Homework 1

(Due date: September 21st @ 11:59 pm)

Presentation and clarity are very important! Show your procedure!

Problem 1 (31 pts)

a) Simplify the following functions using ONLY Boolean Algebra Theorems. For each resulting simplified function, sketch the logic circuit using AND, OR, XOR, and NOT gates. (15 pts)

✓ $F = \overline{\bar{x} + x(y + \bar{z})}$ ✓ $F(x, y, z) = \prod(M_2, M_4, M_6, M_7)$ ✓ $F = (z + \bar{y})(\bar{z} + x)(\bar{y} + x)$

b) Using Boolean Algebra Theorems, prove that: $x(y \oplus z) = (xy) \oplus (xz)$ (6 pts)

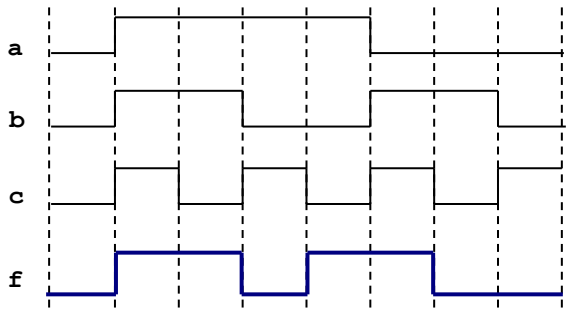
c) For the following Truth table with two outputs: (10 pts)
- Provide the Boolean functions using the Canonical Sum of Products (SOP), and Product of Sums (POS). (4 pts)
- Express the Boolean functions using the minterms and maxterms representations.
- Sketch the logic circuits as Canonical Sum of Products and Product of Sums. (4 pts)

x	y	z	f_1	f_2
0	0	0	1	1
0	0	1	0	0
0	1	0	1	0
0	1	1	1	1
1	0	0	1	0
1	0	1	0	1
1	1	0	1	1
1	1	1	0	1

Problem 2 (24 pts)

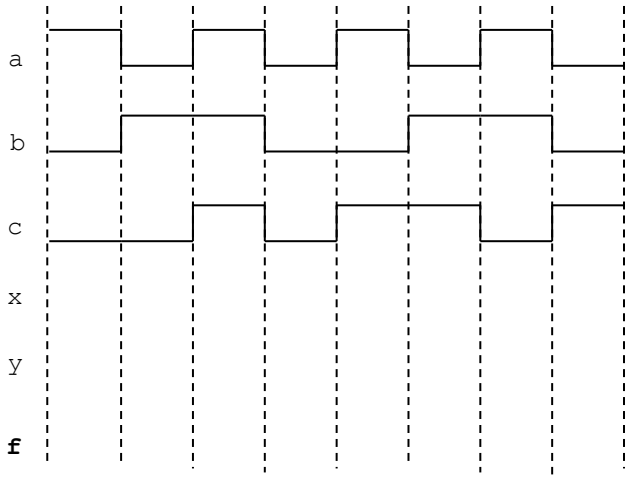
a) The following is the timing diagram of a logic circuit with 3 inputs. Sketch the logic circuit that generates this waveform. Then, complete the VHDL code. (8 pts)

```
library ieee;
use ieee.std_logic_1164.all;

entity wave is
  port ( a, b, c: in std_logic;
                f: out std_logic);
end wave;

architecture struct of wave is
-- ???
begin
   -- ???


end struct;
```

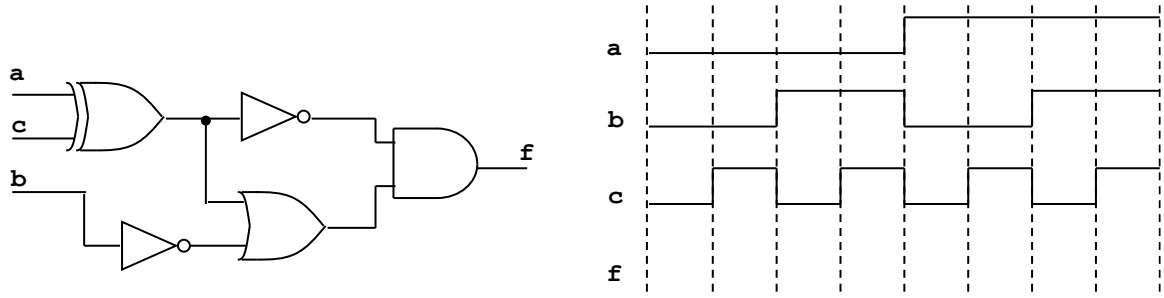


b) Complete the timing diagram of the logic circuit whose VHDL description is shown below: (5 pts)

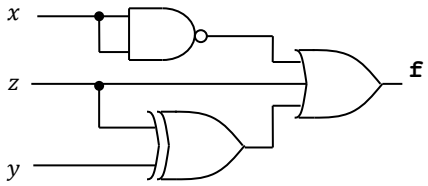
```
library ieee;
use ieee.std_logic_1164.all;

entity circ is
  port ( a, b, c: in std_logic;
         f: out std_logic);
end circ;

architecture struct of circ is
  signal x, y: std_logic;

begin
  f <= y xor (not a);
  x <= a nand b;
  y <= x xnor (not c);
end struct;
```



c) Complete the timing diagram of the following circuit: (5 pts)



d) Complete the truth table describing the output of the following circuit and write the simplified Boolean equation (6 pts).



x	y	z	f
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

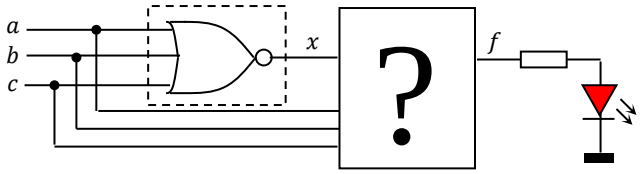
$f =$

PROBLEM 3 (10 PTS)

- Complete the truth table for a circuit with 4 inputs x, y, z, w that activates an output ($f = 1$) when the number of 1's in the inputs is even. For example: If $xyzw = 1100 \rightarrow f = 1$. If $xyzw = 1011 \rightarrow f = 0$.
- Design (provide the simplified Boolean equation for f and sketch the logic circuit).

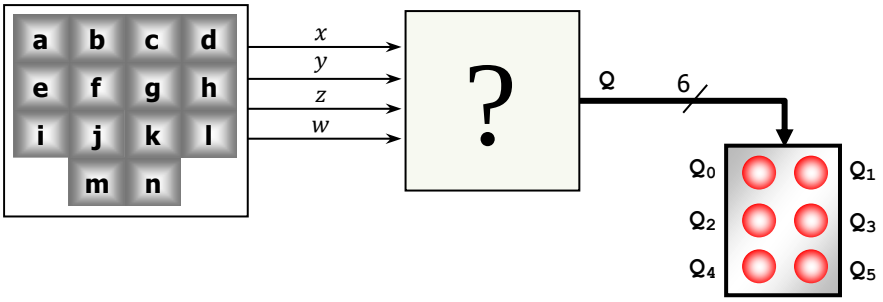
PROBLEM 4 (11 PTS)

- Design a circuit (simplify your circuit) that verifies the logical operation of a 3-input NOR gate. f = '1' (LED ON) if the NOR gate does NOT work properly. Assumption: when the NOR gate is not working, it generates 1's instead of 0's and vice versa.



PROBLEM 5 (25 PTS)

- A 14-letter keypad produces a 4-bit code as shown in the table. We want to design a logic circuit that converts those 4-bit codes to Braille code, where the 6 dots are represented by LEDs. A raised (or embossed) dot is represented by an LED ON (logic value of '1'). A missing dot is represented by a LED off (logic value of '0').
  - ✓ Complete the truth table for each output (Q_0-Q_5). (4 pts)
  - ✓ Provide the simplified expression for each output (Q_0-Q_5). Use Karnaugh maps for Q_3, Q_2, Q_0 and the Quine-McCluskey algorithm for Q_5, Q_4, Q_1. Note it is safe to assume that the codes `1110` and `1111` will not be produced by the keypad.



x	y	z	w	Letter
0	0	0	0	a
0	0	0	1	b
0	0	1	0	c
0	0	1	1	d
0	1	0	0	e
0	1	0	1	f
0	1	1	0	g
0	1	1	1	h
1	0	0	0	i
1	0	0	1	j
1	0	1	0	k
1	0	1	1	l
1	1	0	0	m
1	1	0	1	n
1	1	1	0	
1	1	1	1