CS 4341
Homework #1
Assigned: January 22nd
Due: February 7th

Part 1

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Section 002

1. Binary Numbers (5 points)

Show each of the following as a decimal, octal, and hexadecimal number.

	Binary	Decimal	Octal	Hexadecimal
(a)	110111	55	67	37
(b)	1011001	89	131	59
(c)	10010000	144	220	90
(d)	11101001	233	351	E9
(e)	101111001	377	571	179

2. Digital Abstraction (5 points)

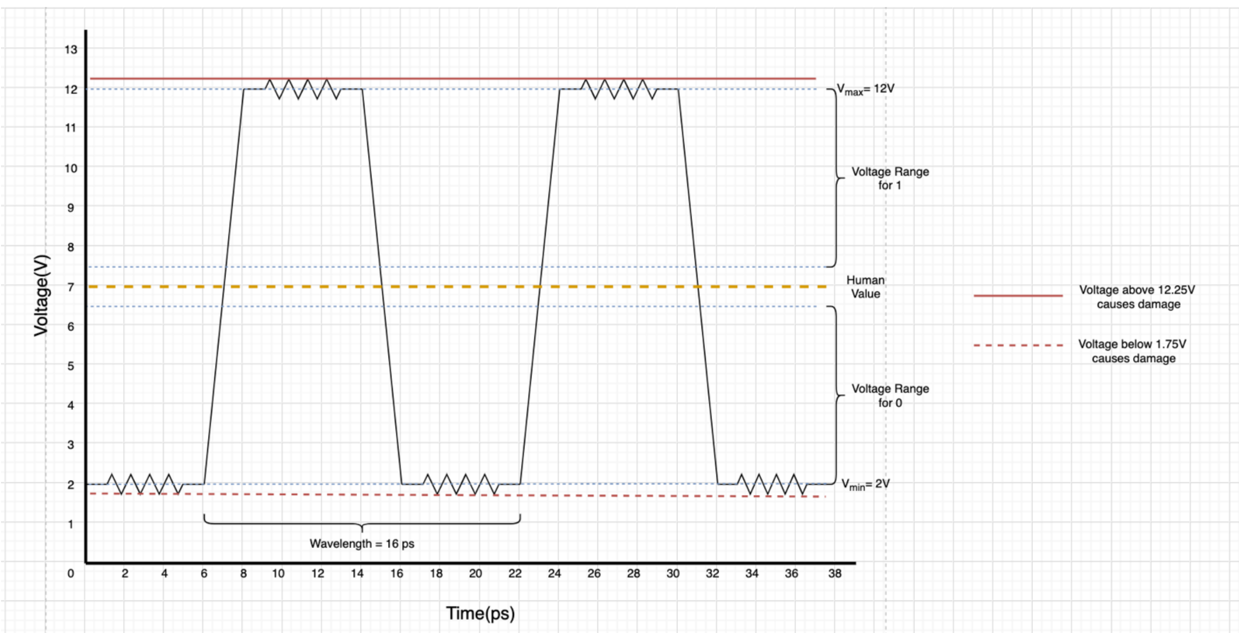
How many *total* bits does it take to…

a) Count 36 petals on a rose? 6
b) Count 20 sides on a icosahedron? 5
c) Count the number of miles in the Indy 500? (Yes, it is 500 miles) 9
d) Count the 114 days until May 14th? 7
e) Count the range from 0 to 1024 *inclusive*? 11

3. Voltage Diagram 5 points

Draw a voltage square-wave diagram, voltage against time units, including the following pieces of information.

- a V_{max} of 12 Volts
- a V_{min} of 2 Volts
- 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.
- Damage starts to occur below 1.75 Volts.
- Damage also starts to occur above 12.25 Volts.
- The "Human" value is at 50%.
- A wavelength of 16 picoseconds



4. Simplify the following Boolean Equations. For simplification, it should use the fewest literals (variables) and disjunctive normal form (disjunctive). You my use any method: proofing, algorithms, or even truth tables, though show your work.

    a) (ab')'(a'c')'(b'c')' (5 points)

(a'+b)(a+c)(b+c)	DeMorgan's Law
(a'a+a'c+ba+bc)(b+c)	Distribution
(a'c+ba+bc)(b+c)	Complementation
a'bc+a'cc+abb+abc+bbc+bcc	Distribution
a'(bc+cc)+b(ab+ac+bc+cc)	Reverse Distributive
a'(bc+c)+b(ab+ac+bc+c)	Idempotence
a'c+b(ab+ac+c)	Absorption
a'c+b(ab+c)	Absorption
a'c+abb+bc	Distributive
a'c+ab+bc	Idempotence

    Final Answer in DNF: ab+ a'c+bc

    b) p'q'r's'+p'q'rs'+p'qr's'+p'qrs'+pq'r's'+pq'rs'+pqr's'+pqr's (5 points)

p'q's'(r+r')+p'qs'(r+r')+pq's'(r+r')+pqr'(s+s')	Reverse Distribution
p'q's'+p'qs'+pq's'+pqr'	Complementation
p's'(q+q')+q's'(p+p')+pqr'	Idempotence/Reverse Distribution
p's'+q's'+pqr'	Complementation

    Final Answer in DNF: p's'+q's'+pqr'

    c) check out www.wolframalpha.com. (For Fun)

5. Definition of Terms (10 points)

    a) Disjunctive Normal Form, DNF (1 point)
        - Disjunctive Normal Form is a way to write a logic equation in a which terms are connected by ORs. Sum of Products is a type of DNF.

    b) Conjunctive Normal Form, CNF (1 point)
        - Conjunctive Normal Form is a way to write a logic equation in a which terms are connected by ANDs. Product of Sums is a type of CNF.

    c) Min Term (1 point)
        - A row of a truth table that evaluates to 1

    d) Max Term (1 point)
        - A row of a truth table that evaluates to 0

    e) Sigma Σ Notation (1 point)
        - Sigma notation is shorthand for a truth table in that it contains all the rows of input that equal 1 (minterms).

f) Pi Π Notation (1 point)

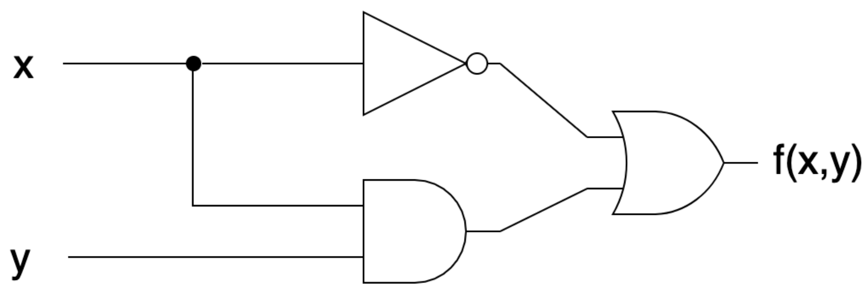
- Pi notation is shorthand for a truth table in that it contains all the rows of input that equal 0 (maxterms).

g) “normalized” equation, and its relation to the NAND form. (4 points)

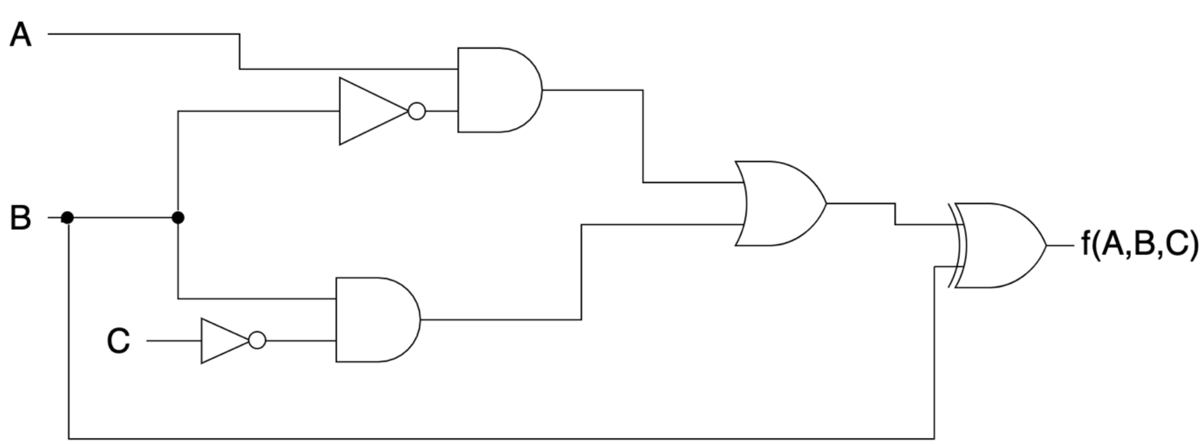
- Normalizing an equation is when you reduce a logic equation down to a form that takes the fewest number of literals and gates. There are 2 types of normal forms: DNF and CNF, which are defined above. To get to the related NAND form, you use DeMorgan’s Law to turn all the different gates and inverters into only NAND gates. For example, an OR gate can turn into an AND gate with all of its inputs and output inverted. You can then tranfer the inverter of the inputs back to where they exit the previous output. An invertor can become a NAND by putting the input into a NAND twice. For example: A’ becomes (A NAND A). An AND gate can become a NAND by putting the inputs through a NAND gate and then inverting the result by having the output of the first NAND gate be both of the inputs for the second NAND gate.

6. Convert Equations to Circuits

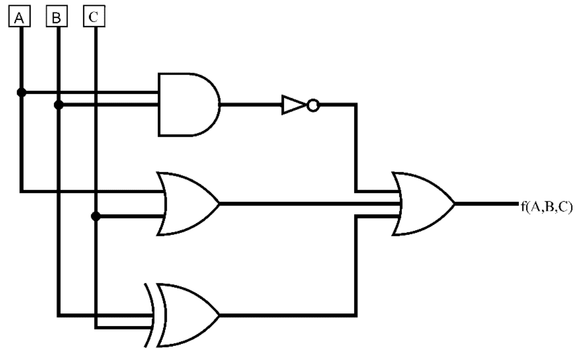
a) f(x,y)=x’+xy (5 points)



b) f(A,B,C)=(AB’+BC’)⊕B (5 points)

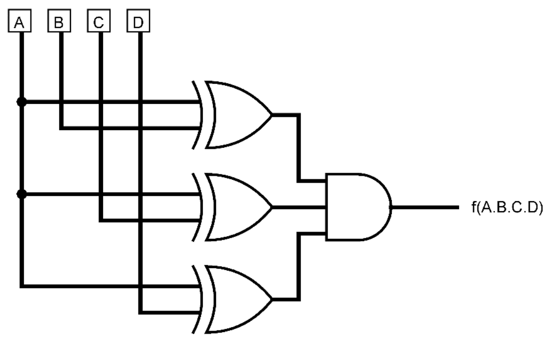


7. Convert Circuit to Equation. For this problem, you are to demonstrate that you can recognize the operations that make up the circuit. In this case, you do not need to simplify the equation.
   a) Convert the circuit to an equation. (5 points)



(AB)’+(A+C)+(B⊕C)

   b) Convert the circuit to an equation. (5 points)



(A⊕B)(A⊕C)(A⊕D)

Hint: K-Maps are based on Grey Codes. Labelling and bit positioning are the two most common errors on K-Maps. Have some blank grids that you can relabel.

i_2 \ i_1i_0	**00**	**01**	**11**	**10**
0				
1				

i_3i_2 \ i_1i_0	**00**	**01**	**11**	**10**
00				
01				
11				
10				

8. 3-Bit K-Maps (5 points)

a) Draw the K-Map for the following truth table, and show the normalized equation and the NAND form of the equation. (5 points)

A	B	C	f(A,B,C)
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

A \ BC	**00**	**01**	**11**	**10**
0	**1**	**1**	**0**	**1**
1	**0**	**0**	**1**	**0**

A	B	C
0	0	x
0	x	0
1	1	1

A’B’+A’C’+ABC Normalized Equation
A’(B’+C’)+ABC
A’(BC)’+ABC
((A’(BC)’)’(ABC)’)’ NAND Form

b) Draw the K-Map for the following Π notation, and show the normalized equation. (5 points)

g(J, K, L)=Π(0,1,6,7)

J	K	L	g(J,K,L)
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	0

A \ BC	**00**	**01**	**11**	**10**
0	**0**	**0**	**1**	**1**
1	**1**	**1**	**0**	**0**

Normalized Equation: A’B+AB’

9. 4-Bit K-Map 5
   a) Draw the K-Map for the following Σ notation and show the normalized equation and the NAND circuit. (10 points)

$$f(A,B,C,D)=\Sigma(0,1,4,5,9)$$

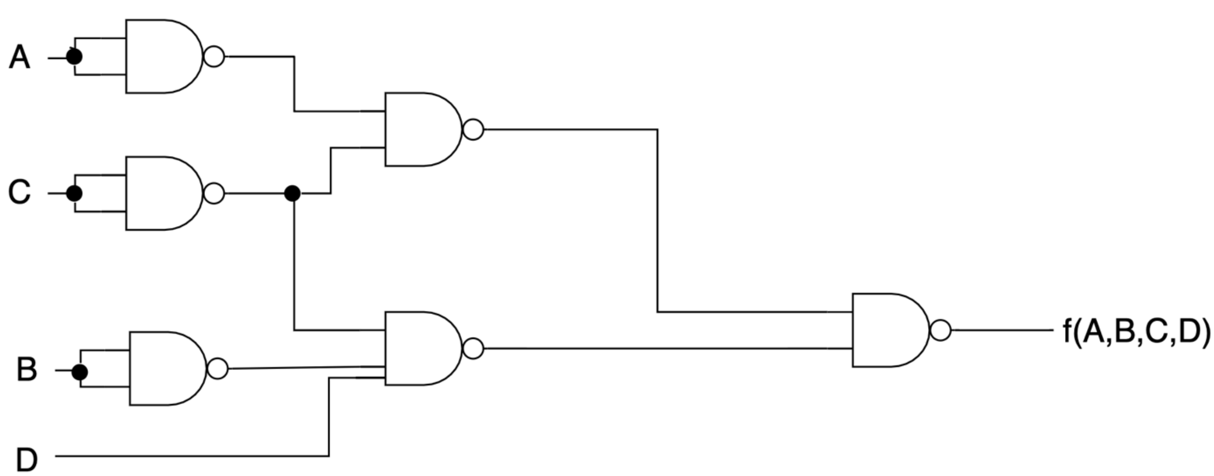
A	B	C	D	f(A,B,C,D)
0	0	0	0	1
0	0	0	1	1
0	0	1	0	0
0	0	1	1	0
0	1	0	0	1
0	1	0	1	1
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	1
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	0

AB \ CD	00	01	11	10
00	1	1	0	0
01	1	1	0	0
11	0	0	0	0
10	0	1	0	0

A	B	C	D
0	x	0	x
x	0	0	1

Normalized Equation: A'C' + B'C'D

NAND Circuit:



b) Draw the K-Map for the following equation and show the normalized equation and the NAND circuit. (10 points)

h(p,q,r,s) = p’r’s+p’q’r’+ p’q’r+pr’s+pq’rs’+qr’s+p’q’s

pq \ rs	00	01	11	10
00	**1**	**1**	**1**	**1**
01	**0**	**1**	**0**	**0**
11	**0**	**1**	**0**	**0**
10	**0**	**1**	**0**	**1**

p	q	r	s
0	0	x	x
x	x	0	1
x	0	1	0

Normalized Equation: p’q’+r’s+q’rs’

((p’q’)’(r’s)’)’+q’rs’

((((p’q’)’(r’s)’))(q’rs’)’)’

NAND Equation: ((p’q’)’(r’s)’(q’rs’)’)’

NAND Circuit: