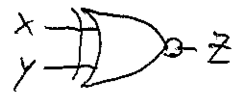
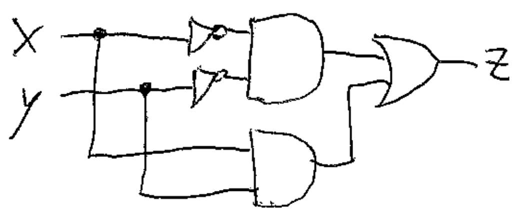
2.4. a. XNOR



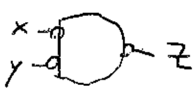
x	y	z
0	0	1
0	1	0
1	0	0
1	1	1

b. $z = \bar{x}\bar{y} + xy$

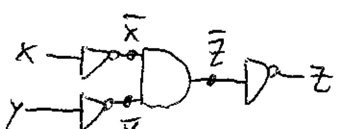
c.



2.5. a.



$\rightarrow$



$\rightarrow \bar{z} = \bar{x}\bar{y} \rightarrow z = \overline{\bar{x}\bar{y}} = x + y$ (OR)

(De Morgan)

OR gate: (positive logic)

x	y	z
0V	0V	0V
0V	3.3V	3.3V
3.3V	0V	3.3V
3.3V	3.3V	3.3V

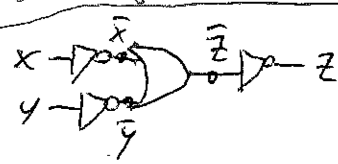
if 0V→1 and 3.3V→0 (negative logic) $\longrightarrow$

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

AND gate

b.

$\rightarrow$



$\rightarrow \bar{z} = \bar{x} + \bar{y} \rightarrow z = \overline{\bar{x} + \bar{y}} = xy$ (AND)

(De Morgan)

AND gate:

x	y	z
0V	0V	0V
0V	3.3V	0V
3.3V	0V	0V
3.3V	3.3V	3.3V

if 0V→1 and 3.3V→0 $\longrightarrow$

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

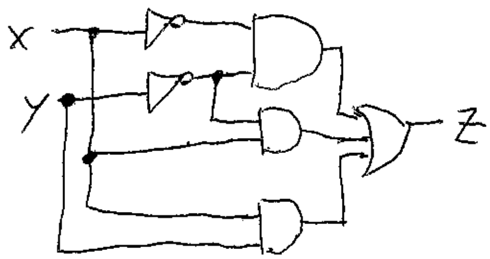
(OR)

2.6. ~x|~y = ~(x&y) → x&y = ~(~x|~y)

~(x|y) = ~x&~y → x|y = ~(~x&~y)

2.7. a. $z = \bar{x}\bar{y} + x\bar{y} + xy$

b.



c. $z = x + \bar{y}$

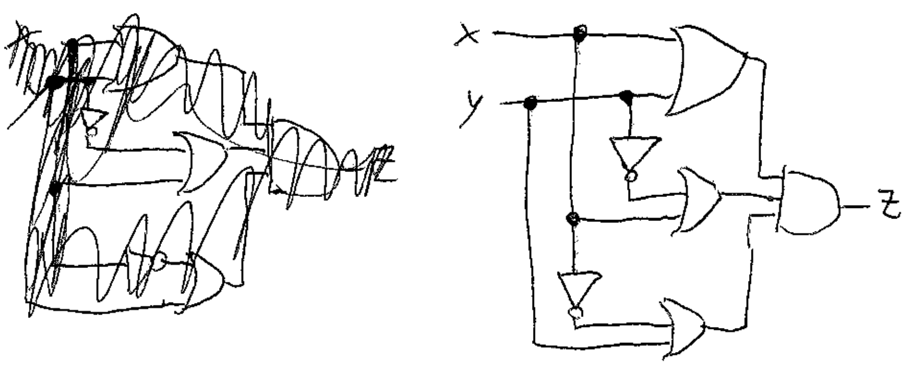
d.

2.8. a. $z = xy$

b.

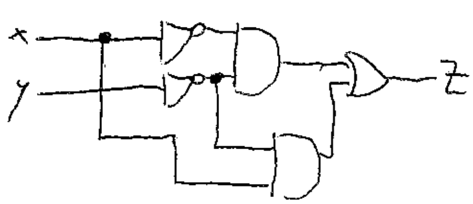
c. $z = (x+y)(x+\bar{y})(\bar{x}+y)$

d.



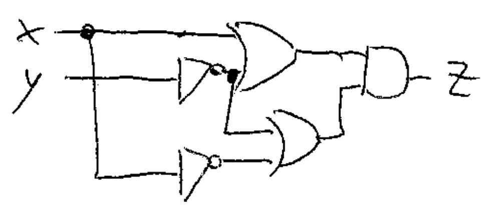
2.9. a. $z = \bar{x}\bar{y} + x\bar{y}$

b.



c. $z = (x+\bar{y})(\bar{x}+\bar{y})$

d.



3.1. a.

A	B	C	V1	V0
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

b. $V0 = \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC$

$V1 = \bar{A}BC + A\bar{B}C + AB\bar{C} + ABC$

c. V0

A \ BC	00	01	11	10
0	0	1	0	1
1	1	0	1	0

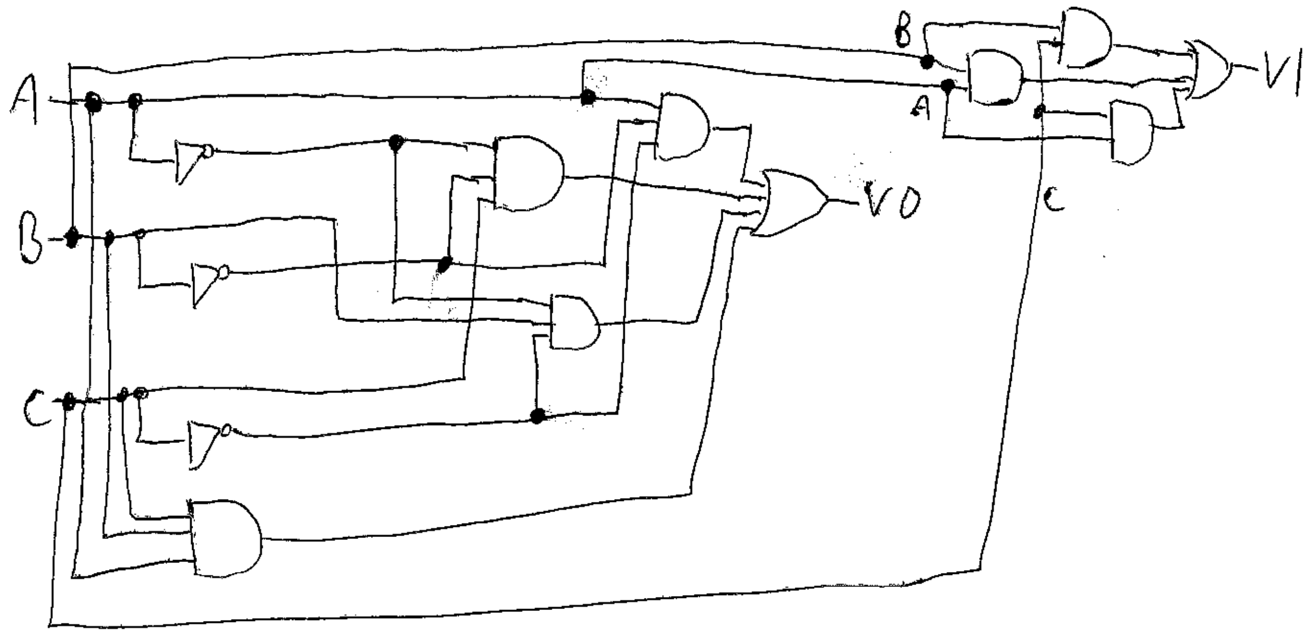
cannot be reduced!

V1

A \ BC	00	01	11	10
0	0	0	1	0
1	0	1	1	1

$V1 = AB + BC + AC$

d.



3.5. a. ~x & ~y | ~x & y | x & y = ~x & ~y | (~x | x) & y = ~x & ~y | y = ~x | y

b. (x | y) & (~x | y) = x & ~x | x & y | y & ~x | y & y = y & (x | ~x | y) = y

c. ~x & (x | y) = ~x & x | ~x & y = ~x & y

d. (~x & y) | ~x = ~x | ~x & y = ~x & (1 | y) = ~x

e. y & (x | ~y) = y & x

3.6

x	y	z	minterm
0	0	0	$m0 = \bar{x}\bar{y}\bar{z}$
0	0	1	$m1 = \bar{x}\bar{y}z$
0	1	0	$m2 = \bar{x}y\bar{z}$
0	1	1	$m3 = \bar{x}yz$
1	0	0	$m4 = x\bar{y}\bar{z}$
1	0	1	$m5 = x\bar{y}z$
1	1	0	$m6 = xy\bar{z}$
1	1	1	$m7 = xyz$

If there are fewer 0's than 1's, it's probably easiest to circle the 0's and set equal to $\bar{f}$. But this doesn't always lead most quickly to minimization (fewest gates).

a.

x \ yz	00	01	11	10
0	1	1	1	1
1				

$f(x,y,z) = \bar{x}$

b.

x \ yz	00	01	11	10
0	1			1
1	1			1

$f(x,y,z) = \bar{z}$

c.

x \ yz	00	01	11	10
0	1	1	0	1
1	1	1	0	1

$\bar{f} = yz \Rightarrow f(x,y,z) = \overline{yz}$ <u>One gate</u>

(If you circle the 1's, you get $f = \bar{y} + \bar{z}$, which is <u>three</u> gates.)

d.

x \ yz	00	01	11	10
0	0	1	1	0
1	1	1	1	1

$\bar{f} = \bar{x}\bar{z} \Rightarrow f(x,y,z) = \overline{\bar{x}\bar{z}} = x + z$

e.

x \ yz	00	01	11	10
0	1	0	1	1
1	1	0	1	1

$\bar{f} = \bar{y}z \Rightarrow f(x,y,z) = \overline{\bar{y}z}$

3.7. a.

wx \ yz	00	01	11	10
00	1	1		
01	1	1		
11			1	1
10			1	1

$f(w,x,y,z) = \overline{w}\,\overline{y} + wy = \sim(w \wedge y)$

$= w \sim\wedge y$

b.

wx \ yz	00	01	11	10
00				
01		1	1	
11		1	1	
10		1	1	

$f(w,x,y,z) = xz + wz$ 3 gates

$= z(x+w)$ 2 gates

c.

wx \ yz	00	01	11	10
00	1			1
01		1	1	
11		1	1	
10	1			1

$f(w,x,y,z) = xz + \overline{x}\,\overline{z} = x \sim\wedge z$

d.

wx \ yz	00	01	11	10
00			1	1
01			1	1
11	1		1	1
10	1		1	1

$f(w,x,y,z) = y + w\overline{z}$

e.

wx \ yz	00	01	11	10
00	0	0	0	0
01	1	1	1	1
11	0	1	0	0
10	1	1	1	1

$\overline{f} = \overline{w}\,\overline{x} + wx\overline{z} + wxy$

$f = \overline{\overline{w}\,\overline{x} + wx\overline{z} + wxy}$ 7 gates

If we circle 1's instead:

$f = \overline{w}x + w\overline{x} + w\overline{y}z$

$= w \wedge x + w\overline{y}z$ 4 gates

3.8.a.

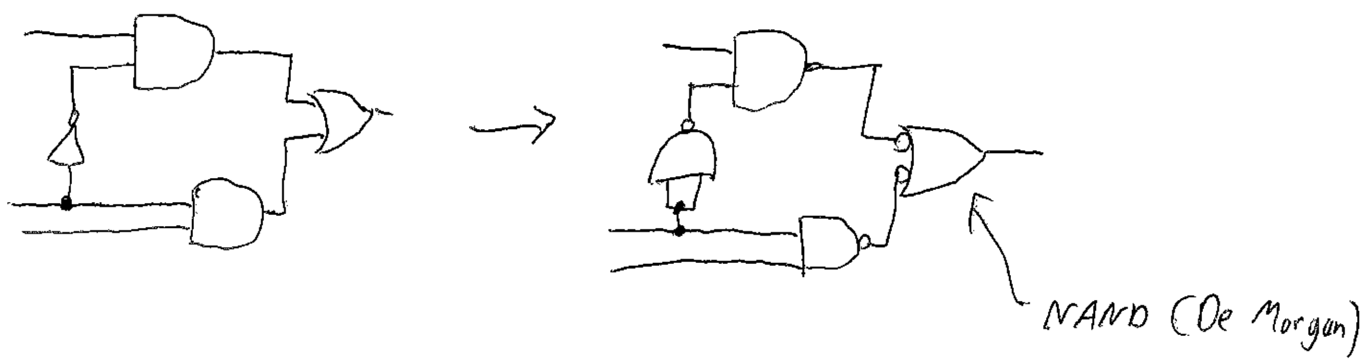
x[2] \ x[1]x[0]	00	01	11	10
0	1	1		1
1	1			

$Z = \overline{x[1]}\,\overline{x[0]} + \overline{x[2]}\,\overline{x[0]} + \overline{x[2]}\,\overline{x[1]}$

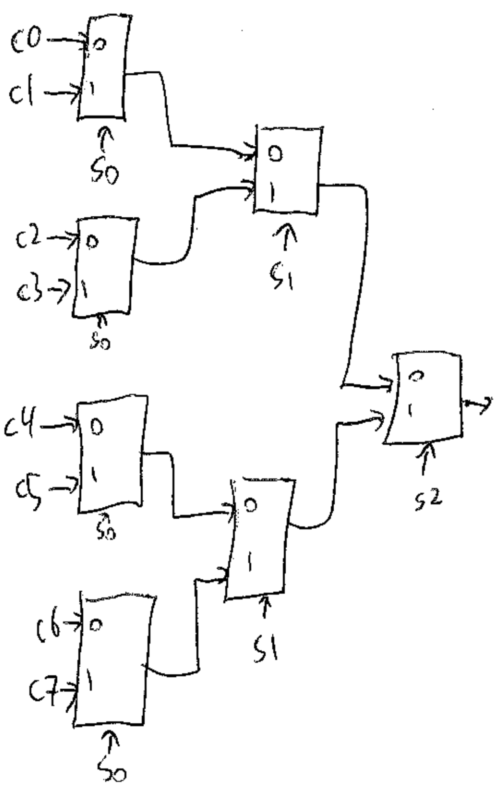
7 gates

$Z = \overline{x[1]+x[0]} + \overline{x[2]+x[0]} + \overline{x[2]+x[1]}$ 4 gates

4.1.

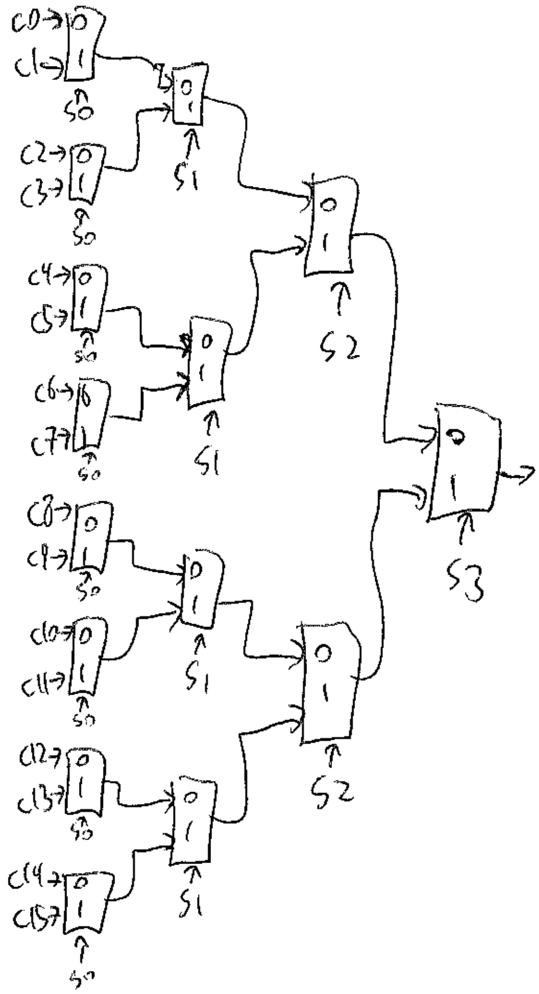


5.1.



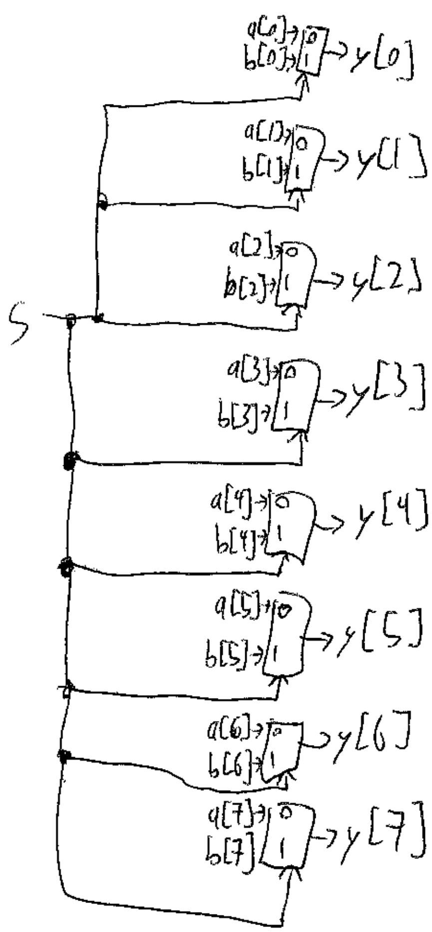
3 control lines (s2, s1, s0)

5.2.



4 control lines

5.3.



Notice the difference between an 8-line 2-to-1 MUX (5.3) and a 16-to-1 MUX (5.2).

5.13. See Figure 5.22

$a(x_3,x_2,x_1,x_0) = \sum m(1,4,11,13) = \overline{x_3}\,\overline{x_2}\,\overline{x_1}x_0 + \overline{x_3}x_2\overline{x_1}\,\overline{x_0} + x_3\overline{x_2}x_1x_0 + x_3x_2\overline{x_1}x_0$

can't be simplified (four isolated 1's if you draw K map)

$b(x_3,x_2,x_1,x_0) = \sum m(5,6,11,12,14,15) = \overline{x_3}x_2\overline{x_1}x_0 + x_2x_1\overline{x_0} + x_3x_1x_0 + x_3x_2\overline{x_0}$

$x_3x_2 \backslash x_1x_0$	00	01	11	10
00				
01		1		1
11	1		1	1
10			1	

don't need this one

$c(x_3,x_2,x_1,x_0) = \sum m(2,12,14,15) = \overline{x_3}\,\overline{x_2}x_1\overline{x_0} + x_3x_2\overline{x_0} + x_3x_2x_1$

$x_3x_2 \backslash x_1x_0$	00	01	11	10
00				1
01				
11	1		1	1
10				

$d(x_3,x_2,x_1,x_0) = \sum m(1,4,7,10,15) = \overline{x_3}\,\overline{x_2}\,\overline{x_1}x_0 + \overline{x_3}x_2\overline{x_1}\,\overline{x_0} + x_2x_1x_0 + x_3\overline{x_2}x_1\overline{x_0}$

$x_3x_2 \backslash x_1x_0$	00	01	11	10
00		1		
01	1		1	
11			1	
10				1

e is done in Fig. 5.24

$f(x_3,x_2,x_1,x_0) = \sum m(1,2,3,7,13) = \overline{x_3}\,\overline{x_2}x_0 + \overline{x_3}\,\overline{x_2}x_1 + \overline{x_3}x_1x_0 + x_3x_2\overline{x_1}x_0$

$x_3x_2 \backslash x_1x_0$	00	01	11	10
00		1	1	1
01			1	
11		1		
10				

$g(x_3,x_2,x_1,x_0) = \sum m(0,1,7,12) = \overline{x_3}\,\overline{x_2}\,\overline{x_1} + \overline{x_3}x_2x_1x_0 + x_3x_2\overline{x_1}\,\overline{x_0}$

$x_3x_2 \backslash x_1x_0$	00	01	11	10
00	1	1		
01			1	
11	1			
10				

5.23

p4:

b3b2 \ b1b0	00	01	11	10
00				
01				
11	1	1	1	1
10			1	1

$$p4 = b3\,b2 + b3\,b1 = b3(b2+b1)$$

3 gates 2 gates

p3:

b3b2 \ b1b0	00	01	11	10
00				
01				
11				
10	1	1		

$$p3 = b3\,\overline{b2}\,\overline{b1} \quad \text{3 gates}$$

$$= \overline{\overline{b3}+b2+b1} \quad \text{2 gates}$$

p2:

b3b2 \ b1b0	00	01	11	10
00				
01	1	1	1	1
11			1	1
10				

$$p2 = \overline{b3}\,b2 + b2\,b1 \quad \text{4 gates}$$

$$= b2(\overline{b3}+b1) \quad \text{3 gates}$$

p1:

b3b2 \ b1b0	00	01	11	10
00			1	1
01			1	1
11	1	1		
10				

$$p1 = \overline{b3}\,b1 + b3\,b2\,\overline{b1} \quad \text{5 gates}$$

$$= \overline{b3+\overline{b1}} + b3\,b2\,\overline{b1} \quad \text{4 gates}$$

p0:

b3b2 \ b1b0	00	01	11	10
00		1	1	
01		1	1	
11		1	1	
10		1	1	

$$p0 = b0$$

no gates!

6.1. a.

```
  11010010
+ 01100101
----------
  00110111
```

carry flag = 1
overflow flag = 0

(unsigned: 210 + 101 = 55 | 2's comp: -46 + 101 = 55)

b.

```
  01011011
+ 01100110
----------
  11000001
```

Carry flag = 0
overflow flag = 1

(unsigned: 91 + 102 = 193 | 2's comp: 91 + 102 = -63)

c.

```
  11001010
+ 11010111
----------
  10100001
```

carry flag = 1
overflow flag = 0

(unsigned: 202 + 215 = 161 | 2's comp: -54 - 41 = -95)

d.

```
  00110011
+ 10101010
----------
  11011101
```

carry flag = 0
overflow flag = 0

(unsigned: 51 + 170 = 221 | 2's comp: 51 - 86 = -35)

6.2. a.

```
3F =   0011 1111
29 = + 0010 1001
     -----------
       01101000
```

carry flag = 0
overflow = 0

(unsigned: 63 + 41 = 104 | 2's comp: 63 + 41 = 104)

b.

```
AC =   1010 1100
2D = + 0010 1101
     -----------
       1101 1001
```

carry flag = 0
overflow = 0

(unsigned: 172 + 45 = 217 | 2's comp: -84 + 45 = -39)

c.

```
72 =   0111 0010
8B = + 1000 1011
     -----------
       1111 1101
```

carry flag = 0
overflow = 0

(unsigned: 114 + 139 = 253 | 2's comp: 114 - 117 = -3)

d.

```
E1 =   1110 0001
75 = + 0111 0101
     -----------
       0101 0110
```

carry flag = 1
overflow = 0

(unsigned: 225 + 117 = 1 86 | 2's comp: -31 117 = 86)

6.3. a.

$$\begin{array}{r} 1101\ 0010 \\ -\,0110\ 0101 \\ \hline \end{array} \rightarrow \begin{array}{r} 1101\ 0010 \\ +\,1001\ 1011 \\ \hline 0110\ 1101 \end{array}$$

carry = 1 $\Rightarrow$ borrow = 0
overflow = 1

b.

$$\begin{array}{r} 01011011 \\ -\,01100110 \\ \hline \end{array} \rightarrow \begin{array}{r} 0101\ 1011 \\ +\,1001\ 1010 \\ \hline 1111\ 0101 \end{array}$$

carry = 0 $\Rightarrow$ borrow = 1
overflow = 0

c.

$$\begin{array}{r} 11001010 \\ -\,11010111 \\ \hline \end{array} \rightarrow \begin{array}{r} 1100\ 1010 \\ +\,00101001 \\ \hline 11110011 \end{array}$$

carry = 0 $\Rightarrow$ borrow = 1
overflow = 0

d.

$$\begin{array}{r} 00110011 \\ -\,10101010 \\ \hline \end{array} \rightarrow \begin{array}{r} 00110011 \\ +\,01010110 \\ \hline 10001001 \end{array}$$

carry = 0 $\Rightarrow$ borrow = 1
overflow = 1