Student Name: Noel Romero

CS 4341 Homework 1 – Class Section 002/003 (please circle one)

Dr. Doug DeGroot's Class

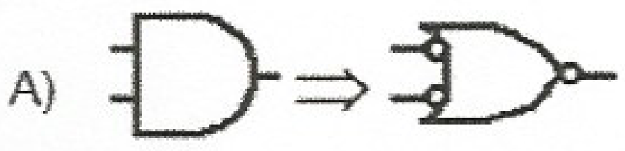
Instructions:

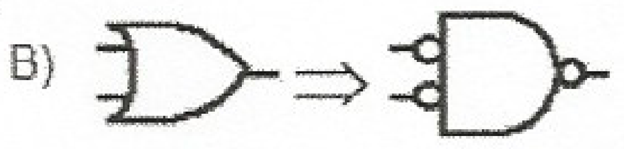
1. **This homework is due on Thursday, September 17.**
2. Please print and use a copy of this handout for your answers. You may add extra pages as needed. When you're done, scan all pages and group them into a single PDF file (no Word Text files or anything else; only PDF).
3. Draw and write neatly and legibly. If neither I nor our graders can read your answers, points will be deducted for the entire question.
4. Show all work, including intermediate calculations. Add simple explanations for each step where appropriate.
5. On each circuit diagram, label all inputs and outputs.
6. Use alphabetic ordering of variables when writing Boolean expressions, and use standard binary number order for your Truth Tables.
7. For each mistake in your answers, diagrams, tables, etc., a minimum of 2-4 points will be deducted. Totally wrong final answers will have all points for that question deducted.
8. **Sign your name to the top sheet of your papers.**
9. **Do all work on your own, but you may use the book, web, etc., just not each other.**

1. Are any of the following pairs of circuits equivalent? Circle the correct answer. 10 pts!

A	B	$\bar{A}$	$\bar{B}$	$\bar{A}+\bar{B}$	$\overline{\bar{A}+\bar{B}}$	AB	$\bar{A}\bar{B}$	$\overline{AB}$
0	0	1	1	1	0	0	1	0
0	1	1	0	1	0	0	0	1
1	0	0	1	1	0	0	0	1
1	1	0	0	0	1	1	0	1

A+B	$\bar{A}+B$	$A\bar{B}$	$\overline{AB}$
0	1	0	ø
1	1	0	1
1	0	1	0
1	1	0	1

A)  YES / NO

B)  YES / NO

C)  YES / NO

2. Determine whether the following function is true or false. Show/explain your reasoning. 10 pts

eq 1 = $x'y' + x'z + x'z'$ = eq 2 = $x'z' + y'z' + x'z$

let eq 1 = $x'y + x'z + x'z'$

let eq 2 = $x'z' + y'z' + x'z$

True: ____________ False: FALSE

eq 1 ≠ eq 2

since eq 1 ⇒ $x'y'$

& eq 2 ⇒ $x' + y'z'$

eq 2 output depends on three variables & eq 1 output depends on only two variables

eq 1

$x'y' + x'z + x'z'$

$x'(y' + z + z')$ $z + z' = 1$

$x'(y' + 1)$ $y' + 1 = y'$

$x'y'$

eq 2

$x'z' + y'z' + x'z$

$x'z' + x'z + y'z'$

$x'(\underbrace{z' + z}_{1}) + y'z'$

$x' + y'z'$

#3 Note full work & final answers for Number 3 can be found in the following page

m1 a b c d
m2 a b c d
m3 a b c d
m4 a b c d
m5 a b c d

3. **Write the following expression in both minimal and canonical Sum of Products (SOP) form.** **10 pts**

$(b + d)(a' + b' + c) = ba' + bb' + bc + da' + db' + dc$

$b(a' + 1 + c) + d(a' + b' + c)$

$b(a' + c) + d(a' + b' + c)$

$ba' + bc + da' + db' + dc$

m1 m2 m3 m4 m5

$ba' \cdot 1 \cdot 1 + bc \cdot 1 \cdot 1 + da' \cdot 1 \cdot 1 + db' \cdot 1 \cdot 1 + dc \cdot 1 \cdot 1$

Minimal: $a'b + bc + a'd + b'd + dc$

Canonical: $a'bcd + a'bcd' + a'bc'd + a'bc'd' + abcd + abcd' + ab'cd + ab'c'd + a'b'c'd$

$ba'(c+c')(d+d') + bc(a+a')(d+d') + da(b+b')(c+c') + db(a+a')(c+c') + dc(a+a')(b+b')$

$(ba'c + ba'c')(d+d')$ $(bca + bca')(d+d')$

$dba'c + d'ba'c + dba'c' + d'ba'c' + dbca + d'bca + \cancel{dbca'} + d'bca'$

#4 Note the full work for finding the minimal equation can be found in the following papers

4. **Write the following expression in both minimal and canonical Product of Sums (POS) form.** **10 pts**

$a'b(c+c') + a'c'(b'+b) + abc$

$a'b(1 + c')$

$a'bc'$

$a'bc + a'bc' + a'c'b' + a'c'b + abc$

$a'b + a'c' + abc$

let $Y = a'b + a'c' + abc$

Minimal: $a'c + bc$

Canonical: $(\bar{a} + b + \bar{c})(a + b + \bar{c})(a + \bar{b} + \bar{c})(\bar{a} + b + c)$

a	b	c	a'	c'	a'b	a'c'	abc	a'b+a'c'+abc	Maxterm
1	0	1	0	0	0	0	0	0	$\bar{a}+b+\bar{c}$
1	1	1	0	0	1	0	1	1	$\bar{a}+\bar{b}+\bar{c}$
0	0	1	1	0	0	0	0	0	$a+b+\bar{c}$
0	1	1	1	0	0	0	0	0	$a+\bar{b}+\bar{c}$
1	0	0	0	1	0	0	0	0	$\bar{a}+b+c$
1	1	0	0	1	1	0	0	1	$\bar{a}+\bar{b}+c$
0	0	0	1	1	0	1	0	1	$a+b+c$
0	1	0	1	1	0	1	0	1	$a+\bar{b}+c$

$Y = (\bar{a} + b + \bar{c})(a + b + \bar{c})(a + \bar{b} + \bar{c})$
$(\bar{a} + b + c)$

#3

$ba'(c+c')(d+d') + bc(a+a')(d+d') + da(b+b')(c+c') + db(a+a')(c+c) + dc(a+a')(b+b')$

$(ba'c+ba'c')(d+d') + (bca+bca')(d+d') + (dab+dab')(c+c') + (dba+dba')(c'+c) + (dca+dca')(b+b')$

$\overset{m_1}{dba'c} + \overset{m_2}{d'ba'c} + \overset{m_3}{dba'c'} + \overset{m_4}{d'ba'c'} + \overset{m_5}{dbca} + \overset{m_6}{d'bca} + \cancel{dbca'} + \cancel{d'bca'} + \cancel{cdab} + \overset{m_7}{cdab'} + \overset{m_8}{c'dab} + \overset{m_9}{c'dab'} + \cancel{c'dba} + \cancel{cdba} + \overset{m_{10}}{c'dba'} + \overset{m_{11}}{cdba'}$

$+ \cancel{bdc} + \cancel{b'dc} + \cancel{bdca'} + \overset{m_{12}}{b'dca'}$

Canonical:

$Y = a'bcd + a'bcd' + a'bc'd + a'bc'd' + abcd + abcd' + ab'cd + abc'd + ab'c'd$

m_1 $a'bcd$

m_2 $a'bcd'$

m_3 $a'bc'd$

m_4 $a'bc'd'$

m_5 $abcd$

m_6 $abcd'$

m_7 $ab'cd$

m_8 $abc'd$

m_9 $ab'c'd$

~~m_{10} $a'bc'd$~~

~~m_{11} $a'bcd$~~

~~m_{12} $a'b'cd$~~

Minimal: $a'b + bc + a'd + b'd + cd$

#4. Part A → Finding minimal

$$a'b(c+c') + a'c'(b'+b) + abc$$

$$a'bc + a'bc' + a'c'b' + \cancel{a'c'b} + abc$$

$$a'c(b+b') + bc(a'+a)$$

$$\underline{a'c + bc}$$

5. **Obtain the truth tables of the following functions, and express each function in sum-of-products (SOP) form.** **15 pts**

a. $Y = (c' + d)(b + c')$

c	b	d	c'	c'+d	b+c'	$Y = (c'+d)(b+c')$	Minterm	Minterm num
0	1	1	1	1	1	1	$\bar{c}bd$	m_0
1	1	1	0	1	1	1	cbd	m_1
0	0	1	1	1	1	1	$\bar{c}\bar{b}d$	m_2
1	0	1	0	1	0	0	$c\bar{b}d$	m_3
0	1	0	1	1	1	1	$\bar{c}b\bar{d}$	m_4
1	1	0	0	0	1	0	$cb\bar{d}$	m_5
0	0	0	1	1	1	1	$\overline{cbd}$	m_6
1	0	0	0	0	0	0	$c\bar{b}\bar{d}$	m_7

Let $Y = F(c,b,d) = (c+d)(b+c)$

$\therefore$ $Y = (b\bar{c}d) + (bcd) + (\bar{b}\bar{c}d) + (b\bar{c}\bar{d}) + (\bar{b}\bar{c}\bar{d})$

Let $Y = F(c,b,d) = ($
$(cd + b'c + bd')(b+d)$

b. $Y = (cd + b'c + bd')(b + d)$

c	b	d	b'	d'	cd	b'c	bd'	cd+b'c+bd	b+d	$Y = (cd+b'c+bd')(b+d)$	minterm
1	1	1	0	0	1	0	0	1	1	1	cbd V
1	0	1	1	0	1	1	0	1	1	1	$c\bar{b}d$ V
0	1	1	0	0	0	0	0	0	1	0	$\bar{c}bd$ X
0	0	1	1	0	0	1	0	1	1	1	$\bar{c}\bar{b}d$ V
1	1	0	0	1	0	0	1	1	1	1	$cb\bar{d}$ V
1	0	0	1	1	0	1	0	1	0	0	$c\bar{b}\bar{d}$ X
0	1	0	0	1	0	0	1	1	1	1	$\bar{c}b\bar{d}$ V
0	0	0	1	1	0	0	0	0	0	0	$\bar{c}b\bar{d}$ X

$Y = bcd + \bar{b}cd + \bar{b}\bar{c}d + bc\bar{d} + b\bar{c}\bar{d}$

6. **Given a functional specification in either a circuit, Boolean equation, or Truth Table, why would we want to simplify it if our simplified version is logically equivalent? 10 pts**

We would want to use the simplified version so that we can decrease complexity & decrease cost when building a circuit.

7. **Convert the following minimal Boolean formula to the correct canonical Sum-of-Products (SOP) form. Show your work.** **10 pts**

3 vars $\rightarrow$ a, b, c

m_1: a ✓, B x, c x m_2: a x, b ✓, c ✓

$Y = \overset{m_1}{a} + \overset{m_2}{b'c}$ $Y = a \cdot 1 \cdot 1 + 1 \cdot b'c$

$Y = a \cdot (b'+b)(c'+c) + (a'+a)b'c$

$(ab' + ab)(c'+c) + a'b'c + ab'c$

$c'ab' + cab' + c'ab + cab + a'b'c + \cancel{ab'c}$

$Y = c'ab' + cab' + c'ab + cab + ca'b'$

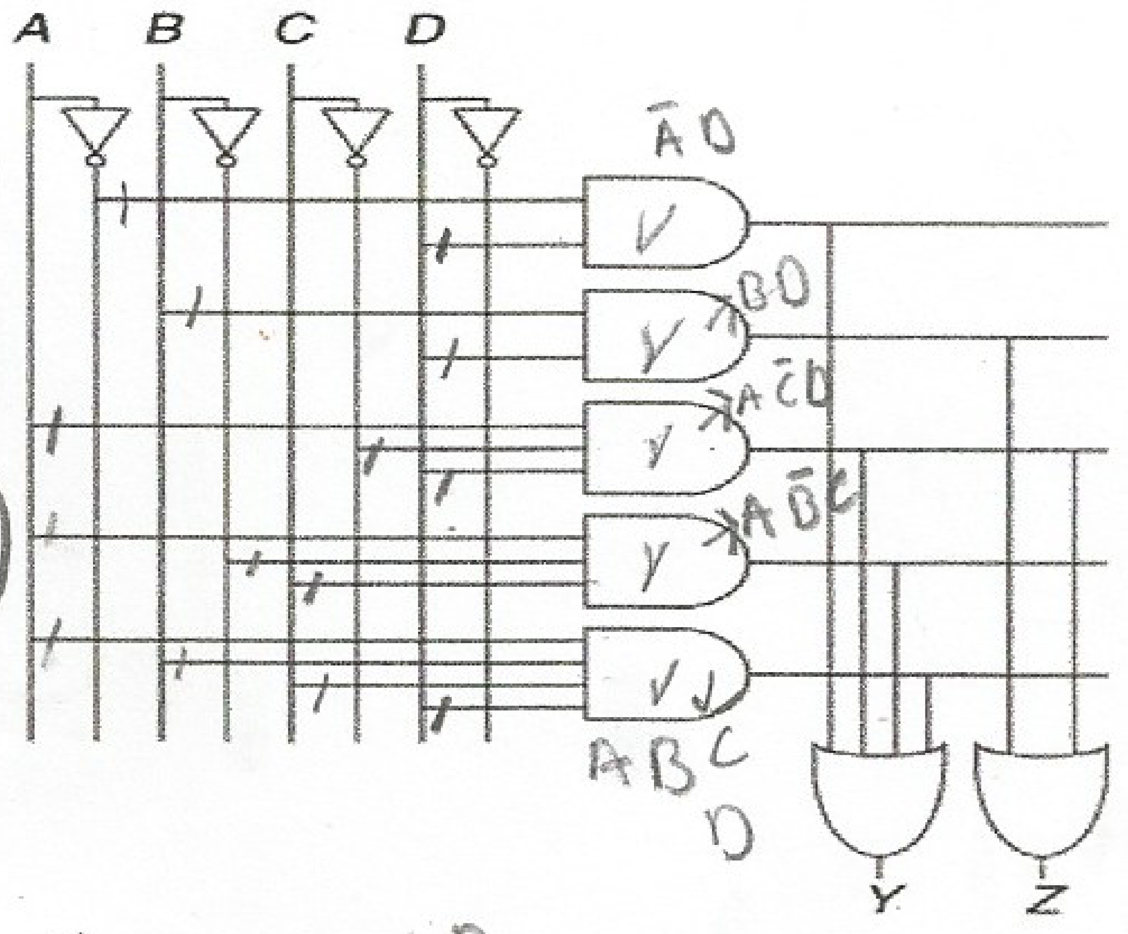
$\boxed{Y = ab'c' + ab'c' + abc' + abc + a'b'c}$

8. **Write Boolean equations for the outputs of the following circuit. Then minimize the equations using Boolean algebra manipulation. And then finally draw an improved circuit with the same function.** **25 pts**

$Y = \bar{A}D + A\bar{C}D + A\bar{B}C + ABCD$

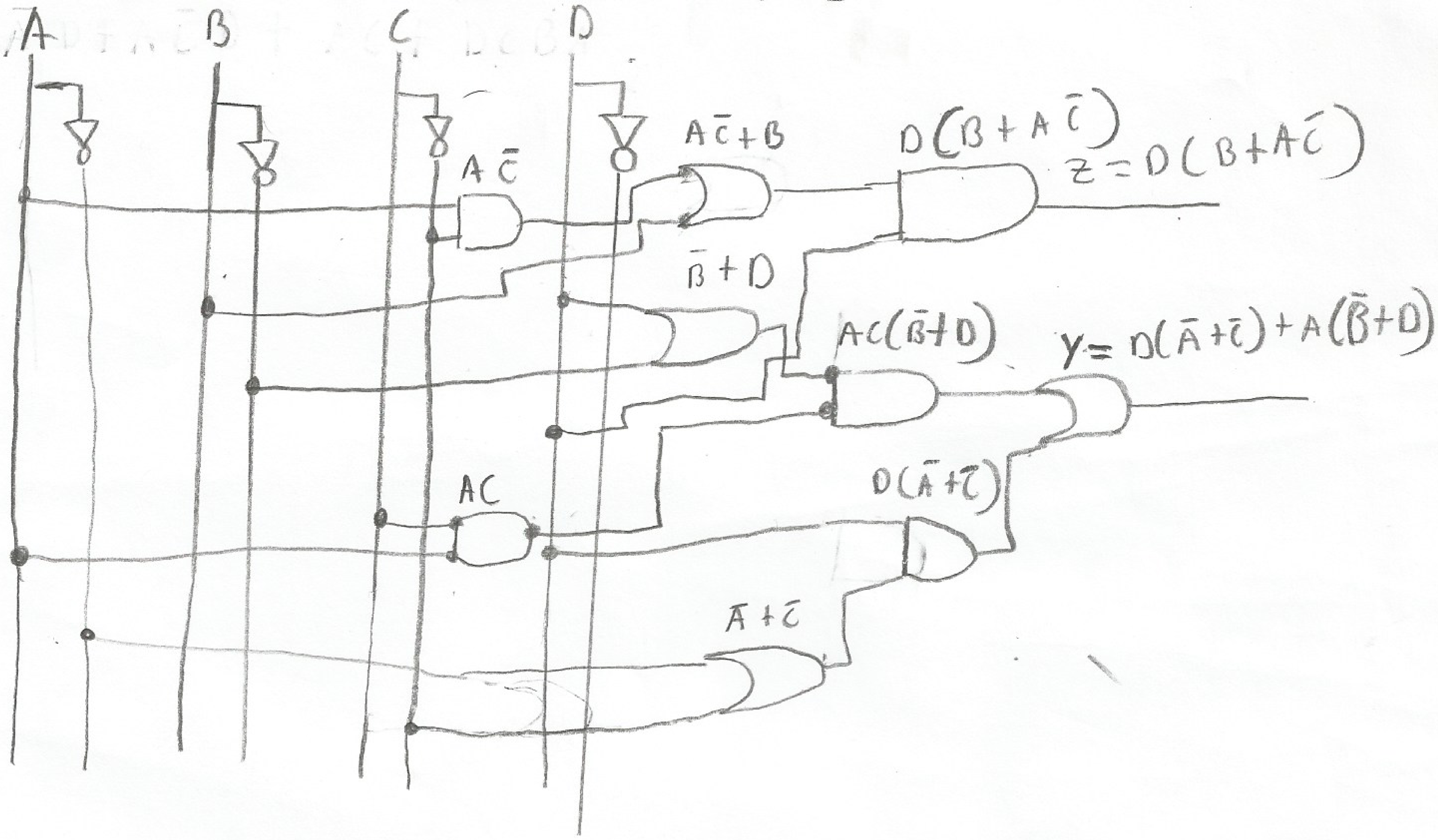
$= D(\bar{A} + A\bar{C}) + AC(\bar{B} + BD)$

$= D(\bar{A} + \bar{C}) + AC(\bar{B} + D)$



$Z = BD + AD\bar{C}$

$Z = D(B + A\bar{C})$



I did this homework entirely on my own. I did not collaborate with anyone.

Signed: ______________________ Date: 9-17/2020