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

EGR 224 Spring 2020

Test I

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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 communicate with 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 communicate with 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 and **make sure that your name** *and* **NetID are** *clearly* **written at the top of** *every* **page**. 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 preprinted pages of the test. Also, in the box for the problem, write a note that says "see extra page."

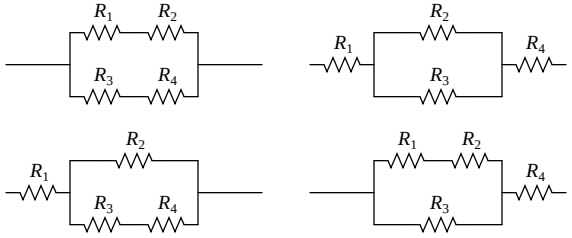
You will *not* be stapling your test but instead will be turning in your test to the box at the front of the room. Carefully stack the test pages in order (with any additional pages properly labeled and after all the original test pages) and put them in the box with the top left corner of the front of the test going into the back left corner of the 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 unless you are required to determine a numerical answer. 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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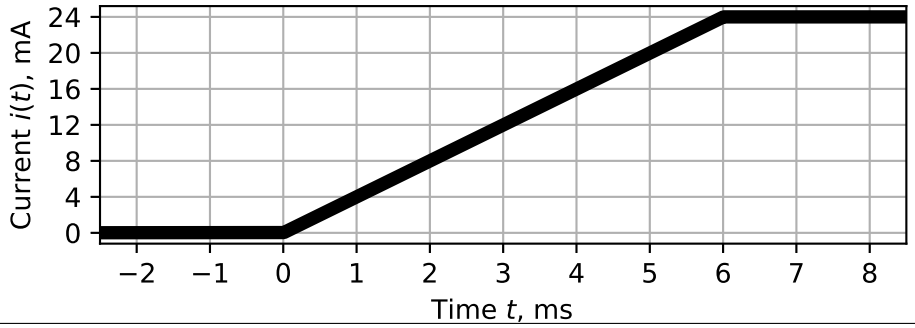
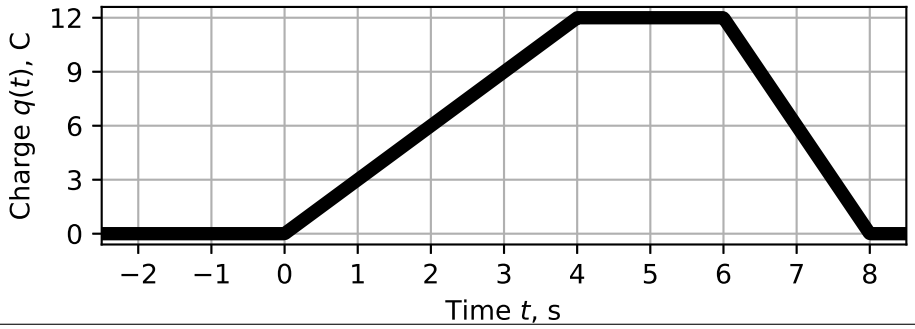
Problem I: [20 pts.] Basics

Numerical answers may be left as (unsimplified) fractions. Your work and answers for each part must be in the boxes provided.

(1) Assume the graph below represents some amount of current $i(t)$ pass by a particular location in the circuit. How much charge passed by the location over the time interval between 3 ms and 5 ms?



(2) Assume the graph below represents the amount of charge that has passed by a particular location in a circuit since time 0 sec. Make a sketch of the current passing by that particular location for all $t \geq 0$ sec.



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(3) Four rechargeable 1.5V AAA batteries are connected in series with each other and with a 600 Ω resistor.

(a) The package they came in is labeled "Up to 800 mAh each!" - what is 800 mAh a measure of?

(b) Assuming the batteries are either fully charged or fully discharged, how much current will run through the resistor while the batteries are fully charged?

(c) How long would you expect the batteries to have retain a charge in this configuration?

(4) An independent source is connected across a network of three resistors, all of the same resistance $R_x = 6$ kΩ. The equivalent resistance of the network is measured as 18 kΩ and the total power absorbed by the network is measured as 200 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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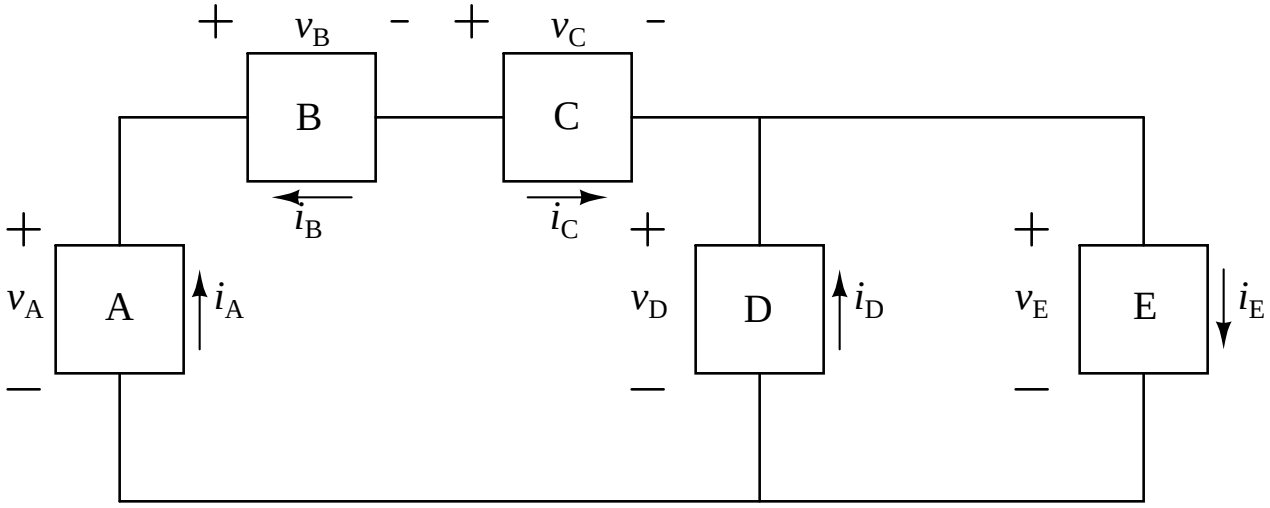
Problem II: [12 pts.] Power

Given the block diagram below and the labeled quantities, fill out the table's missing entries for sign convention (**A** or **P**), voltage measurement, current measurement, and power absorbed. Put any work below the table.



Element	Conv.	Voltage v, V	Current i, A	Power Absorbed p_{abs}, W
A		30		
B				40
C			8	
D			-2	
E				60

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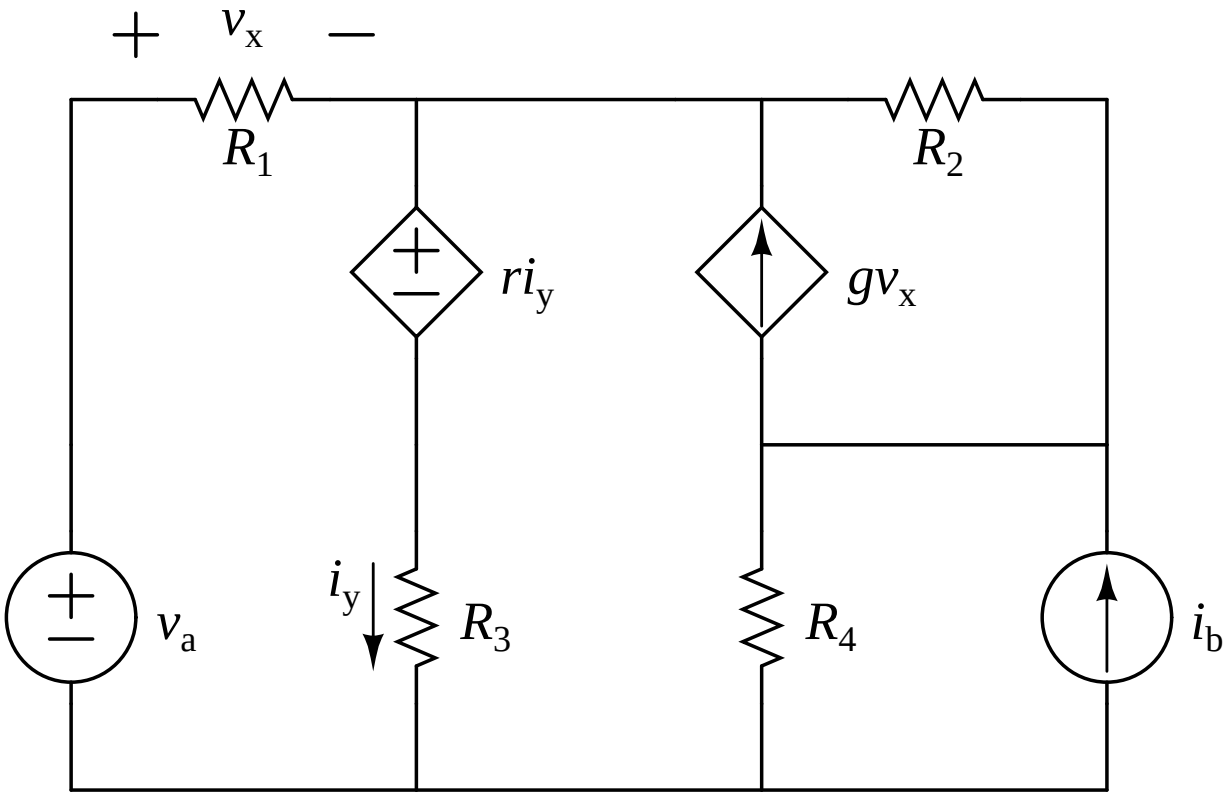
Problem III: [18 pts.] Node Voltage Method

Given the following circuit:



and assuming that constants r and g, 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 box below the expression.

- $p_{\text{abs},R_4} =$

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

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

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Equations and unknowns for Problem III:

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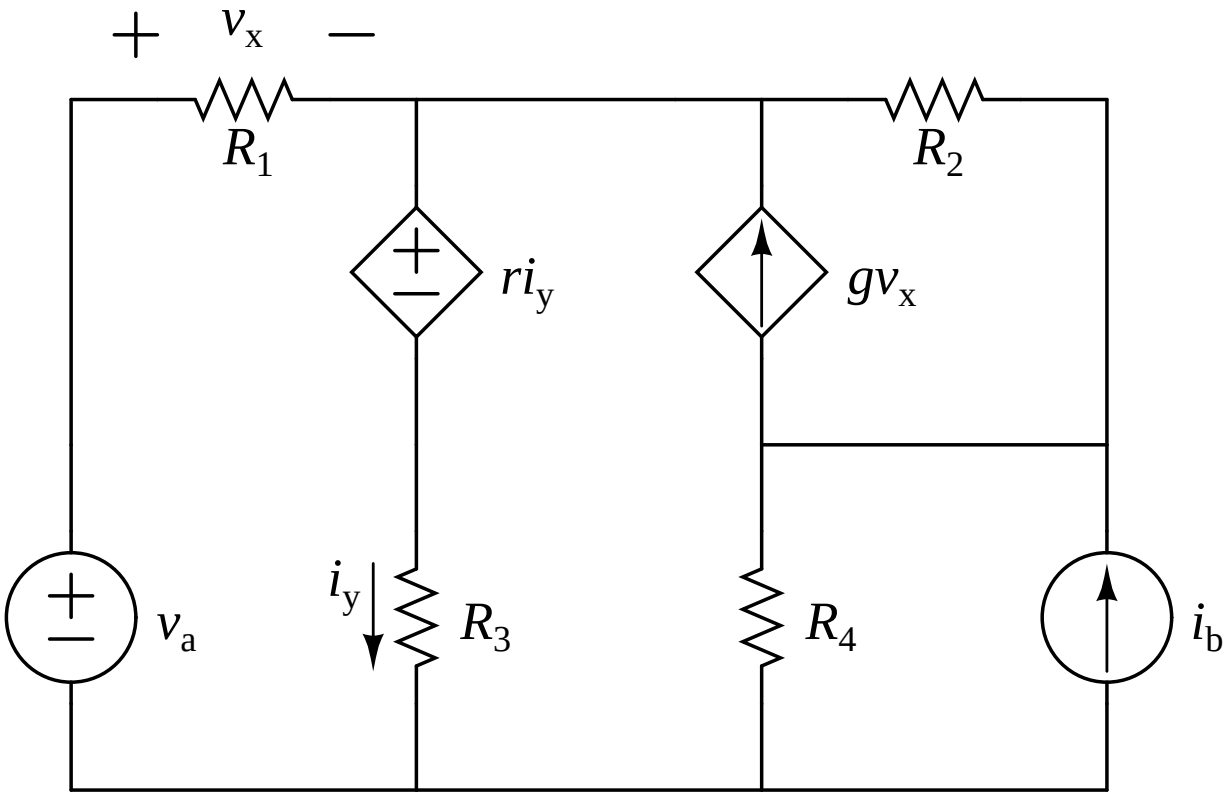
Problem IV: [18 pts.] Branch / Mesh Current Method
Given the following circuit:



and assuming that constants r and g, 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. 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 and any work done in the box below the expression.

- $p_{\text{abs},R_4} =$

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

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

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Equations and unknowns for Problem IV:

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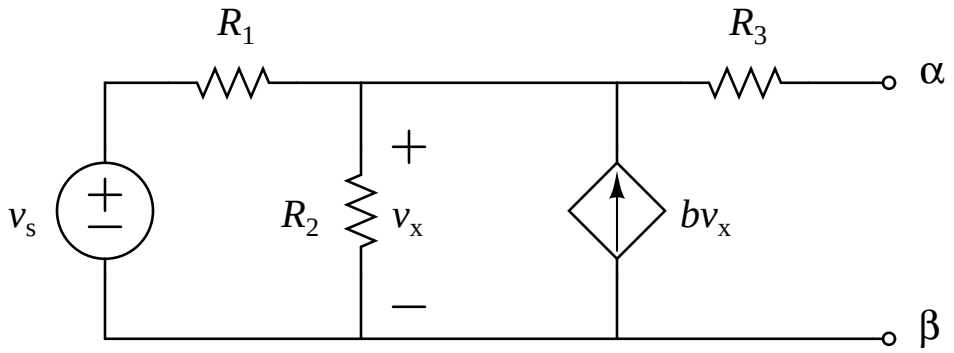
Problem V: [22 pts.] Thévenin/Norton 1

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, R_2, R_3), the value for the source (i_s), and the value for the constant b 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 for Problem V:

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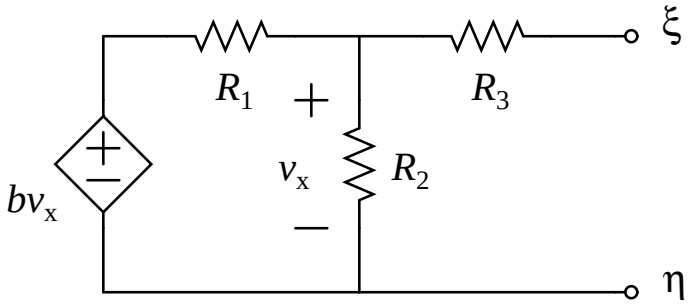
Problem VI: [10 pts.] Thévenin/Norton 2

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, R_2, R_3) and the value for the constant b are known, find expressions for v_{Th}, i_{N}, and R_{Th}, then draw the Thévenin and Norton 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.