Duke University
Edmund T. Pratt, Jr. School of Engineering

EGR 224 Spring 2013

Test I

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Name (please print) SOLUTION

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: ____________________

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.

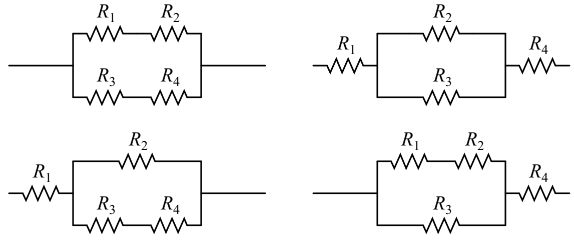
Make sure that your name *and* NET ID are *clearly* written at the top of *every* page, just in case problem parts come loose in the shuffle. Make sure that the work you are submitting for an answer is clearly marked as such. Finally, when turning in the test, individually staple all the work for each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

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

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



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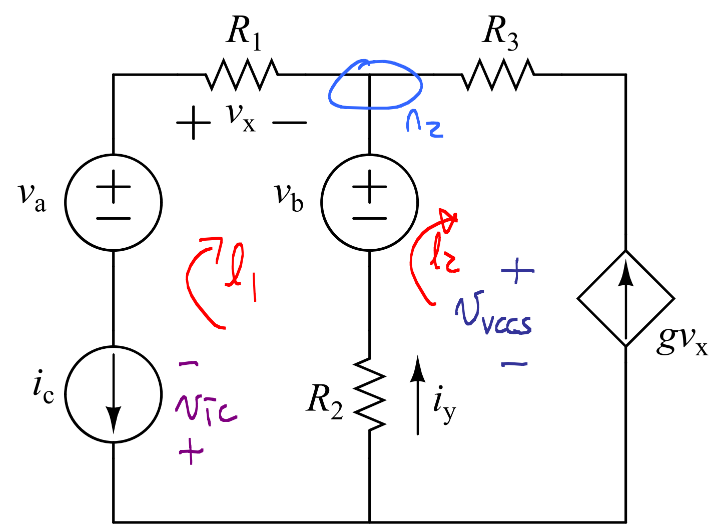
Problem I: [20 pts.] The Basics

Given the following circuit:



and assuming that constant g, the values for the passive elements (R_1 through R_3), and the values for the independent sources (v_a, v_b, and i_c) are known, determine expressions for the following items in terms of known values. Note - if you solve for an unknown in terms of known quantities and clearly indicate that expression, you may use that unknown in later calculations without substitution. Put your expressions next to the appropriate bullet below:

- v_x Since i_c & R_1 in series, $v_x = -i_c R_1$ by Ohm's law

- i_y KCL, n_2: $i_c - i_y - g v_x = 0$ $\quad i_y = i_c - g v_x = i_c + g i_c R_1$

- $p_{abs,R_3} =$ $i_{R_3}^2 R_3 = (g v_x)^2 R_3$

- $p_{del,v_b} =$ $i_y v_b$

- $p_{del,i_c} =$ KVL, l_1: $v_{ic} - v_a + v_x + v_b - R_2 i_y = 0$ so
  $v_{ic} = v_a - v_x - v_b + R_2 i_y$ $\quad p_{del,ic} = i_c v_{ic}$

- $p_{del,VCCS} =$ KVL, l_2: $R_2 i_y - v_b - g v_x R_3 + v_{VCCS} = 0$ so
  $v_{VCCS} = -R_2 i_y + v_b + g v_x R_3$ $\quad p_{del,VCCS} = g v_x v_{VCCS}$

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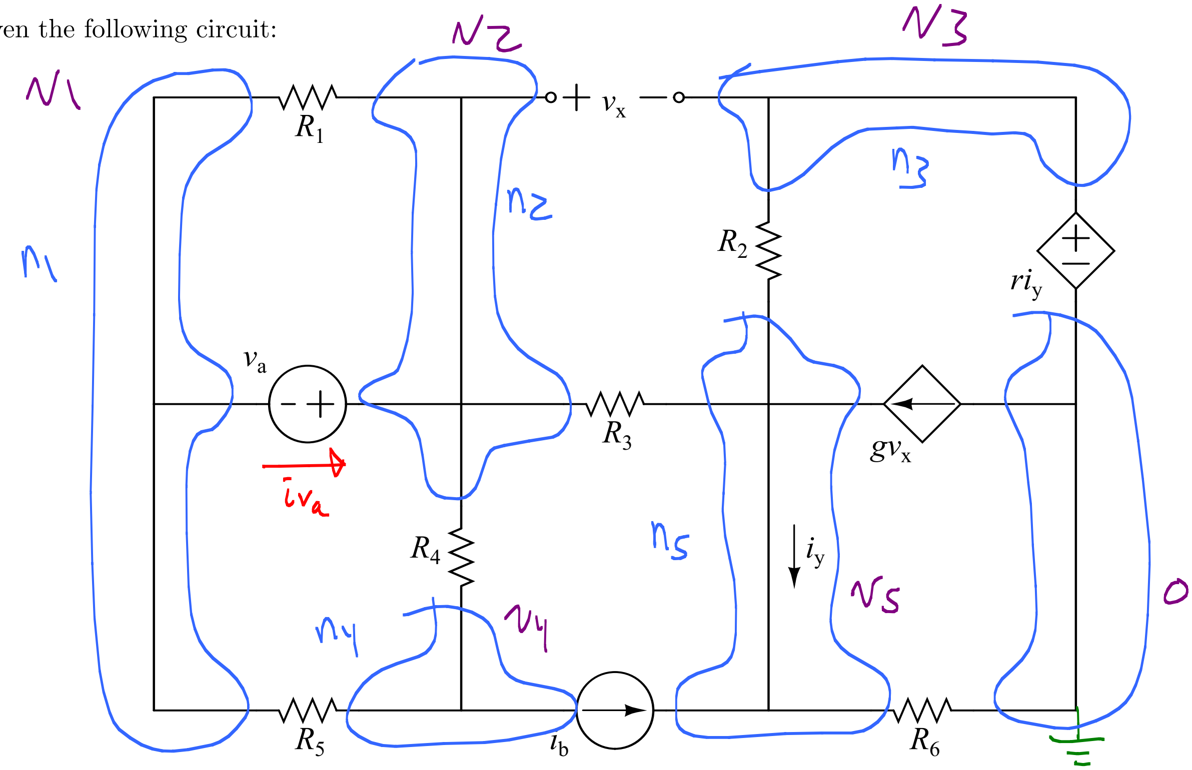
Problem II: [20 pts.] Node Voltage Method

Given the following circuit:



and assuming that constants g and r, the values for the passive elements (R_1 through R_6), and the values for the independent sources (v_a and i_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; you can label the circuit above.

(2) Assuming you are able to solve for those unknowns, write expressions for

- $p_{\text{abs},R_4} =$ $(v_2 - v_4)^2 / R_4$

- $p_{\text{del},v_a} =$ get i_{va} from KCL, n_1: $i_{va} + \frac{v_1 - v_4}{R_5} + \frac{v_1 - v_2}{R_1} = 0$ or

  KCL, n_2: $-i_{va} + \frac{v_2 - v_1}{R_1} + \frac{v_2 - v_5}{R_3} + \frac{v_2 - v_4}{R_4} = 0$

  $P_{del} = v_a i_{va}$

6 nodes − 1 + 2 controlling vars = 7 unk

v_1 v_2 v_3 v_4 v_5 v_x i_y

6 nodes − 1 − 2 v. source = 3 KCL

2 Source 2 Controlling

KCL, sn12 $\frac{v_2 - v_5}{R_3} + \frac{v_2 - v_4}{R_4} + \frac{v_3 - v_4}{R_5} = 0$

KCL, n4: $\frac{v_4 - v_1}{R_5} + \frac{v_4 - v_2}{R_4} + i_b = 0$

KCL, n5: $-i_b + \frac{v_5 - v_2}{R_3} + \frac{v_5 - v_3}{R_2} - g v_x + \frac{v_5 - 0}{R_6} = 0$

SRC Va: $v_a = v_2 - v_a$

SRC CCVS: $r i_y = v_3 - 0$

CTRL, vx: $v_x = v_2 - v_3$

CTRL, iy: use either top or bottom of node 5

$i_y = -i_b - \frac{v_5}{R_6}$ or

$i_y = \frac{v_2 - v_5}{R_3} + \frac{v_3 - v_5}{R_2} + g v_x$

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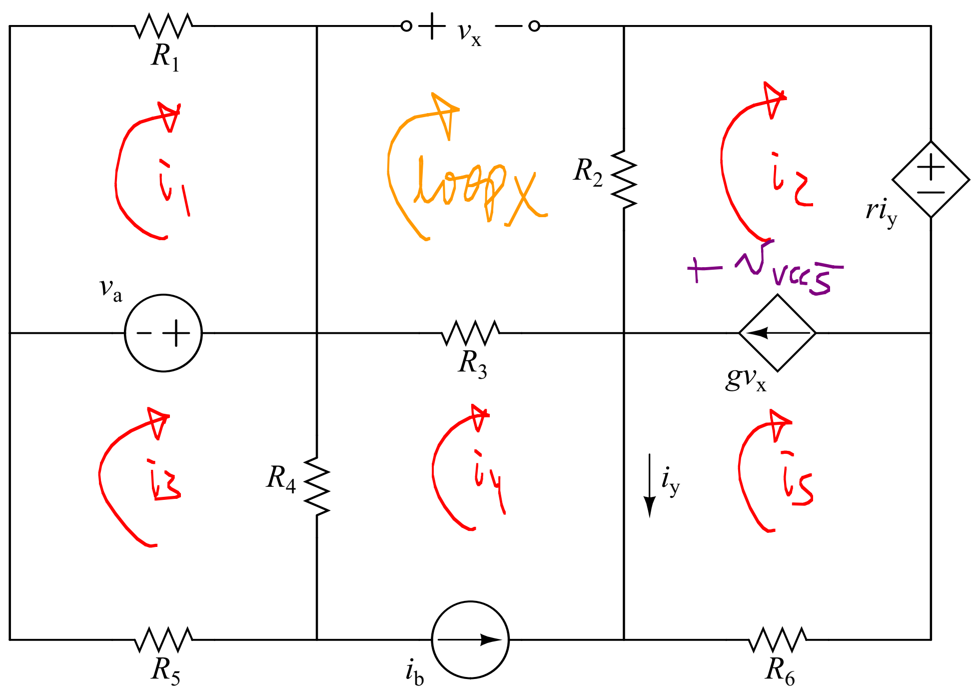
Problem III: [20 pts.] Branch/Mesh Current Method

Given the following circuit:



and assuming that constants g and r, the values for the passive elements (R_1 through R_6), and the values for the independent sources (v_a and i_b) are known,

(1) *Clearly* demonstrate the use of either the Branch Current Method or the 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. State which method 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; you can label the circuit above.

(2) Assuming you are able to solve for those unknowns, write expressions for

- $p_{\text{abs},R_4} =$ $(i_3 - i_4)^2 R_4$

- $p_{\text{del,VCCS}} =$

use either KVL, l_2: $-v_{vccs} + R_2 i_2 + r i_y = 0$ OR
KVL, l_5: $v_{vccs} + i_5 R_6 = 0$ to get v_{vccs};

$p_{del,vccs} = g v_x v_{vccs}$

5 mesh + 2 measurement = 7 unk

$i_1 \quad i_2 \quad i_3 \quad i_4 \quad i_5 \quad v_x \quad i_y$

5 mesh − 2 i. source = 3 KVL

2 Source $\qquad$ 2 Control

KVL, l_1: $v_a + R_1 i_1 = 0$

KVL, sl_{25}: $R_2 i_2 + r i_y + R_6 i_5 = 0$

KVL, l_3: $-v_a + R_4(i_3 - i_4) + R_5 i_3 = 0$

SRC, i_b: $i_b = -i_4$

SRC VCCS: $g v_x = i_2 - i_5$

CTRL i_y: $i_y = i_4 - i_5$

CTRL v_x: use loop x

$$R_3(-i_4) + v_x + R_2(-i_2) = 0$$

$$v_x = R_3 i_4 + R_2 i_2$$

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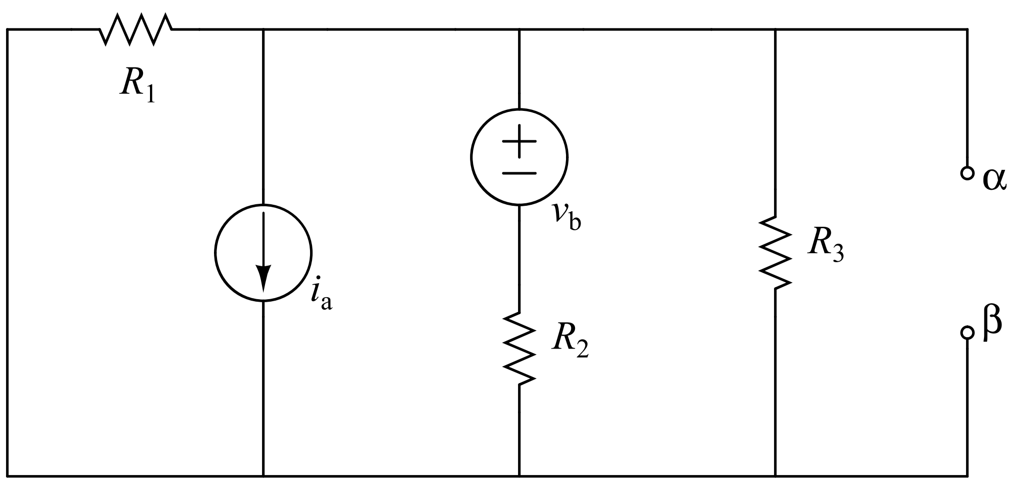
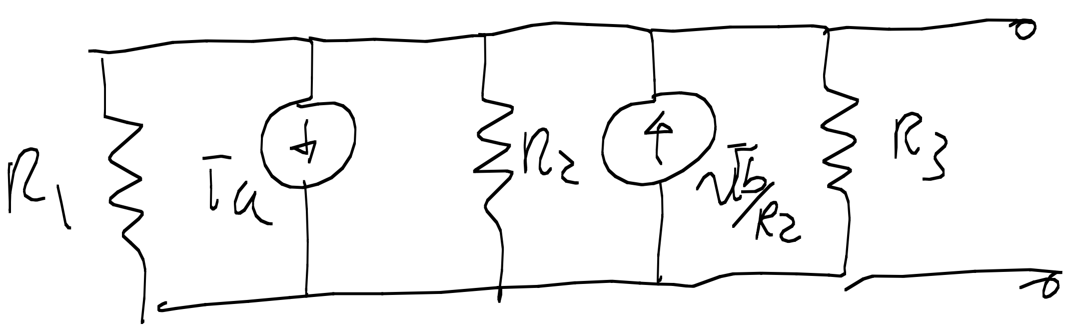
Problem IV: [20 pts.] Thévenin/Norton 1

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 (i_a and v_b) 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. *Note:* 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. Be sure to clearly indicate where α and β are in your equivalent circuit drawings.

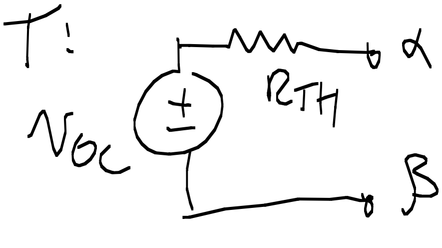
Transform v_b + R_2 into Norton:



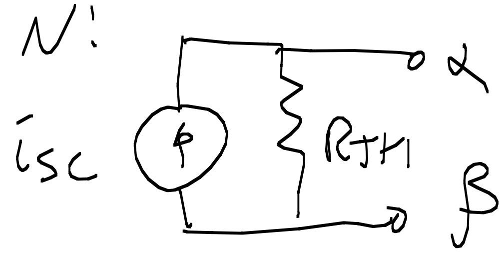
$R_{TH} = R_1 \| R_2 \| R_3$ $\quad i_{sc} = \frac{v_b}{R_2} - i_a$

$v_{oc} = i_{sc} R_{TH}$

T:



N:



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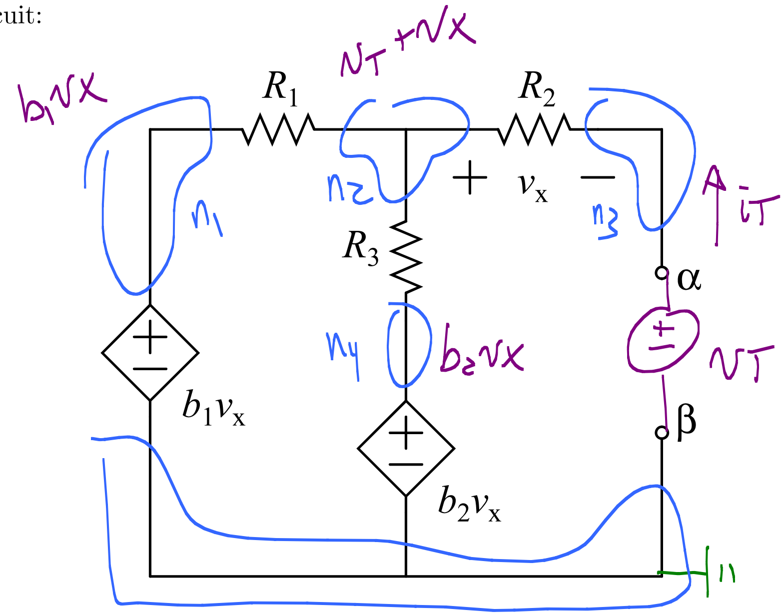
Problem V: [20 pts.] Thévenin/Norton 2

Given the following circuit:



and assuming that the values for the passive elements (R_1 through R_3) and the values for the constants b_1 and b_2 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. *Note:* 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. Be sure to clearly indicate where α and β are in your equivalent circuit drawings.

$v_{OC} = i_{SC} = 0$ since no indep. src; use v_T/i_T with test source

KCL, n_4: $\frac{v_T+v_x-b_1v_x}{R_1} + \frac{v_T+v_x-b_2v_x}{R_3} + \frac{v_x}{R_2} = 0$

$$v_x\left(\frac{1-b_1}{R_1}+\frac{1-b_2}{R_3}+\frac{1}{R_2}\right) = -v_T\left(\frac{1}{R_1}+\frac{1}{R_3}\right)$$

$i_T = \frac{-v_x}{R_2}$ so $v_x = -i_T R_2$

$$-i_T R_2\left(\frac{1-b_1}{R_1}+\frac{1-b_2}{R_3}+\frac{1}{R_2}\right) = -v_T\left(\frac{1}{R_1}+\frac{1}{R_3}\right)$$

$$R_T = \frac{v_T}{i_T} = \frac{R_2\left(\frac{1-b_1}{R_1}+\frac{1-b_2}{R_3}+\frac{1}{R_2}\right)}{\left(\frac{1}{R_1}+\frac{1}{R_3}\right)}$$

or

$$\frac{R_2R_3(1-b_1)+R_1R_2(1-b_2)+R_1R_3}{R_1+R_3}$$

T/N: