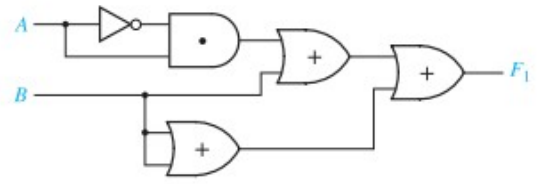
2.10 Illustrate the following equations using circuits of switches:
(a) $XY + XY' = X$ (b) $(X + Y')Y = XY$

2.11 Simplify each of the following expressions by applying *one* of the theorems. State the theorem used.
(a) $(A' + B' + C)(A' + B' + C)'$ (b) $AB(C' + D) + B(C' + D)$
(c) $AB + (C' + D)(AB)'$ (d) $(A'BF + CD')(A'BF + CEG)$

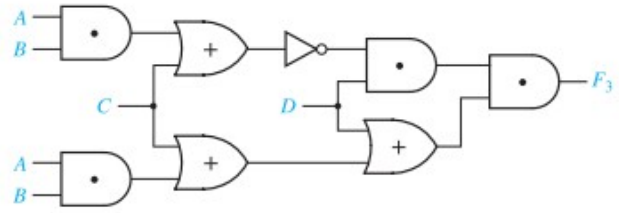
2.12 Simplify each of the following expressions by applying *one* of the theorems. State the theorem used.
(a) $(X + Y'Z) + (X + Y'Z)'$
(b) $[W + X'(Y + Z)][W' + X'(Y + Z)]$
(c) $(V'W + UX)'(UX + Y + Z + V'W)$

2.13 For each of the following circuits, find the output and design a simpler circuit that has the same output. (*Hint:* Find the circuit output by first finding the output of each gate, going from left to right, and simplifying as you go).

(a)



(c)



2.14 Draw a circuit that uses only one AND gate and one OR gate to realize each of the following functions:

(b) $(V + W + Y + Z)(U + W + Y + Z)(W + X + Y + Z)$

2.15 Use *only* DeMorgan's relationships and Involution to find the complements of the following functions:

(a) $f(A, B, C, D) = [A + (BCD)'][(AD)' + B(C' + A)]$

2.16 Using *just* the definition of the dual of a Boolean algebra expression, find the duals of the following expressions:

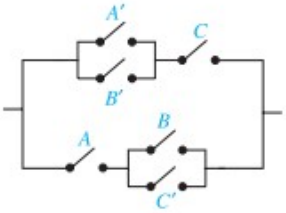
(a) $f(A, B, C, D) = [A + (BCD)'][(AD)' + B(C' + A)]$

2.17 For the following switching circuit, find the logic function expression describing the circuit by the three methods indicated, simplify each expression, and show they are equal.

(a) subdividing it into series and parallel connections of subcircuits until single switches are obtained

(b) finding all paths through the circuit (sometimes called *tie sets*), forming an AND term for each path and ORing the AND terms together

(c) finding all ways of breaking all paths through the circuit (sometimes called *cut sets*), forming an OR term for each cut set and ANDing the OR terms together.



2.18 For each of the following Boolean (or switching) algebra expressions, indicate which, if any, of the following terms describe the expression: product term, sum-of-products, sum term, and product-of-sums. (More than one may apply.)

(a) $X'Y$

(b) $XY' + YZ$

(c) $(X' + Y)(WX + Z)$

(d) $X + Z$