

Numbering Systems and Computer Codes - Mozilla Firefox

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

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Numbering Systems and Computer Codes
Prepared by The Computer Information Systems Department

Decimal Numbering Systems:

The decimal numbering system is a base 10 numbering system (this means there are 10 digits we can use - these digits are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9). When we talk about a number, we understand what the number is because of its face value and its positional value. Thus, the digit 5 has a different meaning when it is in the tens position than when it is in the ones position (i.e. when it is in the tens position, we express it as 50 and when it is in the ones position, we express it as 5). In this case, the face value of the digit is 5 and the positional value of a number is based on the position it occupies. In decimal, the positional value of a number is based on the powers of 10 (remember, we are in base 10):

5	7	2	4	Face value
10^3	10^2	10^1	10^0	Positional Value (powers of 10)
1000	100	10	1	Resolved positional value

To figure out the value of 5724, we do the following:

$$5 \times 10^3 = 5 \times 1000 = 5000$$

$$7 \times 10^2 = 7 \times 100 = 700$$

$$2 \times 10^1 = 2 \times 10 = 20$$

$$4 \times 10^0 = 4 \times 1 = 4$$

5724

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.

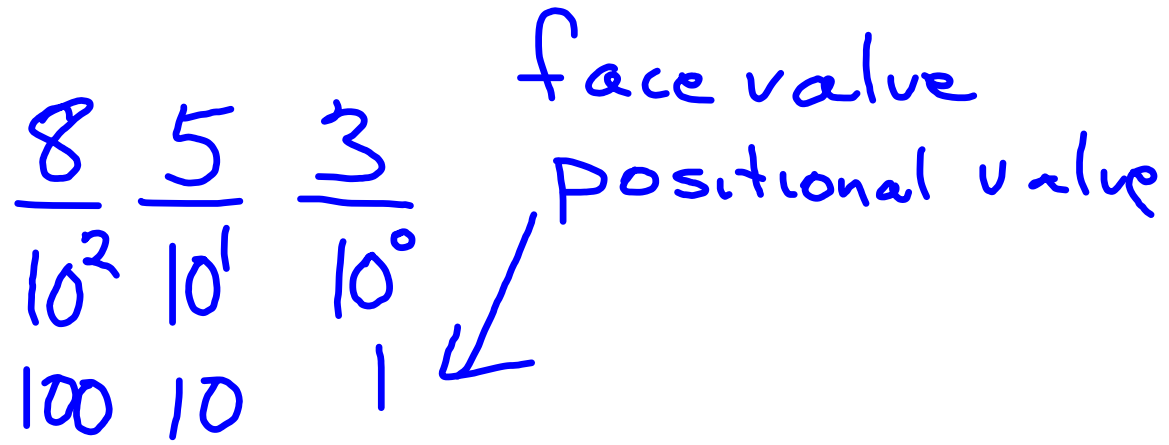
Example: binary number 1011011

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

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Decimal base 10 0-9



$$\begin{array}{r} 8 \\ \times 100 \\ \hline 800 \end{array} + \begin{array}{r} 5 \\ \times 10 \\ \hline 50 \end{array} + \begin{array}{r} 3 \\ \times 1 \\ \hline 3 \end{array}$$

853

Binary base 2 (0,1)

face value $1011101_2 = \frac{93}{10}$

positional value

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

128 $1 \times 64 = 64$
 $0 \times 32 = 0$
 $1 \times 16 = 16$
 $1 \times 8 = 8$
 $1 \times 4 = 4$
 $0 \times 2 = 0$
 $1 \times 1 = 1$

93

$93_{10} = \frac{\quad}{2}$

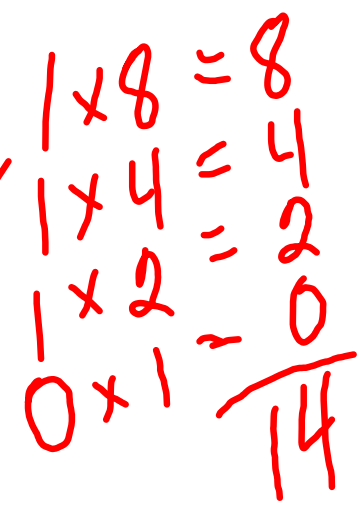
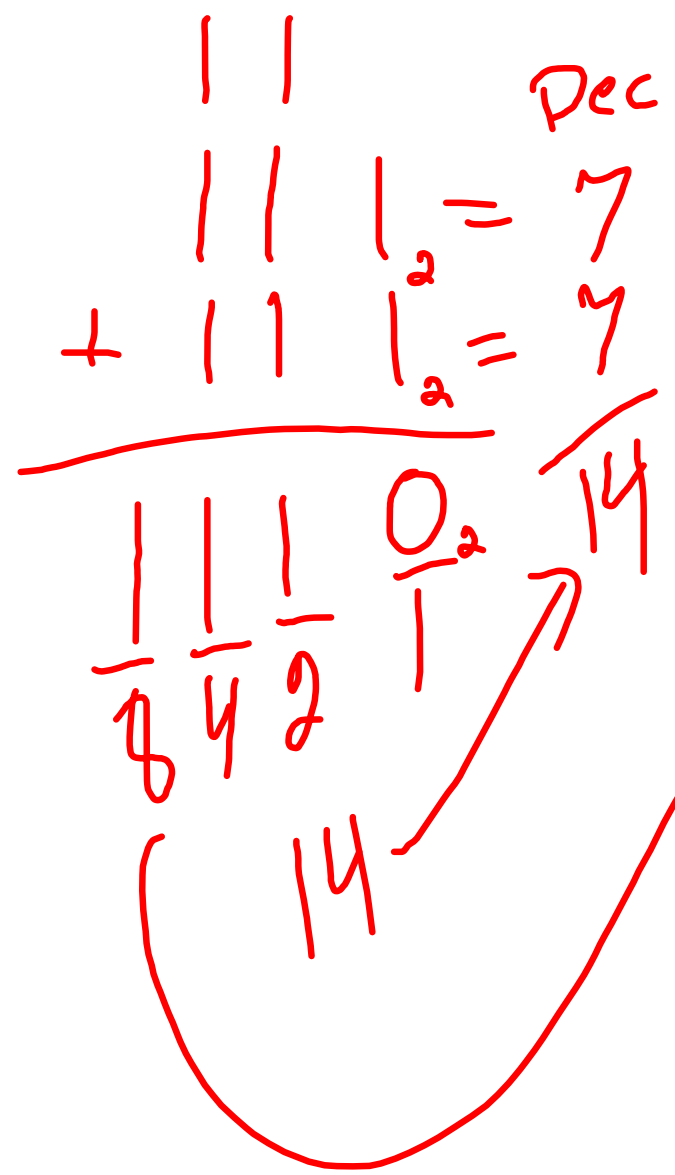
93_{10}	29	1	0	1	1	101
-64	16	2^6	2^5	2^4	2^3	2^2
29	3	64	32	16	8	4
-16	13	2^2	2^1	2^0	1	0
13	1	4	2	1	0	1
-4	9	64	32	16	8	4
9	5	2^2	2^1	2^0	1	0
-4	1	4	2	1	0	1
1	1	1	0	1	1	01
-1	0	64	32	16	8	4
0	0	2^2	2^1	2^0	1	0
0	0	4	2	1	0	1
0	0	1	0	1	1	01

Bin	Dec
0	0
1	1
10	2
11	3
100	4
101	5
110	6
111	7
1000	8
1001	9

2^3	2^2	2^1	2^0	
8	4	2	1	
1	0	0	0	= 8
1	1	1	1	= 15
				0 = 4
				1 = 3
				0 = 2

Bin
 0
 10
 11
 100
 101
 110
 111
 1000
 1001

Dec
 0
 2
 3
 4
 5
 6
 7
 8
 9



$$\begin{array}{r}
 11 \\
 101 = 5 \\
 110 = 6 \\
 11 = 3 \\
 + 100 = 4 \\
 \hline
 10010 \\
 16 \ 8 \ 2 \ 1 \\
 16+2=18 \rightarrow 18
 \end{array}$$

$$\begin{array}{r}
 1 \ 0 \ 1 \\
 2^3 \ 2^2 \ 2^1 \ 2^0 \\
 8 \ 4 \ 2 \ 1 \\
 1 \times 4 = 4 \\
 0 \times 2 = 0 \\
 1 \times 1 = 1 \\
 \hline
 5
 \end{array}$$

$$\begin{array}{r}
 \text{10(2)} \\
 \cancel{1}011 = 11 \\
 - 101 = 5 \\
 \hline
 110 \\
 421 \\
 4+2=6
 \end{array}$$

$$\begin{array}{r}
 \cancel{1}0010 = 18 \\
 - 110 = 6 \\
 \hline
 1100 \\
 8+4=12
 \end{array}$$

Hex 16 digits (0-9, A, B, C, D, E, F)

10 11 12 13 14 15

$$\frac{B}{16^3} \frac{3}{16^2} \frac{D}{16^1} \frac{face}{16^0} = \frac{2877}{10}$$

positional

$$\begin{array}{r} 256 \\ \times 11 \\ \hline 256 \\ 256 \\ \hline 2816 \end{array}$$

$$B \times 16^2 = B \times 256 = 11 \times 256 = 2816$$

$$3 \times 16^1 = 3 \times 16 =$$

$$D \times 16^0 = D \times 1 = 13 \times 1 =$$

$$\begin{array}{r} 40 \\ 13 \\ \hline 2877 \end{array}$$

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Hexadecimal Numbering System:

The next numbering system is the hexadecimal numbering system. This is the base 16 numbering system, therefore there are 16 digits (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F). The letter A carries the same value as decimal 10, the letter B carries the same value as decimal 11, the letter C carries the same value as decimal 12, the letter D carries the same value as decimal 13, the letter E carries the same value as decimal 14, and the letter F carries the same value as decimal 15. Hexadecimal, like any other numbering system has the face value of digits and the positional value. The positional value is based on the powers of 16 since hexadecimal is the base 16 numbering system.

Example: Hexadecimal number A359

A	3	5	9	face value
16^3	16^2	16^1	16^0	positional value (powers of 16)
4096	256	16	1	resolved positional value

Converting hexadecimal to decimal:

To convert hexadecimal to its decimal equivalent, we multiply the face value times the positional value:

$$\begin{array}{r}
 A \times 16^3 = \quad 10 \times 4096 = \quad 40960 \text{ (note A is equivalent to decimal 10)} \\
 3 \times 16^2 = \quad 3 \times 256 = \quad 768 \\
 5 \times 16^1 = \quad 5 \times 16 = \quad 80 \\
 9 \times 16^0 = \quad 9 \times 1 = \quad 9 \\
 \hline
 41817
 \end{array}$$

The equivalent of hexadecimal A359 in decimal is 41817.

Converting decimal to hexadecimal:

Now we will take the decimal number 41817 and convert it back to hexadecimal. To do this, we will follow the same steps we used in converting decimal to binary with one change. In this time we are concerned with multiplying by the face value (in binary this was not a concern because multiplying by 1 doesn't change anything).

The following are the decimal equivalents for some of the commonly used powers of 16:

Done

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Dec	Bin	Hex
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F
<hr/>		
16	10000	10

Every hex digit
 can be expressed
 using 4 binary
 digits
 every 4 binary digits
 can be expressed
 with 1 hex digit

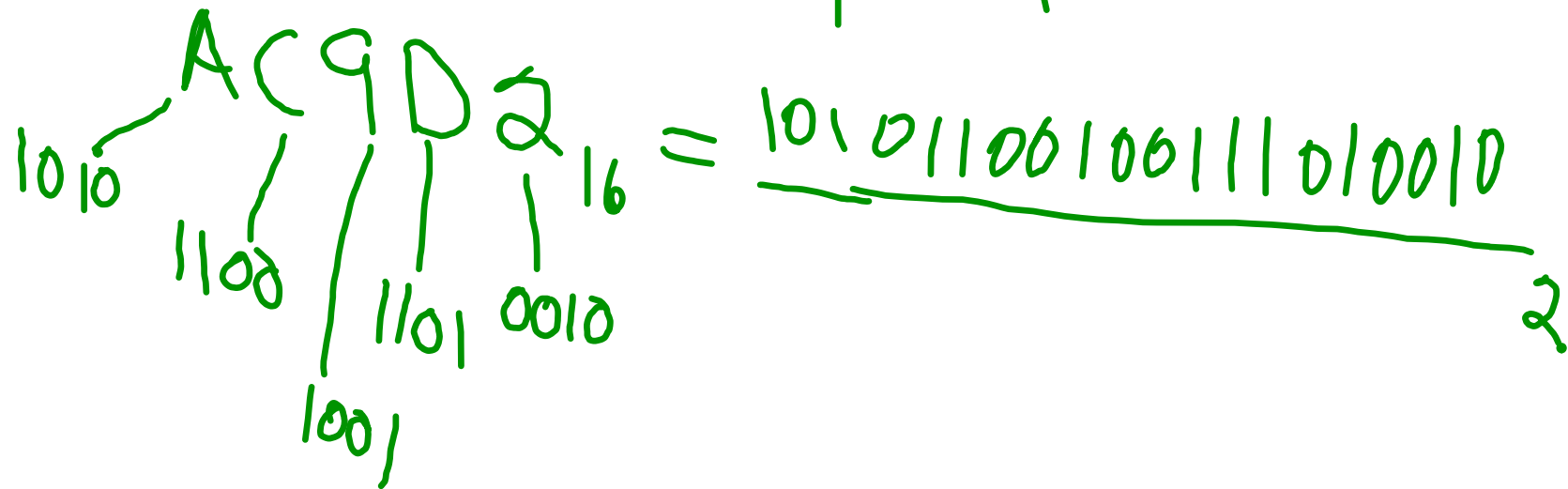
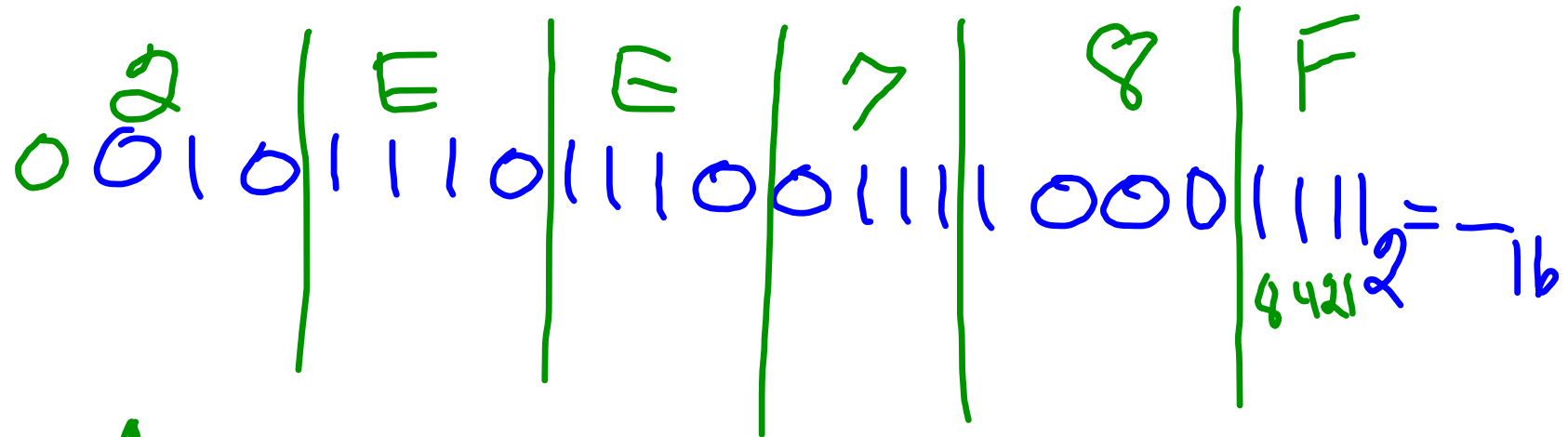
$$B3D_{16} = 2877_{10} = \underline{\quad} 16$$

2877

$$\begin{array}{r}
 2560 - 10 \\
 \hline
 317 \\
 -256 - 1 \\
 \hline
 61 \\
 -48 - 3 \\
 \hline
 13
 \end{array}$$

<u> </u>	<u>B</u>	<u>3</u>	<u>D</u>	←
16^3	16^2	16^1	16^0	
4096	256	16	1	

Bin-hex
hex-bin



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Clipboard: Paste, Copy, Format Painter, Cut, Copy

Font: Times New Roman, 14, Bold, Italic, Underline, Text Color, Background Color, Font Color

Paragraph: Bullets, Numbering, Indentation, Paragraph Spacing, Text Alignment, Line and Paragraph Spacing, Show/Hide Paragraph Marks

Styles: AaBbCcI, AaBbCcI, AaBbCcI, AaBbC, AaBbC, Caption, Normal, No Spacing, Heading 1, Heading 2, Change Styles

Binary arithmetic:

$\begin{array}{r} 1110 \\ + 1110 \\ \hline \end{array}$	$\begin{array}{r} 11011 \\ 1110 \\ + 11100 \\ \hline \end{array}$	$\begin{array}{r} 110111 \\ + 101110 \\ \hline \end{array}$	$\begin{array}{r} 11110 \\ 11111 \\ + 11011 \\ \hline \end{array}$
$\begin{array}{r} 1101 \\ - 100 \\ \hline \end{array}$	$\begin{array}{r} 10101 \\ - 1101 \\ \hline \end{array}$	$\begin{array}{r} 100010 \\ - 1111 \\ \hline \end{array}$	$\begin{array}{r} 111011 \\ - 11110 \\ \hline \end{array}$

Hexadecimal conversion: (note that the 16, 10 and 2 at the end of the number are the base)

DBA₁₆ = _____₁₀

3574₁₀ = _____₁₆

A5CE₁₆ = _____₁₀

5371₁₀ = _____₁₆

110111111001₂ = _____₁₆

F7D₁₆ = _____₂

10110011101011101101₂ = _____₁₆

B7D8₁₆ = _____₂

F7D₁₆

Words: 155

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