Faculty of Engineering
ELECTRICAL AND ELECTRONIC ENGINEERING DEPARTMENT

EENG211 / INFE211 Digital Logic Design I

Spring 2008-09

Instructor:
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Midterm EXAMINATION

May 09, 2009

Duration : 90 minutes

Number of Problems: 8

Good Luck

STUDENT'S	
NUMBER	
NAME	SOLUTIONS
SURNAME	
GROUP NO	

Problem		**Points**
1		4
2		4
3		3
4		4
5		4
6		4
7		3
8		4
TOTAL		30

1. Use 8 bits (including the **sign**) to solve the following problem:
   a. Convert decimal +61 and +27 to binary using the signed-2's complement representation. **(2 pts.)**
   b. Perform the binary equivalent of (+ 27) + (– 61) **(1 pt.)**
   c. Perform the binary equivalent of (– 27) + (– 61) **(1 pts.)**

a.

Integer	Remainder		Integer	Remainder
61			27	
30	1		13	1
15	0		6	1
7	1		3	0
3	1		1	1
1	1		0	1
0	1			

$(61)_{10} = (00111101)_2$ $(27)_{10} = (00011011)_2$

$(-61)_{10}$ = (11000011) $(-27)_{10}$ = (11100101)

b.

$$\begin{array}{cccccccccc} & & & & & & 1 & 1 & \\ & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 \\ + & 1 & 1 & 0 & 0 & 0 & 0 & 1 & 1 \\ \hline & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 0 \end{array}$$

c.

$$\begin{array}{cccccccccc} & 1 & & & & 1 & 1 & 1 & \\ & 1 & 1 & 1 & 0 & 0 & 1 & 0 & 1 \\ + & 1 & 1 & 0 & 0 & 0 & 0 & 1 & 1 \\ \hline \not{1} & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \end{array}$$

2. Simplify the following Boolean expressions to a minimum number of literals.
   a. $A'C' + ABC + AC'$ **(2 pts.)**
   b. $(A'+C)(A'+C')(A+B+C'D)$ **(2 pts.)**

   Note: Show the steps how you reached the final answer.

a. $$A'C' + ABC + AC' = \left(\underbrace{A' + A}_{1}\right)C' + ABC =$$
$$C' + ABC = (C' + AB)(C' + C) = C' + AB$$

b. $$(A'+C)(A'+C')(A+B+C'D) = (A'A' + A'C' + A'C + CC')(A+B+C'D)$$
$$(A' + A'C' + A'C)(A+B+C'D) = \left(\underbrace{A' + A'\underbrace{(C'+C)}_{1}}_{A'}\right)(A+B+C'D) =$$
$$A'A + A'B + A'C'D = A'(B + C'D)$$

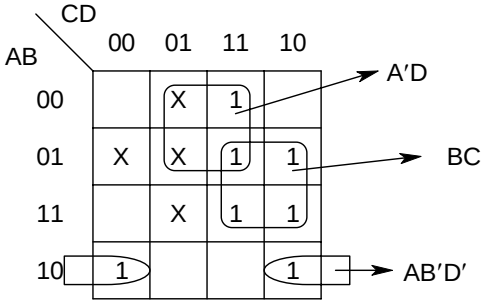
3. Express the following function as a **sum of minterms** and as a **product of maxterms. (3 pts.)**

$$F(A,B,C,D) = A \oplus B + (C \oplus D)' = \sum(0,3,4,5,6,7,8,9,10,11,12,15) = \prod(1,2,13,14)$$

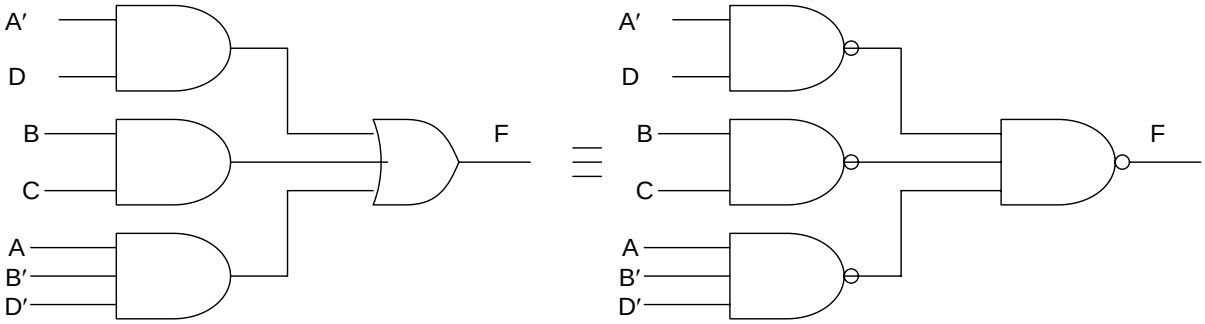
A	B	C	D	$A \oplus B$	$C \oplus D$	$(C \oplus D)'$	F
0	0	0	0	0	0	1	1
0	0	0	1	0	1	0	0
0	0	1	0	0	1	0	0
0	0	1	1	0	0	1	1
0	1	0	0	1	0	1	1
0	1	0	1	1	1	0	1
0	1	1	0	1	1	0	1
0	1	1	1	1	0	1	1
1	0	0	0	1	0	1	1
1	0	0	1	1	1	0	1
1	0	1	0	1	1	0	1
1	0	1	1	1	0	1	1
1	1	0	0	0	0	1	1
1	1	0	1	0	1	0	0
1	1	1	0	0	1	0	0
1	1	1	1	0	0	1	1

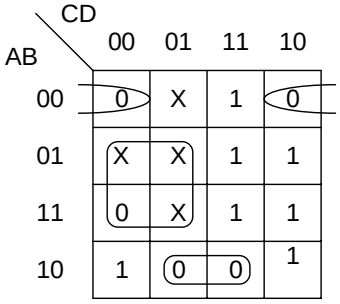
4. Simplify the following Boolean function *F*, together with the don't care conditions *d*, and implement it with
   a. two-level NAND gate circuits **(2 pts.)**
   b. two-level NOR gate circuits. **(2 pts.)**

$$F(A,B,C,D) = \sum(3,6,7,8,10,14,15)$$
$$d(A,B,C,D) = \sum(1,4,5,13)$$

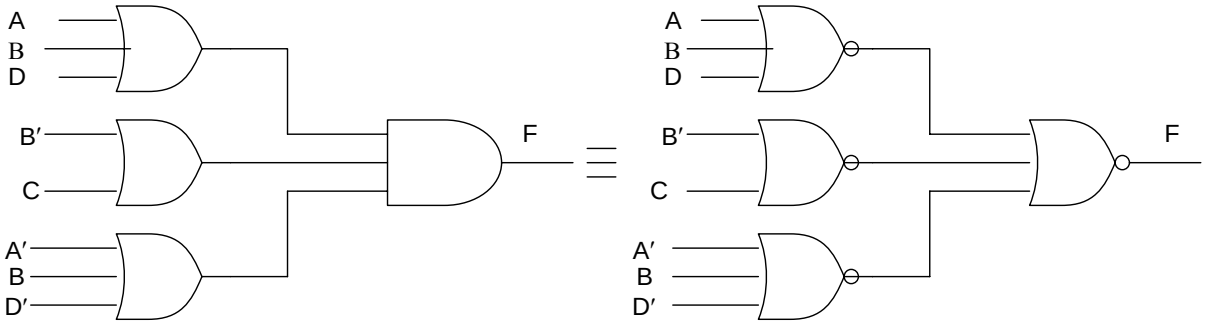


$$F(A,B,C,D) = A'D + BC + AB'D'$$





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

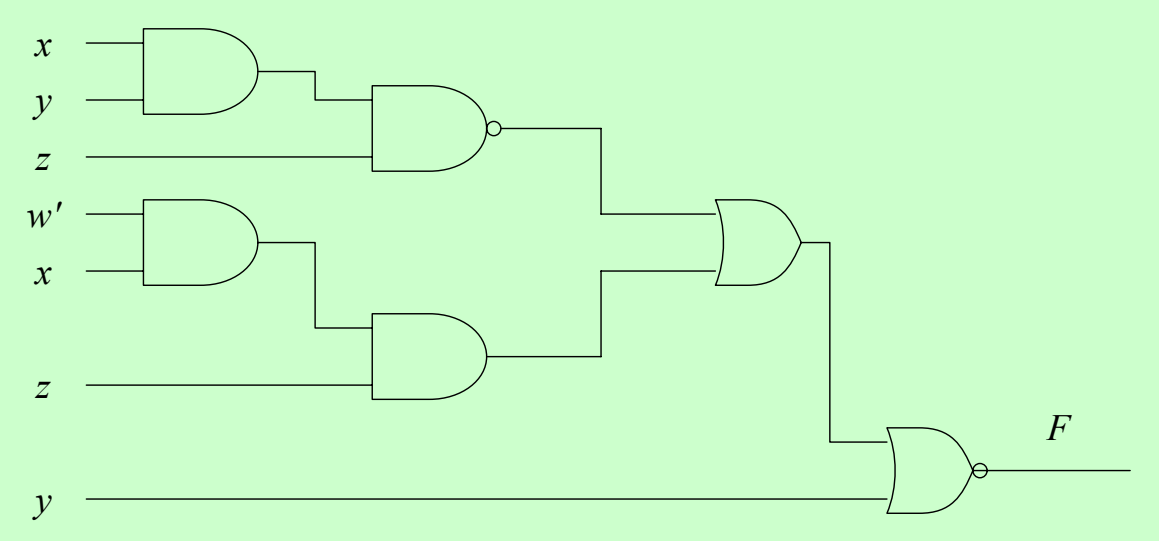


5. You are given 6 gates to implement the following Boolean function. **Each gate has 2 inputs only**. **(4 pts.)**

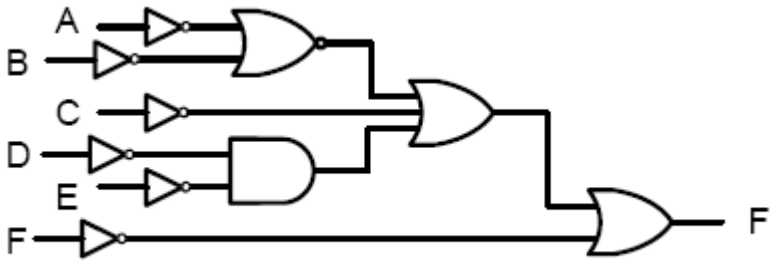
Type	Quantity
AND	3
OR	1
NAND	1
NOR	1

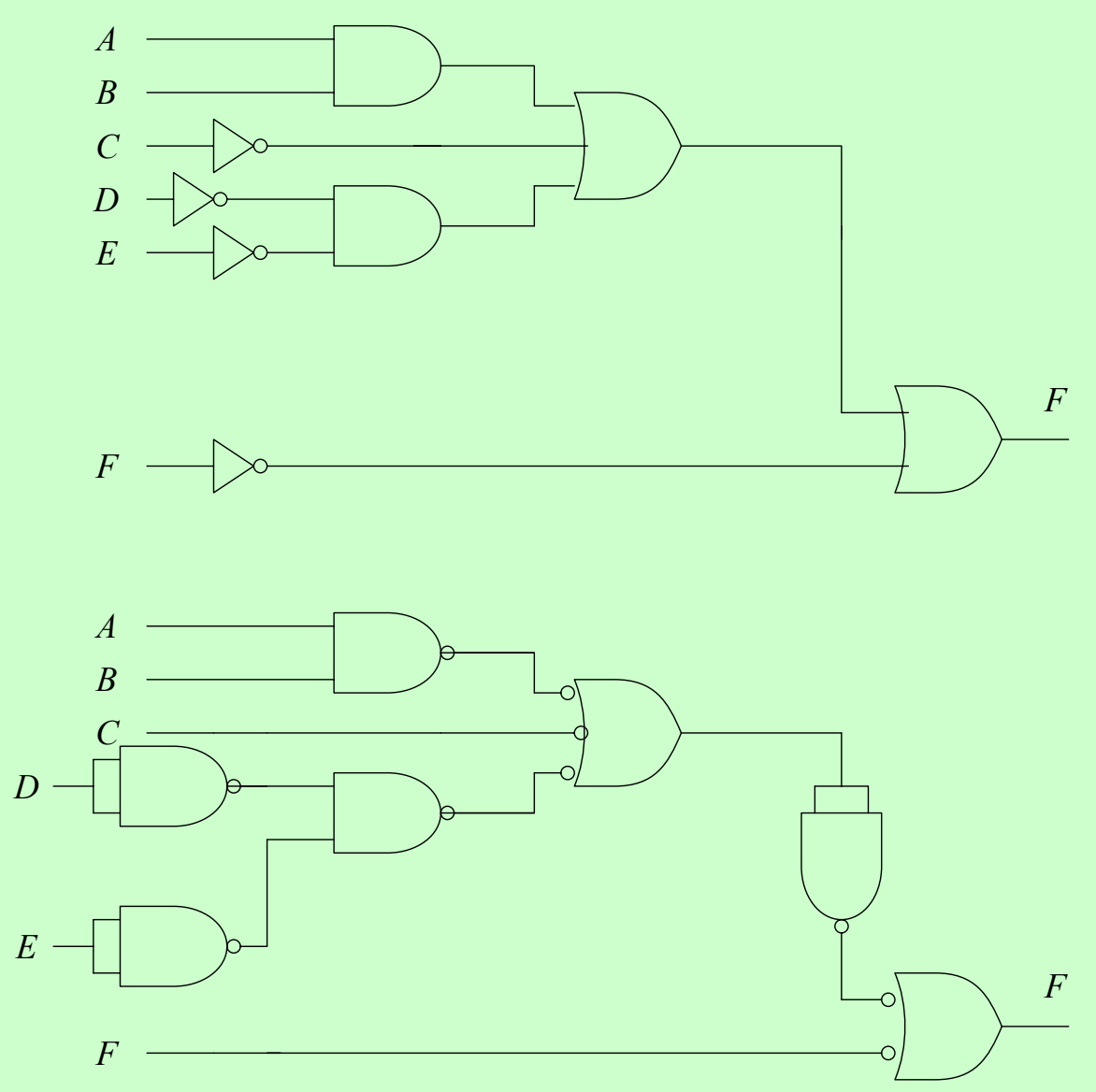
$$F(w,x,y,z) = \left((xyz)' + w'xz + y \right)'$$

Assume that both the normal and complement inputs are available.

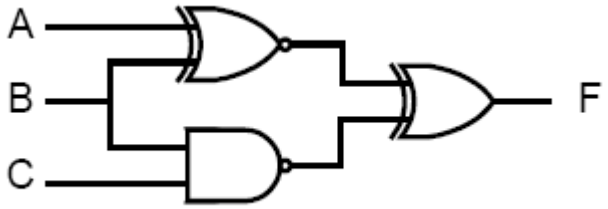


6. Redraw the following circuit by using only **NAND gates**. **(4 pts.)**
   Note: Use A, B, C … as inputs and **do not use** A', B', C' ….





7. Analyze the following circuit and determine the output F as sum of minterms. **(3 pts.)**

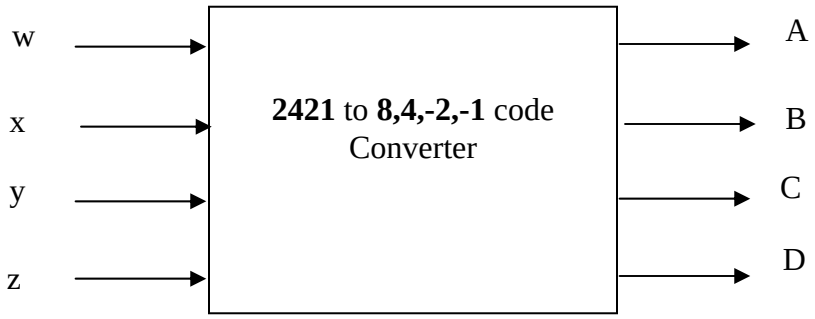


A	B	C	A⊕B	$(A \oplus B)'$	BC	$(BC)'$	$(A \oplus B)' \oplus (BC)'$
0	0	0	0	1	0	1	0
0	0	1	0	1	0	1	0
0	1	0	1	0	0	1	1
0	1	1	1	0	1	0	0
1	0	0	1	0	0	1	1
1	0	1	1	0	0	1	1
1	1	0	0	1	0	1	0
1	1	1	0	1	1	0	1

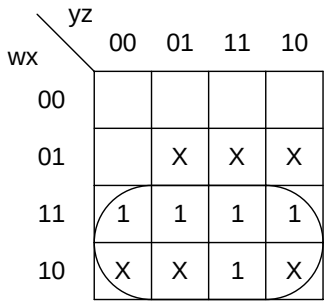
$$F(A,B,C) = \sum(2,4,5,7)$$

8. Design a code converter that converts a decimal digit from **2421** code to **8,4,-2,-1** code. **(4 pts.)**

Decimal Digit	**2421 wxyz**	**8,4,-2,-1 ABCD**
0	0000	0000
1	0001	0111
2	0010	0110
3	0011	0101
4	0100	0100
5	1011	1011
6	1100	1010
7	1101	1001
8	1110	1000
9	1111	1111

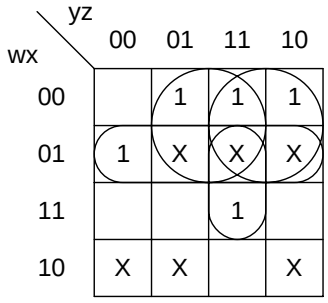


A



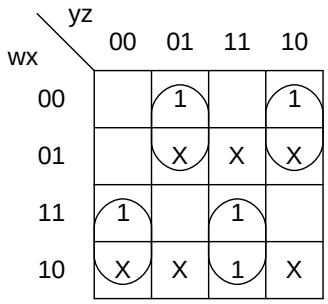
$$A = w$$

B



$$B = w'x + w'y + w'z + xyz$$

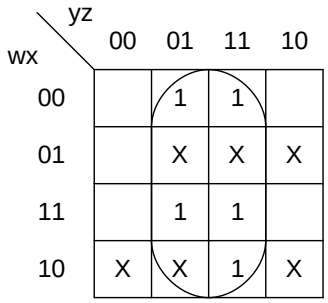
C



$$C = w'y'z + w'yz' + wy'z' + wyz$$

$$C = w \oplus y \oplus z$$

D



$$D = z$$