

# Simple Binary Addition

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These slides introduce simple addition with Binary Numbers

# Simple Binary Addition

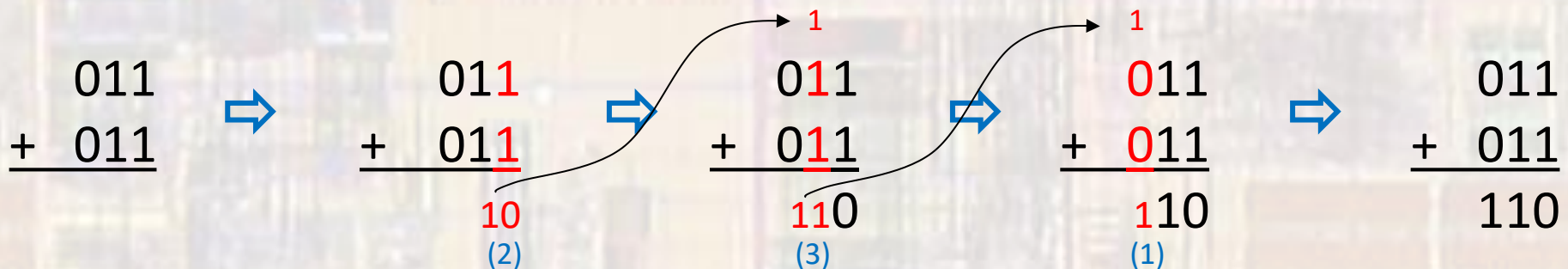
- Elementary school concepts
  - Add columns of numbers and keep track of the carry over to the next column
  - We normally use the decimal number system
    - Digits: 0-9
    - Carry over is in sets of 10

The diagram illustrates the process of adding 245 and 189 in three stages, connected by blue arrows:

- Stage 1:** Shows the initial addition:
$$\begin{array}{r} 245 \\ + 189 \\ \hline \end{array}$$
- Stage 2:** Shows the first carry-over. The 9s column is underlined in red, and the sum '14' is written below it. A curved arrow points from the '4' to the '1' above the 8s column.
$$\begin{array}{r} 245 \\ + \underline{189} \\ \hline 14 \end{array}$$
- Stage 3:** Shows the second carry-over. The 8s column is underlined in red, and the sum '134' is written below it. A curved arrow points from the '4' to the '1' above the 4s column.
$$\begin{array}{r} 245 \\ + \underline{189} \\ \hline 134 \end{array}$$
- Final Result:** Shows the completed addition with the final sum '434' written below the 8s column.
$$\begin{array}{r} 245 \\ + \underline{189} \\ \hline 434 \end{array}$$

# Simple Binary Addition

- Extend elementary school concepts
  - Add columns of numbers and keep track of the carry over to the next column
  - Use the binary number system
    - Digits: 0-1
    - Carry over is in sets of 2



# Simple Binary Addition

- Examples

$$\begin{array}{r}
 \text{2 sets of 2} \\
 \downarrow \\
 \text{1 set of 2} \swarrow \quad \searrow \text{1 set of 2} \\
 \quad \quad \quad \color{red}{1\ 2\ 1} \\
 \quad \quad \quad 0010 \\
 \quad \quad \quad 0011 \\
 + \quad \quad \quad \underline{0111} \\
 \quad \quad \quad 1100
 \end{array}$$

$$\begin{array}{r}
 \color{red}{1\ 1} \\
 001 \\
 + \quad \underline{011} \\
 100
 \end{array}$$

$$\begin{array}{r}
 \color{red}{1\ 2\ 2\ 2\ 1} \\
 000110 \\
 001111 \\
 + \quad \underline{001111} \\
 100100
 \end{array}$$

$$\begin{array}{r}
 \color{red}{1\ 3\ 2\ 2\ 1} \\
 001110 \\
 001110 \\
 001001 \\
 + \quad \underline{001011} \\
 110000
 \end{array}$$

# Simple Binary Addition

- Overflow

- In elementary school we did not care how many digits the answer required

$$\begin{array}{r} 745 \\ + 589 \\ \hline 1334 \end{array}$$

- In binary addition – we are generally representing something that ultimately is to be executed in hardware
  - Our hardware cannot change the number of bits (wires) it can hold
  - We must establish a maximum number size (# of bits) and create an error when the result of the addition does not fit in this size
  - The error is called an **overflow**
- **We will deal with this issue in a future lecture**