

EGR 224 Spring 2016
Test I
Michael R. Gustafson II

Name (please print) _____

KEY

In keeping with the Community Standard, I have neither provided nor received any assistance on this test. I understand if it is later determined that I gave or received assistance, I will be brought before the Undergraduate Conduct Board and, if found responsible for academic dishonesty or academic contempt, fail the class. I also understand that I am not allowed to speak to anyone except the instructor about any aspect of this test until the instructor announces it is allowed. I understand if it is later determined that I did speak to another person about the test before the instructor said it was allowed, I will be brought before the Undergraduate Conduct Board and, if found responsible for academic dishonesty or academic contempt, fail the class.

Signature: _____

Key

Instructions

First - please turn **off** any cell phones or other annoyance-producing devices. Vibrate mode is not enough - your device needs to be in a mode where it will make no sounds during the course of the test, including the vibrate buzz or those acknowledging receipt of a text or voicemail.

Please be sure to put each problem on its own page or pages - do *not* write answers to more than one problem on any piece of paper and do not use the back of a problem for work on a *different* problem. You will be turning in each of the problems independently. This cover page should be stapled to the front of Problem 1.

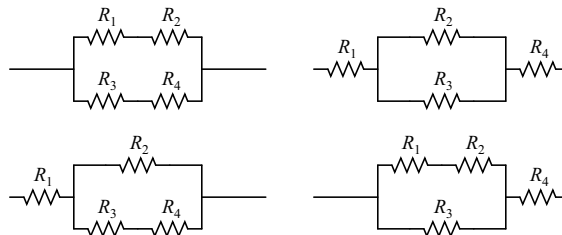
Make sure that your name *and* NET ID are *clearly* written at the top of *every* page, just in case problem parts come loose in the shuffle. Make sure that the work you are submitting for an answer is clearly marked as such. Finally, when turning in the test, individually staple all the work for each problem and place each problem's work in the appropriate folder.

Note that there may be people taking the test after you, so you are not allowed to talk about the test - even to people outside of this class - until I send along the OK. This includes talking about the specific problem types, how long it took you, how hard you thought it was - really anything. Please maintain the integrity of this test.

You may use the || symbol for resistances in parallel and do not need to expand that construction. Be clear with your use of parentheses, however; simply writing something like

$$R_{eq} = R_1 + R_2 \parallel R_3 + R_4$$

is too vague since it could refer to any of the four combinations below:



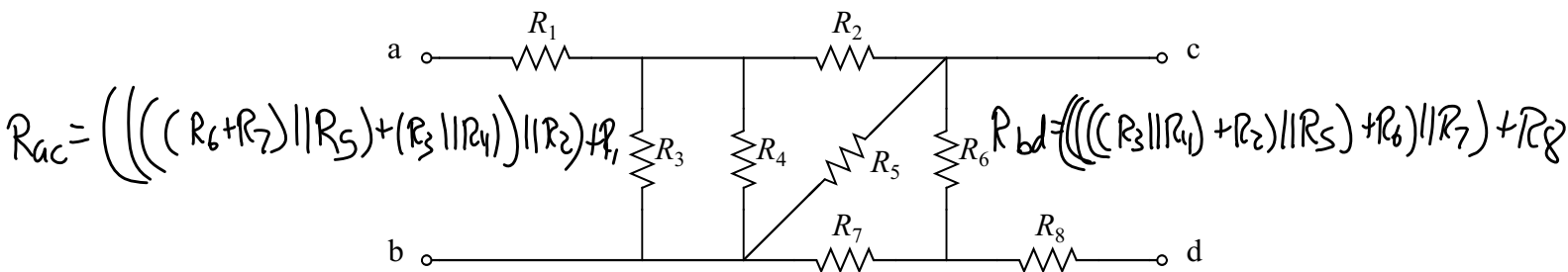
Name (please print):

Community Standard (print ACPUB ID):

Problem I: [24 pts.] Equivalents and Division

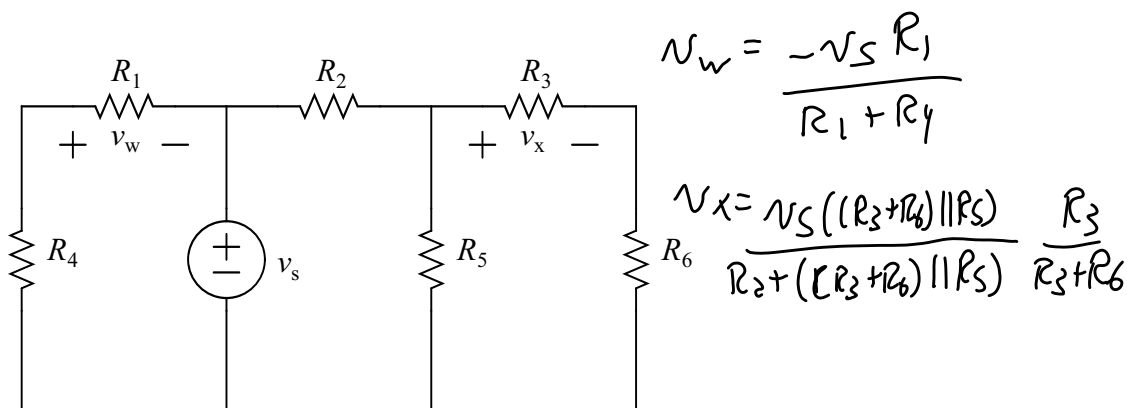
For all parts of this problem, you can *carefully* use the \parallel symbol (and parentheses) as appropriate and do *not* need to simplify expressions using that symbol.

(1) For the following network:



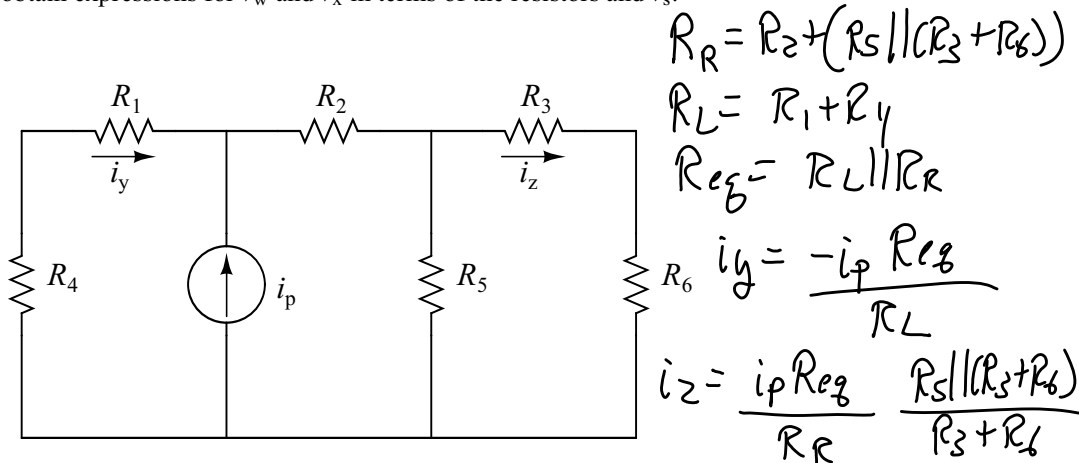
- (a) Find the equivalent resistance as seen from terminals **a** and **c**, R_{ac}
 (b) Find the equivalent resistance as seen from terminals **b** and **d**, R_{bd} .

(2) For the following circuit:



clearly show voltage division to obtain expressions for v_w and v_x in terms of the resistors and v_s .

(3) For the following circuit:



clearly show current division to obtain expressions for i_y and i_z in terms of the resistors and i_p .

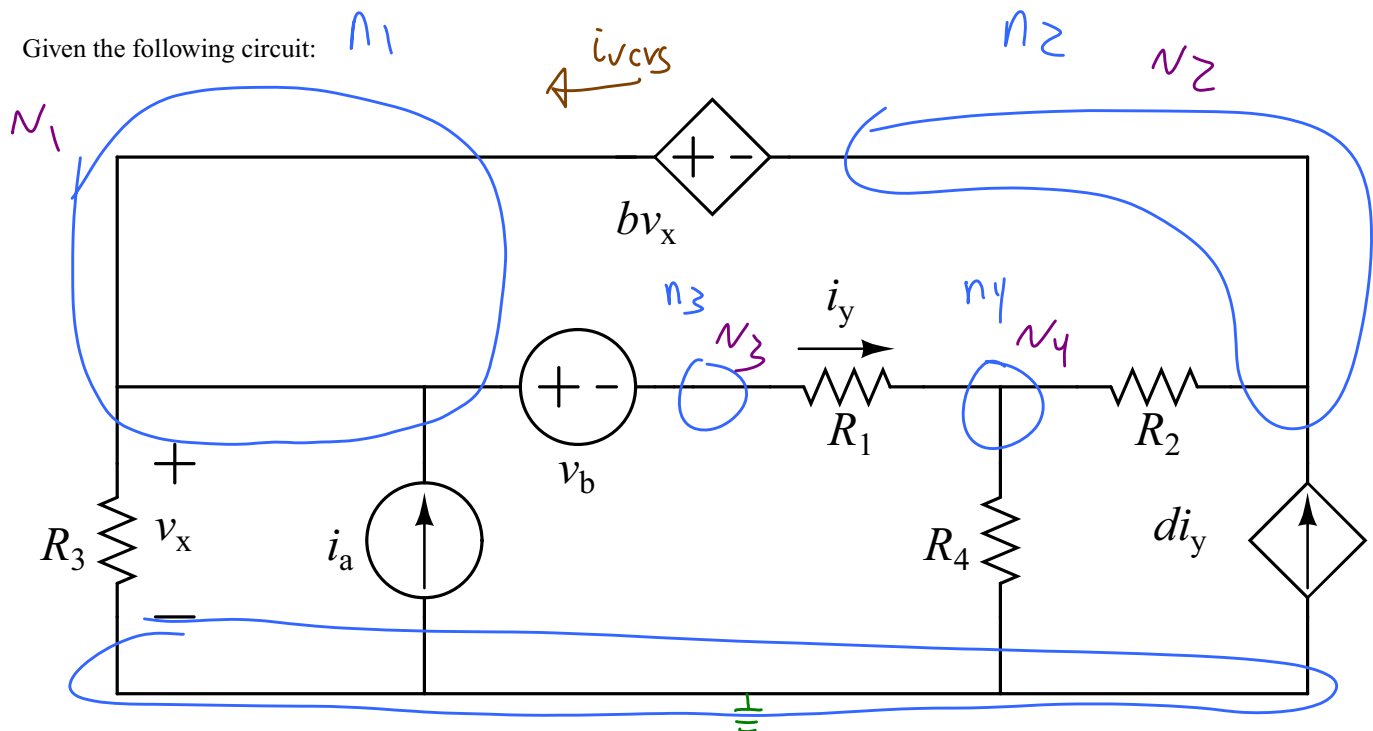
Name (please print):

Community Standard (print ACPUB ID):

Problem II: [20 pts.] Node Voltage Method

LAZY LABELS

Given the following circuit:



and assuming that constants b and d , the values for the passive elements (R_1 through R_4), and the values for the independent sources (i_a and v_b) are known,

- (1) Clearly demonstrate the use of the Node Voltage Method in labeling unknowns for the circuit and in determining a complete set of linearly independent equations that could be used to solve for these unknowns. List the set of unknowns you believe your equations will find. Please put the list of unknowns and the equations on a separate piece of paper and in a box; you can label the circuit above.
- (2) Assuming you are able to solve for those unknowns, write expressions for the following. Put your expressions next to the appropriate bullet below even if your work is elsewhere:

• $P_{\text{abs}, R_2} = (v_2 - v_4)^2 / R_2$

• $P_{\text{del}, \text{VCVS}} = \text{get } i_{\text{vcvs}} \text{ from } \frac{v_x}{R_3} - i_a + i_y \text{ or } n_2: di_y + \frac{v_4 - v_2}{R_2}$
 $P_{\text{del}} = b v_x i_{\text{vcvs}}$

• $P_{\text{del}, \text{CCCS}} = v_2 di_y$

Unk: $v_1, v_2, v_3, v_4, v_x, i_y$

#KCL = $S_{\text{nodes}} - \text{gnd} - 2 \text{vsrc} = 2$

KCL_{n4}: $\frac{v_4 - v_3}{R_1} + \frac{v_4}{R_4} + \frac{v_4 - v_2}{R_2} = 0$

KCL_{n1}: $\frac{v_1}{R_3} - i_a + \frac{v_3 - v_4}{R_1} + \frac{v_2 - v_4}{R_2} - di_y = 0$

SR_{Cb}: $v_b = v_1 - v_3$

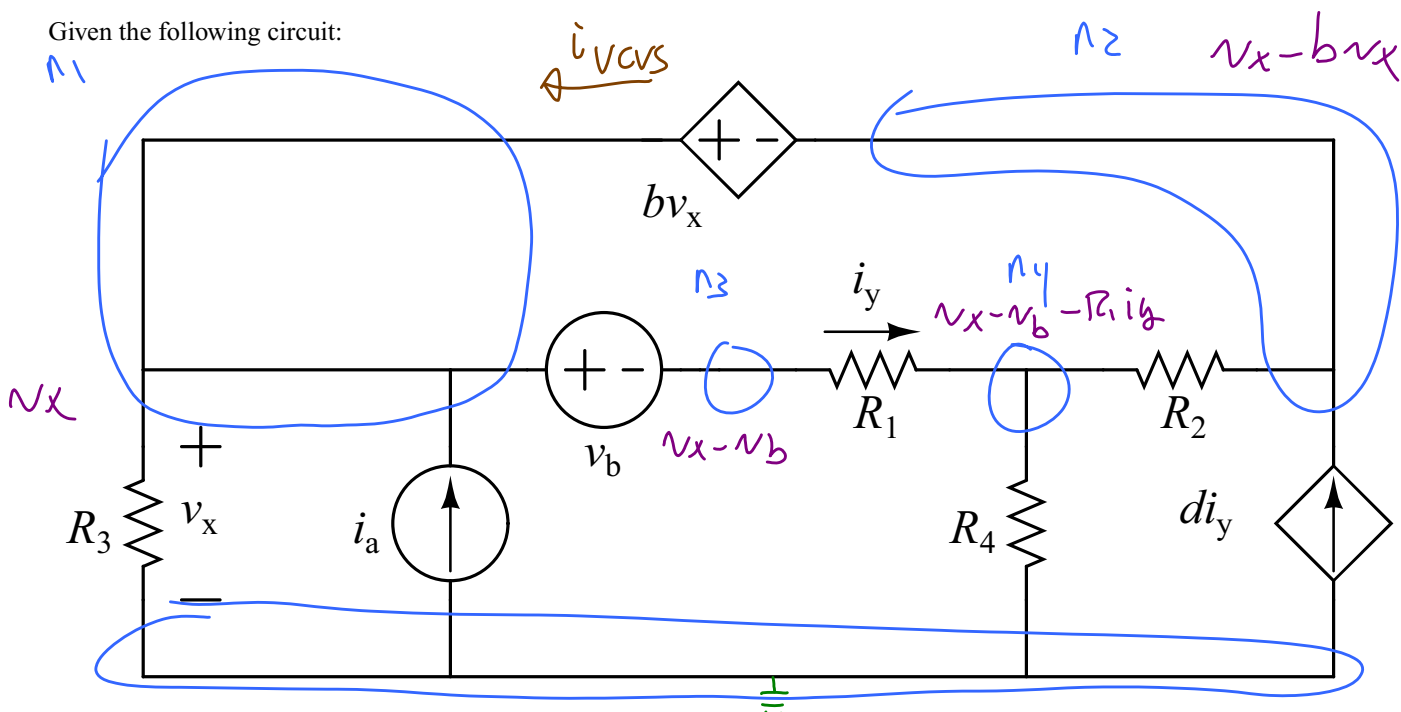
SR_{VCVS}: $b v_x = v_1 - v_2$

Meas v_x : $v_x = v_1$

Meas i_y : $i_y = \frac{v_3 - v_4}{R_1}$

Problem II: [20 pts.] Node Voltage Method SMART LABELS

Given the following circuit:



and assuming that constants b and d , the values for the passive elements (R_1 through R_4), and the values for the independent sources (i_a and v_b) are known,

- Clearly demonstrate the use of the Node Voltage Method in labeling unknowns for the circuit and in determining a complete set of linearly independent equations that could be used to solve for these unknowns. List the set of unknowns you believe your equations will find. Please put the list of unknowns and the equations on a separate piece of paper and in a box; you can label the circuit above.
- Assuming you are able to solve for those unknowns, write expressions for the following. Put your expressions next to the appropriate bullet below even if your work is elsewhere:

• $P_{\text{abs}, R_2} = \frac{(v_b + R_1 i_y - b v_x)^2}{R_2}$

• $P_{\text{del}, \text{VCVS}} =$ get i_{VCVS} from
 $s_{n13}: \frac{v_x}{R_3} - i_a + i_y$ or $n2: \frac{v_b + R_1 i_y - b v_x}{R_2} - d i_y$
 $P_{\text{del}} = b v_x i_{\text{VCVS}}$

• $P_{\text{del}, \text{CCCS}} = (v_x - b v_x) d i_y$

Unknown: v_x, i_y ; still $\geq \text{KCL}$
 $\text{KCL}, n_4: -i_y + \frac{(v_x - v_b - R_1 i_y)}{R_1} + \frac{(-v_b - R_1 i_y + b v_x)}{R_2} = 0$

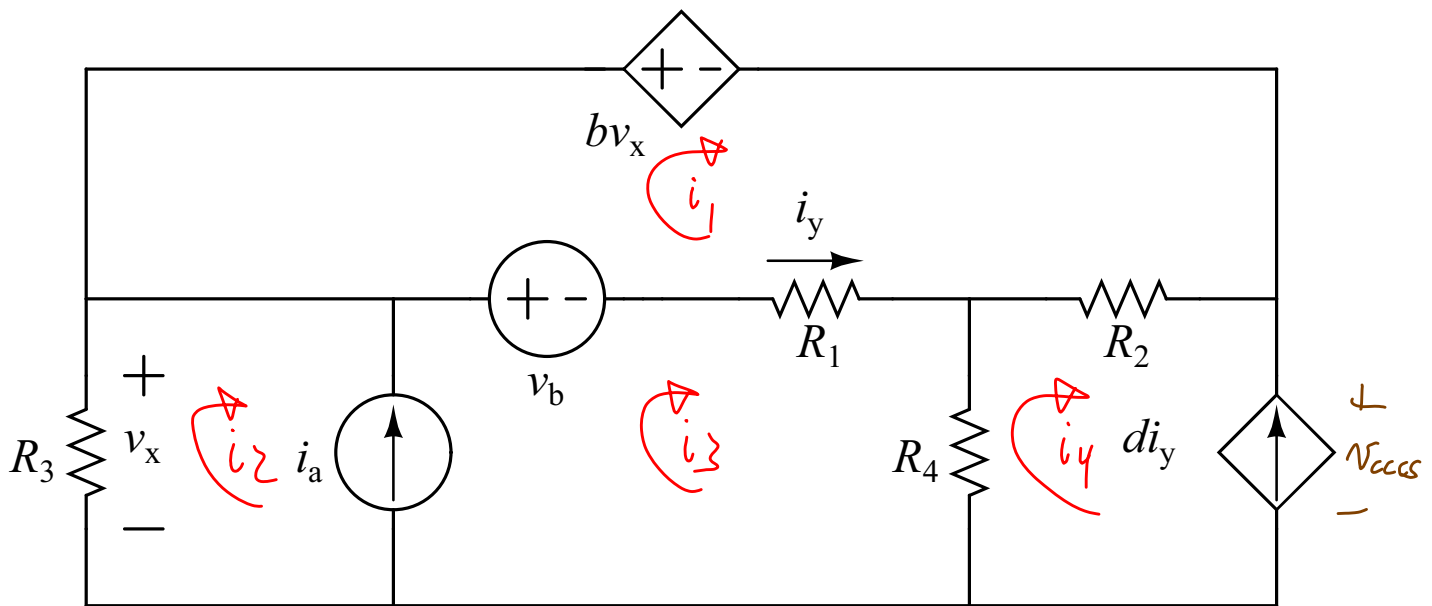
$\text{KCL}, s_{n123}: \frac{v_x}{R_3} - i_a + i_y + \frac{(v_b + R_1 i_y - b v_x)}{R_2} - d i_y = 0$

Name (please print):

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Problem III: [20 pts.] Branch/Mesh Current Method

Given the following circuit:



and assuming that constants b and d , the values for the passive elements (R_1 through R_4), and the values for the independent sources (i_a and v_b) are known,

- (1) Clearly demonstrate the use of either the Branch Current Method or Mesh Current Method in labeling unknowns for the circuit and in determining a complete set of linearly independent equations that could be used to solve for these unknowns. Indicate which method (BCM or MCM) you are using. List the set of unknowns you believe your equations will find. Please put the list of unknowns and the equations on a separate piece of paper and in a box; you can label the circuit above.
- (2) Assuming you are able to solve for those unknowns, write expressions for the following. Put your expressions next to the appropriate bullet below even if your work is elsewhere

• $P_{\text{abs}, R_2} = (i_1 - i_4)^2 R_2$

• $P_{\text{del}, \text{VCVS}} = -bv_x i_1$

• $P_{\text{del}, \text{CCCS}} =$
 from i_4 , $v_{\text{cccs}} = R_4(i_3 - i_4) + R_2(i_1 - i_4)$
 $P_{\text{del}} = v_{\text{cccs}} di_y$

Unk: $i_1, i_2, i_3, i_4, v_x, i_y$

#KVL: 2/mesh - 2 isrc = 2

KVL l_1 : $bv_x + R_2(i_1 - i_4) + R_1(i_1 - i_3) - v_b = 0$

KVL sl_{23} : $R_3 i_2 + v_b + R_1(i_3 - i_1) + R_4(i_3 - i_4) = 0$

SRCS i_a : $i_a = i_3 - i_2$

SRCCCS: $di_y = -i_4$

MEAS v_x : $v_x = -R_3 i_2$

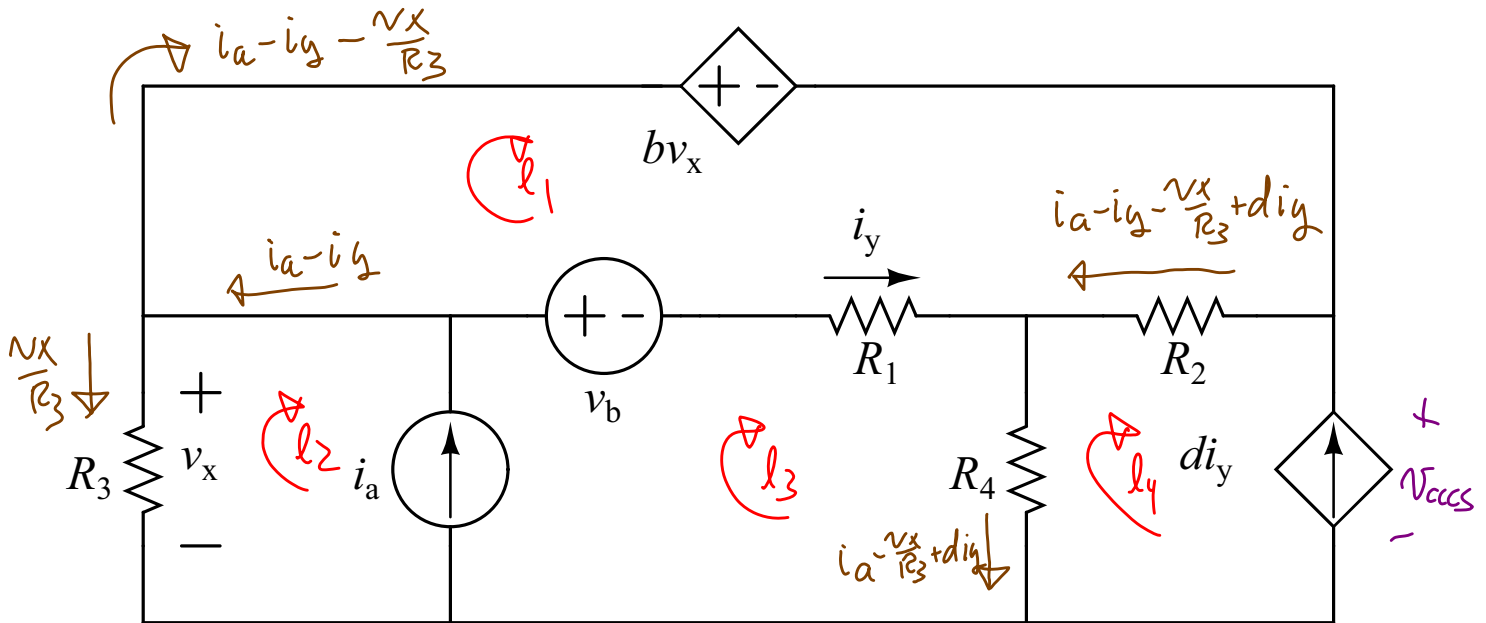
MEAS i_y : $i_y = i_3 - i_1$

Name (please print):

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Problem III: [20 pts.] Branch Mesh Current Method

Given the following circuit:



and assuming that constants b and d , the values for the passive elements (R_1 through R_4), and the values for the independent sources (i_a and v_b) are known,

- (1) Clearly demonstrate the use of either the Branch Current Method or Mesh Current Method in labeling unknowns for the circuit and in determining a complete set of linearly independent equations that could be used to solve for these unknowns. Indicate which method (BCM or MCM) you are using. List the set of unknowns you believe your equations will find. Please put the list of unknowns and the equations on a separate piece of paper and in a box; you can label the circuit above.
- (2) Assuming you are able to solve for those unknowns, write expressions for the following. Put your expressions next to the appropriate bullet below even if your work is elsewhere

- $P_{\text{abs}, R_2} = (i_a - i_y - \frac{v_x}{R_3} + di_y)^2 R_2$

Unk: v_x, i_y

KVL, l_1 : $bv_x + R_2(i_a - i_y - \frac{v_x}{R_3} + di_y) - R_1 i_y - v_b = 0$

KVL, l_2 : $-v_x + v_b + R_1 i_y + R_4(i_a - \frac{v_x}{R_3} + di_y) = 0$

- $P_{\text{del}, \text{VCVS}} = -bv_x(i_a - i_y - \frac{v_x}{R_3})$

- $P_{\text{del}, \text{CCCS}} = \text{from KVL, } l_4, v_{\text{cccs}} = R_4(i_a - \frac{v_x}{R_3} + di_y) + R_2(i_a - i_y - \frac{v_x}{R_3} + di_y)$
 $P_{\text{del}} = v_{\text{cccs}} di_y$

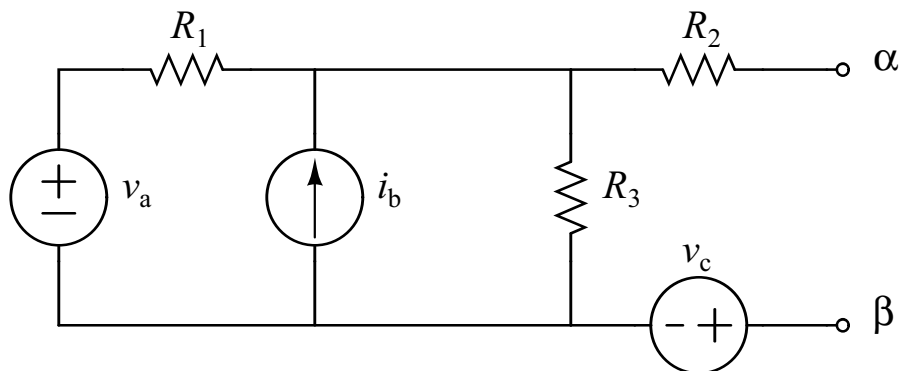
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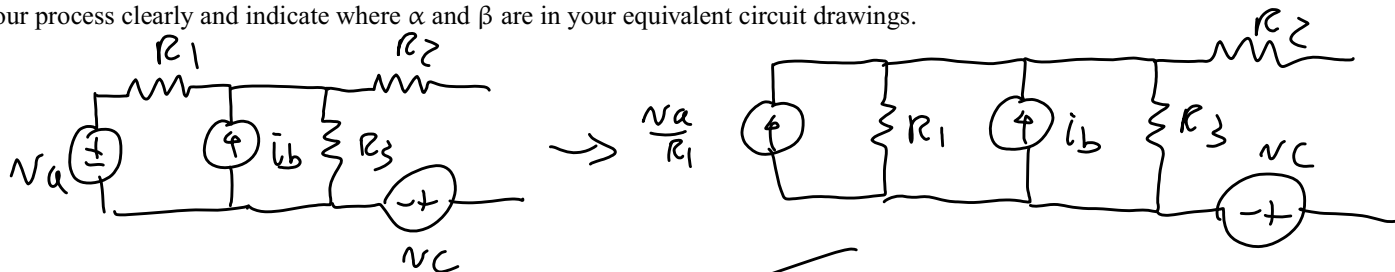
Problem IV: [16 pts.] Thévenin/Norton I

using source x-forms

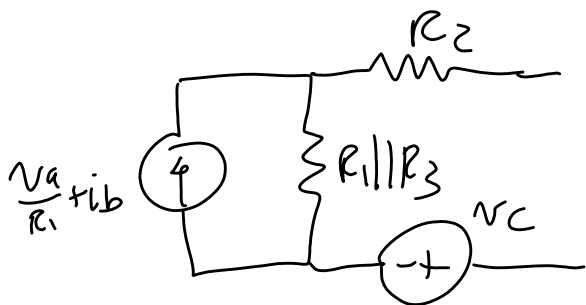
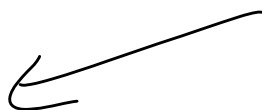
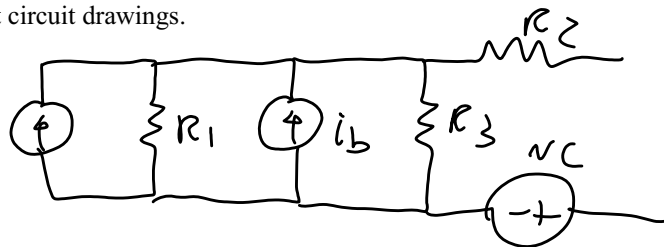
Note: for the problem below you must *fully solve* expressions for any variables that are unknown; you cannot simply leave unsolved systems of equations. You do *not*, however, need to simplify any compound fractions, nor do you need to expand any use of the parallel resistance symbol discussed on the cover page. Furthermore, once a variable is fully solved in terms of known values, that variable can also be considered “known” - you do not need to back-substitute. Given the following circuit:



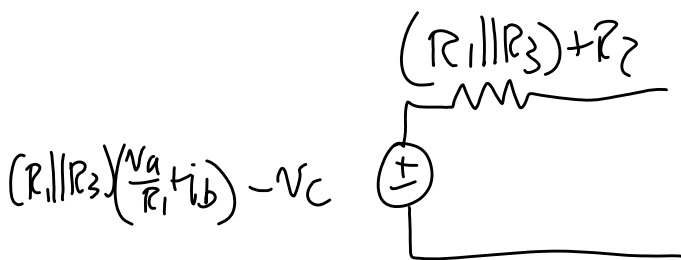
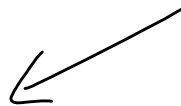
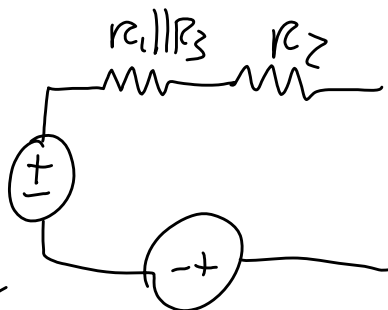
and assuming that the values for the passive elements (R_1 through R_3) and the values for the independent sources (v_a , i_b , v_c) are known, draw both the Thévenin and Norton equivalent circuits with respect to terminals α and β in terms of the known values. Be sure to show your process clearly and indicate where α and β are in your equivalent circuit drawings.



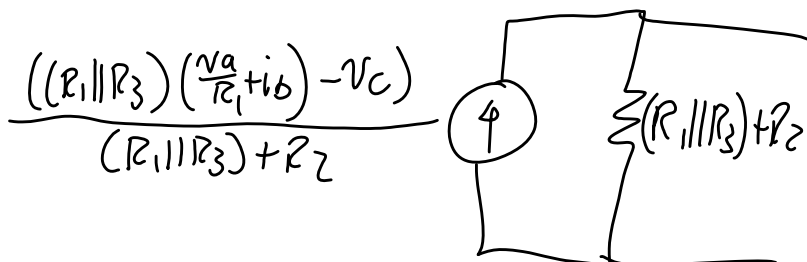
$$\rightarrow \frac{v_a}{R_1}$$



$$\rightarrow (R_1 \parallel R_3) \left(\frac{v_a}{R_1} + i_b \right)$$



Thévenin



Norton

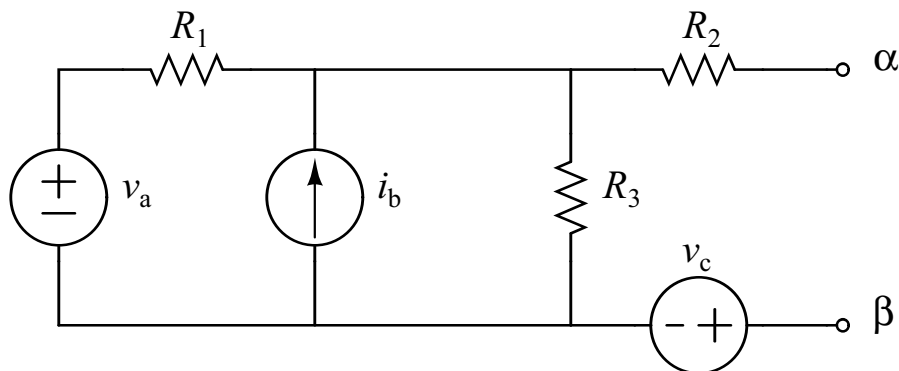
Name (please print):

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Problem IV: [16 pts.] Thévenin/Norton I

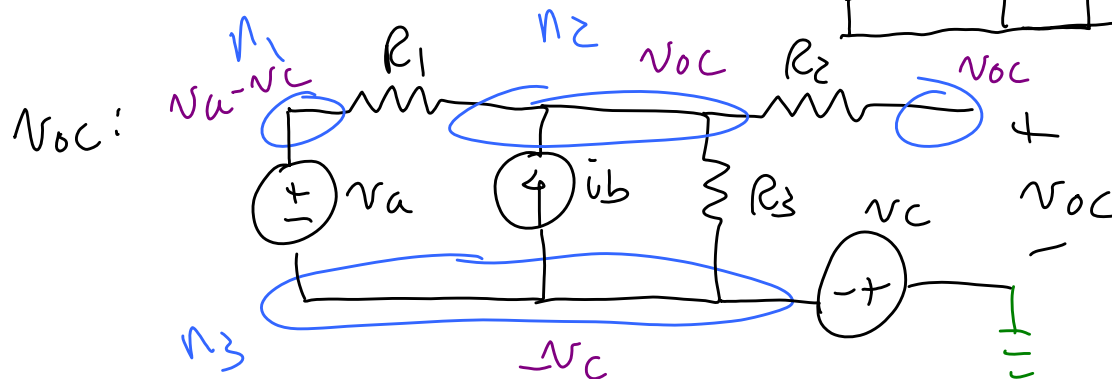
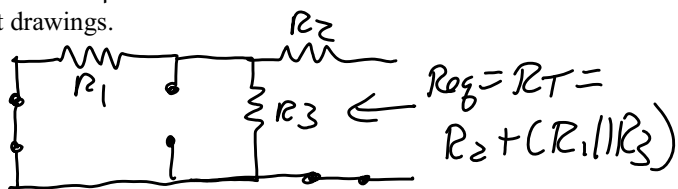
R_{Th} , V_{OC}

Note: for the problem below you must *fully solve* expressions for any variables that are unknown; you cannot simply leave unsolved systems of equations. You do *not*, however, need to simplify any compound fractions, nor do you need to expand any use of the parallel resistance symbol discussed on the cover page. Furthermore, once a variable is fully solved in terms of known values, that variable can also be considered “known” - you do not need to back-substitute. Given the following circuit:



and assuming that the values for the passive elements (R_1 through R_3) and the values for the independent sources (v_a , i_b , v_c) are known, draw both the Thévenin and Norton equivalent circuits with respect to terminals α and β in terms of the known values. Be sure to show your process clearly and indicate where α and β are in your equivalent circuit drawings.

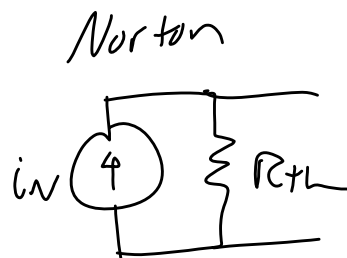
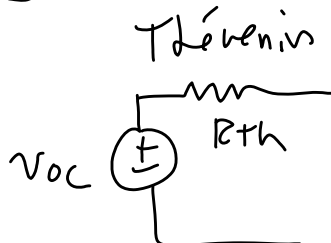
All indep; R_{Th} if sources off:



$$KCL, n_2: \frac{V_{OC} - v_a + v_c}{R_1} - i_b + \frac{V_{OC} + v_c}{R_3} = 0$$

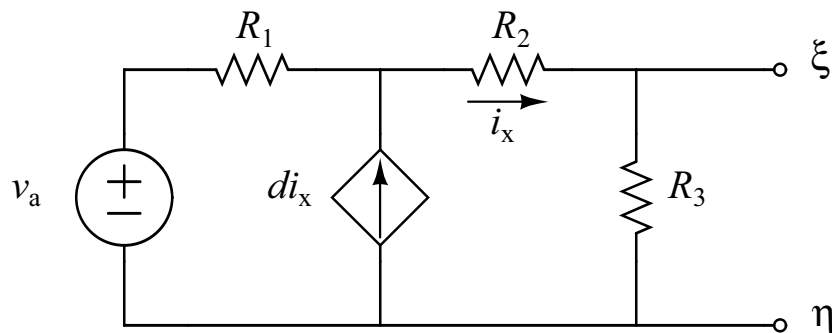
$$V_{OC} = \frac{\frac{v_a}{R_1} + i_b - \frac{v_c}{R_1} - \frac{v_c}{R_3}}{\frac{1}{R_1} + \frac{1}{R_3}} = V_{Th}$$

$$i_{SC} = i_N = \frac{V_{Th}}{R_{Th}}$$

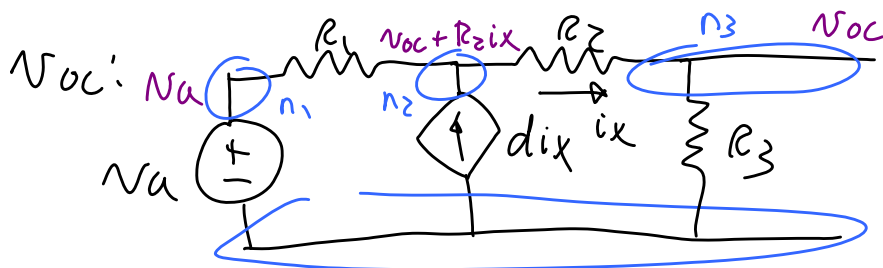


Problem V: [20 pts.] Thévenin/Norton II

Note: for the parts below you must *fully solve* expressions for any variables that are unknown; you cannot simply leave unsolved systems of equations. You do *not*, however, need to simplify any compound fractions, nor do you need to expand any use of the parallel resistance symbol discussed on the cover page. Furthermore, once a variable is fully solved in terms of known values, that variable can also be considered “known” - you do not need to back-substitute. Given the following circuit:



and assuming that the values for the passive elements (R_1 and R_2), the value for the source (v_a), and the value for the constant d are known, draw the Norton equivalent circuit with respect to terminals ξ and η in terms of the known values. Be sure to show your process clearly and indicate where ξ and η are in your equivalent circuit drawings.



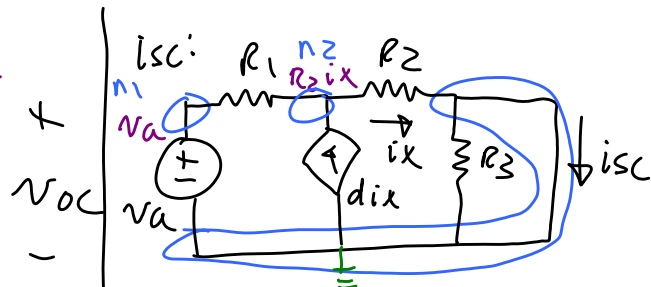
$$\text{KCL}_{n3}: -i_x + \frac{V_{OC}}{R_3} = 0 \quad i_x = \frac{V_{OC}}{R_3}$$

$$\text{KCL}_{n2}: \frac{V_{OC} + R_2 i_x - v_a}{R_1} - d i_x + i_x = 0$$

$$\frac{V_{OC} + \frac{R_2}{R_3} V_{OC} - v_a}{R_1} - \frac{d}{R_3} V_{OC} + \frac{V_{OC}}{R_3} = 0$$

$$V_{OC} = \frac{\frac{v_a}{R_1}}{\frac{1}{R_1} + \frac{R_2}{R_1 R_3} - \frac{d}{R_3} + \frac{1}{R_3}}$$

or $\frac{R_3 v_a}{R_1 + R_2 + R_3 - d R_1}$; note if $d=0$ this is just voltage div.



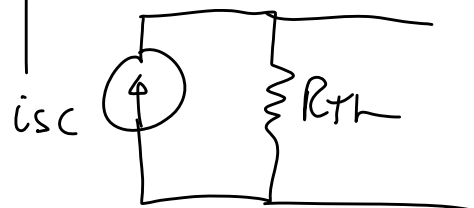
$$I_{SC} = i_x$$

$$\text{KCL}_{n2}: \frac{R_2 i_x - v_a}{R_1} - d i_x + i_x = 0$$

$$i_x = \frac{v_a}{\frac{R_2}{R_1} - d + 1} = I_{SC} = \frac{v_a}{R_1 + R_2 - d R_1}$$

$$R_{TH} = V_{OC} / I_{SC}$$

Norton:



if $d=0$,
just
Ohm's
Law.