ECSE 2010
Electric Circuits
Exam 1
Spring 2006

Name SOLUTIONS

Section (please circle one)

MR	MR	MR
10-12	2-4	4-6
Millard	Salama	Kraft

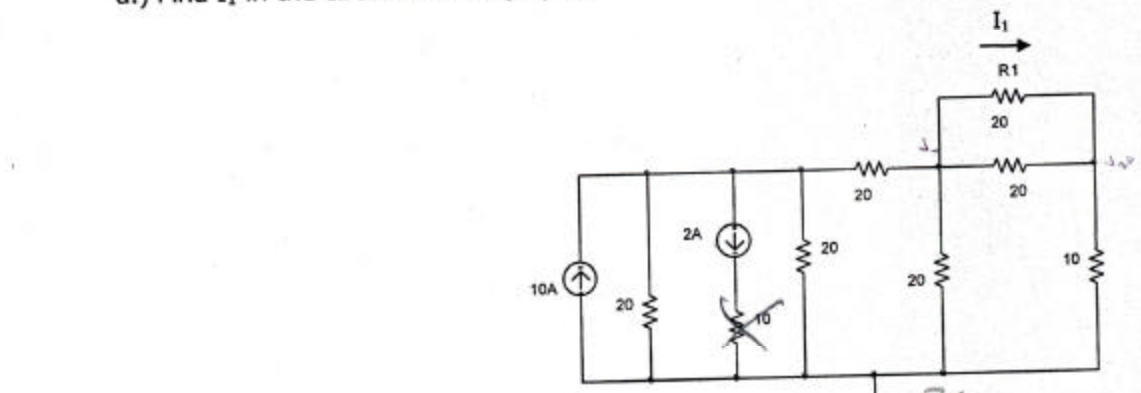
Problem No.	Pts.	Score
1	20pts	X/20
2	20pts	X/20
3	20pts	X/20
4	20pts	X/20
5	20pts	X/20
Total	100pts	X/100

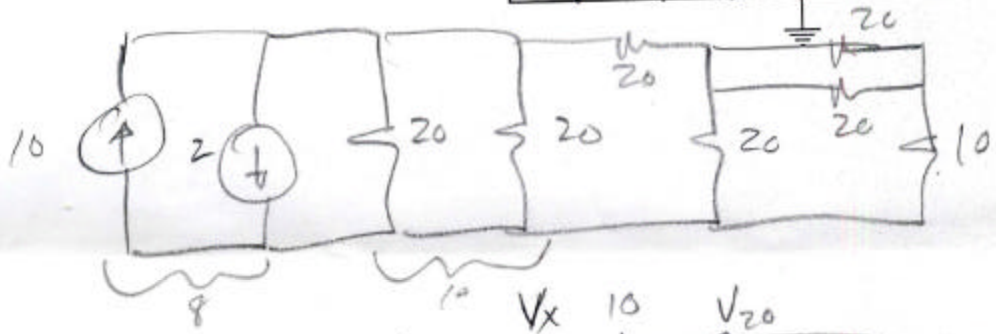
Please Note:

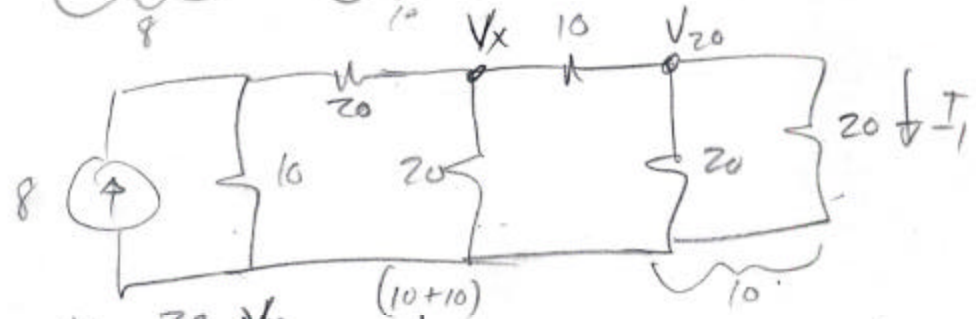
* Place all your answers in the spaces provided.
* You MUST show your work to receive any credit.

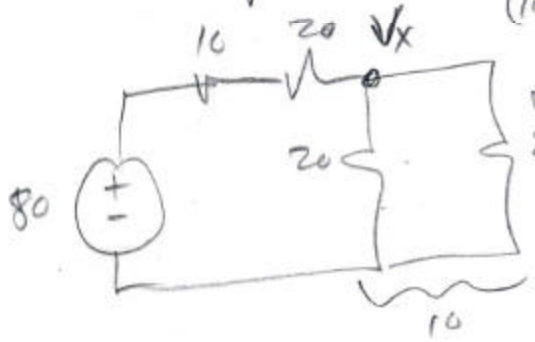
Problem 1 (20pts)

a.) Find I_1 in the circuit shown. (10pts)









$$V_x = 80\,\frac{10}{30+10} = 20V$$

I_1	.5A

10pts

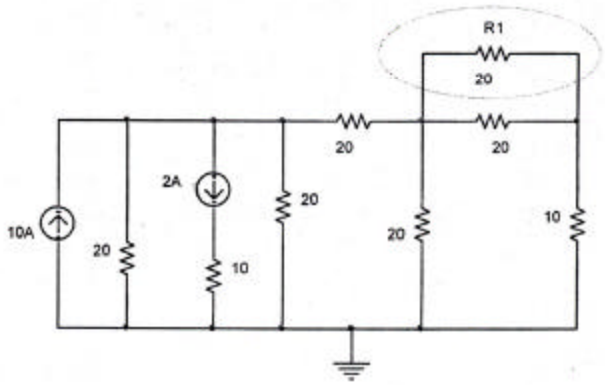
(5pts reductio
5pts solving

$$V_{20} = \frac{1}{2}V_x = 10V$$

$$I_1 = \frac{V_{20}}{20} = \frac{10V}{20} = .5A$$

Problem 1 (cont)

b.) Find the power absorbed by R_1 for in the circuit shown. (10pts)



$V_{R_1} = V_{20}$ (from prior page) } 5pts

$V_{R_1} = 10V$

$P_{R_1} = I_{R_1} \times V_{R_1} = .5A \times 10V = 5W$

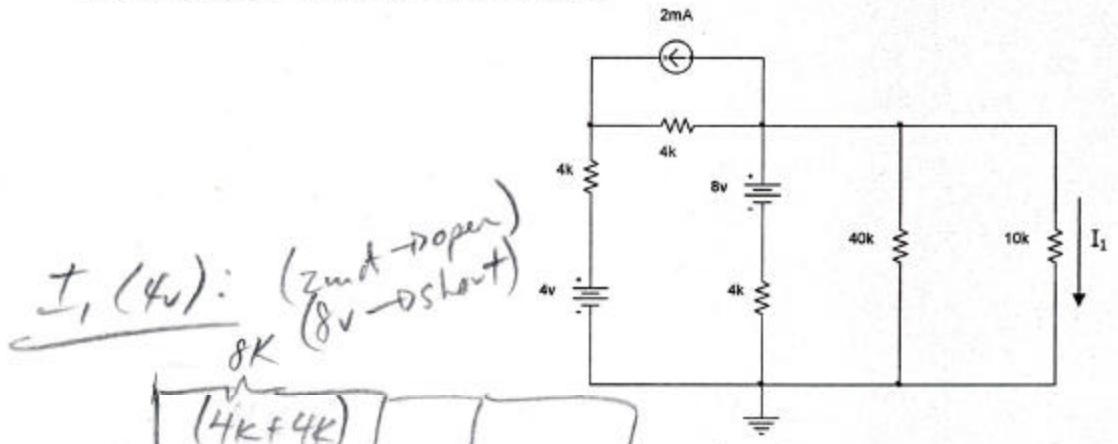
OR } 5pts

$P_{R1} = I_{R_1}^2 \times R = (.5)^2 \times 20$

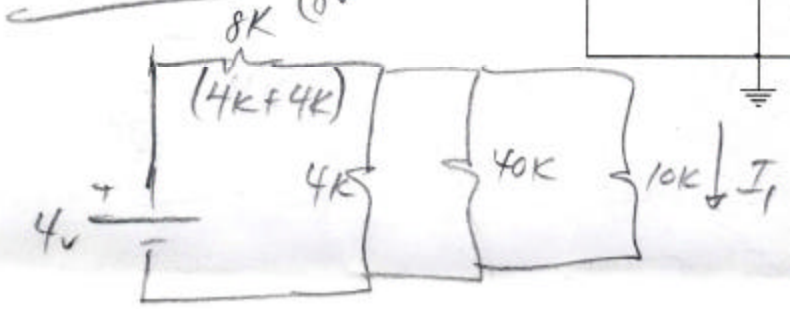
P_{R1}	$5W$	10pts

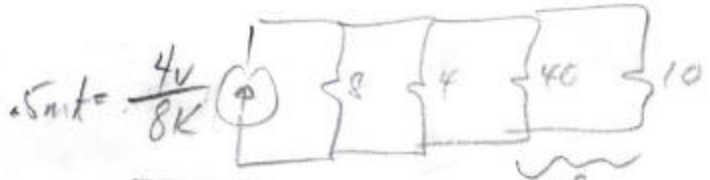
Problem 2 (20pts)

a.) Find I_1 (flowing through the 10k resistor) due to each of the sources using superposition for the circuit shown. (15pts)



I_1 (4v): (2mA → open) (8v → short)

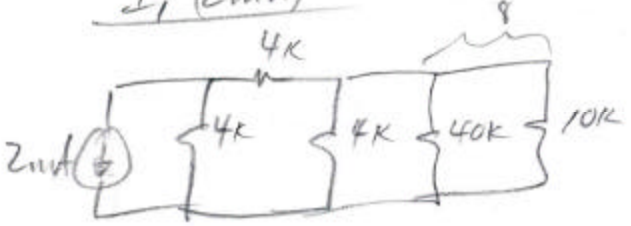


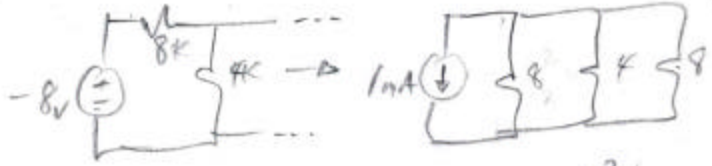


$V = .5 \times 2 = 1.0v$

$I_{10} = \frac{1v}{10K} = 100\,\mu A$

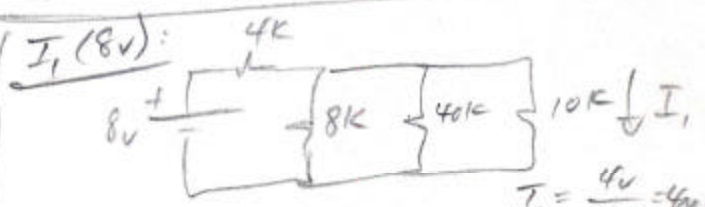
I_1 (2mA):





$I_1 = \frac{-2v}{10K} = -200\,mA$

I_1 (8v):



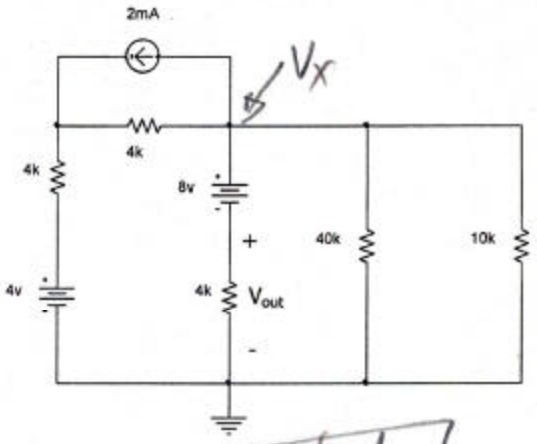
$I_1 = \frac{4v}{10K} = 400\,\mu A$

I_1 (4v)	100 μA	5pts
I_1 (2mA)	-200 μA	5pts
I_1 (8v)	400 μA	5pts

$I_{TOT} = 300\,\mu A$

Problem 2 (cont)

b.) Find V_{out} across the designated 4k resistor in the circuit shown. (5pts)



$V_{OUT} = V_x - 8v$ [from part A]

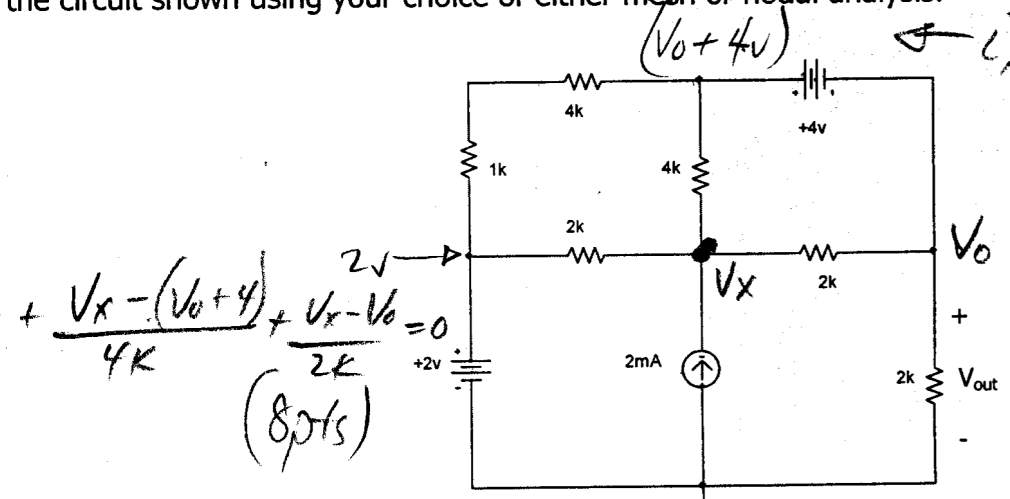
$V_x = I_{10K} \times 10K = 300\mu A \times 10K = 3v$ (3pts)

$V_x = 3v - 8v = -5v$ (2pts)

V_{out}	$-5v$	5pts

Problem 3 (20pts)

Find V_{out} for the circuit shown using your choice of either mesh or nodal analysis.



@ V_x:

(1) $\frac{V_x - 2}{2K} - 2mA + \frac{V_x - (V_o+4)}{4K} + \frac{V_x - V_o}{2K} = 0$ (8pts)

(x4K)

@ V_o:

(2) $\frac{V_o - V_x}{2K} + \frac{V_o}{2K} + \underbrace{\frac{(V_o+4v) - V_x}{4K} + \frac{(V_o+4v) - 2}{5K}}_{i_x} = 0$ (8pts)

(x20K)

(1) $2(V_x - 2) - 8 + V_x - V_o - 4 + 2(V_x - V_o) = 0$

$V_x(2+1+2) + V_o(-1-2) = 4 + 8 + 4$

$5V_x - 3V_o = 16$ $\quad |x3| \rightarrow 15V_x - 9V_o = 48$

(2) $10(V_o - V_x) + 10V_o + 5(V_o + 4) - 5V_x + 4(V_o + 4) - 8 = 0$

$V_x(-10-5) + V_o(10+10+5+4) = -20 - 16 + 8$

$-15V_x + 29V_o = -28$

$+15V_x - 9V_o = 48$

$20V_o = 20$

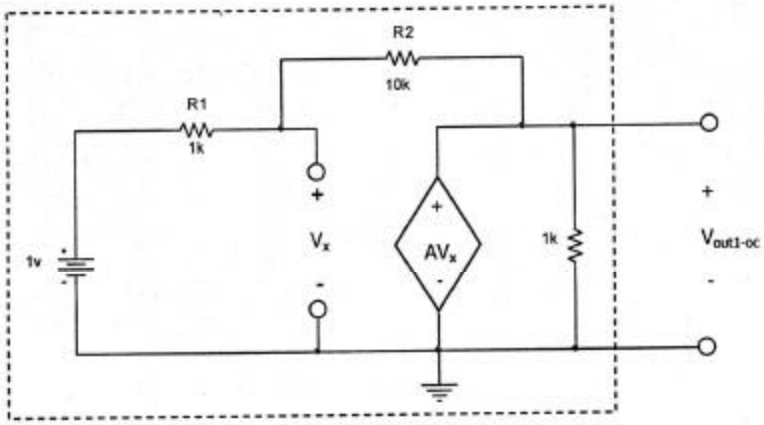
$V_o = \frac{20}{20} = 1v$

V_{out}	$1v$

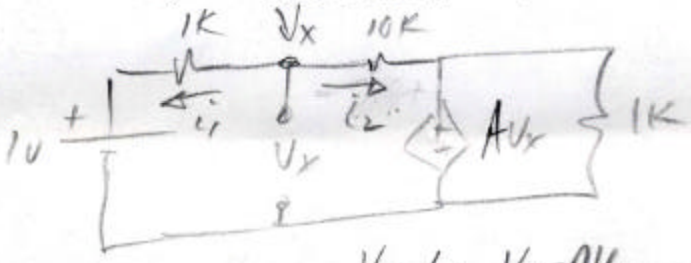
(4pts)

Problem 4 (20pts)

Given the following circuit:



a.) Find $V_{out1\text{-}oc}$ ($V_{Thevenin}$), the open circuit output voltage if **A=9**. (5pts)



$i_1 + i_2 = 0 \;;\; \frac{V_x - 1}{1K} + \frac{V_x - AV_x}{10K} = 0$

$10(V_x - 1) + V_x - AV_x = 0$

$10V_x - 10 + V_x - 9V_x = 0$

$2V_x = 10$

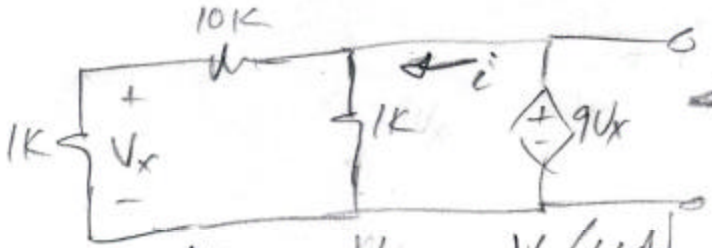
$V_x = 5V$

$V_{TH} = 9V_x = 45V$

V_{TH}	45V

(5pts)

b.) Find the equivalent resistance ($R_{Thevenin}$) that a multimeter would read across the two wires that exit the box if **A=9**. (5pts)



$R_{eq} = \frac{9V_x}{i} = \frac{AV_x}{i}$

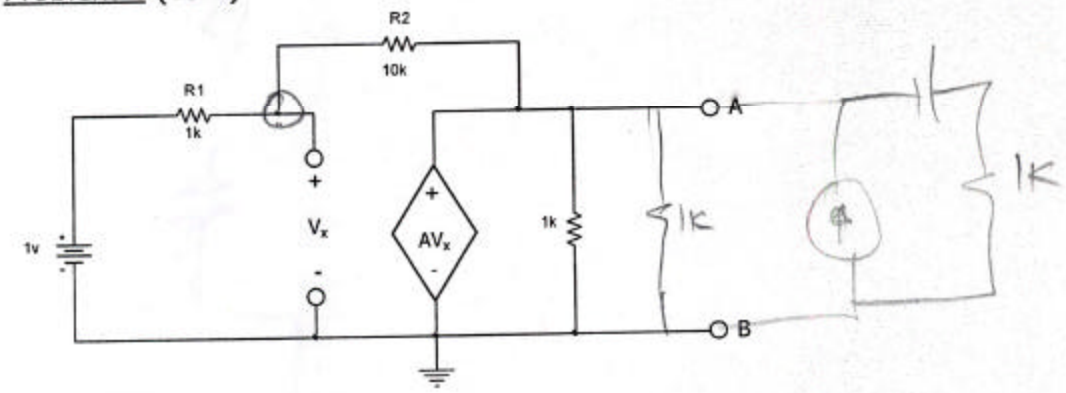
$i = \frac{AV_x}{1K} + \frac{V_x}{1K} = \frac{V_x(1+A)}{1K}$

R_{TH}	900

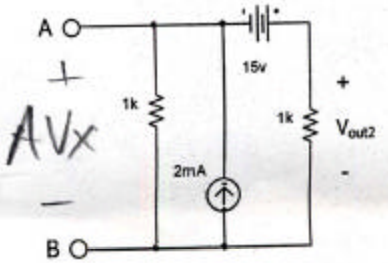
(5pts)

$R_{eq} = \frac{AV_x}{V_x(1+A)} \times 1K = \frac{9}{10} \times 1000 = 900$

Problem 4 (cont)



c.) Find V_{out2} if the following load network is connected to the output of the above circuit and **A=100,000**. (10pts)



@ V_x:

$$\frac{1_v - V_x}{1K} = \frac{V_x - AV_x}{10K}$$

$$10(1 - V_x) = V_x - AV_x$$

$$10 - 10V_x = V_x - AV_x + 10V_x$$

$$11V_x - AV_x = 10$$

$$V_x(11 - A) = 10$$

$$V_x = \frac{10}{(11-A)}$$

$$AV_x = \frac{10}{(11-A)} \times A = \frac{10 \cdot 10^5}{11 - 10^5} \approx -10 \quad (8\text{pts})$$

$V_{OUT} = AV_x + 15v$

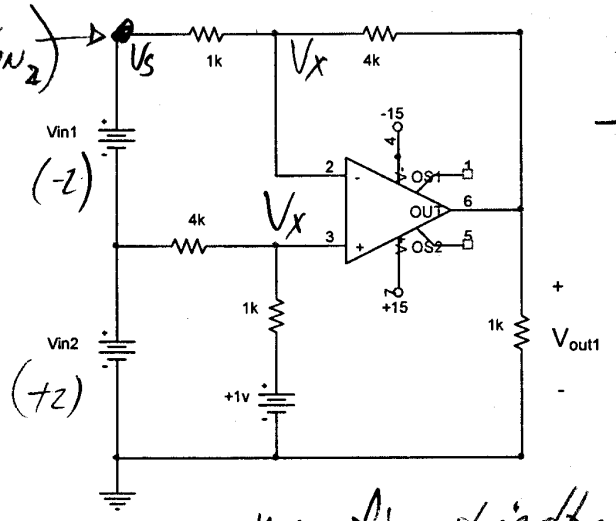
$V_{OUT} = -10 + 15v$

$V_{OUT} = +5v$ (2pts)

V_{out2}	+5v

Problem 5 (20pts)

Assume that all the Op Amps have ± 15 volt supplies for the following circuits.



$(V_{IN_1} + V_{IN_2})$

@ Vx

$$\frac{V_{IN_2} - V_x}{4K} = \frac{V_x - 1v}{1K}$$

$$V_{IN_2} - V_x = 4V_x - 4$$

$$5V_x = V_{IN_2} + 4$$

$$V_x = \frac{V_{IN_2} + 4}{5} \quad (4pts)$$

negative feedback! $(V_+ - V_-)$

a.) Find V_{out1} in terms of V_{in1} and V_{in2} (shown the above circuit). (10pts)

@ V_x (on top)

$$\frac{(V_{IN_1} + V_{IN_2}) - V_x}{1K} = \frac{V_x - V_{OUT_1}}{4K} \quad (4pts)$$

$$4(V_{IN_1} + V_{IN_2}) - 4V_x = V_x - V_{OUT_1}$$

$$V_{OUT_1} = V_x + 4V_x - 4(V_{IN_1} + V_{IN_2})$$

$$V_{OUT_1} = 5V_x - 4(V_{IN_1} + V_{IN_2})$$

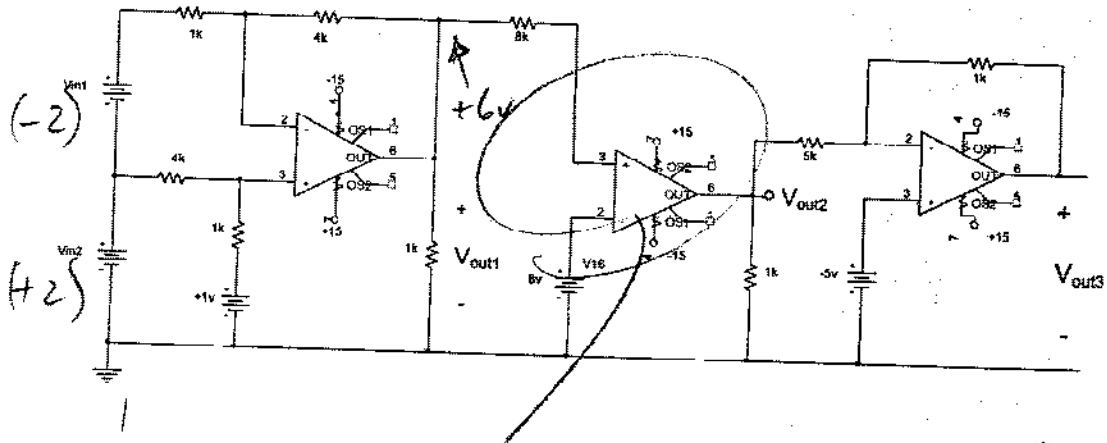
$$V_{OUT_1} = 5\left(\frac{V_{IN_2} + 4}{5}\right) - 4(V_{IN_1} + V_{IN_2})$$

$$= -3V_{IN_2} - 4V_{IN_1} + 4 \quad (2pts)$$

V_{out1}	$-3V_{IN_2} - 4V_{IN_1} + 4$

Problem 5 (cont)

b.) Find the expression relating V_{out2} to V_{out1}. (5pts)



no neg. feedback! (3pts)

$V_{OUT_2} = (+\infty) \times V_D = (+\infty) \times (V_+ - V_-)$

$= (+\infty) \times (+6 - 8) = (+\infty)(-2v)$

$\rightarrow -\infty \rightarrow -V_{cc}$!

V_{out2}	$-15v$

(2pts)

c.) Find V_{out3} if V_{in1} = -2v and V_{in2} = +2v (using the circuit shown in part B above). (5pts)

$$\frac{V_{OUT_2} - (-5)}{5K} = \frac{-5 - V_{OUT_3}}{1K} \quad (4pts)$$

$V_{OUT_2} - 5 = -25 - 5V_{OUT_3}$

$5V_{OUT_3} = -25 - 5 - V_{OUT_2}$

$V_{OUT_3} = \frac{-30 - V_{OUT_2}}{5} = \frac{-30 - (-15)}{-5} = -6 + 3 = -3v$

V_{out3}	$-3v$

(1pt)