

Binary Addition

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These slides introduce addition with Binary Numbers

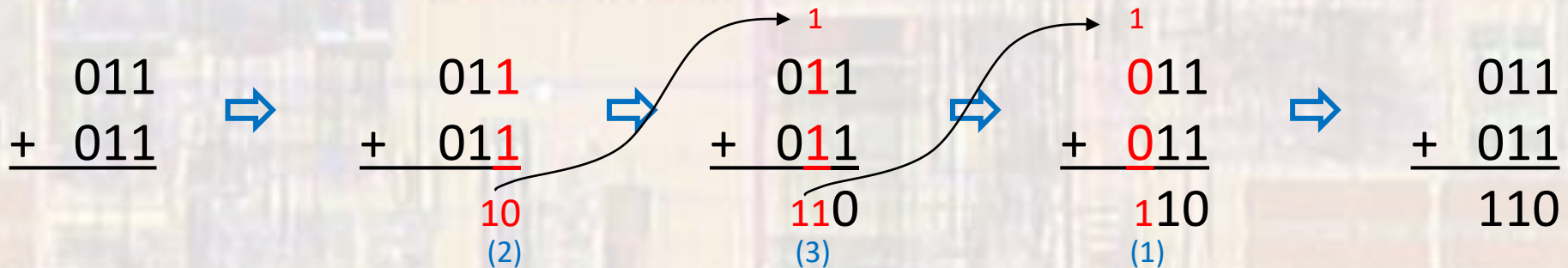
Binary Addition

- 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

$$\begin{array}{r} 245 \\ + 189 \\ \hline \end{array} \Rightarrow \begin{array}{r} 245 \\ + 189 \\ \hline 14 \end{array} \Rightarrow \begin{array}{r} 245 \\ + 189 \\ \hline 134 \end{array} \Rightarrow \begin{array}{r} 1 \\ 245 \\ + 189 \\ \hline 434 \end{array}$$

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



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**

Binary Addition

- Overflow - Unsigned
 - Overflow is defined as:
 - Result does not fit into the allowed # of bits

3 bit addition

$$\begin{array}{r} 101 \\ + 011 \\ \hline 1000 \\ \text{overflow} \end{array}$$

5 bit addition

$$\begin{array}{r} 00101 \\ + 00011 \\ \hline 01000 \\ \text{OK} \end{array}$$

6 bit addition

$$\begin{array}{r} 010101 \\ + 101011 \\ \hline 1010000 \\ \text{overflow} \end{array}$$

8 bit addition

$$\begin{array}{r} 10011101 \\ + 00001001 \\ \hline 10100110 \\ \text{OK} \end{array}$$

Our programs will ignore the overflow and just give us the bits that fit

