CHAPTER 2

2.1 **(a)**

$x\,y\,z$	$x + y + z$	$(x + y + z)'$	x'	y'	z'	$x'y'z'$
0 0 0	0	1	1	1	1	1
0 0 1	1	0	1	1	0	0
0 1 0	1	0	1	0	1	0
0 1 1	1	0	1	0	0	0
1 0 0	1	0	0	1	1	0
1 0 1	1	0	0	1	0	0
1 1 0	1	0	0	0	1	0
1 1 1	1	0	0	0	0	0

$x\,y\,z$	(xyz)	$(xyz)'$	x'	y'	z'	$x' + y' + z'$
0 0 0	0	1	1	1	1	1
0 0 1	0	1	1	1	0	1
0 1 0	0	1	1	0	1	1
0 1 1	0	1	1	0	0	1
1 0 0	0	1	0	1	1	1
1 0 1	0	1	0	1	0	1
1 1 0	0	1	0	0	1	1
1 1 1	1	0	0	0	0	0

(b)

$x\,y\,z$	$(xy + z)$	$(x + z)$	$(y + z)$	$(x + z)(y + z)$
0 0 0	0	0	0	0
0 0 1	1	1	1	1
0 1 0	0	0	1	0
0 1 1	1	1	1	1
1 0 0	0	1	0	0
1 0 1	1	1	1	1
1 1 0	1	1	1	1
1 1 1	1	1	1	1
1 1	1 1	1	1 1	

(c)

$x\,y\,z$	$x(y + z)$	xy	xz	$xy + xz$
0 0 0	0	0	0	0
0 0 1	0	0	0	0
0 1 0	0	0	0	0
0 1 1	0	0	0	0
1 0 0	0	0	0	0
1 0 1	1	0	1	1
1 1 0	1	1	0	1
1 1 1	1	1	1	1

(d)

$x\,y\,z$	x	$y + z$	$x + (y + z)$	$(x + y)$	$(x + y) + z$
0 0 0	0	0	0	0	0
0 0 1	0	1	1	0	1
0 1 0	0	1	1	1	1
0 1 1	0	1	1	1	1
1 0 0	1	0	1	1	1
1 0 1	1	1	1	1	1
1 1 0	1	1	1	1	1
1 1 1	1	1	1	1	1

(e)

xyz	yz	$x(yz)$	xy	$(xy)z$
0 0 0	0	0	0	0
0 0 1	0	0	0	0
0 1 0	0	0	0	0
0 1 1	1	0	0	0
1 0 0	0	0	0	0
1 0 1	0	0	0	0
1 1 0	0	0	1	0
1 1 1	1	1	1	1

2.2 **(a)** $x'y' + x'y = x'(y' + y) = x'$

(b) $(x' + y)(x' + y') = x' + x'y' + x'y + yy' = x'$

(c) $x'y'z + xy'z + yz = y'z + yz = z$

(d) $(A + B)'(A' + B')' = (A'B')(A\,B) = (A'B')(BA) = A'(B'B)A = 0$

(e) $(a + b + c')(a'b' + c) = aa'b' + ac + ba'b' + bc + c'a'b' + c'c = ac + bc + a'b'c'$

(f) $a'b'c + ab'c + abc + a'bc = b'c + bc = c$

2.3 **(a)** $A'B'C + AB'C + BC = B'C + BC = C$

(b) $x'y'z' + y'z = y'(x'z' + z) = y'(x' + z) = x'y' + y'z$

(c) $(x + y)'(x' + y') = x'y'(x' + y') = x'y'$

(d) $x'y'z' + w'x'yz' + wx'yz' = x'z'(y' + w'y) + wx'yz' = x'z'(y' + w'y + wy) = x'z'$

(e) $(BC' + A'D)(AB' + CD') = BC'AB' + BC'CD' + A'DAB' + A'DCD' = 0$

(f) $(a + c)(a' + b + c)(a' + b' + c) = (ab + ac + a'c + bc + c)(a' + b' + c)$
$= (ab + c)(a' + b' + c) = abc + a'c + b'c + c$
$= abc + c(a'+b'+1)$
$= c$

2.4 **(a)** $A'C' + ABC + AC = A'C' + AC(B + 1) = A'C' + AC = (A \text{ XNOR } C)$

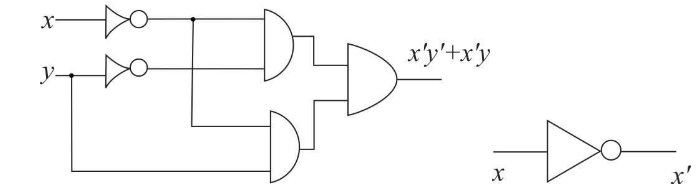
(b) $(x'y' + z)' + z + xy + wz = (x'y')'z' + z + xy + wz = [(x + y)z' + z] + xy + wz$
$= (z + z')(z + x + y) + xy + wz = z + wz + x + xy + y$
$= z(1 + w) + x(1 + y) + y = x + y + z$

(c) $A'B(D' + C'D) + B(A + A'CD) = B(A'D' + A'C'D + A + A'CD) = B(A'D' + A + A'D(C + C')$
$= B(A + A'(D' + D)) = B(A + A') = B$

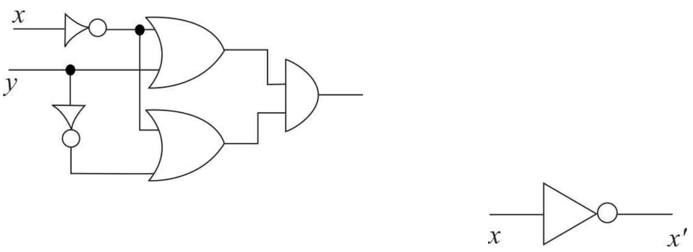
(d) $(A' + C)(A' + C')(A + B + C'D) = (A' + CC')(A + B + C'D)$
$= A'(A + B + C'D) = AA' + A'B + A'C'D = A'(B + C'D)$

(e) $A'BD' + ABC'D' + ABCD' = BD'(A' + AC' + AC)$
$= BD'$

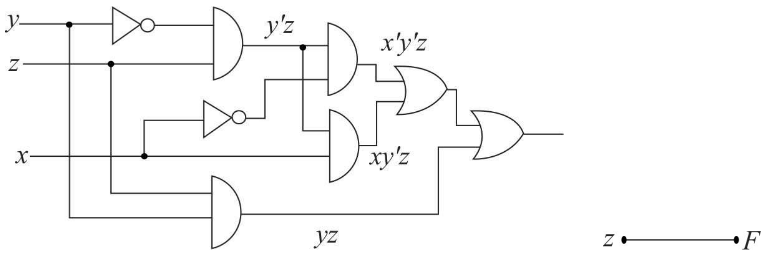
2.5 **(a)** $x'y' + x'y = x'$



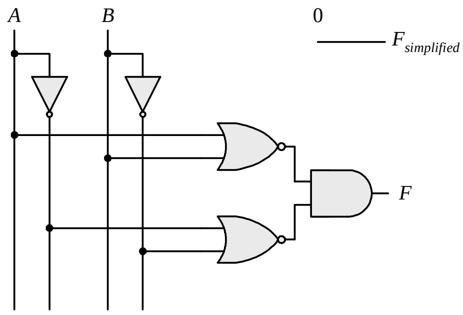
(b) $(x' + y)(x' + y') = x'$



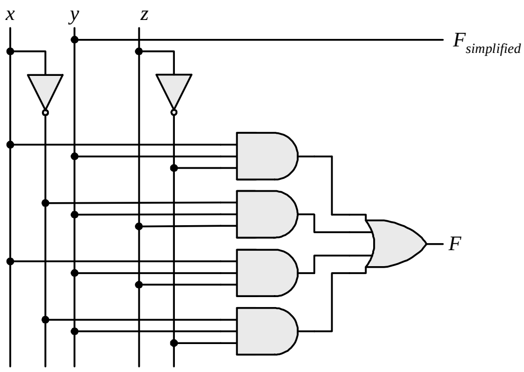
(c) $x'y'z + xy'z + yz = z$



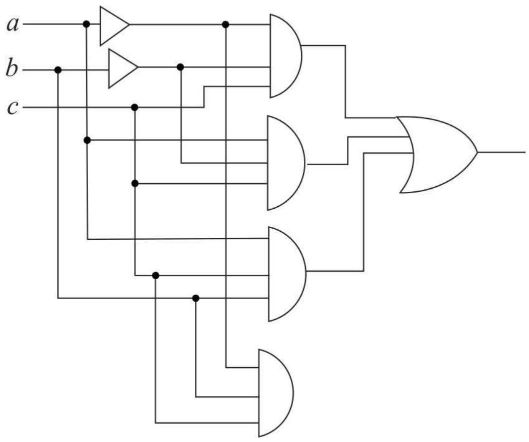
(d)



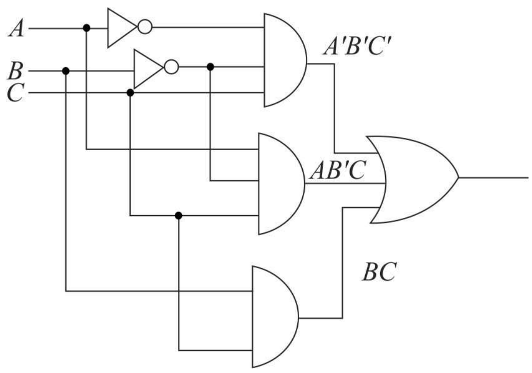
(e)



(f) $a'b'c + ab'c + abc + a'bc = c$

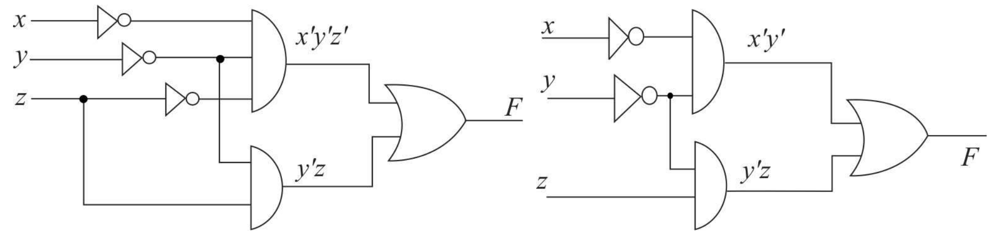


2.6 **(a)** $A'B'C + AB'C + BC = C$

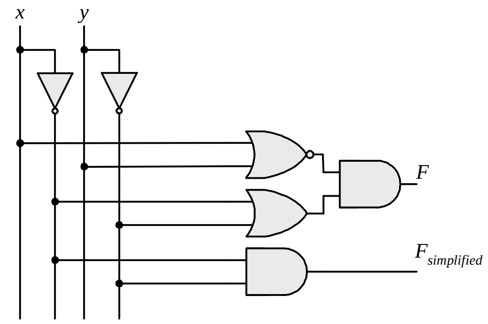


Simplified diagram is same as 2.6 (f) simplified diagram, $F = C$.

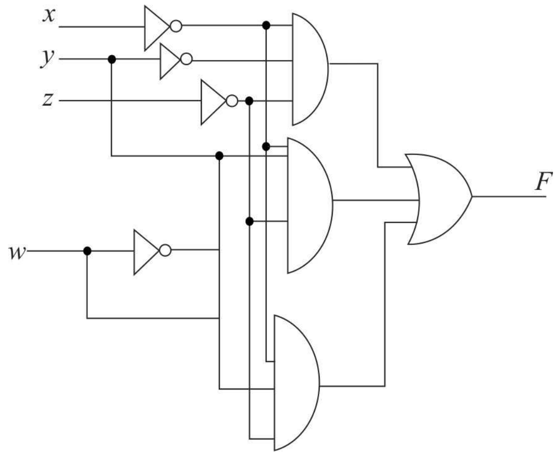
(b) $x'y'z' + y'z = x'y' + y'z = F$

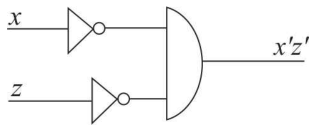


(c)

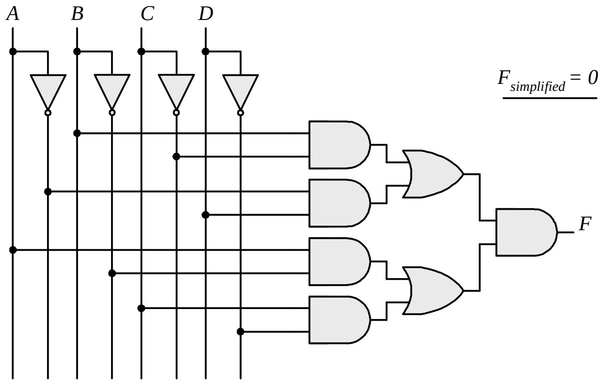


(d) $x'y'z' + w'x'yz' + wx'yz' = x'z' = F$

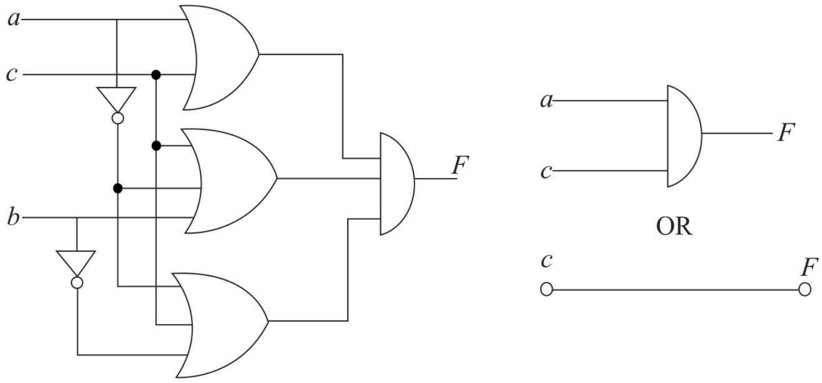




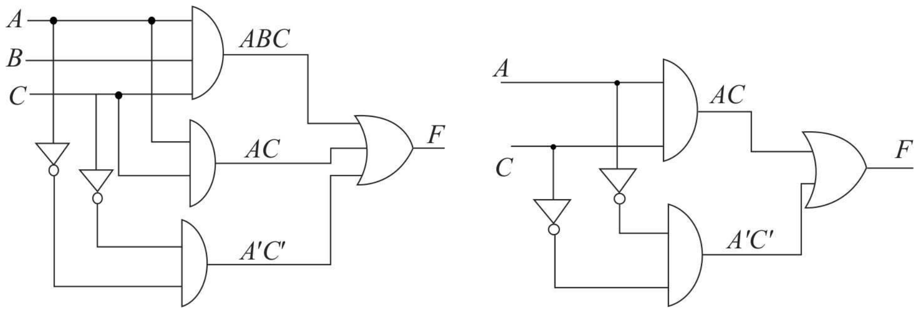
(e)



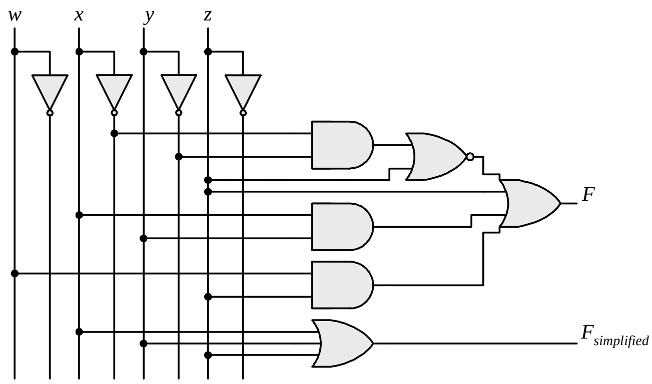
(f) $(a + c)(a' + b + c)(a' + b' + c) = C = F$



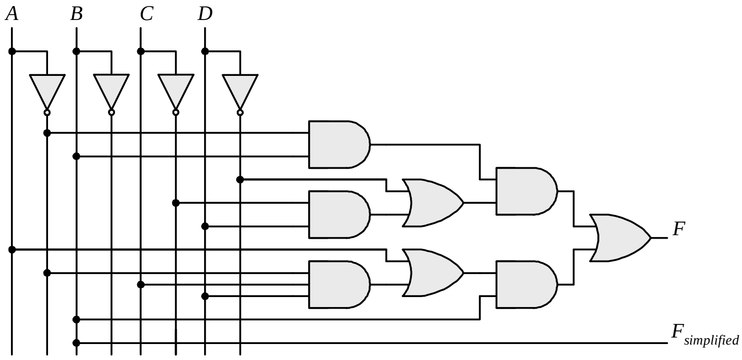
2.7 **(a)** $A'C' + ABC + AC = A'C' + AC = F$



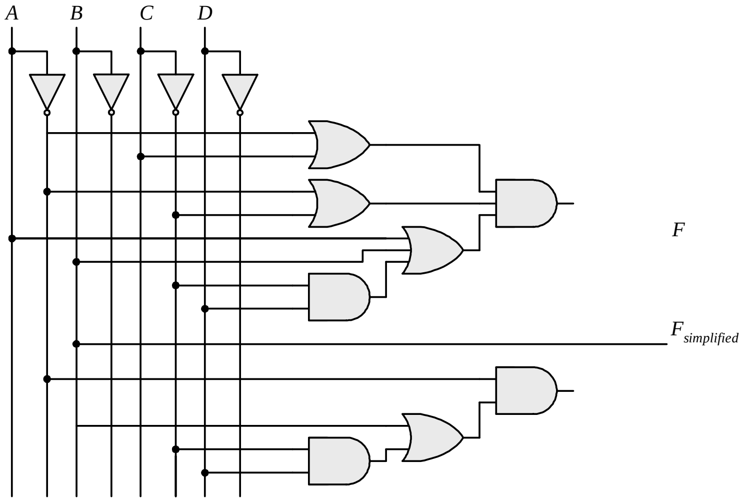
(b)



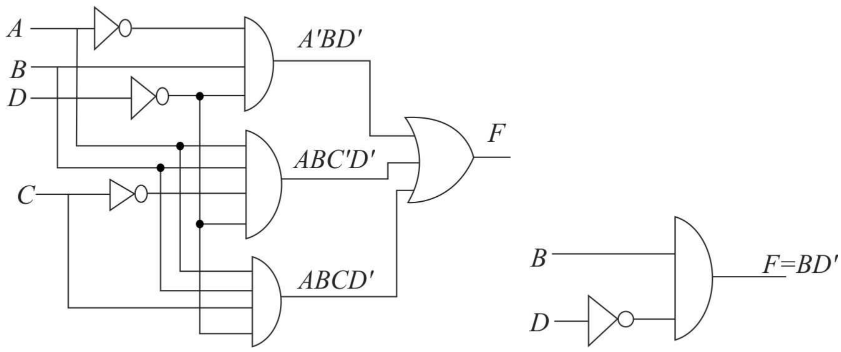
(c)



(d)



(e) $A'BD' + ABC'D' + ABCD' = BD' = F$



2.8

$F = AC + BD$

$F' = (AC + BD)' = (AC)'(BD)' = (A' + C')(B' + D')$

$F.F' = (AC + BD)(AC)'(BD)'$

$= (AC)(AC)' + (BD)(BD)'$

$= ((AC) + (AC)')' + ((BD) + (BD)')'$

$= (1)' + (1)'$ because, $(AC) + (AC)' = 1$ and $(BD) + (BD)' = 1$

$= 0$

$F + F' = (AC + BD) + (A' + C')(B' + D')$

$= ((AC)'(BD)')' + (AC)'(BD)'$
$= X' + X$ Assume: $(AC)'(BD)' = X$
$= (X.X')' = (0)'$ because, $X.X' = 0$
$= 1$

2.9 **(a)** $F = x'y' + xy$
$F' = (x'y' + xy)' = (x'y')'(xy)' = (x + y)(x' + y') = xy' + x'y$

(b) $F = ac + ab' + a'bc'$
$F' = (ac + ab' + a'bc')'$
$= (ac)'(ab')'(a'bc')'$
$= (a' + c')(a' + b)(a + b' + c)$
$= (a' + a'b + a'c' + bc')(a + b' + c)$
$= (a'(1 + b + c') + bc')(a + b' + c)$
$= (a' + bc')(a + b' + c)$
$= (a' + bc')(a + (bc')')$
$= (a' + x)(a + x')$ assume: $bc' = x$
$= a'x' + ax$
$= (a \text{ xnor } x) = (a \text{ xnor } bc')$

(c) $F' = [z + z'(v'w + xy)]' = z'[z'(v'w + xy)]'$
$= z'[z'v'w + xyz']' = z'[(z'v'w)'(xyz')']$
$= z'[(z + v + w') + (x' + y' + z)]$
$= z'z + z'v + z'w' + z'x' + z'y' + z'z$
$= z'(v + w' + x' + y')$

(d) $F = (B + C')(A + C')(B' + C')$
$F' = B'C + A'C + BC = A'C + C = C(1 + A') = C$

2.10 **(a)** $F_1 + F_2 = \Sigma m_{1i} + \Sigma m_{2i} = \Sigma(m_{1i} + m_{2i})$

(b) $F_1 F_2 = \Sigma m_i \Sigma m_j$ where $m_i m_j = 0$ if $i \neq j$ and $m_i m_j = 1$ if $i = j$

2.11 **(a)** $F = y'z' + x'y' + xz + x'z$
$= x'y'z' + xy'z' + x'y'z' + x'y'z + xyz + xy'z + x'yz + x'y'z$
$= x'y'z' + x'y'z + x'yz + xy'z' + xy'z + xyz$

$F(x, y, z) = \Sigma(0, 1, 3, 4, 5, 7)$

x	y	z	F
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1

(b) $F = ac + bc' = abc + ab'c + abc' + a'bc'$

$F(a, b, c) = \Sigma(2, 5, 6, 7)$

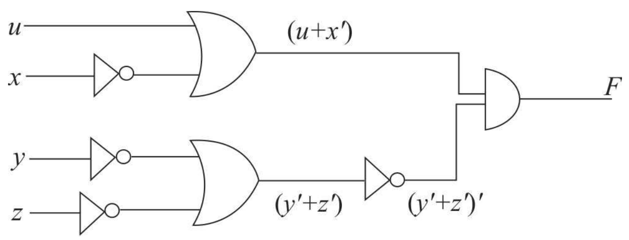
a	b	c	F
0	0	0	0
0	0	1	0

0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

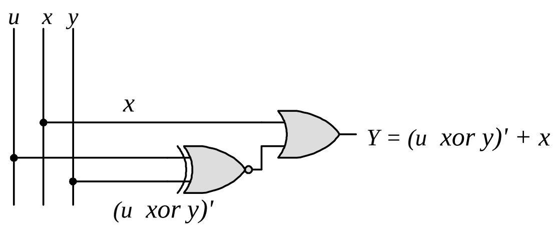
2.12 A = 10110001
B = 00001110

(a) A AND B = 00000000
(b) A OR B = 10111111
(c) A XOR B = 10111111
(d) NOT B = 11110001
(e) NOT A = 01001110
(f) A NAND B = 11111111
(g) A NOR B = 01000000

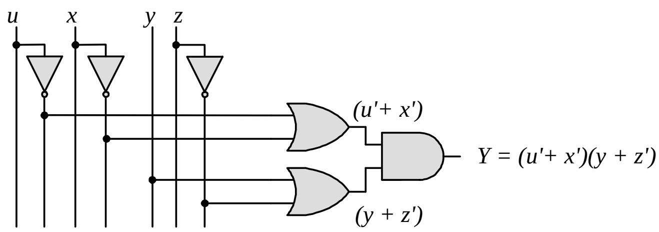
2.13 **(a)** $F = (u + x')(y' + z')'$



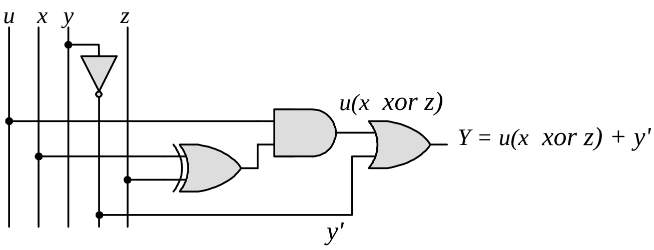
(b)



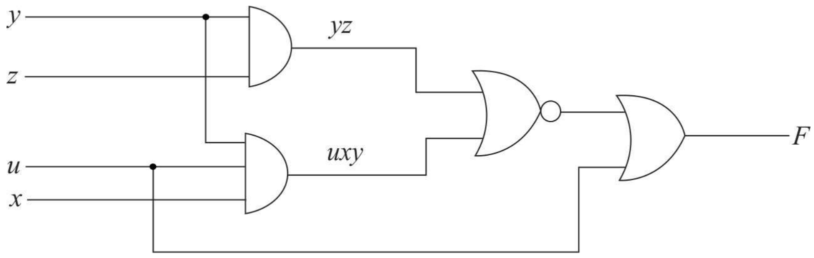
(c)



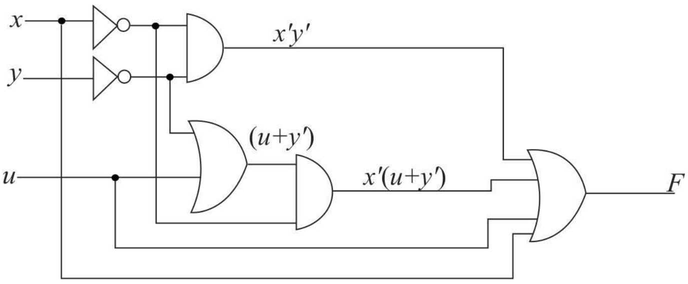
(d)



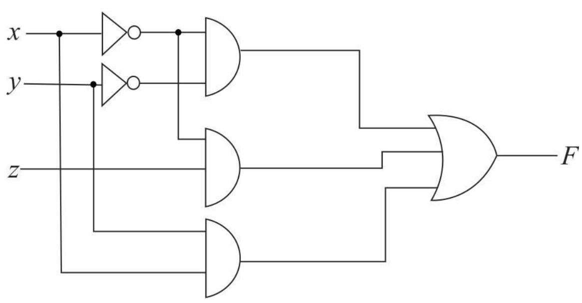
(e) $F = u + (yz + uxy)'$



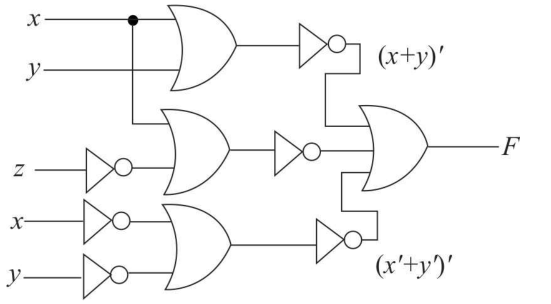
(f) $F = u + x + x'(u + y') + x'y'$



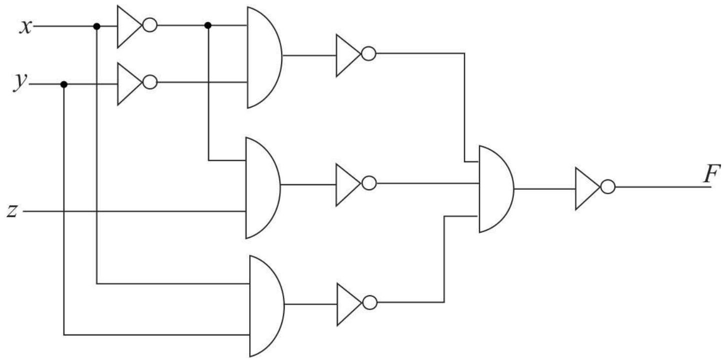
2.14 **(a)** $F = x'y' + x'z + xy$



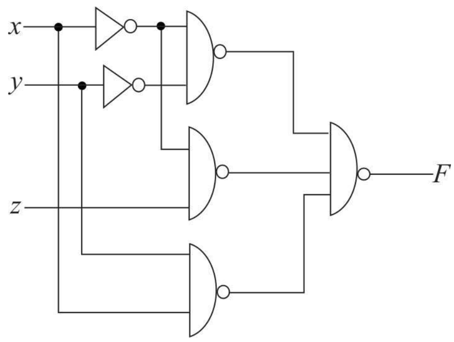
(b) $F = x'y' + x'z + xy = (x + y)' + (x + z')' + (x' + y')'$



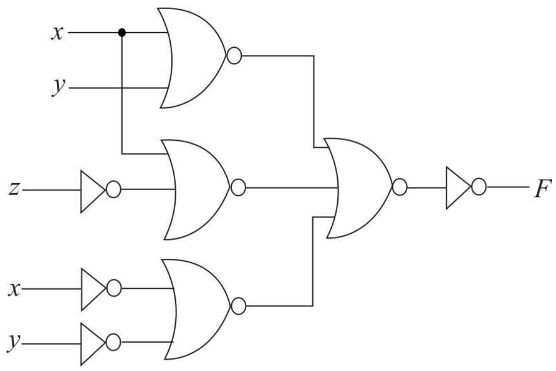
(c) $F = x'y' + x'z + xy = [(x'y')'(x'z)'(xy)']'$



(d) $F = x'y' + x'z + xy = [(x'y')'(x'z)'(xy)']'$



(e) $F = x'y' + x'z + xy = (x + y)' + (x + z')' + (x' + y')'$



2.15 $T_1 = A'BC' + A'BC + AB'C' + AB'C = A'B + AB' = A \oplus B$

$T_2 = A'B'C' + A'B'C + ABC' + ABC = A'B' + AB = (A \oplus B)'$

2.16 **(a)** Logical product of all the 3 variable maxterms can be written as,

$F(a, b, c) = M_7.M_6.M_5.M_4.M_3.M_2.M_1.M_0$
$= m_7'.m_6'.m_5'.m_4'.m_3'.m_2'.m_1'.m_0'$ because; $mi' = Mi$
$= (m_7 + m_6 + m_4 + m_3 + m_2 + m_1 + m_0)'$
$= ((a' + a)\ (b'c' + b'c + bc' + bc))'$
$= ((b' + b)\ (c' + c))'$ because; $a + a' = 1$
$= (1)'$
$= 0$

OR

$= M_7.M_6.M_5.M_4.M_3.M_2.M_1.M_0$
$= (a + b + cc')\ (a + b' + cc')\ (a' + b + cc')\ (a' + b' + cc')$
$= (a + bb')\ (a' + bb')$ because; $cc' = 0$ & $(a + b)\ (a + b') = a + bb'$
$= aa'$
$= 0$

(b) Logical product of all n variable maxterms can be written as,

$= \Sigma(Mi\ Mi')$ for, $i = 0, 1, \ldots, (2^n - 1)$
$= M_0\ M_0' + M_1\ M_1' + M_2\ M_2' + \ldots\ldots + M_2^{\,n-1}\ M_2^{\,n-1}{}'$
$= 0 + 0 + \ldots + 0$ because, $X.X' = 0$
$= 0$

2.17 **(a)** $(b + c'd)(a' + cd') = a'b + bcd' + a'c'd + 0$
$= a'b\ (c + c')(d + d') + (a + a')bcd' + a'(b + b')c'd$
$= \Sigma(1, 4, 5, 6, 7, 14) = \pi(0, 2, 3, 8, 9, 10, 11, 12, 13, 15)$

(b) $(ad + b'c + bd')(b + d) = abd + bd' + ad + b'cd$
$= ab(c + c')d + (a + a')b\ (c+c')d' + a(b + b')(c + c')d + (a + a')b'cd$
$= \Sigma(3, 4, 6, 9, 11, 12, 13, 14, 15)$
$= \pi(0, 1, 2, 5, 7, 8, 10)$

(c) $(b + d)(b + d')(a+c) = (aa' + b + cc' + d)(aa' + b + cc' + d')(a + bb' + c + dd')$
$= \Sigma(6, 7, 12, 13, 14, 15) = \pi(0, 1, 3, 4, 5, 8, 9, 11, 10, 2)$

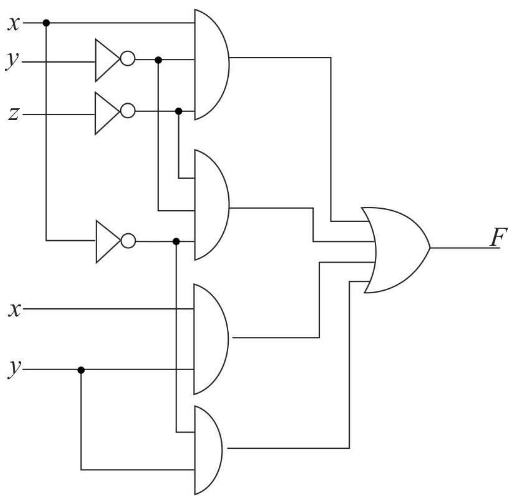
(d) $ad + bcd + ab'c' + b'c'd' = a(b + b')(c + c')d + (a + a')bcd + ab'c'\ (d + d') + (a + a')b'c'd'$
$= axyd + xbcd + ab'c'x + xb'c'd' = 1x41 + x111 + 100x + x000$
$= \Sigma(0, 7, 8, 9, 11, 13, 15) = \pi(1, 2, 3, 4, 5, 6, 10, 12, 14)$

2.18 $F = xy'z' + x'y'z' + xy + x'y = xy'z' + x'y'z' + xyz + xyz' + x'yz + x'yz' = \Sigma(0, 2, 3, 4, 6, 7)$

(a)

x	y	z	F
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	1

(b)



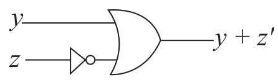
(c) $F = xy'z' + x'y'z' + xy + x'y = y'z' + y = y + z'$

(d)

x	y	z	(a)	(d)
0	0	0	1	1
0	0	1	0	0
0	1	0	1	1
0	1	1	1	1
1	0	0	1	1
1	0	1	0	0
1	1	0	1	1
1	1	1	1	1

Hence, (a) = (d).

(e)



Total number of gates is = 2(1 – NOT and 1 – OR)
Total number of gates as per (b) are = 8(3 – NOT, 4 – AND and 1 – OR)

2.19 $F(A, B, C, D) = B'D + A'D + BD + BCD$

= _ 0 _ 1 + 0 _ _ 1 + _ B _ D + _ B C D

_ 0 _ 1 → 0001(1), 0011(3), 1001(9), 1011(11)

0 _ _1 → 0001(1), 0011(3), 0101(5), 0111(7)

_ 1 _ 1 → 0101(5), 0111(7), 1101(13), 1111(15)

_1 1 1 → 0111(7), 1111(15)

$= \Sigma(1, 3, 5, 7, 9, 11, 13, 15)$

$= \pi(0, 2, 4, 6, 8, 10, 12, 14)$

2.20 **(a)** $F(A, B, C, D) = \Sigma(0, 3, 5, 7, 9, 11, 13)$
$F'(A, B, C, D) = \Sigma(1, 2, 4, 6, 8, 10, 12, 14, 15)$

(b) $F(x, y, z) = \pi(2, 4, 6, 8)$
$F'(x, y, z) = \Sigma(2, 4, 6, 8)$

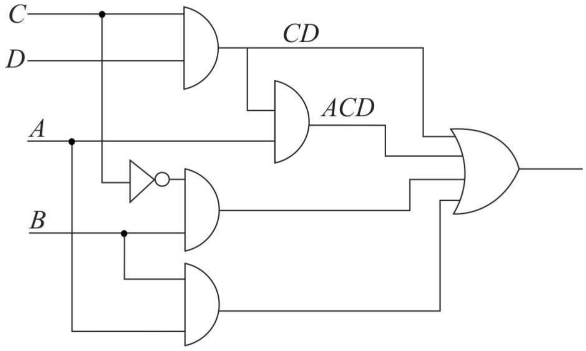
2.21 **(a)** $F(w, x, y, z) = \Sigma(1, 3, 5, 7, 9) = \pi(0, 2, 4, 6, 8, 10, 11, 12, 13, 14, 15)$

(b) $F(A, B, C, D) = \pi(3, 5, 8, 11, 13, 15) = \Sigma(0, 1, 2, 4, 6, 7, 9, 10, 12, 14)$

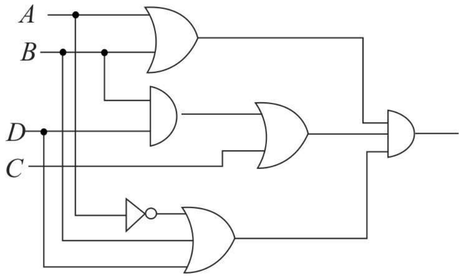
2.22 **(a)** $(u + x'w)(x + u'v) = ux + x'wu'v$ → (SOP form)
$= (u + x'wu'v)(x + x'wu'v)$
$= (u + x')(u + w)(u + v)(x + w)(x + u')(x + v)$ → (POS form)

(b) $x' + z(x + y')(y + z') = x' + (xz + zy')(y + z') = x' + xyz$
$= x' + yz$ → SOP form
$= (x' + y)(x' + z)$ → POS form

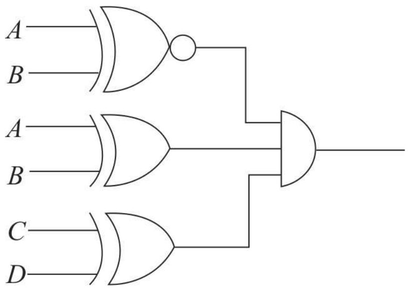
2.23 **(a)** $BC' + AB + ACD + CD$



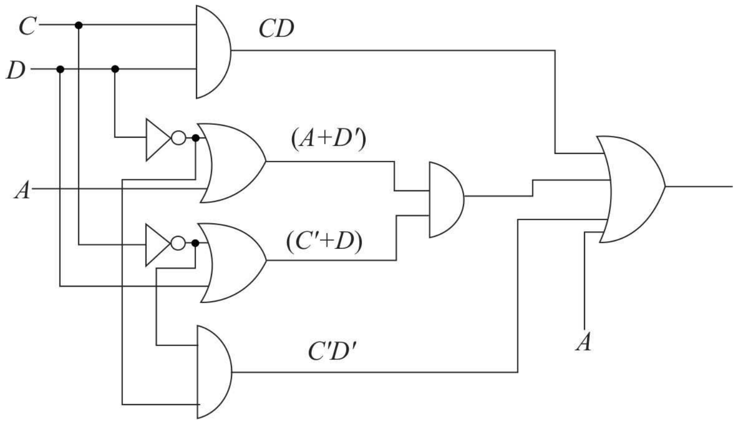
(b) $(A + B)(C + BD)(A' + B + D)$



(c) $(AB + A'B')(CD' + C'D)(A'B + AB')$



(d) $A + CD + (A + D')(C' + D) + C'D'$



2.24 $x \oplus y = x'y + xy'$ *and* $(x \oplus y)' = (x + y')(x' + y)$

Dual of $x'y + xy' = (x' + y)(x + y') = (x \oplus y)'$

2.25 **(a)** $x | y = xy' \neq y | x = x'y$ Not commutative

$(x | y) | z = xy'z' \neq x | (y | z) = x(yz')' = xy' + xz$ Not associative

(b) $(x \oplus y) = xy' + x'y = y \oplus x = yx' + y'x$ Commutative

$(x \oplus y) \oplus z = \Sigma(1, 2, 4, 7) = x \oplus (y \oplus z)$ Associative

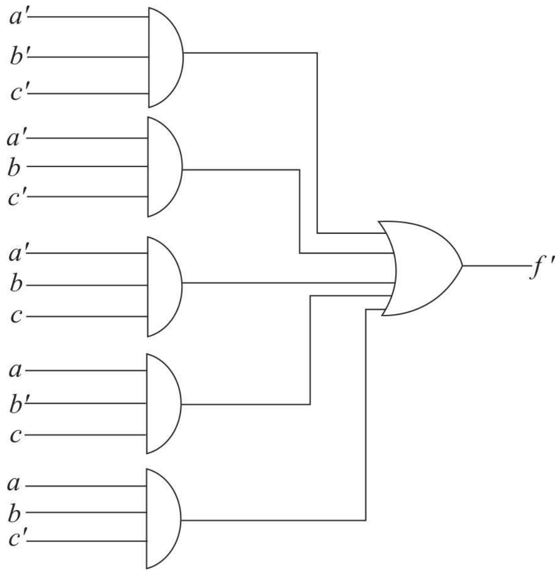
2.26 NOR (+ve logic) NAND (−ve logic)

$x \quad y \quad z$ $x \quad y \quad z$

0	0	1	0	0	1
0	1	0	0	1	1
1	0	0	1	0	1
1	1	0	1	1	0

In positive logic LOW = 0 HIGH = 1
In negative logic LOW = 1 HIGH = 0

2.27 $f_1 = \Sigma(0, 2, 3, 5, 6)$
$f_1(a, b, c) = a'b'c' + a'bc' + a'bc + ab'c + abc'$



2.28 **(a)** $y = a(bcd)'e = a(b' + c' + d')e$

$y = a(b' + c' + d')e = ab \quad + ac \quad + ad$
$= \Sigma(17, 19, 21, 23, 25, 27, 29)$

a bcde	y	a bcde	y
0 0000	0	1 0000	0
0 0001	0	**1 0001**	1
0 0010	0	1 0010	0
0 0011	0	**1 0011**	1
0 0100	0	1 0100	0
0 0101	0	**1 0101**	1
0 0110	0	1 0110	0
0 0111	0	**1 0111**	1
	0		0
0 1000	0	1 1000	0
0 1001	0	**1 1001**	1
0 1010	0	1 1010	0
0 1011	0	**1 1011**	1
0 1100	0	1 1100	0
0 1101	0	**1 1101**	1
0 1110	0	1 1110	0
0 1111	0	1 1111	0

(b) $y_1 = a \oplus (c + d + e) = a'(c + d + e) + a(c'd'e') = a'c + a'd + a'e + ac'd'e'$

$y_2 = b'(c + d + e)f = b'cf + b'df + b'ef$

$y_1 = a \ (c + d + e) = a'(c + d + e) + a(c'd'e') = a'c + a'd + a'e + ac'd'e'$

$y_2 = b'(c + d + e)f = b'cf + b'df + b'ef$

a'-c---	*a'--d--*	*a'---e-*	*a-c'd'e'-*
001000 = 8	000100 = 8	000010 = 2	100000 = 32
001001 = 9	000101 = 9	000011 = 3	100001 = 33
001010 = 10	000110 = 10	000110 = 6	110000 = 34
001011 = 11	000111 = 11	000111 = 7	110001 = 35
001100 = 12	001100 = 12	001010 = 10	
001101 = 13	001101 = 13	001011 = 11	
001110 = 14	001110 = 14	001110 = 14	
001111 = 15	001111 = 15	001111 = 15	
011000 = 24	010100 = 20	010010 = 18	
011001 = 25	010101 = 21	010011 = 19	
011010 = 26	010110 = 22	010110 = 22	
011011 = 27	010111 = 23	010111 = 23	
011100 = 28	011100 = 28	011010 = 26	
011101 = 29	011101 = 29	011001 = 27	
011110 = 30	011110 = 30	011110 = 30	
011111 = 31	011111 = 31	011111 = 31	

-b' c--f	-b' -d-f	-b' --ef
001001 = 9	001001 = 9	000011 = 3
001011 = 11	001011 = 11	000111 = 7
001101 = 13	001101 = 13	001011 = 11
001111 = 15	001111 = 15	001111 = 15
101001 = 41	101001 = 41	100011 = 35
101011 = 43	101011 = 43	100111 = 39
101101 = 45	101101 = 45	101011 = 51
101111 = 47	101111 = 47	101111 = 55

$y_1 = \Sigma$ (2, 3, 6, 7, 8, 9, 10 ,11, 12, 13, 14, 15, 18, 19, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35)

$y_2 = \Sigma$ (3, 7, 9, 13, 15, 35, 39, 41, 43, 45, 47, 51, 55)

ab cdef	y_1 y_2	*ab cdef*	y_1 y_2	*ab cdef*	y_1 y_2	*ab cdef*	y_1 y_2
00 0000	0 0	01 0000	0 0	10 0000	1 0	11 0000	0 0
00 0001	0 0	01 0001	0 0	10 0001	1 0	11 0001	0 0
00 0010	1 0	01 0010	1 0	10 0010	1 0	11 0010	0 0
00 0011	1 1	01 0011	1 0	10 0011	1 1	11 0011	0 1
00 0100	0 0	01 0100	0 0	10 0100	0 0	11 0100	0 0
00 0101	0 0	01 0101	0 0	10 0101	0 0	11 0101	0 0
00 0110	1 0	01 0110	1 0	10 0110	0 0	11 0110	0 0
00 0111	1 1	01 0111	1 0	10 0111	0 1	11 0111	0 1
00 1000	1 0	01 1000	1 0	10 1000	0 0	11 1000	0 0
00 1001	1 1	01 1001	1 0	10 1001	0 1	11 1001	0 0
00 1010	1 0	01 1010	1 0	10 1010	0 0	11 1010	0 0
00 1011	1 0	01 1011	1 0	10 1011	0 1	11 1011	0 0
00 1100	1 0	01 1100	1 0	10 1100	0 0	11 1100	0 0
00 1101	1 1	01 1101	1 0	10 1101	0 1	11 1101	0 0
00 1110	1 0	01 1110	1 0	10 1110	0 0	11 1110	0 0
00 1111	1 1	01 1111	1 0	10 1111	0 1	11 1111	0 0

2.29 **(a)** True.

(b) False.

2.30 $(b + d)(a' + b' + c)(a + c) = (a'b + bc + a'd + db' + cd)(a + c)$
$= ab'c + a'b'd + acd + a'bc + b'c + a'dc + cb'd + cd$
$= bc + ab'd + cd + a'dc + cb'd$

2.31 $a'b + a'c' + bc = a'b(c + c') + a'(b + b')c' + (a + a')bc$
$= a'bc + a'bc' + a'b'c' + abc = m_3 + m_2 + m_0 + m_7$
$= \Sigma(0, 2, 3, 7) = \pi(1, 4, 5, 6) = (a + b + c') (a' + b + c) (a' + b + c') (a' + b' + c)$