

1.

(a). $\overline{AB} + (\overline{C} + \overline{D})$
 $= \overline{A+B} + (\overline{C} + \overline{D})$

(b). $\overline{AB(CD+EF)}$
 $= \overline{AB} + \overline{CD+EF}$
 $= \overline{A+B} + (\overline{CD} \cdot \overline{EF})$
 $= \overline{A+B} + [(\overline{C} + \overline{D})(\overline{E} + \overline{F})]$

(c). $(\overline{A} \overline{B} \overline{C} \overline{D}) + (\overline{A} + \overline{B} + \overline{C} + \overline{D})$

(d). $(\overline{A+B+C+D}) + (A \overline{B} \overline{C} \overline{D})$

(e). $(AB) + \overline{CD+EF} + \overline{AB+CD}$
 $= (AB) + (\overline{CD} \cdot \overline{EF}) + (\overline{AB} \cdot \overline{CD})$
 $= \overline{AB} + [(\overline{C} + \overline{D})(\overline{E} + \overline{F})] + (\overline{AB} \cdot \overline{CD})$

2.

A	B	C	(a).	(b).	(c)	(d)	(e)
0	0	0	0	0	0	0	0
0	0	1	1	0	0	0	1
0	1	0	1	0	0	1	1
0	1	1	1	0	1	0	1
1	0	0	1	0	0	1	1
1	0	1	1	0	1	1	1
1	1	0	1	0	1	1	1
1	1	1	1	1	1	1	1

3.

(a) $X = BC + DEB\overline{C} + DE$
 $= \overline{BC} + DE$

(b). $X = BC\overline{C}\overline{D} + BCCE$
 $= \overline{BCE}$

(c). $X = B + CBD + C(C+\overline{D})E$
 $= B + CE + C\overline{D}E$
 $= \overline{B+CE}$

4.

AB	00	01	11	10
CD	00	01	11	10
00	✓	✓	✓	✓
01	✓	✓	✓	✓
11	✓	✓	✓	✓
10	✓	✓	✓	✓

AB	00	01	11	10
CD	00	01	11	10
00	✓			
01	✓			
11			✓	
10			✓	

(a). $\overline{CD} + A + \overline{CB}$
(already in MSOP form).

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

AB	00	01	11	10
CD	00	01	11	10
00	✓	✓	✓	✓
01	✓	✓	✓	✓
11	✓	✓	✓	✓
10	✓	✓	✓	✓

AB	00	01	11	10
CD	00	01	11	10
00	✓			
01	✓			
11			✓	
10			✓	

AB	00	01	11	10
CD	00	01	11	10
00	✓	✓	✓	✓
01	✓	✓	✓	✓
11	✓	✓	✓	✓
10	✓	✓	✓	✓

(c). $\overline{B}\overline{C} + A\overline{C}\overline{D}$

(d). \overline{BC}

(e). $\overline{B} + \overline{D}$

5.

AB	00	01	11	10
C	0	0	1	1
0	✓	✓	✓	✓
1	✓	✓	✓	✓

$\overline{A+B+C}$

$(A+C)$

X	00	01	11	10
Y	0	0	1	1
0	✓	✓	✓	✓
1	✓	✓	✓	✓

$X+Y$

$\overline{X+Z}$

(b). $(X+Y)(\overline{X+Z})$

(a). $(A+C)(\overline{A+B+C})$

AB	00	01	11	10
C	0	0	1	1
0			✓	
1			✓	

(c). ABC

6. (a) $X = \overline{A} + \overline{A}B + AC = \overline{A} + C.$

(b). $X = \overline{\overline{A}B + \overline{A}CD + DB\overline{D}}$
 $= \overline{\overline{A}(B + CD)}$
 $= A + (\overline{B} \overline{CD}) = A + \overline{B} \overline{C} + \overline{B} \overline{D}.$

7. Denote π as the binary NAND. i.e. $x \pi y := x \text{ NAND } y$. And $\text{NAND}(x_1, x_2, \dots, x_n)$ as the n -ary NAND.
 $:= \text{NOT}(x_1 x_2 \dots x_n).$

(a) $X = \overline{A}B + CD + (\overline{A}\overline{B})(ACD + \overline{B}E)$ (b). $X = \overline{\overline{A}\overline{B}\overline{C}\overline{D} + \overline{D}\overline{E}\overline{F} + \overline{A}\overline{F}}$
 $= \overline{A}B + CD + \overline{A}\overline{B}\overline{B}E$
 $= \overline{A}B + CD + \overline{A}\overline{B}$
 $= \overline{\overline{A} + CD}$
 $= \overline{A \cdot \overline{CD}}$
 $= A \pi (C \pi D)$

where $u = \overline{u} = \overline{\overline{A}\overline{B}\overline{C}\overline{D}} = \text{NAND}(A, B, \overline{C}, \overline{D})$
 $= \text{NAND}(A, B, C \pi C, D \pi D)$
 $v = \overline{v} = \overline{\overline{D}\overline{E}\overline{F}} = \text{NAND}(D, E, F) = \text{NAND}(D, E \pi E, F)$
 $w = \overline{w} = \overline{\overline{A}\overline{F}} = (A \pi F) \pi (A \pi F).$

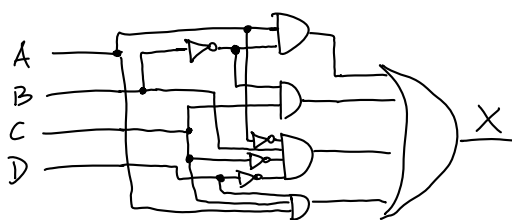
(c). $X = \overline{\overline{A}B + \overline{A}\overline{C}\overline{D} + \overline{A}\overline{C}\overline{E}}$
 $= \overline{(\overline{A+B})(\overline{A+C+D})(\overline{A+C+E})} = \text{NAND}(M, N, P)$

where $M = \overline{M} = \overline{\overline{A}B} = \overline{A} \pi B = (A \pi A) \pi B$
 $N = \overline{N} = \overline{\overline{A}\overline{C}\overline{D}} = \text{NAND}(A \pi A, C \pi C, D)$
 $P = \overline{P} = \overline{\overline{A}\overline{C}\overline{E}} = \text{NAND}(A \pi A, C \pi C, E).$

8.

AB	00	01	11	10
00	.	✓	.	✓
01	.	.	.	✓
11	✓	.	✓	✓
10	✓	.	✓	✓

$X = \overline{A}B + \overline{B}C + \overline{A}B\overline{C}\overline{D} + ACD$



9. Denote ∇ as the binary NOR, i.e. $x \nabla y := x \text{ NOR } y$. And $\text{NOR}(x_1, \dots, x_n)$ be the n -ary NOR.
 $:= \text{NOT}(x_1 + x_2 + \dots + x_n).$

(a). $X = \overline{\overline{A}B\overline{C}}$ (b). $X = \overline{\overline{A} + \overline{B} + \overline{C}}$
 $= \overline{\overline{A+B+C}}$
 $= \text{NOR}(A \nabla A, B \nabla B, C \nabla C).$
(c). $X = A + B = \overline{\overline{A+B}} = \overline{\text{NOR}(A, B, \overline{C})} = \text{NOR}(A \nabla A, B \nabla B, C \nabla C) \nabla \text{NOR}(A \nabla A, B \nabla B, C \nabla C).$
(d). $X = A + B + \overline{C} = \overline{\overline{A+B+\overline{C}}} = \overline{\text{NOR}(A, B, \overline{C})} = \text{NOR}(A \nabla A, B \nabla B, C \nabla C) \nabla \text{NOR}(A \nabla A, B \nabla B, C \nabla C).$

(e). $X = \text{OR}(\overline{A}, \overline{B}, \overline{C}, \overline{D})$
 $= \overline{\text{NOR}(\overline{A}, \overline{B}, \overline{C}, \overline{D})}$
 $= \text{NOR}(A \nabla A, B \nabla B, C \nabla C, D \nabla D) \nabla \text{NOR}(A \nabla A, B \nabla B, C \nabla C, D \nabla D)$

(f). $X = \overline{\overline{A+B} \nabla \overline{C+D}}$ (g). $X = \overline{\overline{AB\overline{C}\overline{D}} + \overline{AB\overline{C}\overline{D}} + \overline{AB\overline{C}\overline{D}}}$
 $= (\overline{A+B}) \nabla (\overline{C+D})$
 $= \overline{\text{NOR}(AB\overline{C}\overline{D}, \overline{AB\overline{C}\overline{D}}, \overline{AB\overline{C}\overline{D}})} = \text{NOR}(u, v, w) \nabla \text{NOR}(u, v, w)$
where $u = \overline{A+B+C+D} = \overline{A+B+C+(D \nabla E)} = \text{NOR}(A \nabla A, B \nabla B, C \nabla C, (D \nabla D) \nabla (E \nabla E))$
 $v = \overline{A+B+C} = \text{NOR}(A \nabla A, B \nabla B, C)$. $w = \text{NOR}(A \nabla A, B \nabla B, E).$

10. (a) $X = \overline{\overline{A}\overline{B}\overline{C}} = \text{NAND}(A \pi A, B \pi B, C \pi C).$

(b). $X = \overline{\text{NAND}(A, B, C)} = \text{NAND}(A, B, C) \pi \text{NAND}(A, B, C).$

(c). $X = \overline{\overline{A} \cdot \overline{B} \cdot \overline{C}} = (A \pi A) \pi (B \pi B) \pi (C \pi C)$

(d). $X = \overline{\overline{A} \cdot \overline{B} \cdot \overline{C}} = (A \pi B) \pi (C \pi D)$

