1. Using K-maps only, find a minimal sum-of-products expression for each of the following logic functions and implement using NAND logic gates only.
   a. \( F(x, y, z) = \Sigma m \{1, 3, 5, 6, 7\} \)
   b. \( F(w, x, y, z) = \Sigma m \{1, 4, 5, 6, 7, 9, 14, 15\} \)
   c. \( F(w, x, y) = \Pi M \{1, 4, 5, 6, 7\} \)
   d. \( F(w, x, y, z) = \Sigma m \{0, 1, 6, 7, 8, 9, 14, 15\} \)
   e. \( F(A, B, C, D) = \Pi M \{4, 5, 6, 13, 15\} \)
   f. \( F(A, B, C, D) = \Sigma m \{4, 5, 6, 11, 13, 14, 15\} \)
   g. \( F = ABC + AB\overline{C} + \overline{A}BC + \overline{AB}C + \overline{A}BC + A\overline{B}\overline{C} \)
   h. \( F = A'B'C'D' + A'BC'D' + AB'C'D' + A'B'CD' + A'B'CD + AB'CD' + AB'CD \)
2. Simplify function $Z$ using K maps only.

$$Z = F + GH'$$

$$F = (A + B + C + D) + AB' + A'CD' + A'CDB' + A'CDB$$

$$G = A'B + CD + AB'CD' + AB'CD$$

$$H = A'BC + A'B' + A'C'$$

- Implement $Z$ using NOR gates only.
3. A lift door control is to operate in the following manner. When the lift stops at a floor the door will open and a signal is generated that remains on until all the passengers are on or off the lift. An additional signal is also generated to ensure that the doors do not close on a passenger in the doorway. Doors will close if a call button has been pressed on another floor or if a lift passenger has pressed a button for another floor. Design the lift control combinational circuit using minimum number of NAND gates.
4. Simplify the following expressions using K-map for each K-map indicate all the Prime Implicants (PIs) and show which of them are Essential PIs (EPIs)

i. \( F(A, B, C) = \Pi M(0, 1, 2, 5, 6) \)

ii. \( F = A \overline{B} \overline{C} + B \overline{C} \overline{D} + C \overline{D} + \overline{A} \overline{B} \)

iii. \( F(A, B, C, D) = \Pi M(0, 1, 2, 3, 6, 7, 8, 9, 12, 14, 15) \)

iv. \( F(A, B, C, D) = \Sigma m(1, 6, 7, 9, 12) + d(8, 11, 15) \)
5. \( F(A,B,C,D) = \prod (0,2,4,5,6,9,10) + d(7,11,12,13,14,15) \)

Using K-Maps, **simplify** the above function and **implement it using logic gates**:

i) to the minimal Product-of-Sums (POS).

\[
\begin{array}{ccccccc}
& A & B & C & D \\
\hline
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 \\
0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1 & 1 \\
0 & 0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 & 1 \\
0 & 0 & 1 & 1 & 0 \\
0 & 0 & 1 & 1 & 1 \\
0 & 1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 1 \\
0 & 1 & 0 & 1 & 0 \\
0 & 1 & 0 & 1 & 1 \\
0 & 1 & 1 & 0 & 0 \\
0 & 1 & 1 & 0 & 1 \\
0 & 1 & 1 & 1 & 0 \\
0 & 1 & 1 & 1 & 1 \\
\end{array}
\]

\( F(A,B,C,D) = \)

ii) to the minimal Sum-of-Products (SOP).

\[
\begin{array}{ccccccc}
& A & B & C & D \\
\hline
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 \\
0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1 & 1 \\
0 & 0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 & 1 \\
0 & 0 & 1 & 1 & 0 \\
0 & 0 & 1 & 1 & 1 \\
0 & 1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 1 \\
0 & 1 & 0 & 1 & 0 \\
0 & 1 & 0 & 1 & 1 \\
0 & 1 & 1 & 0 & 0 \\
0 & 1 & 1 & 0 & 1 \\
0 & 1 & 1 & 1 & 0 \\
0 & 1 & 1 & 1 & 1 \\
\end{array}
\]

\( F(A,B,C,D) = \)
6. Get the function $f(A,B,C,D)$ from the circuit below and simplify it. Re-implement the minimized version using only NOR gates.