King Fahd University of Petroleum and Minerals
College of Computer Science and Engineering
Computer Engineering Department

COE 202: Digital Logic Design (3-0-3)
Term 141 (Fall 2014-2015)
Major Exam 1
Saturday October 18, 2014

Time: 90 minutes, Total Pages: 8

Name:_KEY_____ ID:_____ Section: _____

Notes:

- Do not open the exam book until instructed
- **No Calculators are allowed** (*basic, advanced, cell phones, etc*.)
- Answer all questions
- All steps must be shown
- Any assumptions made must be clearly stated

Question	Maximum Points	Your Points
1	17	
2	16	
3	12	
4	15	
Total	60	

Question 1. **(17 points)**

(I) Without converting to decimal, express the binary number $(111.0101)_2$ in **Octal** and **Hexadecimal**. **(4 points)**

$(111.010\_100)_2 = (7.24)_8$.

$(0111.0101)_2 = (7.5)_{16}$.

(II) Express the decimal number 129.33 in **Binary** and **BCD** (with 4-bit fraction accuracy).

(6 points)

$129=128+1=2^7+2^0=10000001$.

0.33 x 2 = 0.66 => 0
0.66 x 2 = 1.32 => 1
0.32 x 2 = 0.64 => 0
0.64 x 2 = 1.28 => 1

$129.33 = (1000\ 0001.0101)_2 = (0001\ 0010\ 1001.\ 0011\ 0011)_{BCD}$

(III) Adding an **even parity** bit as the MSB, the Binary code 1001101 becomes 01001101.

(1 point)

(IV) Perform the following arithmetic operations in the given bases. (Show your work) **(6 points)**

Binary Multiplication	**Binary Subtraction**	**Hexadecimal Addition**
1011 x 101 1011 00000 101100 110111	100.10 - 11.01 001.01	37A + 93 40D

Question 2. **(16 points)**

Use Boolean algebra to solve the following questions. Show clearly all your steps.

(I) Simplify each the following Boolean functions to the specified number of literals:

a. $F1 = x\,y\,z + \overline{x}\,y + \overline{x}\,\overline{y}$ **(3 literals)** **(3 points)**

= xyz + x' (y + y')
= xyz + x`
= x' + yz

b. $F2 = \overline{x}\,\overline{y}\,\overline{z} + \overline{x}\,y\,\overline{z} + \overline{x}\,y\,z + x\,\overline{y}\,\overline{z}$ **(4 literals)** **(4 points)**

= y'z' (x' + x) + x'y (z` + z)

= y'z' + x'y

c. $F3 = w\,x + w\,x\,y + \overline{w}\,y\,z + \overline{w}\,\overline{y}\,z + \overline{w}\,x\,y\,\overline{z}$ **(6 literals)** **(5 points)**

= (wx + wxy) + (w'yz + w'y'z) + w'xyz'

= wx + w'z + w'xyz'

= wx + w'(z + xyz')

= wx + w'(z + xy)

= wx + w'z + w'xy

= w'z + x(w+ w'y)

= w'z + x(w+ y)

= w'z + wx + xy

(II) **Without simplification**, write out the **complement** and **dual** forms of the following expression:

$(x + \overline{y}\,\overline{z})(w\,\overline{x}\,z + \overline{w}\,y\,\overline{z})$ **(4 points)**

The **complement** of the function is:

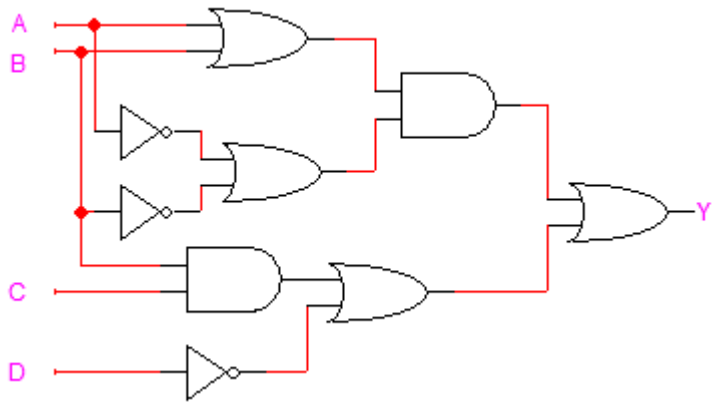
F' = x'. (y + z) + (w' + x + z') . (w + y' + z)

The **dual** of the function is:

x. (y' + z') + (w + x' + z) . (w' + y + z')

Question 3. **(12 points)**

(I) Express the Boolean function Y of the following given circuit without simplification: **(3 points)**



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

(II) Given the Boolean function $F(X, Y, Z) = (X + Y)(\bar{X} + Z)(\bar{Y} + \bar{Z})$: **(6 points)**

a. Express F as a **product-of-maxterms**, $F = \prod M$.

b. Find the ***algebraic*** **sum-of-minterms** expression for *F*.

a. $\overline{F} = \overline{X}\,\overline{Y} + X\,\overline{Z} + Y\,Z = \sum m\,(0, 1, 3, 4, 6, 7)$

$F = \prod M(0, 1, 3, 4, 6, 7)$

b. $F = \sum m\,(2,\ 5)$

$F = \overline{X}\,Y\,\overline{Z} + X\,\overline{Y}\,Z$

(III) Given that $F(A,B,C) = \sum m\,(0,2,5,6)$ and $G(A,B,C) = \prod M\,(1,2,5,7)$, express the function $F.\bar{G}$ as a **sum-of-minterms**. **(3 points)**

$$\bar{G} = \sum m(1,2,5,7)$$

$$F.\bar{G} = \sum m(2,5)$$

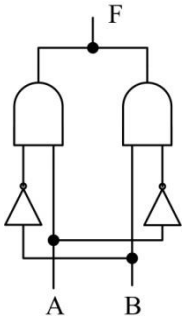
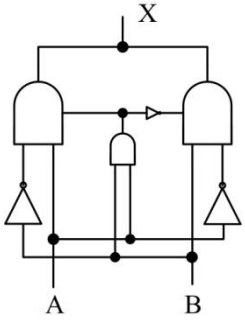
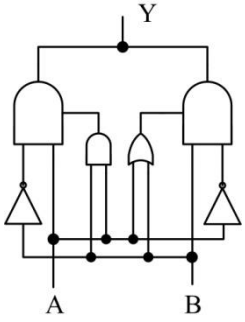
Question 4. **(15 points)**

(I) Circle the correct word in the following statements: **(3 Points)**

a. It is desirable to have a low noise margin NM_L as (**large** - small) as possible
b. It is desirable to have a high noise margin NM_H as (**large** - small) as possible
c. It is desirable to have V_{IH} as (large - **small**) as possible
d. It is desirable to have V_{IL} as (**large** - small) as possible
e. It is desirable to have V_{OH} as (**large** - small) as possible
f. It is desirable to have V_{OL} as (large - **small**) as possible

(II) Fill in the Truth Table for each of the following three circuits. Indicate whether the circuit operates properly or not. If circuit operation is improper (invalid) state the reason for that. Inputs A, and B are independent of one another and may assume any possible binary values.

(6 Points)

Circuit	If circuit operation is valid, what is the output function?	If circuit operation is invalid, state why.
	A B F 0 0 0 0 1 X 1 0 X 1 1 0	The output has a short circuit at 2 conditions AB= 01 and 10
	A B X 0 0 0 0 1 1 1 0 0 1 1 0	√
	A B Y 0 0 Hi-Z 0 1 1 1 0 0 1 1 0	The output has a short circuit at AB= 11 but the outputs are the same (0) in this case, i.e. no conflict.

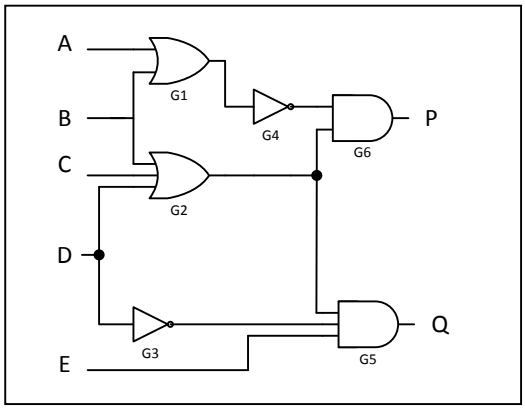
(III) The shown table gives propagation delays of some basic gates. For the circuit shown below, answer the following:

Gate	Delay
Inverter	1 ns
2-Input AND	2 ns
2-Input OR	3 ns
3-Input AND	3 ns
3-Input OR	4 ns

d. Identify the critical path of the circuit (path with longest propagation delay). What is its associated delay value? **(3 Points)**

Critical Path is: G2-G5

Delay of Critical Path = 4 + 3 = 7ns



e. What is the maximum frequency at which the circuit may be operated? **(1 Point)**

Fmax = $1/(7x\ 10^{-9}) \approx 142.8$ M Hz

f. The gate which drives the largest load is gate ____**G2**____ **(1 Point)**

g. Name *a gate* that has the highest fanin in the circuit ({G2, G5}), the fanin of this gate is ____**3**____ **(1 Point)**