Logic Design HW#1(115 points in total)

1. **(Gate Logic)** Draw schematics for the following functions in terms of AND, OR and NOT gates. (8 points / 2 points for each subproblems)

   A. XY+XZ

   B. $\overline{X(Y+Z)}$

   C. $\overline{X}+\overline{YZ}$

   D. $\overline{\overline{X}+\overline{Y}}+\overline{X+Y}+\overline{Y+\overline{Z}}$

2. (Gate Logic) Draw the schematics for the following functions using NAND gates and inverters only: (4 points / 2 points for each subproblems)

   A. $[\overline{X(\overline{YZ})}]$

   B. XY+XZ

3. **(Laws and Theorems of Boolean Algebra)** Use DeMorgan's law to compute the complement of the following Boolean expressions: (10 points / 2 points for each subproblems)

A. $\overline{A}+\overline{B}\ \overline{C}+\overline{B}\ \overline{D}$

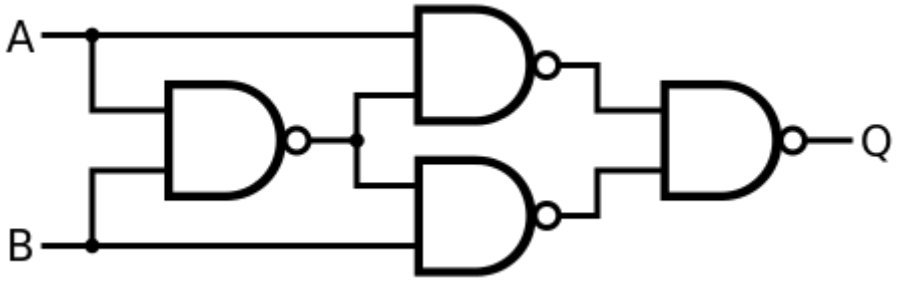
B. $(\overline{A}+\overline{B}+\overline{C})(\overline{B}+CD)$

C. $\overline{X}(\overline{Y}+\overline{Z})$

D. $X+Y\overline{Z}$

E. $X(YZ+Z\overline{W}+\overline{V}S)$

4. (Laws and Theorems of Boolean Algebra) Using Boolean algebra, verify that the schematic of figure below implements an XOR function. (4 points)



5. (Boolean Simplification) consider the function: (6 points / 3 points for each subproblems)

$$f(A,B,C,D) = (AD+A\overline{C})[B(C+\overline{B}D)]$$

A. Draw its schematic using AND, OR, and NOT gates.

B. Using Boolean algebra, put the function into its minimized form and draw the resulting schematic.

6. (Canonical Forms) consider the function: (12 points / 3 points for each subproblems)

$$f(A,B,C,D) = \sum m(0,1,2,7,8,13)$$

A. Write this as a Boolean expression in canonical minterm form.

B. Rewrite the expression in canonical maxterm form.

C. Write the complement of f in “little m” notation and as a canonical minterm expression.

D. Write the complement of f in “big M” notation and as a canonical maxterm expression.

7. (Boolean Simplification) Use Karnaugh maps(K-maps) to simplify the following functions in sum-of-products form. How many literals appear in your minimized solutions? (9 points / 3 points for each subproblems)

A. $f(X,Y,Z) = \Pi M(0,1,6,7)$

B. $f(W,X,Y,Z) = \Pi M(1,3,7,9,11,15)$

C. $f(A,B,C,D) = \sum m(0,2,4,6)$

8. (Boolean Simplification) Use Karnaugh maps(K-maps) to simplify the following functions in sum-of-products form taking advantage of the don't cares provided. (6 points / 3 points for each subproblems)

   A. $f(A,B,C,D) = \sum m(0,1,4,10,11,14)+\sum d(5,15)$

   B. $f(A,B,C,D) = \sum m(2,3,7,9,11,13)+ \sum d(1,10,15)$

9. (Boolean Simplification) What are the prime implicants for each of the expressions in Problem 8? Which are essential? How many don't cares are set to 1 in each case? (6 points)

10. (Quine-McCluskey Method) Use the Quine-McCluskey method to find the minimum sum-of-products form for the following Boolean expressions. (6 points)

$$F(A,B,C,D) = \sum m(1,3,5,7,11,12,13,14,15) + \sum d(4,8,10)$$

11. (Mapping to NANDs/NORs) Draw schematics for the following expressions, mapped into NAND-only networks. You may assume that literals and their complements are available. (9 points / 3 points for each subproblems)

A. $\left(\overline{AB}\right)\left(\overline{\overline{A}\,\overline{C}}\right)$

B. $\overline{(AB + \overline{A}\,\overline{C})}$

C. $\overline{A}$B + A + $\overline{C}$ + $\overline{D}$

12. (Mapping to NANDs/NORs) Draw schematics for the following expressions, mapped into NOR-only networks. You may assume that literals and their complements are available. (6 points / 3 points for each subproblems)

A. (A+B)($\overline{A}$ +C)

B. $\overline{(A+B)\cdot(\overline{A}+C)}$

13. (Multilevel Logic) Consider the following multilevel Boolean expressions:

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

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

Perform the following: (9 points / 3 points for each subproblems)

A. Show how to implement each function as a multilevel NAND-only gate-level implementation.

B. Repeat A., but using NOR gates only.

C. Find the two-level minimized sum-of-products forms.

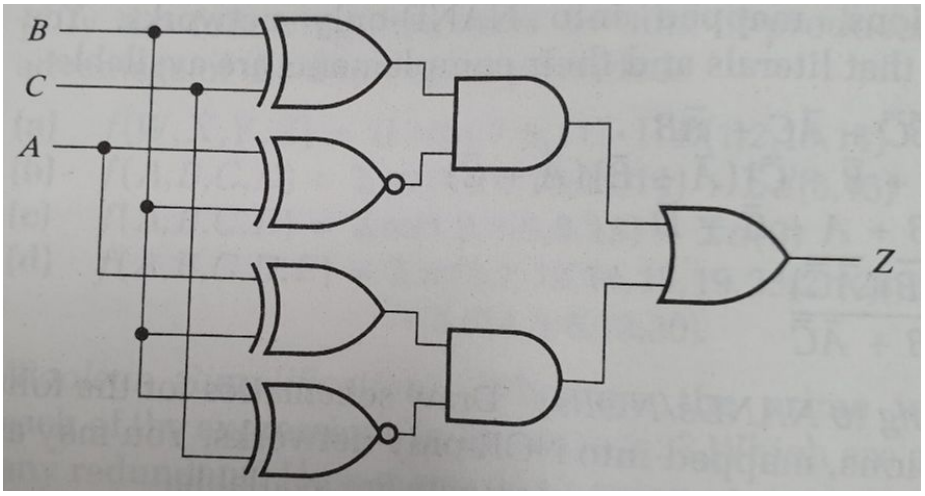
14. (Multi level logic) Reverse engineer the circuit shown in the schematic of figure below in order to derive a two-level realization. (12 points / 3 points for each subproblems)

A. Find the Boolean expression that describes the circuit.

B. Construct the truth table for the function.

C. Write the function in canonical sum-of-products form (little m notation).

D. Simplify the function using K-maps.



15. (Hazard-Free Design) Given the following specifications of Boolean functions, implement them as hazard-free circuits: (8 points / 4 points for each subproblems)

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

B. $F(A,B,C,D) = \overline{A}D + B\overline{C} + AC$