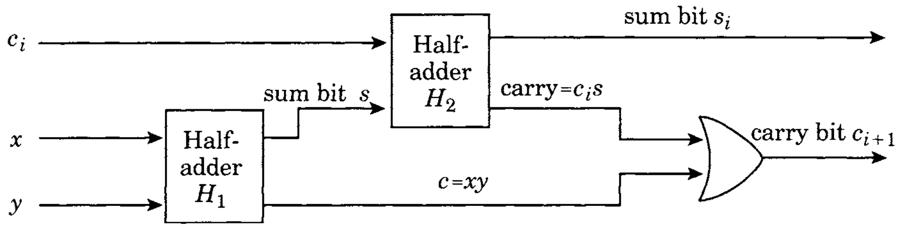
Figure 12.32

A full-adder.

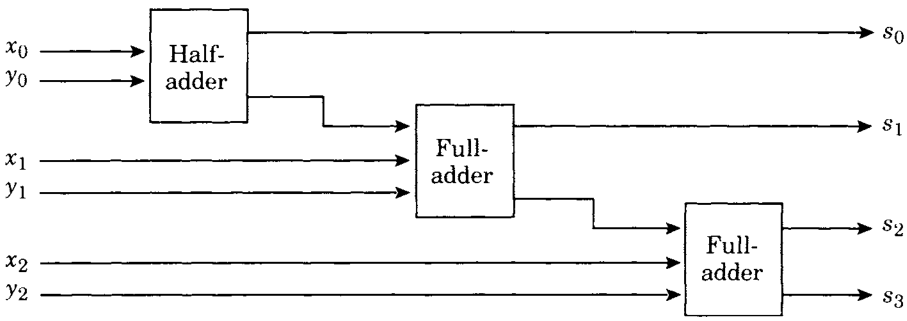


We close this section by showing how we can use half- and full-adders to compute the sum of two n-bit numbers.

EXAMPLE 12.26 Using a half-adder and full-adder, design a circuit that computes the sum of two 3-bit numbers $x = x_2x_1x_0$ and $y = y_2y_1y_0$.

SOLUTION:
A half-adder accepts two bits outputting the sum and carry bits. On the other hand, a full-adder accepts three bits to produce the sum and carry bits. The circuit in Figure 12.33 produces the sum $s = s_3s_2s_1s_0$.

Figure 12.33



■

The range of possible combinatorial circuits expands as logic gates from half- and full-adders describe many electrical systems through the production of bit sums.

11/18 03:05 do end (wk10) ↓ more
03:12 correct 03:13

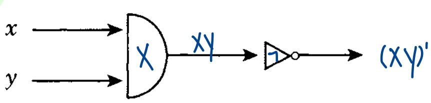
Exercises 12.4

When will the combinatorial circuit for each boolean expression produce 1 as the output?

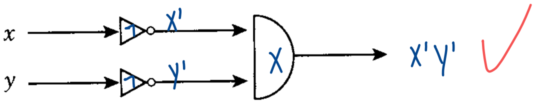
1. x' X=0 ✓ **2.** $x+y$ X=1 or Y=1 **3.** xy X=Y=1 ✓

Find the output produced by the combinatorial circuits in Exercises 4–13.

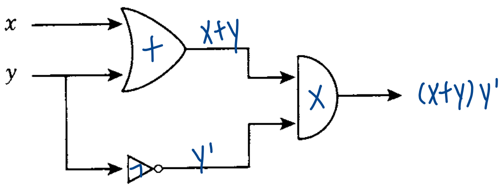
4.



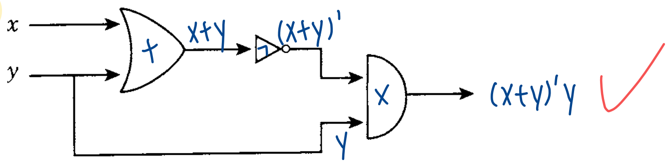
5.


x
y
x'
y'
x'y'

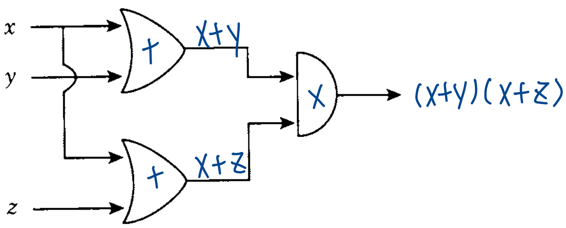
6.


x
y
x+y
y'
(x+y)y'

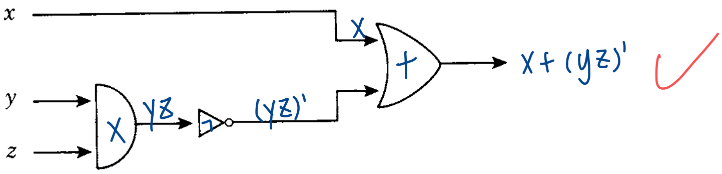
7.


x
y
x+y
(x+y)'
y
(x+y)'y

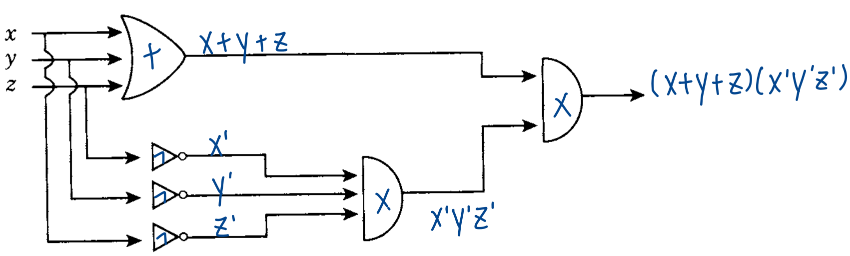
8.


x
y
z
x+y
x+z
(x+y)(x+z)

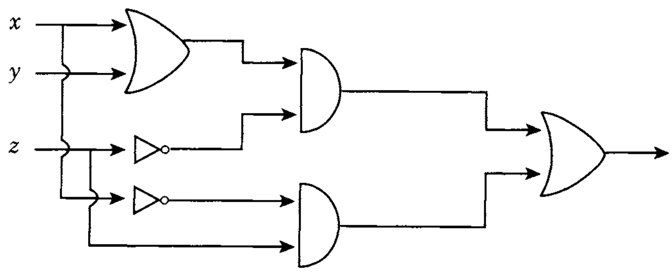
9.


x
y
z
x
yz
(yz)'
x+(yz)'

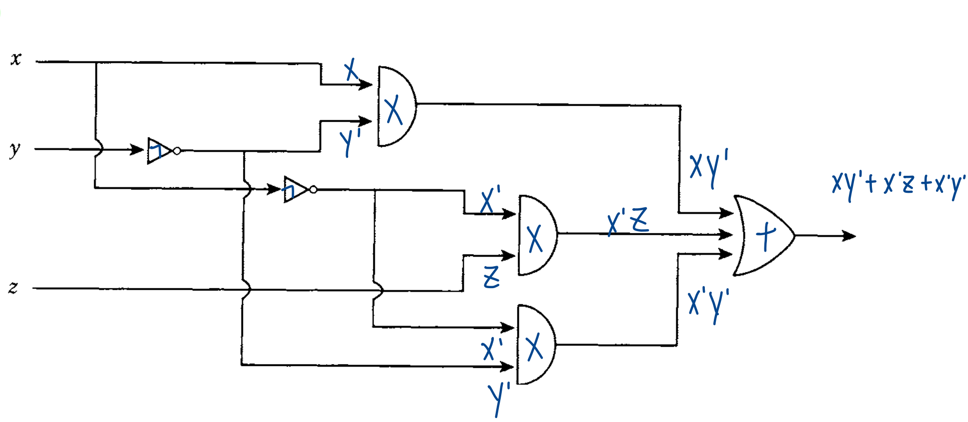
10.


x
y
z
x+y+z
x'
y'
z'
x'y'z'
(x+y+z)(x'y'z')

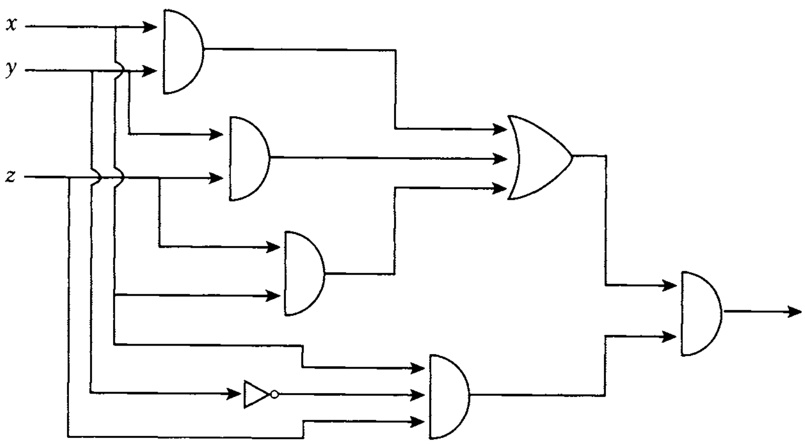
11.



12.



13.



14–17. Devise a logic table for each circuit in Exercises 6–9.

18–21. Construct a combinatorial circuit for each boolean expression in Exercises 9, 10, 14, and 15 in Section 12.2.

Using only NAND gates, design a combinatorial circuit that receives x and y as input signals and outputs:

22. x' **23.** $x+y$ **24.** xy

25–27. Redo Exercises 22–24, using only NOR gates.

Figure 12.44

	yz	yz'	$y'z'$	$y'z$
wx			1	
wx'			1	1
$w'x'$	1	1		
$w'x$	1	1		

(2) Using the Karnaugh map in Figure 12.44, we have:

$$
\begin{aligned}
E_2 &= (wxy'z' + wx'y'z') + (wx'y'z' + wx'y'z) \\
&\quad + (w'x'yz + w'x'yz' + w'xyz + w'xyz') \\
&= wy'z'(x + x') + wx'y'(z + z') + [w'x'y(z + z') + w'xy(z + z')] \\
&= wy'z' + wx'y' + (w'x'y + w'xy) \\
&= wy'z' + wx'y' + w'y(x + x') \\
&= wy'z' + wx'y' + w'y
\end{aligned}
$$

■

11/18 02:48 do – 03:00 end \\ – correct 03:04 (wk10)

These cases suggest that Karnaugh maps simplify boolean expressions more easily than algebraic laws, especially when variables are few.

Exercises 12.5

	yz	y'z	yz'	y'z'
x				
x'	1	1	1	1

→ x'

	y	y'
x	1	1
x'		1

Simplify each boolean expression using the laws of boolean algebra.

1. $xy + xy'$ = x **2.** $x(x + y) + xy'$ = x **3.** $(x + y)xy'$ xy' + ~~x~~ **4.** $xy + xy' + x'y'$ = x + y'

5. $x'yz + x'y'z' + x'yz' + x'y'z$ = x' **6.** $xy'z' + x'y'z' + xy'z + x'y'z$

7. $(x + y)(x + y + z)xy$ **8.** $(x + y + z)xyz$

9. $(x + y)(y + z)(z + x)$ **10.** $(xy + yz + zx)xyz$

11. $(x + y)(x' + y)(x + y')$ **12.** $(x + y' + z)(x + y + z')xy'z'$

13. $(x + y)(y + z)(z + x)xyz$ **14.** $(x + yz)(y + zx)(z + xy)$

15. $wxyz + w'xy'z' + wxyz' + w'xy'z$ **16.** $wx'yz + wx'yz' + w'x'yz' + w'xyz'$

Find the boolean expression represented by each Karnaugh map.

17.

	y	y'
x	1	1
x'		

18.

	y	y'
x	1	
x'	1	

19.

	y	y'
x		1
x'	1	

20.

	y	y'
x	1	
x'		1

Display each sum of minterms in a Karnaugh map.

21. $xy + x'y'$ **22.** $x'y + xy'$

Using a Karnaugh map, simplify each sum of minterms.

23. $xy + xy'$ **24.** $xy + xy' + x'y'$

not simplifying.

Find the boolean expression represented by each Karnaugh map.

25.

	yz	yz'	$y'z'$	$y'z$	
x	1	1	1		→ xy
x'			1		→ y'z'

)+

xyz + xyz' + xy'z' + x'y'z'

26.

	yz	yz'	$y'z'$	$y'z$	
x	1				→ yz
x'	1	1	1		→ x'z'

)+

27.

	yz	yz'	$y'z'$	$y'z$	
x		1	1		
x'		1	1		→ z'

xyz' + xy'z' + x'yz' + x'y'z'

28.

	yz	yz'	$y'z'$	$y'z$	
x	1				→ yz
x'	1	1			→ x'y

)+

29.

	yz	yz'	y'z'	y'z	
x			1	1	→ xy'
x'					

31.

	yz	yz'	y'z'	y'z	
x			1	1	→ y'
x'			1	1	

Using a Karnaugh map, simplify each boolean expression.

29. $xy'z + xy'z'$ = xy' ✓ **30.** $xyz + xy'z + x'yz + x'y'z$

31. $xy'z' + xy'z + x'y'z' + x'y'z$ = y' ✓ **32.** $xyz + xyz' + x'y'z' + x'y'z$

33–36. Using a Karnaugh map, simplify the boolean expressions in Exercises 25–28.

Find the boolean expression represented by each Karnaugh map.

37.

	yz	yz'	$y'z'$	$y'z$
wx		1	1	
wx'		1	1	
$w'x'$		1	1	
$w'x$		1	1	

38.

	yz	yz'	$y'z'$	$y'z$
wx	1			1
wx'				
$w'x'$				
$w'x$	1			1

39.

	yz	yz'	$y'z'$	$y'z$
wx	1			
wx'	1			
$w'x'$			1	1
$w'x$			1	1

40.

	yz	yz'	$y'z'$	$y'z$
wx	1	1	1	
wx'			1	1
$w'x'$				
$w'x$	1			

Represent each sum of minterms in a Karnaugh map.

41. $wxy'z + w'xyz$ **42.** $wxyz + wxy'z + w'xyz + w'xy'z$

43. $wxy'z + wx'y'z + w'xy'z + w'x'y'z$ **44.** $wx'yz' + wx'y'z' + w'x'yz' + w'x'y'z'$

45–48. Using a Karnaugh map, simplify the boolean expressions in Exercises 37–40.

Using a Karnaugh map, simplify each boolean expression.

49. $wxyz + wx'yz + w'x'yz + w'xyz$

50. $wx'yz' + wx'y'z' + w'x'yz' + w'x'y'z'$

51. $wx'yz + wx'yz' + wx'y'z' + w'x'y'z' + w'xy'z' + w'xy'z$

52. $wxyz + wxyz' + wxy'z' + wxy'z + wx'y'z + w'x'y'z + w'xy'z$