

## Binary addition

When we add two binary numbers we use place value and carrying as we do in the denary number system. The only difference is that when we reach two in one column (10) we put a zero and carry the 1 to the next column.

For example:

1101 + 0111 // 13 + 7

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1 1 0 1

0 1 1 1

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101 0 0

1 1 1

Let's break down each column from the right:

- 1 and 1 is two. As two is 10 in binary, we place a zero and carry the 1
- In the next column we have 1 and 0 which is one but because we have carried the the previous 1 we have two again so we put a 0 and again carry a 1
- Now we have 1 and 1 which is two but we also have the carried 1 which makes three. In binary three is 11 so we put a 1 and carry the extra 1
- This gives us two in the final column 10 but we have no room left to carry so we put 10 itself in the final place making
- In total we have 10100 which makes twenty

## More examples to practise with

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## Binary multiplication

Let's remind ourselves of how we do long multiplication within the denary number system:

$$36 * 12$$

So we multiply the bottom unit by the top unit and the top ten and then repeat the process with the bottom ten and sum the results.

36

12

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$$2 * 6 = 12$$

$$2 * 30 = 60$$

$$10 * 6 = 60$$

$$10 * 30 = 300$$

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432

It is the same in binary multiplication but is actually easier because we are only ever multiplying by ones and zeros.

When we multiply binary numbers in columns we multiply each of the top numbers by the bottom in sequence and then sum the results as in denary.

An important difference is that when we move along the bottom row from the  $2^0$ , to  $2^2$ , to  $2^4$  etc we must put a zero in the preceding column as a place holder. The



$$\begin{array}{r} 111 \\ 101 \times \\ \hline \end{array}$$

sequence is shown below:

$$\begin{array}{r}
 111 \\
 101 \times \\
 \hline
 111
 \end{array}$$

Figure 1: multiplication\_02.gif

$$\begin{array}{r}
 111 \\
 101 \times \\
 \hline
 111 \\
 0000
 \end{array}$$

Figure 2: multiplication\_03.gif

A handwritten binary multiplication problem. The first number is 111 and the second is 101, with a multiplication symbol (x) to the right. A horizontal line is drawn under the second number. Below the line, the partial products are written: 111 (shifted one position to the left), 0000 (shifted two positions to the left), and 11100 (shifted three positions to the left). The first '1' in the first number and the first '1' in the second number are highlighted in green.

$$\begin{array}{r} 111 \\ 101 \times \\ \hline 111 \\ 0000 \\ 11100 \end{array}$$

Figure 3: multiplication\_04.gif