Name: ______________________________ (please print)

Signature: ___________________________

Section (underline one): Trombetta Shattuck

ECE 2300 – Exam #1
February 25, 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. It is assumed that your work will begin on the same page as the problem statement. If you choose to begin your work on another page, you must indicate this on the page with the problem statement, with a clear indication of where the work can be found. **If your work continues on to another page, indicate clearly where your work can be found. Failure to indicate this clearly will result in a loss of credit.**
4. Show all units in solutions, intermediate results, and figures. Units in the exam will be included between square brackets.
5. Do not use red ink. Do not use red pencil.
6. You will have 90 minutes to work on this quiz.

1. ________________/35

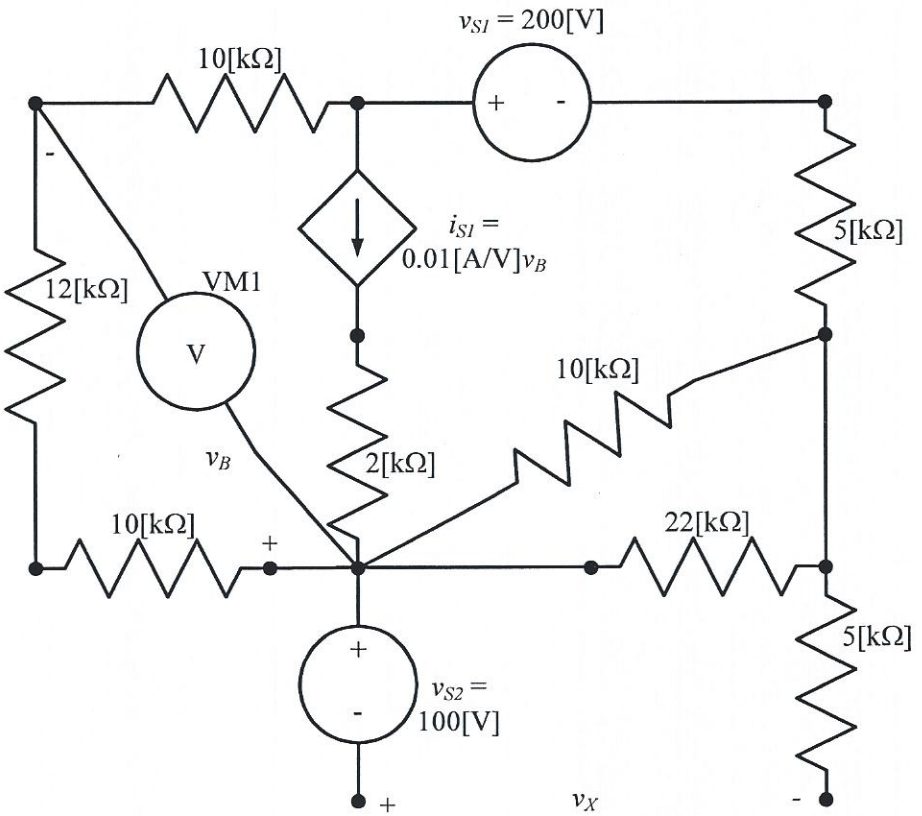
2. ________________/35

3. ________________/30

Total________________/100

1. (35 points) In the circuit below, the voltmeter VM1 is a d'Arsonval-based voltmeter with an equivalent resistance of 200 [kΩ]. It was constructed from a d'Arsonval meter movement rated at 100 [mV] and 2.5 [mA]. For this circuit, do the following.

a) Find the power delivered to the circuit by the voltage source v_{S1};
b) Find the power delivered to the circuit by the dependent current source.



We can simplify this problem: v_{S2} and the 5 [kΩ] resistor (lower right) have no effect on the rest of the circuit, and we don't need v_X.

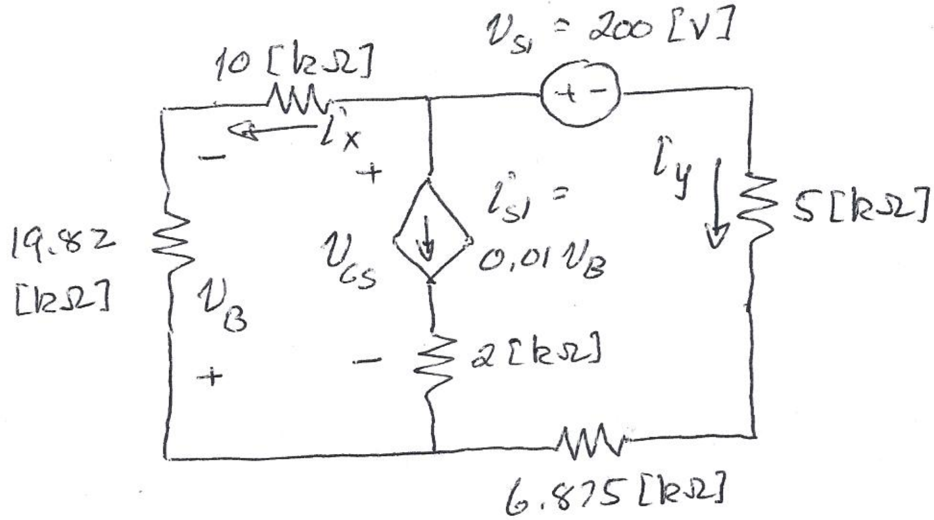
Also, the meter can be replaced by a 200 [kΩ] resistor, which is in parallel with 12 [kΩ] + 10 [kΩ].

$$(12 [k\Omega] + 10 [k\Omega]) \parallel 200 [k\Omega] = 19.82 [k\Omega]$$

Finally, $10 [k\Omega] \parallel 22 [k\Omega] = 6.875 [k\Omega]$

next page

Re-draw:



One way to solve this is to write three equations for i_x, i_y, v_B. We can then find v_{cs}, which we need for the power delivered by i_{s1}.

KCL: $i_x + i_y + 0.01\, v_B = 0$ Ohm: $v_B = -19820\, i_x$

KVL: $200 + 11875\, i_y + v_B - 10000\, i_x = 0$

Solution: $i_x = -0.0865$ [mA] $i_y = -17.06$ [mA]

$v_B = 1.715$ [V]

Now, KVL:

$$v_{cs} + 2000\,(0.01\, v_B) - 11.875 \times 10^3\, i_y - 200 = 0$$

$$\Rightarrow v_{cs} = -36.88 \text{ [V]}$$

a) $P_{del,vs1} = -v_{s1} \cdot i_y = -(200)(-17.06 \times 10^{-3}) = 3.41$ [W]

b) $P_{del,is1} = -v_{cs}\, i_{s1} = -(-36.88)(0.01)(1.715) = 0.632$ [W]

2. (35 points) The device shown in Figure 1 below can be modeled by a voltage source in series with a resistance. Figure 2 shows the relationship between the current i_A and the voltage v_A at the terminals of this device. Three identical copies of the device are connected into the circuit shown in Figure 3. The devices are connected so that terminal A of each device is connected to A1, A2, or A3. For the circuit in Figure 3, do the following.

a) Find the voltage v_X.
b) Find the current i_X.

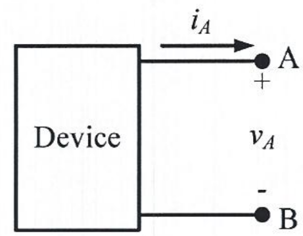


Figure 1

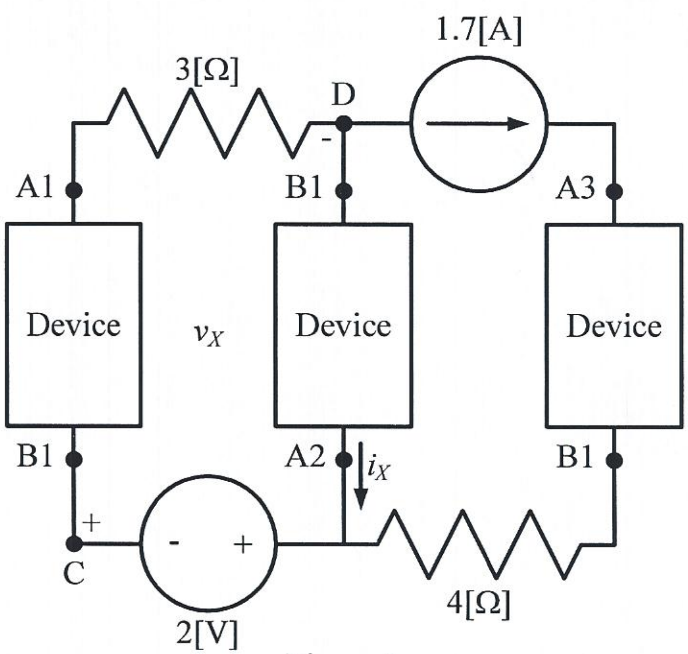


Figure 3

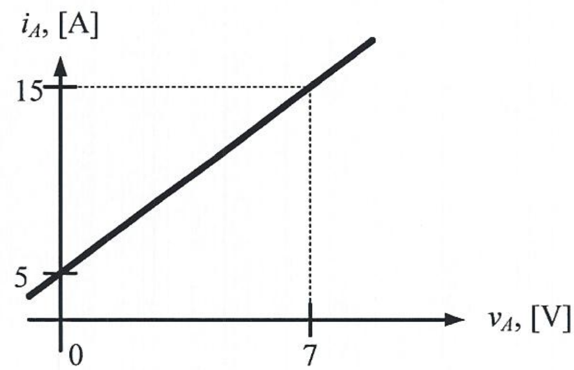
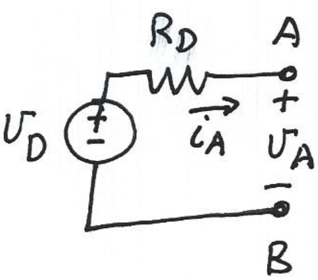


Figure 2

The first step is to find a model for the device. We draw the circuit model, and the plug in two values from the plot in Figure 2 in the KVL for the model. KVL yields:

$$-v_D + i_A R_D + v_A = 0$$



So, we have:

$$-v_D + 5[A] R_D + 0 = 0$$

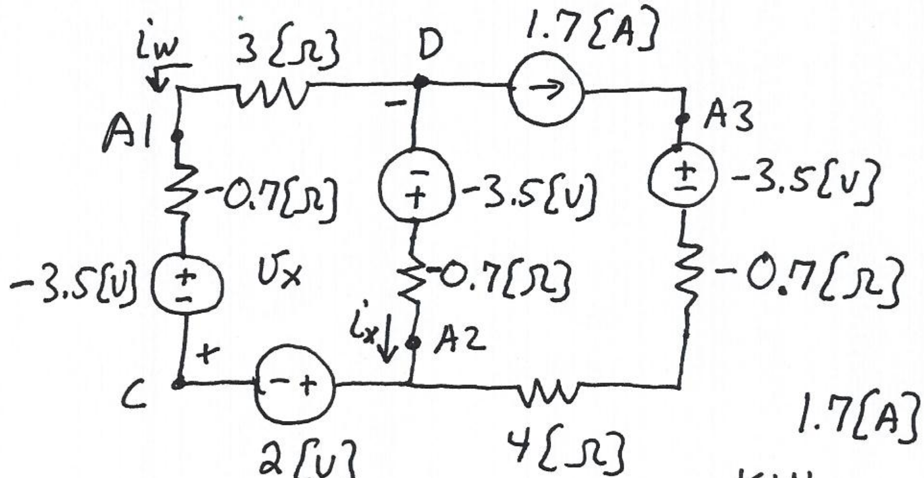
$$-v_D + 15[A] R_D + 7[V] = 0$$

Solving, we have → $v_D = -3.5[V]$, $R_D = -700[m\Omega]$

(See next page)

Room for extra work

With this, we have a model we can put in for each of the devices shown in Figure 3.



Using this circuit, we can write the following equations.

KCL @ D

$$1.7[A] + i_X + i_W = 0$$

KVL around Left hand loop

$$0 = 3.5\{V\} - i_W(-0.7\{\Omega\}) - i_W 3\{\Omega\} + 3.5\{V\} + i_X(-0.7\{V\}) + 2\{V\}$$

We have two equations in two unknowns, so we can solve, to get: $i_W = 6.369\{A\}$

Part b) soln. is ⟶ $\boxed{i_X = -8.069\{A\}}$

To get v_X, we take KVL again, to write

$$-v_X + 3.5\{V\} - i_W(-0.7\{\Omega\}) - i_W 3\{\Omega\} = 0$$

Solving, we get

$\boxed{v_X = -11.15\{V\}}$ for part a).

3. (30 points) A student wishes to measure the current i_x in the circuit of Figure 1. To do this she uses the d'Arsonval meter movement shown in Figure 2. She measures i_x using two methods. In method #1, she constructs a d'Arsonval-based voltmeter with a full-scale reading of 50 [V]. She uses this to measure v_X, and then divides the result by R_X to get the current. In method #2, she uses the same d'Arsonval meter movement to construct an ammeter with a full-scale reading of 2 [A], and uses this to measure i_X directly.

What is the percent error in measuring i_X in each case? To calculate error, use the formula below, where "actual current" refers to the value of i_X with no meter. Keep at least four significant figures in your work.

$$\%error = \frac{measured\ current - actual\ current}{actual\ current}$$

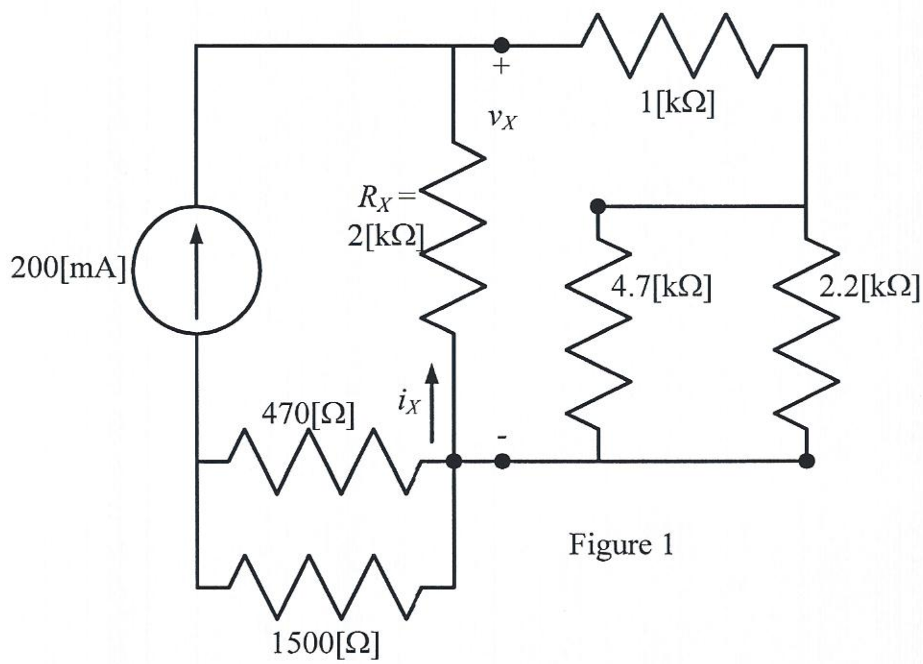


Figure 1

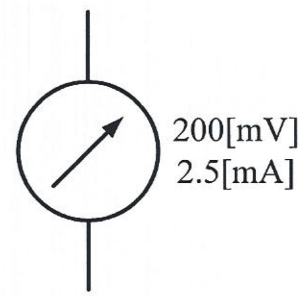


Figure 2

We can simplify this circuit by combining the 4.7 [kΩ] and 2.2 [kΩ] resistors, which together are in series with 1 [kΩ]. Also, if we are planning on using current divider to get i_x, we don't need the 470 [Ω] or 1500 [Ω] resistors - they can be ignored and replaced with a short.

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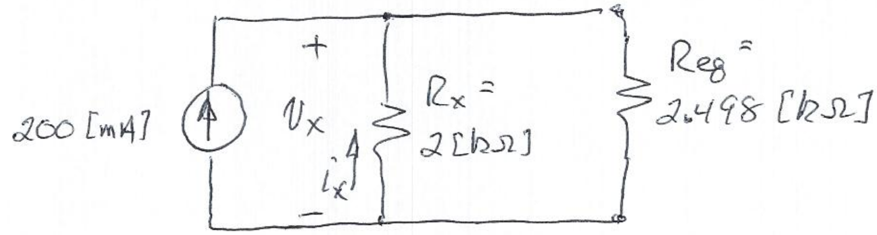
Room for extra work

Req:

$1[k\Omega] + 4.7[k\Omega] \parallel 2.2[k\Omega]$

$\Rightarrow R_{eq} = 2.498\ [k\Omega]$

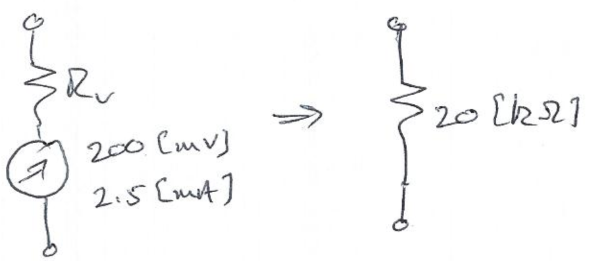


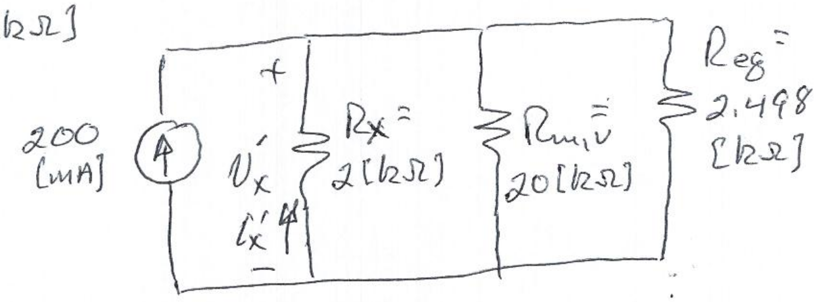
Now with no meter,

$$i_x = -0.2 \frac{2.498}{2.498+2} = -0.11107\ [A]$$

Voltmeter:

$$R_{m,v} = \frac{50\ [V]}{2.5\ [mA]} = 20\ [k\Omega]$$





$$R_{m,v} \parallel R_{eq} = 2.2206\ [k\Omega] \Rightarrow v_x' = R_x \cdot 200[mA] \cdot \frac{2.2206}{2.2206+2}$$

$$= 210.45\ [V] \ !$$

[oops! This is off-scale, This was unintended - the current source should have been 20 [mA].]

$$i_x' = \frac{-v_x'}{R_x} = -0.1052\ [A]$$

$$\%\ \text{error} = \frac{-0.1052-(-0.11107)}{-0.11107} = \underline{-5.31\%}$$

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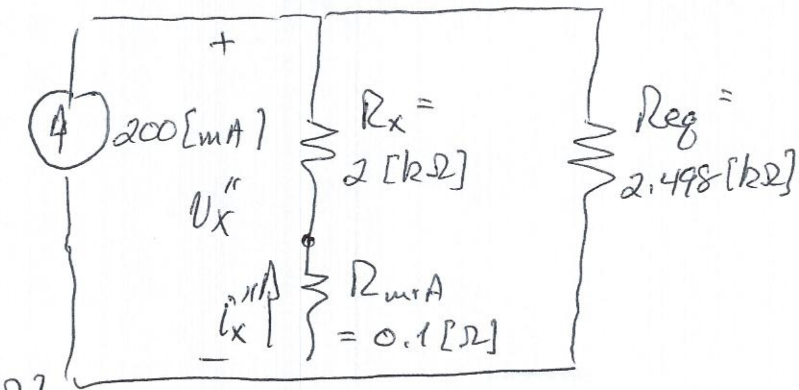
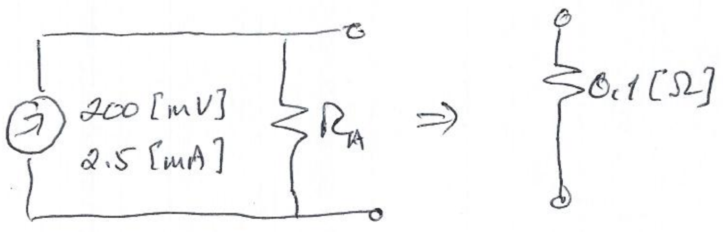
Room for extra work

Ammeter:

$$R_{m,A} = \frac{200\,[mV]}{2\,[A]} = 0.1\,[\Omega]$$





$$i_x'' = -200\,[mA] \cdot \frac{2.498}{2.498 + (2 + 0.0001)} = -0.111069\,[A]$$

$$\%\ error = \frac{-0.111069 - (-0.11107)}{-0.11107} = -0.0009\,\%$$

To 4 significant figures, this is <u>0%</u>!