1. (A + B + C)’ = A’B’C’ is proven below. By the Duality Principle (ABC)’ = A’ + B’ + C’
   Remember that X’ represents the complement of X, or NOT X.

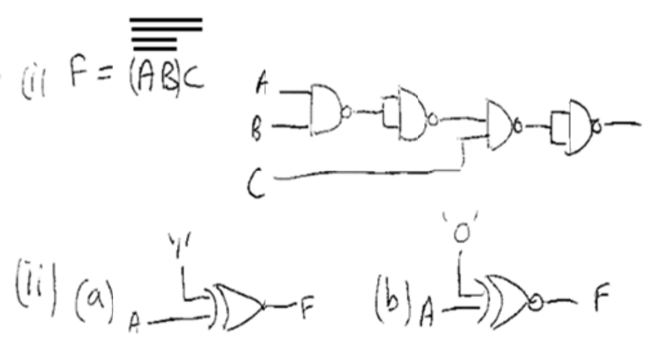
A B C	A’	B’	C’	A’B’C’	A + B + C	(A + B + C)’
0 0 0	1	1	1	1	0	1
0 0 1	1	1	0	0	1	0
0 1 0	1	0	1	0	1	0
0 1 1	1	0	0	0	1	0
1 0 0	0	1	1	0	1	0
1 0 1	0	1	0	0	1	0
1 1 0	0	0	1	0	1	0
1 1 1	0	0	0	0	1	0

Columns 5 and 7 are the same, proving De Morgan’s theorem for three variables.

2. (X + Y)’(X’ + Y’)’ = X’Y’XY = 0

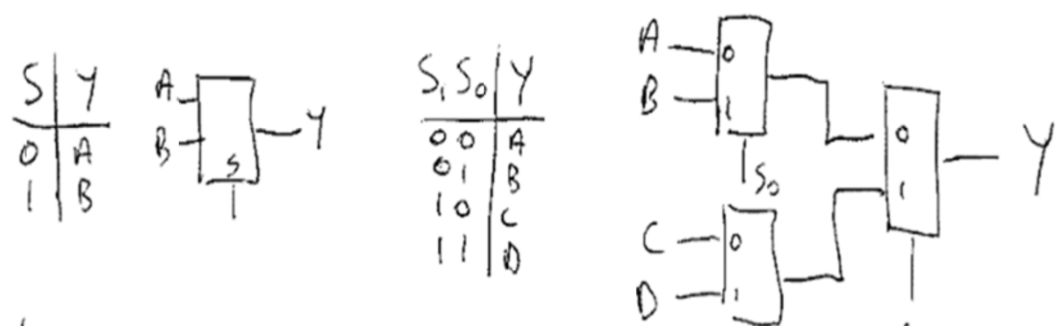
3. (i) X.Y = 10010000 (ii) X ⊕ Y = 01001101

4.



5. F = A’B + A’BC’ + AC
   F = A’B(C + C’) + A’BC’ + AC(B + B’)
   F = A’BC + A’BC’ + A’BC’ + ABC + AB’C
   F = A’BC + A’BC’ + ABC + AB’C

6.

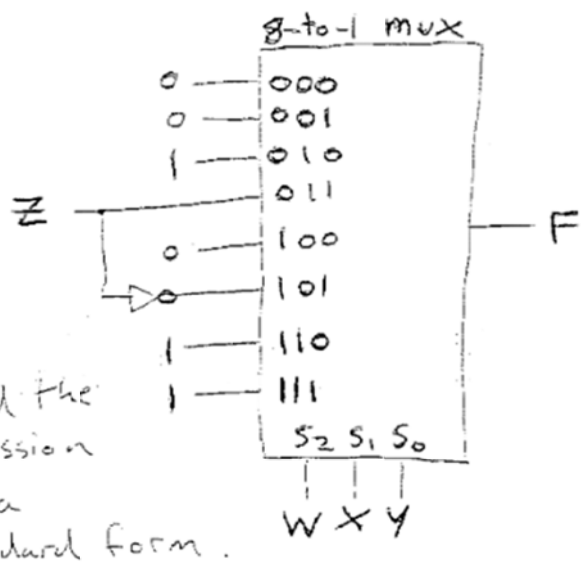


Select lines must be clearly shown.

7.

W	X	Y	Z	F
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	1
0	1	0	1	1
0	1	1	0	0
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	1
1	0	1	1	0
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

Expand the expression to a standard form.



8.

A_2	A_1	A_0	Z_7	Z_6	Z_5	Z_4	Z_3	Z_2	Z_1	Z_0
0	0	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	1	0
0	1	0	0	0	0	0	0	1	0	0
0	1	1	0	0	0	0	1	0	0	0
1	0	0	0	0	0	1	0	0	0	0
1	0	1	0	0	1	0	0	0	0	0
1	1	0	0	1	0	0	0	0	0	0
1	1	1	1	0	0	0	0	0	0	0

$Z_0 = \overline{A_2}\,\overline{A_1}\,\overline{A_0}$

$Z_1 = \overline{A_2}\,\overline{A_1}\,A_0$

$Z_2 = \overline{A_2}\,A_1\,\overline{A_0}$

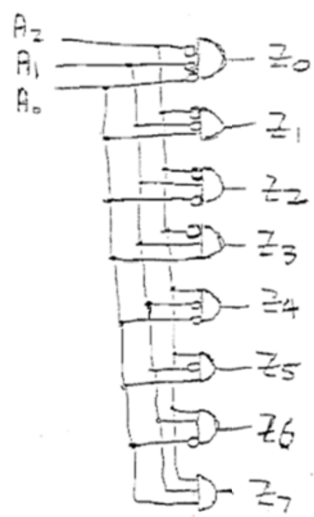
$Z_3 = \overline{A_2}\,A_1\,A_0$

$Z_4 = A_2\,\overline{A_1}\,\overline{A_0}$

$Z_5 = A_2\,\overline{A_1}\,A_0$

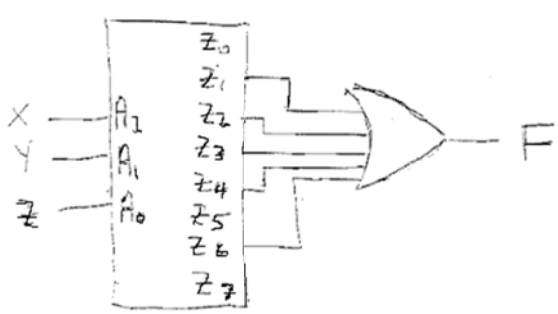
$Z_6 = A_2\,A_1\,\overline{A_0}$

$Z_7 = A_2\,A_1\,A_0$



X	Y	Z	F
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

$F(X,Y,Z) = \sum(1,2,3,4,6)$



9.

A_1	A_0	Z_3	Z_2	Z_1	Z_0
0	0	0	0	0	1
0	1	0	0	1	0
1	0	0	1	0	0
1	1	1	0	0	0

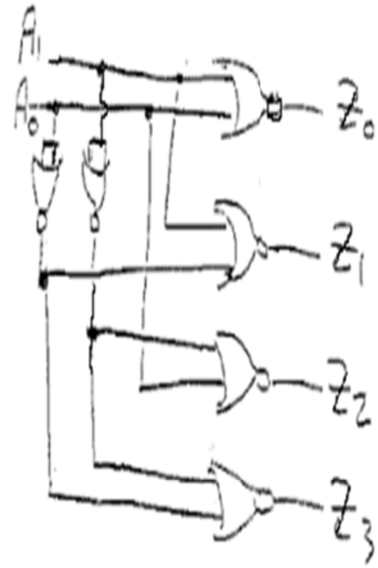
$$Z_0 = \bar{A}_1 \bar{A}_0 = \overline{A_1 + A_0}$$

$$Z_1 = \bar{A}_1 A_0 = \overline{A_1 + \bar{A}_0}$$

$$Z_2 = A_1 \bar{A}_0 = \overline{\bar{A}_1 + A_0}$$

$$Z_3 = A_1 A_0 = \overline{\bar{A}_1 + \bar{A}_0}$$

(involution then De Morgan)



10.

A	B	C	D	F
0	0	0	0	0
0	0	0	1	1
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1
0	1	1	1	1
1	0	0	0	0
1	0	0	1	1
1	0	1	0	1
1	0	1	1	1
1	1	0	0	1
1	1	0	1	0
1	1	1	0	0
1	1	1	1	0

$$F(A,B,C,D) = \sum(1,6,7,9,10,11,12)$$

or

full Boolean expression,

which notation is easier ?