CHAPTER 2

2-1.*

a) $\overline{XYZ} = \overline{X} + \overline{Y} + \overline{Z}$

Verification of DeMorgan's Theorem

X	Y	Z	XYZ	$\overline{XYZ}$	$\overline{X}+\overline{Y}+\overline{Z}$
0	0	0	0	1	1
0	0	1	0	1	1
0	1	0	0	1	1
0	1	1	0	1	1
1	0	0	0	1	1
1	0	1	0	1	1
1	1	0	0	1	1
1	1	1	1	0	0

b) $X + YZ = (X+Y)\cdot(X+Z)$

The Second Distributive Law

X	Y	Z	YZ	$X+YZ$	$X+Y$	$X+Z$	$(X+Y)(X+Z)$
0	0	0	0	0	0	0	0
0	0	1	0	0	0	1	0
0	1	0	0	0	1	0	0
0	1	1	1	1	1	1	1
1	0	0	0	1	1	1	1
1	0	1	0	1	1	1	1
1	1	0	0	1	1	1	1
1	1	1	1	1	1	1	1

c) $\overline{X}Y + \overline{Y}Z + X\overline{Z} = X\overline{Y} + Y\overline{Z} + \overline{X}Z$

X	Y	Z	$\overline{X}Y$	$\overline{Y}Z$	$X\overline{Z}$	$\overline{X}Y+\overline{Y}Z+X\overline{Z}$	$X\overline{Y}$	$Y\overline{Z}$	$\overline{X}Z$	$X\overline{Y}+Y\overline{Z}+\overline{X}Z$
0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	1	0	1	0	0	1	1
0	1	0	1	0	0	1	0	1	0	1
0	1	1	1	0	0	1	0	0	1	1
1	0	0	0	0	1	1	1	0	0	1
1	0	1	0	1	0	1	1	0	0	1
1	1	0	0	0	1	1	0	1	0	1
1	1	1	0	0	0	0	0	0	0	0

2-2.*

a) $\overline{X}\,\overline{Y} + \overline{X}Y + XY \quad = \quad \overline{X} + Y$

$= (\overline{X}Y + \overline{X}\,\overline{Y}) + (\overline{X}Y + XY)$

$= \overline{X}(Y + \overline{Y}) + Y(X + \overline{X})$

$= \overline{X} + Y$

b) $\overline{A}B + \overline{B}\,\overline{C} + AB + \overline{B}C \quad = \quad 1$

$= (\overline{A}B + AB) + (\overline{B}\,\overline{C} + \overline{B}C)$

$= B(A + \overline{A}) + \overline{B}(C + \overline{C})$

$B + \bar{B} = 1$

c) $Y + \bar{X}Z + X\bar{Y} \quad = \quad X + Y + Z$

$= Y + X\bar{Y} + \bar{X}Z$

$= (Y + X)(Y + \bar{Y}) + \bar{X}Z$

$= Y + X + \bar{X}Z$

$= Y + (X + \bar{X})(X + Z)$

$= X + Y + Z$

d) $\bar{X}\bar{Y} + \bar{Y}Z + XZ + XY + Y\bar{Z} \quad = \quad \bar{X}\bar{Y} + XZ + Y\bar{Z}$

$= \bar{X}\bar{Y} + \bar{Y}Z(X + \bar{X}) + XZ + XY + Y\bar{Z}$

$= \bar{X}\bar{Y} + X\bar{Y}Z + \bar{X}\bar{Y}Z + XZ + XY + Y\bar{Z}$

$= \bar{X}\bar{Y}(1 + Z) + X\bar{Y}Z + XZ + XY + Y\bar{Z}$

$= \bar{X}\bar{Y} + XZ(1 + \bar{Y}) + XY + Y\bar{Z}$

$= \bar{X}\bar{Y} + XZ + XY(Z + \bar{Z}) + Y\bar{Z}$

$= \bar{X}\bar{Y} + XZ + XYZ + Y\bar{Z}(1 + X)$

$= \bar{X}\bar{Y} + XZ(1 + Y) + Y\bar{Z}$

$= \bar{X}\bar{Y} + XZ + Y\bar{Z}$

2-3.+

a) $AB\bar{C} + B\bar{C}\bar{D} + BC + \bar{C}D \quad = \quad B + \bar{C}D$

$= AB\bar{C} + ABC + BC + B\bar{C}\bar{D} + B\bar{C}D + \bar{C}D$

$= AB(\bar{C} + C) + B\bar{C}(\bar{D} + D) + BC + \bar{C}D$

$= AB + B\bar{C} + BC + \bar{C}D$

$= B + AB + \bar{C}D$

$= B + \bar{C}D$

b) $WY + \bar{W}Y\bar{Z} + WXZ + \bar{W}X\bar{Y} \quad = \quad WY + \bar{W}X\bar{Z} + \bar{X}Y\bar{Z} + X\bar{Y}Z$

$= (WY + W\bar{X}Y\bar{Z}) + (\bar{W}XY\bar{Z} + \bar{W}\bar{X}Y\bar{Z}) + (WXYZ + WX\bar{Y}Z) + (\bar{W}X\bar{Y}Z + \bar{W}X\bar{Y}\bar{Z})$

$= (WY + WXYZ) + (\bar{W}XY\bar{Z} + \bar{W}X\bar{Y}\bar{Z}) + (\bar{W}\bar{X}Y\bar{Z} + W\bar{X}Y\bar{Z}) + (WX\bar{Y}Z + \bar{W}X\bar{Y}Z)$

$= WY + \bar{W}X\bar{Z}(Y + \bar{Y}) + \bar{X}Y\bar{Z}(\bar{W} + W) + X\bar{Y}Z(W + \bar{W})$

$= WY + \bar{W}X\bar{Z} + \bar{X}Y\bar{Z} + X\bar{Y}Z$

c) $A\bar{D} + \bar{A}B + \bar{C}D + \bar{B}C \quad = \quad (\bar{A} + \bar{B} + \bar{C} + \bar{D})(A + B + C + D)$

$= \overline{\overline{A\bar{D} + \bar{A}B + \bar{C}D + \bar{B}C}}$

$= \overline{(\bar{A} + D)(A + \bar{B})(C + \bar{D})(B + \bar{C})}$

$= \overline{(\bar{A}\bar{B} + AD + \bar{B}D)(BC + B\bar{D} + \bar{C}\bar{D})}$

$= \overline{\bar{A}\bar{B}\bar{C}\bar{D} + ABCD}$

$= (A + B + C + D)(\bar{A} + \bar{B} + \bar{C} + \bar{D}) = (\bar{A} + \bar{B} + \bar{C} + \bar{D})(A + B + C + D)$

2-4.+

Given: $A \cdot B = 0, A + B = 1$

Prove: $(A + C)(\bar{A} + B)(B + C) \quad = \quad BC$

$= (AB + \bar{A}C + BC)(B + C)$

$= AB + \bar{A}C + BC$

$$= 0 + C(\bar{A} + B)$$
$$= C(\bar{A} + B)(0)$$
$$= C(\bar{A} + B)(A + B)$$
$$= C(AB + \bar{A}B + B)$$
$$= BC$$

2-5.+

Step 1: Define all elements of the algebra as four bit vectors such as *A, B* and *C*:

$A = (A_3, A_2, A_1, A_0)$

$B = (B_3, B_2, B_1, B_0)$

$C = (C_3, C_2, C_1, C_0)$

Step 2: Define OR_1, AND_1 and NOT_1 so that they conform to the definitions of AND, OR and NOT presented in Table 2-1.

a) $A + B = C$ is defined such that for all i, $i = 0, \ldots, 3$, C_i equals the OR_1 of A_i and B_i.

b) $A\,B = C$ is defined such that for all i, $i = 0, \ldots, 3$, C_i equals the AND_1 of A_i and B_i.

c) The element 0 is defined such that for A = “0”, for all i, $i = 0, \ldots, 3$, A_i equals logical 0.

d) The element 1 is defined such that for A = “1”, for all i, $i = 0, \ldots, 3$, A_i equals logical 1.

e) For any element A, $\bar{A}$ is defined such that for all i, $i = 0, \ldots, 3$, $\bar{A}_i$ equals the NOT_1 of A_i.

2-6.

a) $\bar{A}\bar{C} + \bar{A}BC + \bar{B}C = \bar{A}\bar{C} + \bar{A}BC + (\bar{A}\bar{B}C + \bar{B}C)$

$= \bar{A}\bar{C} + (\bar{A}BC + \bar{A}\bar{B}C) + \bar{B}C$

$= (\bar{A}\bar{C} + \bar{A}C) + \bar{B}C = \bar{A} + \bar{B}C$

b) $\overline{(A + B + C)}\,\overline{(ABC)}$

$= \bar{A}\bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}\bar{B}\bar{C} + \bar{A}\bar{B}\bar{C}\bar{C}$

$= (\bar{A}\bar{A})\bar{B}\bar{C} + \bar{A}(\bar{B}\bar{B})\bar{C} + \bar{A}\bar{B}(\bar{C}\bar{C})$

$= \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}\bar{C} = \bar{A}\bar{B}\bar{C}$

c) $AB\bar{C} + AC = A(B\bar{C} + C) = A(B + C)$

d) $\bar{A}\bar{B}D + \bar{A}\bar{C}D + BD$

$= (\bar{A}\bar{B} + B + \bar{A}\bar{C})D$

$= (\bar{A} + \bar{A}\bar{C} + B)D$

$= (\bar{A} + B)D$

e) $\overline{(\bar{A} + B)}\,\overline{(\bar{A} + \bar{C})}\,\overline{(A\bar{B}C)}$

$= (A\bar{B})(AC)(\bar{A} + B + \bar{C}) = A\bar{B}C(\bar{A} + B + \bar{C})$

$= 0$

2-7.*

a) $\bar{X}\bar{Y} + XYZ + \bar{X}Y = \bar{X} + XYZ = (\bar{X} + XY)(\bar{X} + Z) = (\bar{X} + X)(\bar{X} + Y)(\bar{X} + Z)$

$= (\bar{X} + Y)(\bar{X} + Z) = \bar{X} + YZ$

b) $X + Y(Z + \overline{X + Z}) = X + Y(Z + \bar{X}\bar{Z}) = X + Y(Z + \bar{X})(Z + \bar{Z}) = X + YZ + \bar{X}Y$

$= (X + \bar{X})(X + Y) + YZ = X + Y + YZ = X + Y$

c) $\bar{W}X(\bar{Z} + \bar{Y}Z) + X(W + \bar{W}YZ) = \bar{W}X\bar{Z} + \bar{W}X\bar{Y}Z + WX + \bar{W}XYZ$

$= \overline{W}X\overline{Z} + \overline{W}XZ + WX = \overline{W}X + WX = X$

d) $(AB + \overline{A}\,\overline{B})(\overline{C}\,\overline{D} + CD) + \overline{AC} = AB\overline{C}\,\overline{D} + ABCD + \overline{A}\,\overline{B}CD + \overline{A}\,\overline{B}\,\overline{C}\,\overline{D} + \overline{A} + \overline{C}$

$= ABCD + \overline{A} + \overline{C} = \overline{A} + \overline{C} + A(BCD) = \overline{A} + \overline{C} + C(BD) = \overline{A} + \overline{C} + BD$

2-8.

a) $F = A\overline{B}C + \overline{A}\,\overline{C} + AB$

$= \overline{(\overline{A} + B + \overline{C})} + \overline{(A + C)} + \overline{(\overline{A} + \overline{B})}$

b) $\overline{\overline{F}} = \overline{\overline{A\overline{B}C + \overline{A}\,\overline{C} + AB}}$

$= \overline{\overline{(A\overline{B}C)}\,\overline{(\overline{A}\,\overline{C})}\,\overline{(AB)}}$

2-9.*

a) $\overline{F} = (\overline{A} + B)(A + \overline{B})$

b) $\overline{F} = ((V + \overline{W})\overline{X} + \overline{Y})Z$

c) $\overline{F} = [\overline{W} + \overline{X} + (Y + \overline{Z})(\overline{Y} + Z)][W + X + Y\overline{Z} + \overline{Y}Z]$

d) $\overline{F} = \overline{A}B\overline{C} + (A + B)\overline{C} + \overline{A}(B + C)$

2-10.*

Truth Tables a, b, c

X	Y	Z	a
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

A	B	C	b
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

W	X	Y	Z	c
0	0	0	0	0
0	0	0	1	0
0	0	1	0	1
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1
0	1	1	1	0
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

a) Sum of Minterms: $\overline{X}YZ + X\overline{Y}Z + XY\overline{Z} + XYZ$

Product of Maxterms: $(X + Y + Z)(X + Y + \overline{Z})(X + \overline{Y} + Z)(\overline{X} + Y + Z)$

b) Sum of Minterms: $\overline{A}\,\overline{B}\,\overline{C} + \overline{A}\,\overline{B}C + \overline{A}BC + ABC$

Product of Maxterms: $(A + \overline{B} + C)(\overline{A} + B + C)(\overline{A} + B + \overline{C})(\overline{A} + \overline{B} + C)$

c) Sum of Minterms: $\overline{W}\,\overline{X}Y\overline{Z} + \overline{W}XY\overline{Z} + W\overline{X}Y\overline{Z} + WX\overline{Y}\,\overline{Z} + WX\overline{Y}Z + WXY\overline{Z}$
$+ WXYZ$

Product of Maxterms: $(W + X + Y + Z)(W + X + Y + \overline{Z})(W + X + \overline{Y} + \overline{Z})$
$(W + \overline{X} + Y + Z)(W + \overline{X} + Y + \overline{Z})(W + \overline{X} + \overline{Y} + \overline{Z})$
$(\overline{W} + X + Y + Z)(\overline{W} + X + Y + \overline{Z})(\overline{W} + X + \overline{Y} + \overline{Z})$

2-11.

a) $E = \Sigma m(1, 2, 4, 6) = \Pi M(0, 3, 5, 7)$, $F = \Sigma m(0, 2, 4, 7) = \Pi M(1, 3, 5, 6)$

b) $\overline{E} = \Sigma m(0, 3, 5, 7)$, $\overline{F} = \Sigma m(1, 3, 5, 6)$

c) $E + F = \Sigma m(0, 1, 2, 4, 6, 7)$, $E \cdot F = \Sigma m(2, 4)$

d) $E = \bar{X}\bar{Y}Z + \bar{X}Y\bar{Z} + X\bar{Y}\bar{Z} + XY\bar{Z}$, $F = \bar{X}\bar{Y}\bar{Z} + \bar{X}Y\bar{Z} + X\bar{Y}\bar{Z} + XYZ$

e) $E = \bar{Z}(X + Y) + \bar{X}\bar{Y}Z$, $F = \bar{Z}(\bar{X} + \bar{Y}) + XYZ$

2-12.*

a) $(AB + C)(B + \bar{C}D) = AB + AB\bar{C}D + BC = AB + BC$ s.o.p.

$= B(A + C)$ p.o.s.

b) $\bar{X} + X(X + \bar{Y})(Y + \bar{Z}) = (\bar{X} + X)(\bar{X} + (X + \bar{Y})(Y + \bar{Z}))$

$= (\bar{X} + X + \bar{Y})(\bar{X} + Y + \bar{Z})$ p.o.s.

$= (1 + \bar{Y})(\bar{X} + Y + \bar{Z}) = \bar{X} + Y + \bar{Z}$ s.o.p.

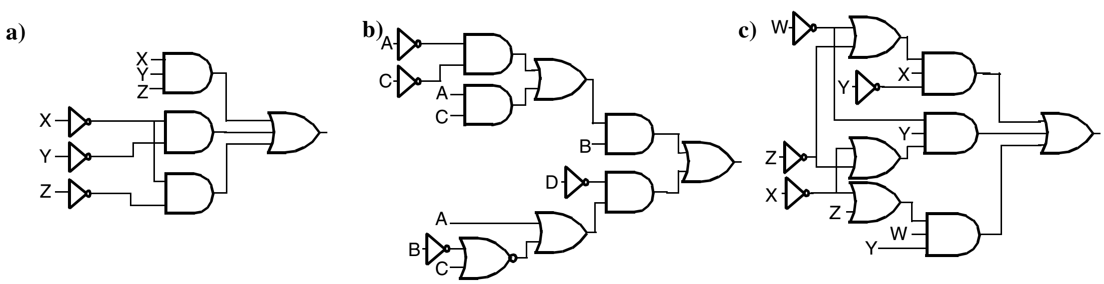
c) $(A + B\bar{C} + CD)(\bar{B} + EF) = (A + B + C)(A + B + D)(A + \bar{C} + D)(\bar{B} + EF)$

$= (A + B + C)(A + B + D)(A + \bar{C} + D)(\bar{B} + E)(\bar{B} + F)$ p.o.s.

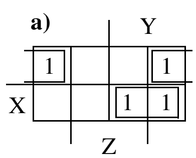
$(A + B\bar{C} + CD)(\bar{B} + EF) = A(\bar{B} + EF) + B\bar{C}(\bar{B} + EF) + CD(\bar{B} + EF)$

$= A\bar{B} + AEF + B\bar{C}EF + \bar{B}CD + CDEF$ s.o.p.

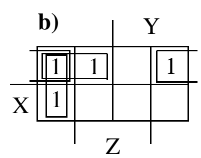
2-13.



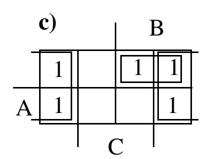
2-14.



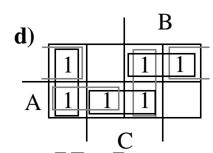
$\bar{X}\bar{Z} + XY$



$\bar{X}\bar{Y} + \bar{X}\bar{Z} + \bar{Y}\bar{Z}$



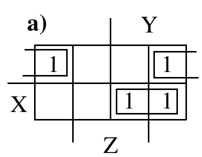
$\bar{C} + \bar{A}B$



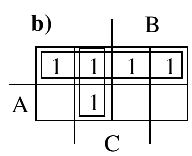
□ $\bar{B}\bar{C} + \bar{A}B + AC$

or □ $BC + A\bar{B} + \bar{A}\bar{C}$

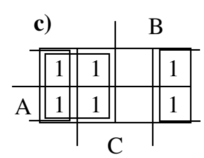
2-15. *



$\bar{X}\bar{Z} + XY$

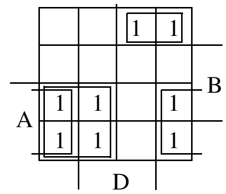


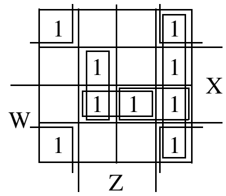
$\bar{A} + C\bar{B}$

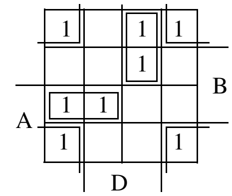


$\bar{B} + \bar{C}$

2-16.



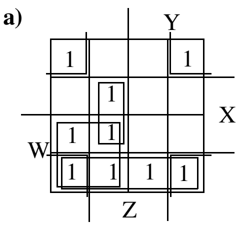




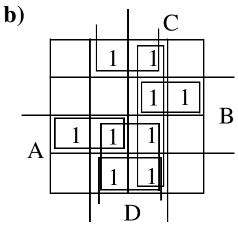
$A\bar{C} + A\bar{D} + \bar{A}\bar{B}C$ $\quad$ $Y\bar{Z} + \bar{X}\bar{Z} + X\bar{Y}Z + (WXZ \text{ or } WXY)$ $\quad$ $\bar{B}\bar{D} + AB\bar{C} + \bar{A}CD$

2-17.

a)



b)

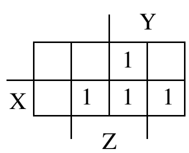


$F = \bar{X}\bar{Z} + W\bar{Y} + W\bar{X} + X\bar{Y}Z$

$F = \bar{B}D + \bar{A}BC + AB\bar{C} + (AD \text{ or } CD)$

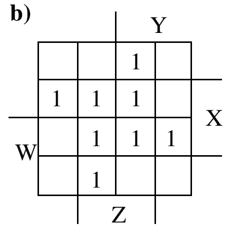
2-18. *

a)



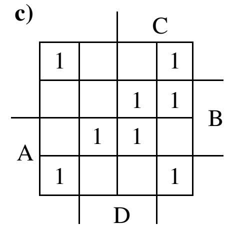
$\Sigma m(3, 5, 6, 7)$

b)



$\Sigma m(3, 4, 5, 7, 9, 13, 14, 15)$

c)



$\Sigma m(0, 2, 6, 7, 8, 10, 13, 15)$

2-19.*

a) $Prime = XZ, WX, \bar{X}\bar{Z}, W\bar{Z}$
$Essential = XZ, \bar{X}\bar{Z}$

b) $Prime = CD, AC, \bar{B}\bar{D}, \bar{A}BD, \bar{B}C$
$Essential = AC, \bar{B}\bar{D}, \bar{A}BD$

c) $Prime = AB, AC, AD, B\bar{C}, \bar{B}D, \bar{C}D$
$Essential = AC, B\bar{C}, \bar{B}D$

2-20.

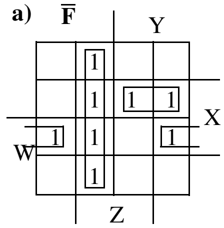
a) $Prime = \bar{X}Y, \bar{X}\bar{Z}, W\bar{Y}\bar{Z}, WX\bar{Y}, X\bar{Y}Z, \bar{W}XZ, \bar{W}YZ$
$Essential = \bar{X}Y, \bar{X}\bar{Z}$
$F = \bar{X}Y + XZ + WX\bar{Y} + \bar{W}XZ$

b) $Prime = \bar{A}B\bar{C}, \bar{A}CD, ABC, A\bar{C}D, BD$
$Essential = \bar{A}B\bar{C}, \bar{A}CD, ABC, A\bar{C}D$
$Redundant = BD$
$F = \bar{A}B\bar{C} + \bar{A}CD + ABC + A\bar{C}D$

c) $Prime = \bar{Y}\bar{Z}, W\bar{Y}, \bar{W}\bar{Z}, WXZ, XYZ, \bar{W}XY$
$Essential = W\bar{Y}, \bar{W}\bar{Z}$
$Redundant = \bar{Y}\bar{Z}$
$F = W\bar{Y} + \bar{W}\bar{Z} + XYZ$

2-21.

a) $\overline{F}$

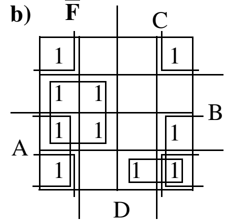


$\overline{F} = \Sigma m(1, 5, 6, 7, 9, 12, 13, 14)$

$F = \overline{\overline{Y}Z + WX\overline{Z} + \overline{W}XY}$

$F = (Y + \overline{Z})(\overline{W} + \overline{X} + Z)(W + \overline{X} + \overline{Y})$

b) $\overline{F}$



$\overline{F} = \Sigma m(0, 2, 4, 5, 8, 10, 11, 12, 13, 14)$

$F = \overline{B\overline{C} + \overline{B}\overline{D} + A\overline{D} + A\overline{B}C}$

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

2-22.*

a) s.o.p. $CD + A\overline{C} + \overline{B}D$
p.o.s. $(\overline{C} + D)(A + D)(A + \overline{B} + C)$

b) s.o.p. $\overline{A}\overline{C} + \overline{B}\overline{D} + A\overline{D}$
p.o.s. $(\overline{C} + \overline{D})(\overline{A} + \overline{D})(A + \overline{B} + \overline{C})$

c) s.o.p. $\overline{B}\overline{D} + \overline{A}BD + (\overline{A}BC \text{ or } \overline{A}C\overline{D})$
p.o.s. $(\overline{A} + \overline{B})(B + \overline{D})(\overline{B} + C + D)$

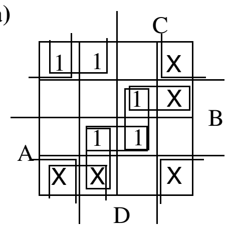
2-23.

a) s.o.p. $\overline{A}\overline{B}\overline{C} + \overline{A}BD + ABC + A\overline{B}\overline{D}$
or $\overline{A}\overline{C}D + BCD + AC\overline{D} + \overline{B}\overline{C}\overline{D}$
p.o.s. $(A + B + \overline{C})(A + \overline{B} + D)(\overline{A} + \overline{B} + C)(\overline{A} + B + \overline{D})$
or $(A + \overline{C} + D)(\overline{B} + C + D)(\overline{A} + C + \overline{D})(B + \overline{C} + \overline{D})$

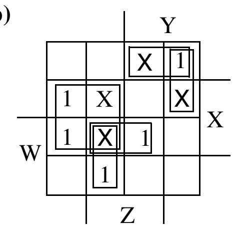
b) s.o.p. $\overline{Z} + \overline{W}X + \overline{X}\overline{Y}$
p.o.s. $(\overline{W} + \overline{X} + \overline{Z})(X + \overline{Y} + \overline{Z})$

2-24.

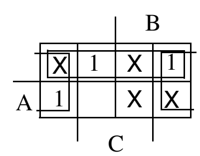
a)



b)



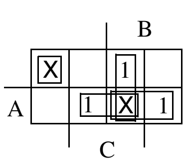
c)



$F = \overline{B}\overline{C} + BCD + ABD$ $\quad F = X\overline{Y} + W\overline{Y}Z + WXZ + (\overline{W}\overline{X}Y \text{ or } \overline{W}Y\overline{Z})$ $\quad F = \overline{A} + \overline{C}$

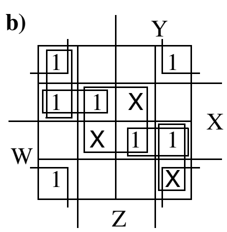
2-25.*

a)



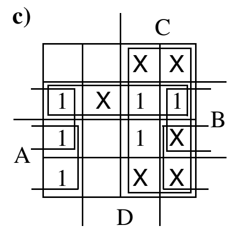
$Primes = AB, AC, BC, \overline{A}\overline{B}\overline{C}$
$Essential = AB, AC, BC$
$F = AB + AC + BC$

b)



$Primes = \overline{X}\overline{Z}, XZ, \overline{W}X\overline{Y}, WXY, \overline{W}\overline{Y}\overline{Z}, WY\overline{Z}$
$Essential = \overline{X}\overline{Z}$
$F = \overline{X}\overline{Z} + \overline{W}X\overline{Y} + WXY$

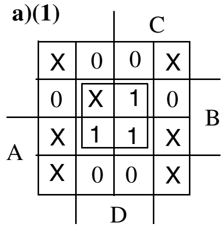
c)



$Primes = \overline{A}B, C, A\overline{D}, B\overline{D}$
$Essential = C, A\overline{D}$
$F = C + A\overline{D} + (B\overline{D} \text{ or } \overline{A}B)$

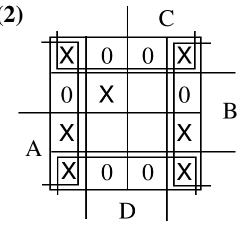
2-26.

a)(1)



$F = BD$

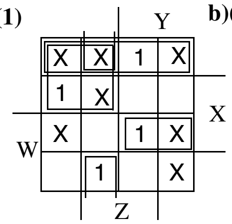
a)(2)



$\overline{F} = \overline{B} + \overline{D}$

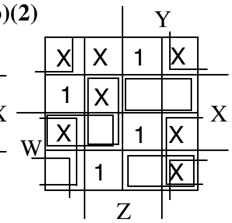
$F = BD$

b)(1)



$F = \overline{W}\,\overline{X} + \overline{W}\,\overline{Y} + \overline{X}\,\overline{Y}Z + WXY$

b)(2)

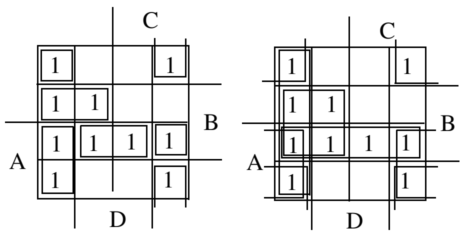


$\overline{F} = (W\overline{Z} \text{ or } \overline{X}\,\overline{Z}) + \overline{W}XY + W\overline{X}Y + (WX\overline{Y} \text{ or } X\overline{Y}Z)$

$F = ((\overline{W} + Z) \text{ or } (X + Z))(W + \overline{X} + \overline{Y})(\overline{W} + X + \overline{Y}) + (\overline{W} + \overline{X} + Y) \text{ or } (\overline{X} + Y + \overline{Z})$

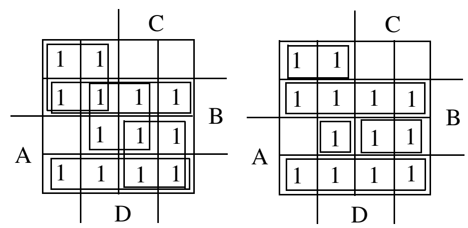
2-27.

a) $F = \overline{A}\,\overline{B}\,\overline{C}\,\overline{D} + \overline{A}B\overline{C} + A\overline{C}\,\overline{D} + ABD + ABC\overline{D} + \overline{B}C\overline{D}$



There are other solutions depending on how ties are resolved.

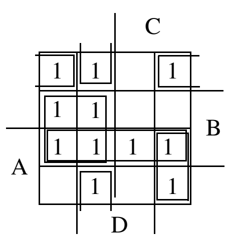
b) $F = \overline{A}\,\overline{C} + \overline{A}B + BD + AC + A\overline{B}$



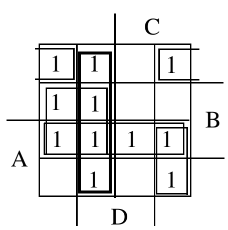
There are other solutions depending on how ties are resolved.

2-28.+

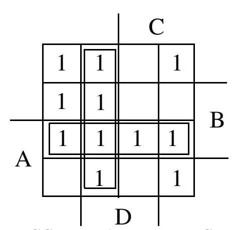
$F = \overline{A}\,\overline{B}\,\overline{D} + \overline{B}\,\overline{C}D + B\overline{C} + AB + AC\overline{D}$



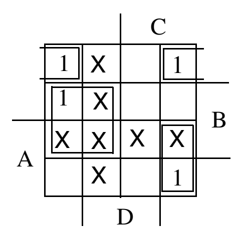
F and **F**; Cost = 18



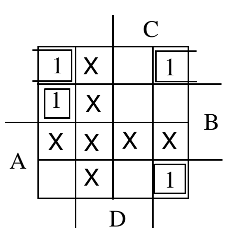
EXPAND



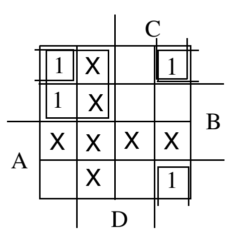
ESSENTIAL PRIMES



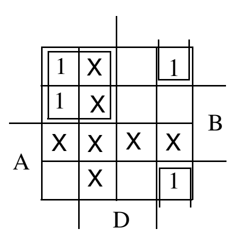
IRREDUNDANT COVER; Cost = 17



REDUCE



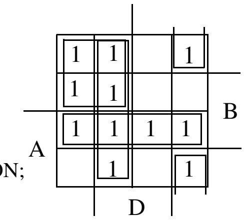
EXPAND



IRREDUNDANT COVER; Cost = 13

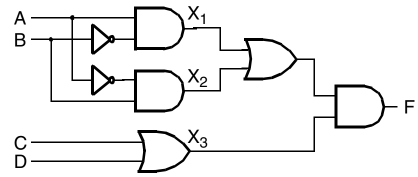
REDUCE, EXPAND, IRREDUNDANT COVER, and LAST GASP produce no lasting changes.

FINAL SOLUTION; Cost = 13

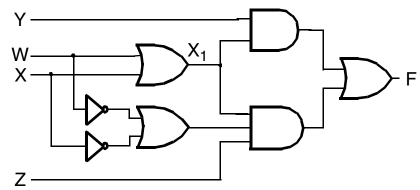


2-29.

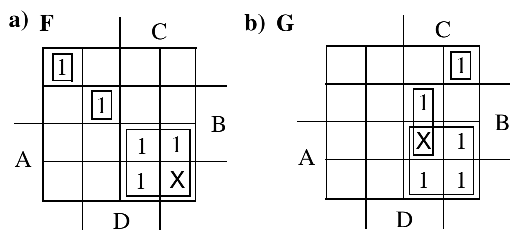
a)
$$
\begin{aligned}
F &= A\bar{B}C + \bar{A}BC + A\bar{B}D + \bar{A}BD \\
X_1 &= A\bar{B} \\
X_2 &= \bar{A}B \\
F &= X_1C + X_1D + X_2C + X_2D \\
&= (X_1 + X_2)(C + D) \\
X_3 &= C + D \\
F &= (X_1 + X_2)X_3
\end{aligned}
$$



b)
$$
\begin{aligned}
F &= WY + XY + \bar{W}XZ + W\bar{X}Z \\
&= (W + X)Y + (\bar{W}X + W\bar{X})Z \\
&= (W + X)Y + (W + X)(\bar{W} + \bar{X})Z \\
X_1 &= W + X \\
F &= X_1Y + X_1(\bar{W} + \bar{X})Z
\end{aligned}
$$



2-30.



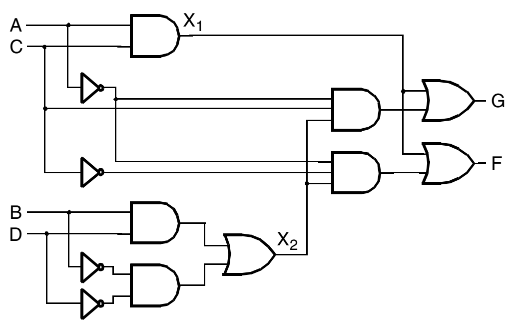
$$
\begin{aligned}
F &= AC + \bar{A}B\bar{C}D + \bar{A}\bar{B}\bar{C}\bar{D} \\
&= AC + \bar{A}\bar{C}(BD + \bar{B}\bar{D})
\end{aligned}
$$

$$
\begin{aligned}
G &= AC + BCD + \bar{A}\bar{B}C\bar{D} \\
&= AC + (ABCD + \bar{A}BCD) + \bar{A}\bar{B}C\bar{D} \\
&= AC + \bar{A}C(BD + \bar{B}\bar{D})
\end{aligned}
$$

$$
\begin{aligned}
X_1 &= AC \\
X_2 &= BD + \bar{B}\bar{D}
\end{aligned}
$$

$$F = X_1 + \bar{A}\bar{C}X_2$$

$$G = X_1 + \bar{A}CX_2$$



2-31.

a)
$$
\begin{aligned}
F &= AB(\overline{C\bar{D} + \bar{C}D}) + \bar{B}(C\bar{D} + \bar{C}D) + \bar{A}(\overline{B + CD}) \\
&= AB(\bar{C} + D)(C + \bar{D}) + \bar{B}(C\bar{D} + \bar{C}D) + \bar{A}(\bar{B}(\bar{C} + \bar{D})) \\
&= AB\bar{C}\bar{D} + ABCD + \bar{B}C\bar{D} + \bar{B}\bar{C}D + \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}\bar{D}
\end{aligned}
$$

b)
$$
\begin{aligned}
T &= YZ(W + \bar{X}) + \bar{Y}\bar{Z}(\bar{W}Y + X) \\
&= WYZ + \bar{X}YZ + X\bar{Y}\bar{Z}
\end{aligned}
$$

2-32.*

$$X \oplus Y = X\bar{Y} + \bar{X}Y$$

$$\text{Dual }(X \oplus Y) = \text{Dual }(X\bar{Y} + \bar{X}Y)$$

$$= (X + \bar{Y})(\bar{X} + Y)$$

$$= \overline{\bar{X}Y + X\bar{Y}}$$

$$= \overline{X\bar{Y} + \bar{X}Y}$$

$$= \overline{X \oplus Y}$$

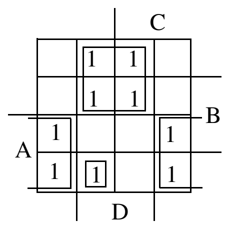
2-33.

$$AB\bar{C}D + A\bar{D} + \bar{A}D = AB\bar{C}D + (A \oplus D)$$

Note that $X + Y = (X \oplus Y) + XY$

Letting $X = AB\bar{C}D$ and $Y = A \oplus D$,

We can observe from the map below or determine algebraically that XY is equal to 0.



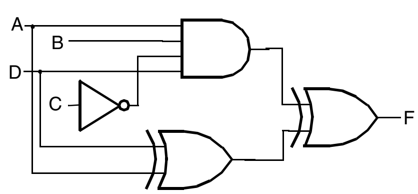
For this situation,

$$X + Y = (X \oplus Y) + XY$$

$$= (X \oplus Y) + 0$$

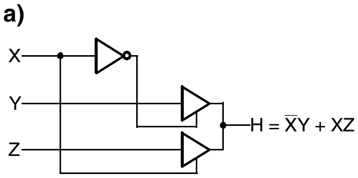
$$= X \oplus Y$$

So, we can write $F(A, B, C, D) = X \oplus Y = AB\bar{C}D \oplus (A \oplus D)$

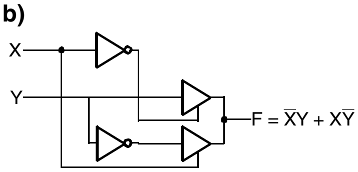


2-34.

a)

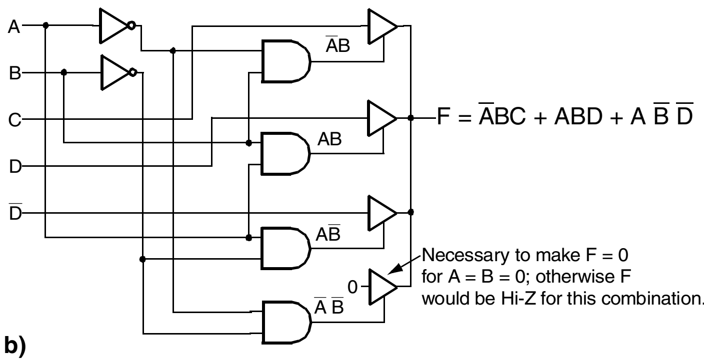


b)



2-35.

a)



b)

There are no three-state output conflicts.