Name: SOLUTION 1 (please print)

Signature: _____

ECE 2300 – Quiz #3 version 1
October 2, 2012

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

1. This quiz is closed book, closed notes. You may use one 8.5" x 11" crib sheet, or its equivalent.
2. Show all work necessary to complete the problem. A solution without the appropriate work shown will receive no credit.
3. Show all units in solutions, intermediate results, and figures. Units in the quiz will be included between square brackets.
4. Do not use red ink. Do not use red pencil.
5. You will have 30 minutes to work on this quiz.

_____/20

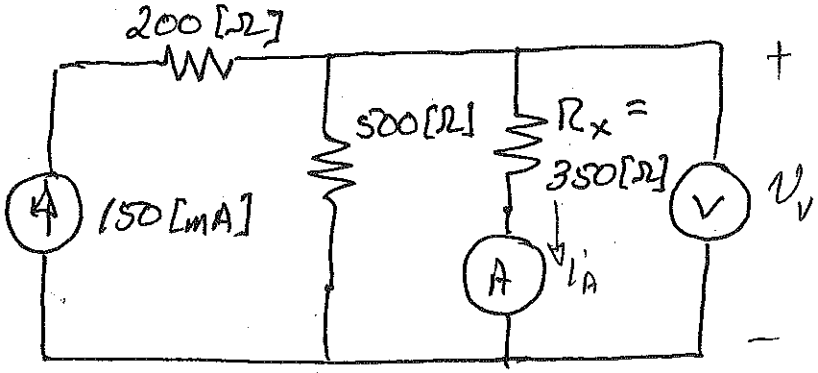
A measurement of the resistance R_X is made by inserting an ammeter (A) and voltmeter (V) into the circuit shown below. The resistance is to be determined by dividing the voltmeter reading by the ammeter reading. The ammeter has a resistance of 5.5 [Ω] and a full-scale current reading of 200 [mA]. The voltmeter has a resistance of 1 [k Ω] and a full-scale reading of 50 [V].

a) What does the ammeter read?
b) What is the error in measuring R_X? Error is defined as

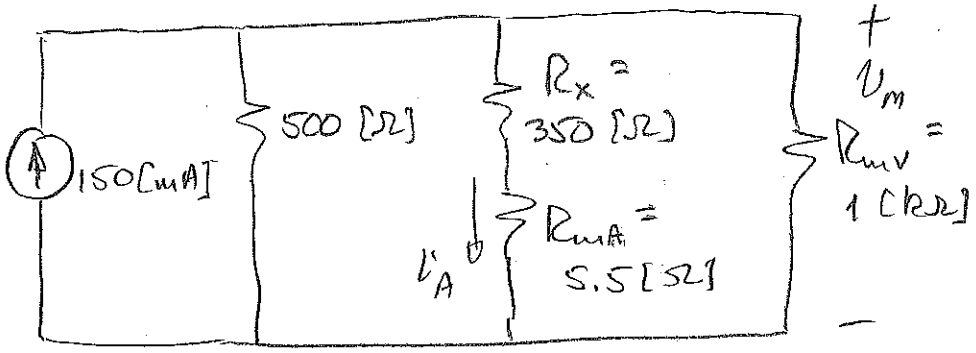
$$e = \frac{R_{X,meas} - R_{X,actual}}{R_{X,actual}} x100\%$$

where $R_{X,meas}$ is the measured value and $R_{X,actual}$ is the actual value (which is given in the circuit diagram).

c) A student wishes to replace one of the meters with a new meter to obtain a measurement of R_X with an error of no more than 0.25% in magnitude. Which meter should she replace, and what should be the resistance of the new meter?



a) The meter "reads" the current through it, which is labelled i_A on the diagram. We first replace the meters with their equivalent resistances:



(Note that the 200 Ω resistor will have no effect on i_A or v_m, because it is in series with a current source...)

Room for extra work

If we combine 1 [kΩ] and 500 [Ω], we can use CDR to find i_A:

$1000 \,//\, 500 = 333.33\ \Omega \Rightarrow i_A = 0.150 \dfrac{333.33}{333.33 + (350 + 5.5)}$

$i_A = 72.58\ [mA]$

+b So the current meter reads 72.58 [mA]

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b). The measured R_x is $v_m / i_A = R_{x,meas}$.

$v_m = i_A \cdot (R_x + 5.5) \Rightarrow R_{x\,meas} = R_x + 5.5 = 355.5\ [\Omega]$

The error is

+b $e = \dfrac{R_{x\,meas} - R_{x\,true}}{R_{x\,true}} \times 100\% = \dfrac{355.5 - 350}{350} = 1.57\%$

+6

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c) Looking at the result to part b), it should be clear that we are measuring $(R_x + R_{m,A})$ instead of R_x. So we need a lower-resistance ammeter.

+b $\dfrac{(R_x + R_{m,A}) - R_x}{R_x} = \dfrac{R_{m,A}}{R_x} = 0.0025$

$\Rightarrow R_{m,A} = 0.0025 R_x = 0.875\ [\Omega]$

So we need an ammeter with resistance 0.875 [Ω].

Note that we never even needed to find v_m. Changing the voltmeter will not help in this case.

Name: SOLUTIONS / (please print)

Signature: _____

ECE 2300 – Quiz #3 Version 2
October 2, 2012

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

1. This quiz is closed book, closed notes. You may use one 8.5" x 11" crib sheet, or its equivalent.
2. Show all work necessary to complete the problem. A solution without the appropriate work shown will receive no credit.
3. Show all units in solutions, intermediate results, and figures. Units in the quiz will be included between square brackets.
4. Do not use red ink. Do not use red pencil.
5. You will have 30 minutes to work on this quiz.

_____/20

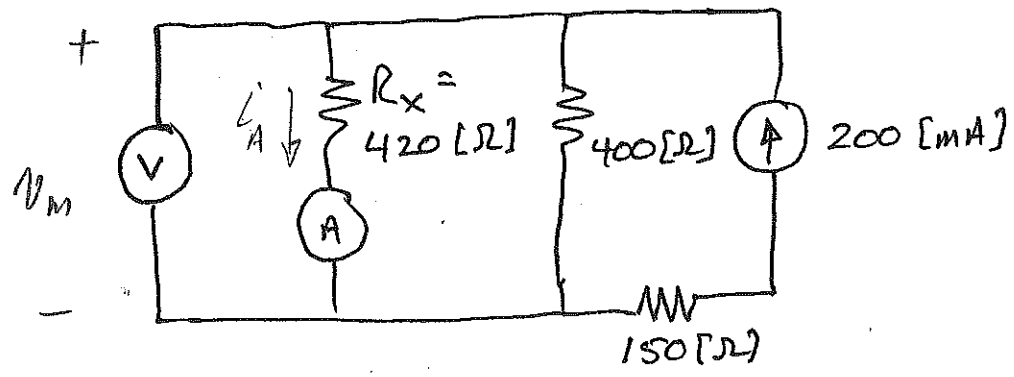
A measurement of the resistance R_X is made by inserting an ammeter (A) and voltmeter (V) into the circuit shown below. The resistance is to be determined by dividing the voltmeter reading by the ammeter reading. The ammeter has a resistance of 7.5 [Ω] and a full-scale current reading of 200 [mA]. The voltmeter has a resistance of 2 [k Ω] and a full-scale reading of 50 [V].

a) What does the ammeter read?
b) What is the error in measuring R_X? Error is defined as

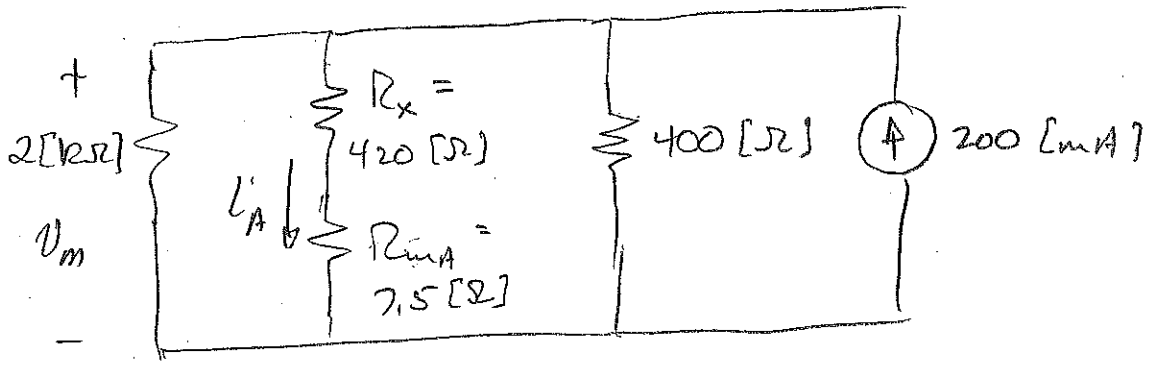
$$e = \frac{R_{X,meas} - R_{X,actual}}{R_{X,actual}} x100\%$$

where $R_{X,meas}$ is the measured value and $R_{X,actual}$ is the actual value (which is given in the circuit diagram).

c) A student wishes to replace one of the meters with a new meter to obtain a measurement of R_X with an error of no more than 0.25% in magnitude. Which meter should she replace, and what should be the resistance of the new meter?



a) The meter "reads" the current through it, which is labelled i'_A on the diagram. We first replace the meters with their equivalent resistances:



(Note that the 150 [Ω] resistor will have no effect on i'_A or V_M, since it is in series with a current source.)

Room for extra work

If we combine 2 [kΩ] and 400 [Ω], we can use CDR to find I'_A:

$2000 // 400 = 333.33\ [\Omega] \Rightarrow I'_A = 0.20 \dfrac{333.33}{333.33 + (420 + 7.5)}$

$I'_A = 87.62\ [mA]$

So the current meter reads 87.62 [mA].

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b) The measured R_x is $V_M / I'_A = R_{x,meas}$.

$V_M = I'_A (R_x + 7.5) \Rightarrow R_{x,meas} = R_x + 7.5 = 427.5\ [\Omega]$

The error is

$$e = \frac{R_{x,meas} - R_{x,true}}{R_{x,true}} \times 100\% = \frac{427.5 - 420}{420} \times 100\% = \underline{\underline{1.79\%}}$$

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c) Looking at the result to part b), it should be clear that we are measuring $(R_x + R_{m,A})$ instead of R_x. So we need a lower-resistance ammeter.

$$\frac{(R_x + R_{m,A}) - R_x}{R_x} = \frac{R_{m,A}}{R_x} = 0.0025$$

$\Rightarrow R_{m,A} = 0.0025\, R_x = 1.05\ [\Omega]$.

Note that we never even needed to find V_M. Changing the voltmeter will not help in this case.