Faculty of Engineering

DEPARTMENT of ELECTRICAL AND ELECTRONIC ENGINEERING

EENG (INFE)115 Introduction to Logic Design

Instructors:

M. K. Uyguroğlu
G. Yemişcioğlu

Midterm EXAMINATION

November 17, 2016

Duration : 90 minutes

Number of Questions: 4

Good Luck

STUDENT'S	
NUMBER	
NAME	
SURNAME	
GROUP NO	

Question		**Points**
1		25
2		25
3		25
4		25
TOTAL		100

Read the following instructions carefully:

1. **Calculators** are not allowed.
2. Switch off **mobile phones** and **do not borrow** any stationery from your friends.
3. In your solutions, **show all details** you claim credit for.

Question 1

a) Convert the binary number 11011.0101 to decimal. Show your steps. Show only the first two digits after the decimal point. (**3 pts**.)

$$1\times 2^4+1\times 2^3+1\times 2^1+1+1\times 2^{-2}+1\times 2^{-4}=16+8+2+1+\frac{1}{4}+\frac{1}{16}$$

$$=27.31$$

b) Convert the following decimal numbers to binary: (Show your steps.) (**8 pts**.)

i. 37

	Remainder
37/2 = 18	1
18/2 = 9	0
9/2 = 4	1
4/2 = 2	0
2/2 = 1	0
½ = 0	1

$$(37)_{10}=(100101)_2$$

ii. 0.9

.

0.9 x 2 = 1.8	1
0.8 x 2 = 1.6	1
0.6 x 2 = 1.2	1
0.2 x 2 = 0.4	0
0.4 x 2 = 0.8	0
0.8 x 2 = 1.6	1

.

.

$$(0.9)_{10}=\left(0.1\overline{1100}\right)_2 \quad (1100 \text{ is repeated})$$

c) Convert (10100101010.11)2 to hexadecimal and to octal. (**4 pts**.)

$$\underset{5\quad 2\quad A\quad C}{\left(010100101010.1100\right)}=(52A.C)_{16}$$

$$\underset{2\quad 4\quad 5\quad 2\quad 6}{\left(010100101010.110\right)}=(2452.6)_8$$

d) Convert +20 and +45 to binary, using the signed-2's complement representation and **enough digit to accommodate** the numbers. Then perform the binary equivalent of (-20) – (+45). (**10 pts**.)

$(20)_{10} = (10100)_2 \Rightarrow (+20) = (00010100) \quad (-20) = (11101100)$

$(45)_{10} = (101101)_2 \Rightarrow (+45) = (00101101) \quad (-45) = (11010011)$

$(65)_{10} = (1000001)_2 \Rightarrow (+65) = (01000001)$ 8 bits are required.

$(-20) - (+45) = (-20) + (-45)$

$$\begin{array}{cccccccc} & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 0 \\ + & 1 & 1 & 0 & 1 & 0 & 0 & 1 & 1 \\ \hline \not{1} & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 \end{array} \Rightarrow -(01000001) = (-65)$$

Question 2

a) Simplify the Boolean function $F(x,y,z) = \prod(1,3,6,7)$ in sum of products using **algebraic manipulation** and implement it

i. with AND and inverter gates

ii. with OR and inverter gates

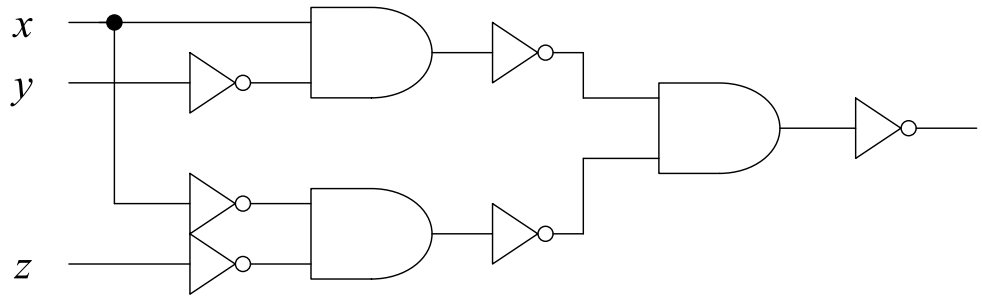
(**15 pts.)**

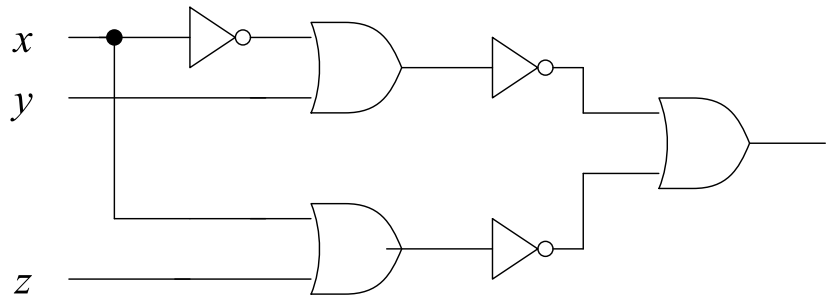
$$F(x,y,z) = \prod(1,3,6,7) = \sum(0,2,4,5)$$

$$F(x,y,z) = x'y'z' + x'yz' + xy'z' + xy'z = x'z'\underbrace{(y+y')}_{1} + xy'\underbrace{(z+z')}_{1} = x'z' + xy'$$

$F(x,y,z) = \left((x'z')'(xy')'\right)'$ implementation with AND and inverters

$F(x,y,z) = (x+z)' + (x'+y)'$ implementation with OR and inverters.





b) Express the following function as a sum of minterms and as a product of maxterms (**10 pts**.)

$$F(a,b,c,d) = a'(b'+d) + acd' = a'b' + a'd + acd'$$

a	b	c	d	$a'b'$	$a'd$	acd'	F	min$term$
0	0	0	0	1	0	0	1	0
0	0	0	1	1	1	0	1	1
0	0	1	0	1	0	0	1	2
0	0	1	1	1	1	0	1	3
0	1	0	0	0	0	0	0	4
0	1	0	1	0	1	0	1	5
0	1	1	0	0	0	0	0	6
0	1	1	1	0	1	0	1	7
1	0	0	0	0	0	0	0	8
1	0	0	1	0	0	0	0	9
1	0	1	0	0	0	1	1	10
1	0	1	1	0	0	0	0	11
1	1	0	0	0	0	0	0	12
1	1	0	1	0	0	0	0	13
1	1	1	0	0	0	1	1	14
1	1	1	1	0	0	0	0	15

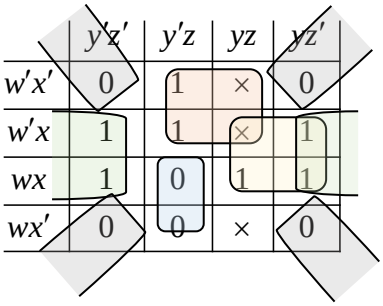
$$F(a,b,c,d) = \sum(0,1,2,3,5,7,10,14)$$
$$F(a,b,c,d) = \prod(4,6,8,9,11,12,13,15)$$

Question 3

For a given Boolean function $F(w,x,y,z) = \sum(1,4,5,6,12,14,15)$ which has the don't care conditions $d(w,x,y,z) = \sum(3,7,11)$

a) Determine the sum of products (SOP).
b) Implement F with only NAND gates.
c) Determine the product of sums (POS).
d) Implement F with only NOR gates.

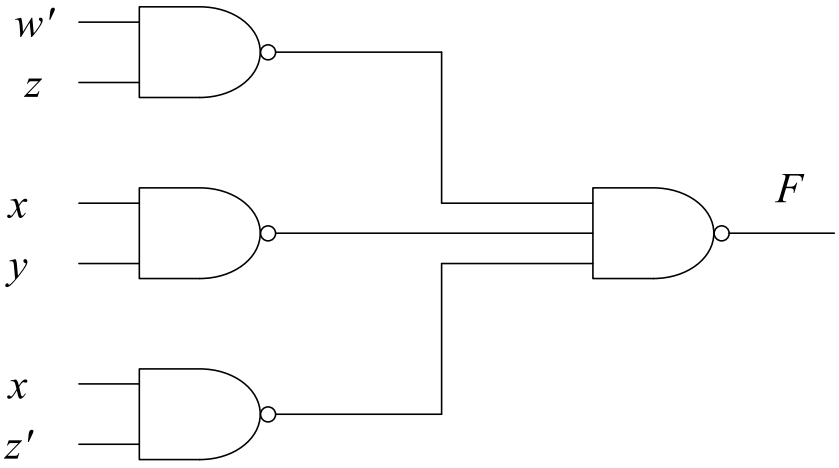
(**25 pts.**)

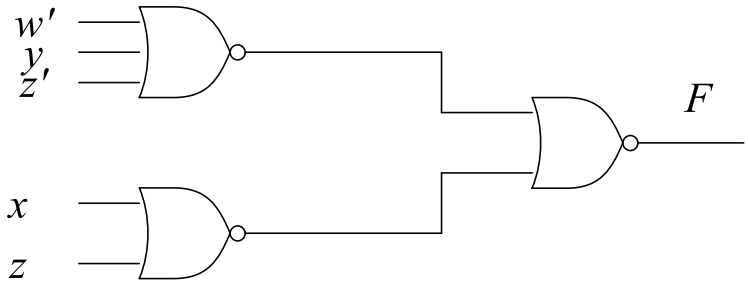


$F(w,x,y,z) = w'z + xy + xz'$

$F'(w,x,y,z) = x'z' + wy'z$

$F(w,x,y,z) = (x+z)(w'+y+z')$





Question 4

Implement the following Boolean function $F'(x,y,z) = y' + x'z'$ using the two-level forms.

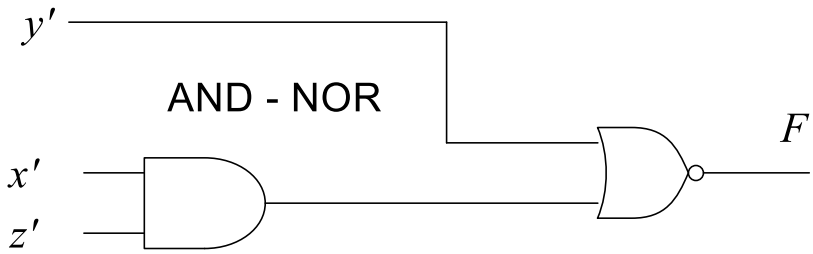
a) Karnaugh map of F'
b) NAND-AND for sum of products (SOP)
c) AND-NOR for sum of products (SOP)
d) OR-NAND for product of sums (POS)
e) NOR-OR for product of sums (POS)

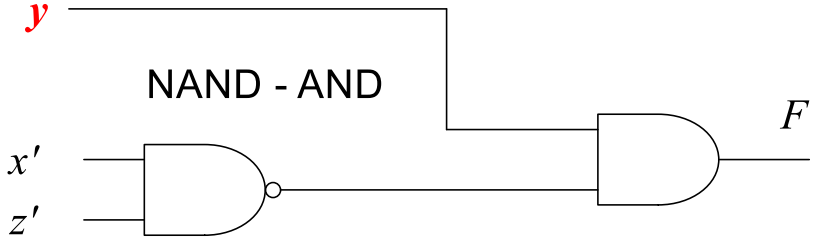
(**25 pts.**)

a)

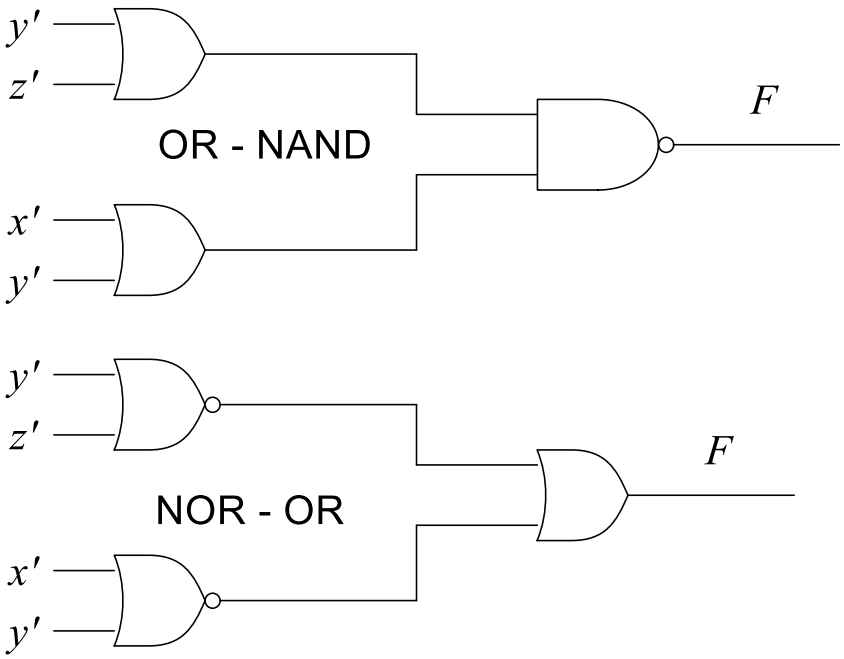
	$y'z'$	$y'z$	yz	yz'
x'	0	0	1	0
x	0	0	1	1

$$F'(x,y,z) = y' + x'z'$$
$$F(x,y,z) = (y' + x'z')'$$





$$F(x,y,z) = yz + xy$$
$$F'(x,y,z) = (y'+z')(x'+y')$$
$$F(x,y,z) = ((y'+z')(x'+y'))'$$


y′
z′
OR - NAND
F
x′
y′

y′
z′
NOR - OR
F
x′
y′