

Binary Arithmetic Operation



Addition of Positive Numbers

$$0 + 0 = 0$$

$$0 + 1 = 1$$

$$1 + 0 = 1$$

$$1 + 1 = 10 \text{ with a carry-over of 1}$$

$$\begin{array}{r} & & 1 \\ & (+) & 1 \\ \hline \end{array}$$

Carry-overs of binary addition are performed in the same manner as in decimal addition.

Addition of Positive Numbers

$$0 + 0 = 0$$

$$0 + 1 = 1$$

$$1 + 0 = 1$$

$$1 + 1 = 10 \text{ with a carry-over of 1}$$

$$\begin{array}{r} & & 1 \\ & (+) & 1 \\ \hline & 0 \end{array}$$

Carry-overs of binary addition are performed in the same manner as in decimal addition.

Addition of Positive Numbers

$$0 + 0 = 0$$

$$0 + 1 = 1$$

$$1 + 0 = 1$$

$$1 + 1 = 10 \text{ with a carry-over of 1}$$

A binary addition diagram. On the left, there is a vertical column of digits: the first digit is 1, the second is + (operator), the third is 1, and the fourth is 0 (sum). A red arrow points from the top 1 down to the + sign, indicating the carry-over. To the right of the column is the result: 1 above the line and 0 below the line, separated by a horizontal line.

$$\begin{array}{r} 1 \\ (+) \\ 1 \\ \hline 0 \end{array}$$

Carry-overs of binary addition are performed in the same manner as in decimal addition.

Addition of Positive Numbers

$$0 + 0 = 0$$

$$0 + 1 = 1$$

$$1 + 0 = 1$$

$$1 + 1 = 10 \text{ with a carry-over of 1}$$

A binary addition diagram. On the left, there are two columns of binary digits: the first column has '1' above it and the second has '0'. A red arrow points from the top '1' down to the '+' sign between the two columns. Below the columns is a horizontal line with '1' to its left and '0' to its right.

$$\begin{array}{r} 1 \\ + 1 \\ \hline 1 0 \end{array}$$

Carry-overs of binary addition are performed in the same manner as in decimal addition.

Addition of Positive Numbers

$$0 + 0 = 0$$

$$0 + 1 = 1$$

$$1 + 0 = 1$$

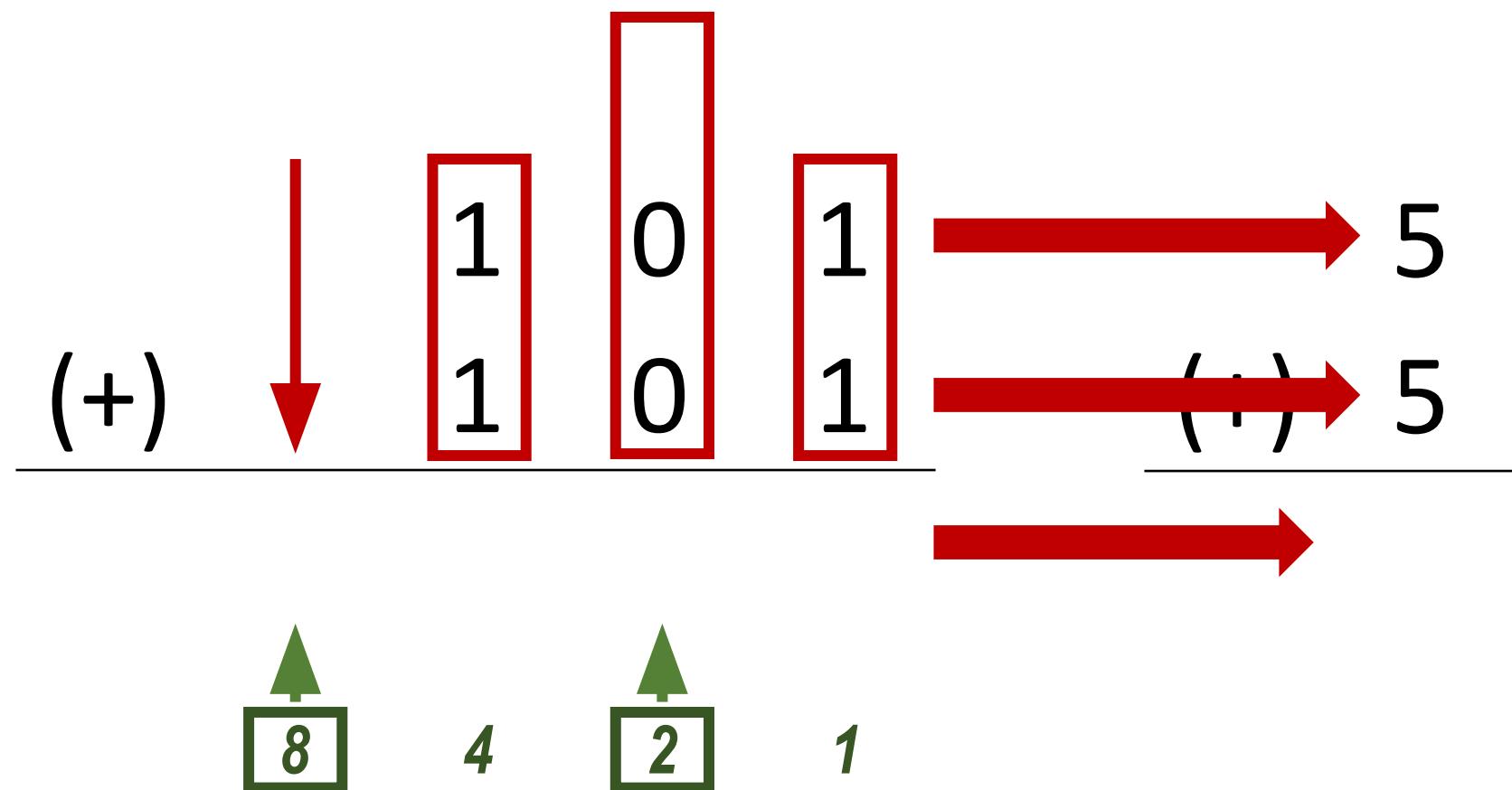
$$1 + 1 = 10 \text{ with a carry-over of 1}$$

$$\begin{array}{r} & & 1 \\ & & 1 \\ & (+) & 1 \\ \hline 1 & 0 \end{array}$$

Carry-overs of binary addition are performed in the same manner as in decimal addition.

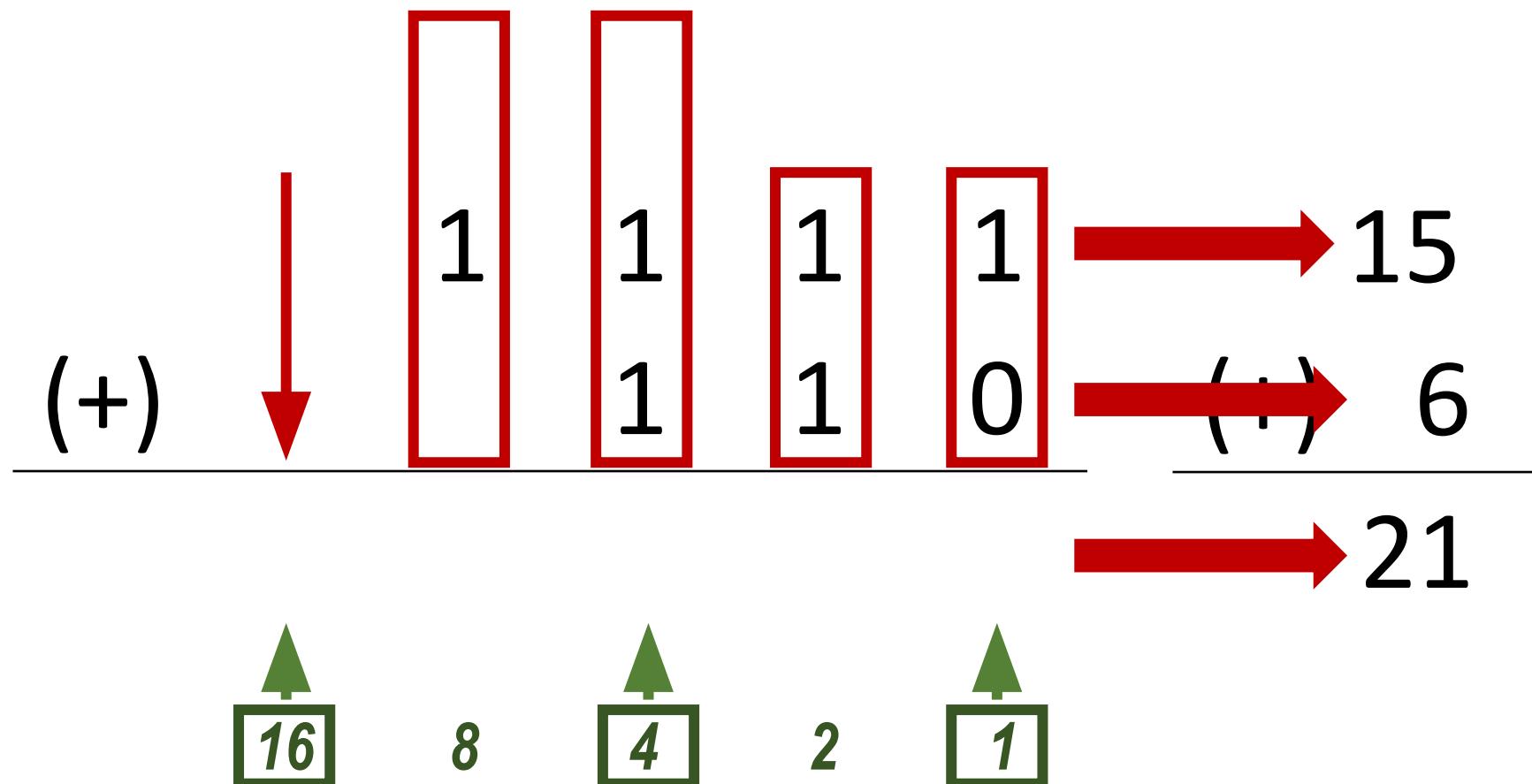
Addition of Positive Numbers

EXAMPLE #1



Addition of Positive Numbers

EXAMPLE #2



Addition of Positive Numbers

EXAMPLE #3

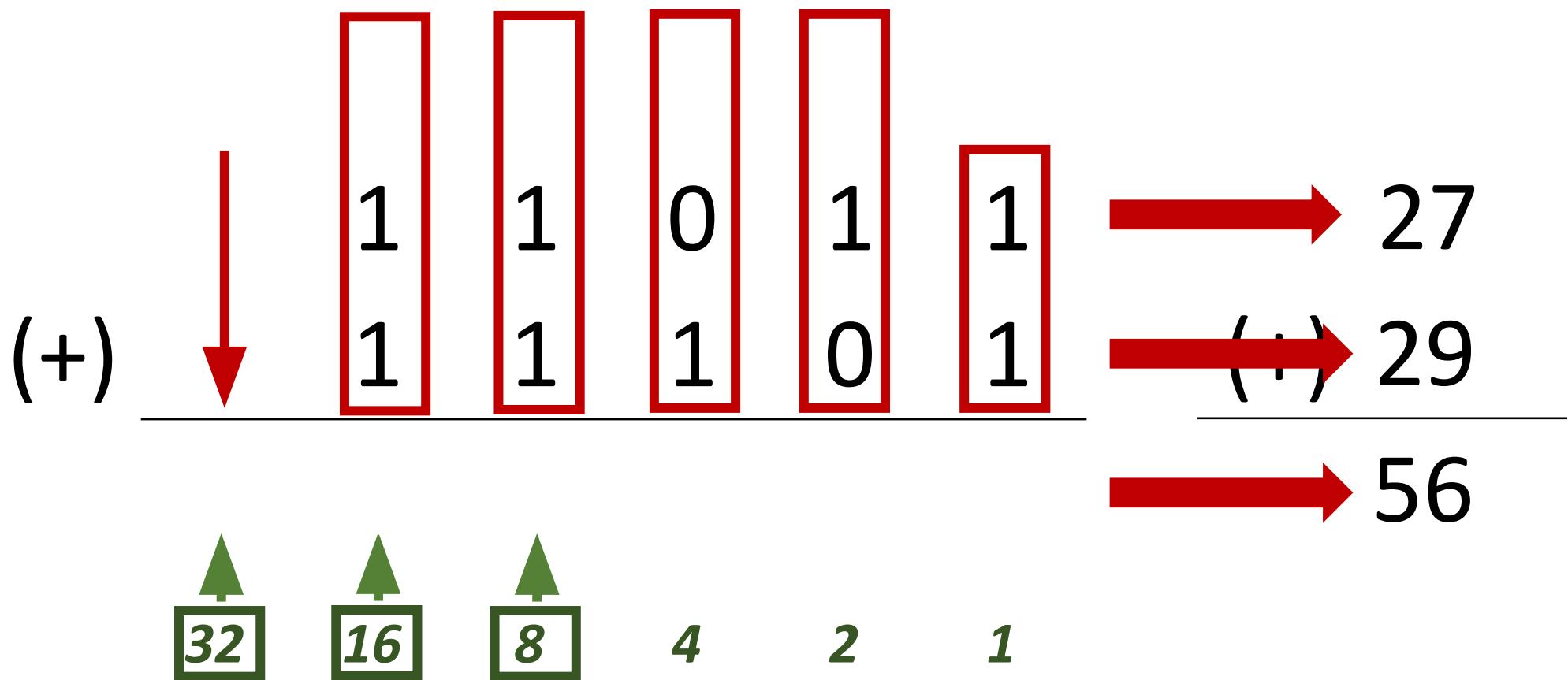
$$\begin{array}{r} (+) \\ \hline 1 & 1 & 0 & 0 & 1 \\ 1 & 0 & 1 & 0 & 0 \\ \hline \end{array}$$

25
20
 $\overline{45}$

32 16 8 4 2 1

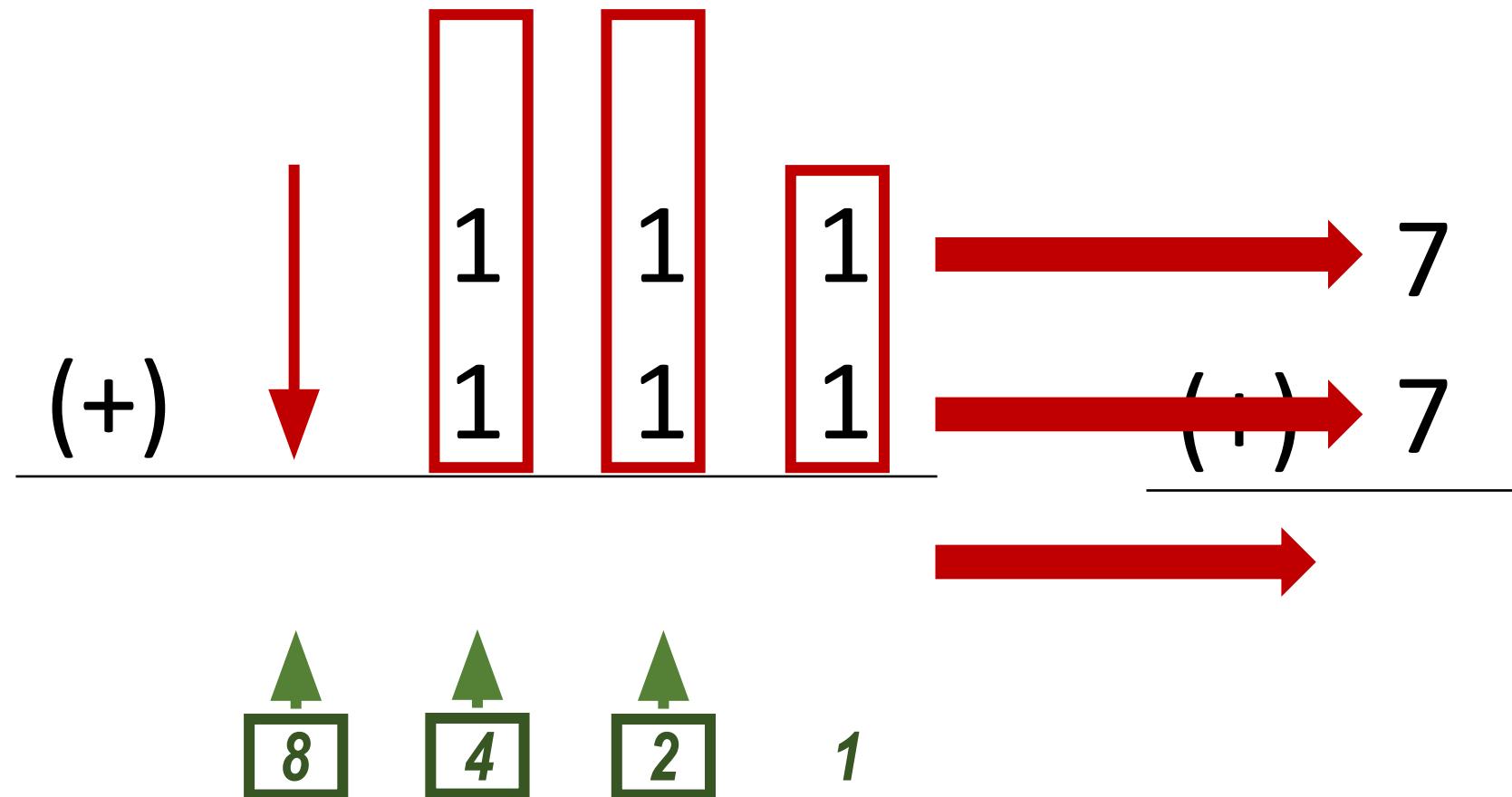
Addition of Positive Numbers

EXAMPLE #4



Addition of Positive Numbers

EXAMPLE #5



Addition of Negative Numbers

To get 1's complement of a binary number, simply invert the given number.

- The number **0** represents the positive sign
- The number **1** represents the negative sign

To get 1's complement of a binary number, simply **invert** the given number. You can simply implement logic circuit using only NOT gate for each bit of Binary number input.

Addition of Negative Numbers

- 1's complement binary numbers are very useful in Signed number representation (-5)
- Positive numbers are simply represented as Binary number (5)

If the number is negative then it is represented using 1's complement.

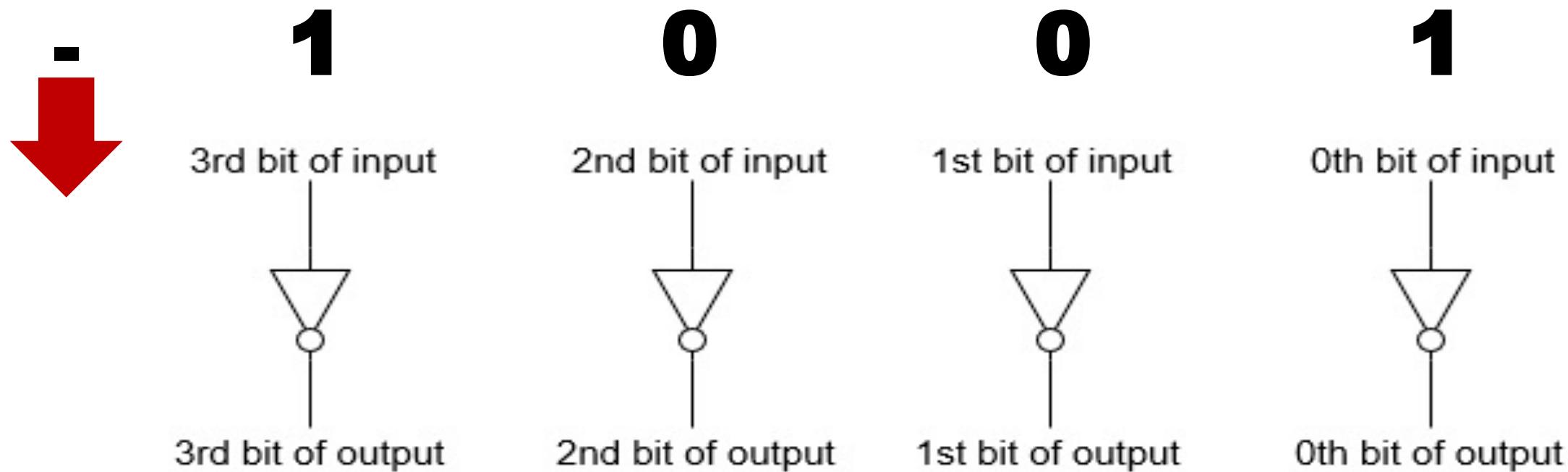
+5 is **101** and written as 0101 wherein 0 represent positive sign

-5 is **010** and written as 1010 wherein 1 represent negative sign



1's complement

Addition of Negative Numbers



1

Addition of Negative Numbers

Binary number	1's complement
-000	1111
-001	1110
-010	1101
-011	1100
-100	1011
-101	1010
-110	1001
-111	1000

Addition of Negative Numbers

Case 1: Addition of the positive number with a negative number when the **positive number has a greater magnitude**.

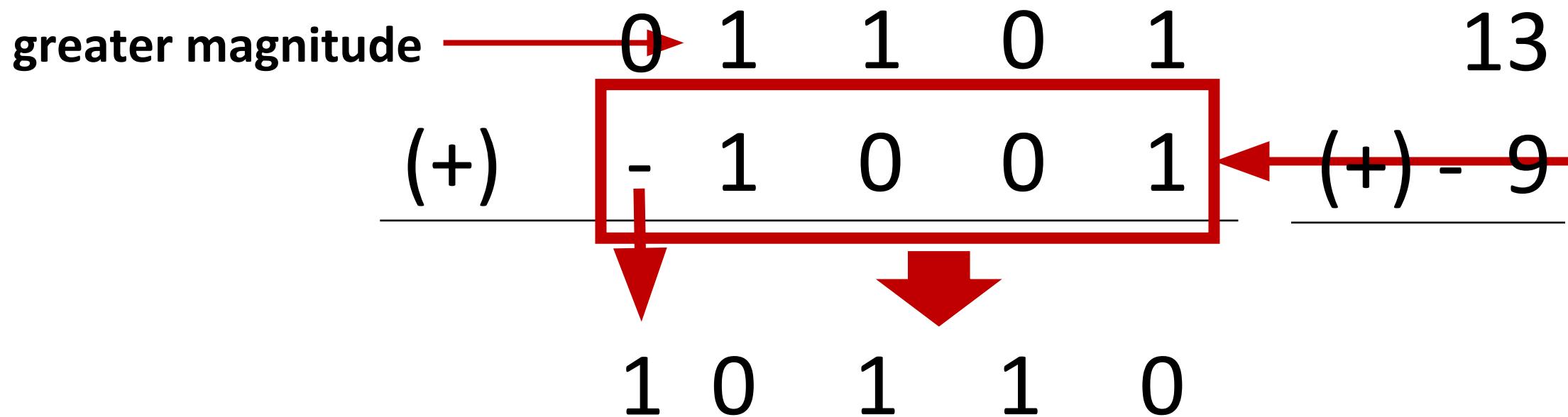
Case 2: Adding a positive value with a negative value in case the **negative number has a higher magnitude**.

Case 3: Addition of **two negative numbers**.

Addition of Negative Numbers (Case 1)

Add 1101 and **-1001** → 10110

STEP 1. Find the 1's complement of the negative number 1001.



Addition of Negative Numbers (Case 1)

Add **1101** and **-1001**

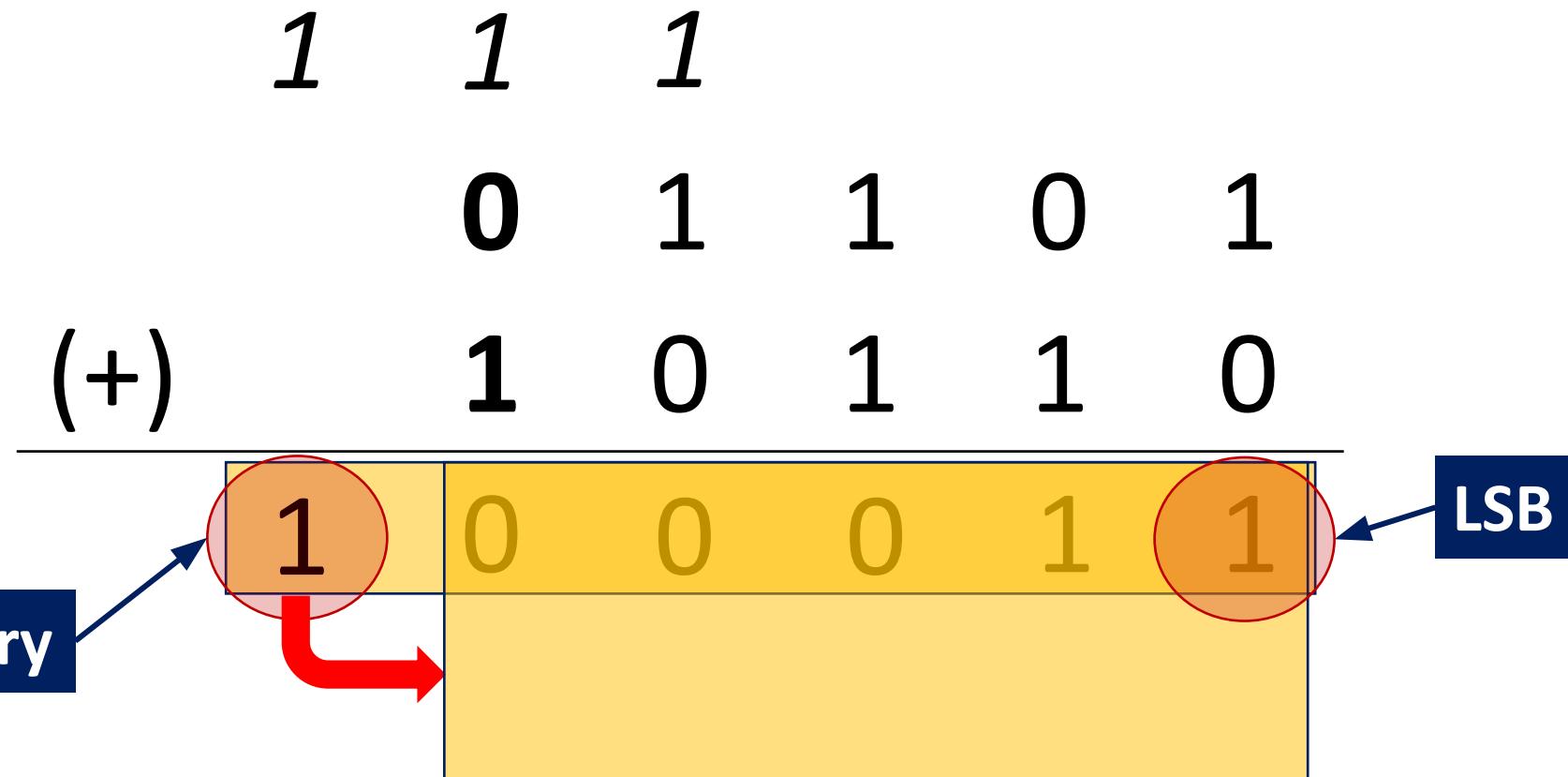
STEP 2. Add both the numbers.

$$\begin{array}{r} 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \\ (+) & 1 & 0 & 1 & 1 & 0 \\ \hline 1 & 0 & 0 & 0 & 1 & 1 \end{array}$$

Addition of Negative Numbers (Case 1)

Add 1101 and -1001

Step 3. By adding both numbers, an end-around carry 1 will be get. Add this end-around carry to the LSB of the result..



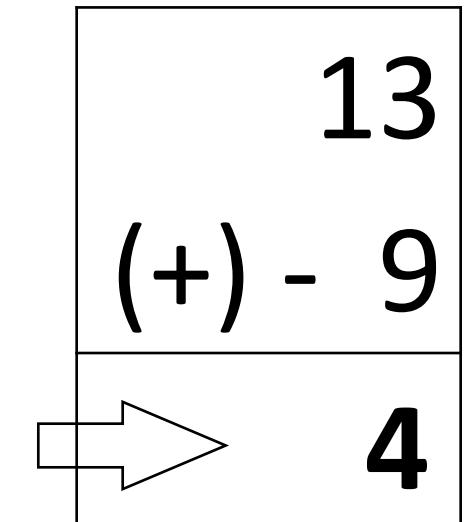
Addition of Negative Numbers (Case 1)

Add 1101 and -1001

STEP 4. Add both the numbers.

$$\begin{array}{r} & & 1 & 1 \\ & 0 & 0 & 0 & 1 & 1 \\ (+) & & & & & 1 \\ \hline & 0 & 0 & 1 & 0 & 0 \end{array}$$

The result is 00100, which is 4 in decimal form. The red underlines at the bottom indicate that the result is positive.



Addition of Negative Numbers (Case 1)

Example #1:

Add 11101 and -10101

$$\begin{array}{r} 0 \quad 1 \quad 1 \quad 1 \quad 0 \quad 1 \\ (+) \quad \boxed{- \quad 1 \quad 0 \quad 1 \quad 0 \quad 1} \\ \hline \end{array}$$

↓

$$\begin{array}{r} 0 \quad 1 \quad 1 \quad 1 \quad 0 \quad 1 \\ (+) \quad \boxed{1 \quad 0 \quad 1 \quad 0 \quad 1 \quad 0} \\ \hline \end{array}$$

Addition of Negative Numbers (Case 1)

Add 11101 and -10101

$$\begin{array}{r} & 0 & 1 & 1 & 1 & 0 & 1 \\ (+) & 1 & 0 & 1 & 0 & 1 & 0 \\ \hline \end{array}$$

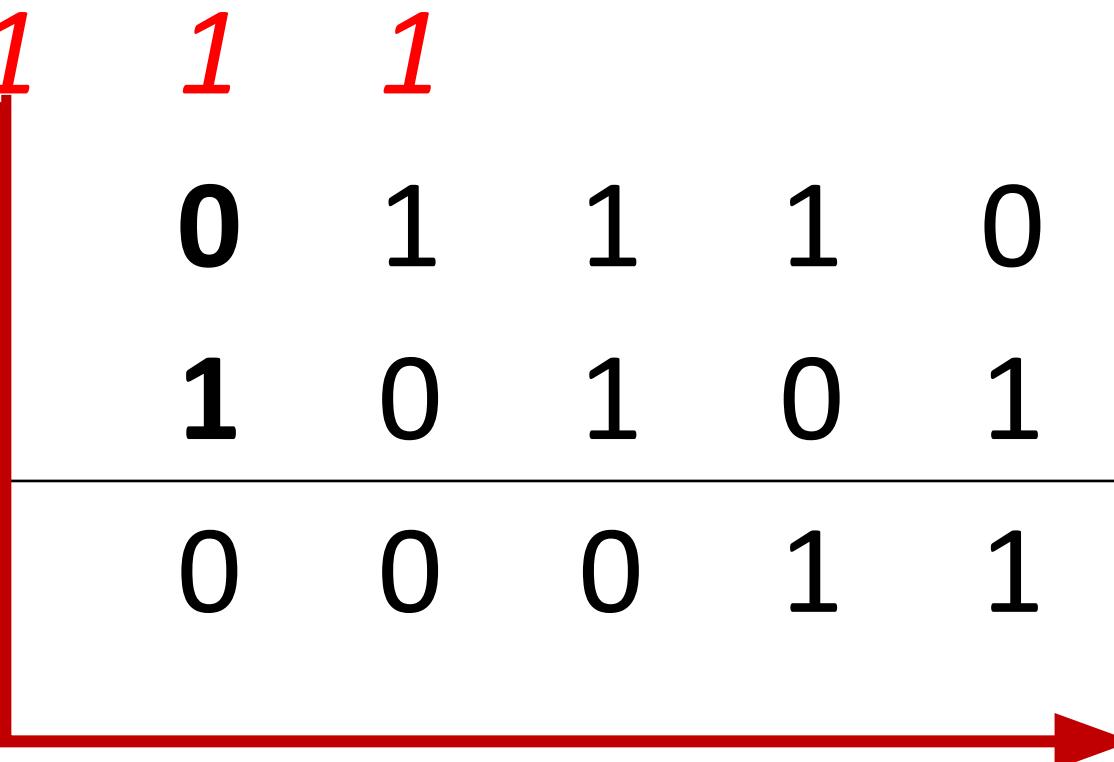
Addition of Negative Numbers (Case 1)

Add 11101 and -10101

$$\begin{array}{r} & 1 & 1 & 1 \\ & 0 & 1 & 1 & 1 & 0 & 1 \\ (+) & 1 & 0 & 1 & 0 & 1 & 0 \\ \hline & 0 & 0 & 0 & 1 & 1 & 1 \end{array}$$

Addition of Negative Numbers (Case 1)

Add 11101 and -10101

$$\begin{array}{r} & 1 & 1 & 1 \\ & 0 & 1 & 1 & 1 & 0 & 1 \\ (+) & 1 & 0 & 1 & 0 & 1 & 0 \\ \hline & 0 & 0 & 0 & 1 & 1 & 1 \end{array}$$


Addition of Negative Numbers (Case 1)

Add 11101 and -10101 \rightarrow $29 + (-21) = 8$

$$\begin{array}{r} & 1 & 1 & 1 \\ & 0 & 1 & 1 & 1 & 0 & 1 \\ (+) & 1 & 0 & 1 & 0 & 1 & 0 \\ \hline & 0 & 0 & 0 & 1 & 1 & 1 \\ & & & & & 1 \\ \hline & 0 & 0 & 1 & 0 & 0 & 0 \end{array} \rightarrow 8$$

Addition of Negative Numbers (Case 1)

Example #2:

Add 11001 and -1010

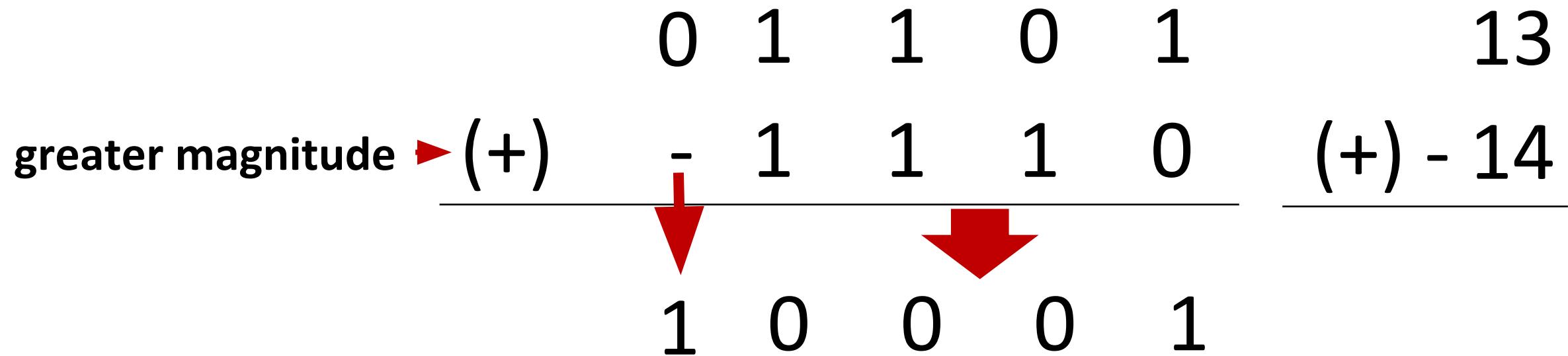
$$25 + -10 = 15$$

	1	1			1	
	0	1	1	0	0	1
(+)	1	1	0	1	0	1
<hr/>						
	0	0	1	1	1	0
<hr/>						
	0	0	1	1	1	1

Addition of Negative Numbers (Case 2)

Add 1101 and -1110

STEP 1: First find the 1's complement of the negative number 1110. So, for finding 1's complement, we change all 0 to 1, and all 1 to 0.



Addition of Negative Numbers (Case 2)

Add 1101 and -1110

STEP 2: Add both the numbers.

$$\begin{array}{r} & & & 1 \\ & 0 & 1 & 1 & 0 & 1 \\ (+) & 1 & 0 & 0 & 0 & 1 \\ \hline & 1 & 1 & 1 & 0 \end{array}$$

Addition of Negative Numbers (Case 2)

Add 1101 and -1110

STEP 3: Find the 1's complement of the result then add a negative sign before the number to identify that it is a negative number.

$$\begin{array}{r} & & & 1 \\ & 0 & 1 & 1 & 0 & 1 \\ (+) & 1 & 0 & 0 & 0 & 1 \\ \hline & 1 & 1 & 1 & 1 & 0 \end{array}$$

Addition of Negative Numbers (Case 2)

Add 1101 and -1110

STEP 3: Find the 1's complement of the result then add a negative sign before the number to identify that it is a negative number.

1					
0	1	1	0	1	
(+)	1	0	0	0	1
0	0	0	0	0	

13	1101
(+)	- 14
-1	-00001

→ -

Addition of Negative Numbers (Case 2)

Example #1:

Add **0101** and **-1011**

$$\begin{array}{r} & 0 & 1 & 0 & 1 \\ (+) & \boxed{- & 1 & 0 & 1 & 1} \\ \hline & 1 & 0 & 1 & 0 & 0 \end{array}$$

A vertical addition problem. The top row has digits 0, 1, 0, 1. To its left is a plus sign in parentheses. The bottom row has digits -1, 0, 1, 1. To its left is a minus sign in a red box. A horizontal line separates the two rows. Below the result, the digits 1, 0, 1, 0, 0 are shown. A large red arrow points from the bottom of the minus sign in the second column down to the 0 in the result.

Addition of Negative Numbers (Case 2)

Example #1:

Add **0101** and **-1011**

$$\begin{array}{r} & \textcolor{red}{0} & 0 & 1 & 0 & 1 \\ (+) & 1 & 0 & 1 & 0 & 0 \\ \hline \end{array}$$

Addition of Negative Numbers (Case 2)

Example #1:

Add **0101** and **-1011**

$$\begin{array}{r} & & 1 \\ & 0 & 0 & 1 & 0 & 1 \\ (+) & 1 & 0 & 1 & 0 & 0 \\ \hline & 1 & 1 & 0 & 0 & 1 \end{array}$$

Addition of Negative Numbers (Case 2)

Example #1:

Add 0101 and -1011

$$5 + -11 = -6$$

$$\begin{array}{r} & & 1 \\ & 0 & 0 & 1 & 0 & 1 \\ (+) & 1 & 0 & 1 & 0 & 0 \\ \hline & 1 & 1 & 0 & 0 & 1 \\ & - & 0 & 1 & 1 & 0 \end{array}$$

Addition of Negative Numbers (Case 2)

Example #2:

Add -110111 and 101

$$\begin{array}{r} \boxed{-110111} \\ (+) \phantom{-110111} \\ \hline 1001000 \end{array}$$

Addition of Negative Numbers (Case 2)

Example #2:

Add -110111 and 101

$$\begin{array}{r} 1 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0 \\ (+) \qquad \qquad \qquad 1 \ 0 \ 1 \\ \hline 1 \ 0 \ 0 \ 1 \ 1 \ 0 \ 1 \end{array}$$

Addition of Negative Numbers (Case 2)

Example #2:

Add -110111 and 101

$$-55 + 5 = -50$$

$$\begin{array}{r} & 1 & 0 & 0 & 1 & 0 & 0 & 0 \\ (+) & & & & & & 1 & 0 & 1 \\ \hline & 1 & 0 & 0 & 1 & 1 & 0 & 1 \\ & - & 1 & 1 & 0 & 0 & 1 & 0 \end{array}$$

Addition of Negative Numbers (Case 2)

Example #3:

Add 1011 and -10111

$$\begin{array}{r} & & 1 & 0 & 1 & 1 \\ & & \boxed{-1 & 0 & 1 & 1 & 1} \\ (+) & & \hline & & 1 & 0 & 1 & 0 & 0 & 0 \end{array}$$

Addition of Negative Numbers (Case 2)

Example #3:

Add **1011** and **-10111**

$$\begin{array}{r} 0 \ 0 \ 1 \ 0 \ 1 \ 1 \\ (+) \ 1 \ 0 \ 1 \ 0 \ 0 \ 0 \\ \hline \end{array}$$

Addition of Negative Numbers (Case 2)

Example #3:

Add 1011 and -10111

$$11 + -23 = -12$$

$$\begin{array}{r} & & 1 \\ & 0 & 0 & 1 & 0 & 1 & 1 \\ (+) & 1 & 0 & 1 & 0 & 0 & 0 \\ \hline & 1 & 1 & 0 & 0 & 1 & 1 \\ & - & 0 & 1 & 1 & 0 & 0 \end{array}$$

Addition of Negative Numbers (Case 3)

Add -1101 and -1110

STEP 1: Find the 1's complement of the negative numbers then add 1 as MSB to represent negative sign.

$$\begin{array}{r} - & 1 & 1 & 0 & 1 \\ (+) - & 1 & 1 & 1 & 0 \\ \hline \end{array} \quad \text{→} \quad \begin{array}{r} + & 1 & 0 & 0 & 1 & 0 \\ (+) & 1 & 0 & 0 & 0 & 1 \\ \hline \end{array}$$

Addition of Negative Numbers (Case 3)

Add -1101 and -1110

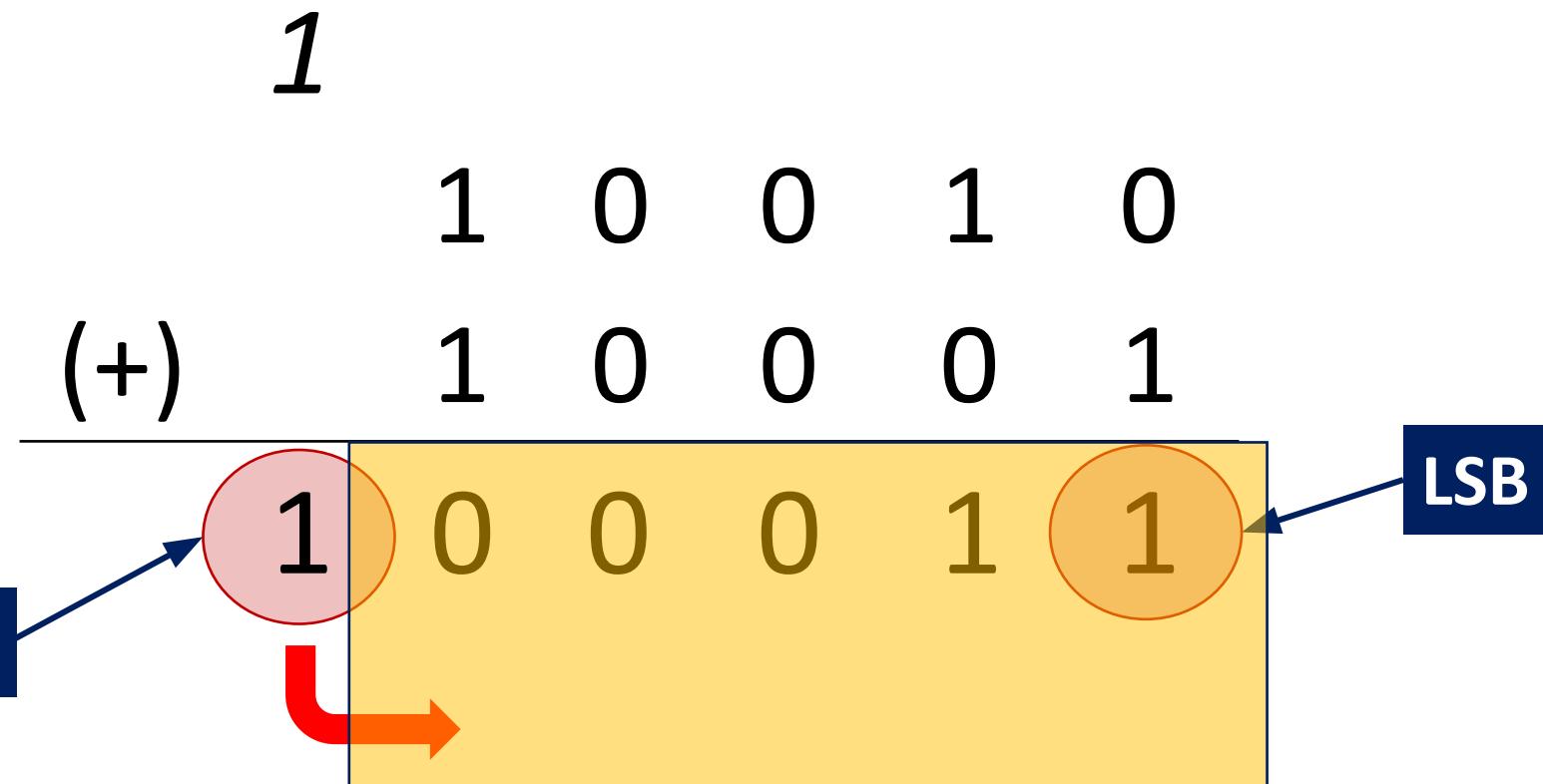
STEP 2: Add both the complement numbers.

$$\begin{array}{r} & 1 \\ & 1 \ 0 \ 0 \ 1 \ 0 \\ (+) & 1 \ 0 \ 0 \ 0 \ 1 \\ \hline & 1 \ 0 \ 0 \ 0 \ 1 \ 1 \end{array}$$

Addition of Negative Numbers (Case 3)

Add -1101 and -1110

STEP 3: By adding both numbers, we get the end-around carry 1. We add this end-around carry to the LSB



Addition of Negative Numbers (Case 3)

Add **-1101** and **-1110**

STEP 4: Add both the numbers.

$$\begin{array}{r} & & 1 & 1 \\ & 0 & 0 & 0 & 1 & 1 \\ (+) & & & & & 1 \\ \hline & 0 & 0 & 1 & 0 & 0 \end{array}$$

Addition of Negative Numbers (Case 3)

Add -1101 and -1110

STEP 5: Find the 1's complement of the result to get final answer.

$$\begin{array}{r} & & 1 & 1 \\ & 0 & 0 & 0 & 1 & 1 \\ (+) & & & & & 1 \\ \hline & 0 & 0 & 1 & 0 & 0 \end{array}$$

Addition of Negative Numbers (Case 3)

Add -1101 and -1110

STEP 5: Find the 1's complement of the result to get final answer.

$$\begin{array}{r} & 1 & 1 \\ & 0 & 0 & 0 & 1 & 1 \\ (+) & & & & & 1 \\ \hline 0 & 0 & 1 & 0 & 0 \end{array} \rightarrow 1 \ 1 \ 0 \ 1 \ 1$$

The diagram shows the addition of two negative binary numbers, -1101 and -1110. The numbers are aligned by their most significant bits. A '+' sign is placed under the first column of zeros. The result of the addition is shown below the line: 00100. This result is highlighted with a red rectangle. A large red arrow points from this result to the final answer, which is 11011. The final answer is a 5-bit binary number where the most significant bit is 1, indicating a negative result, and the remaining four bits are 1011, which is the 1's complement of the expected sum (00101).

Addition of Negative Numbers (Case 3)

-13 -14

Add -1101 and -1110

STEP 6: Add a negative sign before the number so that we can identify that it is a negative number.

$$\begin{array}{r} & 1 & 1 \\ & 0 & 0 & 0 & 1 & 1 \\ (+) & & & & & 1 \\ \hline 0 & 0 & 1 & 0 & 0 \end{array}$$

$$\begin{array}{r} -1101 \\ + -1110 \\ \hline -27 \end{array}$$

Addition of Negative Numbers (Case 3)

Example #1:

Add -1011 and -1101

$$\begin{array}{r} & - & 1 & 0 & 1 & 1 \\ (+) & - & 1 & 1 & 0 & 1 \\ \hline & & & & & \end{array}$$

Addition of Negative Numbers (Case 3)

Example #1:

Add -1011 and -1101

$$\begin{array}{r} 1 \quad 0 \quad 1 \quad 0 \quad 0 \\ \hline (+) \quad - \quad 1 \quad 1 \quad 0 \quad 1 \end{array}$$

Addition of Negative Numbers (Case 3)

Example #1:

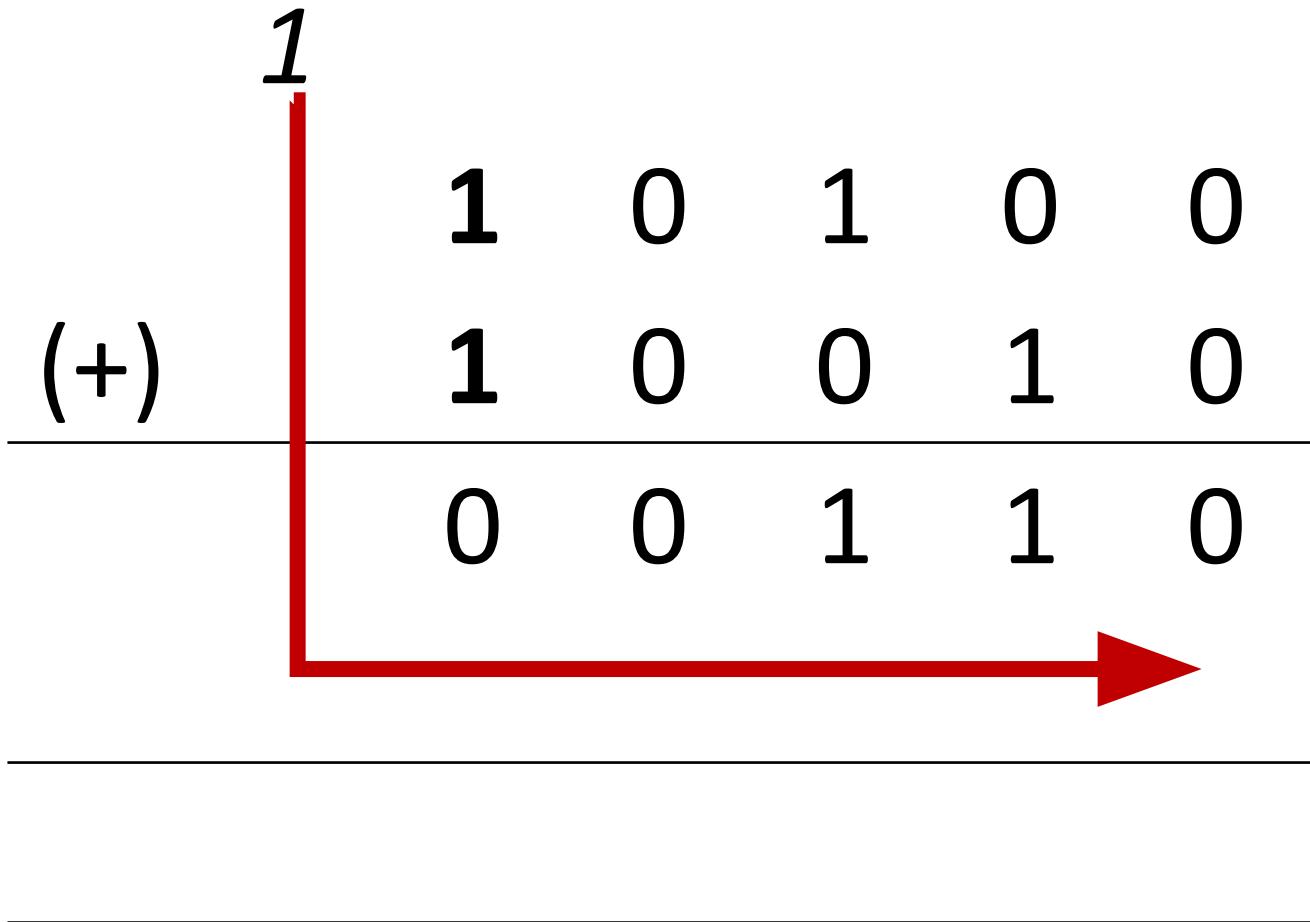
Add -1011 and -1101

$$\begin{array}{r} 1 \quad 0 \quad 1 \quad 0 \quad 0 \\ (+) \quad 1 \quad 0 \quad 0 \quad 1 \quad 0 \\ \hline \end{array}$$

Addition of Negative Numbers (Case 3)

Example #1:

Add -1011 and -1101



Addition of Negative Numbers (Case 3)

Example #1:

Add -1011 and -1101

$$\begin{array}{r} & & 1 \\ & 1 & 0 & 1 & 0 & 0 \\ (+) & 1 & 0 & 0 & 1 & 0 \\ \hline & 0 & 0 & 1 & 1 & 0 \\ & & & & & 1 \\ \hline & & & & & \end{array}$$

Addition of Negative Numbers (Case 3)

Example #1:

Add -1011 and -1101

$$\begin{array}{r} & & 1 \\ & 1 & 0 & 1 & 0 & 0 \\ (+) & 1 & 0 & 0 & 1 & 0 \\ \hline & 0 & 0 & 1 & 1 & 0 \\ & & & & & 1 \\ \hline & 0 & 0 & 1 & 1 & 1 \end{array}$$

Addition of Negative Numbers (Case 3)

Example #1:

Add -1011 and -1101

$$\begin{array}{r} & & 1 \\ & 1 & 0 & 1 & 0 & 0 \\ (+) & 1 & 0 & 0 & 1 & 0 \\ \hline & 0 & 0 & 1 & 1 & 0 \\ & & & & & 1 \\ \hline & 0 & 0 & 1 & 1 & 1 \\ \hline & 1 & 1 & 0 & 0 & 0 \end{array}$$

Addition of Negative Numbers (Case 3)

Example #1:

Add -1011 and -1101

$$-11 + -13 = -24$$

1

1 0 1 0 0

(+)

1 0 0 1 0

0 0 1 1 0

1

0 0 1 1 1

- 1 1 0 0 0

Addition of Negative Numbers (Case 3)

Exercise #2:

Add **-1100** and **-0101**

$$\begin{array}{r} -1100 \\ -0101 \\ \hline \end{array}$$

(+)

$$\begin{array}{r} -1100 \\ -0101 \\ \hline \end{array}$$

Addition of Negative Numbers (Case 3)

Exercise #2:

Add -1100 and -0101

$$\begin{array}{r} 1 \quad 0 \quad 0 \quad 1 \quad 1 \\ (+) \qquad - \quad 0 \quad 1 \quad 0 \quad 1 \\ \hline \end{array}$$

Addition of Negative Numbers (Case 3)

Exercise #2:

Add -1100 and -0101

$$\begin{array}{r} 1 \quad 0 \quad 0 \quad 1 \quad 1 \\ \hline (+) \quad - \quad 0 \quad 1 \quad 0 \quad 1 \end{array}$$

Addition of Negative Numbers (Case 3)

Exercise #2:

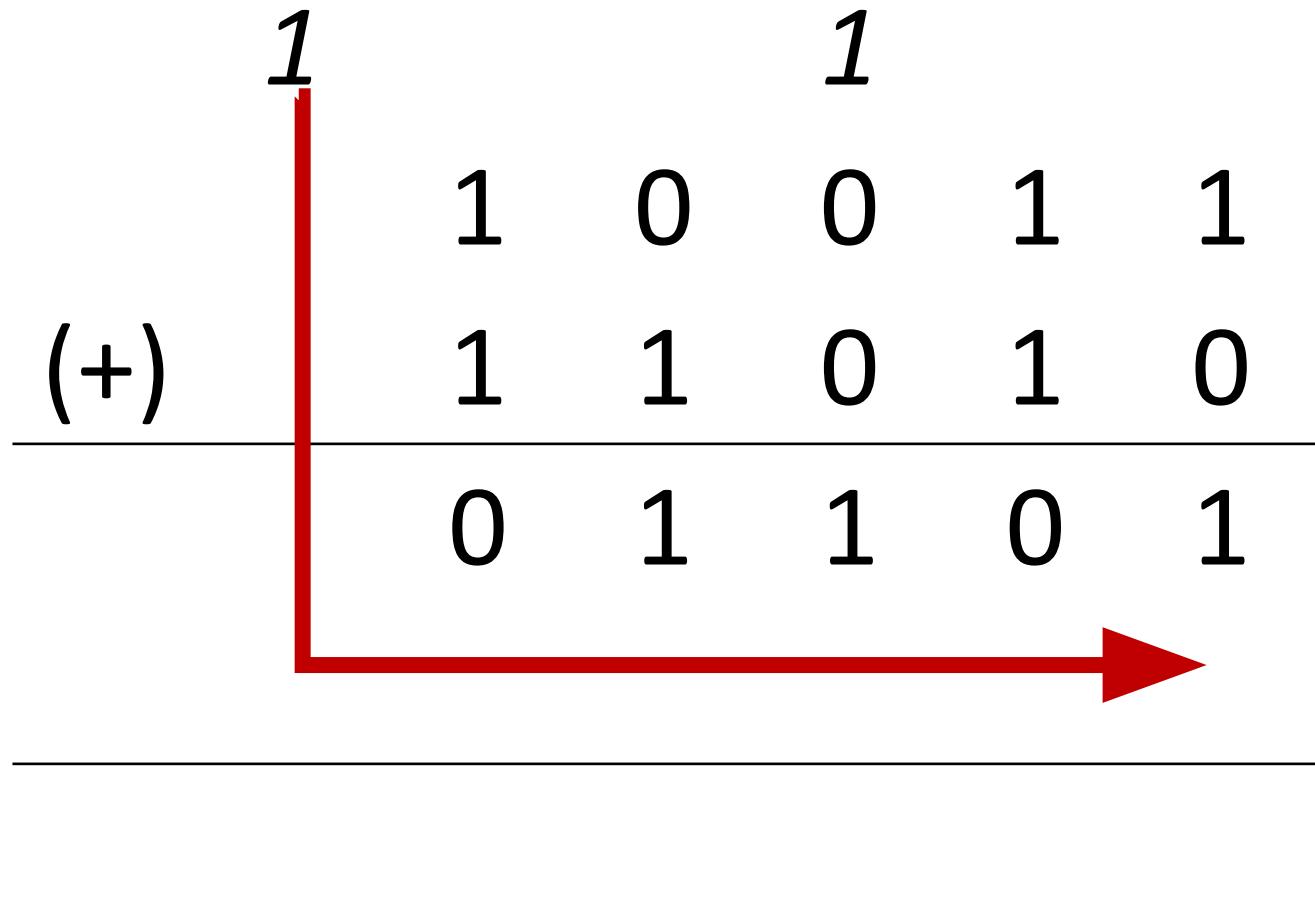
Add **-1100** and **-0101**

$$\begin{array}{r} & 1 & 0 & 0 & 1 & 1 \\ (+) & 1 & 1 & 0 & 1 & 0 \\ \hline \end{array}$$

Addition of Negative Numbers (Case 3)

Exercise #2:

Add **-1100** and **-0101**



Addition of Negative Numbers (Case 3)

Exercise #2:

Add -1100 and -0101

$$\begin{array}{r} & 1 & & 1 \\ & 1 & 0 & 0 & 1 & 1 \\ (+) & 1 & 1 & 0 & 1 & 0 \\ \hline & 0 & 1 & 1 & 0 & 1 \\ & & & & & 1 \\ \hline & & & & & \\ & & & & & \\ \hline \end{array}$$

Addition of Negative Numbers (Case 3)

Exercise #2:

Add -1100 and -0101

$$\begin{array}{r} & 1 & & 1 \\ & 1 & 0 & 0 & 1 & 1 \\ (+) & 1 & 1 & 0 & 1 & 0 \\ \hline & 0 & 1 & 1 & 0 & 1 \\ & & & & & 1 \\ \hline & 0 & 1 & 1 & 1 & 0 \end{array}$$

Addition of Negative Numbers (Case 3)

Exercise #2:

Add -1100 and -0101

$$\begin{array}{r} & 1 & & 1 \\ & 1 & 0 & 0 & 1 & 1 \\ (+) & 1 & 1 & 0 & 1 & 0 \\ \hline & 0 & 1 & 1 & 0 & 1 \\ & & & & & 1 \\ \hline & 0 & 1 & 1 & 1 & 0 \\ \hline & 1 & 0 & 0 & 0 & 1 \end{array}$$

Addition of Negative Numbers (Case 3)

Exercise #2:

Add -1100 and -0101

$$-12 + -5 = -17$$

$$\begin{array}{r} & 1 & & 1 \\ & 1 & 0 & 0 & 1 & 1 \\ (+) & 1 & 1 & 0 & 1 & 0 \\ \hline & 0 & 1 & 1 & 0 & 1 \\ & & & & & 1 \\ \hline & 0 & 1 & 1 & 1 & 0 \\ \hline - & 1 & 0 & 0 & 0 & 1 \end{array}$$

Addition of Negative Numbers (Case 3)

Exercise #3:

Add -1001 and -0100

$$\begin{array}{r} \boxed{-10001} \\ + -0100 \\ \hline \end{array}$$

Addition of Negative Numbers (Case 3)

Exercise #3:

Add -1001 and -0100

$$\begin{array}{r} 1 \quad 0 \quad 1 \quad 1 \quad 0 \\ (+) \qquad - \quad 0 \quad 1 \quad 0 \quad 0 \\ \hline \end{array}$$

Addition of Negative Numbers (Case 3)

Exercise #3:

Add -1001 and -0100

$$\begin{array}{r} 1 \quad 0 \quad 1 \quad 1 \quad 0 \\ (+) \quad - \quad 0 \quad 1 \quad 0 \quad 0 \\ \hline \end{array}$$

Addition of Negative Numbers (Case 3)

Exercise #3:

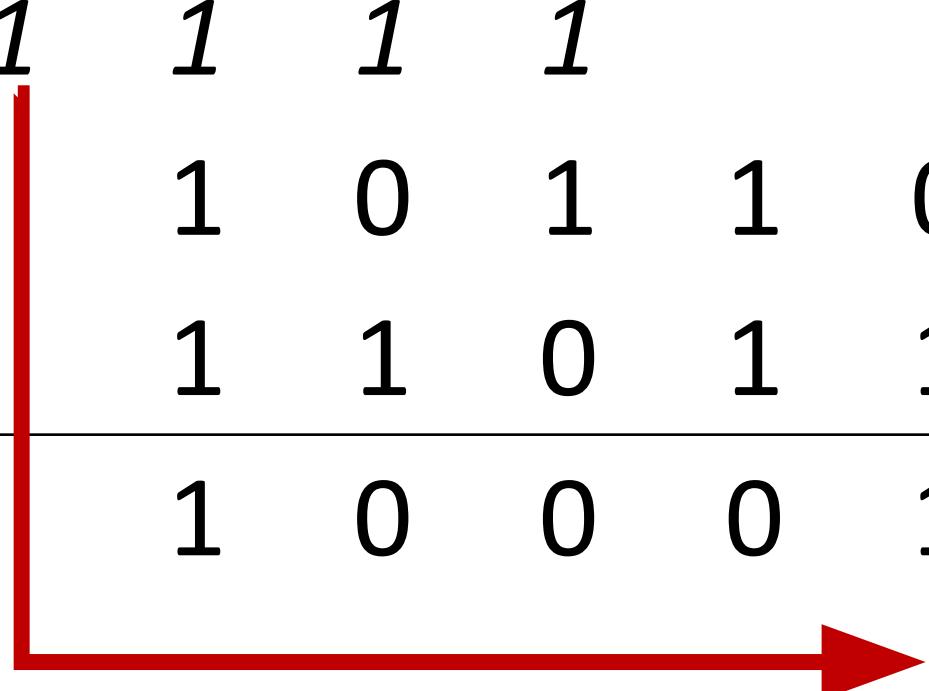
Add -1001 and -0100

$$\begin{array}{r} 1 \quad 0 \quad 1 \quad 1 \quad 0 \\ (+) \quad 1 \quad 1 \quad 0 \quad 1 \quad 1 \\ \hline \end{array}$$

Addition of Negative Numbers (Case 3)

Exercise #3:

Add -1001 and -0100

$$\begin{array}{r} & 1 & 1 & 1 & 1 \\ & | & & & \\ (+) & 1 & 0 & 1 & 1 & 0 \\ \hline & 1 & 1 & 0 & 1 & 1 \\ \hline & 1 & 0 & 0 & 0 & 1 \end{array}$$


Addition of Negative Numbers (Case 3)

Exercise #3:

Add -1001 and -0100

$$\begin{array}{r} & 1 & 1 & 1 & 1 \\ & 1 & 0 & 1 & 1 & 0 \\ (+) & 1 & 1 & 0 & 1 & 1 \\ \hline & 1 & 0 & 0 & 0 & 1 \\ & & & & & 1 \\ \hline \end{array}$$

Addition of Negative Numbers (Case 3)

Exercise #3:

Add -1001 and -0100

$$\begin{array}{r} & 1 & 1 & 1 & 1 \\ & 1 & 0 & 1 & 1 & 0 \\ (+) & 1 & 1 & 0 & 1 & 1 \\ \hline & 1 & 0 & 0 & 0 & 1 \\ & & & & & 1 \\ \hline & 1 & 0 & 0 & 1 & 0 \end{array}$$

Addition of Negative Numbers (Case 3)

Exercise #3:

Add -1001 and -0100

$$\begin{array}{r} & 1 & 1 & 1 & 1 \\ & 1 & 0 & 1 & 1 & 0 \\ (+) & 1 & 1 & 0 & 1 & 1 \\ \hline & 1 & 0 & 0 & 0 & 1 \\ & & & & & 1 \\ \hline & 1 & 0 & 0 & 1 & 0 \\ \hline 0 & 1 & 1 & 0 & 1 \end{array}$$

Addition of Negative Numbers (Case 3)

Exercise #3:

Add -1001 and -0100

$$-9 + -4 = -13$$

$$\begin{array}{r} & 1 & 1 & 1 & 1 \\ & 1 & 0 & 1 & 1 & 0 \\ (+) & 1 & 1 & 0 & 1 & 1 \\ \hline & 1 & 0 & 0 & 0 & 1 \\ & & & & & 1 \\ \hline & 1 & 0 & 0 & 1 & 0 \\ \hline - & 0 & 1 & 1 & 0 & 1 \end{array}$$

Subtraction of Positive Numbers

$$0 - 0 = 0$$

$$0 - 1 = 1 \text{ borrowed from next higher order digit}$$

Q $10 - 1 = 1$

$$1 - 0 = 1$$

$$1 - 1 = 0$$

Subtraction of Positive Numbers

EXAMPLE #1

$$\begin{array}{r} & & 1 \\ & 0 & \cancel{+10} & \rightarrow +10 \\ -1 & -0 & 0 & \\ \hline & 0 & 1 & 1 \\ & (-) & & 1 \\ & & & \hline & 3 \end{array}$$

The diagram illustrates the subtraction of positive numbers using a number line. The top part shows the number line from 0 to 10. A red arrow points from the number 10 to the right, indicating the direction of addition. The bottom part shows the subtraction problem $-1 - 0 = -1$. The result is shown as $(-) 1$, which is equivalent to 3 when considering the context of the number line.

Subtraction of Positive Numbers

EXAMPLE #2

$$\begin{array}{r} & 1 & 1 \\ & \text{---} & \text{---} \\ 0 & 10 & 10 & 10 \\ -1 & 0 & 0 & 0 \\ \hline & (-) & & 1 \\ & & & \hline & 0 & 1 & 1 & 1 \\ & & & & \hline & (-) & 1 & & \\ & & & & \hline & & & 7 \end{array}$$

The diagram illustrates the subtraction of positive numbers using a number line. The top row shows the number line with tick marks at 1 and 1. The bottom row shows the subtraction process: 0 minus 1, resulting in -1. A red arrow points from the 10 in the minuend to the 1 in the subtrahend, indicating the borrowing step. The result is 8. The final answer is 7.

Subtraction of Positive Numbers

EXAMPLE #3

$$\begin{array}{r} & 1 & 1 \\ & \text{---} & \text{---} \\ 0 & 10 & 10 & 10 \\ -1 & 0 & 0 & 0 \\ \hline (-) & & 1 & 1 & \hline & & 0 & 1 & 0 & 1 \\ & & \hline & & 8 & & \\ & & \hline & & (-) & 3 & \hline & & & & 5 & & \end{array}$$

A subtraction problem involving binary numbers. The top row shows the binary representation of 11 (1011). The second row shows the binary representation of -1 (1000), indicated by a minus sign and a bar over the first digit. A red arrow points from the first digit of the second row to the first digit of the first row, indicating the borrowing process. The result of the subtraction is shown in three rows below: the first row contains the binary digits 011011 (0110 11), the second row contains the binary digits 11 (11), and the third row contains the decimal value 5 (5).

Subtraction of Positive Numbers

EXAMPLE #4

$$\begin{array}{r} & 1 & 1 & 0 & 1 \\ (-) & & 1 & 0 & 0 \\ \hline & 1 & 0 & 0 & 1 \end{array} \qquad \begin{array}{r} 13 \\ (-) 4 \\ \hline 9 \end{array}$$

Subtraction of Positive Numbers

EXAMPLE #5

$$\begin{array}{r} & 1 & 0 & 1 & 1 \\ (-) & & 1 & 0 & 1 \\ \hline & 0 & 1 & 1 & 0 \end{array} \qquad \begin{array}{r} & & & 11 \\ (-) & & & 5 \\ \hline & & & 6 \end{array}$$