2.21

A	B	C	H	F	G
0	0	0	0	0	0
0	0	1	1	1	x
0	1	0	1	0	1
0	1	1	1	1	x
1	0	0	0	0	0
1	0	1	1	0	1
1	1	0	0	0	0
1	1	1	1	1	x

2.26 (a) $F = [(A' + B)'B]'C + B = [A' + B + B']C + B$
$= C + B$

2.26 (b) $G = [(AB)'(B + C)]'C = (AB + B'C')C = ABC$

2.30

$F = (X+Y')Z + X'YZ'$ (from the circuit)
$= (X+Y'+ X'YZ')(Z+X'YZ')$ (distributive law)
$= (X+Y'+X')(X+Y'+Y)(X+Y'+Z')(Z+X')(Z+Y)(Z+Z')$ (distributive law)
$= (1+Y')(X+1)(X+Y'+Z')(Z+X')(Z+Y)(1)$ (complementation laws)
$= (1)(1)(X+Y'+Z')(Z+X')(Z+Y)(1)$ (0 and 1 operations)
$= (X+Y'+Z')(Z+X')(Z+Y)$ (0 and 1 operations)

$G = (X +Y' + Z')(X' + Z)(Y + Z)$ (from the circuit)

3.6 (a) $(W + X' + Z')\,(W' + Y')\,(W' + X + Z')\,(W + X')\,(W + Y + Z)$
$= (W + X')\,(W' + Y')\,(W' + X + Z')\,(W + Y + Z)$
$= (W + X')\,[W' + Y'(X + Z')]\,(W + Y + Z)$
$= [W + X'(Y + Z)]\,[W' + Y'(X + Z')] = WY'(X + Z') + W'X'(Y + Z)$ {Using $(X + Y)(X' + Z) = X'Y + XZ$ with $X=W$}
$= WY'X + WY'Z' + W'X'Y + W'X'Z$

3.6 (b) $(A + B + C + D)\,(A' + B' + C + D')\,(A' + C)\,(A + D)\,(B + C + D)$
$= (B + C + D)\,(A' + C)\,(A + D) = (B + C + D)\,(A'D + AC)$ {Using $(X + Y)(X' + Z) = X'Y + XZ$ with $X = A$}
$= A'DB + A'DC + A'D + ABC + AC + ACD = A'D + AC$

3.8

$F = AB \oplus [(A \equiv D) + D] = AB \oplus (AD + A'D' + D) = AB \oplus (A'D' + D) = AB \oplus (A' + D)$
$= (AB)'(A' + D) + AB(A' + D)' = (A' + B')(A' + D) + AB(AD')$
$= A' + B'D + ABD'$ {Using $(X + Y)(X + Z) = X + YZ$} $= A' + BD' + B'D$ {Using $X + X'Y = X + Y$}

3.10 (a) $(X + W)(Y \oplus Z) + XW'$

$= (X + W)(YZ' + Y'Z) + XW'$

$= XYZ' + XY'Z + \underline{WYZ'} + \underline{WY'Z} + \underline{XW'}$

Using Consensus Theorem

$WYZ' + WY'Z + XW'$

3.10 (b) $(A \oplus BC) + BD + ACD = A'BC + A(BC)' + BD + ACD$

$= A'BC + A(B' + C') + BD + ACD$

$= A'BC + \underline{AB'} + AC' + \underline{BD} + ACD$

$= A'BC + AB' + AC' + AD + BD + \cancel{ACD}$

(Add consensus term AD, eliminate ACD)

$= A'BC + AB' + AC' + BD$

(Remove consensus term AD)

3.12 $\underline{A'CD'E} + A'B'D' + \underline{ABCE} + ABD = A'B'D' + ABD + BCD'E$

Proof: *LHS:* $A'CD'E + \underline{BCD'E} + \underline{A'B'D'} + ABCE + \underline{ABD}$ Add consensus term to left-hand side and use it to eliminate two consensus terms

$= BCD'E + A'B'D' + ABD$ This yields the right-hand side.

$\therefore$ LHS = RHS

3.16 (a) $(\underline{KL} \oplus \underline{M}) + M'N' = \underline{(KL)'}M + KLM' + M'N' = (K' + L')M + KL\underline{M'} + \underline{M'}N' = \underline{M}(K' + L') + \underline{M'}(KL + N')$

$= (M' + K' + L')(M + N' + KL) = (M' + K' + L')(M + N' + K)(M + N' + L)$

3.16 (b) $M'(\underline{K \oplus N'}) + MN + K'N = M'[K'N' + KN] + MN + K'N = K'M'N' + KM'\underline{N} + M\underline{N} + K'\underline{N}$

$= K'M'N' + N(M + \underline{K}M' + \underline{K'})$

$= K'M'N' + N(\underline{M} + K' + \underline{M'}) = K'M'\underline{N'} + \underline{N} = N + K'M' = (K' + N)(M' + N)$

3.19 (a) $x \oplus y \oplus xy = x \oplus [y(xy)' + y'(xy)] = x \oplus [yx'] = x(yx')' + x'(yx') = x(y' + x) + x'y = x + x'y = x + y$

(b) $x \equiv y \equiv xy = (xy + x'y') \equiv xy = (xy + x'y')xy + (xy + x'y')'(xy)' = xy + (xy' + x'y)(x' + y') = xy + x'y + xy'$

$= x + y$

3.20 (a) $xy \oplus xz = xy(x' + z') + (x' + y')xz = xyz' + xyz = x(yz' + yz') = x(y \oplus z)$

(b) For $y = 1$, the left hand side is $x + z'$ but the right hand side is $x'z'$ which are not equal.

3.27 $WXY' + (W'Y' \equiv X) + (Y \oplus WZ)$

$= WXY' + W'Y'X + (W'Y')'X' + Y(WZ)' + Y'WZ$

$= \underline{WXY'} + \underline{W'XY'} + (W + Y)X' + Y(W' + Z') + Y'WZ$

$= XY' + WX' + X'Y + W'Y + YZ' + WY'Z + WY'$

$= XY' + \underline{WX'} + \cancel{X'Y} + \underline{W'Y} + YZ' + \cancel{WY'Z} + \underline{WY'}$

$= \underline{XY'} + \underline{WX'} + W'Y + YZ' + \cancel{WY'}$

$= XY' + WX' + W'Y + YZ'$

Alternate Solutions: $F = W'Y + WX' + WZ' + XY'$

$F = YZ' + W'X + XY' + WY'$

$F = W'X + X'Y + XZ' + WY'$

$F = W'X + XY' + WZ' + WY'$