CSc 28
HW: combinational circuits

1. Minimize each of the following functions using K-Maps. For each one of the question first write the function using the min-terms and then use the k-map to simplify it.

a) $f(A,B,C) = \Sigma\ min(1,3,4,6)$
b) $f(A,B,C) = \Sigma min(0,6)$
c) $f(A,B,C,D) = \Sigma min(0,2,5,7,8,10,13,15)$
d) $f(A,B,C,D) = \Sigma min(1,4,11,14)$
e) $f(A,B,C,D) = \Sigma\ min(0,3,5,6,9,10,12,15)$

2. Use K-Maps to write a simplified minterm for each of the following functions. Also write each function in the form $\Sigma min(, , ,)$

a) f(A,B,C) = A’B’C+ ABC’+ AB’C+ A’BC’ + A’B’C’
b) f(A,B,C) = A’B’C’ + A’BC + AB’C’ + ABC
c) f(A,B, C) = A’BC’+ ABC’+ AB’C+ A’BC
d) f(A,B) = A’B+ AB+ A’B’ + B’A

For the following two problems determine an un-normalized expression from the given truth tables and draw the corresponding logic circuit.

3.

x	y	f
0	0	1
0	1	0
1	0	1
1	1	0

4.

x	y	z	f
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	1

For the following twp problems determine a minimal SOP (sum of product) expression and draw its circuit.

5. Problem 1.a

6. Problem 2.a

7. Given that f(w, x, y, z) = ∑(0, 2, 5, 8, 9, 11, 12, 13). That is f is the sum of the given min-terms.

8. Given f(w, x, y, z) = $xz + xy\bar{z} + w\bar{x}\bar{y}$ find a minimal SOP expression for f.

9. Design the circuit for f = $a \oplus b$ using only NAND gates

10. show that NOR gate is a complete set

11. show that{OR, NOT} is a complete set

12. show that {AND, NOT} is a complete set

13. design a circuit to add two bits(half adder) discussed in class

14. write the following logical expression in its complete form

f(a,b,c,d} = ab + cd'+ bd + abc + bcd'

15. Use KMap to minimize the following function: f(x,y,z) = xy + xyz+ yz' + x'z' + x'y'z'

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CSC 28 – 01 22SU | 24 JUNE 2022

1. (a) $f(A,B,C) = \Sigma \min(1,3,4,6)$

$= A'B'C + A'BC + AB'C' + ABC'$

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

$f(A,B,C) = A'C + AC'$

(b) $f(A,B,C) = \Sigma \min(0,6)$

$= A'B'C' + ABC'$

A \ BC	00	01	11	10
0	1			
1				1

$f(A,B,C) = A'B'C' + ABC'$

(c) $f(A,B,C,D) = \Sigma \min(0,2,5,7,8,10,13,15)$

$= A'B'C'D' + A'B'CD' + A'BC'D + A'BCD + AB'C'D'$
$+ AB'CD' + ABC'D + ABCD$

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

$f(A,B,C,D) = B'D' + BD$

(d) $f(A,B,C,D) = \Sigma \min(1,4,11,14)$

$= A'B'C'D + A'BC'D' + AB'CD + ABCD'$

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

$f(A,B,C,D) = A'B'C'D + A'BC'D'$
$+ AB'CD + ABCD'$

(e) $f(A,B,C,D) = \Sigma min(0,3,5,6,9,10,12,15)$

$= A'B'C'D' + A'B'CD + A'BC'D + A'BCD' + AB'C'D + AB'CD' + ABC'D' + ABC'D$

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

$f(A,B,C,D) = A'B'C'D' + A'B'CD + A'BC'D + A'BCD' + AB'C'D + AB'CD' + ABC'D' + ABC'D$

2. (a) $f(A,B,C) = A'B'C + ABC' + AB'C + A'BC' + A'B'C'$

$= \Sigma min(0,1,2,5,6)$

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

$f(A,B,C) = A'B' + B'C + BC'$

(b) $f(A,B,C) = A'B'C' + A'BC + AB'C' + ABC$

$= \Sigma min(0,3,4,7)$

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

$f(A,B,C) = B'C' + BC$

(c) $f(A,B,C) = A'BC' + ABC' + AB'C + A'BC$

$= \Sigma min(2,3,5,6)$

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

$f(A,B,C) = AB'C + A'B + BC'$

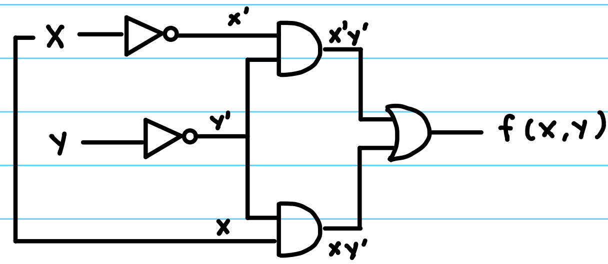
(d) $f(A,B) = A'B + AB + A'B' + B'A$

$= \Sigma min(0,1,2,3)$

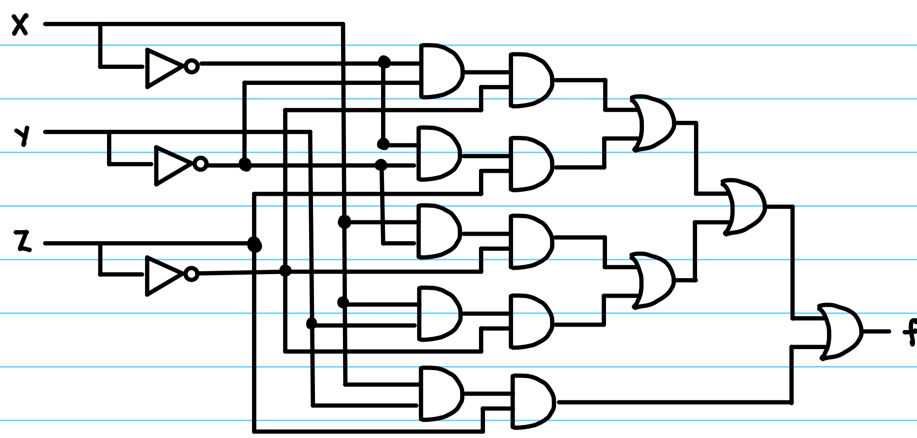
A \ B	0	1
0	1	1
1	1	1

$f(A,B) = 1$

3. $f(x,y) = x'y' + xy'$

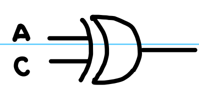


4. $f(x,y,z) = x'y'z' + x'y'z + xy'z' + xyz' + xyz$



5. $f(A,B,C) = \Sigma \min(1,3,4,6)$

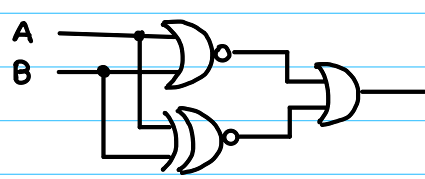
$= A'C + AC' = A \oplus C$



6. $f(A,B,C) = A'B'C + ABC' + AB'C + A'BC' + A'B'C'$

$= A'B' + B'C + BC'$

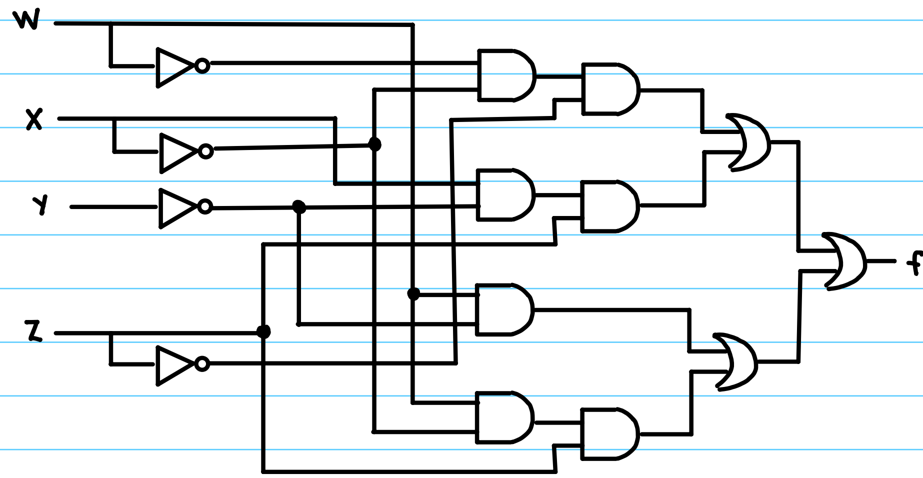
$= (A+B)' + (A \oplus B)$



7. $f(w,x,y,z) = \Sigma(0,2,5,8,9,11,12,13)$

wx \ yz	00	01	11	10
00	1			1
01		1		
11	1	1		
10	1	1	1	

$f(w,x,y,z) = \overline{w}\,\overline{x}\,\overline{z} + x\overline{y}z + w\overline{y} + w\overline{x}z$



8. $f(w,x,y,z) = xz + xy\overline{z} + w\overline{x}\,\overline{y}$

wx \ yz	00	01	11	10
00				
01		1	1	1
11		1	1	1
10	1	1		

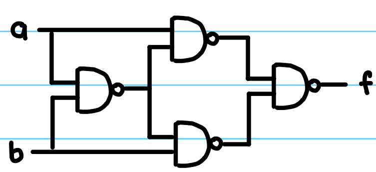
$f(w,x,y,z) = xz + xy + w\overline{x}\,\overline{y}$

9. $f = a \oplus b$

$= \overline{\overline{(\overline{ab})a} \cdot \overline{(\overline{ab})b}} = \overline{\overline{(\overline{ab})a}} + \overline{\overline{(\overline{ab})b}}$

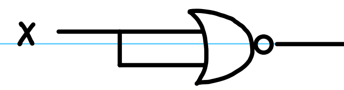
$= (\overline{a}+\overline{b})a + (\overline{a}+\overline{b})b$

$= \overline{a}a + a\overline{b} + \overline{a}b + \overline{b}b = a\overline{b} + \overline{a}b = a \oplus b$



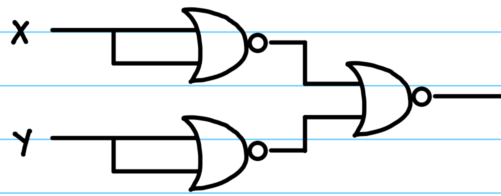
10. NOR gate is a complete set of every gate

- NOT gate



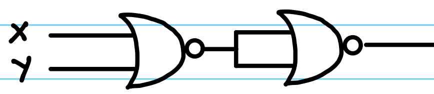
$$\overline{(x+x)} = \bar{x}\cdot\bar{x} = \bar{x}$$

- AND gate



$$\overline{\overline{(x+x)}+\overline{(y+y)}}$$
$$= \overline{\overline{(x+x)}}\,\overline{\overline{(y+y)}}$$
$$= (x+x)(y+y) = xy$$

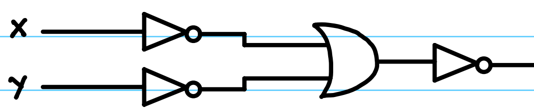
- OR gate



$$\overline{\overline{(x+y)}+\overline{(x+y)}}$$
$$= \overline{\overline{(x+y)}}\cdot\overline{\overline{(x+y)}}$$
$$= (x+y)\cdot(x+y) = x+y$$

11. {OR, NOT} is a complete set

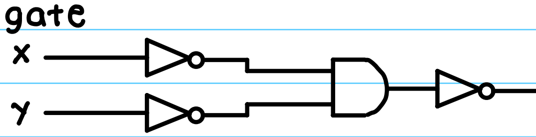
AND gate



$$\overline{\bar{x}+\bar{y}} = \bar{\bar{x}}\cdot\bar{\bar{y}} = xy$$

12. {AND, NOT} is a complete set

OR gate



$$\overline{\bar{x}\cdot\bar{y}} = \bar{\bar{x}}+\bar{\bar{y}} = x+y$$

13. Half adder

TRUTH TABLE

x	y	c	s
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

x \ y	0	1
0	0	1
1	1	0

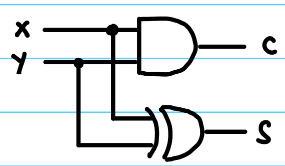
$S = \bar{x}y + x\bar{y}$

$= x \oplus y$

x \ y	0	1
0	0	0
1	0	1

$C = xy$

CIRCUIT:



14. $f(a,b,c,d) = ab + cd' + bd + abc + bcd'$

$= ab(c+c')(d+d') + cd'(a+a')(b+b') + bd(a+a')(c+c')$

$+ abc(d+d') + (a+a')bcd'$

$= abcd + abcd' + abc'd + abc'd' + abcd' + ab'cd'$

$+ a'bcd' + a'b'cd' + abcd + abc'd + a'bcd + a'bc'd$

$+ abcd + abcd' + abcd' + a'bcd'$

$= a'b'cd' + a'bc'd + a'bcd' + a'bcd + ab'cd'$

$+ abc'd' + abc'd + abcd' + abcd$

15. $f(x,y,z) = xy + xyz + yz' + x'z' + x'y'z'$

x \ yz	00	01	11	10
0	1			1
1			1	1

$f(x,y,z) = \bar{x}\bar{z} + xy$