BIRZEIT UNIVERSITY

Electrical and Computer Engineering Department

Second Semester 2018 Digital Systems (ENCS234) Midterm Exam

Time: 11:30 - 13:00 (90 minutes) Date: 22/04/2018 Room: Al-Juraysi001

Instructor:

□ Dr. Mohammed Hussein S, M, W 11:00 - 11:50 PNH201

□ Dr. Mohammed Hussein S, M, W 12:00 - 12:50 Masri204

□ Dr. Ahmad Alsadeh S, M, W 10:00 - 10:50 Masri106

Student Name: ___________________________________ **Student ID**: __________________

Question #	ABET Outcome	Full Mark	Student's Mark
Q1		**30**	
Q2		**13**	
Q3		**17**	
Q4		**14**	
Q5		**12**	
Q6		**14**	
TOTAL		**100**	

Note: write your solution on the space provided. If you need more space, write on the back of the sheet containing the question.

ABET Outcome

(a) an ability to apply knowledge of mathematics, science, and engineering

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

(e) an ability to identify, formulate, and solve engineering problems

Question 1: (**30 points**, 3 points each). Select the correct answer

1. The magnitude of $(80)_{10}$ is:
   A. $(0000101)_2$
   B. $(1010000)_2$
   C. $(1100000)_2$
   D. $(0010000)_2$
   E. $(1011000)_2$

2. The magnitude of $(0.125)_{10}$ is:
   A. $(0.010)_2$
   B. $(0.011)_2$
   C. $(0.111)_2$
   D. (0.100)2
   E. $(0.001)_2$

3. The representation of the decimal number 129.33 in BCD is
   A. $(1000\ 0001.0101)_{BCD}$
   B. $(1000\ 0001.0001\ 0001)_{BCD}$
   C. $(0001\ 0010\ 1001.\ 0011)_{BCD}$
   D. $(0001\ 0010\ 1001.\ 0011\ 0011)_{BCD}$
   E. $(0001\ 0010\ 1001.\ 0101)_{BCD}$

4. Using 2's complement binary representation, the result for 100000 –100011
   A. 111101
   B. 111100
   C. 000011
   D. 111011
   E. Not possible, overflow

5. The simplest form of F = Y(X + Y) + (X+Y)'Z + YZ
   A. F = 1
   B. F = Y
   C. F = X'Z
   D. F = Y + X'Z
   E. F = Y + YZ +X'Z

6. The dual of the function $(x + y'z')(wx'z + w'yz')$ is:
   A. x'.(y + z) + (w' + x + z').(w + y' + z)
   B. x' + (y + z).(w' + x + z')+(w + y' + z)
   C. x.(y' + z') + (w + x' + z).(w' + y + z')
   D. x + (y' + z').(w + x' + z) + (w' + y + z')
   E. x.(y + z) + (w + x + z).(w + y + z)

7. Given the Boolean function F(x,y,z) = (x+y)(x'+z)(y'+z'), the expression of F as a product-of-maxterms is
   A. $F = \sum m\ (2, 5)$
   B. $F = \prod M(2, 5)$
   C. $F= \sum m\ (0, 1, 3, 4, 6, 7)$
   D. $F = \prod M(0, 1, 3, 4, 6, 7)$
   E. $F = \Pi M(0,1,2,5,7)$

8. Shown to the right is the K-Map of the Boolean function **F** subject to the don't care conditions **d**

$F(A, B, C, D) = \sum m(0, 1, 2, 4, 6, 10, 12)$
$d(A, B, C, D) = \sum m(7, 13, 14, 15)$

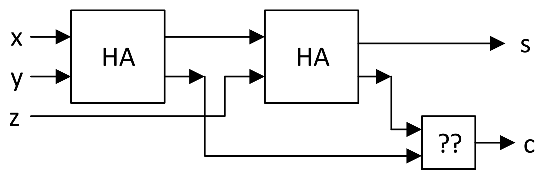
the minimum SOP expression of F is:

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

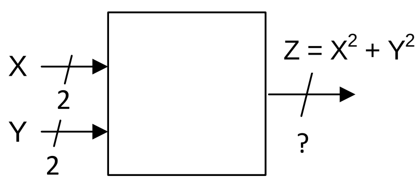
A. F = CD'+ BD'
B. F = BD' + A'B'C'
C. F = CD'+ BD' + A'B'C'
D. F = CD'+ CB +C'D'B+A'B'C'
E. F = CD'+C'D'B+A'B'C'

9. Implementation of full adder with two half adders and an ___ gate

A. OR
B. NOR
C. XOR
D. XNOR



10. A logic circuit has two inputs X & Y each is a 2-bit unsigned umber. It has an output number *Z* such that



the minimum number of bits required for the output number *Z* is
A. 2
B. 3
C. 4
D. 5
E. 6

Max (Z) = $(3)^2 + (3)^2 = 18$ → Requires 5-Bits → Outputs : $Z_4\ Z_3\ Z_2\ Z_1\ Z_0$

Question 2 (**13 points)**: For the given K-map representing the Boolean function F, answer the following questions:

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

A. Which one of the following is a Prime Implicant (PI) of F:

Term	AC'	A'BC	BC'D	C'D	AD'
PI (Yes/No)	**Yes**	**No**	**No**	**Yes**	**Yes**

B. Which one of the following is an Essential Prime Implicant (EPI) of F:

Term	C'D	A'BC	A'C'	BC'D	AD'
EPI (Yes/No)	**Yes**	**No**	**No**	**No**	**Yes**

C. Obtain a simplified sum-of-product (SOP) expression for F.

F = AB + C’D + AD’ + BCD’

Question 3 (**17 points**): Given the Quine-McCluskey method for minimization of the Boolean function

F(A, B, C, D) = ∑m (0, 1, 4, 6, 8, 9 ,10, 12) + d ∑m(5, 7, 14)

A. Grouping minterms by competining the table below (6 points)

A B C D	A B C D	
(0) 0 0 0 0 √		
(1) 0 0 0 1 √ (4) 0 1 0 0 √ (8) 1 0 0 0 √	(0,1) 0 0 0 - √ (0,4) 0 - 0 0 √ (0,8) - 0 0 0 √	(0,1,4,5) 0 - 0 - (0,1,8,9) - 0 0 – (0,4,8,12) - - 0 0 --
(5) 0 1 0 1 √ (6) 0 1 1 0 √ (9) 1 0 0 1 √ (10) 1 0 1 0 √ (12) 1 1 0 0 √	(1,5) 0 - 0 1 √ (1,9) - 0 0 1 √ (4,5) 0 1 0 – √ (4,6) 0 1 – 0 √ (4,12) – 1 0 0 √ (8,9) 1 0 0 – √ (8,10) 1 0 – 0 √ (8,12) 1 – 0 0 √	(4,5,6,7) 0 1 - - (4,6,12,14) - 1 - 0 (8,10,12,14) 1 - - 0
(7) 0 1 1 1 √ (14) 1 1 1 0 √	(5,7) 0 1 - 1 √ (6,7) 0 1 1 - √ (6,14) - 1 1 0 √ (10,14) 1 – 1 0 √ (12,14) 1 1 - 0 √	

B. From the Prime Implicant Chart (8 points)

Prime Implicants	Minterms								Don't care		
	√	√	√	√	√	√	√	√			
	0	1	4	6	8	9	10	12	5	7	14
(0,1,4,5) 0 - 0 -	x	x	x						x		
(0,1,8,9) - 0 0 – (EPI)	x	x			x	(x)					
(0,4,8,12) - - 0 0	x		x		x			x			
(4,5,6,7) 0 1 - -			x	x					x	x	
(4,6,12,14) - 1 - 0			x	x				x			x
(8,10,12,14) 1 - - 0 (EPI)					x		(x)	x			x

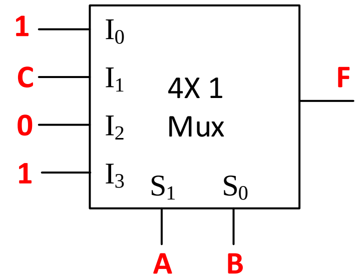
C. Give the minimized result in Boolean expressions (3 points)

F(A, B, C, D) = B'C' + AD' + BD' OR F(A, B, C, D) = B'C' + AD' + A'B

Question 4 (**14 points):** Implement the Boolean function **F(A,B,C) = AB + A'C + A'B'**

A. Using a single 4x1 multiplexer. (6 Points)

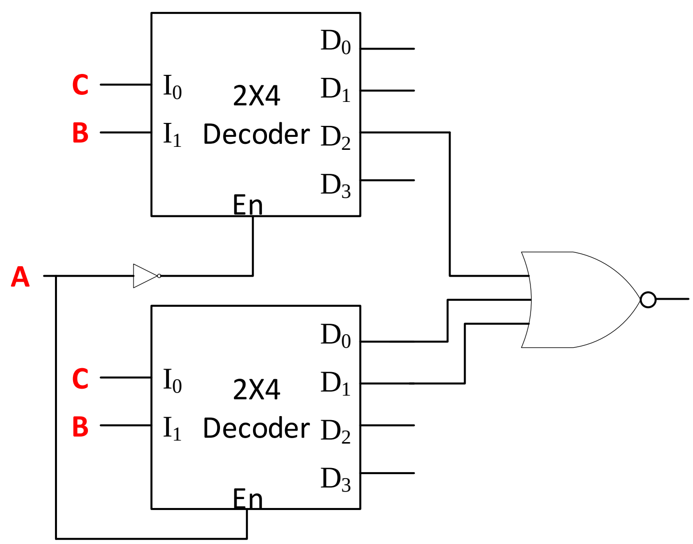
A	B	C	F	
0	0	0	1	I_0= 1
0	0	1	1	
0	1	0	0	I_1= C
0	1	1	1	
1	0	0	0	I_2= 0
1	0	1	0	
1	1	0	1	I_3= 1
1	1	1	1	



B. Using the minimum number of 2x4 decoders with enable and a single NOR gate. (8 Points)

F = ∑m(0, 1, 3, 6, 7)

F' = ∑m(2, 4, 5)

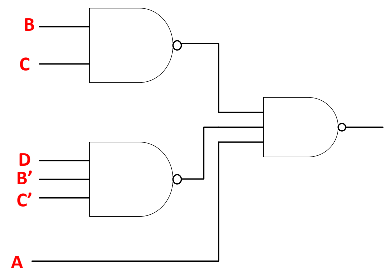


Question 5 (**12 points):**

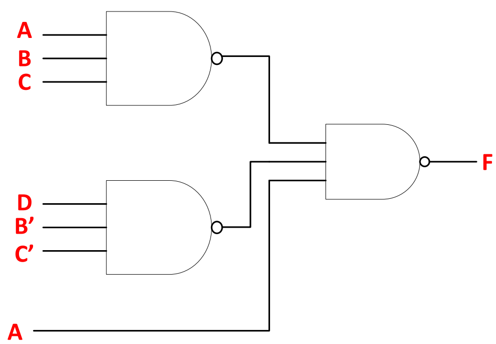
A. *Assuming the availability of the true and complement of signals A, B, C, and D*, implement the function **F = ABC + DB'C' +A'** using a minimum number of **one gate type only**. (6 points)

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

F = A' + BC + B'C'D

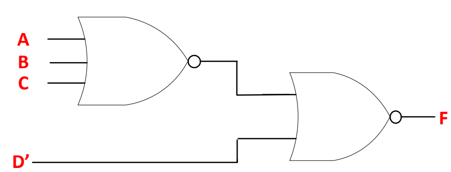


If you answer it directly without minimization, we consider it correct



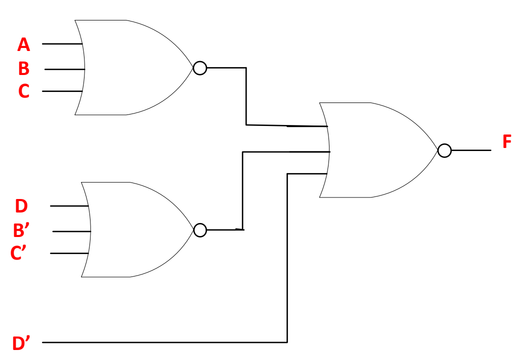
B. *Assuming the availability of the true and complement of signals A, B, C, and D*, implement the function **F = (A+B+C) (D+B'+C').D** using a minimum number of **one gate type only**. (6 points)

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



F = D. (A + B + C)

If you answer it directly without minimization, we consider it correct



Question 6 (**14 points):**
Design a combinational logic circuit which receives a 4-bit unsigned number **X** (X_3 X_2 X_1 X_0) as input and produces an output **Z** which equals the result of integer division of **X** by 3 (e.g., if **X**=7, **Z**=2).

A. How many bits does the output Z have? Why? (2 points)

Max output value = 15/3 = 5 → 3-bits

B. Derive the truth table of this circuit. (6 points)

X_3	X_2	X_1	X_0	Z_2	Z_1	Z_0
0	0	0	0	0	0	0
0	0	0	1	0	0	0
0	0	1	0	0	0	0
0	0	1	1	0	0	1
0	1	0	0	0	0	1
0	1	0	1	0	0	1
0	1	1	0	0	1	0
0	1	1	1	0	1	0
1	0	0	0	0	1	0
1	0	0	1	0	1	1
1	0	1	0	0	1	1
1	0	1	1	0	1	1
1	1	0	0	1	0	0
1	1	0	1	1	0	0
1	1	1	0	1	0	0
1	1	1	1	1	0	1

C. Using K-maps, derive minimized sum-of-products expression for the circuit output(s). of the least significant output bits (***Z₀***). (6 points)

$Z0 = X'_3X_2X'_1 + X_3X_1X_0 + X'_2X_1X_0 + X_3X'_2X_1 + X_3X'_2X_0$

X_3X_2 \ X_1X_0	00	01	11	10
00			1	
01	1	1		
11			1	
10		1	1	1