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 112 (Spring 2012)
Major Exam 1
Thursday March 1, 2012

Time: 90 minutes, Total Pages: 8

Name:_KEY_____ ID:_____ Section: _____

Notes:

- Do not open the exam book until instructed
- **Calculators are not 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	20	
2	12	
3	16	
4	12	
5	15	
Total	75	

Question 1. **(20 points)**

Convert the following numbers from the given base to the other uncrossed bases listed in the table (if needed, express fractions up to 3 digits only). Show your solution steps below the table.

Decimal	**Binary**	**Octal**	**Hexadecimal**	**BCD (8421)**
114.67	1110010.101	162.527		000100010100.01100111
	1011110.10111	136.56	5E.B8	
3930.7617	111101011010.11000011	7532.606	F5A.C3	

Question 2. **(12 points)**

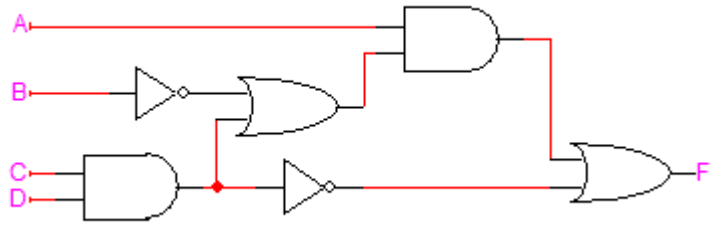
Perform the following arithmetic operations in the specified number system.

Octal Subtraction	Hexadecimal Addition	Binary Subtraction	Binary Multiplication
2 7 3 4 -1 7 7 6 0 7 3 6	F A 3 B + 2 F E 9 1 2 A 2 4	1 1 1 0 0 0 1 0 - 1 0 1 1 1 1 1 1 0 0 1 0 0 0 1 1	1011 × 1011 1011 1011 0000 1011 1111001

Question 3. **(16 points)**

a. Given the function $F(A,B,C,D) = A(\overline{B} + CD) + \overline{CD}$:

i. Draw the logic implementation of the function *F* (*use F as is,* ***do not simplify***):



ii. Compute the **complement** of the function *F* (*use F as is,* ***do not simplify***):

$$\overline{F} = \overline{\left(A(\overline{B} + CD)\right) + \overline{CD}} = \overline{\left(A(\overline{B} + CD)\right)}.\overline{\overline{CD}} = \left(\overline{A} + \overline{(\overline{B} + CD)}\right).CD$$
$$= \left(\overline{A} + (B.\overline{CD})\right).CD = \left(\overline{A} + (B.(\overline{C} + \overline{D}))\right).CD$$

b. *Using Algebraic manipulation*, simplify the following function to **two** literals:

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

By taking the dual we get:

$$G(A,B,C) = ABC + \overline{A}BC + B\overline{C} + \overline{B}C$$
$$= BC(A + \overline{A}) + B\overline{C} + \overline{B}C \qquad \text{by distributive law}$$
$$= BC(1) + B\overline{C} + \overline{B}C$$
$$= BC + B\overline{C} + \overline{B}C = B(C + \overline{C}) + \overline{B}C = B + \overline{B}C \qquad \text{by distributive law}$$
$$= (B + \overline{B})(B + C) \qquad \text{by distributive law}$$
$$= B + C$$

By taking the dual again:

$$G(A,B,C) = BC$$

c. *Using Algebraic manipulation*, simplify the following function to **three** literals:

$$H(A,B,C,D) = AB + \overline{A}C + BD + B\overline{C}$$
$$= AB + \overline{A}C + BD + B\overline{C} + BC \quad \text{by consensus}$$
$$= AB + \overline{A}C + BD + B(\overline{C} + C) \quad \text{by distributive law}$$
$$= AB + \overline{A}C + BD + B$$
$$= \overline{A}C + B \quad \text{by absorption}$$

Question 4. **(12 points)**

I. Given the Boolean function $F(w,x,y,z) = (w + \bar{x}y)\bar{z}$

a. Express the function as a Product of Sum (POS).
b. Express the function as a sum of minterms.

a. $F(w,x,y,z) = (w + \bar{x}y)\bar{z} = (w + \bar{x})(w + y)\bar{z}$
b. $F(w,x,y,z) = (w + \bar{x}y)\bar{z} = w\bar{z} + \bar{x}y\bar{z} = w(\bar{x} + x)(\bar{y} + y)\bar{z} + (\bar{w} + w)\bar{x}y\bar{z} = w\bar{x}\bar{y}\bar{z} + w\bar{x}y\bar{z} + wx\bar{y}\bar{z} + wxy\bar{z} + \bar{w}\bar{x}y\bar{z} + w\bar{x}y\bar{z} = \sum m(2,8,10,12,14)$

II. Given the function $F(A,B,C,D) = \sum m(0,3,4,9)$

a. Give the ***algebraic*** sum of minterms expression for *F*.
b. Express $\bar{F}$ as a product of Maxterms.

a. $F(A,B,C,D) = \bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}\bar{B}CD + \bar{A}B\bar{C}\bar{D} + A\bar{B}\bar{C}D$
b. $\bar{F}(A,B,C,D) = \prod M(0,3,4,9)$

Question 5. **(15 points)**

Fill in the Spaces: (Show all work needed to obtain your answer)

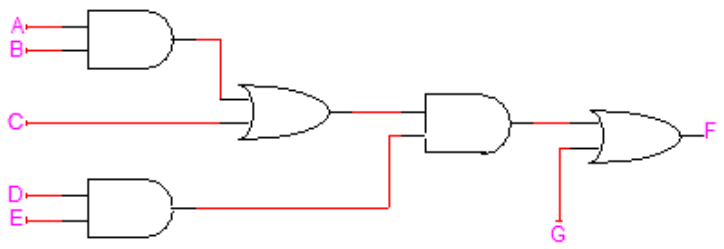
a. In binary system, the largest value that can be expressed using **n** integral digits and **m** fractional digits is $2^{n}-2^{-m}$.

b. Given that an 8-bit register stores the ASCII code of a character in the least significant 7 bits and a parity bit in the most significant bit. Assuming that the register contains the hexadecimal value C5 representing a character, the character stored in the register is E and the parity used is even (i.e. even or odd parity). Note that the ASCII code of character 'A' is 41h and the ASCII code of character 'a' is 61h.

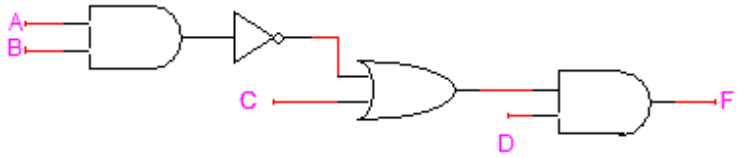
c. The number of minterms and maxterms in the function $F(A,B,C) = A + B + \overline{C}$ is 7 minterms and 1 maxterm.

d. Given the identity $AB + \overline{A}C + BC = AB + \overline{A}C$, using the duality principle $(A+B)(\overline{A}+C)(B+C) = (A+B)(\overline{A}+C)$.

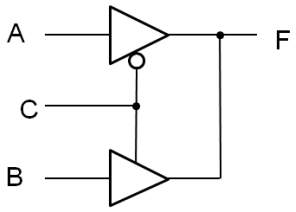
e. Assuming that all gates have the same propagation delay of 2 ns, then the circuit takes 8 ns to produce the correct output.



f. The Boolean function implemented by the circuit given below is $F = D\,(C + \overline{AB})$.



g. The Boolean function implemented by the circuit given below is $F = A\,\bar{C} + B\,C$.



h. Given an inverter with the following parameters V_{OH}=5v V_{OL}=0v, V_{IH}=2.8v, V_{IL}=2.4, the noise margins $NM_H = V_{OH} - V_{IH}$=5-2.8=2.2v and $NM_L = V_{IL} - V_{OL}$=2.4-0=2.4v.