University of Portland
School of Engineering

EE 261-Electrical Circuits-3 cr. hrs.
Fall 2013

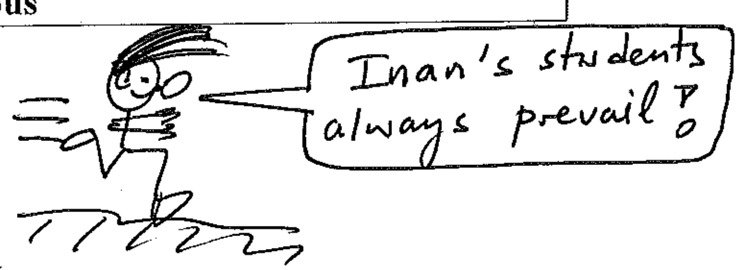
Midterm Exam # 2

(Wednesday, October 30, 2013)
(Closed Book Exam, Two Formula Sheets Allowed)
(Total Time: 55 minutes)

Name: SOLUTIONS! ☺

Signature: ☺

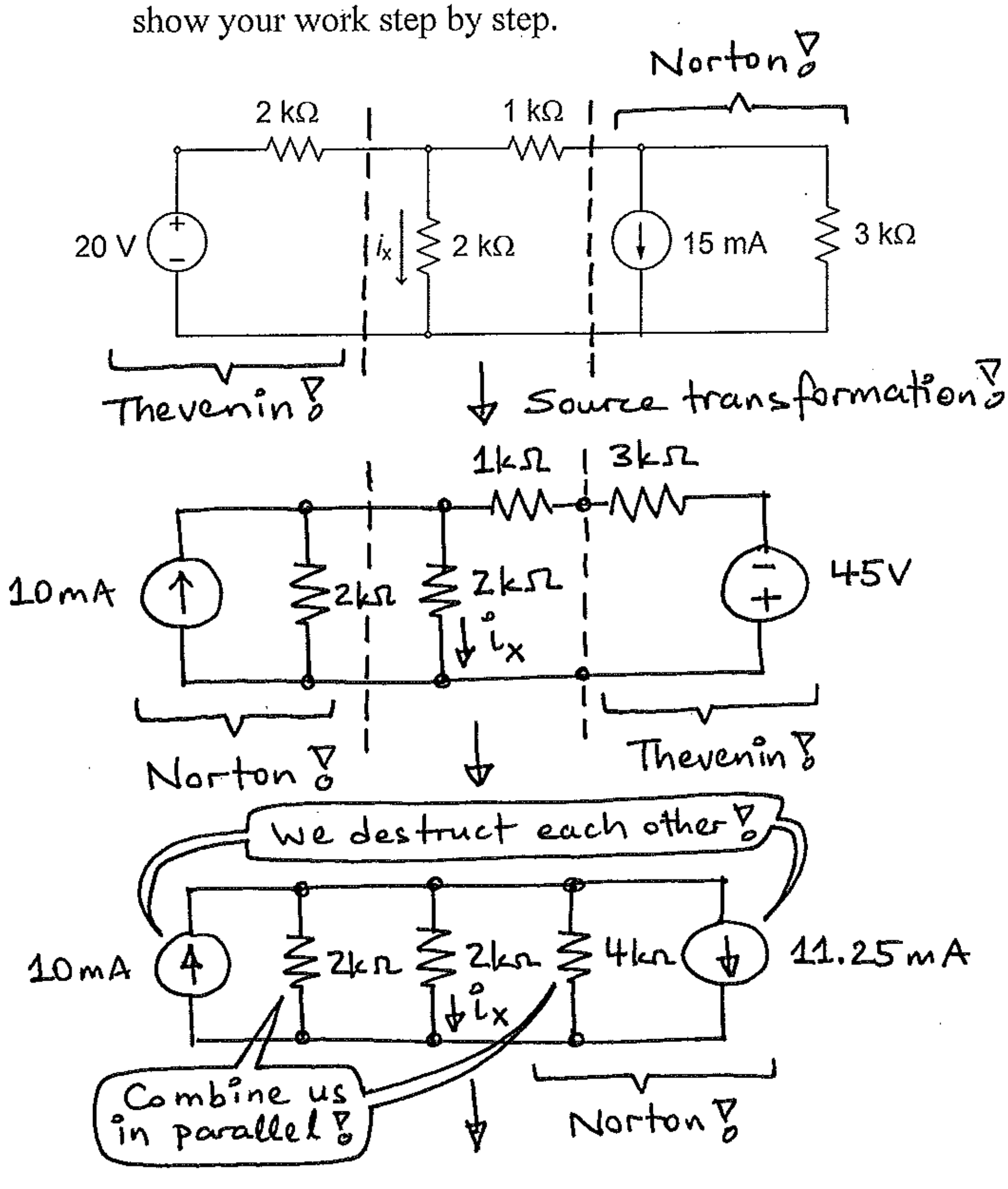
> *"An honest mind possesses a kingdom."*
> **Lucius Annaeus Seneca (4B.C.–65A.D.)**
>
> *"Honest people are the true winners of the universe."*
> **Anonymous**



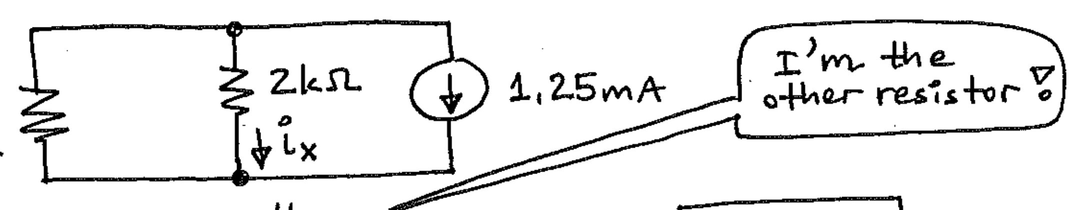
NOTE: You are expected to do Problems #1 to #4 in class. Problem #5 is take-home, due beginning of the class time on Monday, November 4, 2013.

Problem	Score
#1	
#2	
#3	
#4	
#5	
Total	

1. (20 points) For the electric circuit shown, find the current i_x. Please show your work step by step.

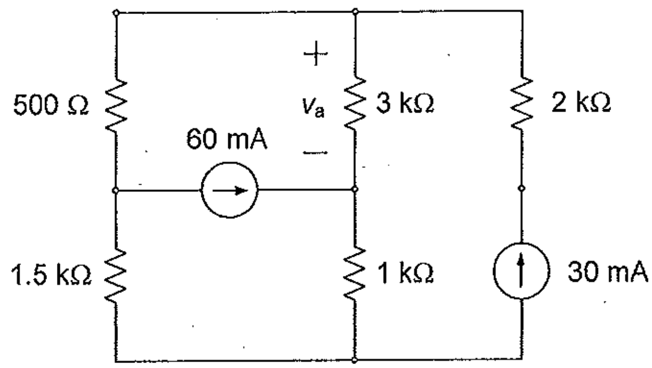


$$\frac{(2k\Omega)(4k\Omega)}{6k\Omega} = \frac{4}{3}\,k\Omega$$

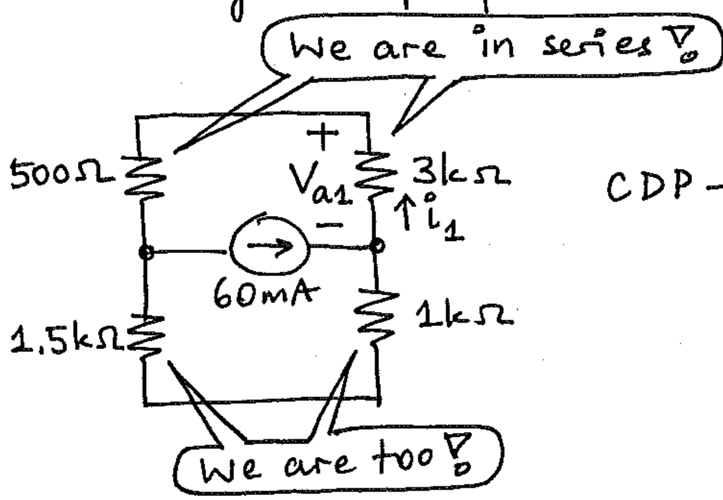


$$\text{CDP} \rightarrow i_x = -\frac{\frac{4}{3}k\Omega}{(\frac{4}{3}+2)k\Omega}(1.25mA) = \boxed{-0.5mA}$$

2. (20 Points) In the electric circuit shown, determine the value of the voltage v_a across the 3 kΩ resistor. (Again, please show your work clearly and provide brief justifications for the steps you take. Provide units.)



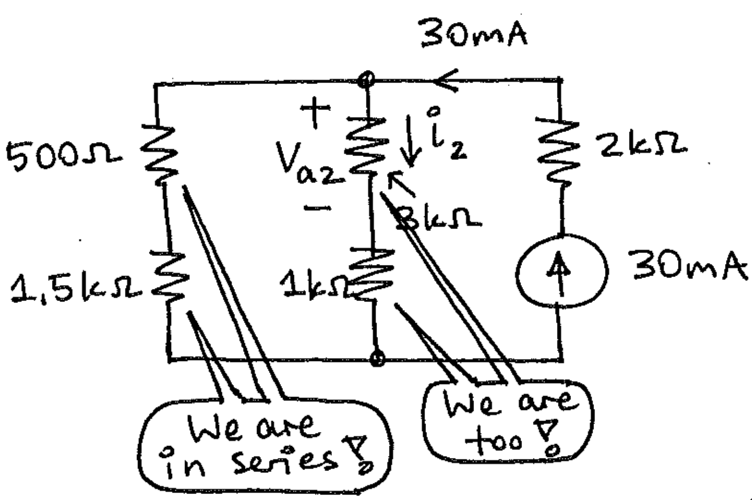
Using superposition principle:



CDP → $i_1 = \frac{2.5k\Omega}{(2.5+3.5)k\Omega}(60mA)$

$= 25mA$.

$V_{a1} = -(3k\Omega)i_1 = -75V$



CDP → $i_2 = \frac{2k\Omega}{(2+4)k\Omega}(30mA)$

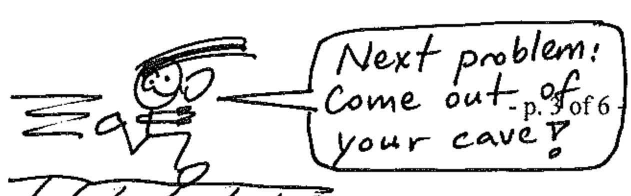
$= 10mA$

$V_{a2} = (3k\Omega)(10mA)$

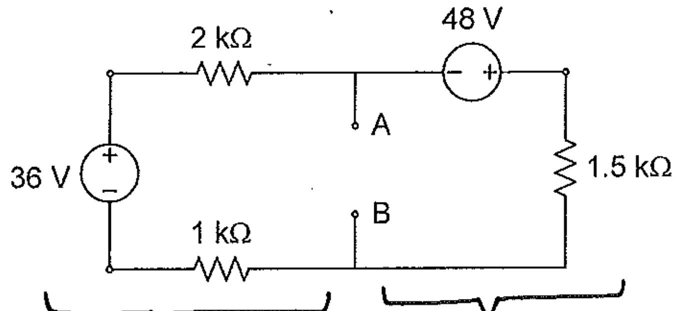
$= 30V$

$\therefore V_a = V_{a1} + V_{a2} = -75 + 30$

$= \boxed{-45V}$

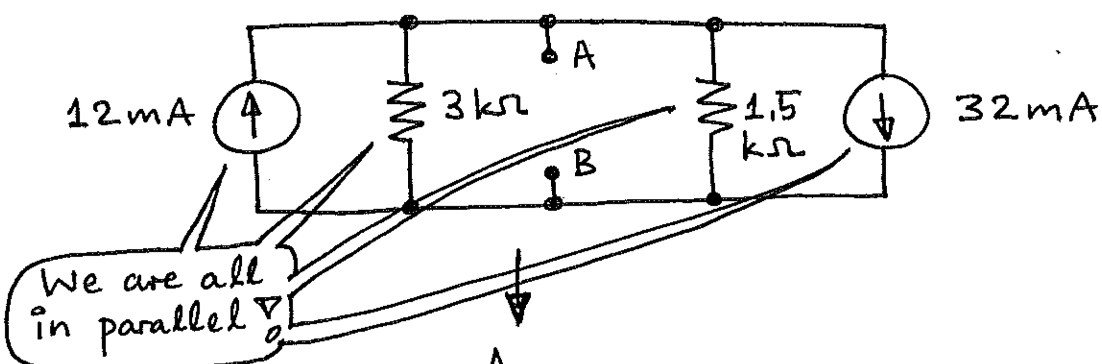


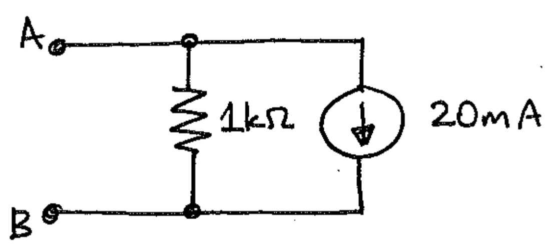
3. (20 Points) Consider the electric circuit shown. Determine the value of the external load resistor R_L to be connected between A-B terminals so that it receives maximum power from this circuit. What is the maximum power delivered to the load resistor chosen? Please provide your work step by step with justifications. <u>Don't forget to calculate the power value!</u>



Thevenin ! Thevenin !

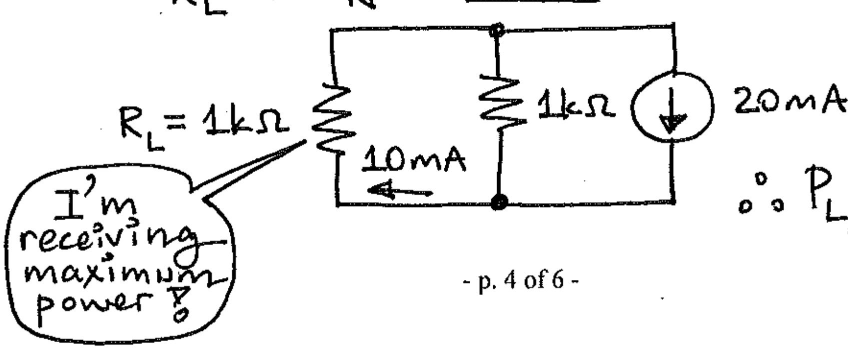
↓ Source transformation !





Based on Maximum Power Transfer Theorem ;

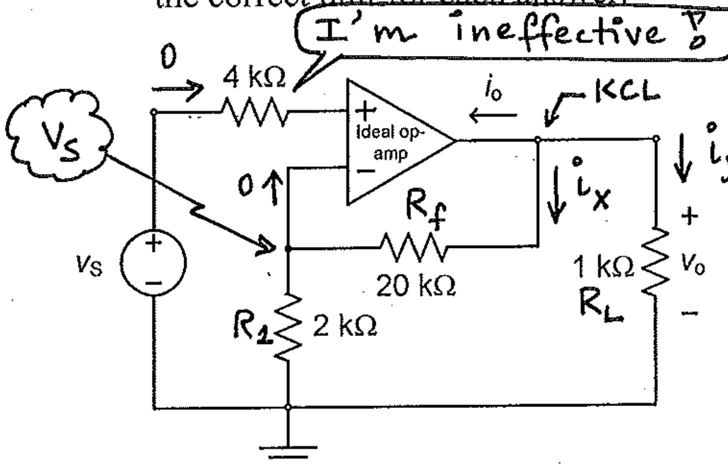
$R_L = R_N = \boxed{1k\Omega}$



$\therefore P_{L_{max}} = (10mA)^2(1k\Omega)$

$= \boxed{0.1W}$

4. (20 Points) For the op-amp circuit shown, determine the values of voltage v_o and current i_o for two cases: (a) $v_s = ½$ V; (b) $v_s = 2$ V. Show your work step by step and provide justifications. Also provide the correct unit for each answer.



$$= \left(1 + \frac{R_f}{R_1}\right) V_s$$

$$= \left(1 + \frac{20k\Omega}{2k\Omega}\right) V_s$$

$$= 11 V_s$$

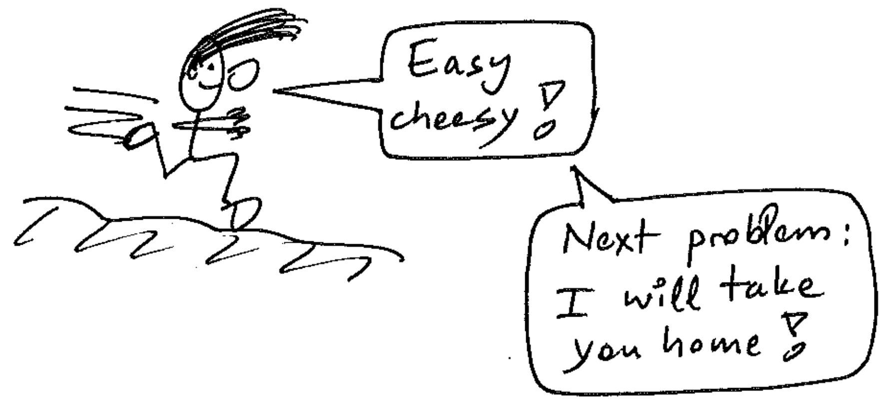
(a) $V_s = \frac{1}{2}\,V \rightarrow V_o = \frac{11}{2} = \boxed{5.5V}$

$$KCL \rightarrow i_o = -i_x - i_y = -\frac{V_o}{R_1 + R_f} - \frac{V_o}{R_L}$$

$$= -\frac{5.5V}{22k\Omega} - \frac{5.5V}{1k\Omega} = \boxed{-5.75mA}$$

(b) $V_s = 2V \longrightarrow V_o = (11)(2) = \boxed{22V}$

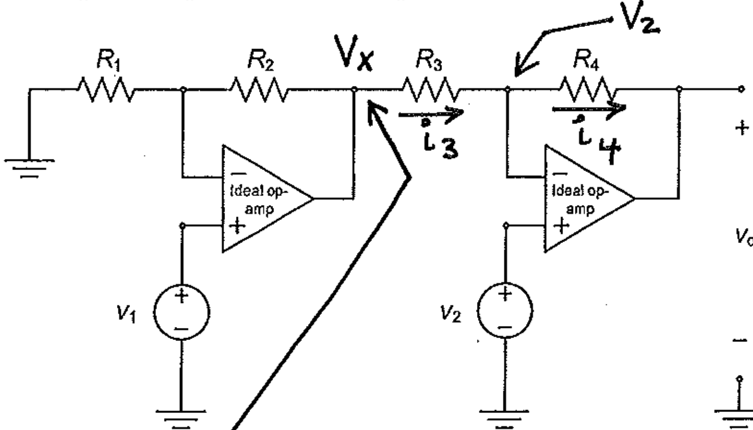
$$i_o = -\frac{22V}{22k\Omega} - \frac{22V}{1k\Omega} = \boxed{-23mA}$$

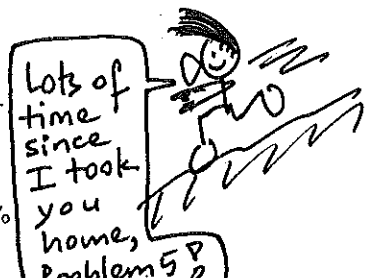


5. (Take-home; Total: 20 points) For the op-amp circuit shown:

(a) (10 points) Find a general simplified expression for the output voltage v_o in terms of the two input voltages, v_1 and v_2. Show your work step by step. What does this circuit do?

(b) (10 points) Design this circuit so that $v_o = 6v_2 - 20v_1$. Note that design means you determine the values of the four resistors to achieve this input-output relationship. Use only kΩ resistors.





(a)

Noninverting amplifier:

$$V_x = \left(1 + \frac{R_2}{R_1}\right) V_1$$

$$i_3 = \frac{V_x - V_2}{R_3} = i_4$$

$$V_o = -R_4 i_4 + V_2$$

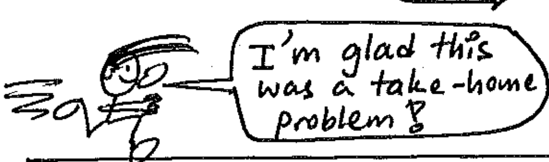
$$= -R_4 \left[\frac{\left(1 + \frac{R_2}{R_1}\right) V_1 - V_2}{R_3} \right] + V_2$$

$$\boxed{V_o = -\frac{R_4 (R_1 + R_2)}{R_1 R_3} V_1 + \left(1 + \frac{R_4}{R_3}\right) V_2}$$

(b) $V_o = 6V_2 - 20V_1 \rightarrow 1 + \frac{R_4}{R_3} = 6$

Let $R_3 = 1k\Omega \rightarrow R_4 = 5k\Omega$

$$-\frac{R_4 (R_1 + R_2)}{R_1 R_3} = -20$$



Let $R_1 = 1k\Omega \rightarrow R_2 = 3k\Omega$

$\therefore$ $R_1 = R_3 = 1k\Omega$, $R_2 = 3k\Omega$, $R_4 = 5k\Omega$