CS 4341
Homework #1
Cohort Name: Team Dan and 3 Others
Assigned: January 23, 2019
Due: February 8, 2019 11:59 pm

Objective:

Complete the following Exercises from the Mano book.

For the written exercises and diagram:

- Turn in a PDF of the Pre-Requisite Form for each member of the Cohort.
- Turn in a PDF file to the blackboard in the form of <COHORTNAME>. Bookwork.PDF.

For the Program and output, the following should be turned in:

- The program in the form of <COHORTNAME>.Program.<EXTENSION>
- An output file as a text file, not a screen capture, in the form of <COHORTNAME>.Output.txt.

Problem 0. Electronically Sign and Turn-In your pre-requisite form for each member of the cohort. (11 points)

Problem 1. Convert the following numbers from one Base to another Base. (6 points)

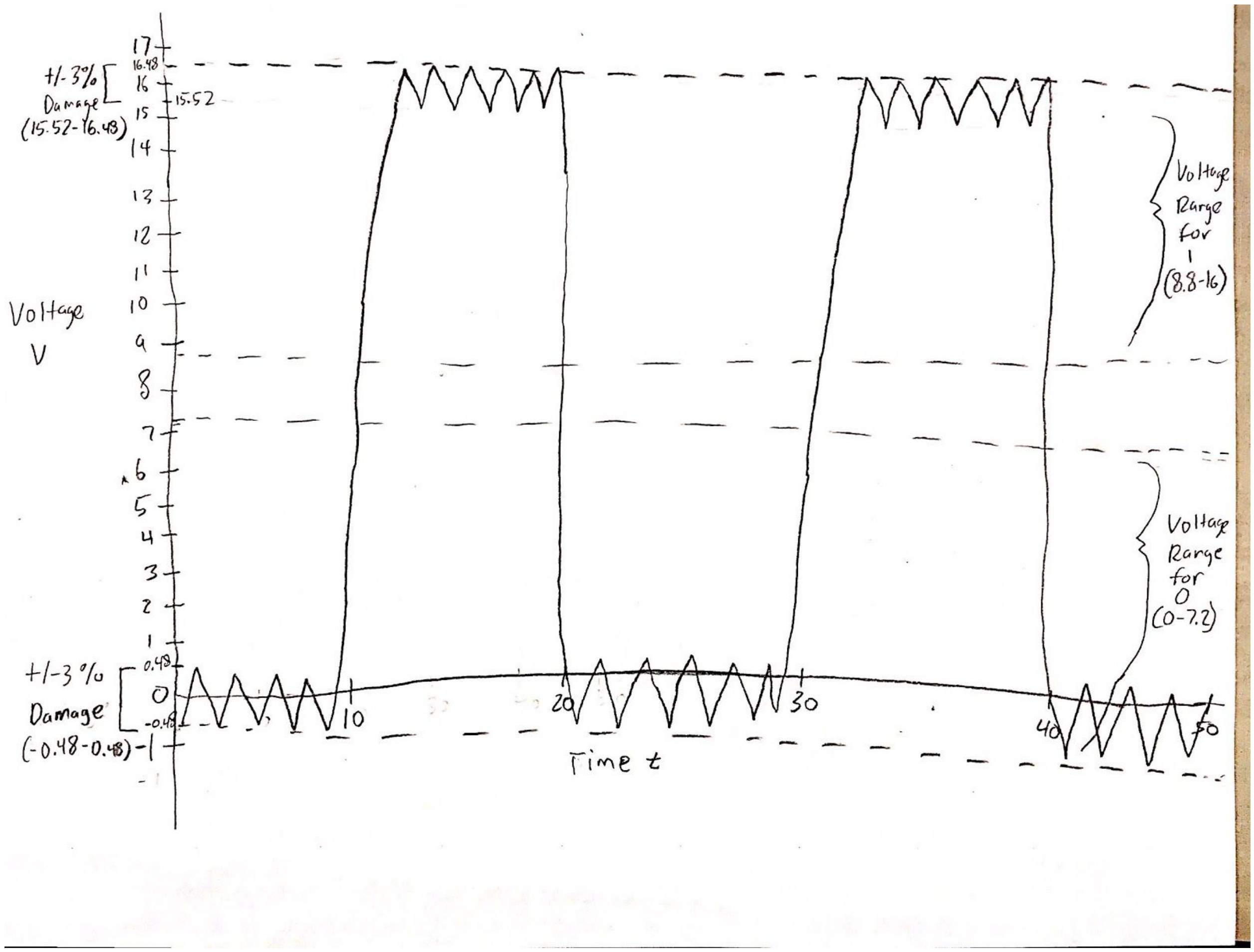
a) 60177756_8 to $Base_{16}$
    a. C0FFEE 1100 0000 1111 1111 1110 1110
b) 111111111_2 to $Base_{10}$
    a. 511
c) 3126770193_{10} to $Base_{16}$
    a. BA5EBA11

Problem 2. Describe the Digital Abstraction for the following: (6 points)

a) How many bits necessary to record the passage of 511 seconds?
    a. 9 bits - This is because with 9 bits we are capable of creating the numbers 0-511 inclusive. So we only need 9 bits to store 511 with the binary number being 111111111.
b) How many bits necessary to record the passage of 512 seconds?
    a. 10 bits - We now need 10 bits instead of 9 because we must store a range of numbers that is larger than out 9 bit limit of 511. We now need an extra bit to create the binary number 1000000000.
c) How many bits necessary to record the passage of 513 seconds?
    a. 10 bits - We need the same number of bits to store 513 as we do for 512 because having 10 bits allows us to record the range 0-1023 inclusive.

Problem 3. Draw a voltage square-wave diagram, voltage against time units, including the following pieces of information. (6 points)

- a V_{max} of 16
- a V_{min} of 0
- a +/- 3% Voltage for damage.
- The value of binary 0 is from 0 to 45% of the range.
- The value of Binary 1 is from 55% to 100% of the range.
- The “Human” value is at 50%.



Problem 4. Simplify the following Boolean Expressions to a minimum number of literals: (5 points)

(a) $\boldsymbol{xy + xy' = x}$

a.

x	*y*	*xy+xy'*
0	*0*	*0 + 0 : 0*
0	*1*	*0 + 0 : 0*
1	*0*	*0 + 1 : 1*
1	*1*	*1 + 0 : 1*

b. $= x(y + y')$

c. $= x(True)$

d. $= x$

(b) $\boldsymbol{(x + y)(x + y') = x}$

a. $(x+y)(x+y')$
b. $= xx+xy'+yx+yy'$
c. $= x + xy' + yx$
d. $= x + x(y' + y)$
e. $= x + x$
f. $= x$

(c) $\boldsymbol{xyz + x'y + xyz' = y}$

a. $xyz + x'y + xyz'$
b. $= y(xz + x' + xz')$
c. $= y(x(z + z') + x')$
d. $= y(x(True) + x')$
e. $= y(x + x')$
f. $= y(True)$
g. $= y$

(d) $\boldsymbol{(x + y)'(x' + y')' = 0}$

a. $(x'y')(xy)$
b. $(x'x)(x'y)(y'x)(y'y)$
c. $(False)(x'y)(y'x)(False)$
d. $= 0$ $(False)$

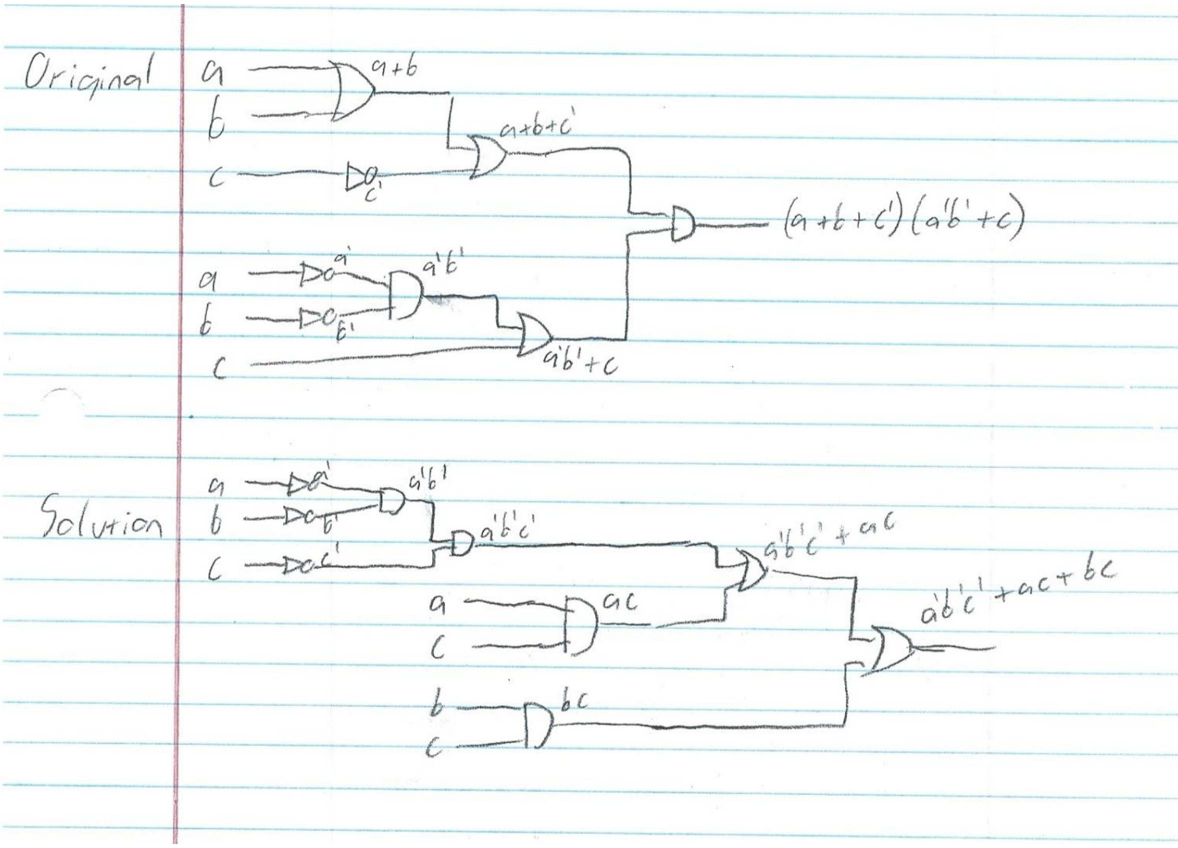
x	*y*	$(x+y)'(x'+y')'$
0	*0*	*0*
0	*1*	*0*
1	*0*	*0*
1	*1*	*0*

e.

(e) $\boldsymbol{(a + b + c')(a'b' + c) = a'b'c' + ac + bc}$

a. $= aa'b'+a'b'b+a'b'c'+ac+bc+cc'$
b. $= False + False + a'b'c' + ac + bc + False$
c. $= a'b'c' + ac + bc$

Problem 5. Draw the circuit for the original equation of part E from problem 4, and the solution as well. (6 points)



Problem 6. (8 points)

a) Explain what a normalized, sum-of-products form is.
    a. A sum-of-products form is a boolean expression consisting only of Minterms, also known as product sums. The reduction of the minterm sum-of-products gives the normalized sum-of-products form.
b) Explain what a Σ notation is.
    a. Sigma(Summation) Notation is the summation of products for the rows that result in 1. These rows are also known as the Minterms.
c) Explain what a Π notation is.
    a. Pi(Product) Notation is the product of sums for the rows that result in one. The Pi notation is the product of all the maxterms whose values equals to 0.

Rewrite the following Boolean expression (b+c)(a+b'+c) as

d) a truth table

a	b	c	(b+c)	(a+b'+c)	(b+c)(a+b'+c)
0	0	0	0	1	0
0	0	1	1	1	1
0	1	0	1	0	0
0	1	1	1	1	1
1	0	0	0	1	0
1	0	1	1	1	1
1	1	0	1	1	1
1	1	1	1	1	1

e) a normalized, sum-of-products form.
    a. F = (a'b'c) + (a'bc) + (ab'c) + (abc') + (abc)
f) Rewrite the expression in a Σ notation
    a. Σ (1,35,6,7)
g) a product-of-sums form
    a. (a + b + c)(a + b' + c)(a + b' + c')
h) Rewrite the expression in a Π notation
    a. Π (0,2,4)

Problem 7. 3-Variable Minimization to sum of product form using 3-bit K-maps. (8 points)

a) F(A,B,C)= Σ (0,2,4,6)
b) F(A,B,C)= Σ (0,1,6,7)
c) F(A,B,C)=(AB)'(BC)'(AC)'
d) F(A,B,C)=(A+B)'(A+C)'(A)

a. $F(A,B,C) = \Sigma(0,2,4,6)$

A \ BC	00	01	11	10
0	1 (0)	0 (1)	0 (3)	1 (2)
1	1 (4)	0 (5)	0 (7)	1 (6)

Sum of products

$\boxed{C'}$

b. $F(A,B,C) = \Sigma(0,1,6,7)$

A \ BC	00	01	11	10
0	1 (0)	1 (1)	0 (3)	0 (2)
1	0 (4)	0 (5)	1 (7)	1 (6)

Sum of Products

$\boxed{A'B' + AB}$

C. $F(A,B,C) = (AB)'(BC)'(AC)'$

A \ BC	00	01	11	10
0	1 (0)	1 (1)	0 (3)	1 (2)
1	1 (4)	0 (5)	0 (7)	0 (6)

Sum of Products

$\boxed{A'B' + A'C' + B'C'}$

A	B	C	(AB)'	(BC)'	(AC)'	(A[illegible]
0	0	0	1	1	1	1
0	0	1	1	1	1	1
0	1	0	1	1	1	1
0	1	1	1	0	1	0
1	0	0	1	1	0	0
1	0	1	1	1	1	0
1	1	0	0	1	0	0
1	1	1	0	0	0	0

d. $F(A,B,C) = (A+B)'(A+C)'(A)$

A	B	C	$(A+B)'$	$(A+C)'$	$(A+B)'(A+C)'(A)$
0	0	0	1	1	0
0	0	1	1	0	0
0	1	0	0	1	0
0	1	1	0	0	0
1	0	0	0	0	0
1	0	1	0	0	0
1	1	0	0	0	0
1	1	1	0	0	0

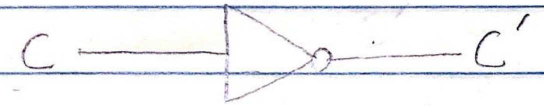
A \ BC	00	01	11	10
0	0 (0)	0 (1)	0 (3)	0 (2)
1	0 (4)	0 (5)	0 (7)	0 (6)

Sum of Products

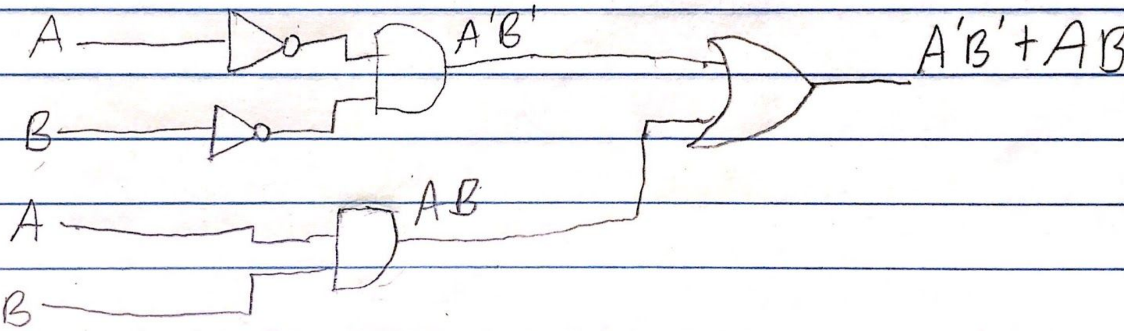
$\boxed{0}$

Problem 8. Draw the logic gate circuits for the problem 7 solutions. (8 points)

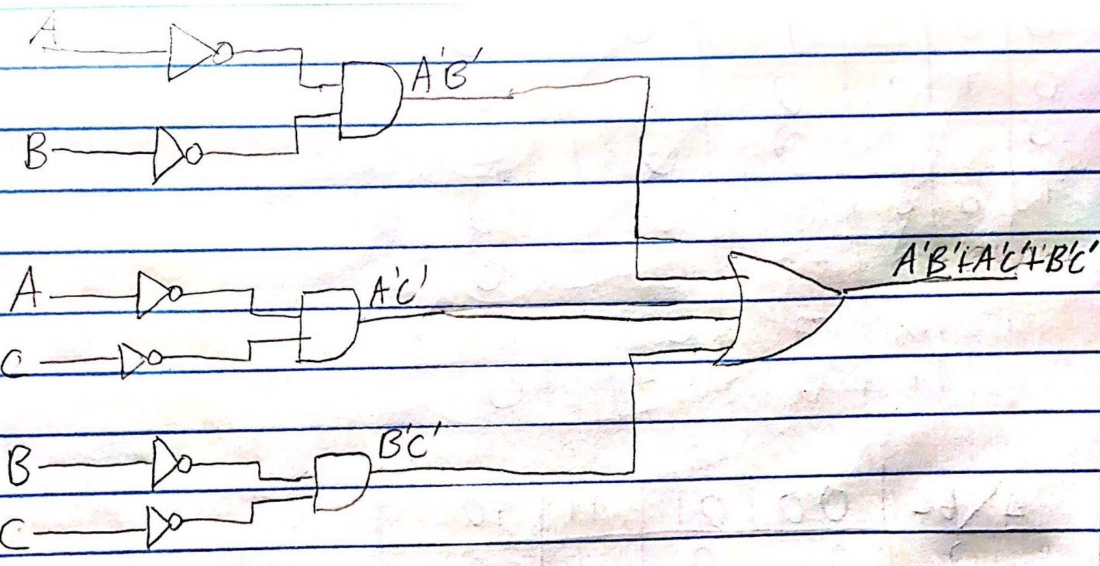
a.



b.



c.



d. No logic gate circuit since. Sum of products is 0

Problem 9. 4-Variable Minimization to sum of product form using 4-bit K-maps. (8 points)

a) F(A,B,C,D)= Σ (1,4,5,7,9,13)
b) F(A,B,C,D)= Σ (0,3,4,7,9,10,13,14)
c) F(A,B,C,D)=A’BC’D’+ABC’D’+A’BCD’+ABCD’
d) F(A,B,C,D)=(CD’)(A’B’+A’B+AB+AB’)

a) $F(A,B,C,D) = \Sigma(1,4,5,7,9,13)$

AB \ CD	00	01	11	10
00	$_0$	1_1	$_3$	$_2$
01	1_4	1_5	1_7	$_6$
11	$_{12}$	1_{13}	$_{15}$	$_{14}$
10	$_8$	1_9	$_{11}$	$_{10}$

$\boxed{C'D + A'BC' + A'BD}$

b) $F(A,B,C,D) = \Sigma(0,3,4,7,9,10,13,14)$

AB \ CD	00	01	11	10
00	1_0	$_1$	1_3	$_2$
01	1_4	$_5$	1_7	$_6$
11	$_{12}$	1_{13}	$_{15}$	1_{14}
10	$_8$	1_9	$_{11}$	1_{10}

$\boxed{A'C'D' + AC'D + A'CD + ACD'}$

c)

AB \ CD	00	01	11	10
00	$_0$	$_1$	$_3$	$_2$
01	1_4	$_5$	$_7$	1_6
11	1_{12}	$_{13}$	$_{15}$	1_{14}
10	$_8$	$_9$	$_{11}$	$_{10}$

$F(A,B,C,D) = A'BC'D' + ABC'D' + A'BCD' + ABCD'$

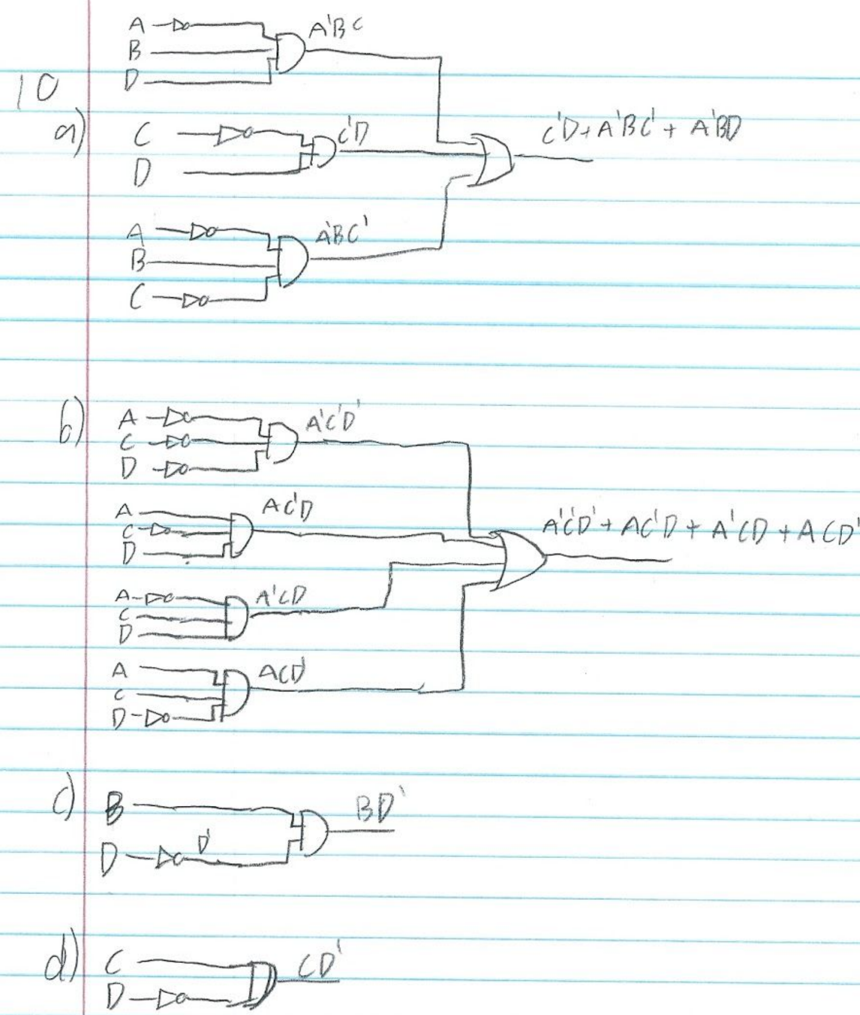
$F(A,B,C,D) = BD'$

d) $F(A,B,C,D) = (CD')(A'B' + A'B + AB + AB')$

AB \ CD	00	01	11	10
00	$_0$	$_1$	$_3$	1_2
01	$_4$	$_5$	$_7$	1_6
11	$_{12}$	$_{13}$	$_{15}$	1_{14}
10	$_8$	$_9$	$_{11}$	1_{10}

$F(A,B,C,D) = CD'$

Problem 10. Draw the logic gate circuits for the problem 9 solutions. (8 points)



Programming Problem (20 Points) - (Programming File/Output File attached separately from this pdf - check the zip folder)

Part 1: Install a VHDL such as Icarus iVerilog on your cohort's laptop.

Include in your code a comment block indicating the software you have chosen and its source.

Part 2: Solve the following problems

Using a Hardware Design Language, write a program that can run the following three circuits.

You must include the code and the output for each of the following equations.

- Each equation should be a separate ***module***
- Each module should be called from the ***testbench***
- The output should be in the form of a ***truth table***

a) Out_1=(A+B')C'(C+D)
b) Out_2=(C'D+BCD+CD')(A'+B)
c) Out_3=(AB+C)D+B'C

Example Output: Columns 1,2, and 3 should hold the answers in the real output.

```
C:\iverilog\workspace\2018>..\..\bin\vvp a.out
         #|A|B|C|D||1|2|3|
=========+=+=+=+=++=+=+=+
         0|0|0|0|0|| | | |
         1|0|0|0|1|| | | |
         2|0|0|1|0|| | | |
         3|0|0|1|1|| | | |
         4|0|1|0|0|| | | |
         5|0|1|0|1|| | | |
         6|0|1|1|0|| | | |
         7|0|1|1|1|| | | |
         8|1|0|0|0|| | | |
         9|1|0|0|1|| | | |
        10|1|0|1|0|| | | |
        11|1|0|1|1|| | | |
        12|1|1|0|0|| | | |
        13|1|1|0|1|| | | |
        14|1|1|1|0|| | | |
        15|1|1|1|1|| | | |
```