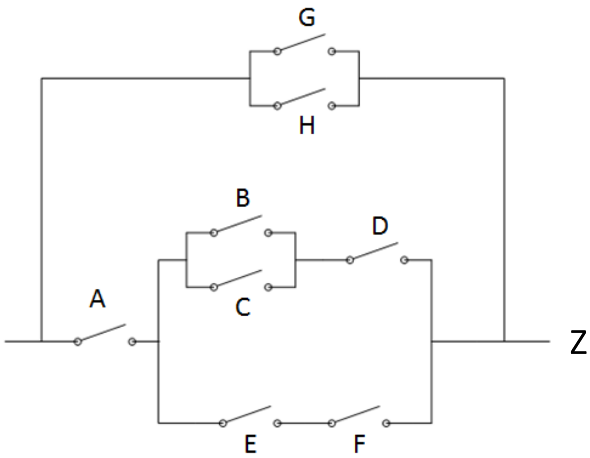
Switching Circuits & Logic Design, Fall 2010

Midterm Examination  (11/12/2010, 3:30pm~5:20pm)

**Problem 1: (12 points)**

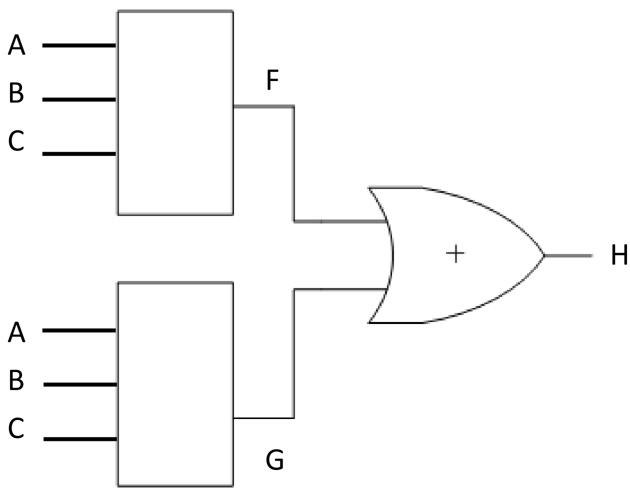
**A.** (6 points) Assume that the binary numbers below are 1's complement numbers. (a)Find the 1's complement of each number. (b)Write down the decimal values of the original binary number and of its 1's complement for (i) 0000000, and (ii) 1000000.

**B.** (6 points) For the following switch circuit, derive its switching algebra expression.




**Problem 2: (12 points)**

In the following circuit, $F = (A' + B) \cdot C$. Derive the truth table for G so that H is as specified in the following truth table. If outputs of G can be either 0 or 1 for some input combination(s), put **ONLY** *don't care ( X)* in your answers (that is, ?=0 ,1,X).




| A | B | C | H | G |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | ? |
| 0 | 0 | 1 | 1 | ? |
| 0 | 1 | 0 | 1 | ? |
| 0 | 1 | 1 | 1 | ? |
| 1 | 0 | 0 | 0 | ? |
| 1 | 0 | 1 | 1 | ? |
| 1 | 1 | 0 | 0 | ? |
| 1 | 1 | 1 | 1 | ? |

**NOTE：There are problems in the back.**

**<u>Problem 3</u>: (12 points)** **Minterm/Maxterm expansion**

For the following four-variable Boolean expressions,

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

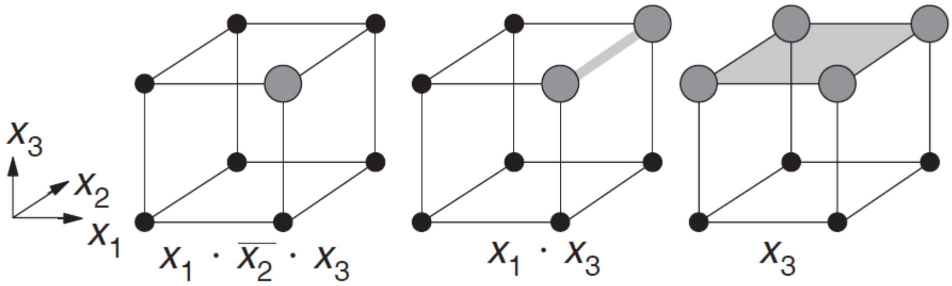
$G(a,b,c,d) = a'bc+ad+abcd'$

**A.** (6 points) Please write the maxterm expansion of $F'$. Assume $a$ is the most significant bit so $ab'c'd'=m_8$.

**B.** (6 points) Please write the minterm expansion of $F \oplus G$.

**<u>Problem 4</u>: (18 points)**

Instead of Karnaugh map, another way of drawing a Boolean expression is using a "Cube map". For example, in the following figure, we have $x_1 \cdot x_2' \cdot x_3 = m_5$, $x_1 \cdot x_3 = m_5 + m_7$, and $x_3 = m_4 + m_5 + m_6 + m_7$.




Given $f(x_1, x_2, x_3) = \Sigma\, m(0, 1, 2, 5, 6, 7)$

**A.** (6 points) Try to draw a Cube map for $f$.

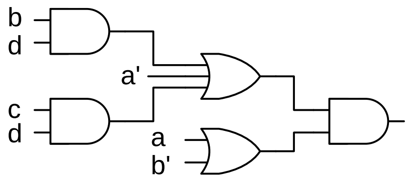
**B.** (6 points) Circle all the prime implicants of $f$ on the Cube map and write down these prime implicants.

**C.** (6 points) Find a minimum sum of products (SOP) for $f$ by circling these product terms on the Cube map, and write the obtained minimum SOP Boolean expression.

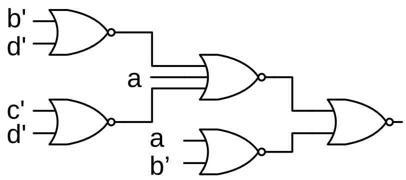
**<u>NOTE：There are problems in the back.</u>**

**<u>Problem 5</u>: (18 points)**

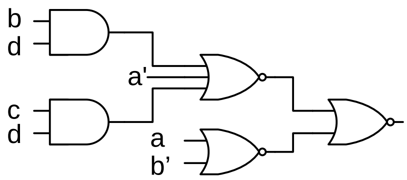
For the following AND-OR-AND circuit,



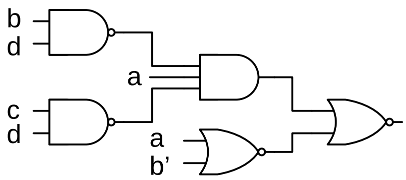

**A.** (8 points) Which of the following circuits are equivalent to the above one? (It is OK to just write-down the answer without derivation process. The correctness of each one costs 2%.)



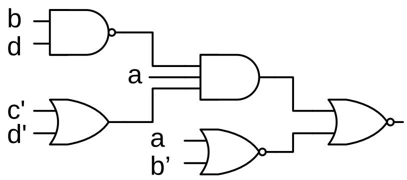

(1)




(2)




(3)




(4)

**B.** (5 points) Please find the minimum sum-of-product expression for this circuit. (Hint: if there are one or more solutions, it is fine to write-down any one of them.)

**C.** (5 points) Implement the circuit in a NAND-NAND form. (Hint: if there are one or more solutions, it is fine to write-down any one of them.)

**<u>Problem 6</u>: (16 points)**

Consider the following maxterm:

F(A,B,C,D) =Π M(1, 2, 3, 6, 7, 8, 9,12)

**A.** (8 points) Find two different minimum circuits which implement F using AND and OR gates. Identify two hazards in each circuit.

**B.** (8 points) Find an OR-AND circuit for F which has no hazard.

**<u>NOTE：There are problems in the back.</u>**

**Problem 7: (12 points)**

Please design a 4-bit absolute subtracter circuit. The block diagram of absolute subtracter is shown in Figure Q7. The output value, Z, is the absolute difference of X and Y. That is, Z = |X-Y|. Note that the value of two inputs (X, Y) are represented in 2's complement , and the value of output Z is represented in unsigned positive number. Use only four 2-to-1 multiplexers, 8 inverters, and 8 full adders to implement your design.

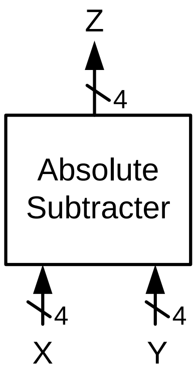



Figure Q7