ECE 210 Mid-term Exam F 2000

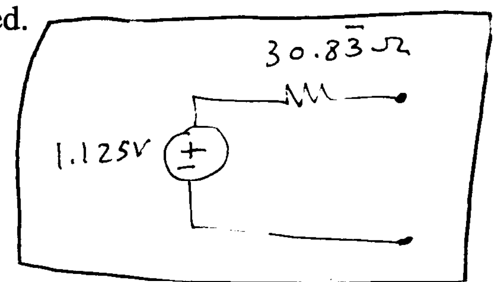
Name:

Honor Code: KEY

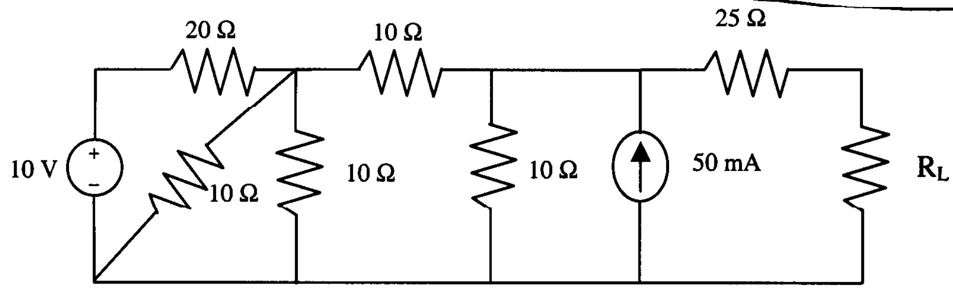
Instructions:

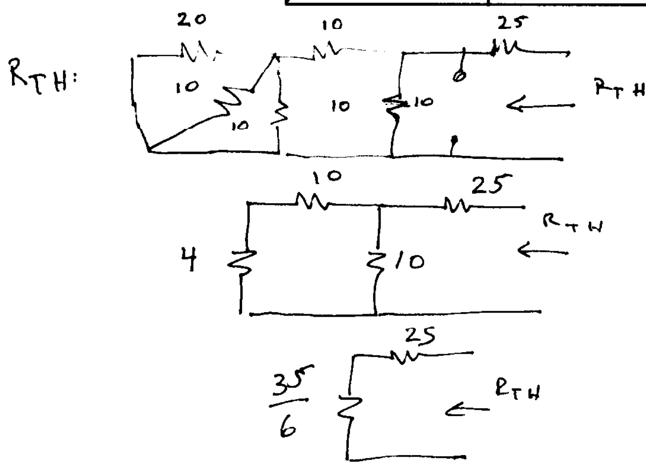
- Use the space on the accompanying pages to work the problems. Do not use a bluebook. Attach additional worksheets if necessary. Label additional sheets with your name.
- If you wish to have partial credit awarded for any of your incorrect answers **you must write clearly and legibly.** Explain your work in words, if necessary.
- Write and sign the honor code when you are finished.
- Don't Panic.

Good Luck.



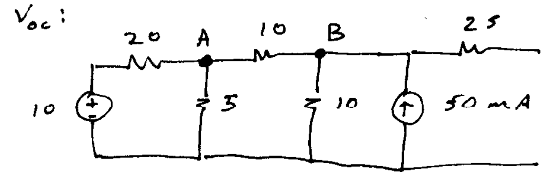
1. [25] Find the Thevenin equivalent circuit for the following.





$R_{TH} = \frac{185}{6} = 30.8\bar{3}\,\Omega$

V_{oc}:



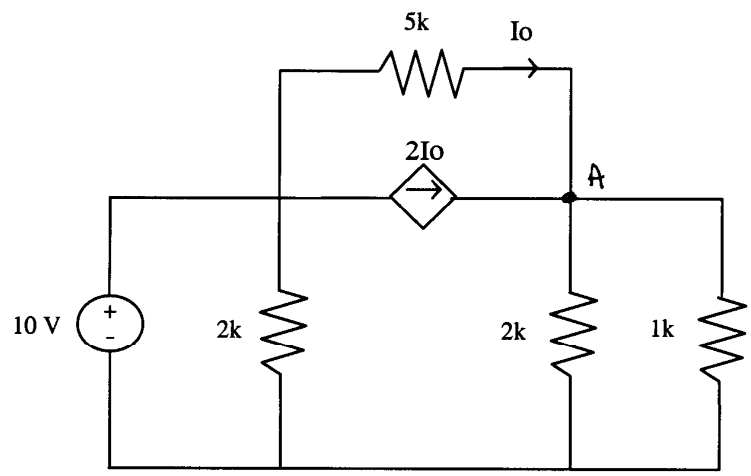
$\frac{A-10}{20} + \frac{A}{5} + \frac{A-B}{10} = 0 \Rightarrow 7A - 2B = 10$

$\frac{B-A}{10} + \frac{B}{10} - 50mA = 0 \Rightarrow -A + 2B = 0.5$

$$\begin{bmatrix} 7 & -2 \\ -1 & 2 \end{bmatrix} \begin{bmatrix} A \\ B \end{bmatrix} = \begin{bmatrix} 10 \\ 0.5 \end{bmatrix}$$

$B = 1.125\ V = V_{oc}$

2. [30] For the following circuit:
   a. [10] Find Io.
   b. [20] Show that the sum of the power absorbed/supplied by the circuit is 0.



a) Nodal @ A: $-I_o - 2I_o + \frac{A}{2000} + \frac{A}{1000} = 0$

$-6000 I_o + 3A = 0$

$A = 2000 I_o$

$I_o = \frac{10 - A}{5000}$ $\qquad A = 10 - 5000 I_o$

$2000 I_o = 10 - 5000 I_o$, $\boxed{I_o = \frac{10}{7} \text{ mA}}$

b) $A = 2000 I_o = 2000\left(\frac{10}{7} \text{ mA}\right) = \frac{20}{7}$ V

Powers:

5K resistor: $P = V^2/R = (10 - 20/7)^2 / 5000 = +10.20$ mW

2K on right: $P = V^2/R = (20/7)^2 / 2000 = +4.08$ mW

1K resistor: $P = V^2/R = (20/7)^2 / 1000 = +8.16$ mW

2k on left: $P = V^2/R = 10^2 / 2000 = +50$ mW

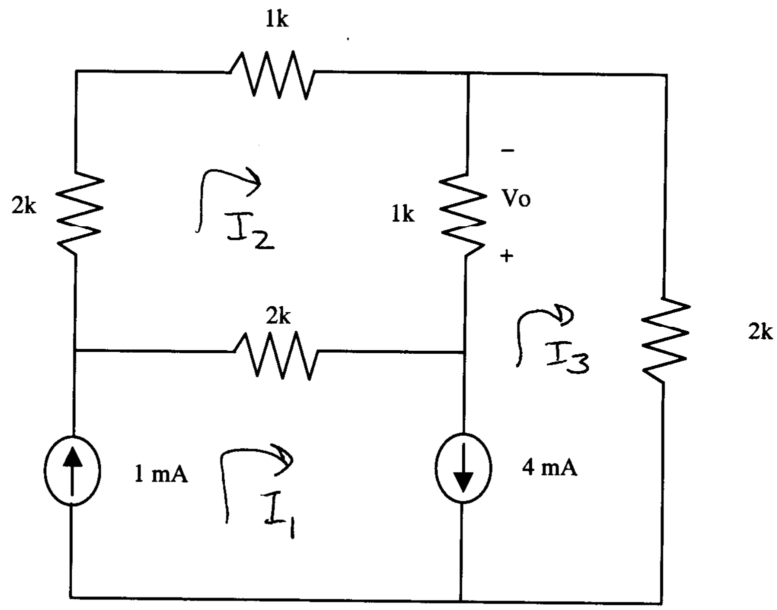
$2I_o$ source: $P = IV = \left(2 \cdot 10/7 \text{ mA}\right)\left(10 - \frac{20}{7}\right) = +20.40$ mW

10 V source: $P = IV = -\left(3I_o + \frac{10}{2000}\right)(10)$

$= -\left(3 \cdot \frac{10}{7} \text{ mA} + \frac{10}{2000}\right)(10) = -92.85$ mW

$\boxed{0 \checkmark}$

3. [15] Find Vo in the following circuit.



$I_1 = 1\,mA$

$I_1 - I_3 = 4\,mA$, $I_3 = -3\,mA$

$$2000\,I_2 + 1000\,I_2 + 1000\,(I_2 - I_3) + 2000\,(I_2 - I_1) = 0$$

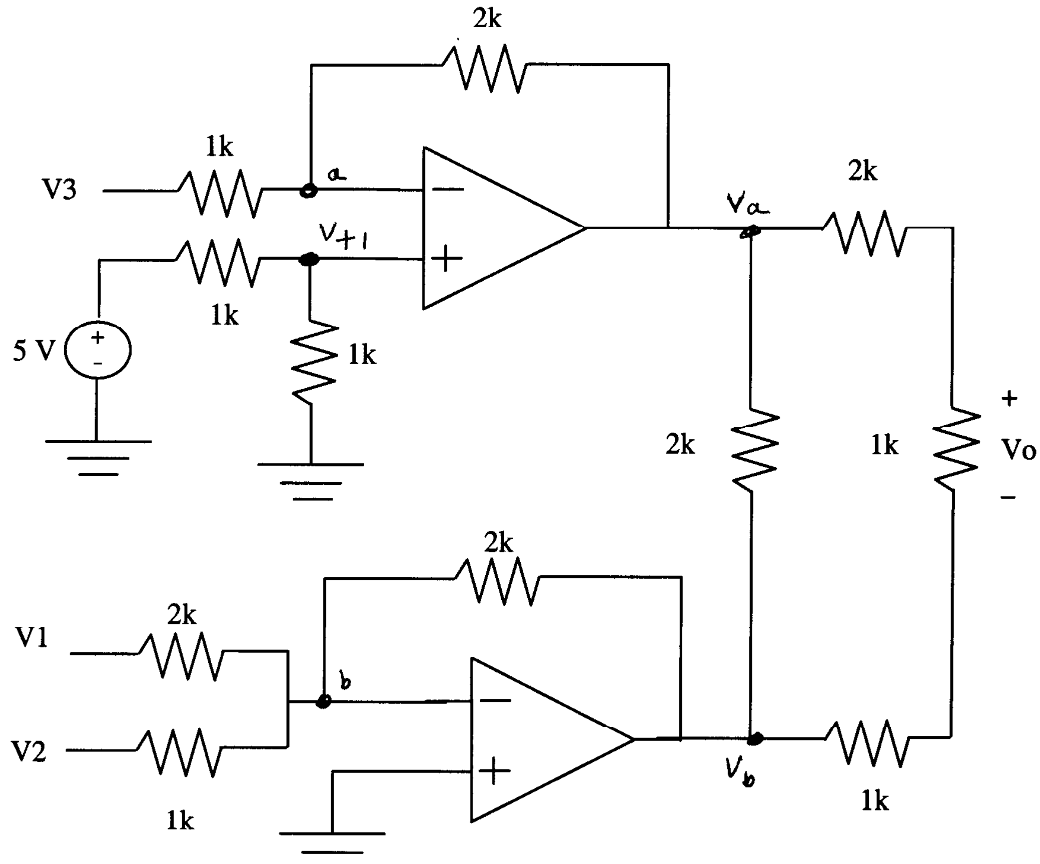
$$-2000\,I_1 + 6000\,I_2 - 1000\,I_3 = 0$$

$$I_2 = \frac{1}{6000}\left(2000\,I_1 + 1000\,I_3\right)$$

$$= \frac{1}{6000}\left(2 - 3\right) = -\frac{1}{6}\,mA$$

$$V_o = 1000\left(I_3 - I_2\right) = 1000\left(-3 + 1/6\right) = -2.833\,V$$

4. [30] Find Vo as a function of V1, V2, and V3 in the following circuit.



Top opamp:

$V_{+1} = 5 \times \left(\frac{1000}{1000+1000} \right) = 2.5\ V$ (Voltage Divider)

nodal at a: $\frac{a - V_3}{1000} + \frac{a - Va}{2000} = 0$, but $a = 2.5\ V$

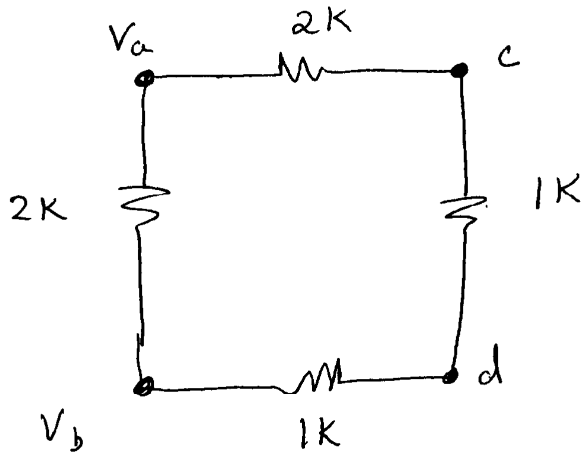
so $V_a = 7.5 - 2V_3$

bottom opamp:

Inverting adder $V_b = -V_1 - 2V_2$

(nodal at b: $\frac{b - V_1}{2000} + \frac{b - V_2}{1000} + \frac{b - V_b}{2000} = 0$)

(cont.)



nodal at c $\quad \dfrac{c - V_a}{2000} + \dfrac{c - d}{1000} = 0$

$$\underline{3c - 2d = V_a}$$

nodal at d $\quad \dfrac{d - c}{1000} + \dfrac{d - V_b}{1000} = 0$

$$\underline{-c + 2d = V_b}$$

add equations $\quad 2c = V_a + V_b$

$$c = \frac{V_a + V_b}{2}$$

$$d = \frac{V_b + c}{2} = \frac{V_b + \frac{1}{2}V_a + \frac{1}{2}V_b}{2} = \frac{3V_b + V_a}{4}$$

$$V_o = c - d = \frac{V_a + V_b}{2} - \frac{3V_b + V_a}{4} = \frac{V_a - V_b}{4}$$

$$\boxed{= \frac{7.5 - 2V_3 + V_1 + 2V_2}{4}}$$