EE 2000 Logic Circuit Design
Semester B 2022/23

Tutorial 1

1. Simplify the following expressions using boolean algebra

(a) $f(w,x,y,z) = xy + \bar{w}\bar{y}z + \bar{w}x\bar{y} + wxy\bar{z} + \bar{w}yz + wz$

Hint: Use adjacency and absorption

Ans: $f(w,x,y,z) = xy + z + \bar{w}x\bar{y}$

(b) $f(x,y,z) = (x+y+z)(x+y+\bar{z})(x+\bar{y}+z)(x+\bar{y}+\bar{z})$

Hint: Use adjacency

Ans: $f(x,y,z) = x$

(c) $f(a,b,c,d) = ab + bcd + ab'c' + abd + bc + abc'$

Hint: Use adjacency, absorption and consensus

Ans: $f(a,b,c,d) = ac' + bc$

(d) $f(a,b,c) = (a+b+c)(a+\bar{b}+c)(a+\bar{b}+\bar{c})(\bar{a}+\bar{b}+\bar{c})$

Hint: Use adjacency

Ans: $f(a,b,c) = (a+c)(\bar{b}+\bar{c})$

2. Given a function $f(x,y,z) = \sum m(0,2,4,6)$

(a) Show the truth table.

Ans:

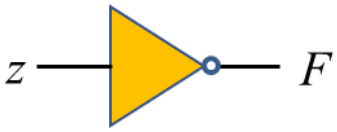
Inputs			Output
x	y	z	$f(x,y,z)$
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

(b) Show the algebraic expression in standard SOP form.

Ans: $f(x,y,z) = x'y'z' + x'yz' + xy'z' + xyz'$

(c) Show the minimum SOP expression and draw the circuit diagram.

Ans: $f(x, y, z) = z'$



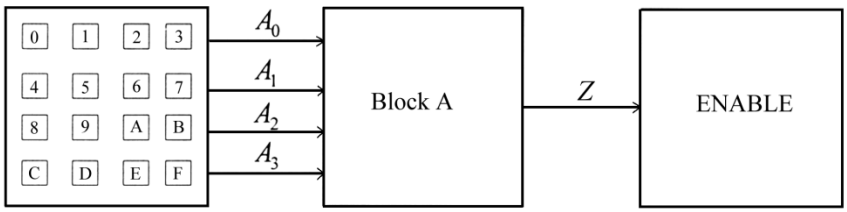
(d) Show the algebraic expression in standard POS form.

Ans: $f(x, y, z) = (x + y + z')(x + y' + z')(x' + y + z')(x' + y' + z')$

(e) Show the minimum POS expression.

Ans: $f(x, y, z) = z'$

3. A simple locker system that has an output signal $Z = 1$ when the hexadecimal keypad input is either 0, 1, 2, 3, 7, 8, 9, A or E; otherwise $Z = 0$. Assume that $A_3\ A_2\ A_1\ A_0$ represent a 4-digit binary number output from the keypad (A_3 as the MSB). Block A decodes these signals and outputs the signal Z.



(a) Write down the truth table of Block A.

Input	*Inputs*				*Output*
	A_3	A_2	A_1	A_0	Z
0	0	0	0	0	1
1	0	0	0	1	1
2	0	0	1	0	1
3	0	0	1	1	1
4	0	1	0	0	0
5	0	1	0	1	0
6	0	1	1	0	0
7	0	1	1	1	1
8	1	0	0	0	1
9	1	0	0	1	1
A	1	0	1	0	1
B	1	0	1	1	0
C	1	1	0	0	0
D	1	1	0	1	0
E	1	1	1	0	1
F	1	1	1	1	0

(b) Find the SOP and POS expression of Block A.

$$f(A_3, A_2, A_1, A_0) = f(w, x, y, z) = w'x'y'z' + w'x'y'z + w'x'yz' + w'x'yz + w'xyz + wx'y'z' + wx'y'z + wx'yz' + wxyz'$$

$$f(w, x, y, z) = w'x'y' + w'x'y + w'xyz + wx'y' + wyz'$$

$$= w'x'y' + w'y(x' + xz) + wx'y' + wyz'$$

…

$$= w'x' + w'yz + wx'y' + wyz'$$

Ans: $f(A_3, A_2, A_1, A_0) = A_3'A_2' + A_3'A_1A_0 + A_3A_2'A_1' + A_3A_1A_0'$

$$f(A_3, A_2, A_1, A_0) = f(w, x, y, z)$$
$$= (w + x' + y + z)(w + x' + y + z')(w + x' + y' + z)(w' + x + y' + z')(w' + x' + y + z)(w' + x' + y + z')(w' + x' + y' + z')$$

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

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

…

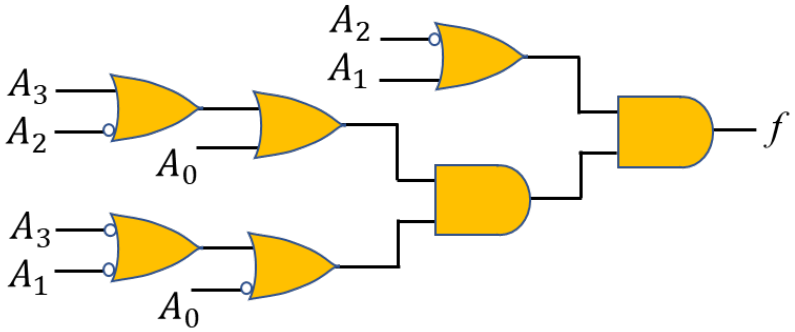
$$= (x' + y)(w + x' + z)(w' + y' + z')$$

Ans: $f(A_3, A_2, A_1, A_0) = (A_2' + A_1)(A_3 + A_2' + A_0)(A_3' + A_1' + A_0')$

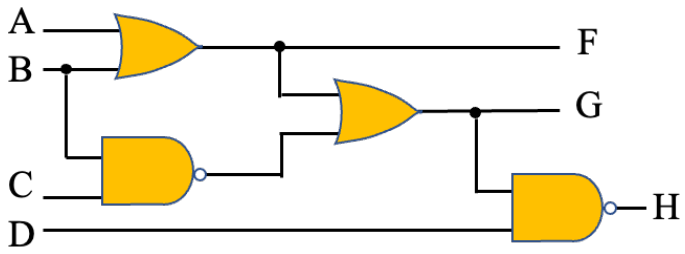
Remarks: you might have different approach. As long as the answer is correct, then it is ok. You can also attempt this question using K-map. It is more straightforward.

(c) Design the circuit of Block A using minimum number of 2-input AND, OR gates and NOT gates.

Ans:



4. (a) Derive Boolean functions to describe the operations of the combinational circuit as follow:

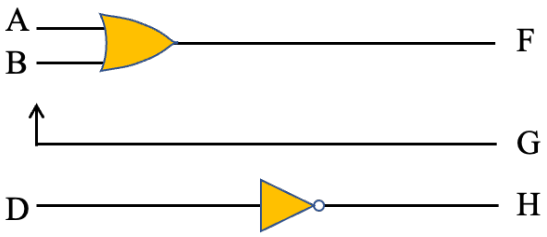


Ans:

$F = A + B$
$G = 1$
$H = D'$

(b) Hence, simplify and draw a new logic circuit.

Ans:



(c) Redraw the logic circuit with only 2-input NAND gates.

Ans: