Name: SOLUTIONS (please print)

Signature: ____________________________

Section (underline one): Trombetta Brankovic

ECE 2300 – Exam #1
October 6, 2012

Keep this exam closed and face up until you are told to begin.

1. This exam is closed book, closed notes. You may use one 8.5" x 11" crib sheet, or its equivalent.
2. Show all work on these pages. Show all work necessary to complete the problem. A solution without the appropriate work shown will receive no credit. A solution which is not given in a reasonable order will lose credit.
3. Show all units in solutions, intermediate results, and figures. Units in the exam will be included between square brackets.
4. Do not use red ink. Do not use red pencil.
5. You will have 90 minutes to work on this quiz.

1. ________________/25

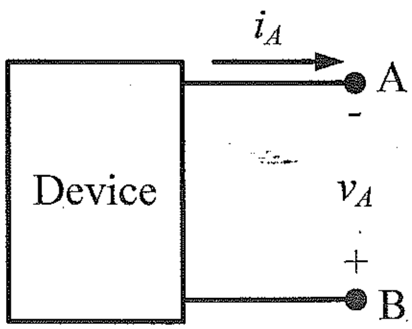
2. ________________/35

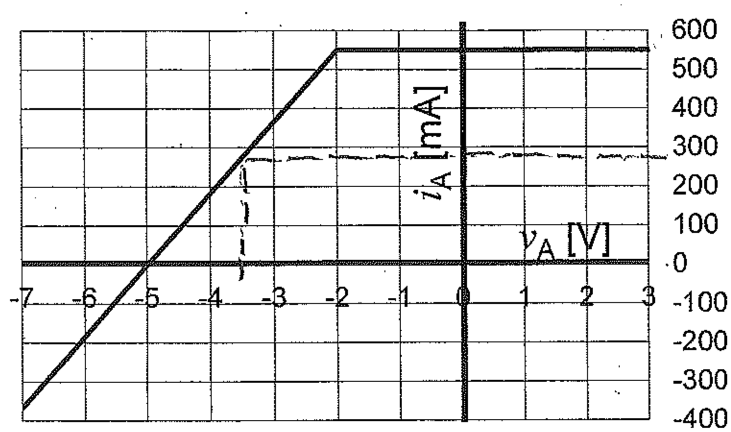
3. ________________/40

Total________________/100

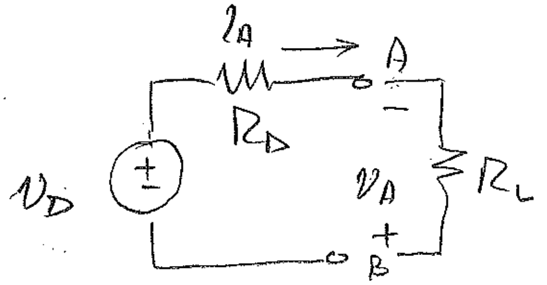
1. (25 points) When v_A is in the range $-5[V] \le v_A \le -2[V]$, the device shown on the left can be modeled as a voltage source in series with a resistance.

a) When a certain load resistor is attached to terminals A, B, the value of v_A is -3.5 [V]. What is the value of the load resistor?
b) Find the value of the model parameters (the voltage source and series resistance) for the device. Draw your model, with the parameters clearly labeled.
c) What circuit element or elements could be used to model the device when $v_A = +2$ [V]? Be sure to indicate the values of your circuit element(s).





a) One way to do this is to find the model parameters, which we will call v_D and R_D:



we will need to do this for part b),
but part a) is easier than that.

$$R_L = \frac{-v_A}{i_A} \quad \text{(Ohm's Law)}$$

Note that v_A is given, and i_A can be read from the graph: $v_A = -3.5$ [V] $\Rightarrow$ $i_A = 275$ [mA]. Then

+5

$$R_L = \frac{-(-3.5)}{0.275} = 12.727 \, [\Omega]$$

This can also be done knowing v_D, R_D:

Room for extra work

From the graph: $i_A = 0 \Rightarrow v_A = -5$ [V].

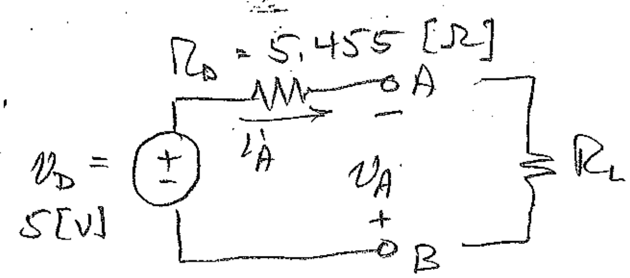
So comparison with the circuit model means

$$v_D = -v_A = 5 \text{ [V]}$$

Now $v_A = -2$ [V] $\Rightarrow i_A = 550$ [mA]

$$R_D = \frac{v_D - (-v_A)}{i_A} = \frac{5+2}{0.550} = 5.455 \ [\Omega]$$

So ...



$+15$

We can also go back and check our R_L calculation:

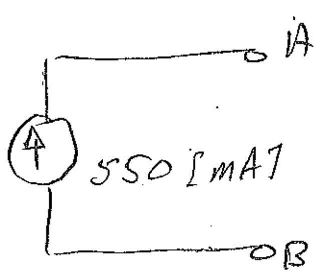
$$-v_D + i_A R_D - v_A = 0 \Rightarrow -5 + i_A(5.455) - (-3.5) = 0$$

$$\Rightarrow i_A = \frac{5-3.5}{5.455} = 0.275 \text{ [A]}$$

So $R_L = -v_A / i_A = 12.273 \ [\Omega]$ ✓

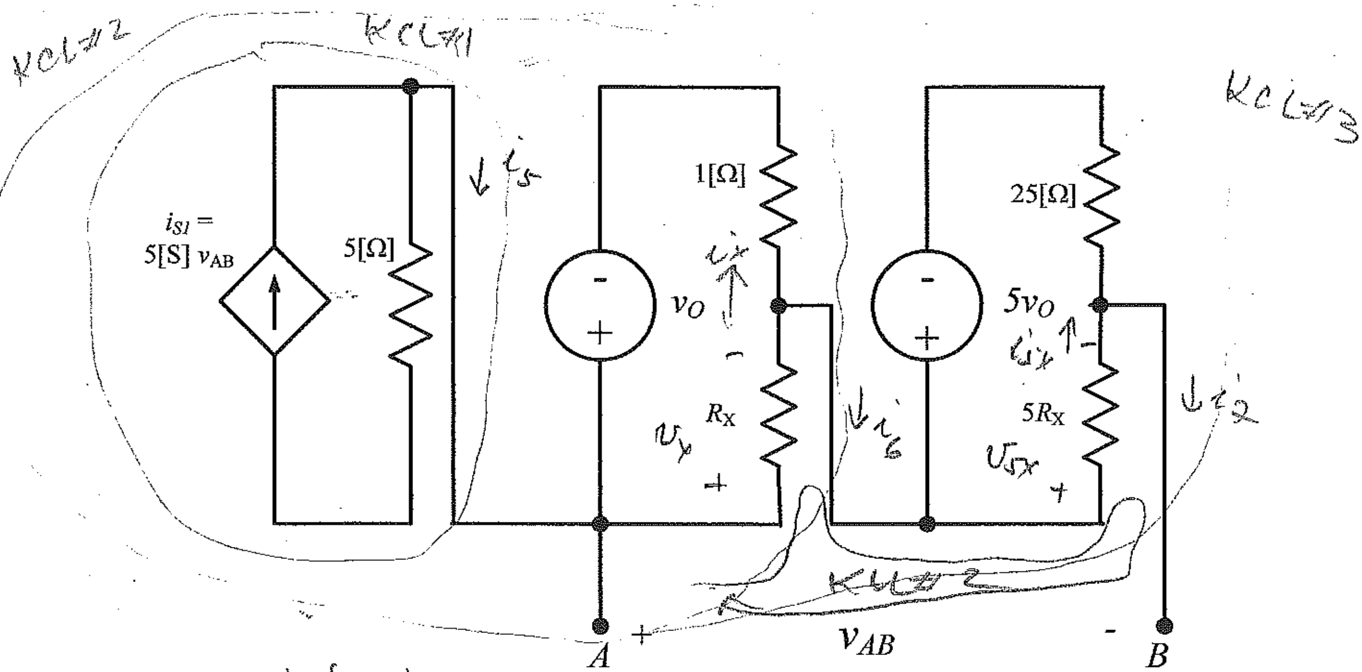
c) If the current is constant we should model this with an ideal current source:

$+5$



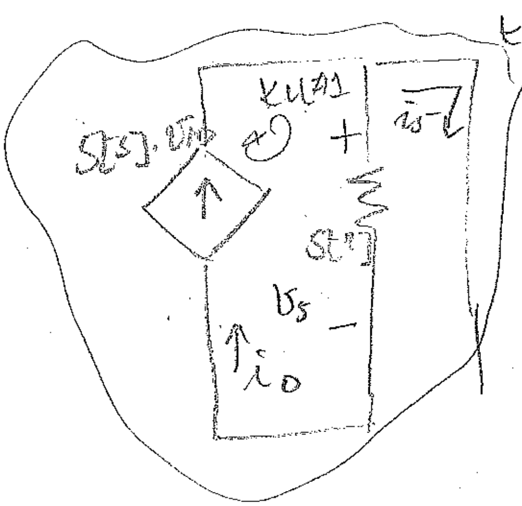
2. (35 points) The electrical circuit shown below is part of a more complex electronic device.

a) Find the value of R_X for which the ratio v_{AB}/v_O is equal to 1.
b) If the power delivered to the rest of the circuit by the 5[Ω] resistor is -10[W], find the value of the open-circuit voltage v_{AB}.
c) Find the energy absorbed by the 5[Ω] resistor in 100 [s].



THE EFFICIENT WAY TO START IS FROM b)

b) $P_{DEL\ BY\ 5[\Omega]} = -10[W]$ $v_{AB} = ?$



KCL#1: $i_5 = 0$; $i_O = 5[S]\cdot v_{AB}$

KVL#1:

$v_5 = 5[\Omega]\cdot v_{AB}\cdot 5[S]$

$-v_5\cdot i_O = P_{DEL.\ BY\ 5[\Omega]}$

$-5[\Omega]\cdot v_{AB}\cdot 5[S]\cdot 5[S]\cdot v_{AB} = -10[W]$

$-5[\Omega]\, v_{AB}^2\cdot 25[S]^2 = -10[VA]$

$v_{AB}^2 = \frac{2[VA][\Omega]}{25[S]^2} \Rightarrow \boxed{v_{AB} = 0.283[V]}$

THEN GO TO c)

c) $W = \int_0^{100} P_{ABS}[s] \cdot dt = P_{AB} \cdot 100[s]$

$W = (-P_{DEL\ BY\ 5C}) \cdot 100[s] = 1000[J]$

$\boxed{W = 1000\ [J]}$

Now LET'S GO TO a);

It is straight forward from KCL#1, KCL#2, and KCL#3 to conclude

$i_5 = 0,\ i_7 = 0,\ i_6 = 0$;

Using Ohm's law:

$i_x = \dfrac{v_0}{(R_x + 1[\Omega])}$ $\quad i_{5x} = \dfrac{5v_0}{5R_x + 25[\Omega]}$

KVL#2:

$v_x + v_{5x} - v_{AB} = 0$

$v_x = i_x \cdot R_x \quad v_{5x} = i_{5x} \cdot 5R_x$

$i_x R_x + i_{5x} \cdot 5R_x - v_{AB} = 0$

$\dfrac{v_0}{(R_x + 1[\Omega])} \cdot R_x + \dfrac{5v_0}{(5R_x + 25[\Omega])} \cdot 5R_x - v_{AB} = 0 \quad / : v_0$

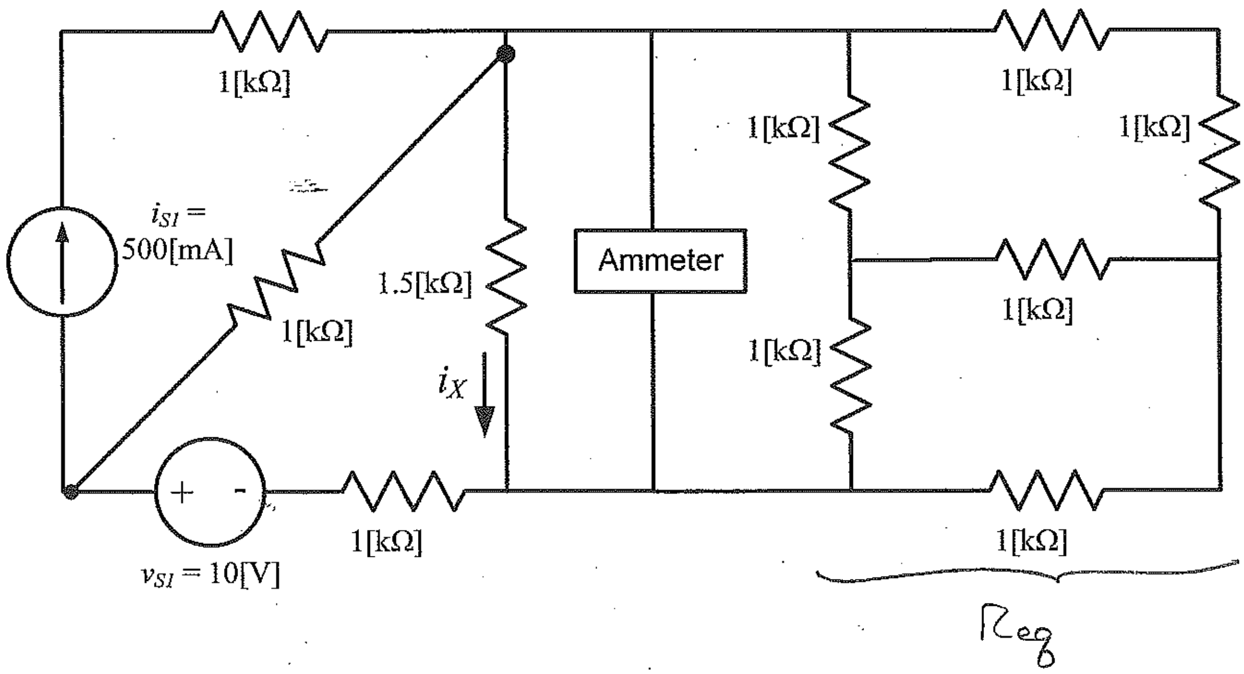
$\dfrac{R_x}{(R_x + 1[\Omega])} + \dfrac{25R_x}{(5R_x + 25[\Omega])} = \dfrac{v_{AB}}{v_0} = 1$

Solving for R_x:

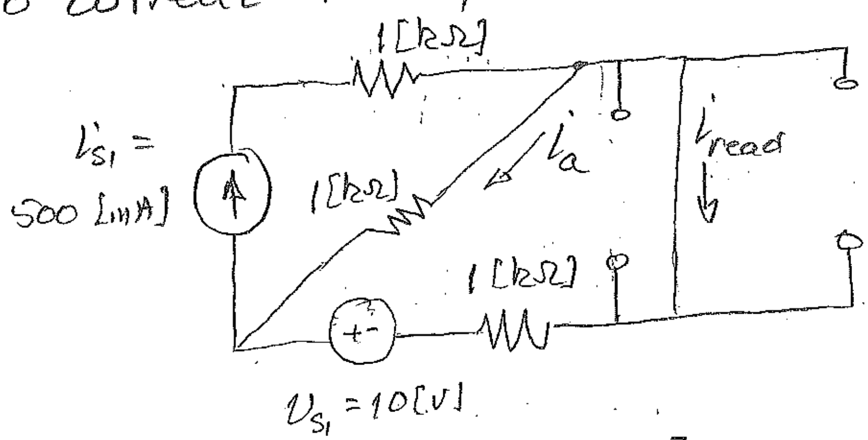
$5R_x^2 + 4R_x - 5 = 0 \Rightarrow \boxed{R_x = 0.68[\Omega]}$ VA ✓

3. (40 points)
a) A student who has not been paying attention in lab class inserts a d'Arsonval-based ammeter into the circuit shown below to measure the current i_X. (His lab partner knows this is not the correct place to put the meter, but does not say anything.) The ammeter has a full-scale current of 500 [mA]. The ammeter resistance is negligible and can be assumed to be 0. What does the ammeter read?

b) The instructor removes the ammeter and puts it in the correct position to read i_X. What does the ammeter read now?



a)
If the ammeter resistance is 0, then Req and the 1.5 [kΩ] resistor are shorted and will have no current through them. The circuit becomes...



The open circuits ...—o o—... indicate where 1.5 [kΩ] and Req are found.

Room for extra work

KCL: $i_{s_1} = i_a + i_{read}$ +12

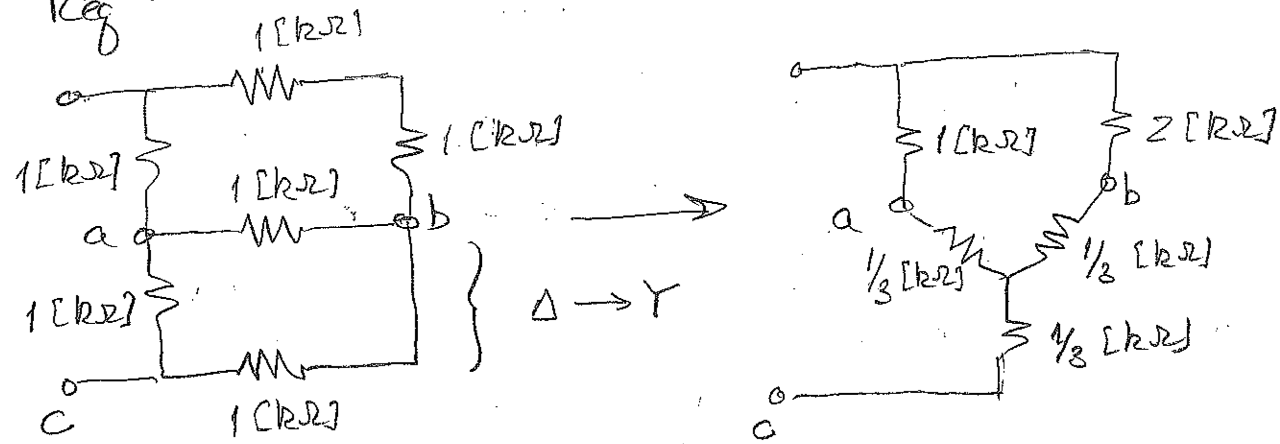
KVL: $1000\, i_a + 10 - 1000\, i_{read} = 0$

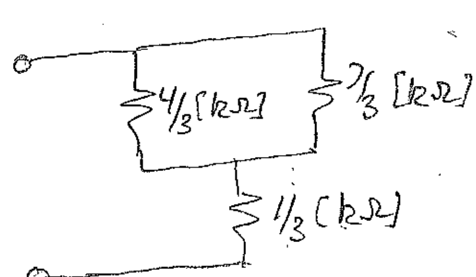
$i_a + 0.01 - i_{read} = 0$

$(0.5 - i_{read}) + 0.01 - i_{read} = 0 \Rightarrow i_{read} = 0.255\,[A]$

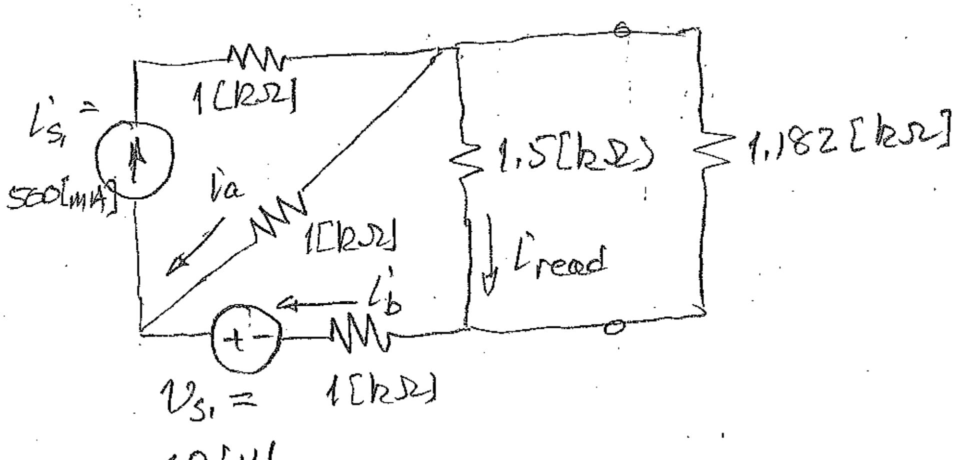
So the meter reads 0.255 [A].

b) The meter is in series with 1.5 [kΩ]. Now we need R_{eq}:





So we have...



$R_{eq} = 4/3\,[k\Omega] \,//\, \frac{2}{3}\,[k\Omega] + 1/3\,[k\Omega]$

$= \frac{13}{11} = 1.182\,(k\Omega)$

+10

meter position +3

pg. 2

Room for extra work

Define $R_{eq} = 1.5[k\Omega] \,//\, 1.182[k\Omega] = 0.6611\ [k\Omega]$.

Then $i_{s1} = i_a' + i_b' = 0.5$

$$1000 i_a' + 10 - (1000 + 661.1) i_b' = 0$$

$$i_a' = 308.35\ [mA] \qquad i_b' = 191.65\ [mA]$$

CDR:

$$i_{read}' = i_b' \cdot \frac{1.182}{1.182 + 1.5} = 84.46\ [mA]$$

+15

So the meter reads 84.46 [mA].