1. Rewrite the following function in SOP form.

   \[ F(a,b,c,d,e) = (a+c')(a+d)(ab'+c+e) \]

   a) \( a+ab'd+ae+c'de \)
   b) \( ab'c+ae+c'de \), from 12b and 12a
   c) \( ab'c+ab'd+ae+c' \)
   d) \( a'bc+ae+c'de \)
   e) \( a+ae+c'de \)

2. Which of the following Boolean expressions are false?

   a) \((x+y)(x+z) = x+yz\), true from 12b
   b) \((x+y)(x'+z) = x'y+xz\), true by truth table (or K-map) comparison
   c) \(xy+x' = x' y + xz\), true from 16a
   d) \(x+(y+z) = (x+y)+z\), true from 11b
   e) none of the above

3. For the following Boolean expressions, which equalities are true?

   \[
   \begin{align*}
   F_1 &= wy'+w'x'y'+w'yz \\
   F_2 &= wxy'+x'y'+w'yz \\
   F_3 &= wy'+x'y'z'+w'x'z+w'y'z \\
   F_4 &= w'xy'+w'y+yz'
   \end{align*}
   \]

   a) \( F_1 = F_2 \)
   b) \( F_1 = F_3 \) and \( F_2 = F_4 \)
   c) \( F_1 = F_2 = F_3 \)
   d) \( F_3 = F_4 \)
   e) none of the above

4. How many literals and variables does the following function have in this form?

   \[ F = a'bc+a'bcd+c'd' \]

   a) 4 literals, 9 variables
   b) 4 variables, 4 literals
   c) 4 variables, 9 literals
   d) 9 variables, 9 literals
   e) none of the above
5. For the circuit:

\( a \)

\( b' \)

\( a' \)

\( b \)

\( b \)

\( c \)

\[ f = ab + a'b' + bc \]

\[ f = (a \oplus b)(bc)' \]

\[ f = a \oplus b \oplus c \]

\[ f = 0 \]

\[ \text{none of the above} \]

6. Draw the minimum cost AND-OR implementation for \( F \). Input variables are available in true and complement forms.

\[ F(A,B,C,D) = \Sigma (1,3,6,7,11,14,15) + \Delta (5,9,10) \]

\[ F = B'D + BC \]
7. Write the VHDL ENTITY and ARCHITECTURE constructs for the circuit described by the equations below. Do not simplify.

\[ \begin{align*}
F &= (A + B')(C + A'B')' \\
G &= AB' + C(A' + B)
\end{align*} \]

ENTITY prob7 IS
  PORT (A, B, C : IN BIT; \\
        F, G : OUT BIT);
END prob7;
ARCHITECTURE LogicFunc OF prob7 IS
BEGIN
  F <= (A OR NOT B) AND NOT (C OR (NOT A AND B)); \\
  G <= (A AND NOT B) OR (C AND (NOT A OR B));
END LogicFunc;

8. Give the MAXTERM notation of the following function.

\[ f = ab + a'bc' + a'c \]

\[ f = \Pi M(0, 4, 5) \]

9. Identify the essential and nonessential prime implicants for the function given below. What is the minimum cost SOP expression? What is the COST?

\[ F(A, B, C, D) = \Sigma m(1, 3, 5, 8, 14, 15) + D(9, 10) \]
10. Draw the minimum NAND-NAND implementation for $F$.

$$F(A,B,C,D) = \Sigma m(1,5,8,13-15) + D(3,10,12)$$

\[ F(A,B,C,D) = \sum m(1,5,8,13-15) + D(3,10,12) \]

\[ F = (A+D)(A+C')(A'+B+D') \]

12. Draw the schematic diagram for a programmed PLA that implements the functions below.

\[ F = (A+B')(C+A'B')' \]
\[ G = AB' + C(A'+B) \]
Axioms of Boolean algebra

1a. \( 0 \cdot 0 = 0 \)
1b. \( 1 + 1 = 1 \)
2a. \( 1 \cdot 1 = 1 \)
2b. \( 0 + 0 = 0 \)
3a. \( 0 \cdot 1 = 1 \cdot 0 = 0 \)
3b. \( 1 + 0 = 0 + 1 = 1 \)
4a. If \( x = 0 \) then \( x' = 1 \)
4b. If \( x = 1 \) then \( x' = 0 \)

Single-Variable theorems

5a. \( x \cdot 0 = 0 \)
5b. \( x + 1 = 1 \)
6a. \( x \cdot 1 = x \)
6b. \( x + 0 = x \)
7a. \( x \cdot x = x \)
7b. \( x + x = x \)
8a. \( x \cdot x' = 0 \)
8b. \( x + x' = 1 \)
9. \( x'' = x \)

Two & three variable properties

10a. \( x \cdot y = y \cdot x \) \hspace{1cm} \text{Commutative}
10b. \( x + y = y + x \)
11a. \( x \cdot (y \cdot z) = (x \cdot y) \cdot z \) \hspace{1cm} \text{Associative}
11b. \( x + (y + z) = (x + y) + z \)
12a. \( x \cdot (y + z) = x \cdot y + x \cdot z \) \hspace{1cm} \text{Distributive}
12b. \( x + y \cdot z = (x + y) \cdot (x + z) \)
13a. \( x + x \cdot y = x \) \hspace{1cm} \text{Absorption}
13b. \( x \cdot (x + y) = x \)
14a. \( x \cdot y + x \cdot y' = x \) \hspace{1cm} \text{Combining}
14b. \( (x + y) \cdot (x + y') = x \)
15a. \( (x \cdot y)' = x' + y' \) \hspace{1cm} \text{DeMorgan’s}
15b. \( (x + y)' = x' \cdot y' \) \hspace{1cm} \text{Theorem}
16a. \( x + x' = x + y \)
16b. \( x \cdot (x' + y) = x \cdot y \)