

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

ECE 110L Spring 2015

Test I

Michael R. Gustafson II

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.

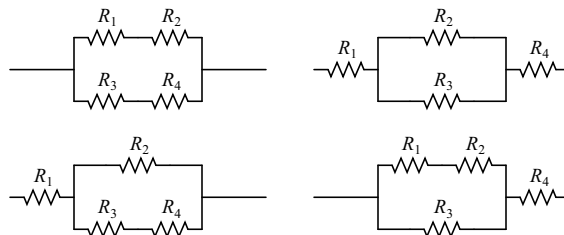
Make sure that your name *and* NET ID are *clearly* written at the top of *every* page, just in case problem parts come loose in the shuffle. Make sure that the work you are submitting for an answer is clearly marked as such. Finally, when turning in the test, individually staple all the work for each 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 \parallel 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: [20 pts.] Digital Logic

(1) Given the following logical function:

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

- (a) Write the logical function in minterm form, assuming A is the most significant bit and D is the least significant bit.
- (b) Clearly construct a Karnaugh map for the function. Be sure to label it appropriately and completely.
- (c) Determine the Minimum Sum of Products (MSOP) form for the function. Be sure to show your process.
- (d) Finally, determine the Minimum Product of Sums (MPOS) form for the function. Be sure to show your process.

(2) Given the following logical function in MSOP form:

$$g(J, K, L) = \overline{J}\overline{K} + JK + KL$$

- (a) Write the logical function in minterm form, assuming J is the most significant bit and L is the least significant bit.
- (b) 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!
- (c) For the logic circuit you just drew, determine the complexity. Clearly indicate how you are computing the complexity.

1a) $\sum m(1, 2, 3, 4, 5, 7, 10, 11)$

1b) $\overline{B}C + \overline{A}D + \overline{A}B\overline{C}$

1c)

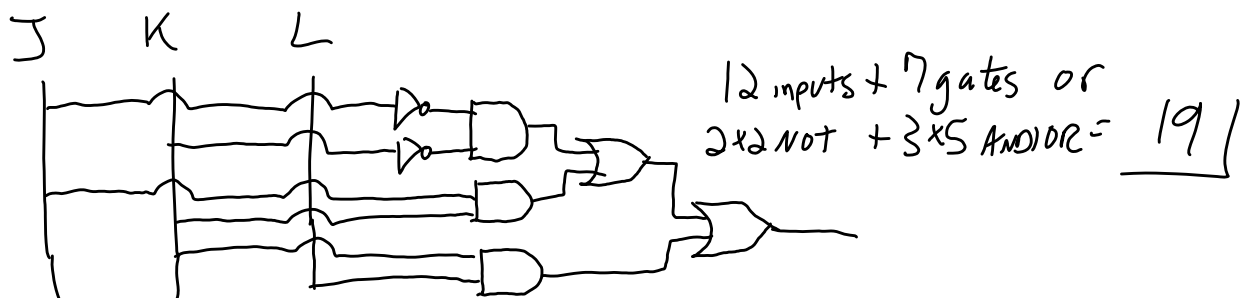
1d) $\overline{f} = AB + A\overline{C} + \overline{B}\overline{C}\overline{D} + B\overline{C}\overline{D}$

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

2a) $\overline{J}\overline{K} = \overline{J}\overline{K}\overline{L} + \overline{J}\overline{K}L$ 0, 1

$JK = JK\overline{L} + JK L$ 6, 7 $\sum m(0, 1, 3, 6, 7)$

$KL = \overline{J}KL + JKL$ 3, 7



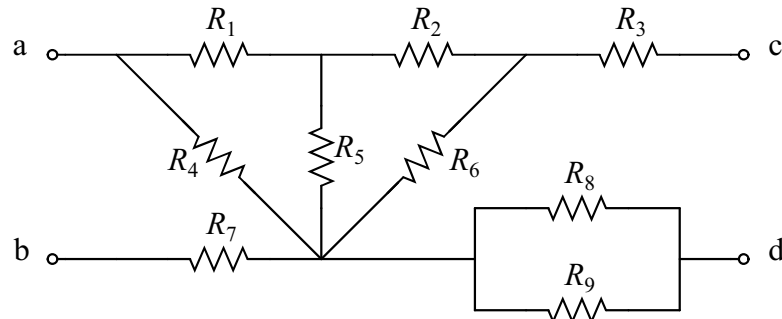
Name (please print):

Community Standard (print ACPUB ID):

Problem II: [20 pts.] Equivalentents 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.

(1) For the following network:



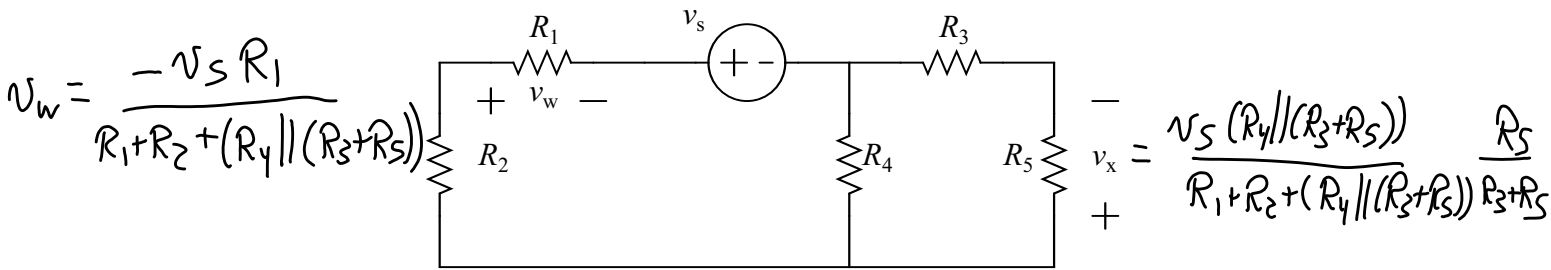
(a) Find the equivalent resistance as seen from terminals *a* and *b*, R_{ab} .

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

$$R_{ab} = R_7 + (R_4 \parallel (R_1 + (R_5 \parallel (R_2 + R_6))))$$

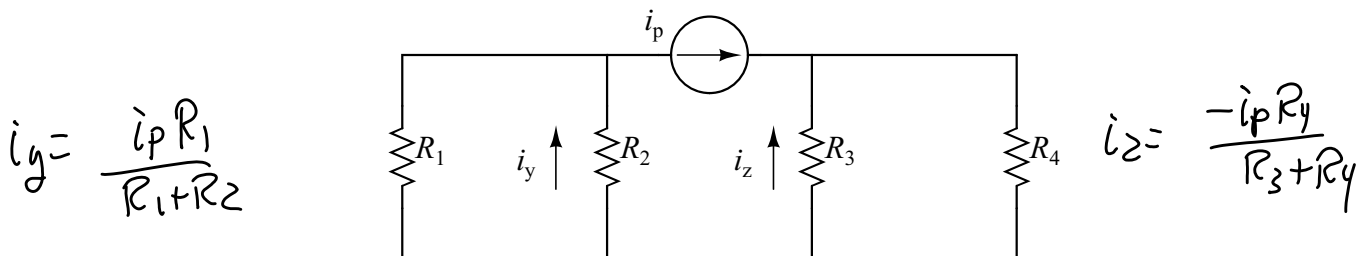
$$R_{cd} = R_3 + (R_6 \parallel (R_2 + (R_5 \parallel (R_1 + R_7)))) + (R_8 \parallel R_9)$$

(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 .

$$i_y = \frac{i_p R_1}{R_1 + R_2}$$

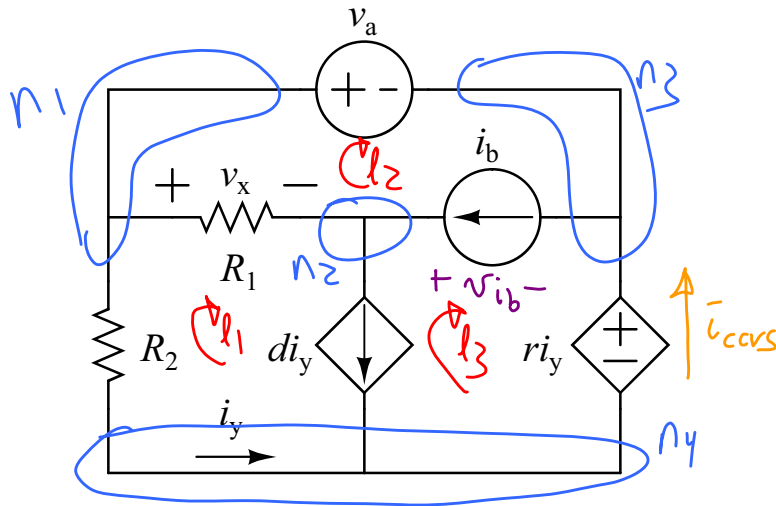
$$i_z = \frac{-i_p R_4}{R_3 + R_4}$$

Name (please print):

Community Standard (print ACPUB ID):

Problem III: [20 pts.] The Basics

Given the following circuit:



and assuming that constants d and r , the values for the passive elements (R_1 and R_2), and the values for the independent sources (v_a and i_b) 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 other calculations without substitution. Clearly indicate the nature and location of any equations you use to solve for an unknown. Put your expressions next to the appropriate bullet below:

• $v_x = R_1(d i_y - i_b)$

• $i_y = \frac{v_a}{R_2 - r}$

• $p_{\text{abs}, R_2} = i_y^2 R_2$

• $p_{\text{del}, i_b} = i_b v_{i_b}$

• $p_{\text{del}, \text{CCVS}} = r i_y i_{\text{ccvs}}$

KVL, $s_{l_{23}}$: $-R_2 i_y + v_a + r i_y = 0$
 $i_y = \frac{v_a}{R_2 - r}$

KCL, n_2 : $-\frac{v_x}{R_1} + d i_y - i_b = 0$
 $v_x = R_1(d i_y - i_b)$

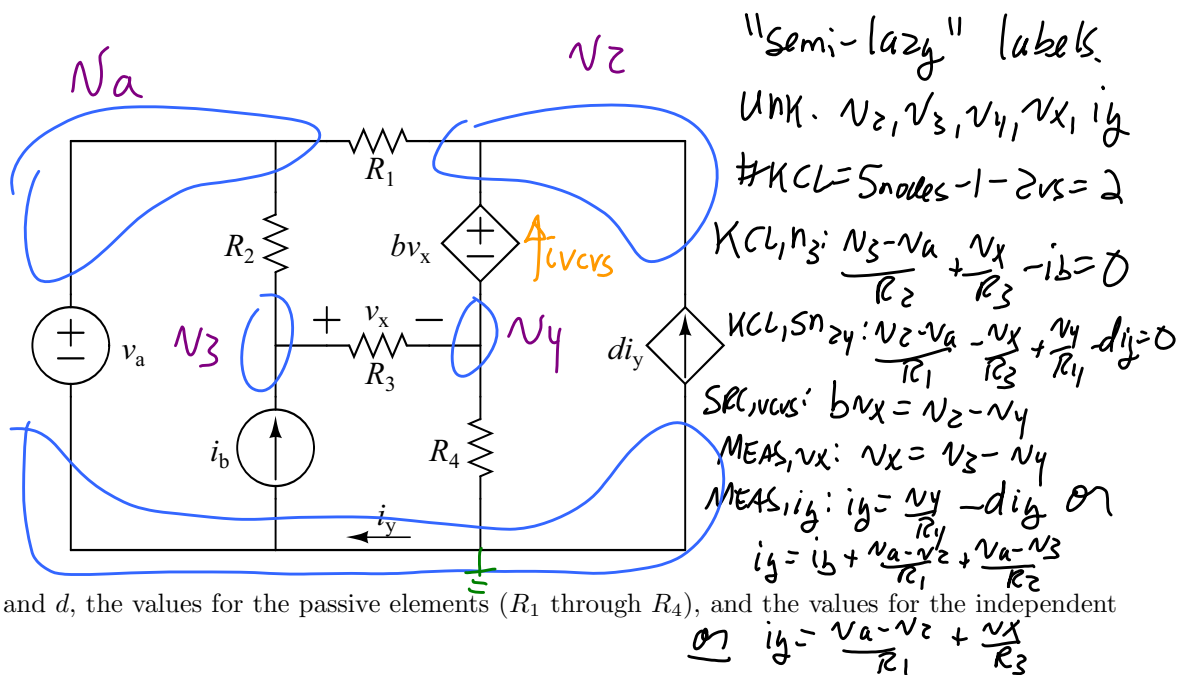
get v_{i_b} from:
 KVL, l_2 : $-v_x + v_a - v_{i_b} = 0$, $v_{i_b} = v_a - v_x$
 KVL, $s_{l_{13}}$: $-R_2 i_y + v_x + v_{i_b} + r i_y = 0$
 $v_{i_b} = (R_2 - r) i_y - v_x$

get i_{ccvs} from:
 KCL, n_4 : $-i_y - d i_y + i_{\text{ccvs}} = 0$; $i_{\text{ccvs}} = (1 + d) i_y$
 KCL, $s_{n_{13}}$: $i_y + \frac{v_x}{R_1} + i_b - i_{\text{ccvs}} = 0$
 $i_{\text{ccvs}} = i_y + \frac{v_x}{R_1} + i_b$

Name (please print):
Community Standard (print ACPUB ID):

Problem IV: [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_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 complete 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

• $p_{abs, R_2} =$

$$(v_a - v_3)^2 / R_2$$

• $p_{del, VCVS} =$

$$b v_x i_{CVS}$$

\rightarrow

$$\text{KCL, } n_2: \frac{v_z - v_a}{R_1} i_{CVS} - d i_y = 0$$

$$\text{or } i_{CVS} = d i_y + \frac{v_z - v_a}{R_1}$$

$$\text{KCL, } n_4: i_{CVS} - \frac{v_x}{R_3} + \frac{v_4}{R_4} = 0$$

$$i_{CVS} = \frac{v_x}{R_3} - \frac{v_4}{R_4}$$

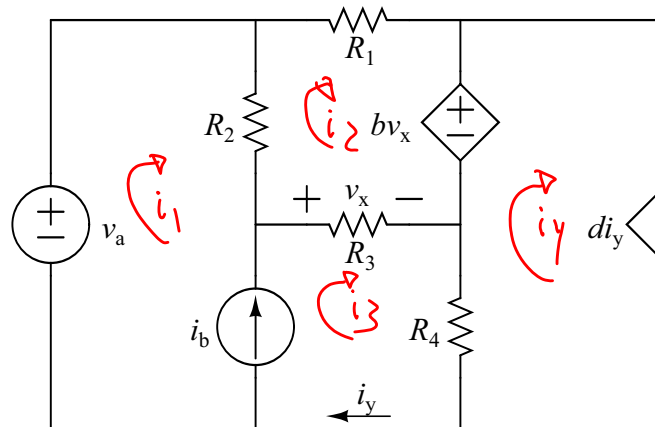
• $p_{del, CCCS} =$

$$d i_y v_z$$

Name (please print):
Community Standard (print ACPUB ID):

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

Given the following circuit:



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

#KVL: 4 mesh - 2 is = 2

KVL, l₂: $R_2(i_2 - i_1) + R_1 i_2 + b v_x - v_x = 0$

KVL, l₃: $-v_a + R_2(i_1 - i_2) + v_x + R_4(i_3 - i_4)$

SRCC, i_b: $i_b = i_3 - i_1$

SRCC, d i_y: $d i_y = -i_4$

MEAS v_x: $v_x = R_3(i_3 - i_2)$

MEAS i_y: $i_y = i_3$

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 Mesh Current Method or the Branch 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 complete set of unknowns you believe your equations will find. Also state whether you believe you are using the MCM or the BCM. 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

• $p_{\text{abs}, R_2} = (i_1 - i_2)^2 R_2$

• $p_{\text{del}, \text{VCVS}} = b v_x (i_4 - i_2)$

• $p_{\text{del}, \text{CCCS}} = d i_y v_{\text{cccs}}$

KVL, l₄: $R_4(i_4 - i_3) - b v_x + v_{\text{cccs}} = 0$

$v_{\text{cccs}} = R_4(i_3 - i_4) + b v_x$
or

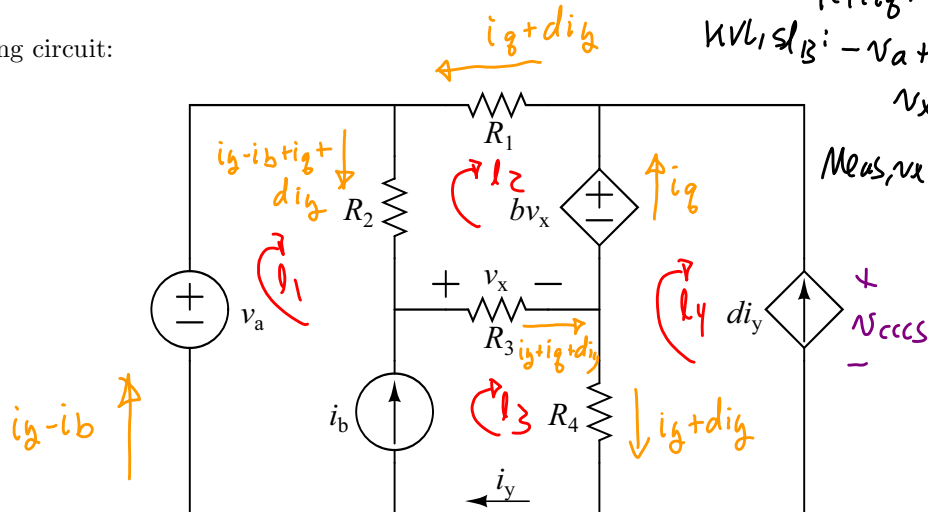
KVL, sl₁₂₃₄: $-v_a + R_1 i_2 + v_{\text{cccs}} = 0$
 $v_{\text{cccs}} = v_a - R_1 i_2$

among others

Community Standard (print ACPUB ID):

Problem V: [20 pts.] Mesh/Branch 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 Mesh Current Method or the Branch 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 complete set of unknowns you believe your equations will find. Also state whether you believe you are using the MCM or the BCM. 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

$$\bullet p_{\text{abs}, R_2} = (i\gamma - i\beta + i\eta + d i\gamma)^2 R_2$$

- $p_{\text{del,VCVS}} = b v_x i_g$

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

$$\begin{aligned} \text{KVL}_1: -R_4(i_g + d i_g) - b v_x + v_{cccs} &= 0 \\ v_{cccs} &= R_4(i_g + d i_g) + b v_x \\ \text{or} \\ \text{KVL}_2: -v_a - R_1(i_g + d i_g) + v_{cccs} &= 0 \\ v_{cccs} &= v_a + R_1(i_g + d i_g) \end{aligned}$$