Name: _____ (please print)

Signature: _____

ECE 2300 – Quiz #3
June 25, 2015

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 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 quiz will be included between square brackets.
4. If the grader has difficulty following your work because it is messy or disorganized, you will lose credit.
5. Do not use red ink. Do not use red pencil.
6. You will have 30 minutes to work on this quiz.

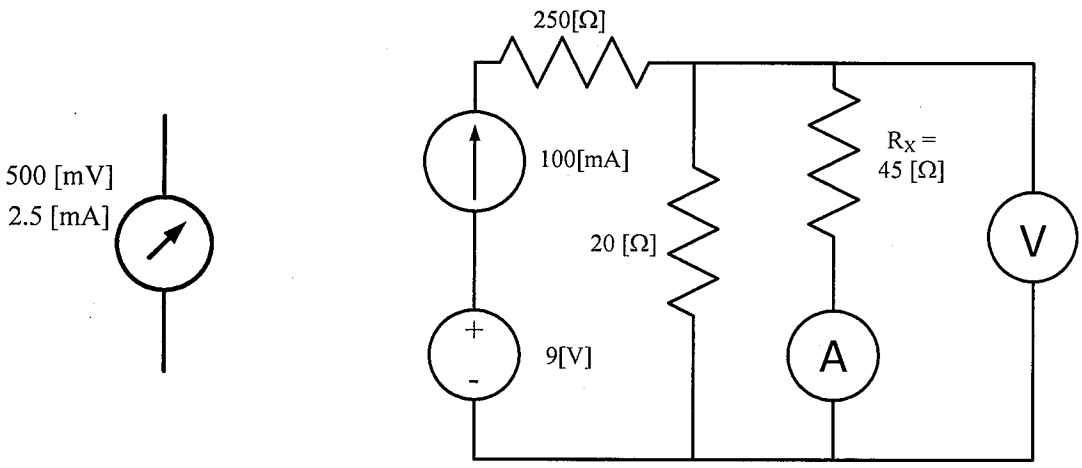
_____/25

A measurement of an unknown resistor R_X is attempted using a voltmeter and an ammeter, as shown in the circuit below. The intention is to simultaneously measure the current through the resistor with the ammeter, and the voltage across the resistor with the voltmeter. The resistance will then be obtained from the ratio of these two readings. The true value of R_X is shown in the circuit diagram (in other words, $R_{X,true} = 45$ [Ω]).

Both the ammeter and the voltmeter are constructed using a d'Arsonval meter movement like the one shown below. The ammeter has a full scale current of 50 [mA]. The voltmeter is has a full scale voltage of 10 [V]. Both meters are inserted into the circuit at the same time.

a) Find the ammeter reading.
b) Find the voltmeter reading.
c) Use the ratio of the voltmeter and ammeter readings to find the measured value of R_X.
d) How much error is there in this resistance measurement? To calculate error, use the true value of R_X is a reference; that is,

$$\%error = \frac{R_{X,measured} - R_{X,true}}{R_{X,true}} x100\% .$$



Room for extra work

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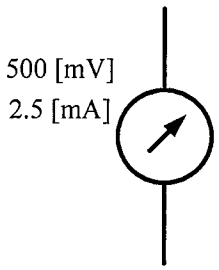
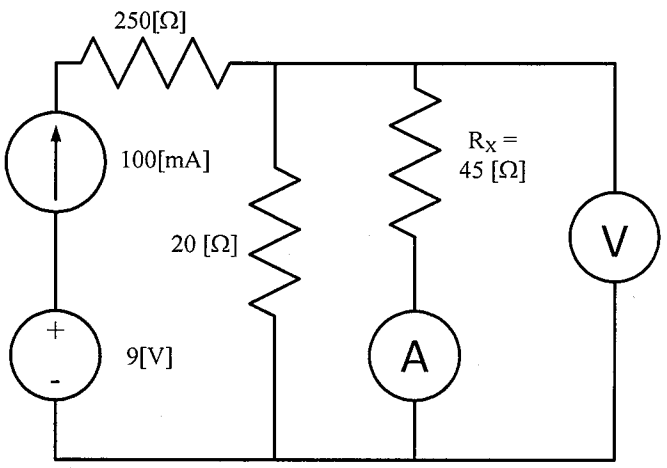




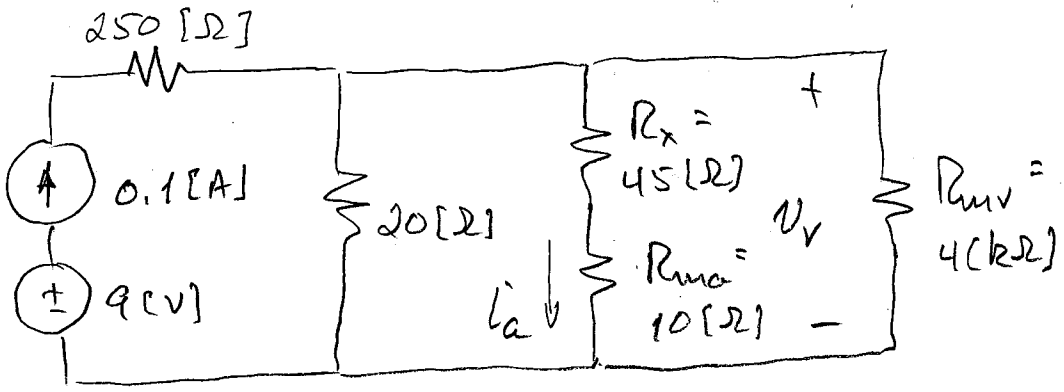
We will need to find the meter resistances and insert them into the circuit.

ammeter: $R_{ma} = \frac{V_{d'A,fs}}{I_{meas,fs}} = \frac{500\,[mV]}{50\,[mA]} = 10\,[\Omega]$

voltmeter $R_{mv} = \frac{V_{meas,fs}}{I_{d'A,fs}} = \frac{10\,[V]}{2.5\,[mA]} = 4\,[k\Omega]$

Room for extra work

Re-draw with meter resistances:



a) The ammeter reads i_a. We will combine R_{mv} in parallel with 20 [Ω] and then use CDR

$$R_{eq,1} = R_{mv} \,//\, 20\,[\Omega] = 19.90\,[\Omega]$$

$$i_a = 0.1 \times \frac{19.90}{19.90 + 45 + 10} = 26.57\,[mA] = i_a$$

b) The voltmeter reads V_V.

$$V_V = i_a \cdot (R_x + R_{ma}) = 1.461\ [V]$$

(So we are measuring $R_x + R_{ma}$!)

c) The measured R_x is

$$R_{x,meas} = \frac{V_V}{i_a} = R_x + R_{ma} = 55\,[\Omega].$$

d) $$\%\ error = \frac{R_{x\,meas} - R_{x,true}}{R_{x,true}} \times 100\% = \frac{55 - 45}{45} = 22.2\%$$