Duke University

Edmund T. Pratt, Jr. School of Engineering

ECE 110 Fall 2019

Test I

Michael R. Gustafson II

Name (please print):

NetID (please print):

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 answer in the correct box, **make sure that your Name and NetID is** *clearly* **written at the start of each problem**, and **make sure that your NetID is** *clearly* **written at the top of all other pages**. If you absolutely need more space for a particular problem, put that work on its own piece of paper, clearly write your name, NetID, and the problem number (in either Arabic or Roman numerals) at the top center of that page, and submit those extra pages in problem-order **after** all printed pages of the test. Also, in the box for the problem, write a note that says "see extra page."

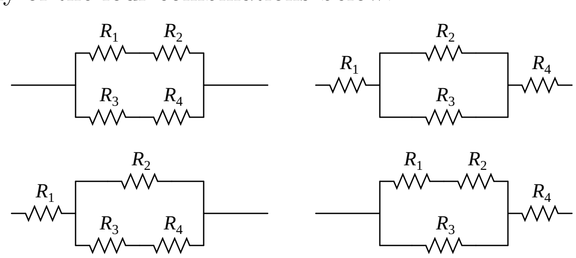
When done with the test, make sure your NetID is at the top of each page and that your name and NetID are clearly printed above. Bring the test and any additional pages with work to be graded to the front of the room and staple the test in the top left corner.

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: [17 pts.] Digital Logic

Given the following logical function:

$$\mathbf{f}(\mathrm{A},\mathrm{B},\mathrm{C},\mathrm{D}) = \mathrm{A}\,\overline{\mathrm{B}}\,\mathrm{C}\,\mathrm{D} + \overline{\mathrm{A}}\,\overline{\mathrm{B}}\,\mathrm{C}\,\mathrm{D} + \mathrm{A}\,\mathrm{B}\,\overline{\mathrm{C}}\,\mathrm{D} + \overline{\mathrm{A}}\,\overline{\mathrm{B}}\,\overline{\mathrm{C}}\,\mathrm{D} + \mathrm{A}\,\overline{\mathrm{B}}\,\overline{\mathrm{C}}\,\mathrm{D}$$

(1) Write the logical function in the compact sum of minterms form (i.e. $\mathbf{f} = \sum_i m_i$) assuming A is the most significant bit and D is the least significant bit.

(2) Clearly construct a Karnaugh map for the function. Be sure to label it appropriately and completely.

(3) Determine the Minimum Sum of Products (MSOP) form for the function. Be sure to show your process.

(4) Using standard 2-input logic gates, draw a logic circuit which implements the MSOP form of the expression. Be sure to clearly indicate whether two wires are connected or merely overlapping. Also be sure to draw your gates correctly and neatly!

(5) For the logic circuit you just drew, determine the complexity. Clearly indicate how you are computing the complexity.

(6) Determine the Minimum Product of Sums (MPOS) form for the function. Be sure to show your process.

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Problem II: [22 pts.] Basics and Division

For all parts of this problem, you can *carefully* use the || symbol (and parentheses) as appropriate and do *not* need to simplify expressions using that symbol. Numerical answers may be left as (unsimplified) fractions. Your work and answers for each part must be in the boxes provided.

(1) An independent source is connected across a network of three resistors, all of the same resistance $R_{\text{x}} = 3\ \text{k}\Omega$. The equivalent resistance of the network is measured as 2 kΩ and the total power absorbed by the network is measured as 50 mW. Given that:

(a) What is the current through the source?

(b) What is the voltage drop across the source?

(c) Determine and draw how the resistors are connected to the source. Label your resistors R_1, R_2, and R_3 for future reference.

(d) What is the power absorbed by each resistor? Be sure to reference each using the labels in the drawing (for example, calculate p_{abs,R_1}). *Hint* - not all resistors absorb the same amount of power for this circuit.

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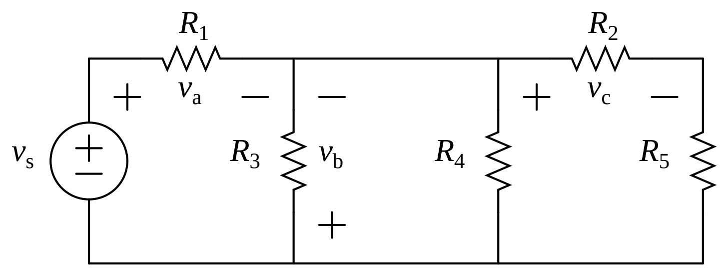
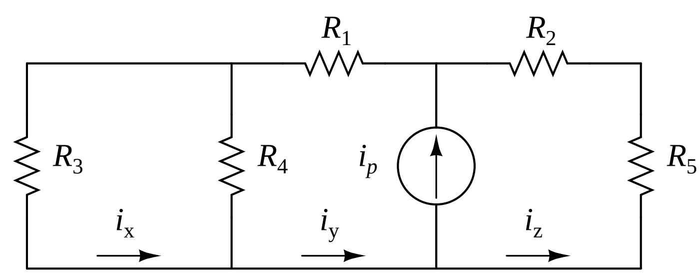
(2) For the following circuit:



clearly show voltage division to obtain expressions for v_a, v_b, and v_c in terms of the resistors and v_s.

(3) For the following circuit:



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

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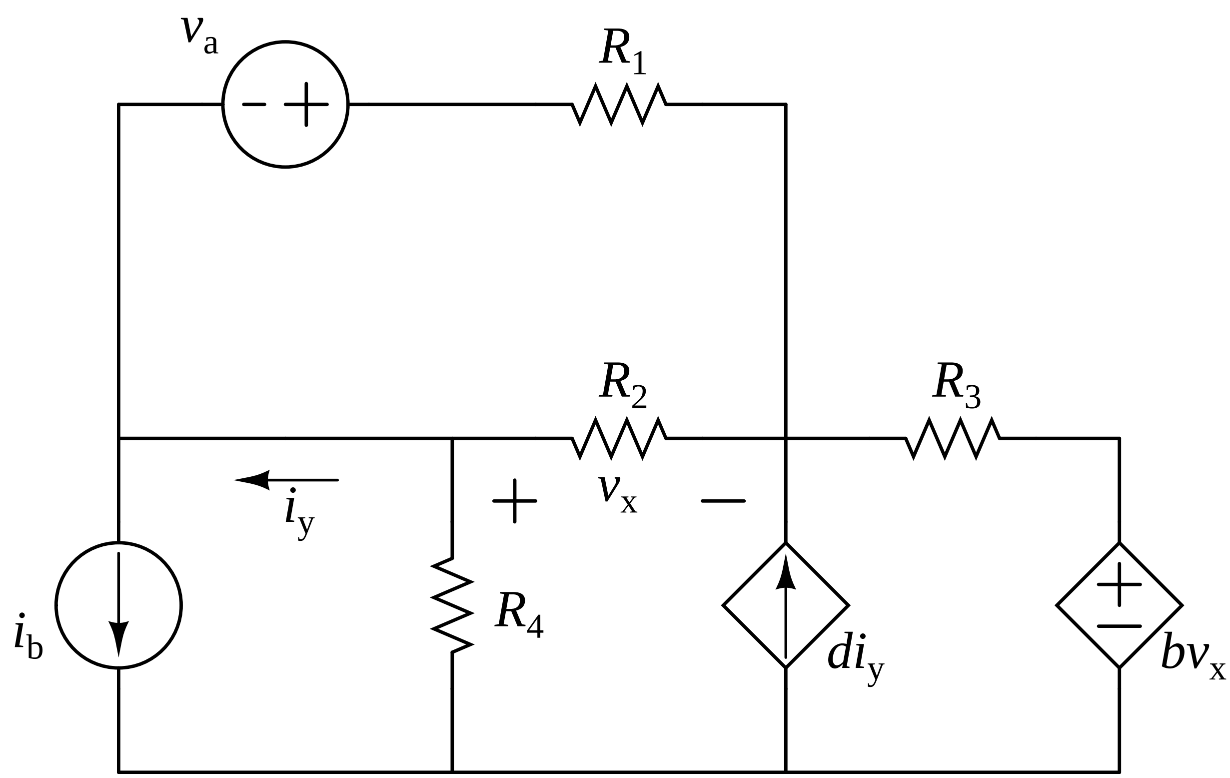
Problem III: [16 pts.] Node Voltage Method

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 (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. Clearly label the circuit above and then put the list of unknowns and the equations on the following page in the box provided.

(2) Assuming you are able to solve for those unknowns, write expressions for the following. Put your expressions and any work done in the boxes below.

- $p_{\text{abs},R_3} =$
- $p_{\text{del,CCCS}} =$
- $p_{\text{del,VCVS}} =$

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Equations and unknowns for NVM:

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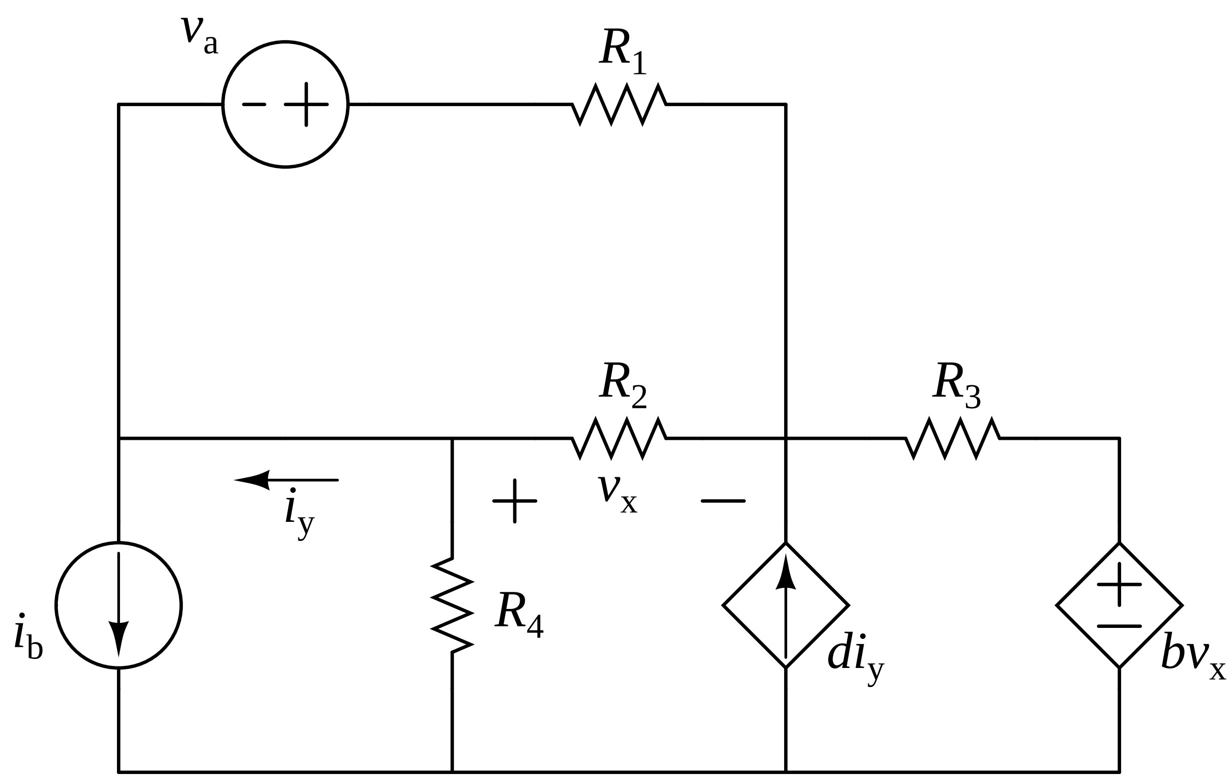
Problem IV: [16 pts.] Branch / Mesh Current Method

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 (v_a and i_b) are known,

(1) *Clearly* demonstrate the use of either the Branch 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. List the set of unknowns you believe your equations will find. Clearly label the circuit above and then put the list of unknowns and the equations on the following page in the box provided.

(2) Assuming you are able to solve for those unknowns, write expressions for the following. Put your expressions and any work done in the boxes below.

- $p_{\text{abs},R_3} =$

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

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

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Equations and unknowns for Current Method:

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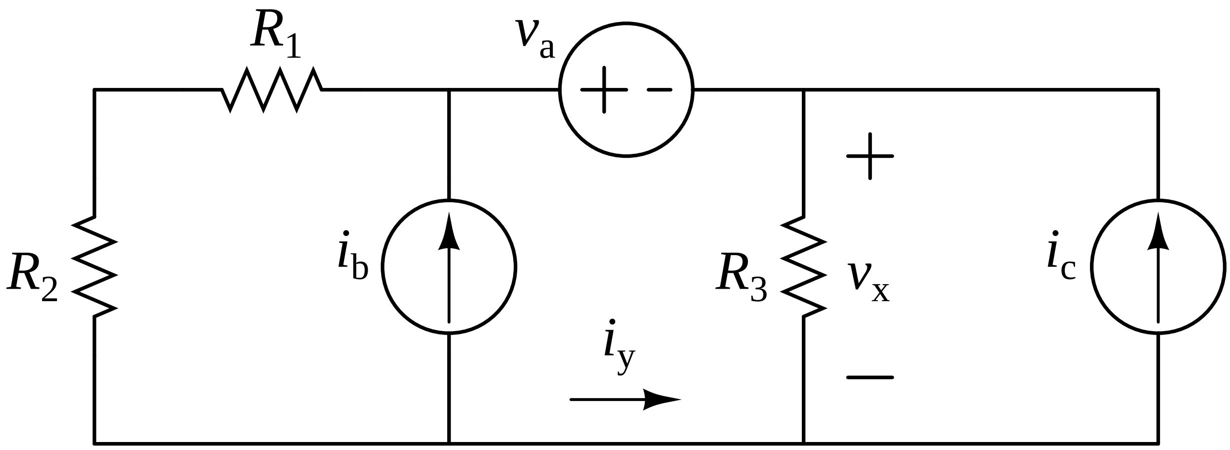
Problem V: [14 pts.] Superposition

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, and i_c) are known, *clearly* demonstrate the use of superposition to find expressions for v_x and i_y. *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. 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.

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Additional Work for Superposition:

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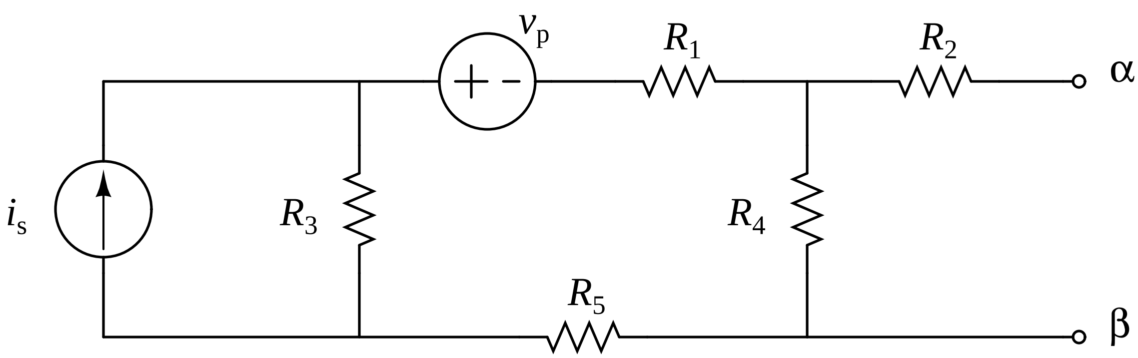
Problem VI: [15 pts.] Thévenin/Norton

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 resistors and the values for the independent sources (v_p and i_s) are known:

(1) Find expressions for v_{Th}, i_N, and R_{Th}, then 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 your work for this part should be on the following page, please!**

(2) Assuming v_{Th}, i_N, and R_{Th} are known, determine the value of the load resistance R_L that could be placed between terminals α and β that would maximize the power transferred to that load. Also determine the power transferred to that load. Put your work and answers for this part here:

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Thévenin/Norton Calculations and Drawings: