DIGITAL DESIGN COEN 312	Lecturers: Dr. A. J. Al-Khalili & DR. S. Das
Answer All Questions. Time Allowed 1 hr. 10min.	Midterm exam. Oct., 2016

Question 1.

1.a Convert 57_{10} to binary (1 Mark)

1. b Perform the following operation in binary A-B
A= 011001 B= 010111 (3 Marks)

Show your steps clearly including the Carries/Borrows

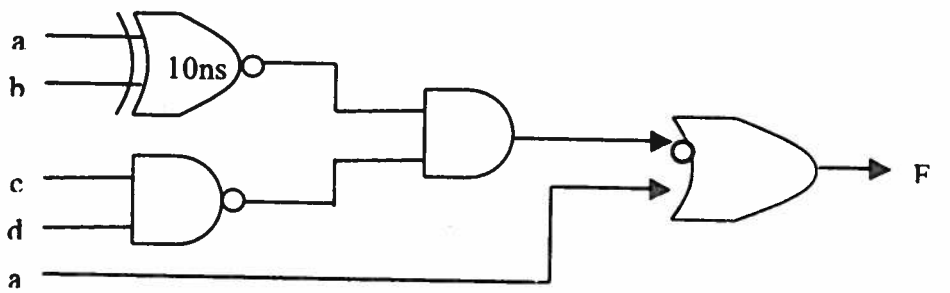
Question 2

(Use Boolean Algebra for Question 2)

2.a Simplify to obtain minimum SOP (3 Marks)
$F(W,X,Y,Z) = [Y \oplus (X + Y')][(W \odot (W + Y)]$

2.b Simplify to obtain minimum SOP (2 Marks)
$F(a,b,c,d) = a'b'(c + d')(1 + 0) + ab(c'd + cd') + (a'b + 0)cd$

2.c Minimize the following circuit, draw final minimized circuit. Detemine speed of operation before and after minimization. All gates have equal delay of 10ns. (4 Marks)



Question 3

3.a Give **minimal SOP** for F(a,b,c,d) given by the following K-map (3 Marks)
Identify the **Prime Implicants and the Essential Prime Implicant** clearly.

F(a,b,c,d) =

cd \ ab	00	01	11	10
00	1	X	X	X
01		1	1	1
11	1			1
10	X	X	X	X

3.b Give the minimal **POS** of $F(A,B,C,) = (A + C)(B + C)$ (1 Mark)

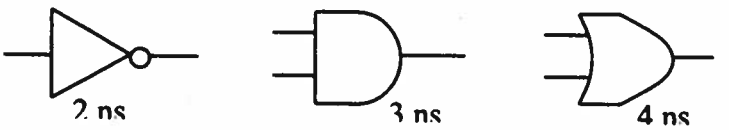
3.c Give the **miniterm list** of $F(A,B,C,D) = A.B$ (1 Mark)

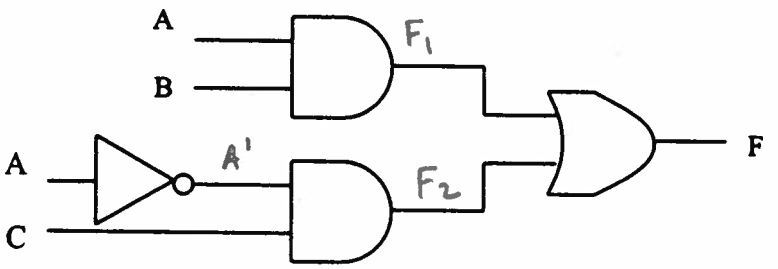
3.d Give the minimal **NOR-NOR** implementation of
$F(A,B,C,D) = ABC + A(D + CB)$ (2 Marks)

Question 3

3.1 Draw the timing diagram for F(A,B,C) = A B + (A' C) for the following consecutive inputs. ABC = 000, 010, 101, 010, 111, 000 (**<u>follow these vectors in order given. Start from ABC = 000</u>**). Assume the following gate delays, AND =3ns, OR gate = 4ns, and inverter = 2ns. (5 Marks)

F = AB + A' C





Question 4.

1.a Convert 57_{10} to binary (1 Mark)

1. b Perform the following operation in binary A-B

A= 011001 B= 010111 (3 Marks)

<u>Show your steps clearly including the Carries/Borrows</u>

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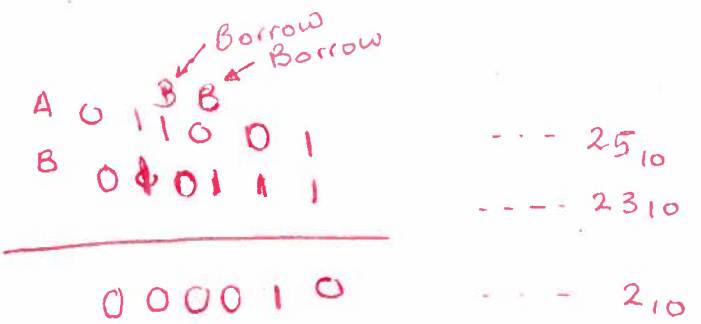
Q1

57_{10}	28	1
28	14	0
14	7	0
7	3	1
3	1	1
1	0	1

$57_{10} = 111001_2$

A - B



OR Using 2' Complement

B = 010111

101000 1's Complement of B

101001 2's " " "

A 011001

101001 +

000010 ← A-B a positive number

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Q2

a) 3 Marks

$A \oplus B = \bar{A}B + A\bar{B}$

$A \odot B = AB + \bar{A}\bar{B}$

, $\overline{A+B} = \bar{A}\bar{B}$

, $\overline{AB} = \bar{A} + \bar{B}$

$[Y \oplus (X+\bar{Y})]$

$Y\overline{(X+\bar{Y})} + \bar{Y}(X+\bar{Y})$

$Y(\bar{X}\cdot Y) + \bar{Y}X + \bar{Y}$

$Y\bar{X} + \bar{Y}$

$(\bar{Y} + \bar{X})$

$[W \odot (W+Y)]$

$W(W+Y) + \bar{W}\overline{(W+Y)}$

$W + \bar{W}\bar{Y}$

$(W + \bar{Y})$

$[(\bar{Y}+\bar{X})\cdot[(W+\bar{Y})] = W\bar{Y} + \bar{Y} + W\bar{X} + \bar{X}\bar{Y}$

$= \bar{Y} + W\bar{X}$

b) 2 Marks

$F = \bar{a}b(c+\bar{d})(1+0) + ab(\bar{c}d + c\bar{d}) + (\bar{a}b + 0)cd$

$= \underline{\bar{a}\bar{b}c} + \bar{a}\bar{b}\bar{d} + ab\bar{c}d + abc\bar{d} + \underline{\bar{a}bcd}$ remove b

$= \bar{a}\bar{b}c + \bar{a}\bar{b}\bar{d} + ab\bar{c}d + abc\bar{d} + \bar{a}cd$

$= \bar{a}(\underline{\bar{b}c} + \bar{b}\bar{d} + cd) + ab\bar{c}d + abc\bar{d}$

remove by Consensus theorm

$= \bar{a}\bar{b}\bar{d} + \bar{a}cd + ab\bar{c}d + abc\bar{d}$

c) 4-Marks

from diagram directly

$F = \overline{\overline{(a \oplus b)\cdot \overline{cd}}} + a$

$= (a \oplus b) + cd + a$

$= a\bar{b} + \bar{a}b + a + cd = a + b + cd$

speed before minimization $3 * 10\,ns = 30\,ns$ or $33.3\,MHz$

" after " $2 * 10\,ns = 20\,ns$ or $50\,MHz$

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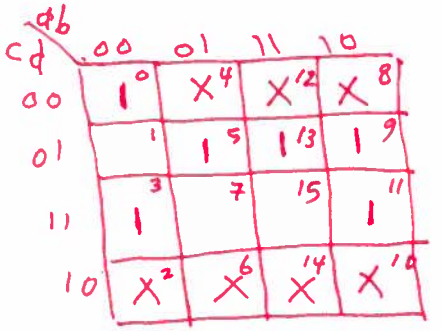
Q3

a/



E-PI 1 $= \sum m(0,2,4,6,8,10,12,14) = \bar{D}$

either E-PI 2 $= \sum m(8,9,10,11) = A\bar{B}$

either E-PI 3 $= \sum m(8,9,12,13) = A\bar{C}$

E-PI 4 $= \sum m(4,5,12,13) = B\bar{C}$

E-PI 5 $= \sum m(2,3,10,11) = C\bar{B}$

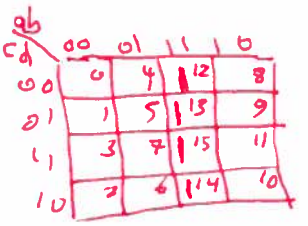
$F(A,B,C,D) = \bar{D} + \begin{cases} A\bar{B} \\ A\bar{C} \end{cases} + B\bar{C} + C\bar{B}$

3 Marks

b) $F(A,B,C) = (A+C)(B+C) = (A+B)(B+C)$ 1 Mark

No minimization

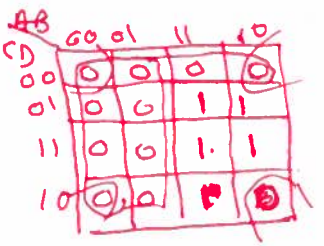
c) $F(A,B,C,D) = AB$



$F(A,B,C,D) = \sum m(12,13,14,15)$ 1 Mark

d) $F(A,B,C,D) = ABC + A(D + CB) = ABC + AD + ABC$

$= ABC + AD$

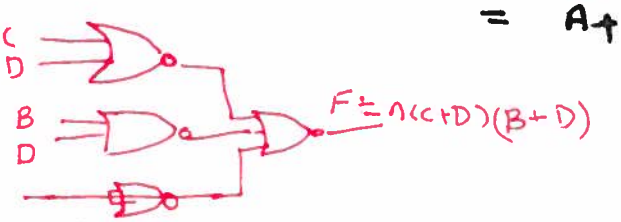


From Kmap

$F(A,B,C,D) = A \cdot (C+D) \cdot (B+D)$

$= \overline{\overline{A(C+D)(B+D)}}$

$= \overline{\bar{A} + \overline{(C+D)} + \overline{(B+D)}}$



2 Marks

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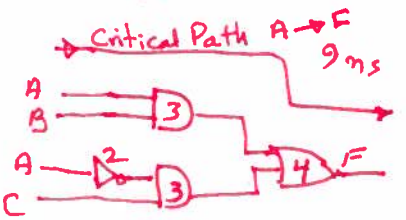
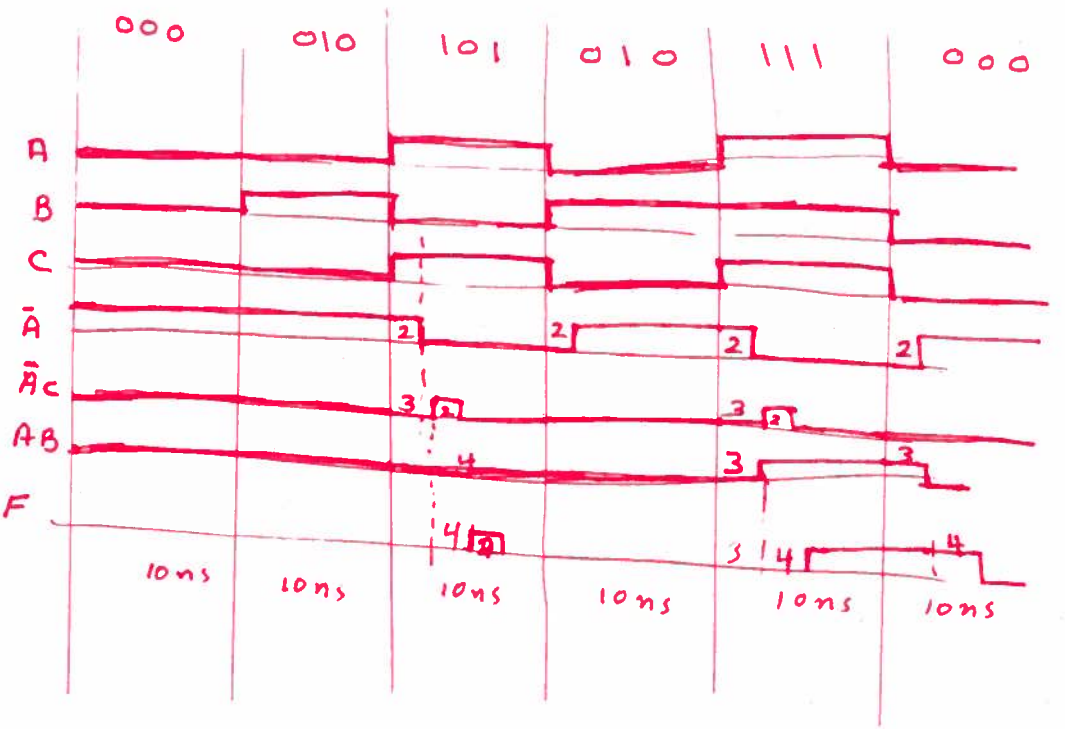
Q4.





5 Marks