



CprE 281: Digital Logic

Instructor: Alexander Stoytchev

<http://www.ece.iastate.edu/~alexs/classes/>

Karnaugh Maps

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Iowa State University, Ames, IA
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Administrative Stuff

- **HW4 is out**
- **It is due on Monday Sep 18 @ 4 pm**
- **It is posted on the class web page**
- **I also sent you an e-mail with the link.**

Administrative Stuff

- **Homework Solutions are posted on BlackBoard**

Quick Review

Do You Still Remember This Boolean Algebra Theorem?

14a. $x \cdot y + x \cdot \bar{y} = x$

Combining

14b. $(x + y) \cdot (x + \bar{y}) = x$

Let's prove 14.a

x	y	$\mathbf{x \cdot y + x \cdot \bar{y} = x}$
0	0	
0	1	
1	0	
1	1	

Let's prove 14.a

x	y	$\mathbf{x \cdot y + x \cdot \bar{y} = x}$
0	0	0
0	1	0
1	0	0
1	1	1

Let's prove 14.a

x	y	$\mathbf{x \cdot y + x \cdot \bar{y} = x}$
0	0	0
0	1	0
1	0	1
1	1	1

Let's prove 14.a

x	y	$\mathbf{x \cdot y + x \cdot \bar{y} = x}$
0	0	0 0 0
0	1	0 0 0
1	0	0 1 1
1	1	1 1 0

Let's prove 14.a

x	y	$\mathbf{x \cdot y + x \cdot \bar{y} = x}$
0	0	0
0	1	0
1	0	1
1	1	1

Let's prove 14.a

x	y	$\mathbf{x} \cdot \mathbf{y} + \mathbf{x} \cdot \bar{\mathbf{y}} = \mathbf{x}$
0	0	0
0	1	0
1	0	1
1	1	1

They are equal.

Motivation

A	B	C	D	F
0	0	0	0	0
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1
0	1	1	1	0
1	0	0	0	0
1	0	0	1	1
1	0	1	0	0
1	0	1	1	1
1	1	0	0	1
1	1	0	1	0
1	1	1	0	1
1	1	1	1	0

**An approach for simplifying
logic expressions**

**How do we guarantee we
have reached minimum
SOP/POS representation?**

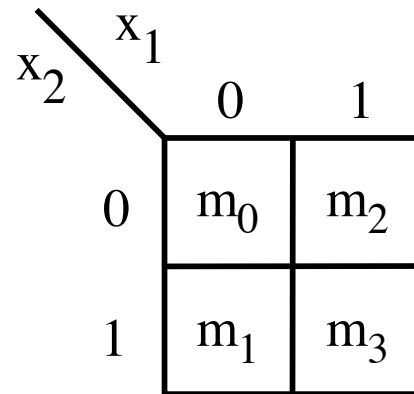
Two-Variable K-Map

Karnaugh Map (K-map)

- View the function in a visual form
- Same information as truth table
- Easier to group minterms

x_1	x_2	
0	0	m_0
0	1	m_1
1	0	m_2
1	1	m_3

(a) Truth table



(b) Karnaugh map

Minterms

x_1	x_2	
0	0	m_0
0	1	m_1
1	0	m_2
1	1	m_3

x_1	x_2	m_0	m_1	m_2	m_3
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

Minterm Example

x_1	x_2	
0	0	0
0	1	1
1	0	0
1	1	1

x_1	x_2	m_0	m_1	m_2	m_3	$m_1 + m_3$
0	0	1	0	0	0	0
0	1	0	1	0	0	1
1	0	0	0	1	0	0
1	1	0	0	0	1	1

Minterm Example

x_1	x_2	
0	0	0
0	1	1
1	0	0
1	1	1

x_1	x_2	m_0	m_1	m_2	m_3	$m_1 + m_3$
0	0	1	0	0	0	0
0	1	0	1	0	0	1
1	0	0	0	1	0	0
1	1	0	0	0	1	1

$$\bar{x}_1 x_2 + x_1 x_2 = x_2$$

Grouping Example

	x_1	0	1
x_2	0	1	0
	1	0	0

m_0

	x_1	0	1
x_2	0	0	0
	1	1	0

m_1

Grouping Example

	x_1	0	1
x_2			
0		1	0
1		0	0

m_0

+

	x_1	0	1
x_2			
0		0	0
1		1	0

m_1

=

	x_1	0	1
x_2			
0		1	0
1		1	0

$m_0 + m_1$

Grouping Example

	x_1	0	1
x_2	0	1	0
	1	0	0

m_0

+

	x_1	0	1
x_2	0	0	0
	1	1	0

m_1

=

	x_1	0	1
x_2	0	1	0
	1	1	0

$m_0 + m_1$

Grouping Example

	x_1	0	1
x_2	0	1	0
	1	0	0

m_0

$\bar{x}_1\bar{x}_2$

+

	x_1	0	1
x_2	0	0	0
	1	1	0

m_1

\bar{x}_1x_2

=

	x_1	0	1
x_2	0	1	0
	1	1	0

$m_0 + m_1$

\bar{x}_1

Property 14a (Combining)

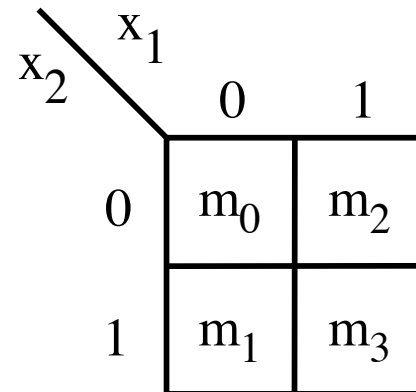
Grouping Rules

- **Group “1”s with rectangles**
- **Both sides a power of 2:**
 - **1x1, 1x2, 2x1, 2x2, 1x4, 4x1, 2x4, 4x2, 4x4**
- **Can use the same minterm more than once**
- **Can wrap around the edges of the map**
- **Some rules in selecting groups:**
 - **Try to use as few groups as possible to cover all “1”s.**
 - **For each group, try to make it as large as you can (i.e., if you can use a 2x2, don't use a 2x1 even if that is enough).**

Two-Variable K-map

x_1	x_2	
0	0	m_0
0	1	m_1
1	0	m_2
1	1	m_3

(a) Truth table



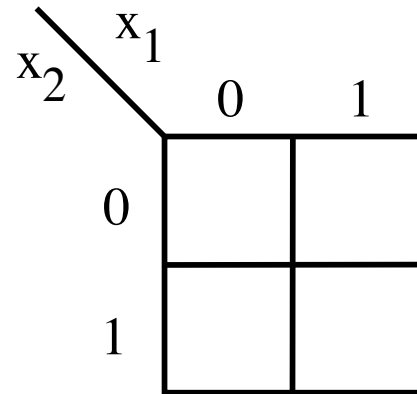
(b) Karnaugh map

Step-By-Step Example

x_1	x_2	
0	0	1
0	1	1
1	0	0
1	1	1

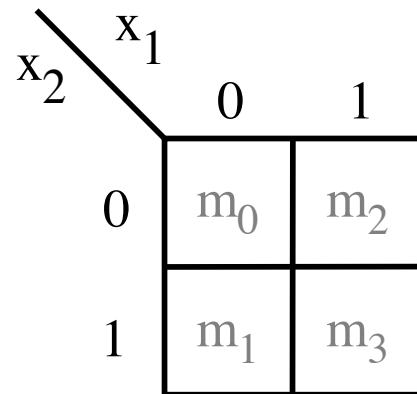
1. Draw The Map

x_1	x_2	
0	0	1
0	1	1
1	0	0
1	1	1



2. Fill The Map

	x_1	x_2	
m_0	0	0	1
m_1	0	1	1
m_2	1	0	0
m_3	1	1	1



2. Fill The Map

	x_1	x_2	
m_0	0	0	1
m_1	0	1	1
m_2	1	0	0
m_3	1	1	1

x_2	x_1	0	1
0		1	0
1		1	1

3. Group

	x_1	x_2	
m_0	0	0	1
m_1	0	1	1
m_2	1	0	0
m_3	1	1	1

x_2	x_1	0	1
0		1	0
1		1	1

3. Group

	x_1	x_2	
m_0	0	0	1
m_1	0	1	1
m_2	1	0	0
m_3	1	1	1

	x_1	0	1
x_2	0	1	0
	1	1	1

3. Group

	x_1	x_2	
m_0	0	0	1
m_1	0	1	1
m_2	1	0	0
m_3	1	1	1

	x_1	0	1
x_2	0	1	0
	1	1	1

4. Write The Expression

x_1	x_2	
0	0	1
0	1	1
1	0	0
1	1	1

x_2	x_1	0	1
0		1	0
1		1	1

4. Write The Expression

x_1	x_2	
0	0	1
0	1	1
1	0	0
1	1	1

$x_2 \backslash x_1$	0	1
0	1	0
1	1	1

$$\bar{x}_1 + x_2$$

Writing The Expression

- Find which variable is constant

		x_1	
		0	1
x_2	0	1	0
	1	1	0

\bar{x}_1 is constant

Writing The Expression

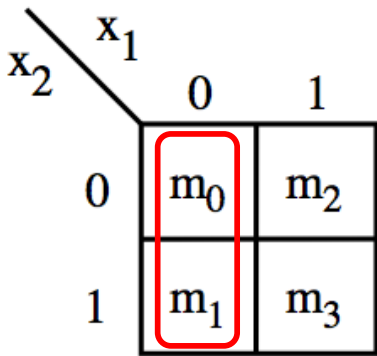
- Find which variable is constant

		x_1	
		0	1
x_2	0	0	1
	1	0	1

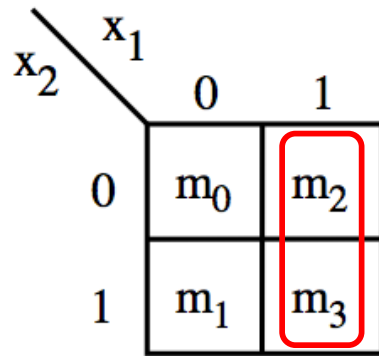
x_1 is constant

These are all valid groupings

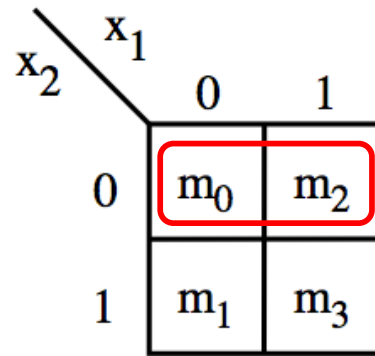
	x_1		
x_2		0	1
0		m_0	m_2
1		m_1	m_3

A 2x2 Karnaugh map for variables x1 and x2. The top row is labeled x1 with values 0 and 1. The left column is labeled x2 with values 0 and 1. The cells contain m0, m2, m1, and m3. Red boxes are drawn around the cells containing m0 and m1, representing a valid grouping.

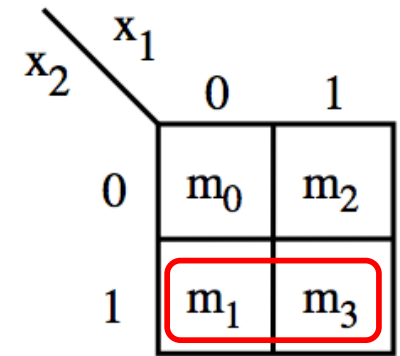
	x_1		
x_2		0	1
0		m_0	m_2
1		m_1	m_3

A 2x2 Karnaugh map for variables x1 and x2. The top row is labeled x1 with values 0 and 1. The left column is labeled x2 with values 0 and 1. The cells contain m0, m2, m1, and m3. Red boxes are drawn around the cells containing m2 and m3, representing a valid grouping.

	x_1		
x_2		0	1
0		m_0	m_2
1		m_1	m_3

A 2x2 Karnaugh map for variables x1 and x2. The top row is labeled x1 with values 0 and 1. The left column is labeled x2 with values 0 and 1. The cells contain m0, m2, m1, and m3. Red boxes are drawn around the cells containing m0 and m2, representing a valid grouping.

	x_1		
x_2		0	1
0		m_0	m_2
1		m_1	m_3

A 2x2 Karnaugh map for variables x1 and x2. The top row is labeled x1 with values 0 and 1. The left column is labeled x2 with values 0 and 1. The cells contain m0, m2, m1, and m3. Red boxes are drawn around the cells containing m1 and m3, representing a valid grouping.

These are also valid

	x_1		
x_2		0	1
0		m_0	m_2
1		m_1	m_3

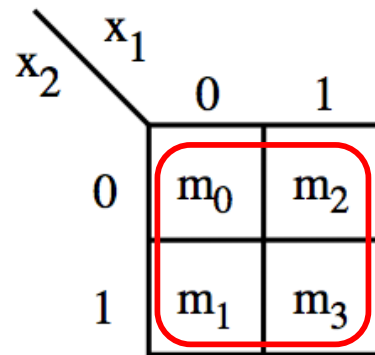
	x_1		
x_2		0	1
0		m_0	m_2
1		m_1	m_3

	x_1		
x_2		0	1
0		m_0	m_2
1		m_1	m_3

	x_1		
x_2		0	1
0		m_0	m_2
1		m_1	m_3

But try to use larger rectangles if possible.

This one is valid too



In this case the result is the constant function 1.

Why are these two not valid?

	x_1		
x_2		0	1
0		m_0	m_2
1		m_1	m_3

	x_1		
x_2		0	1
0		m_0	m_2
1		m_1	m_3

Let's Find Out

		x_1	
	x_2		
		0	1
0		1	0
1		0	0

m_0

		x_1	
	x_2		
		0	1
0		0	0
1		0	1

m_3

Let's Find Out

	x_1	0	1
x_2			
0		1	0
1		0	0

m_0

+

	x_1	0	1
x_2			
0		0	0
1		0	1

m_3

=

	x_1	0	1
x_2			
0		1	0
1		0	1

$m_0 + m_3$

Let's Find Out

	x_1	0	1
x_2	0	1	0
	1	0	0

m_0

+

	x_1	0	1
x_2	0	0	0
	1	0	1

m_3

=

	x_1	0	1
x_2	0	1	0
	1	0	1

$m_0 + m_3$

Let's Find Out

	x_1	0	1
x_2	0	1	0
	1	0	0

+

	x_1	0	1
x_2	0	0	0
	1	0	1

=

	x_1	0	1
x_2	0	1	0
	1	0	1

m_0

+

m_3

=

$m_0 + m_3$

$\bar{x}_1\bar{x}_2$

+

x_1x_2

=

$\bar{x}_1\bar{x}_2 + x_1x_2$

We can't use Property 14a here. This can't be simplified.

Three-Variable K-Map

Location of three-variable minterms

x_1	x_2	x_3	
0	0	0	m_0
0	0	1	m_1
0	1	0	m_2
0	1	1	m_3
1	0	0	m_4
1	0	1	m_5
1	1	0	m_6
1	1	1	m_7

(a) Truth table

		x_1x_2			
		00	01	11	10
x_3	0	m_0	m_2	m_6	m_4
	1	m_1	m_3	m_7	m_5

(b) Karnaugh map

Location of three-variable minterms

x_1	x_2	x_3	
0	0	0	m_0
0	0	1	m_1
0	1	0	m_2
0	1	1	m_3
1	0	0	m_4
1	0	1	m_5
1	1	0	m_6
1	1	1	m_7

(a) Truth table

		x_1x_2			
		00	01	11	10
x_3	0	m_0	m_2	m_6	m_4
	1	m_1	m_3	m_7	m_5

(b) Karnaugh map

Notice the placement of

- **Variables**
- **Binary pair values**
- **Minterms**

Gray Code

- **Sequence of binary codes**
- **Two neighboring lines vary by only 1 bit**

	000
	001
00	011
01	010
11	110
10	111
	101
	100

Gray Code & K-map

	s	x_1	x_2
m_0	0	0	0
m_1	0	0	1
m_2	0	1	0
m_3	0	1	1
m_4	1	0	0
m_5	1	0	1
m_6	1	1	0
m_7	1	1	1

		$s x_1$			
		00	01	11	10
x_2	0	m_0	m_2	m_6	m_4
	1	m_1	m_3	m_7	m_5

Gray Code & K-map

	s	x_1	x_2
m_0	0	0	0
m_1	0	0	1
m_2	0	1	0
m_3	0	1	1
m_4	1	0	0
m_5	1	0	1
m_6	1	1	0
m_7	1	1	1

		$s x_1$			
		00	01	11	10
x_2	0	000	010	110	100
	1	001	011	111	101

Adjacency Rules

		x_1x_2			
		00	01	11	10
x_3	0	m_0	m_2	m_6	m_4
	1	m_1	m_3	m_7	m_5



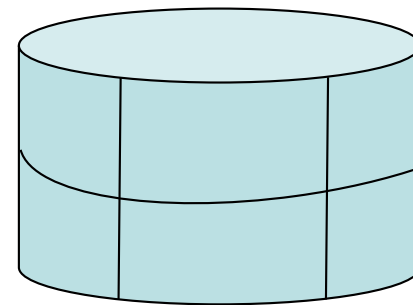
adjacent
columns

Adjacency Rules

		x_1x_2			
		00	01	11	10
x_3	0	m_0	m_2	m_6	m_4
	1	m_1	m_3	m_7	m_5



adjacent
columns



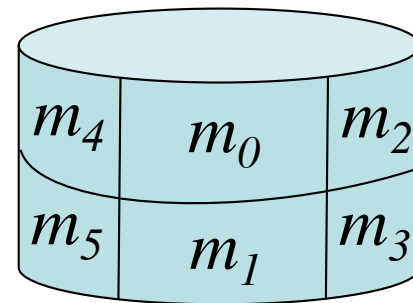
As if the K-map were
drawn on a cylinder

Adjacency Rules

		x_1x_2			
		00	01	11	10
x_3	0	m_0	m_2	m_6	m_4
	1	m_1	m_3	m_7	m_5



adjacent
columns



As if the K-map were
drawn on a cylinder

These are valid groupings

$x_3 \backslash x_1x_2$	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5

$x_3 \backslash x_1x_2$	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5

$x_3 \backslash x_1x_2$	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5

$x_3 \backslash x_1x_2$	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5

These are valid groupings

$x_3 \backslash x_1x_2$	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5

$x_3 \backslash x_1x_2$	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5

$x_3 \backslash x_1x_2$	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5

$x_3 \backslash x_1x_2$	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5

These are valid groupings

$x_3 \backslash x_1x_2$	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5

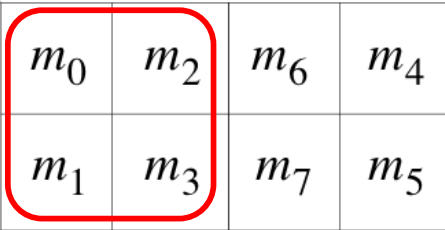
$x_3 \backslash x_1x_2$	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5

$x_3 \backslash x_1x_2$	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5

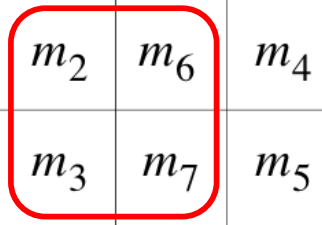
$x_3 \backslash x_1x_2$	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5

These are valid groupings

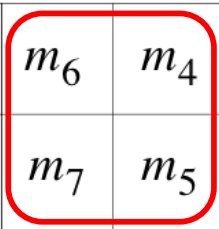
$x_3 \backslash x_1x_2$	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5



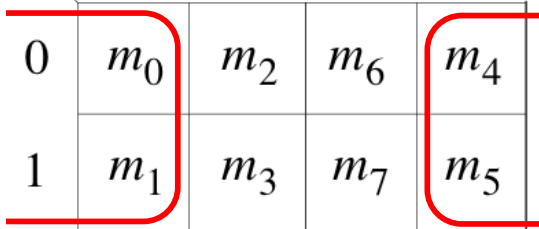
$x_3 \backslash x_1x_2$	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5



$x_3 \backslash x_1x_2$	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5



$x_3 \backslash x_1x_2$	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5



These are valid groupings

x_3 \ x_1x_2	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5

x_3 \ x_1x_2	00	01	11	10
0	m_0	m_2	m_6	m_4
1	m_1	m_3	m_7	m_5

This is a valid grouping

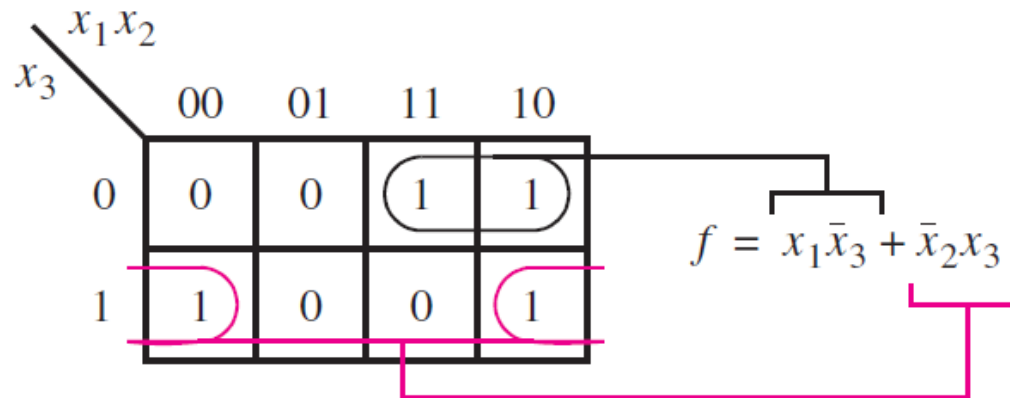
		x_1x_2			
		00	01	11	10
x_3	0	m_0	m_2	m_6	m_4
	1	m_1	m_3	m_7	m_5

Some invalid groupings

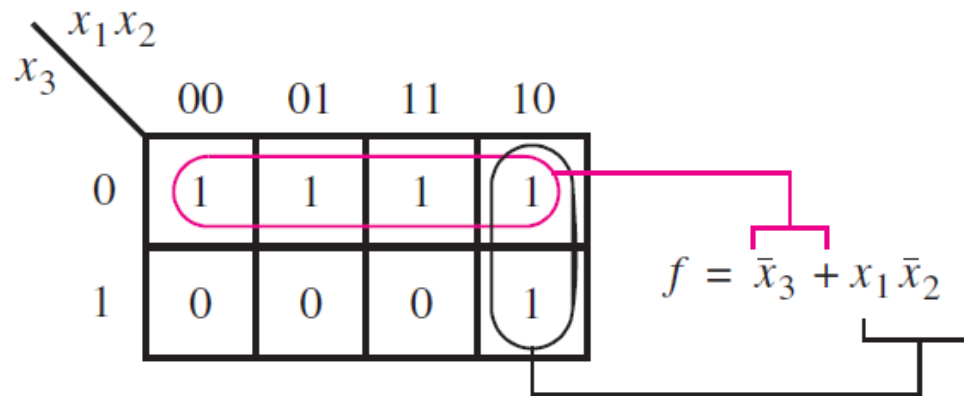
		x_1x_2			
x_3		00	01	11	10
0	m_0	m_2	m_6	m_4	
1	m_1	m_3	m_7	m_5	

		x_1x_2			
x_3		00	01	11	10
0	m_0	m_2	m_6	m_4	
1	m_1	m_3	m_7	m_5	

Examples of three-variable Karnaugh maps



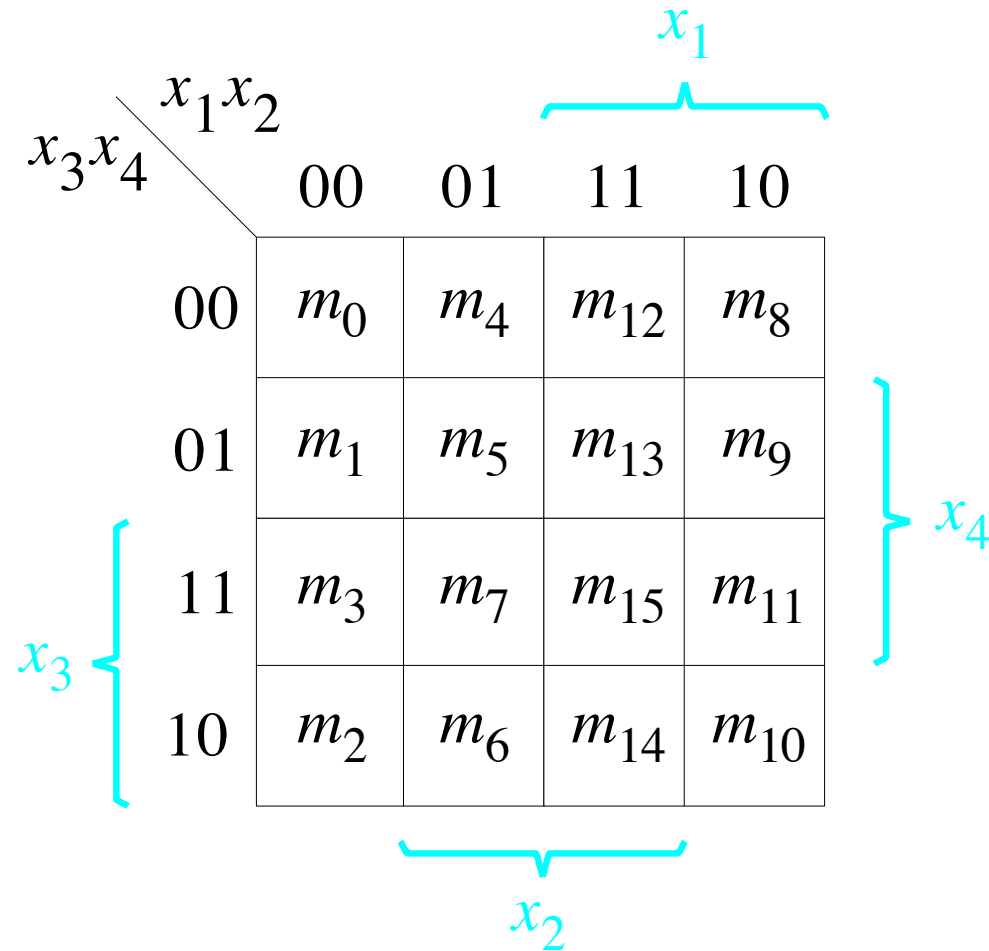
(a) The function of Figure 2.23



(b) The function of Figure 2.48

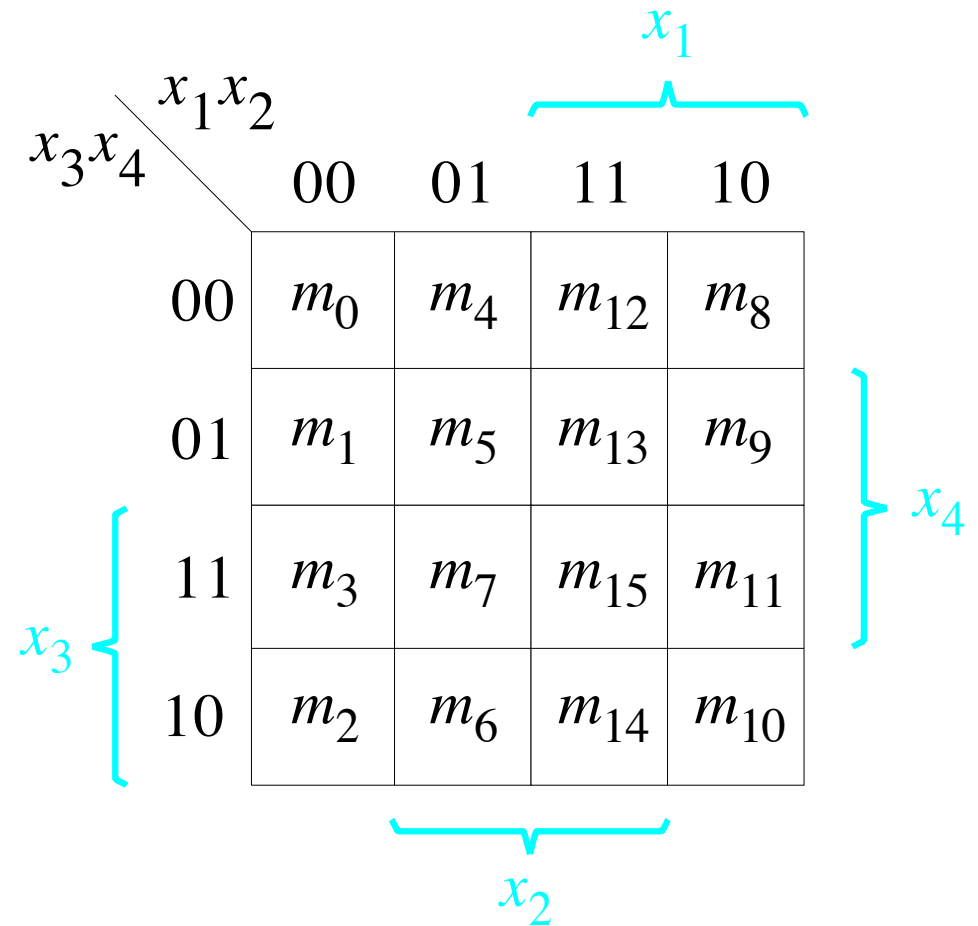
Four-Variable K-Map

A four-variable Karnaugh map



A four-variable Karnaugh map

x1	x2	x3	x4	
0	0	0	0	m0
0	0	0	1	m1
0	0	1	0	m2
0	0	1	1	m3
<hr/>				
0	1	0	0	m4
0	1	0	1	m5
0	1	1	0	m6
0	1	1	1	m7
<hr/>				
1	0	0	0	m8
1	0	0	1	m9
1	0	1	0	m10
1	0	1	1	m11
<hr/>				
1	1	0	0	m12
1	1	0	1	m13
1	1	1	0	m14
1	1	1	1	m15



Adjacency Rules

x_3	x_1x_2	00	01	11	10
0		m_0	m_2	m_6	m_4
1		m_1	m_3	m_7	m_5

adjacent
columns

x_3x_4	x_1x_2	00	01	11	10
00		m_0	m_4	m_{12}	m_8
01		m_1	m_5	m_{13}	m_9
11		m_3	m_7	m_{15}	m_{11}
10		m_2	m_6	m_{14}	m_{10}

adjacent
columns

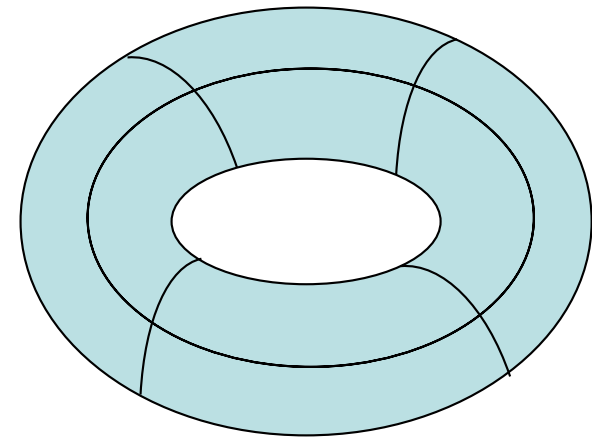
adjacent
rows

Adjacency Rules

$x_3x_4 \backslash x_1x_2$	00	01	11	10
00	m_0	m_4	m_{12}	m_8
01	m_1	m_5	m_{13}	m_9
11	m_3	m_7	m_{15}	m_{11}
10	m_2	m_6	m_{14}	m_{10}

adjacent
rows

adjacent
columns



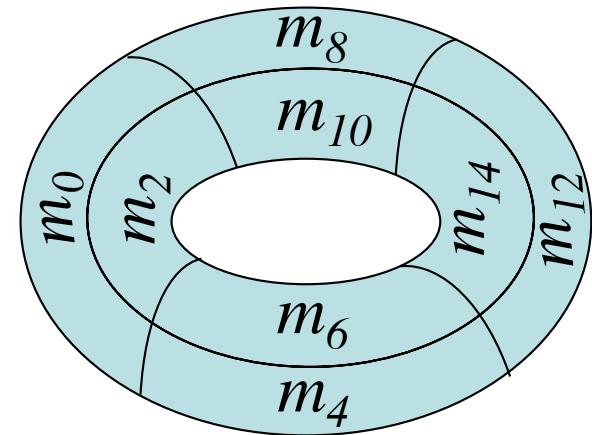
As if the K-map were
drawn on a torus

Adjacency Rules

$x_3x_4 \backslash x_1x_2$	00	01	11	10
00	m_0	m_4	m_{12}	m_8
01	m_1	m_5	m_{13}	m_9
11	m_3	m_7	m_{15}	m_{11}
10	m_2	m_6	m_{14}	m_{10}

adjacent
rows

adjacent
columns



As if the K-map were
drawn on a torus

Some Valid Groupings

		x_1				
		x_1x_2	00	01	11	10
x_3	x_3x_4	00	m_0	m_4	m_{12}	m_8
	01	m_1	m_5	m_{13}	m_9	
	11	m_3	m_7	m_{15}	m_{11}	
	10	m_2	m_6	m_{14}	m_{10}	
		x_2				

		x_1				
		x_1x_2	00	01	11	10
x_3	x_3x_4	00	m_0	m_4	m_{12}	m_8
	01	m_1	m_5	m_{13}	m_9	
	11	m_3	m_7	m_{15}	m_{11}	
	10	m_2	m_6	m_{14}	m_{10}	
		x_2				

		x_1				
		x_1x_2	00	01	11	10
x_3	x_3x_4	00	m_0	m_4	m_{12}	m_8
	01	m_1	m_5	m_{13}	m_9	
	11	m_3	m_7	m_{15}	m_{11}	
	10	m_2	m_6	m_{14}	m_{10}	
		x_2				

		x_1				
		x_1x_2	00	01	11	10
x_3	x_3x_4	00	m_0	m_4	m_{12}	m_8
	01	m_1	m_5	m_{13}	m_9	
	11	m_3	m_7	m_{15}	m_{11}	
	10	m_2	m_6	m_{14}	m_{10}	
		x_2				

Some Valid Groupings

		x_1			
		x_1x_2	x_1x_2	x_1x_2	x_1x_2
x_3x_4	x_3x_4	00	01	11	10
	00	m_0	m_4	m_{12}	m_8
	01	m_1	m_5	m_{13}	m_9
	11	m_3	m_7	m_{15}	m_{11}
10	m_2	m_6	m_{14}	m_{10}	
		x_2			

x_4

x_3

		x_1			
		x_1x_2	x_1x_2	x_1x_2	x_1x_2
x_3x_4	x_3x_4	00	01	11	10
	00	m_0	m_4	m_{12}	m_8
	01	m_1	m_5	m_{13}	m_9
	11	m_3	m_7	m_{15}	m_{11}
10	m_2	m_6	m_{14}	m_{10}	
		x_2			

x_4

x_3

		x_1			
		x_1x_2	x_1x_2	x_1x_2	x_1x_2
x_3x_4	x_3x_4	00	01	11	10
	00	m_0	m_4	m_{12}	m_8
	01	m_1	m_5	m_{13}	m_9
	11	m_3	m_7	m_{15}	m_{11}
10	m_2	m_6	m_{14}	m_{10}	
		x_2			

x_4

x_3

		x_1			
		x_1x_2	x_1x_2	x_1x_2	x_1x_2
x_3x_4	x_3x_4	00	01	11	10
	00	m_0	m_4	m_{12}	m_8
	01	m_1	m_5	m_{13}	m_9
	11	m_3	m_7	m_{15}	m_{11}
10	m_2	m_6	m_{14}	m_{10}	
		x_2			

x_4

x_3

Some Valid Groupings

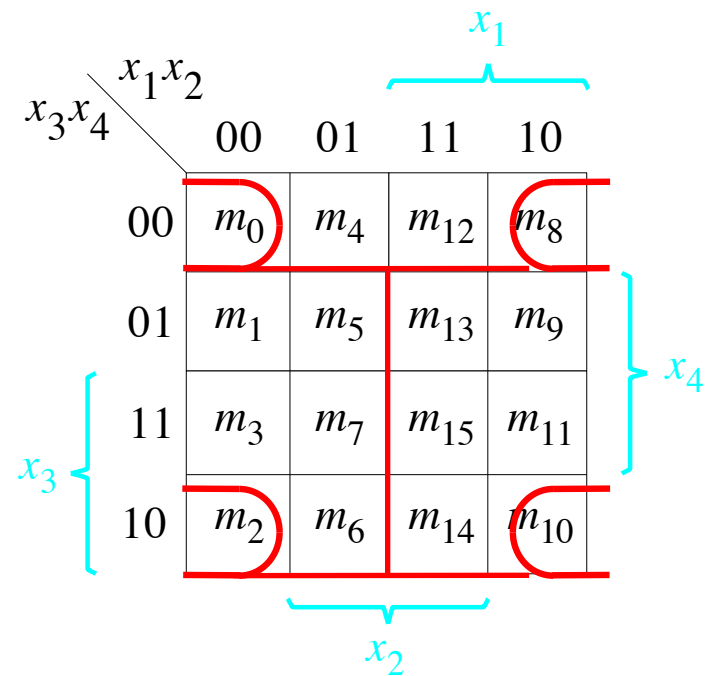
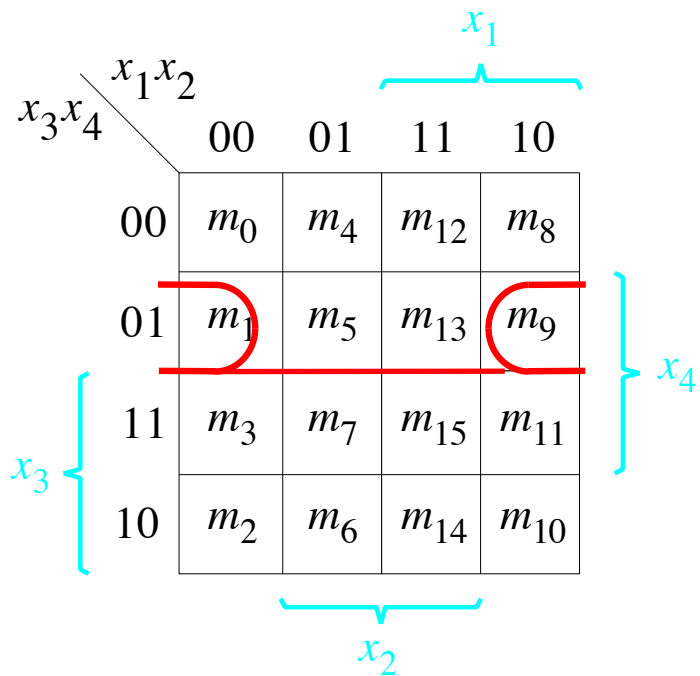
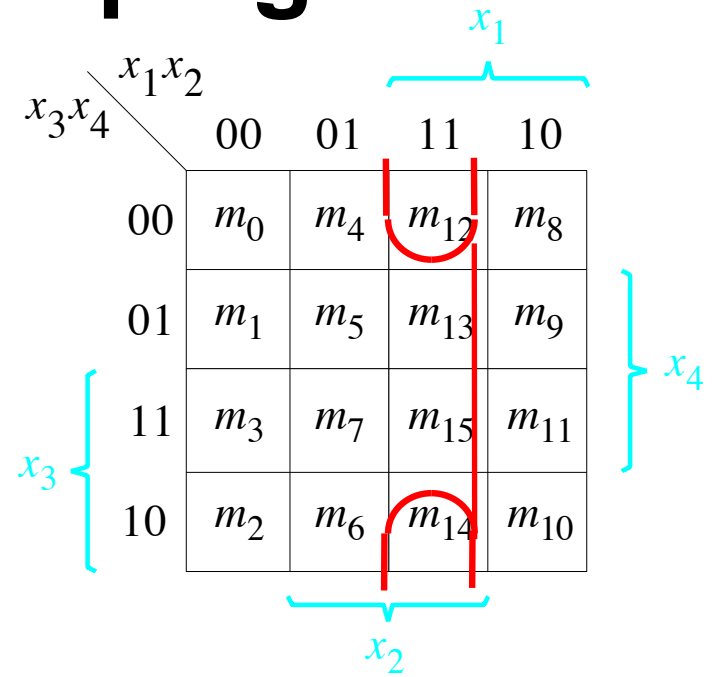
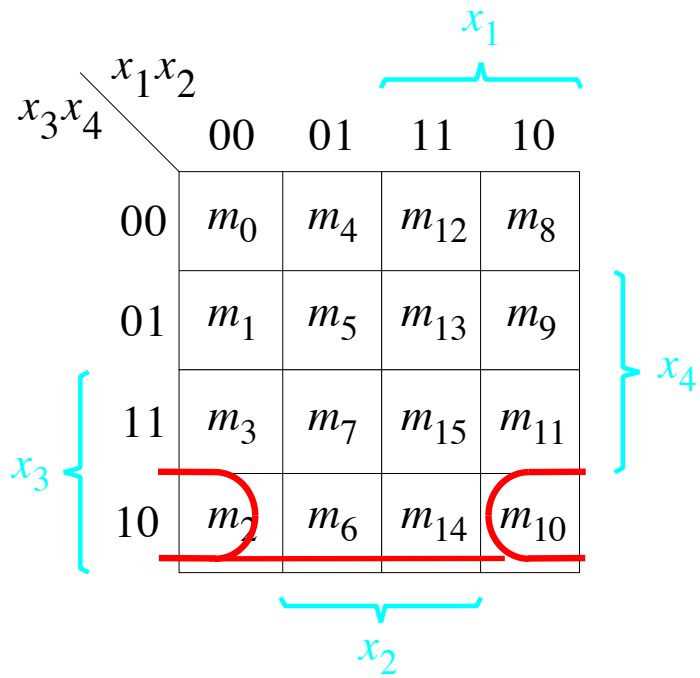
		x_1x_2				
		00	01	11	10	
x_3x_4	00	m_0	m_4	m_{12}	m_8	x_4
	01	m_1	m_5	m_{13}	m_9	
	11	m_3	m_7	m_{15}	m_{11}	
	10	m_2	m_6	m_{14}	m_{10}	
		x_2				

		x_1x_2				
		00	01	11	10	
x_3x_4	00	m_0	m_4	m_{12}	m_8	x_4
	01	m_1	m_5	m_{13}	m_9	
	11	m_3	m_7	m_{15}	m_{11}	
	10	m_2	m_6	m_{14}	m_{10}	
		x_2				

		x_1x_2				
		00	01	11	10	
x_3x_4	00	m_0	m_4	m_{12}	m_8	x_4
	01	m_1	m_5	m_{13}	m_9	
	11	m_3	m_7	m_{15}	m_{11}	
	10	m_2	m_6	m_{14}	m_{10}	
		x_2				

		x_1x_2				
		00	01	11	10	
x_3x_4	00	m_0	m_4	m_{12}	m_8	x_4
	01	m_1	m_5	m_{13}	m_9	
	11	m_3	m_7	m_{15}	m_{11}	
	10	m_2	m_6	m_{14}	m_{10}	
		x_2				

Some Valid Groupings



Some Invalid Groupings

		x_1			
		x_1x_2	x_1x_2	x_1x_2	x_1x_2
x_3	x_3x_4	00	01	11	10
	00	m_0	m_4	m_{12}	m_8
	01	m_1	m_5	m_{13}	m_9
	11	m_3	m_7	m_{15}	m_{11}
	10	m_2	m_6	m_{14}	m_{10}
		x_2			

x_4

		x_1			
		x_1x_2	x_1x_2	x_1x_2	x_1x_2
x_3	x_3x_4	00	01	11	10
	00	m_0	m_4	m_{12}	m_8
	01	m_1	m_5	m_{13}	m_9
	11	m_3	m_7	m_{15}	m_{11}
	10	m_2	m_6	m_{14}	m_{10}
		x_2			

x_4

All sides must be powers of 2.

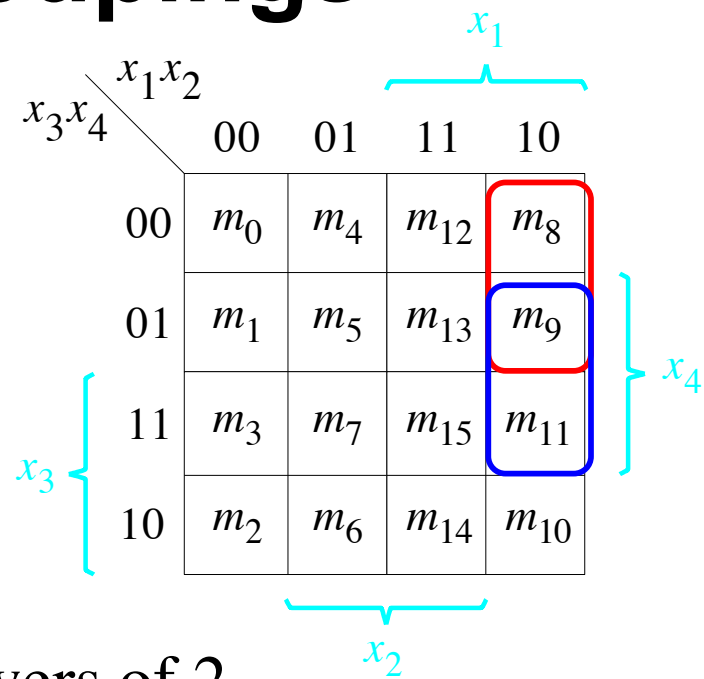
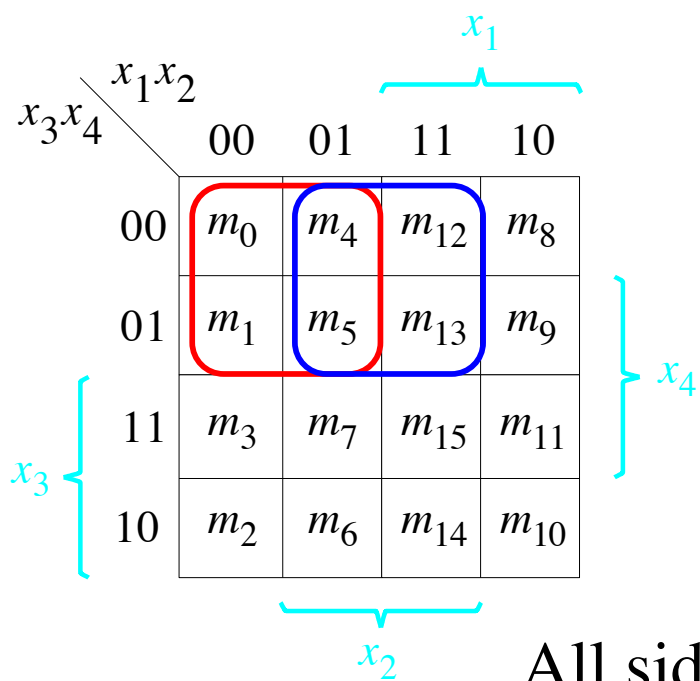
		x_1			
		x_1x_2	x_1x_2	x_1x_2	x_1x_2
x_3	x_3x_4	00	01	11	10
	00	m_0	m_4	m_{12}	m_8
	01	m_1	m_5	m_{13}	m_9
	11	m_3	m_7	m_{15}	m_{11}
	10	m_2	m_6	m_{14}	m_{10}
		x_2			

x_4

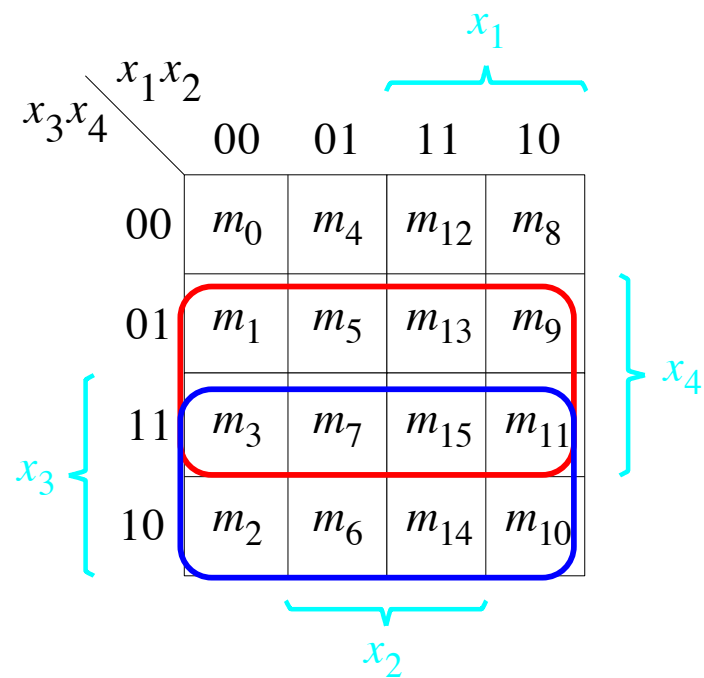
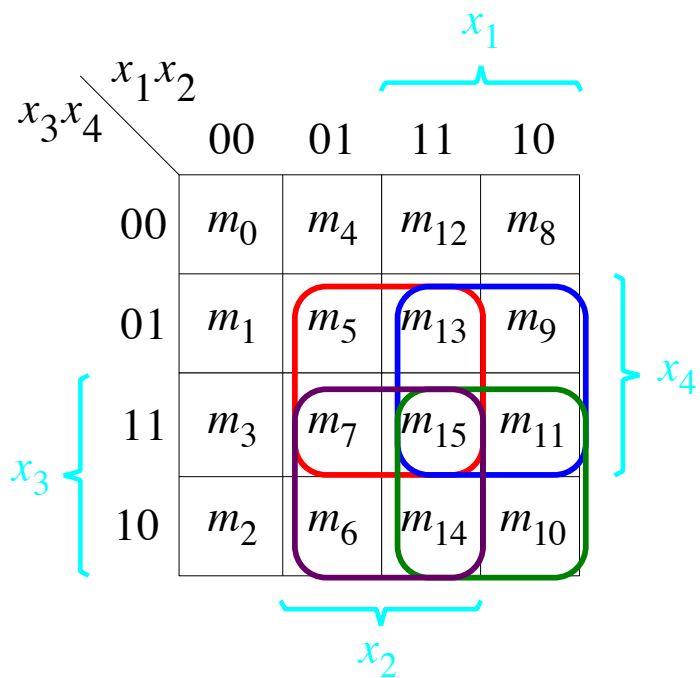
		x_1			
		x_1x_2	x_1x_2	x_1x_2	x_1x_2
x_3	x_3x_4	00	01	11	10
	00	m_0	m_4	m_{12}	m_8
	01	m_1	m_5	m_{13}	m_9
	11	m_3	m_7	m_{15}	m_{11}
	10	m_2	m_6	m_{14}	m_{10}
		x_2			

x_4

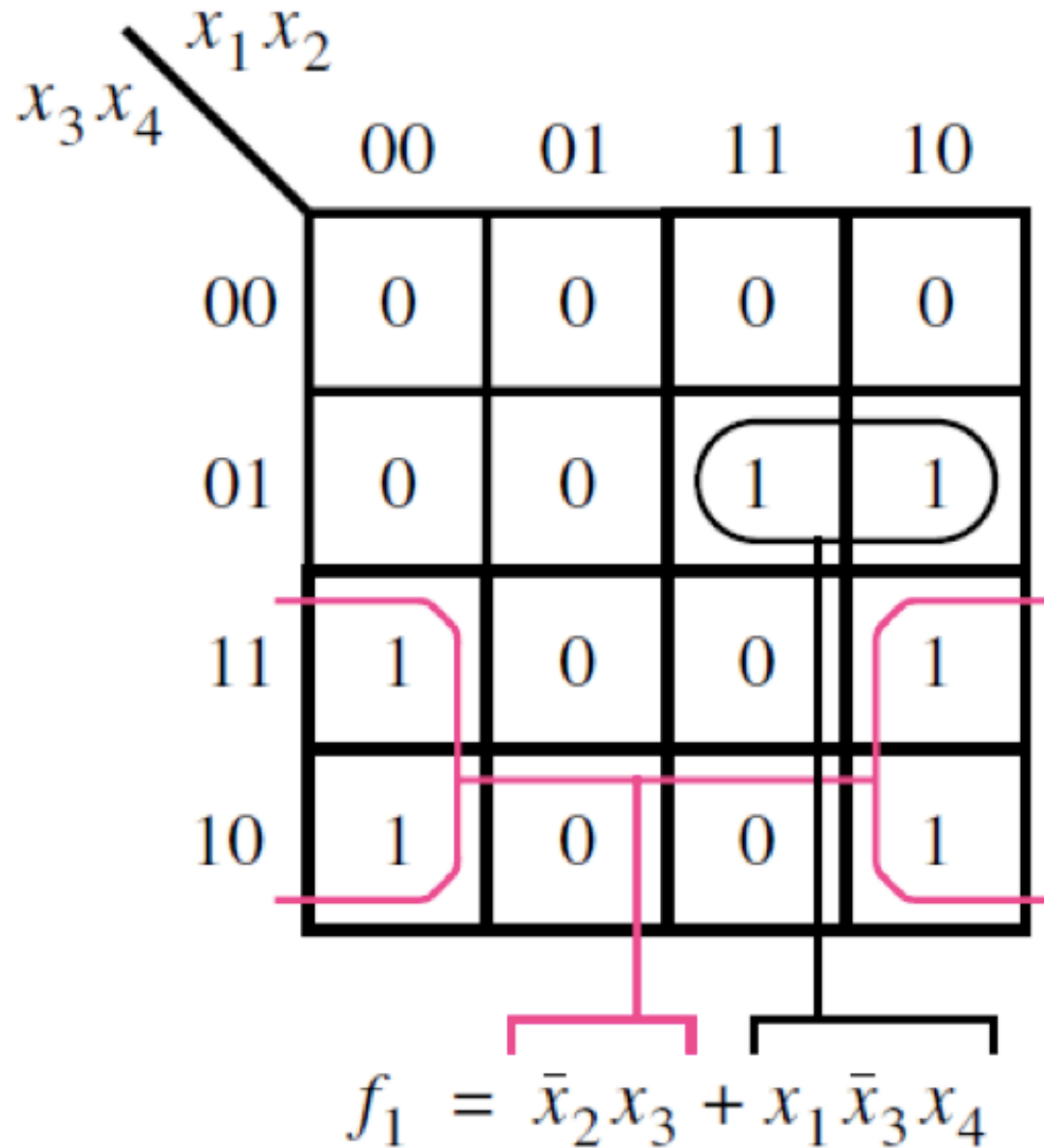
Some **valid** Groupings



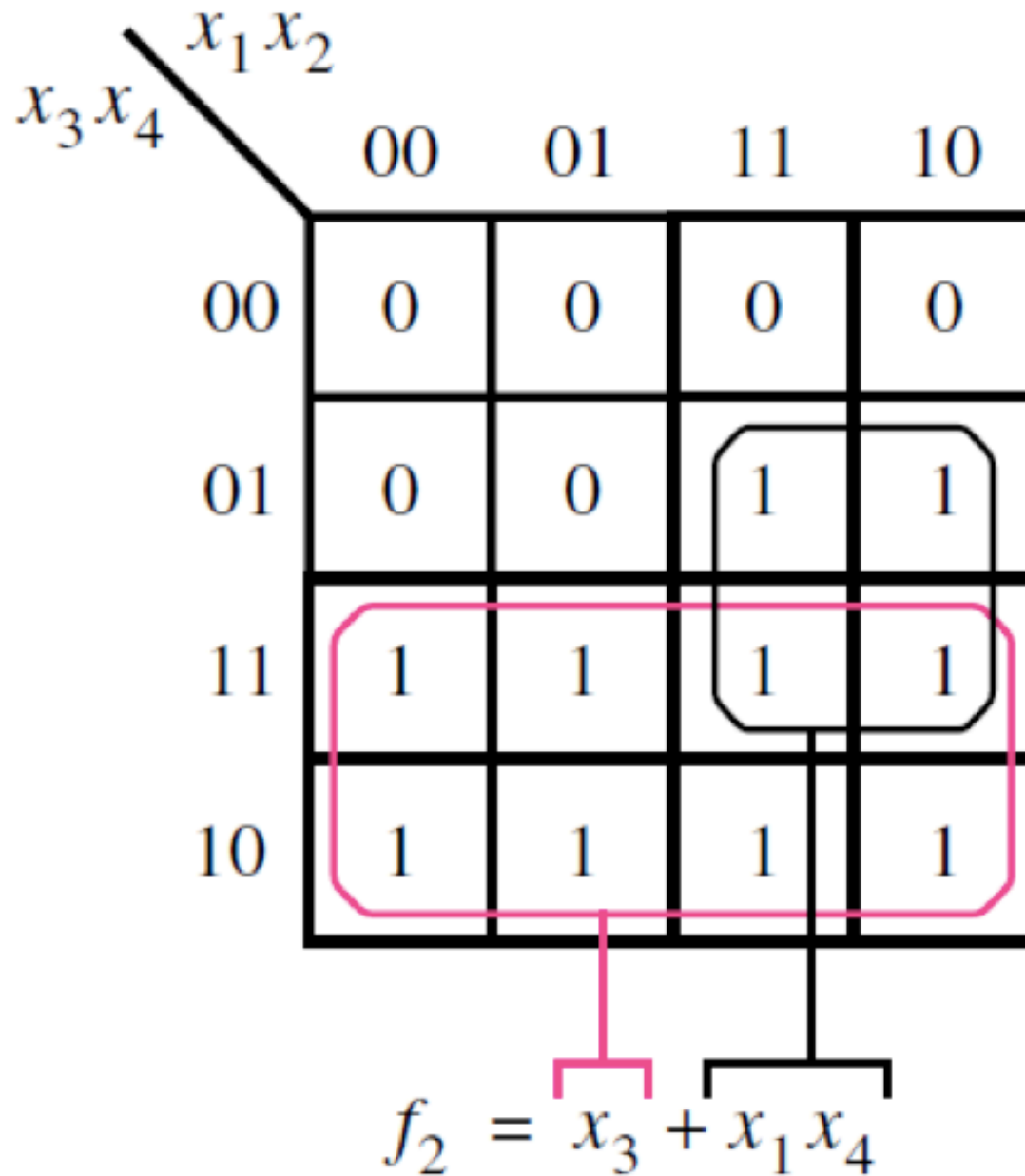
All sides must be powers of 2.



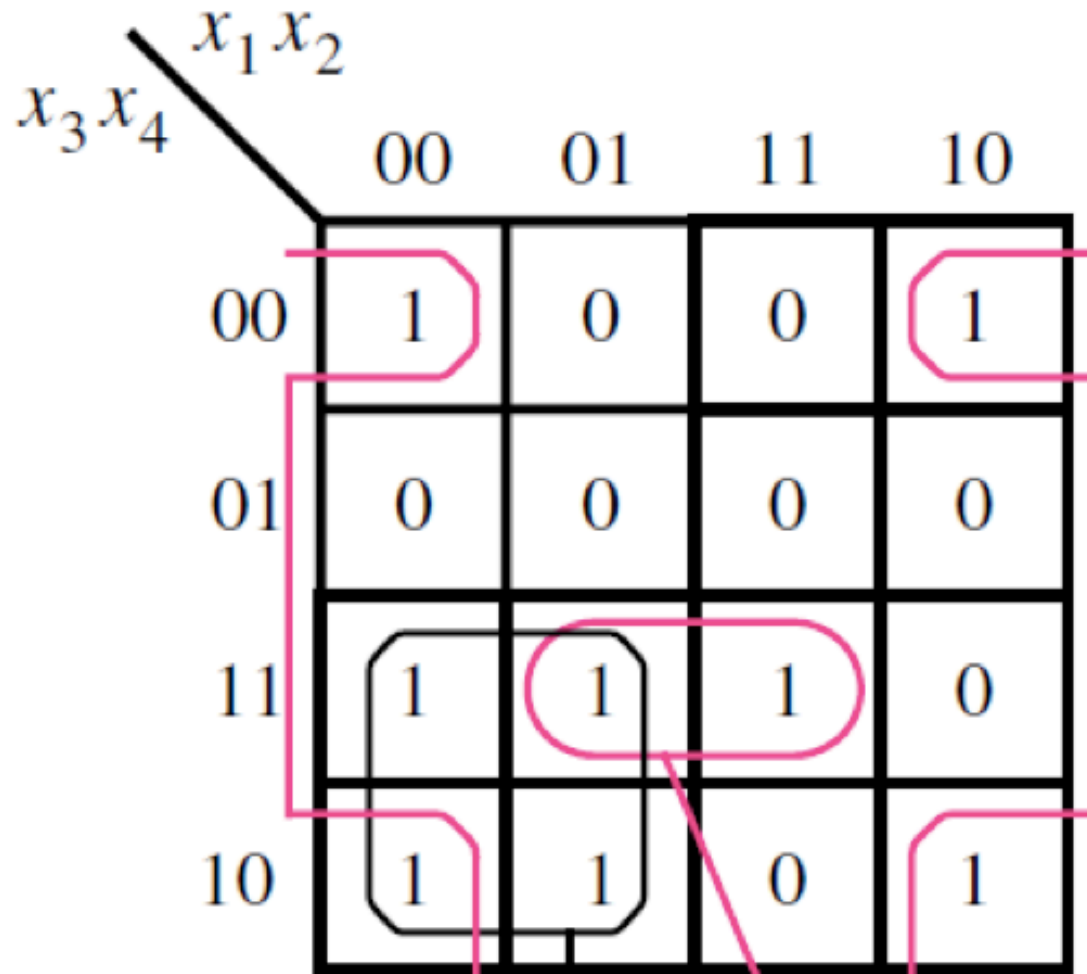
Example of a four-variable Karnaugh map



Example of a four-variable Karnaugh map

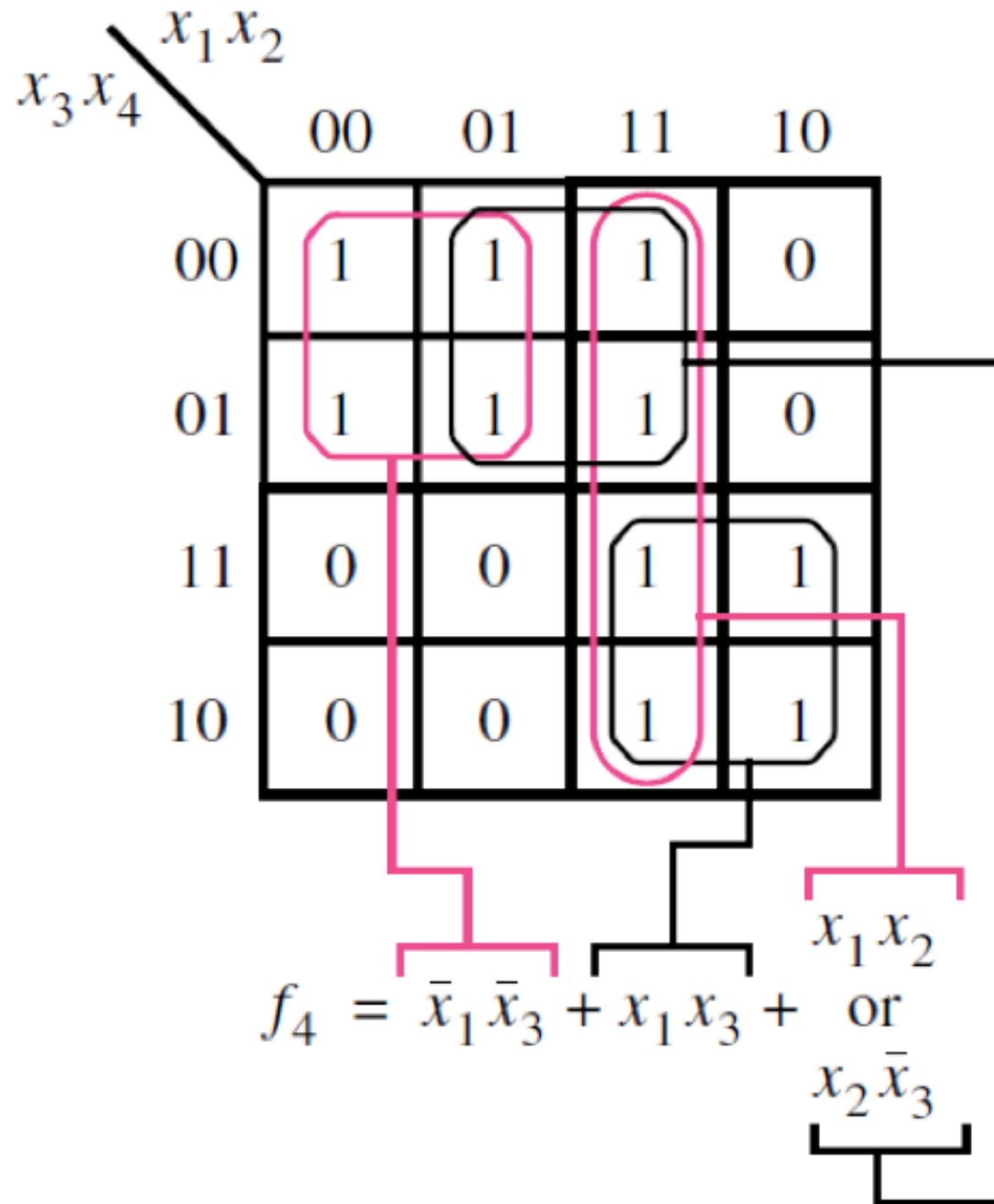


Example of a four-variable Karnaugh map



$$f_3 = \bar{x}_2\bar{x}_4 + \bar{x}_1x_3 + x_2x_3x_4$$

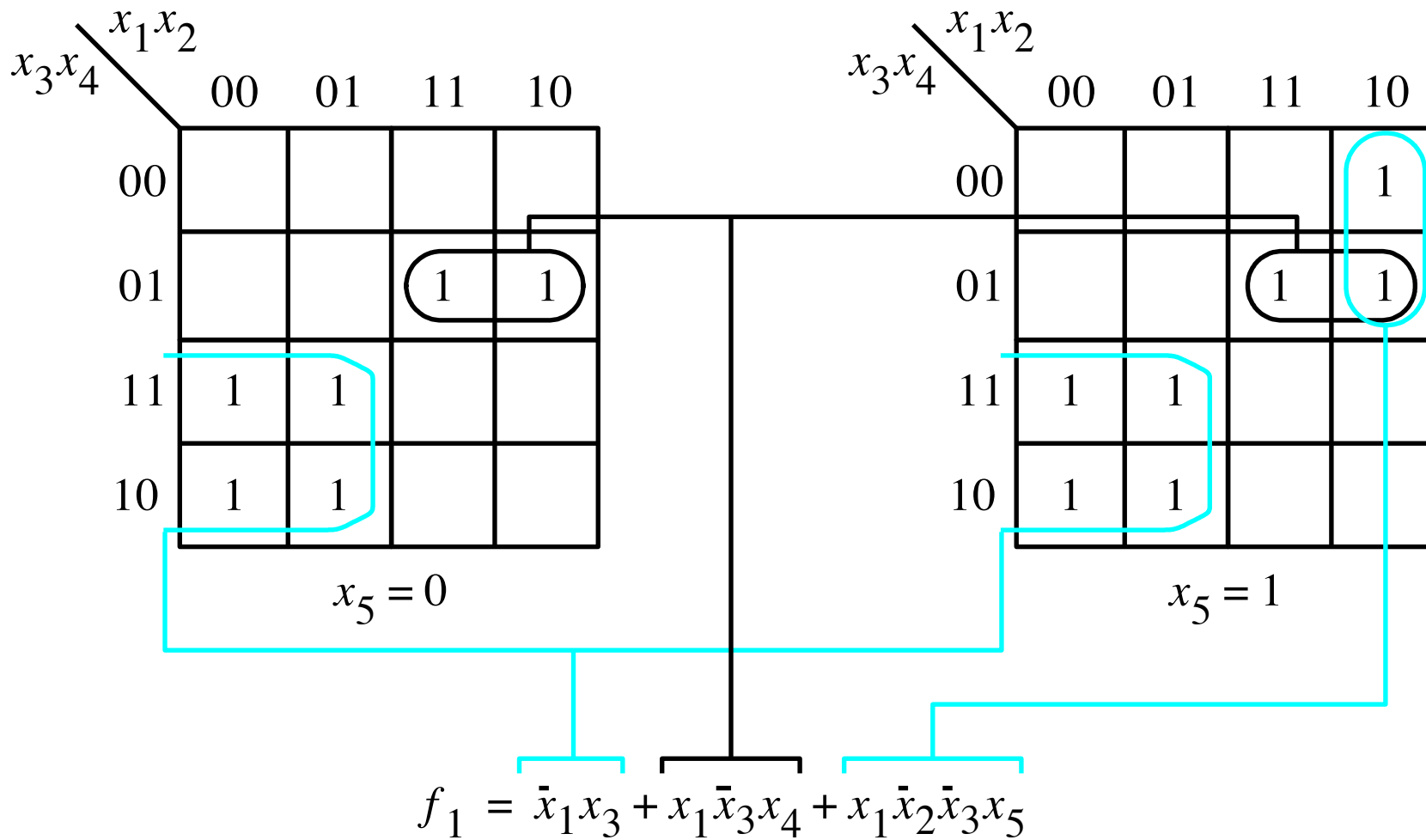
Example of a four-variable Karnaugh map



[Figure 2.54 from the textbook]

Five-Variable K-Map

A five-variable Karnaugh map



[Figure 2.55 from the textbook]

Questions?

THE END