Math: Numbering Systems HowTo
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Decimal System
Decimal (base of 10) We use the decimal numbering system every day. It consists of 10 digits (hence the name decimal). The digits, from smallest to largest are: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. The next number after 9 goes in the next column.

The number 123 is built up as follows:

10^3	10^2	10^1	10^0
Thousands	Hundreds	Tens	Ones
0	1	2	3

= 100 + 20 + 3 = 123

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Binary System
Binary (base 2) The computer is using the binary numbering system. It can only recognize two states, power **on** or **off** = 1 or 0 .
Once again, any number can be broken down into columns.
The number 123 in the decimal system is in binary as follows:

2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
256s	128s	64s	32s	16s	Eights	Fours	Twos	Ones
0	0	1	1	1	1	0	1	1

= 64 + 32 + 16 + 8 + 0 + 2 + 1 = 123

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Hexadecimal System
The hexadecimal numbering system consists of sixteen digits. The digits, from smallest to largest are: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F.
Using the hexadecimal numbering system, from right to left, the first column is the 1's column, then the 16's column, then the 256's, then the 4096's etc.. You multiply the number in each previous column by 16
Once again, any number can be broken down into columns.
The number 123 in the decimal system is in hexadecimal as follows:

16^3	16^2	16^1	16^0
4096	256	16	1
0	0	7	B

= 112 + 11 = 123 decimal (112 = 7 x 16 and B = 11)

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Octal System
The Octal Number System uses base 8 includes only the digits 0 through 7. The Octal system is based on the binary system with a 3-bit boundary.
The number 123 in the decimal system is in octal as follows:

8^4	8^3	8^2	8^1	8^0
4096	512	64	8	1
0	0	1	7	3

= 64 + 56 + 3 = 123 decimal (64 + 8x7 + 3x1) = 123

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B	i	n	a	r	y		Numbers
64	32	16	8	4	2	1	Decimal
0	0	0	0	0	0	1	1
0	0	0	0	0	1	0	2
0	0	0	0	0	1	1	3
0	0	0	0	1	0	0	4
0	0	0	0	1	0	1	5
0	0	1	1	0	1	1	27
0	1	1	0	0	0	0	48
1	0	1	1	1	0	0	92
1	1	1	0	1	0	1	117

To practice make up a number and verify with a calculator!

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Binary Coded Decimal System - BCD

To simplify true binary, a numbering system known as Binary Coded Decimal **BCD** was devised. Each digit of a decimal number is presented in binary = a 4 digit code for each number from 0 to 9.

Binary Number				Decimal Digit
8	4	2	1	
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9

Let's take the decimal number 351 = 351_{10} is in BCD = 0011 0101 0001_{BCD} and in true binary 101011111_2

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Binary	Octal	Decimal	Hex
0000	00	00	00
0001	01	01	01
0010	02	02	02
0011	03	03	03
0100	04	04	04
0101	05	05	05
0110	06	06	06
0111	07	07	07
1000	10	08	08
1001	11	09	09
1010	12	10	0A
1011	13	11	0B
1100	14	12	0C
1101	15	13	0D
1110	16	14	0E
1111	17	15	0F
1 0000	20	16	10

Hex to Binary Conversion

Convert the Hex number to its 4-bit binary equivalent. Combine the 4-bit sections by removing the spaces.

For example, the hex value $0AFB2_H$ will be written:

A	F	B	2
1010	1111	1011	0010

Binary to Hex Conversion

Break the binary number into 4-bit sections from the LSB to the MSB = Right to Left. Convert the 4-bit binary number to its Hex equivalent.

For example, the binary value 1010111110110010_B will be written:

1010	1111	1011	0010
A	F	B	2

Binary to Octal Conversion:

It is easy to convert from an integer binary number to octal. This is accomplished by:
Break the binary number into 3-bit sections from the LSB to the MSB = Right to Left.
Convert the 3-bit binary number to its octal equivalent.

For example, the binary value 1010111110110010_B will be written:

001	010	111	110	110	010
1	2	7	6	6	2

Octal to Binary Conversion:

It is also easy to convert from an integer octal number to binary. This is accomplished by:
Convert the decimal number to its 3-bit binary equivalent.
Combine the 3-bit sections by removing the spaces.

The octal value 127662_Q will be written:

1	2	7	6	6	2
001	010	111	110	110	010

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