

Exercise 2 – Working with Boolean logic expressions

Question 1. [2 marks]

Demonstrate the validity of the following identities for three variables (x, y, z) by means of truth tables.

1. DeMorgan's Theorems:

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

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

2. The Distributive Laws:

$$x + yz = (x+y)(x+z)$$

$$x(y + z) = xy + xz$$

Question 2. [3 marks]

Simplify the following Boolean expressions to a **minimum number of literals**.

1. $xy + xy'$
2. $(A + B)'(A' + B)'$
3. $(a + b + c')(a'b' + c)$
4. $a'bc + abc' + abc + a'bc'$
5. $(a' + c')(a + b' + c')$
6. $ABC'D + A'BC + ABCD$

Question 3. [3 marks]

1. Find the **complement** of the expression: $(a + c)(a + b')(a' + b + c')$
2. Find the complement of the Boolean function $F(w, x, y, z) = wx + yz$. Then, show that $FF' = 0$, and also that $F + F' = 1$.
3. We can perform logical operations on strings of bits by considering each corresponding pair of bits separately (called *bitwise* operations). Given two four-bit strings $A = 0011$, and $B = 0101$, evaluate the four-bit results for each of the following logical operations

A AND B A OR B A XOR B NOT A NOT B A NAND B
A NOR B

4. Given two different Boolean functions E and F, show that:
- The Boolean function $G = E + F$ contains the **sum of the minterms** of E and F.
 - The Boolean function $H = EF$ contains **only the minterms that are common** to E and F.

Question 4. [2 marks]

- Implement (ie. draw the logic diagrams) for the Boolean function: $F(X, Y, Z) = XY + X'Y' + Y'Z$
 - Using only AND, OR and inverter gates
 - Using only OR and inverter gates
 - Using only AND and inverter gates
 - Using only NAND and inverter gates
 - Using only NOR and inverter gates
 - Write the following Boolean expression in **Sum of Products** (SOP) form: $(B + D)(A' + B' + C)$
 - Write the following Boolean expression in **Product of Sums** (POS) form: $A'B + A'C' + ABC$
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Evaluation:

- All Laboratory Exercises must be completed and submitted for grading by the following Laboratory session, unless otherwise prescribed by the Instructor.
- Students are evaluated on all stated requirements.
- It is mandatory that students complete their own work and must be able to justify their answers when asked to do so by teaching staff.