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

EGR 224 Summer 2020

Test I

Michael R. Gustafson II

Name (please print):

NetID (please print): Start Time: End Time:

Submitting your work for a grade implies agreement with the following: 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.

Instructions

The test is open book, open class notes (yours and mine), open Sakai page for this class, and open Pundit. No other resources are allowed. If you have a question about whether something is allowed, ask the instructor. Be sure that you are in a place where you can work undisturbed for the duration of the test. If a situation arises that disrupts your work, let the instructor know - you will be allowed to pause the clock and resume work later. The Start Time above should be when you first started working on the test (after saving it, printing it out, etc.) and the End Time should be when you stopped doing work on the test and started working on scanning / photographing and uploading it.

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 need more space for a particular problem or want to show more work, 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."

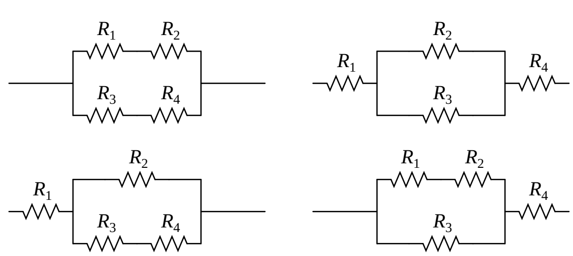
You will be turning your test into Gradescope. Carefully scan or photograph the test pages in order (with any additional pages properly labeled and after all the original test pages) and make a PDF of the scans / photographs. When you upload the PDF, you will also need to indicate where the answers for each problems are. If you used extra sheets, you only need to indicate the original test page for the problem.

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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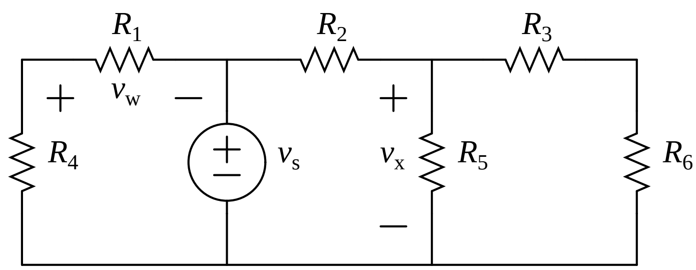
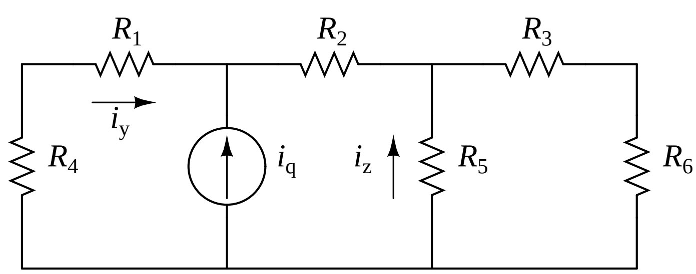
Problem I: [20 pts.] Basics

(1) For the following circuit:



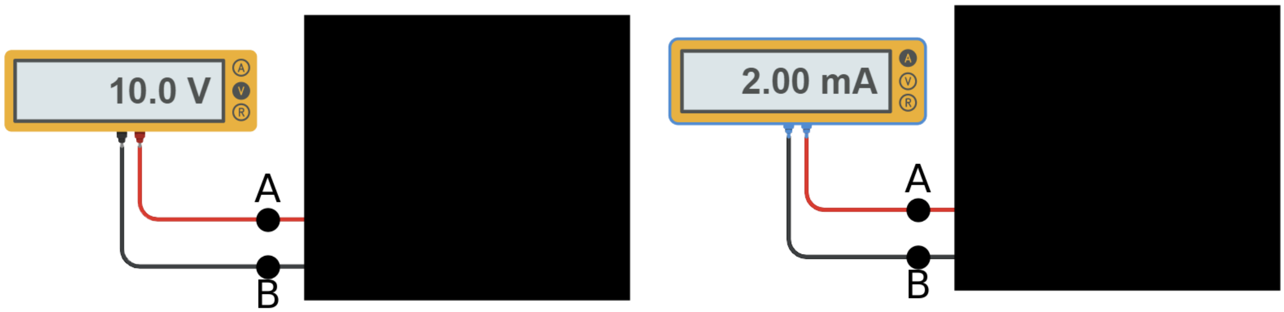
clearly show voltage division to obtain expressions for v_w and v_x in terms of the resistors and v_s.

(2) For the following circuit:



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

You are given a box with two terminals sticking out of it and told that there is one independent source and one resistor in the box. Assume that you have an ideal multimeter (i.e. R_m=0 Ω when measuring currents and R_m=∞ Ω when measuring voltages). When you take a voltage measurement between the terminals you get 10 V; when you take a current measurement between the terminals you get 2 mA:



(3) Draw two possible different configurations for what the source and resistor might look like inside the box. Be sure to clearly indicate where nodes A and B are and label the elements in the box with values.

(4) For the same box, what resistor value could you place between the terminals as a load to get the maximum power transferred to the load? What is the power absorbed by that resistor?

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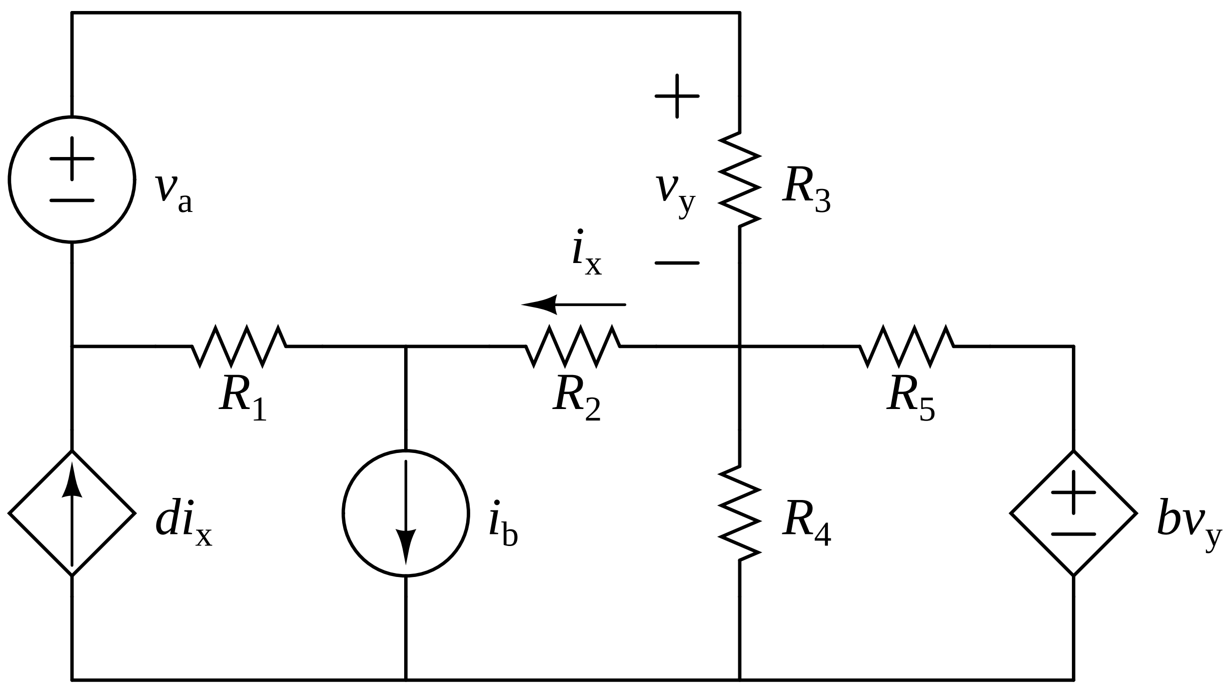
Problem II: [20 pts.] Node Voltage Method
Given the following circuit:



and assuming that constants b and d, the values for the passive elements (R_1 through R_5), 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.

- $p_{\text{abs},R_1} =$

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

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

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Equations and unknowns for Problem II:

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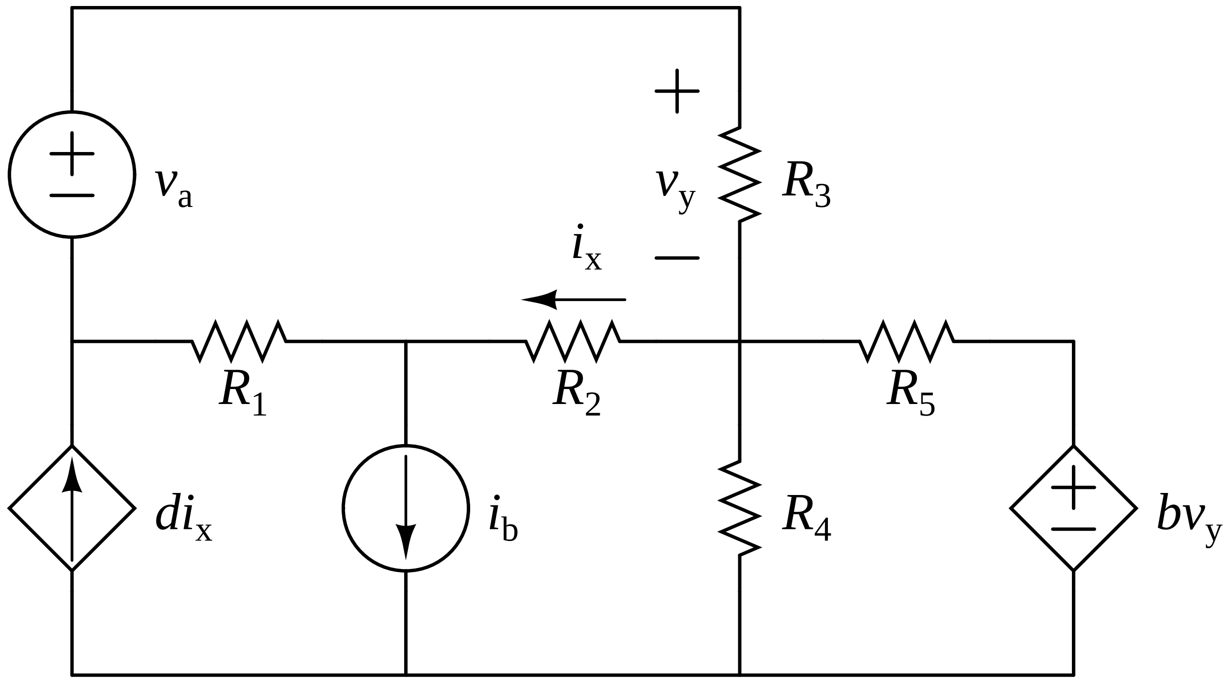
Problem III: [20 pts.] Branch / Mesh Current Method

Given the following circuit:



and assuming that constants b and d, the values for the passive elements (R_1 through R_5), 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.

- $p_{\text{abs},R_1} =$

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

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

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Equations and unknowns for Problem III:

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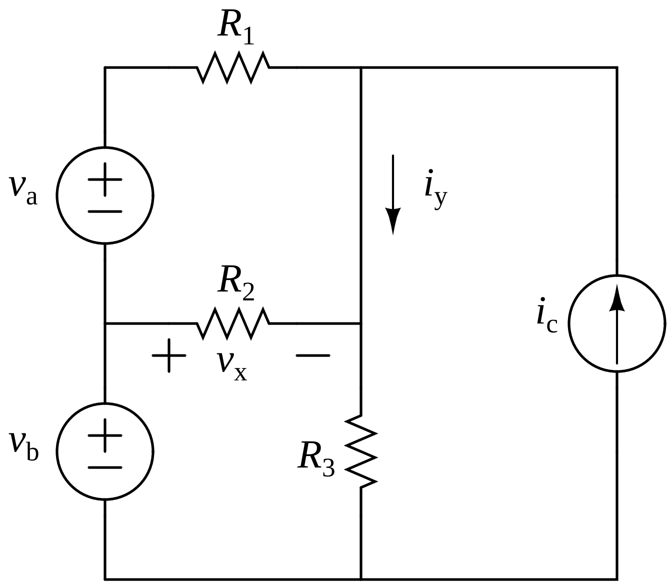
Problem IV: [20 pts.] Superposition

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 sources (v_a, v_b, and i_c) and passive elements (R_1, R_2, R_3) are known, clearly use superposition to create three different circuits, each with a single independent source, then solve for the contributions of each independent source to the measurements v_x and i_y. Be sure to show your process clearly.

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Extra space for Superposition Problem IV:

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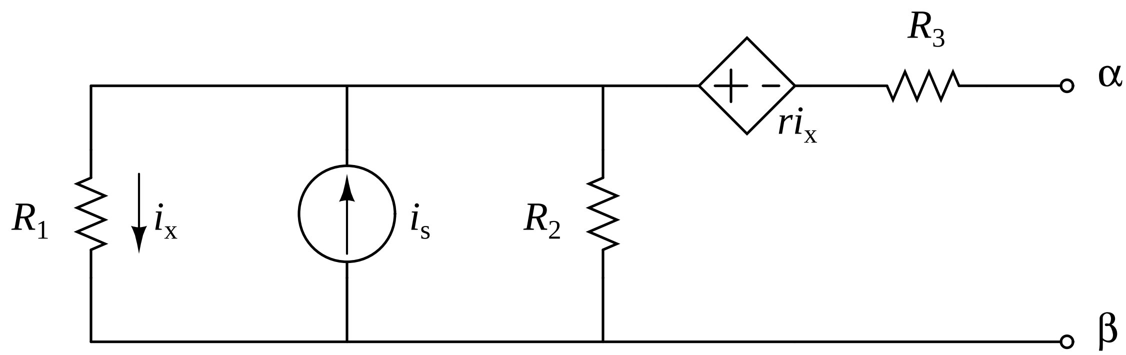
Problem V: [20 pts.] Thévenin/Norton

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 passive elements (R_1, R_2, R_3), the value for the source (i_s), and the value for the constant r 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: