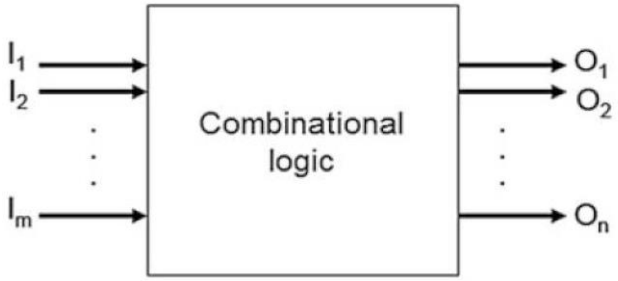
CEG3155: DGD 1

Review

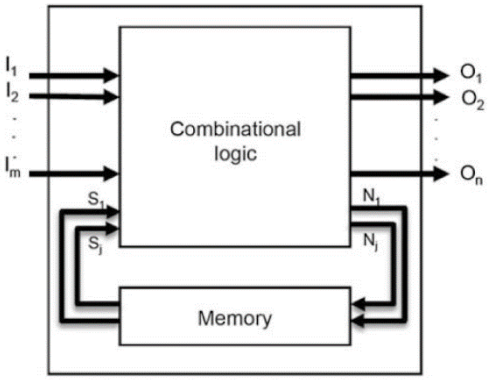
Combinational Logic

- Outputs depend only on the present inputs, i.e. no memory elements.
- Examples:
  - Multiplexers, demultiplexers, encoders, and decoders.
  - Adders, subtractors, multipliers, shifters, comparators, and ALUs.



Sequential Logic

- Outputs depend not only on the present inputs but also on past inputs.
- A memory element is used to store the state of the previous inputs.
- Sequential circuits are usually designed using a Finite State Machine (FSM).
- Examples:
  - Flip-flops, and counters.



IEEE 1164 Standard

- A technical standard published by the IEEE in 1993. (https://perso.telecom-paristech.fr/guilley/ENS/20171205/TP/tp_syn/doc/IEEE_VHDL_1164-1993.pdf)
- It describes the logic values to be used in Electronic Design Automation (EDA) tools.
- Defines the following primary data types:

Character	Value
'U'	Uninitialized
'X'	Strong unknown value
'0'	Strong zero
'1'	Strong one
'Z'	High impedance
'W'	Weak unknown
'L'	Weak zero
'H'	Weak one
'-'	Don't care

- In VHDL, this standard is embodied in the std_logic_1164 package.

Questions

Question 1

Consider the function $f(x1, x2, x3) = m(2, 3, 4, 6, 7)$, use the truth table below to identify the Sum-of-Products (SoP) and Product-of-Sums (PoS).

	$x1$	$x2$	$x3$	Minterms	Maxterms
0	0	0	0	m0 = $\overline{x1}\,\overline{x2}\,\overline{x3}$	M0 = $x1 + x2 + x3$
1	0	0	1	m1 = $\overline{x1}\,\overline{x2}\,x3$	M1 = $x1 + x2 + \overline{x3}$
2	0	1	0	m2 = $\overline{x1}\,x2\,\overline{x3}$	M2 = $x1 + \overline{x2} + x3$
3	0	1	1	m3 = $\overline{x1}\,x2\,x3$	M3 = $x1 + \overline{x2} + \overline{x3}$
4	1	0	0	m4 = $x1\,\overline{x2}\,\overline{x3}$	M4 = $\overline{x1} + x2 + x3$
5	1	0	1	m5 = $x1\,\overline{x2}\,x3$	M5 = $\overline{x1} + x2 + \overline{x3}$
6	1	1	0	m6 = $x1\,x2\,\overline{x3}$	M6 = $\overline{x1} + \overline{x2} + x3$
7	1	1	1	m7 = $x1\,x2\,x3$	M7 = $\overline{x1} + \overline{x2} + \overline{x3}$

Identify the SoP, and PoS terms, and prove that $f(x1, x2, x3)$ can be expressed by SoP or PoS.

Question 2

Use algebraic manipulation to show that for three input variables $x1, x2, x3$:

$$\sum m(1, 2, 3, 4, 5, 6, 7) = x1 + x2 + x3$$

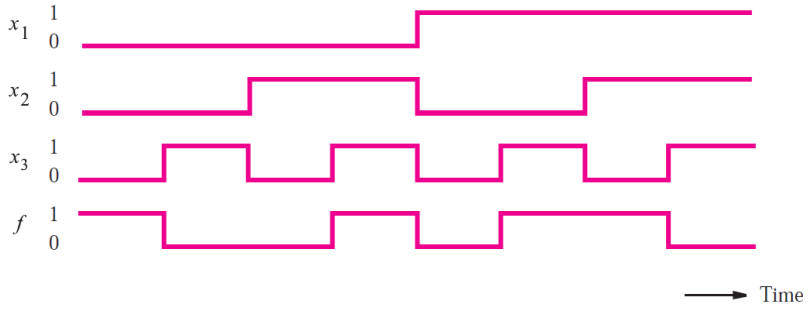
Question 3

Perform the following operations in binary, where numbers are signed and represented in 2's complement form. Then, get the corresponding decimal number.

a) 00000110 + 00001101
b) 11111010 – 11110011
c) 1100 + 1010

Question 4

For the timing diagram in the Figure, synthesize the function $f(x1, x2, x3)$ in the simplest sum-of-products form.



Question 5

Draw the circuit described by the following VHDL code.

```
architecture SomeCode of SomeEntity is
    signal sig1, sig2, out1: std_logic;
begin

    out2 <= not out1;
    sig2 <= (c xor d);
    out1 <= (sig1 and sig2);
    sig1 <= (a and b) or c;

end SomeCode;
```

Question 6

Write VHDL code to implement the function $f(x1, x2, x3) = m(0, 1, 2, 3, 4, 5)$.

Question 7

Design 1-bit full adder in VHDL:

a) Show timing diagrams of the sum and carry-out bits for all possible values of inputs.
b) Show structural implementation of it.