

Decimal - Base 10

face	2	4	7	3
position	10^3	10^2	10^1	10^0
	1000	100	10	1

$$2 \times 10^3 = 2 \times 1000 \\ = 2000$$

10 digits
0-9

Binary - base 2 2 digits 0, 1

$\frac{1}{2^4}$ $\frac{0}{2^3}$ $\frac{1}{2^2}$ $\frac{1}{2^1}$ $\frac{0}{2^0}$ face
16 8 4 2 1 positional

$1 \times 2^4 = 1 \times 16$ " 16
 $0 \times 2^3 = 0 \times 8$ " 0
 $1 \times 2^2 = 1 \times 4$ " 4
 $1 \times 2^1 = 1 \times 2$ " 2
 $0 \times 2^0 = 0 \times 1$ " 0

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http://www.pgrocer.net/Cis17/notes/numbers.html

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Binary Numbering systems:

The binary numbering system works much the same way as the decimal numbering system except that now we are in base 2 so we only have 2 digits (0, 1). The value of the number is still determined by the face value times the positional value, but since we are in base 2, the positional values are the powers of 2. Since the face values can only be 0 or 1, this means that the 0 or 1 is multiplied by the positional place in which it is found.

Example: binary number 1011011

1	0	1	1	0	1	1	Face value
2^6	2^5	2^4	2^3	2^2	2^1	2^0	Positional value
64	32	16	8	4	2	1	Resolved positional value

The positional values are first shown in the powers of 2 and then as the resolved number - in other words, 2 to the 6th is equal to 64.

Converting binary to decimal:

In the previous example to find the decimal equivalent for the number 1011011, we do the following:

$1 \times 2^6 = 1 \times 64 =$	64
$0 \times 2^5 = 0 \times 32 =$	0
$1 \times 2^4 = 1 \times 16 =$	16
$1 \times 2^3 = 1 \times 8 =$	8
$0 \times 2^2 = 0 \times 4 =$	0
$1 \times 2^1 = 1 \times 2 =$	2
$1 \times 2^0 = 1 \times 1 =$	1
	91

Converting decimal to binary:

Before doing this it is important that we review the decimal equivalent for the frequently used powers of 2:

$2^0 = 1$	$2^1 = 2$	$2^2 = 4$	$2^3 = 8$	$2^4 = 16$	$2^5 = 32$
1	2	4	8	16	32

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$$1011011_2 =$$

$$\begin{array}{cccccccc} 1 & 0 & 1 & 1 & 0 & 1 & 1 & \\ 2^6 & 2^5 & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 & \\ 64 & 32 & 16 & 8 & 4 & 2 & 1 & \\ & & & & & & & 9 \\ & & & & & & & 10 \\ & & & & & & & 8 \\ & & & & & & & 2 \\ & & & & & & & 1 \\ & & & & & & & \hline & & & & & & & 9 \end{array}$$

$$9_{10} = \underline{\hspace{2cm}}_2$$

	1	0	1	1	0	1	1
	2^7	2^6	2^5	2^4	2^3	2^2	2^1
	128	64	32	16	8	4	2

$$\begin{array}{r} 9 \\ \underline{64} \\ 27 \\ \underline{16} \\ 11 \end{array}$$

$$\begin{array}{r} 11 \\ \underline{0} \\ 3-2=1-1=0 \end{array}$$

Dec
 9 8 7 6 5 4 3 2 1 0

Bin
 1 0 0 1
 1 0 0 0
 1 1 0 0
 1 1 1 1
 1 0 0 0
 1 0 0 1

1 0 0 0
 2³ 2² 2¹ 2⁰
 8 4 2 1

4 2 1 0 | 1 0 0 1
 2 2 1 0 | 1 0 0 1
 1 0 1 1 | 1 0 0 1
 1 0 1 1 | 1 0 0 1

$$\frac{1}{2^3} \quad \frac{1}{2^2} \quad \frac{1}{2^1} \quad \frac{1}{2^0}$$

$$8 \quad 4 \quad 2 \quad 1$$

$$2^4 \quad 2^3 \quad 2^2 \quad 2^1 \quad 2^0$$

$$16 \quad 8 \quad 4 \quad 2 \quad 1$$

$$1 \times 8 = 8$$

$$1 \times 4 = 4$$

$$1 \times 2 = 2$$

$$1 \times 1 = 1$$

$$15$$

$$\begin{array}{r} 101_2 = 5_{10} \\ + 111_2 = 7_{10} \\ \hline \end{array}$$

$$\begin{array}{r} 1100 \rightarrow 12_{10} \\ \begin{array}{cccc} 1 & 1 & 0 & 0 \\ 8 & 4 & 2 & 1 \end{array} \end{array}$$

$$\begin{array}{r} 1011 = 11_{10} \\ + 1110 = 14_{10} \\ \hline \end{array}$$

$$\begin{array}{r} 11001 \rightarrow 25_{10} \\ \begin{array}{ccccc} 1 & 1 & 0 & 0 & 1 \\ 16 & 8 & 4 & 2 & 1 \end{array} \end{array}$$

$$1 + 1 = 10$$

$$10 + 1 = 11$$

$$11 + 1 = 100$$

$$\begin{array}{r} 11 \\ + 1 \\ \hline 100 \end{array}$$

¹¹	¹⁰	¹⁰	1	= 13	1 + 1 = 10 + 1 = 11
1	1	0	1	= 15	+ 1
1	1	1	1	= 35	<hr style="border: 1px solid red;"/>
1	0	1	1	= 7	100
+	1	1	1	=	
<hr style="border: 1px solid red;"/>				<hr style="border: 1px solid blue;"/>	
10	1000			40	
32	16	8	4	2	1

↗

$$\begin{array}{r}
 \overset{0}{\cancel{1}} \overset{10}{\cancel{1}} \overset{10}{\cancel{0}} \overset{10}{0} \quad | = 25 \\
 - \quad | \quad | \quad | \quad | \quad | = 15 \\
 \hline
 \quad | \quad 0 \quad | \quad 0 = 10
 \end{array}$$