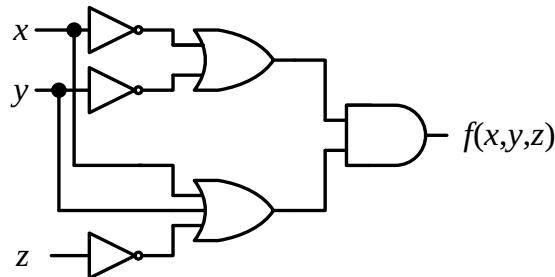


### EE1001 - Tutorial 3 - Answers

1. Draw the logic circuit diagram of the Boolean function  $f(x, y, z) = (x' + y')(x + y + z')$  using AND, OR, NOT gates. The diagram should correspond exactly to the equation. Assume that the complements of the inputs are not available.



2. Proof  $(x + y) \oplus (x + z) = x'(y \oplus z)$  with truth table.

| x | y | z | x' | x + y | x + z | y ⊕ z | (x + y) ⊕ (x + z) | x'(y ⊕ z) |
|---|---|---|----|-------|-------|-------|-------------------|-----------|
| 0 | 0 | 0 | 1  | 0     | 0     | 0     | 0                 | 0         |
| 0 | 0 | 1 | 1  | 0     | 1     | 1     | 1                 | 1         |
| 0 | 1 | 0 | 1  | 1     | 0     | 1     | 1                 | 1         |
| 0 | 1 | 1 | 1  | 1     | 1     | 0     | 0                 | 0         |
| 1 | 0 | 0 | 0  | 1     | 1     | 0     | 0                 | 0         |
| 1 | 0 | 1 | 0  | 1     | 1     | 1     | 0                 | 0         |
| 1 | 1 | 0 | 0  | 1     | 1     | 1     | 0                 | 0         |
| 1 | 1 | 1 | 0  | 1     | 1     | 0     | 0                 | 0         |

3. For the following logic functions, find all the minterms and maxterms for each them and express them in canonical POS and SOP forms.

$$\begin{aligned}
 \text{(a)} \quad f(x, y, z) &= x'y'z + xy + x'y \\
 &= x'y'z + xy(z + z') + x'y(z + z') \\
 &= x'y'z + xyz + xyz' + x'yz + x'yz' \\
 &= m_1 + m_2 + m_3 + m_6 + m_7 \\
 &= \sum m(1, 2, 3, 6, 7) \\
 &= \prod M(0, 4, 5) \\
 &= (x + y + z)(x' + y + z)(x' + y + z')
 \end{aligned}$$

$$(b) \quad f(x,y,z) = x' + xy + xz' + y'z'$$

$$\begin{aligned}
 &= x'(y + y') + xy(z + z') + xz'(y + y') + y'z'(x + x') \\
 &= x'y + x'y' + xyz + xyz' + xyz' + x'y'z' + xy'z' + x'y'z' \\
 &= x'y(z + z') + x'y'(z + z') + xyz + xyz' + x'y'z' + x'y'z' \\
 &= x'yz + x'yz' + x'y'z + x'y'z' + xyz + xyz' + x'y'z' \\
 &= m_0 + m_1 + m_2 + m_3 + m_4 + m_6 + m_7 \\
 &= \sum m(0,1,2,3,4,6,7) \\
 &= \prod M(5) \\
 &= (x' + y + z')
 \end{aligned}$$

$$\begin{aligned}
 (c) \quad F(A,B,C,D) &= AB'(C+BD) + A'B'+AC(B+D) \\
 &= AB'C + \textcolor{red}{AB'BD} + A'B'(C+C') + ACB + ACD \\
 &= AB'C(D+D') + A'B'C(D+D') + A'B'C'(D+D') + ABC(D+D') + ACD(B+B') \\
 &= AB'CD + AB'CD' + A'B'CD + A'B'CD' + A'B'C'D + A'B'C'D' + ABCD + ABCD' + ABCD + A'B'CD \\
 &= m_0 + m_1 + m_2 + m_3 + m_{10} + m_{11} + m_{14} + m_{15} \\
 &= \sum m(0,1,2,3,10,11,14,15) \\
 &= \prod M(4,5,6,7,8,9,12,13) \\
 &= (A+B'+C+D) \cdot (A+B'+C+D') \cdot (A+B'+C'+D) \cdot (A+B'+C'+D') \cdot (A'+B+C+D) \cdot \\
 &\quad (A'+B+C+D') \cdot (A'+B'+C+D) \cdot (A'+B'+C+D')
 \end{aligned}$$

4. For the following logic functions, list all the minterms and maxterms for each of them.

$$\begin{aligned}
 (a) \quad f(x, y, z) &= \sum m(2,4,6,7) \\
 &= x'yz' + x'y'z' + xyz' + xyz \\
 &= \prod M(0,1,3,5) \\
 &= (x + y + z)(x + y + z')(x + y' + z')(x' + y + z')
 \end{aligned}$$

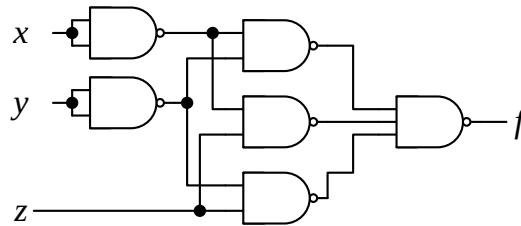
$$\begin{aligned}
 (b) \quad f(w, x, y, z) &= \sum m(0,1,3,7,10,12,15) \\
 &= w'x'y'z' + w'x'y'z + w'x'yz + w'xyz + wx'y'z' + wxy'z' + wxyz \\
 &= \prod M(2,4,5,6,8,9,11,13,14) \\
 &= (w+x+y'+z) \cdot (w+x'+y+z) \cdot (w+x'+y+z') \cdot (w+x'+y'+z) \cdot \\
 &\quad (w'+x+y+z) \cdot (w'+x+y+z') \cdot (w'+x+y'+z) \cdot (w'+x'+y'+z)
 \end{aligned}$$

$$\begin{aligned}
 (c) \quad f(a, b, c) &= \prod M(2,3,5) \\
 &= (a + b' + c)(a + b' + c')(a' + b + c') \\
 &= \sum m(0,1,4,6,7) \\
 &= a'b'c' + abc' + ab'c' + abc' + abc
 \end{aligned}$$

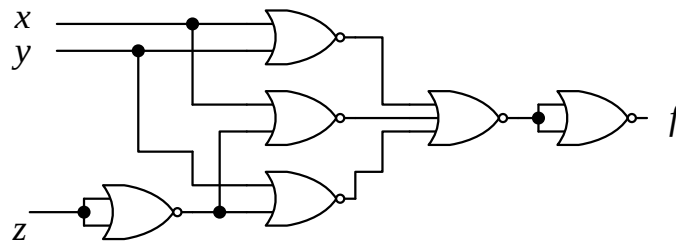
$$\begin{aligned}
 (d) \quad F(A, B, C, D) &= \prod M(0, 2, 3, 7, 9, 13, 14) \\
 &= (A+B+C+D) \cdot (A+B+C'+D) \cdot (A+B+C'+D') \cdot (A+B'+C'+D') \cdot \\
 &\quad (A'+B+C+D') \cdot (A'+B'+C+D') \cdot (A'+B'+C'+D) \\
 &= \sum m(1, 4, 5, 6, 8, 10, 11, 12, 15) \\
 &= A'B'C'D + A'BCD + A'BC'D + A'BCD' + AB'C'D' + \\
 &\quad AB'CD' + AB'CD + ABC'D' + ABCD
 \end{aligned}$$

5. Using DeMorgan's theorem, convert the following Boolean expressions to equivalent expressions that can be implemented with (i) NAND gates only, and (ii) NOR gates only. Draw the circuits.

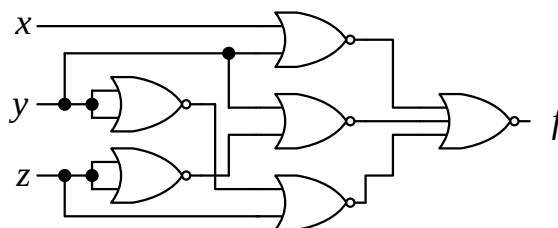
$$(a) \quad f = \overline{\overline{x}} \overline{\overline{y}} + \overline{\overline{x}} \overline{\overline{z}} + \overline{\overline{y}} \overline{\overline{z}} = \overline{\overline{\overline{\overline{x}} \overline{\overline{y}} + \overline{\overline{x}} \overline{\overline{z}} + \overline{\overline{y}} \overline{\overline{z}}}} = \overline{\overline{\overline{x}} \overline{\overline{y}} \cdot \overline{\overline{x}} \overline{\overline{z}} \cdot \overline{\overline{y}} \overline{\overline{z}}}}$$



$$f = \overline{\overline{x}} \overline{\overline{y}} + \overline{\overline{x}} \overline{\overline{z}} + \overline{\overline{y}} \overline{\overline{z}} = \overline{\overline{\overline{\overline{x}} + \overline{\overline{y}} + \overline{\overline{x}} + \overline{\overline{z}} + \overline{\overline{y}} + \overline{\overline{z}}}}$$



$$(b) \quad f = (y + \overline{z})(x + y)(\overline{y} + z) = \overline{\overline{\overline{y + \overline{z}} + \overline{x + y} + \overline{\overline{y} + z}}}}$$



$$f = (y + \bar{z})(x + y)(\bar{y} + z) = \overline{\overline{\overline{y \cdot z}}(\overline{\overline{x \cdot y}}(\overline{\overline{y \cdot z}}))}$$

