9\,V$$

$$V_2 = 0.9\,V$$

$$i_x = \frac{0.9}{50K}$$

$$V_o = 0.9 + \left(\frac{0.9}{50K}\right) 100K = 2.7\,V$$

$$\boxed{V_o = 2.7\,V}$$

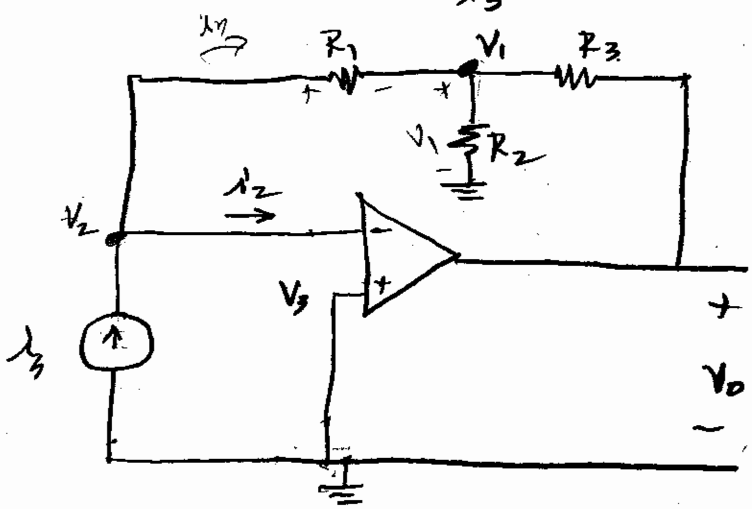
$$i_o = i_x + i_L = \frac{0.9}{50K} + \frac{2.7}{10K}$$

$$i_o = .018\,mA + 0.27\,mA$$

$$\boxed{i_o = 0.288\,mA = 288\,\mu A}$$

5.15 (a) Determine $\frac{v_o}{i_s}$ for the op-Amp ckt below.

(b) With $R_1 = 20k\Omega$, $R_2 = 25k\Omega$, $R_3 = 40k\Omega$ evaluate $\frac{v_o}{i_s}$.



$V_3 = V_2 = 0$, $i_2 = 0$

$\therefore \quad V_1 = -i_s R_1$

Write a nodal eq at V_1

$$\frac{V_1}{R_1} + \frac{V_1}{R_2} + \frac{V_1 - V_o}{R_3} = 0$$

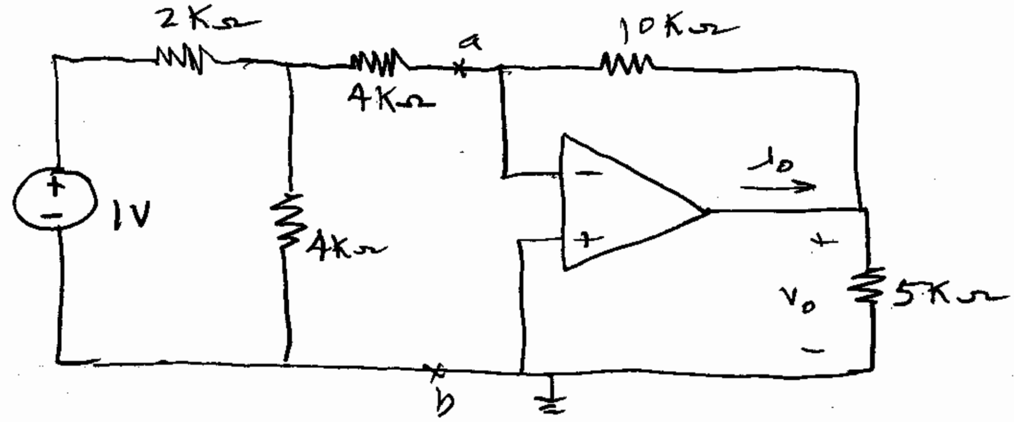
$$\frac{-V_o}{R_3} = \frac{i_s R_1}{R_1} + \frac{i_s R_1}{R_2} + \frac{i_s R_1}{R_3}$$

$$\boxed{\frac{V_o}{i_s} = -\left(R_1 + R_3 + \frac{R_1 R_3}{R_2}\right)}$$

with numbers

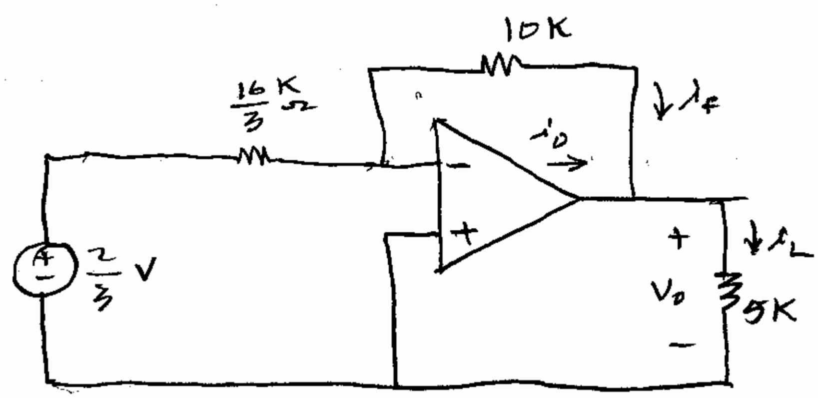
$$\frac{V_o}{i_s} = -\left(20K + 40K + \frac{800K}{25K}\right) = 92K\Omega$$

5.19 Determine i_o



Find the Thevenin ckt to the Left of ab

$$V_{TH} = \frac{1 \times 4}{6} = \frac{2}{3} V, \quad R_{TH} = \frac{2 \times 4}{6} + 4 = \frac{16}{3} Ω$$



$$V_o = -\frac{10K}{(16/3)K} \times \frac{2}{3} = \frac{20}{16} = -\frac{5}{4} V$$

$$i_L = \frac{-5}{4 \cdot 5K} = -0.25 mA$$

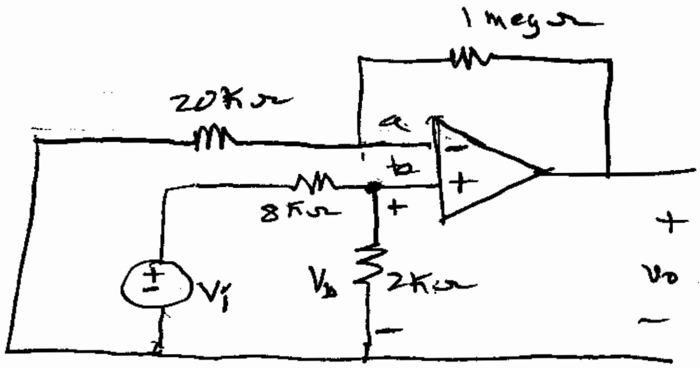
$$i_f = -\frac{V_o}{10K} = +\frac{5}{4 \times 10K} = +\frac{1}{8K} = +.125 mA$$

$$i_o = i_L - i_f = -.375 mA$$

5.27

(a) Determine V_o / V_i

(b) What value of V_i will give $v_o = 15\cos 120\pi t$?



At b:

$$V_b = \frac{V_i\, 2K}{10K} = 0.2V_i$$

Voltage at a is also $0.4 V_i$

Writing a nodal equation at a.

$$\frac{0 - 0.2V_i}{20K} = \frac{0.2V_i - V_o}{1\text{ meg}}$$

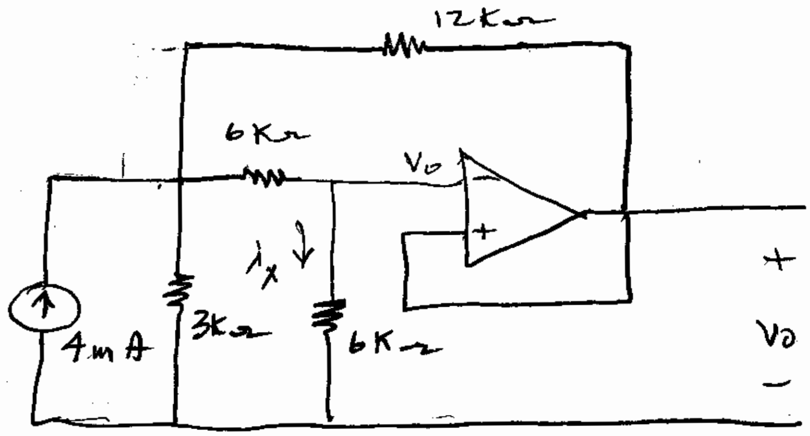
$$-10V_i = 0.2V_i - V_o$$

$$\boxed{\frac{V_o}{V_i} = 10.2}$$

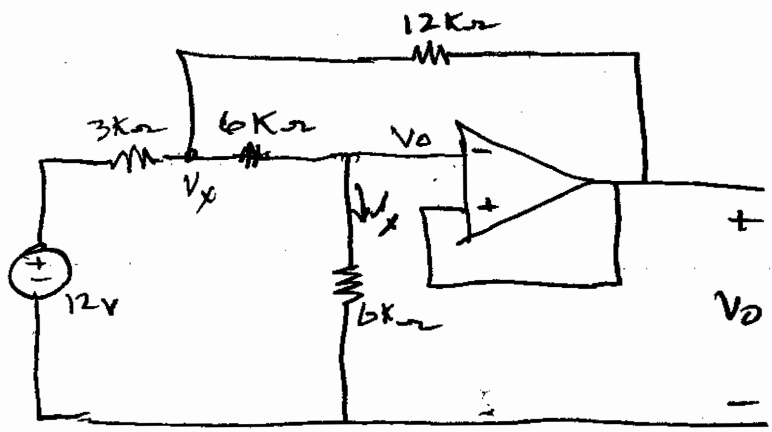
$$V_i = \frac{15\cos 120\pi t}{10.2}$$

$$\boxed{V_i = 1.47\cos 120\pi t}$$

5.31 Find i_x



Use source transformation



$$\frac{V_x - 12}{3K} + \frac{V_x - V_o}{6K} + \frac{V_x - V_o}{12K} = 0$$

$$4V_x - 48 + 2V_x - 2V_o + V_x - V_o = 0$$

$$\boxed{7V_x - 3V_o = 48}$$

$$\frac{V_o - V_x}{6K} + \frac{V_o}{6K} = 0$$

$$\boxed{-V_x + 2V_o = 0}$$

$$V_o = 4.364\text{ V}$$

$$\boxed{i_x = \frac{V_o}{6K} = 0.7273\text{ mA}}$$