# Binary Arithmetic Operation

# Addition of Positive Numbers

**0 + 0 = 0**

**0 + 1 = 1**

**1 + 0 = 1**

**1 + 1 = 10 with a carry-over of 1**

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

***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 with a carry-over of 1**

```
    1
(+) 1
-----
    0
```

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

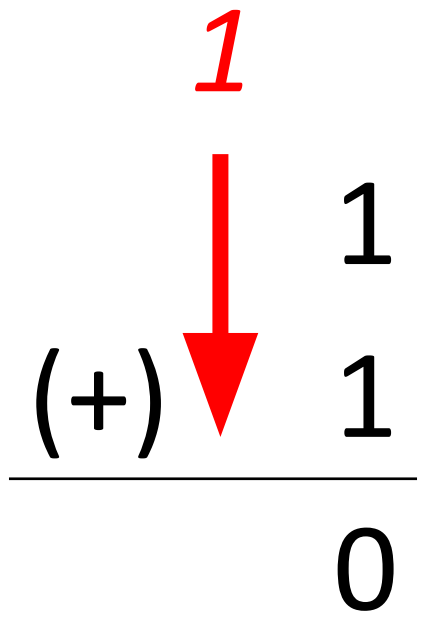
# Addition of Positive Numbers

**0 + 0 = 0**

**0 + 1 = 1**

**1 + 0 = 1**

**1 + 1 = 10 with a carry-over of 1**




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

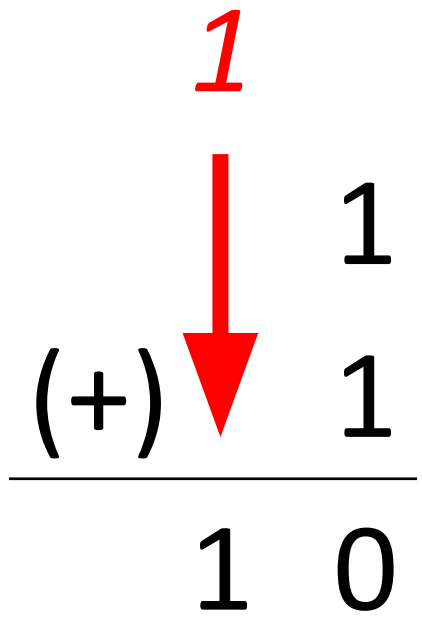
# Addition of Positive Numbers

**0 + 0 = 0**

**0 + 1 = 1**

**1 + 0 = 1**

**1 + 1 = 10 with a carry-over of 1**




***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**

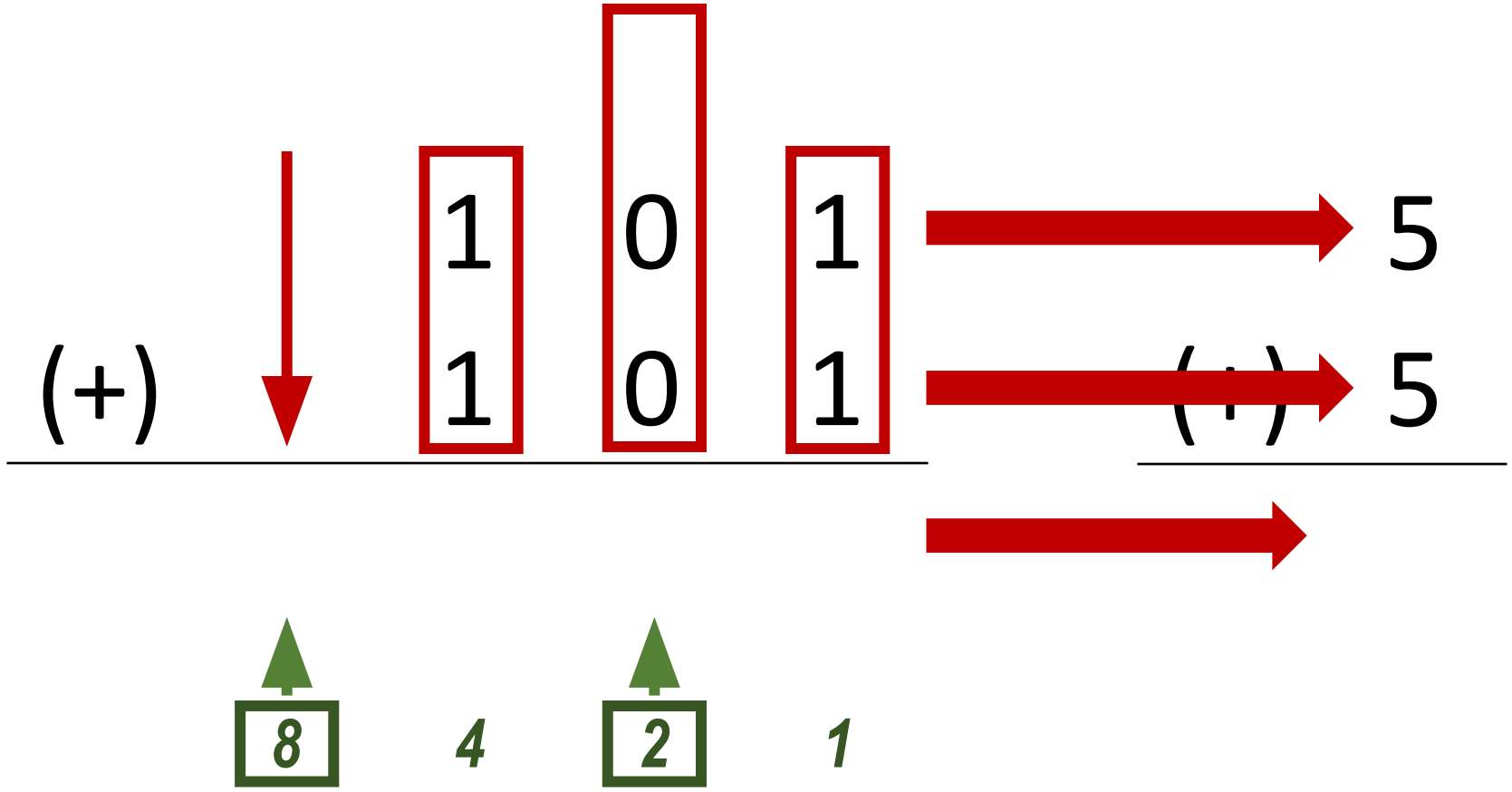
**1 + 1 = 10 with a carry-over of 1**

$$\begin{array}{rr} & \textit{1} \\ & 1 \\ (+) & 1 \\ \hline & \mathbf{1\ 0} \end{array}$$

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

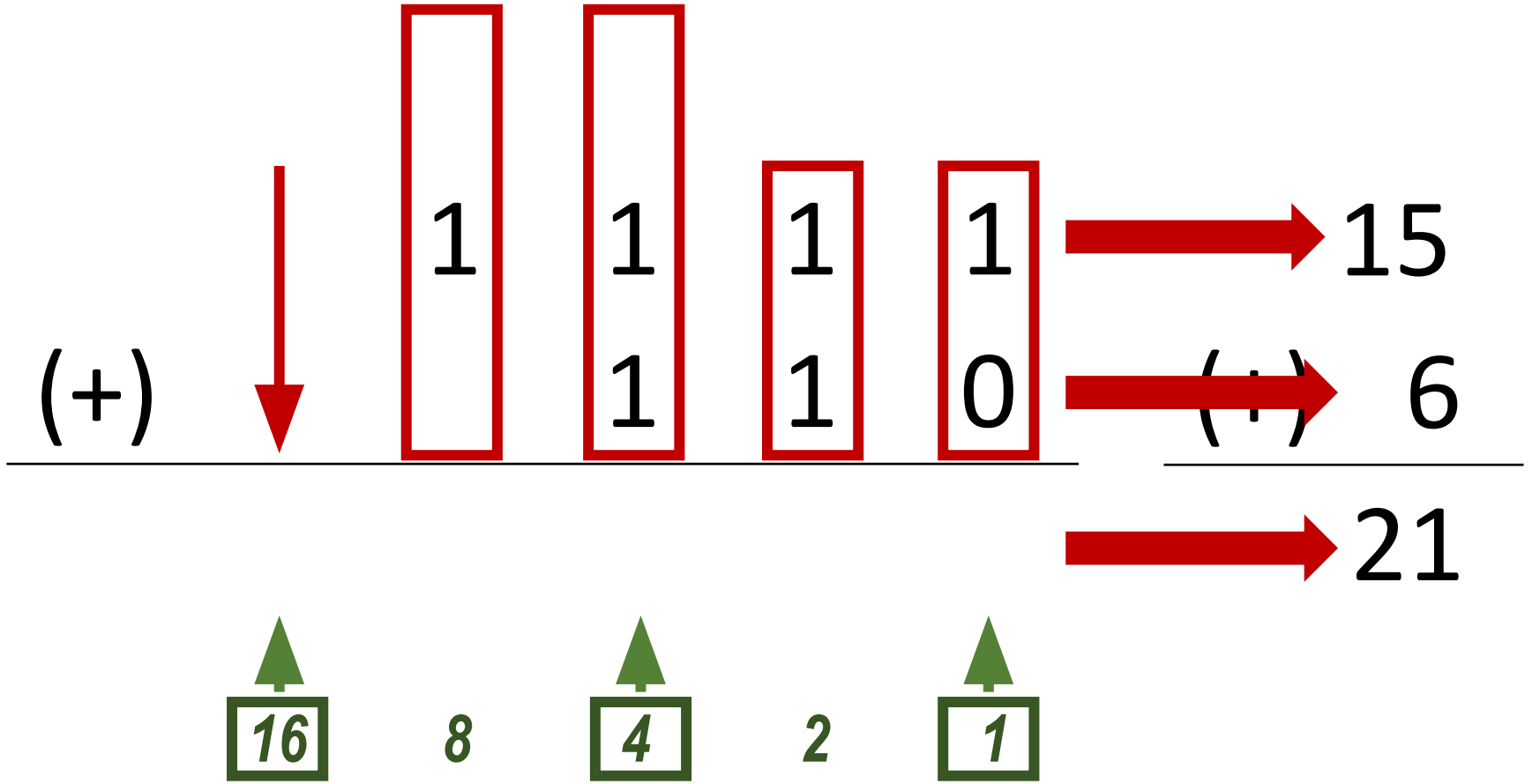
# Addition of Positive Numbers

***EXAMPLE #1***



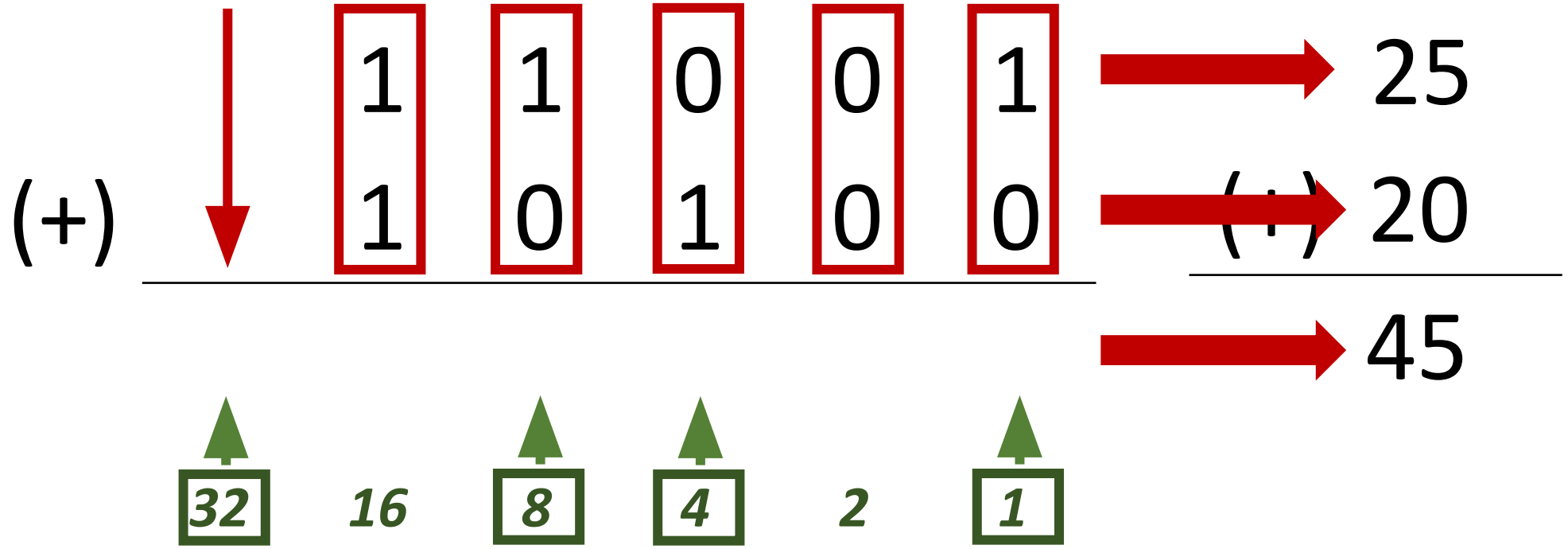
# Addition of Positive Numbers

***EXAMPLE #2***



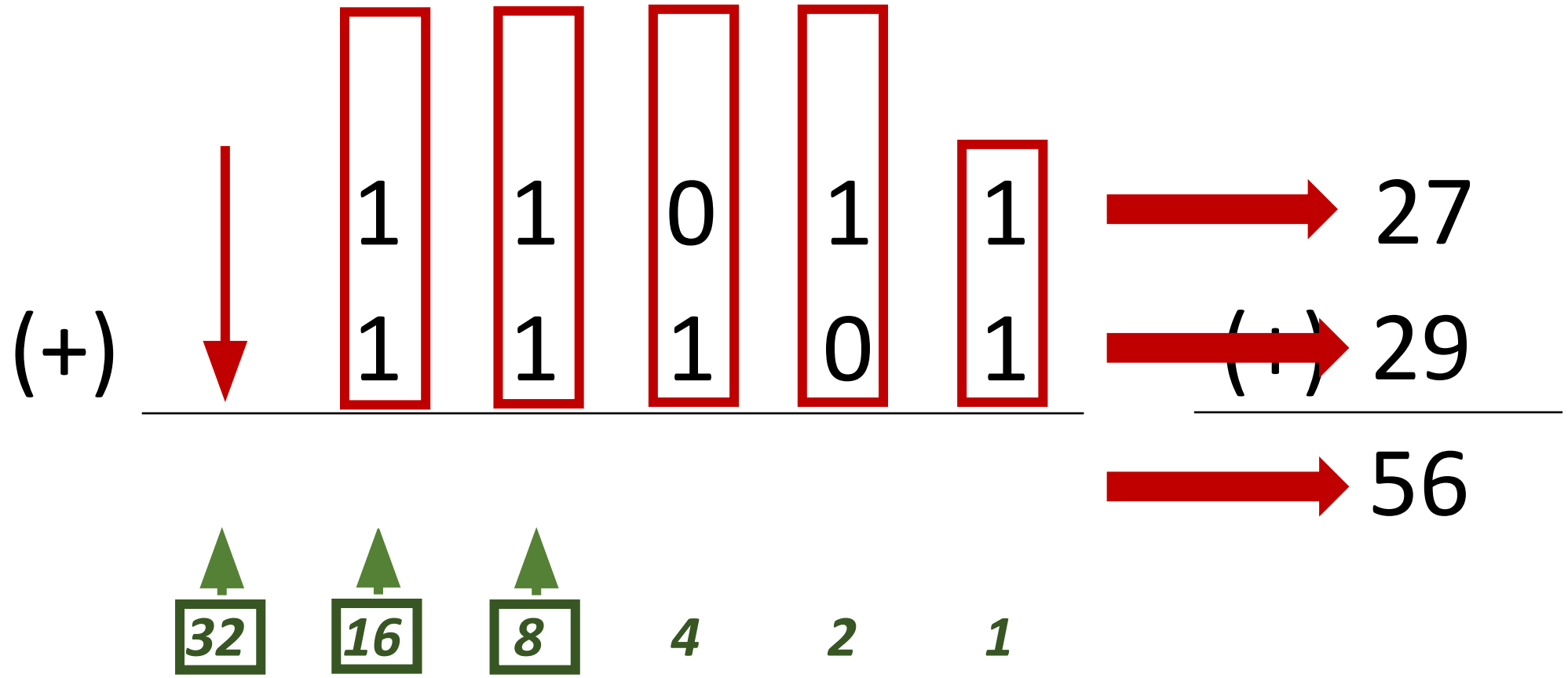
# Addition of Positive Numbers

***EXAMPLE #3***



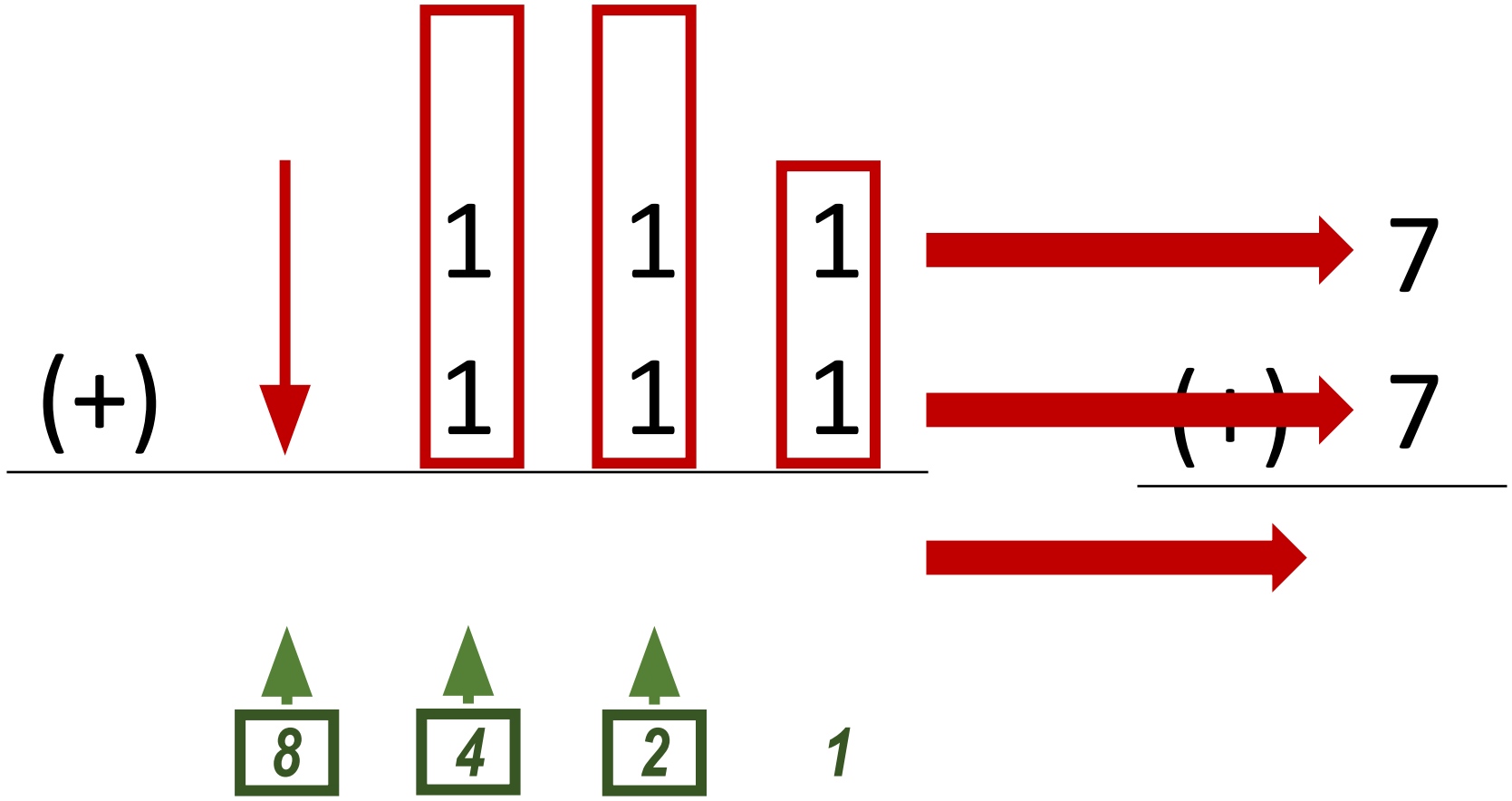
# Addition of Positive Numbers

***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**)

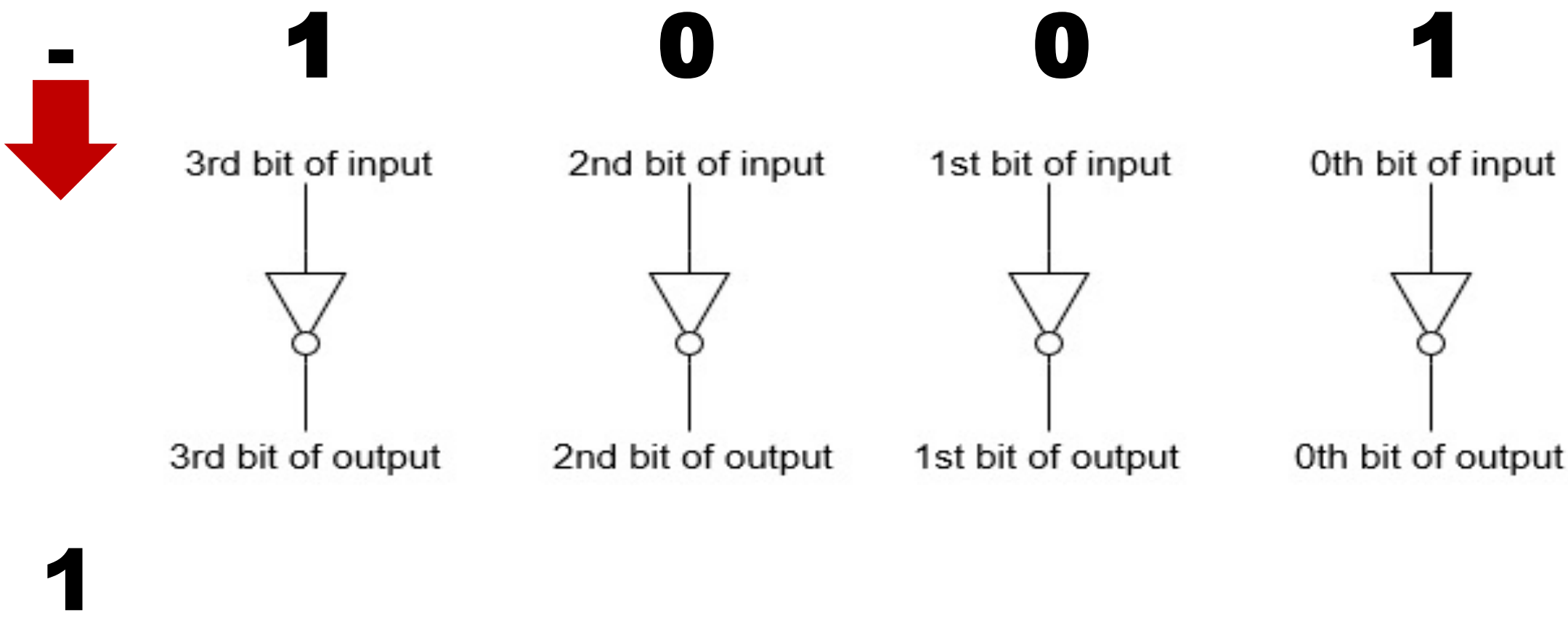
If the number is negative then it is represented using 1’s complement.

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

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

**1’s complement**

# Addition of Negative Numbers



# Addition of Negative Numbers

| Binary number | 1's complement |
|---|---|
| -000 | **1**111 |
| -001 | **1**110 |
| -010 | **1**101 |
| -011 | **1**100 |
| -100 | **1**011 |
| -101 | **1**010 |
| -110 | **1**001 |
| -111 | **1**000 |

# Addition of Negative Numbers

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

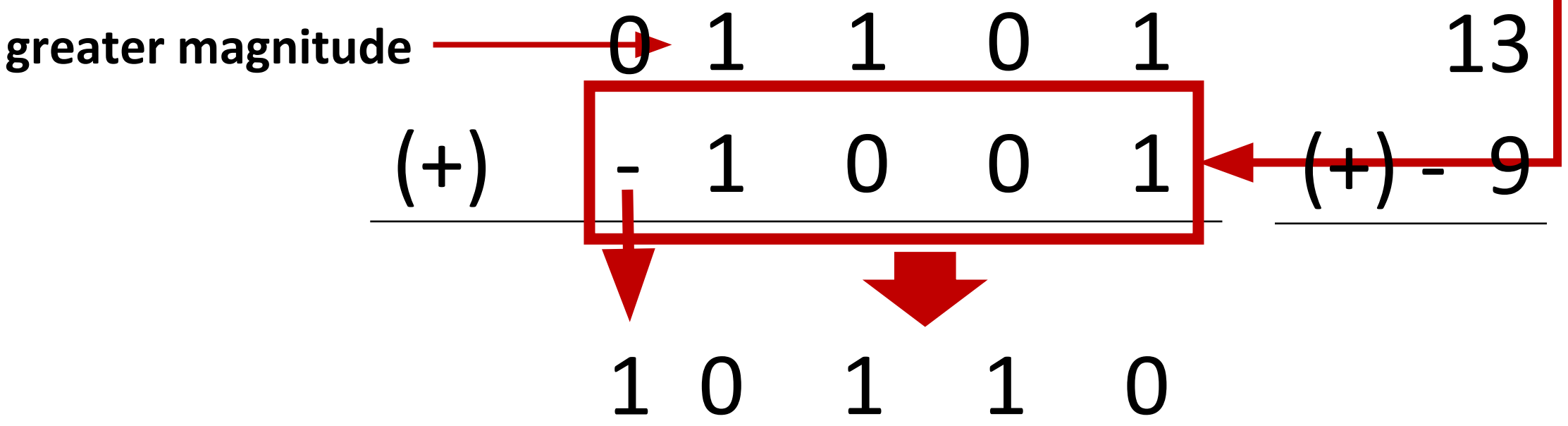
Case 2: Adding a positive value with a negative value in case the **negative number has a higher magnitude**.

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**

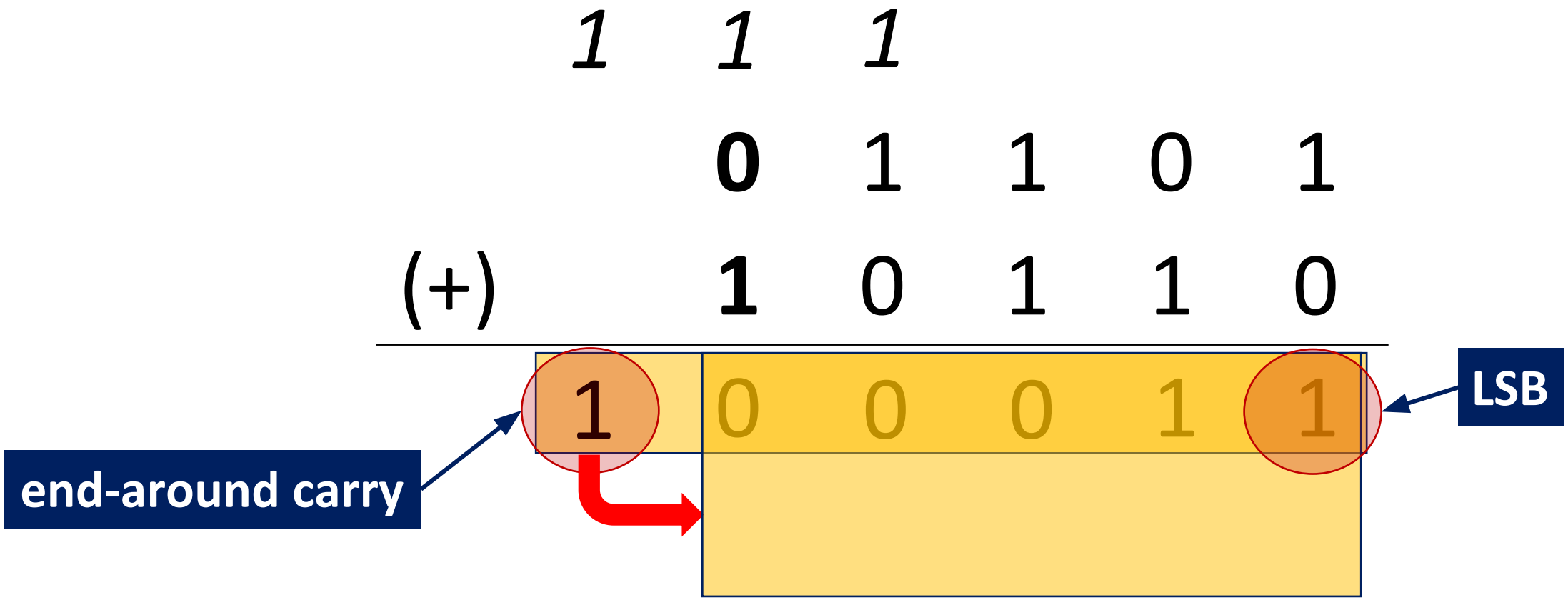
**STEP 2. Add both the numbers.**

| | | | | | | |
|---|---|---|---|---|---|---|
| | *1* | *1* | *1* | | | |
| | | **0** | 1 | 1 | 0 | 1 |
| (+) | | **1** | 0 | 1 | 1 | 0 |
| | 1 | 0 | 0 | 0 | 1 | 1 |

# 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**

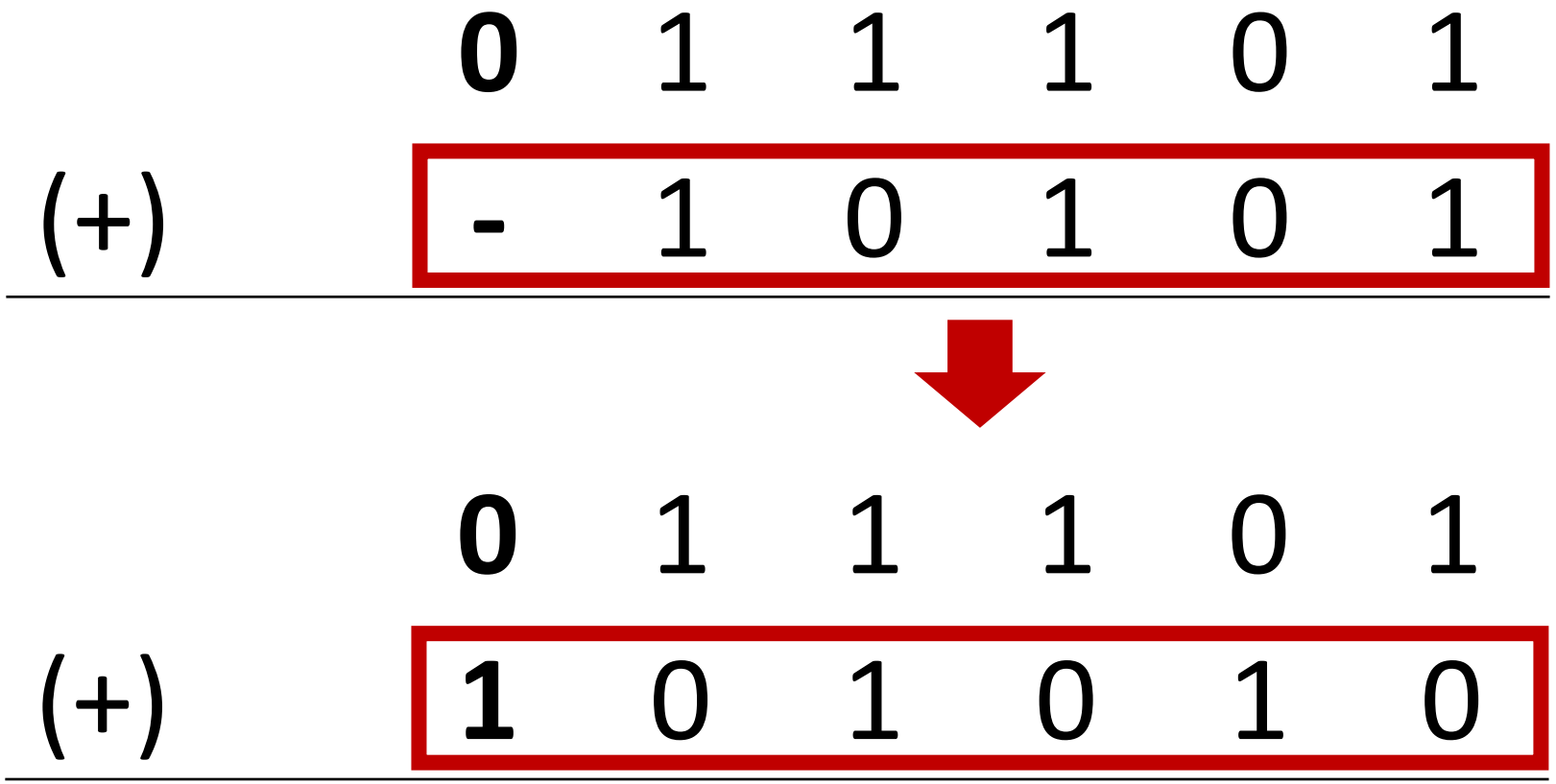
**STEP 4. Add both the numbers.**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | *1* | *1* | | | |
| | 0 | 0 | 0 | 1 | 1 | | 13 |
| (+) | | | | | 1 | | (+) - 9 |
| | 0 | 0 | 1 | 0 | 0 | ⇨ | **4** |

# Addition of Negative Numbers (Case 1)

Example #1:

Add **11101** and **-10101**



# Addition of Negative Numbers (Case 1)

Add **11101** and **-10101**

| | | | | | | |
|---|---|---|---|---|---|---|
| | **0** | 1 | 1 | 1 | 0 | 1 |
| (+) | **1** | 0 | 1 | 0 | 1 | 0 |

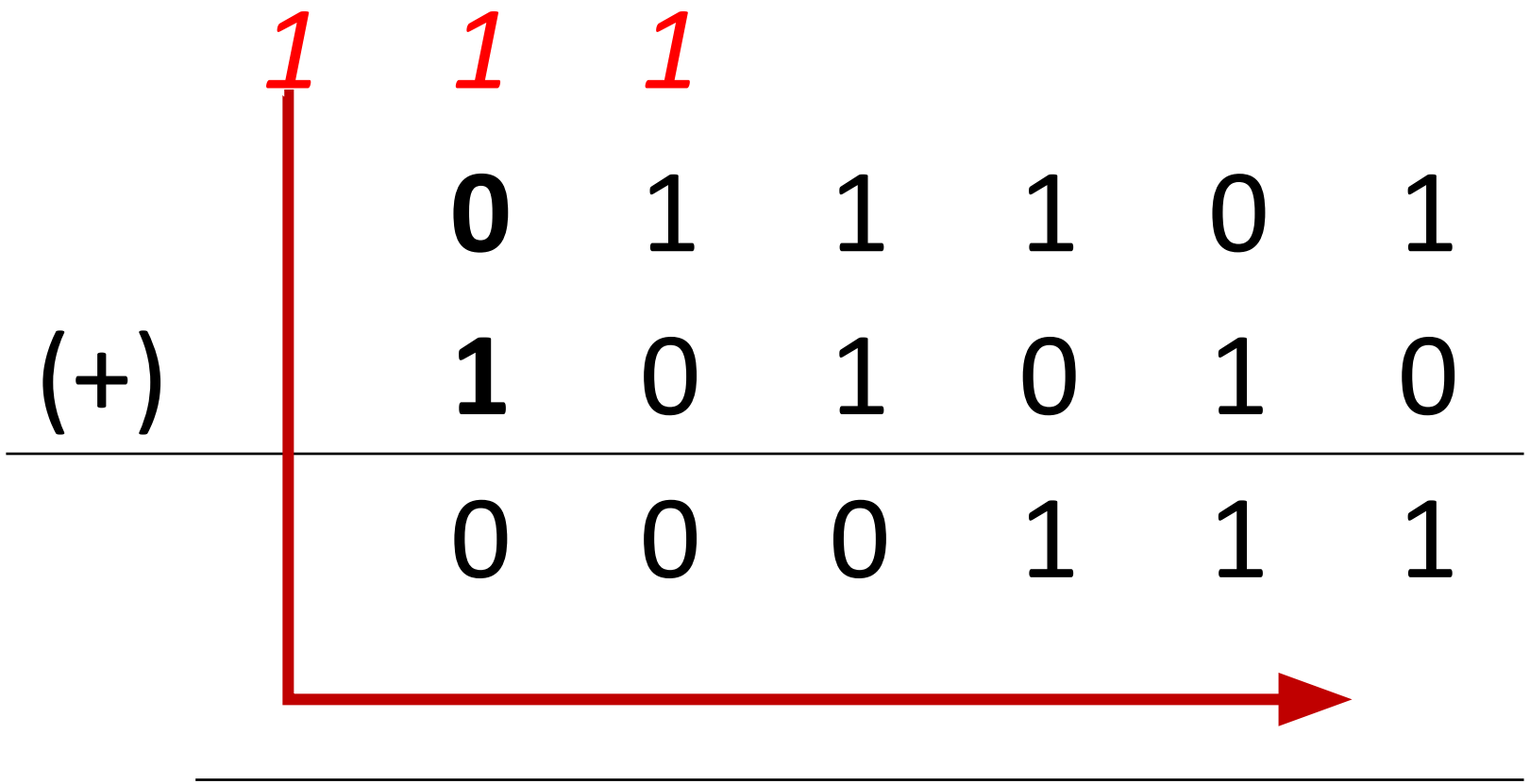
# Addition of Negative Numbers (Case 1)

Add **11101** and **-10101**

| | | | | | | |
|---|---|---|---|---|---|---|
| | *1* | *1* | *1* | | | |
| | | **0** | 1 | 1 | 1 | 0 | 1 |
| (+) | | **1** | 0 | 1 | 0 | 1 | 0 |
| | | 0 | 0 | 0 | 1 | 1 | 1 |

# Addition of Negative Numbers (Case 1)

Add **11101** and **-10101**



# Addition of Negative Numbers (Case 1)

Add **11101** and **-10101** → **29 + (-21) = 8**

| | | | | | | |
|---|---|---|---|---|---|---|
| | *1* | *1* | *1* | | | |
| | | **0** | 1 | 1 | 1 | 0 | 1 |
| (+) | | **1** | 0 | 1 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 1 | 1 | 1 |
| | | | | | | 1 |
| | 0 | 0 | 1 | 0 | 0 | 0 |

**8**

# Addition of Negative Numbers (Case 1)

Example #2:

Add **11001** and **-1010**

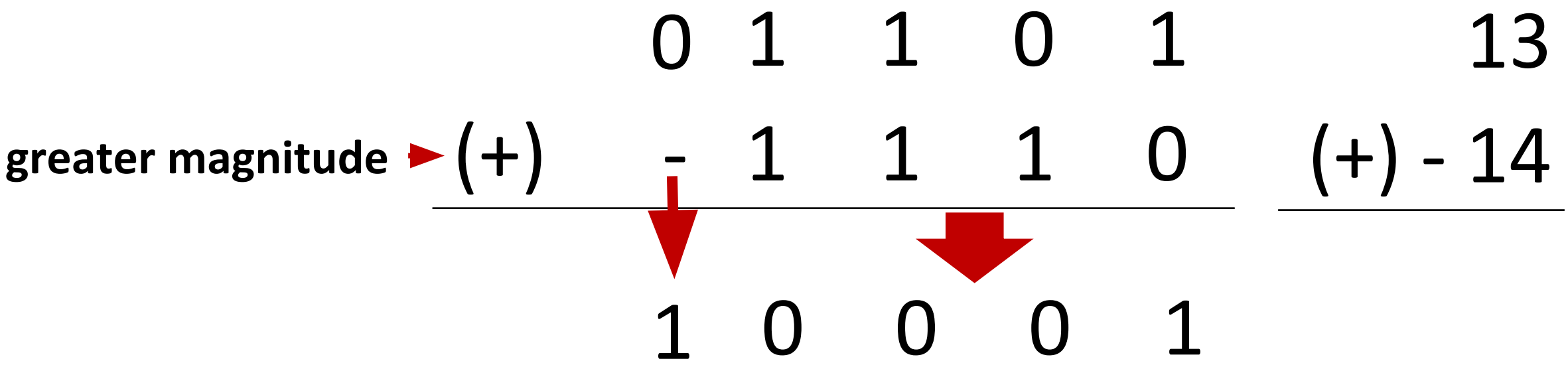
25 + -10 = 15

| | | | | | | |
|---|---|---|---|---|---|---|
| *1* | *1* | | | | *1* | |
| | 0 | 1 | 1 | 0 | 0 | 1 |
| (+) | 1 | 1 | 0 | 1 | 0 | 1 |
| | 0 | 0 | 1 | 1 | 1 | 0 |
| | | | | | | 1 |
| | **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.**

| | | | | | |
|---|---|---|---|---|---|
| | | | | *1* | |
| | **0** | 1 | 1 | 0 | 1 |
| (+) | **1** | 0 | 0 | 0 | 1 |
| | | 1 | 1 | 1 | 0 |

# 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 |
| | 1 | 1 | 1 | 1 | 0 |

# 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.**

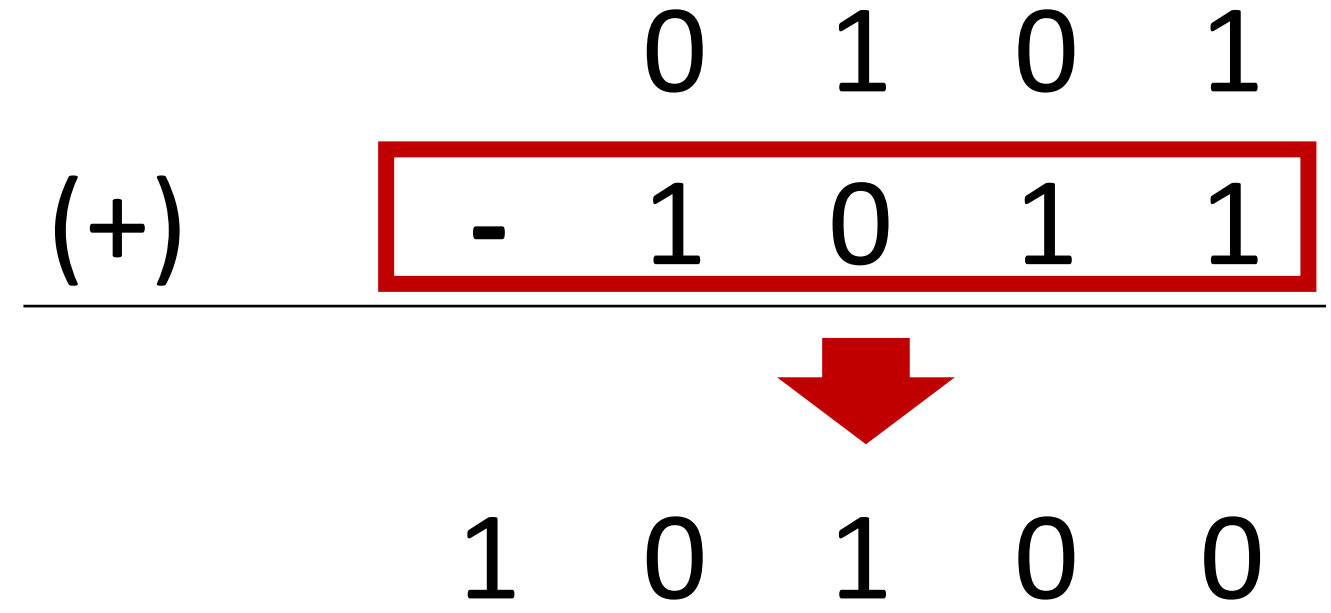
| | | | | | |
|---|---|---|---|---|---|
| | | | | 1 | |
| | 0 | 1 | 1 | 0 | 1 |
| (+) | 1 | 0 | 0 | 0 | 1 |
| | 1 | 1 | 1 | 1 | 0 |

| | |
|---|---|
| 13 | 1101 |
| (+) - 14 | -1110 |
| -1 | -00001 |

# Addition of Negative Numbers (Case 2)

Example #1:

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



# Addition of Negative Numbers (Case 2)

Example #1:
Add **0101** and **-1011**

| | | | | | |
|---|---|---|---|---|---|
| | 0 | 0 | 1 | 0 | 1 |
| (+) | **1** | 0 | 1 | 0 | 0 |

# Addition of Negative Numbers (Case 2)

Example #1:
Add **0101** and **-1011**

| | | | | | |
|---|---|---|---|---|---|
| | *1* | | | | |
| | 0 | 0 | 1 | 0 | 1 |
| (+) | **1** | 0 | 1 | 0 | 0 |
| | **1** | **1** | **0** | **0** | **1** |

# Addition of Negative Numbers (Case 2)

Example #1:
Add **0101** and **-1011**

**5 + -11 = -6**

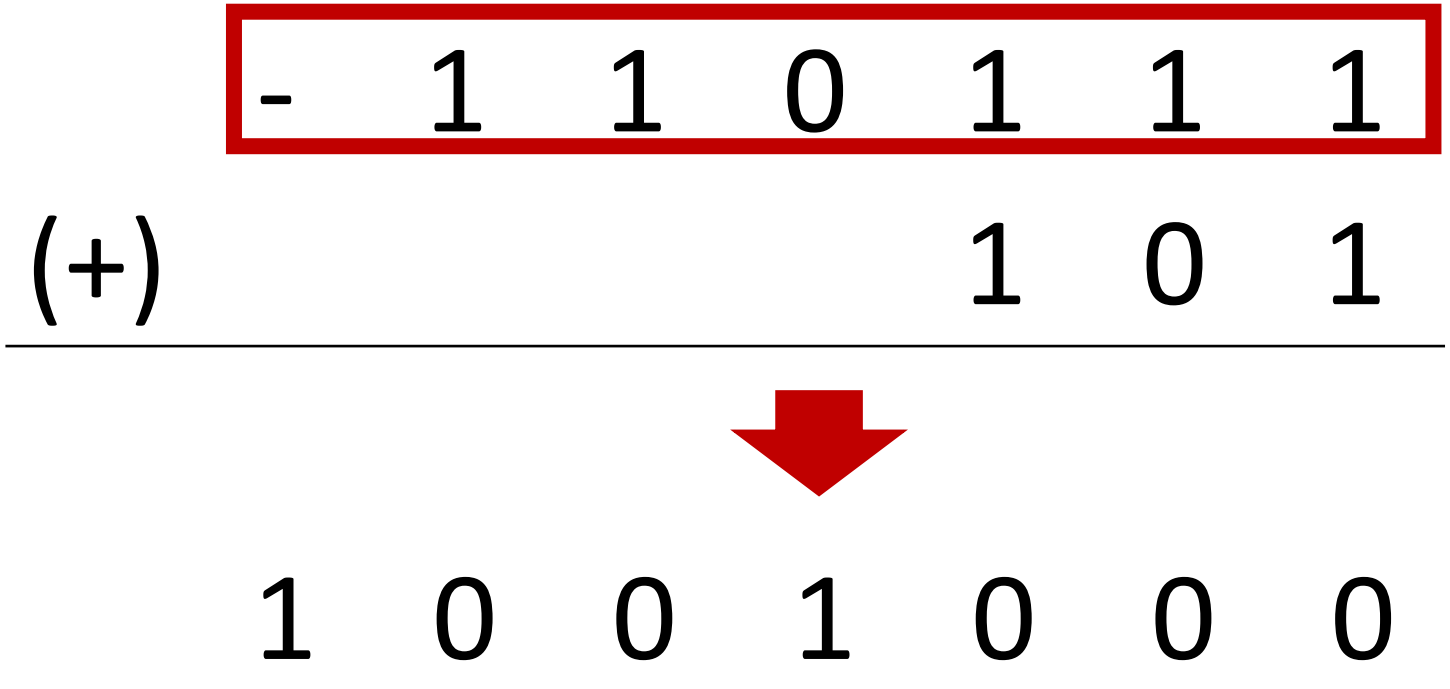
| | | | | | |
|---|---|---|---|---|---|
| | *1* | | | | |
| | 0 | 0 | 1 | 0 | 1 |
| (+) | **1** | 0 | 1 | 0 | 0 |
| | **1** | **1** | **0** | **0** | **1** |

**- 0 1 1 0**

# Addition of Negative Numbers (Case 2)

Example #2:

Add **-110111** and **101**



# Addition of Negative Numbers (Case 2)

Example #2:

Add **-110111** and **101**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| (+) | | | | | 1 | 0 | 1 |
| | 1 | 0 | 0 | 1 | 1 | 0 | 1 |

# Addition of Negative Numbers (Case 2)

Example #2:

Add **-110111** and **101**

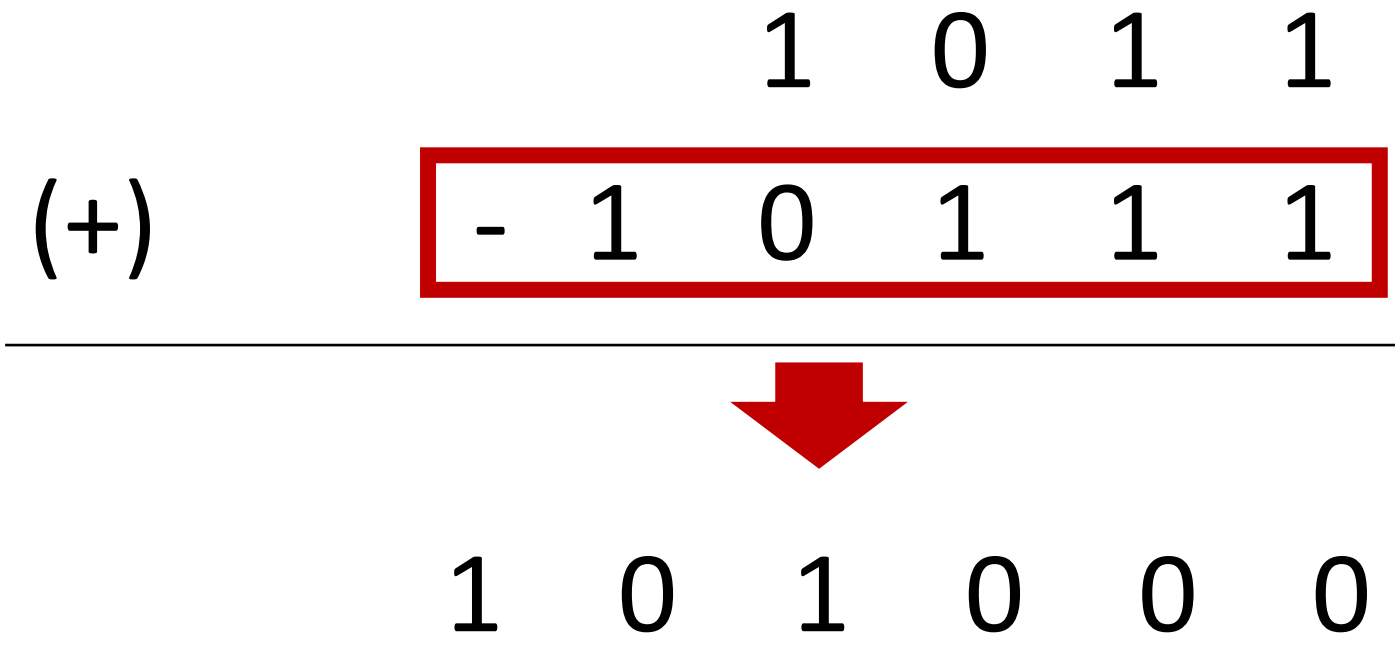
**-55 + 5 = -50**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| (+) | | | | | 1 | 0 | 1 |
| | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| | **-** | **1** | **1** | **0** | **0** | **1** | **0** |

# Addition of Negative Numbers (Case 2)

Example #3:

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



# Addition of Negative Numbers (Case 2)

Example #3:
Add **1011** and **-10111**

| | | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 0 | 1 | 0 | 1 | 1 |
| (+) | 1 | 0 | 1 | 0 | 0 | 0 |

# Addition of Negative Numbers (Case 2)

Example #3:
Add **1011** and **-10111**

**11+ -23 = -12**

| | | | | | | |
|---|---|---|---|---|---|---|
| | *1* | | | | | |
| | 0 | 0 | 1 | 0 | 1 | 1 |
| (+) | 1 | 0 | 1 | 0 | 0 | 0 |
| | 1 | 1 | 0 | 0 | 1 | 1 |
| | **-** | **0** | **1** | **1** | **0** | **0** |

# 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.**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | - | 1 | 1 | 0 | 1 | | **1** | 0 | 0 | 1 | 0 |
| (+) | - | 1 | 1 | 1 | 0 | (+) | **1** | 0 | 0 | 0 | 1 |

# Addition of Negative Numbers (Case 3)

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

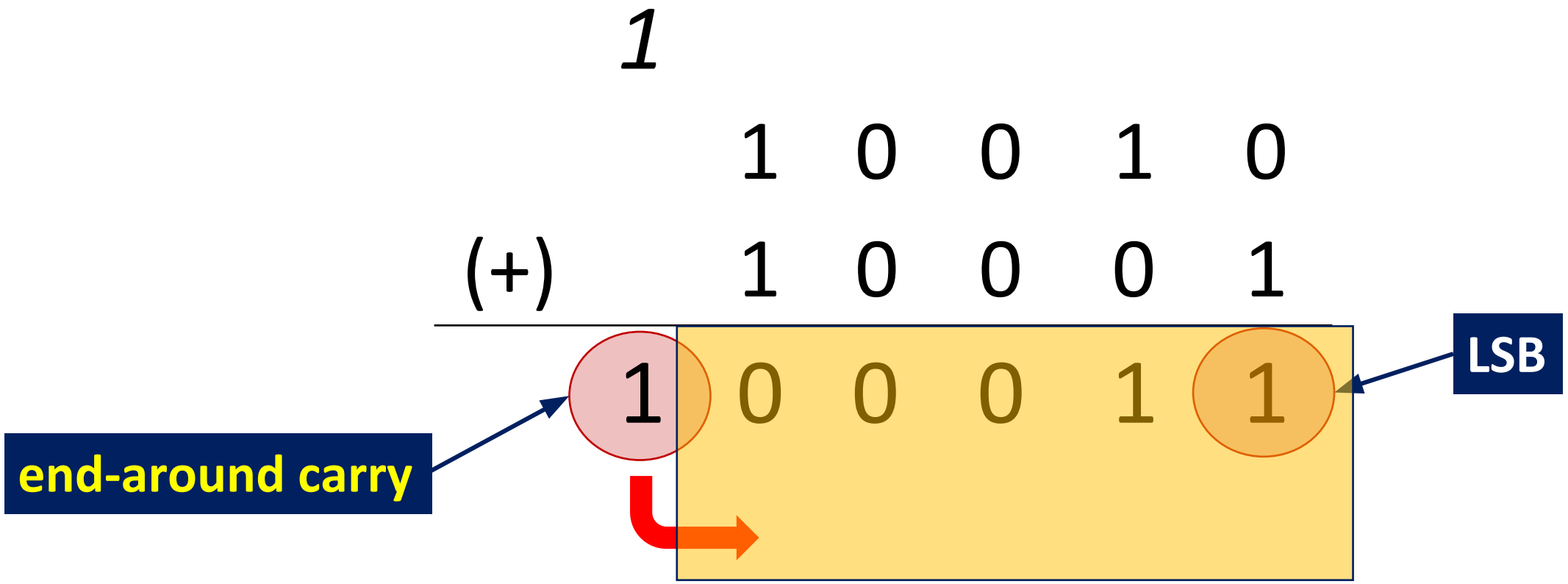
**STEP 2: Add both the complement numbers.**

| | | | | | | |
|---|---|---|---|---|---|---|
| | *1* | | | | | |
| | | 1 | 0 | 0 | 1 | 0 |
| (+) | | 1 | 0 | 0 | 0 | 1 |
| | 1 | 0 | 0 | 0 | 1 | 1 |

# 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.**

| | | | | | |
|---|---|---|---|---|---|
| | | | *1* | *1* | |
| | 0 | 0 | 0 | 1 | 1 |
| (+) | | | | | 1 |
| | 0 | 0 | 1 | 0 | 0 |

# Addition of Negative Numbers (Case 3)

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

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

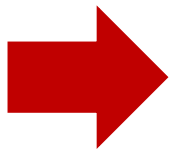
| | | | | | |
|---|---|---|---|---|---|
| | | | *1* | *1* | |
| | 0 | 0 | 0 | 1 | 1 |
| (+) | | | | | 1 |
| | 0 | 0 | 1 | 0 | 0 |

# Addition of Negative Numbers (Case 3)

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

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

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | *1* | *1* | | |
| | | 0 | 0 | 0 | 1 | 1 |
| (+) | | | | | | 1 |
| | 0 | 0 | 1 | 0 | 0 | |



1 1 0 1 1

# 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.**

| | | | | | |
|---|---|---|---|---|---|
| | | *1* | *1* | | |
| | 0 | 0 | 0 | 1 | 1 |
| (+) | | | | | 1 |
| | 0 | 0 | 1 | 0 | 0 |

**-27**

| | | | | | |
|---|---|---|---|---|---|
| - | 1 | 1 | 0 | 1 | 1 |

# Addition of Negative Numbers (Case 3)

Example #1:

Add **-1011** and **-1101**

| | | | | | |
|---|---|---|---|---|---|
| | **-** | 1 | 0 | 1 | 1 |
| (+) | **-** | 1 | 1 | 0 | 1 |
| | | | | | |
| | | | | | |
| | | | | | |

# Addition of Negative Numbers (Case 3)

Example #1:

Add **-1011** and **-1101**

| | | | | | |
|---|---|---|---|---|---|
| | **1** | 0 | 1 | 0 | 0 |
| (+) | **-** | 1 | 1 | 0 | 1 |

# Addition of Negative Numbers (Case 3)

Example #1:

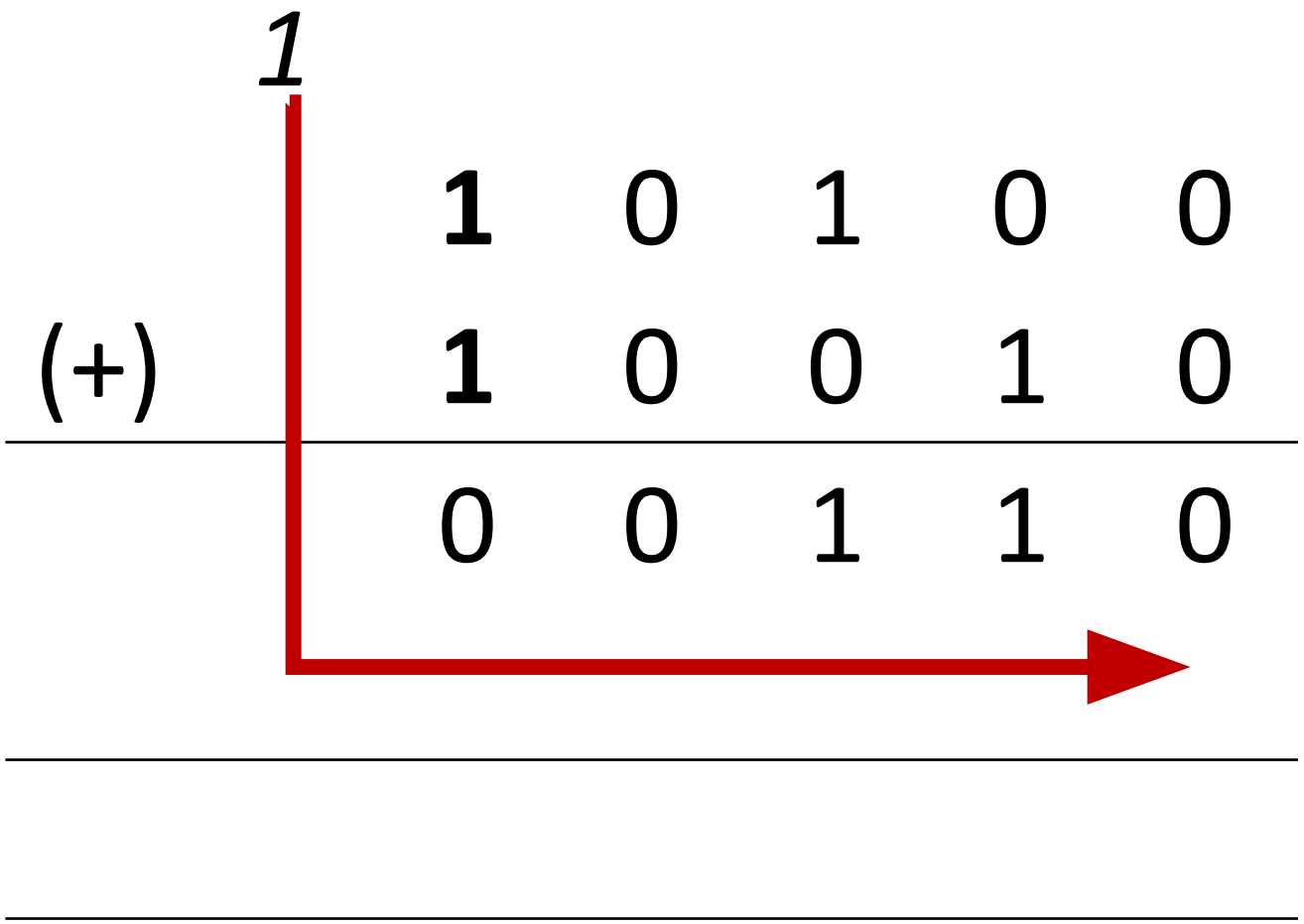
Add **-1011** and **-1101**

| | | | | | |
|---|---|---|---|---|---|
| | **1** | 0 | 1 | 0 | 0 |
| (+) | **1** | 0 | 0 | 1 | 0 |

# Addition of Negative Numbers (Case 3)

Example #1:

Add **-1011** and **-1101**



# Addition of Negative Numbers (Case 3)

Example #1:

Add **-1011** and **-1101**

| | | | | | | |
|---|---|---|---|---|---|---|
| | *1* | | | | | |
| | | **1** | 0 | 1 | 0 | 0 |
| (+) | | **1** | 0 | 0 | 1 | 0 |
| | | 0 | 0 | 1 | 1 | 0 |
| | | | | | | **1** |
| | | | | | | |
| | | | | | | |

# Addition of Negative Numbers (Case 3)

Example #1:

Add **-1011** and **-1101**

| | | | | | | |
|---|---|---|---|---|---|---|
| | *1* | | | | | |
| | | **1** | 0 | 1 | 0 | 0 |
| (+) | | **1** | 0 | 0 | 1 | 0 |
| | | 0 | 0 | 1 | 1 | 0 |
| | | | | | | **1** |
| | | 0 | 0 | 1 | 1 | 1 |

# Addition of Negative Numbers (Case 3)

Example #1:

Add **-1011** and **-1101**

| | | | | | | |
|---|---|---|---|---|---|---|
| | *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)

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**

| | | | | | |
|---|---|---|---|---|---|
| | - | 1 | 1 | 0 | 0 |
| (+) | - | 0 | 1 | 0 | 1 |

# Addition of Negative Numbers (Case 3)

Exercise #2:

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

| | | | | | |
|---|---|---|---|---|---|
| | 1 | 0 | 0 | 1 | 1 |
| (+) | - | 0 | 1 | 0 | 1 |

# Addition of Negative Numbers (Case 3)

Exercise #2:

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

| | | | | | |
|---|---|---|---|---|---|
| | 1 | 0 | 0 | 1 | 1 |
| (+) | - | 0 | 1 | 0 | 1 |

# Addition of Negative Numbers (Case 3)

Exercise #2:

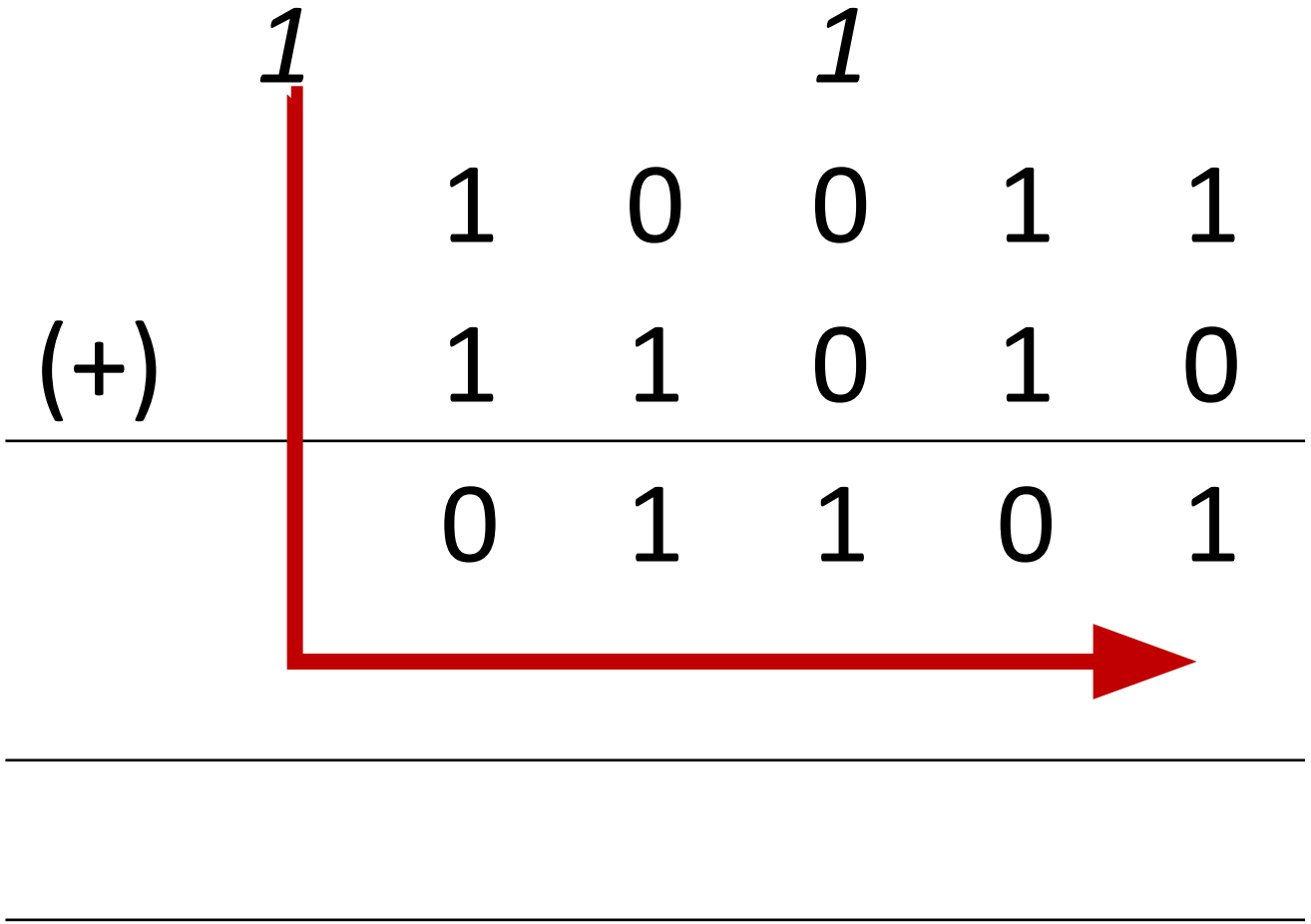
Add **-1100** and **-0101**

| | | | | | |
|---|---|---|---|---|---|
| | 1 | 0 | 0 | 1 | 1 |
| (+) | 1 | 1 | 0 | 1 | 0 |
| | | | | | |
| | | | | | |
| | | | | | |

# Addition of Negative Numbers (Case 3)

Exercise #2:

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



# Addition of Negative Numbers (Case 3)

Exercise #2:

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

| | | | | | | |
|---|---|---|---|---|---|---|
| | *1* | | | *1* | | |
| | | 1 | 0 | 0 | 1 | 1 |
| (+) | | 1 | 1 | 0 | 1 | 0 |
| | | 0 | 1 | 1 | 0 | 1 |
| | | | | | | **1** |
| | | | | | | |
| | | | | | | |

# Addition of Negative Numbers (Case 3)

Exercise #2:

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

| | | | | | | |
|---|---|---|---|---|---|---|
| | *1* | | | *1* | | |
| | | 1 | 0 | 0 | 1 | 1 |
| (+) | | 1 | 1 | 0 | 1 | 0 |
| | | 0 | 1 | 1 | 0 | 1 |
| | | | | | | **1** |
| | | 0 | 1 | 1 | 1 | 0 |

# Addition of Negative Numbers (Case 3)

Exercise #2:

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

| | | | | | | |
|---|---|---|---|---|---|---|
| | *1* | | | *1* | | |
| | | 1 | 0 | 0 | 1 | 1 |
| (+) | | 1 | 1 | 0 | 1 | 0 |
| | | 0 | 1 | 1 | 0 | 1 |
| | | | | | | **1** |
| | | 0 | 1 | 1 | 1 | 0 |
| | | **1** | **0** | **0** | **0** | **1** |

# Addition of Negative Numbers (Case 3)

Exercise #2:

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

**-12 + -5 = -17**

| | | | | | | |
|---|---|---|---|---|---|---|
| | *1* | | | *1* | | |
| | | 1 | 0 | 0 | 1 | 1 |
| (+) | | 1 | 1 | 0 | 1 | 0 |
| | | 0 | 1 | 1 | 0 | 1 |
| | | | | | | **1** |
| | | 0 | 1 | 1 | 1 | 0 |
| | **-** | **1** | **0** | **0** | **0** | **1** |

# Addition of Negative Numbers (Case 3)

Exercise #3:

Add **-1001** and **-0100**

| | | | | | |
|---|---|---|---|---|---|
| | - | 1 | 0 | 0 | 1 |
| (+) | - | 0 | 1 | 0 | 0 |
| | | | | | |
| | | | | | |
| | | | | | |

# Addition of Negative Numbers (Case 3)

Exercise #3:

Add **-1001** and **-0100**

| | | | | | |
|---|---|---|---|---|---|
| | 1 | 0 | 1 | 1 | 0 |
| (+) | - | 0 | 1 | 0 | 0 |
| | | | | | |
| | | | | | |
| | | | | | |

# Addition of Negative Numbers (Case 3)

Exercise #3:

Add **-1001** and **-0100**

| | | | | | |
|---|---|---|---|---|---|
| | 1 | 0 | 1 | 1 | 0 |
| (+) | - | 0 | 1 | 0 | 0 |

# Addition of Negative Numbers (Case 3)

Exercise #3:

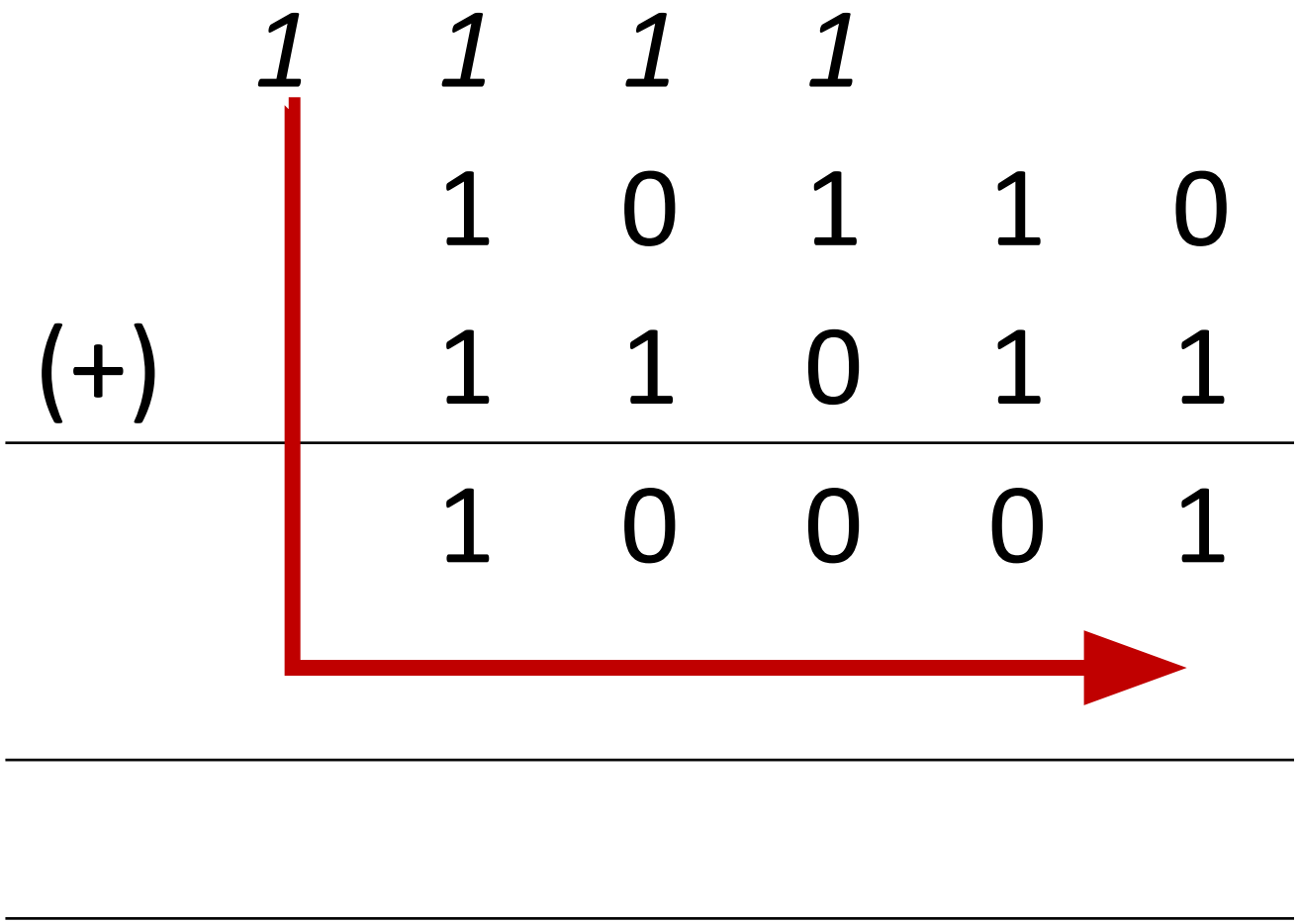
Add **-1001** and **-0100**

| | | | | | |
|---|---|---|---|---|---|
| | 1 | 0 | 1 | 1 | 0 |
| (+) | 1 | 1 | 0 | 1 | 1 |
| | | | | | |
| | | | | | |
| | | | | | |

# Addition of Negative Numbers (Case 3)

Exercise #3:

Add **-1001** and **-0100**



# Addition of Negative Numbers (Case 3)

Exercise #3:

Add **-1001** and **-0100**

| | | | | | | |
|---|---|---|---|---|---|---|
| | *1* | *1* | *1* | *1* | | |
| | | 1 | 0 | 1 | 1 | 0 |
| (+) | | 1 | 1 | 0 | 1 | 1 |
| | | 1 | 0 | 0 | 0 | 1 |
| | | | | | | **1** |

# Addition of Negative Numbers (Case 3)

Exercise #3:

Add **-1001** and **-0100**

| | | | | | | |
|---|---|---|---|---|---|---|
| | *1* | *1* | *1* | *1* | | |
| | | 1 | 0 | 1 | 1 | 0 |
| (+) | | 1 | 1 | 0 | 1 | 1 |
| | | 1 | 0 | 0 | 0 | 1 |
| | | | | | | **1** |
| | | 1 | 0 | 0 | 1 | 0 |

# Addition of Negative Numbers (Case 3)

Exercise #3:

Add **-1001** and **-0100**

| | | | | | | |
|---|---|---|---|---|---|---|
| | *1* | *1* | *1* | *1* | | |
| | | 1 | 0 | 1 | 1 | 0 |
| (+) | | 1 | 1 | 0 | 1 | 1 |
| | | 1 | 0 | 0 | 0 | 1 |
| | | | | | | **1** |
| | | 1 | 0 | 0 | 1 | 0 |
| | | **0** | **1** | **1** | **0** | **1** |

# Addition of Negative Numbers (Case 3)

Exercise #3:

Add **-1001** and **-0100**

**-9 + -4 = -13**

| | | | | | | |
|---|---|---|---|---|---|---|
| | *1* | *1* | *1* | *1* | | |
| | | 1 | 0 | 1 | 1 | 0 |
| (+) | | 1 | 1 | 0 | 1 | 1 |
| | | 1 | 0 | 0 | 0 | 1 |
| | | | | | | **1** |
| | | 1 | 0 | 0 | 1 | 0 |
| | - | **0** | **1** | **1** | **0** | **1** |

# Subtraction of Positive Numbers

**0 - 0 = 0**

**0 - 1 = 1 borrowed from next higher order digit**

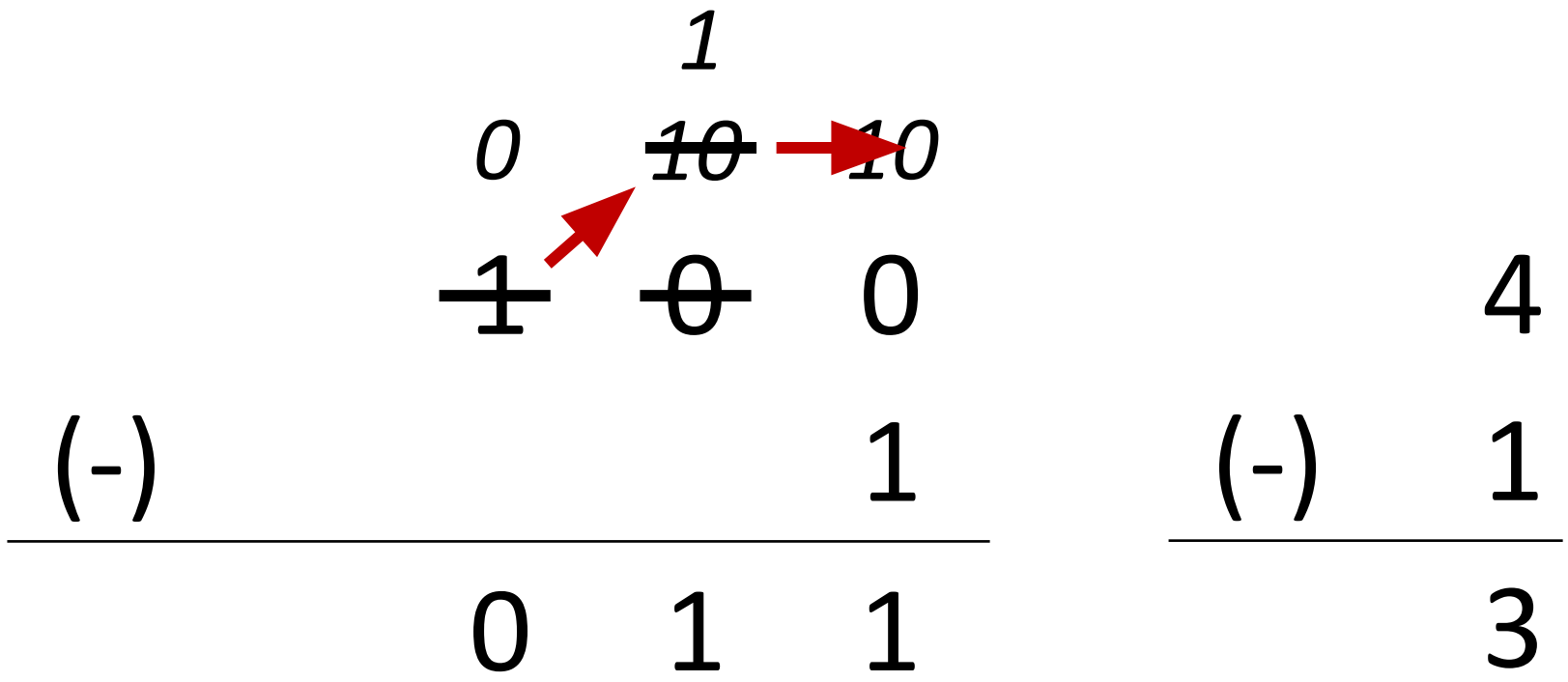
**10 -1 = 1**

**1 - 0 = 1**

**1 - 1 = 0**

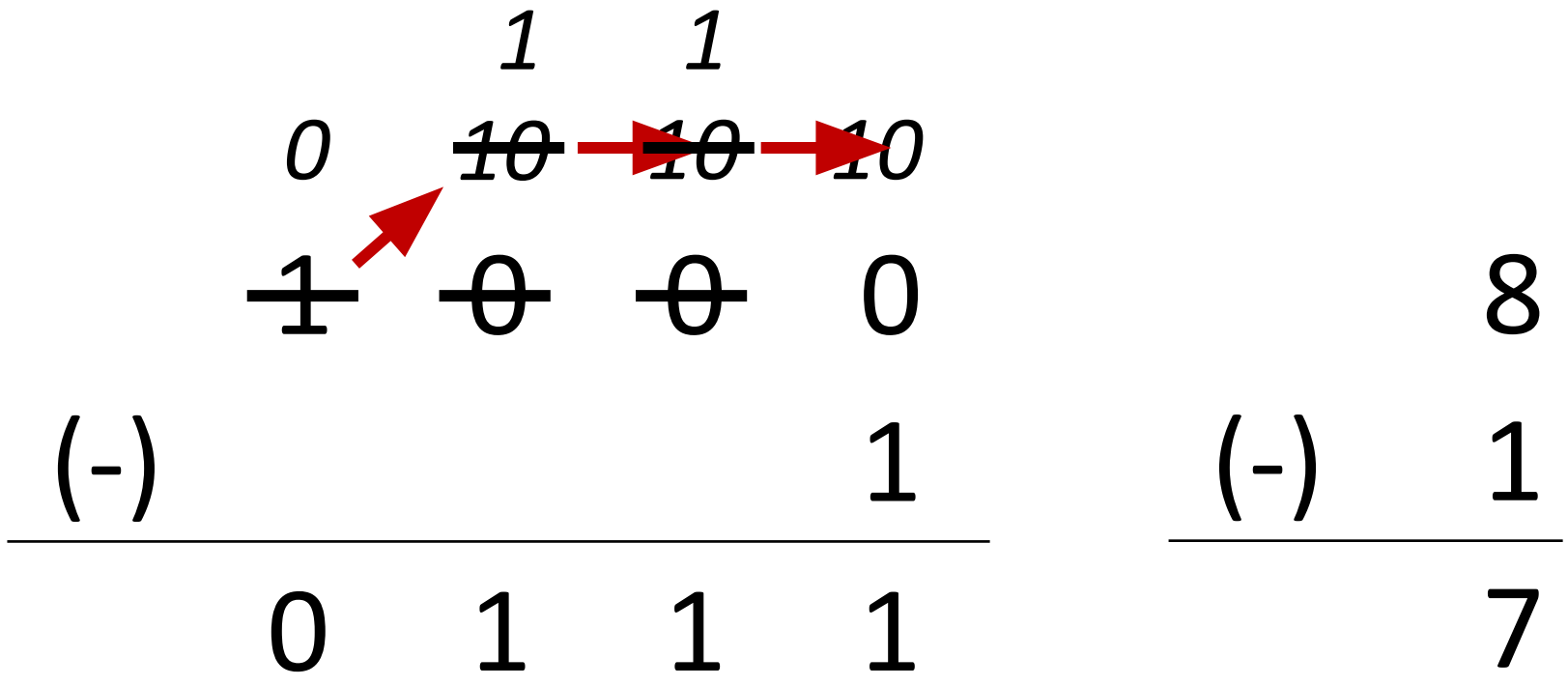
# Subtraction of Positive Numbers

***EXAMPLE #1***



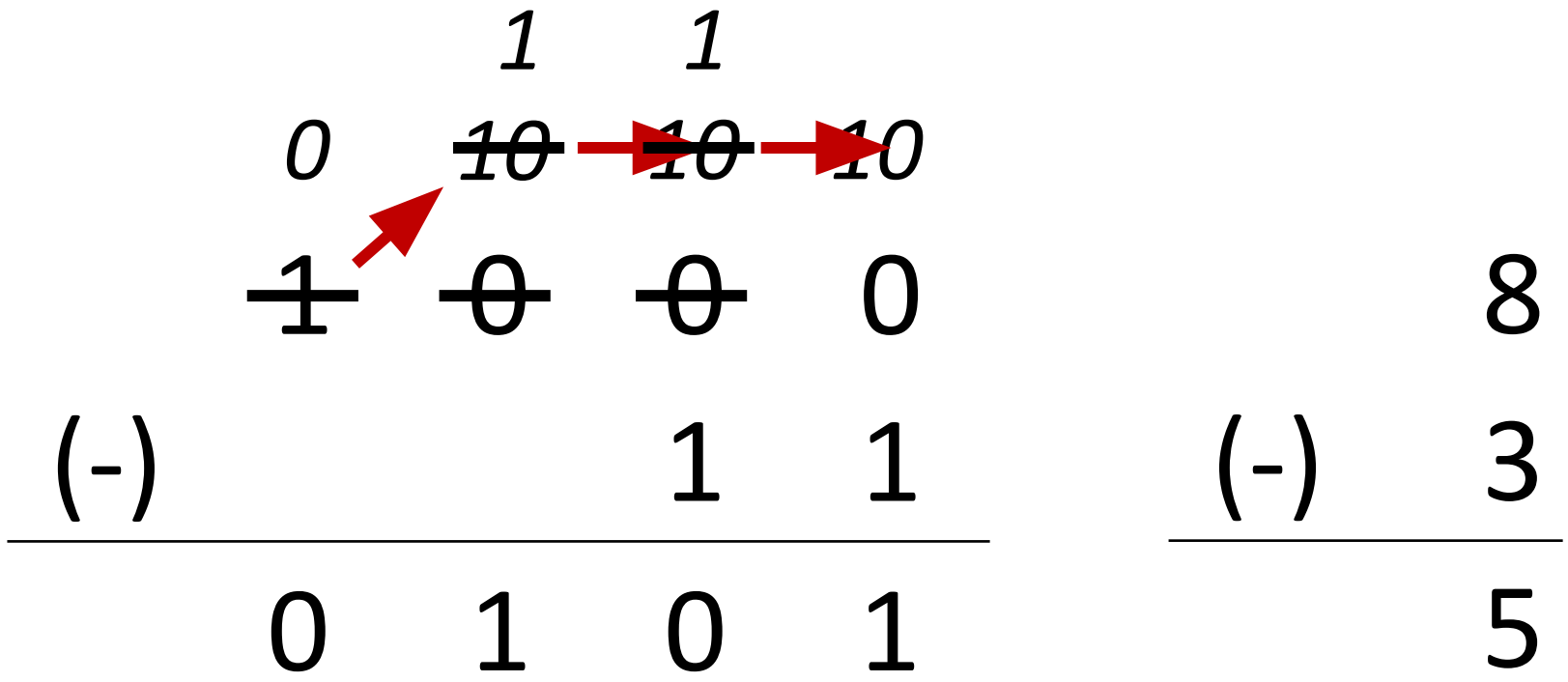
# Subtraction of Positive Numbers

***EXAMPLE #2***



# Subtraction of Positive Numbers

***EXAMPLE #3***



# Subtraction of Positive Numbers

***EXAMPLE #4***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 1 | 0 | 1 | | | 13 |
| (-) | | 1 | 0 | 0 | | (-) | 4 |
| | 1 | 0 | 0 | 1 | | | 9 |

# Subtraction of Positive Numbers

***EXAMPLE #5***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 0 | 1 | 1 | | | 11 |
| (-) | | 1 | 0 | 1 | | (-) | 5 |
| | 0 | 1 | 1 | 0 | | | 6 |