A Brief Explanation of Decimal, Binary, and Hexadecimal Number Systems

Base 10 and Positional Number Systems

We are all familiar with the base 10 number system that we use in our everyday lives. The base 10 number system is just one example of a positional number system. In a positional number system, a number is represented as a series of digits, where each digit position is associated with a weight. For example, the number representing the year 2003 can be represented as follows:

$2003 = 2 * 10^3 + 0 * 10^2 + 0 * 10^1 + 3 * 10^0$

position 3 2 1 0

As you can see, each weight is the power of 10 to the number position starting at 0. The * represents multiplication and any number raised to the power of zero = 1.

Binary and Hexadecimal Number Systems

Binary and hexadecimal number systems are examples of positional number systems with different bases. Binary number systems use a base of 2 while hexadecimal uses a base of 16.

For example, the binary number 1010 is represented as follows:

$1011 = 1 * 2^3 + 0 * 2^2 + 1 * 2^1 + 1 * 2^0 = 1 * 8 + 0 * 4 + 1 * 2 + 1 * 1 = 11$ (base 10)

For example, the hexadecimal number 123 is represented as follows:

$123 = 1 * 16^2 + 2 * 16^1 + 3 * 16^0 * 0 = 1 * 256 + 32 + 3 = 291$ (base 10)

In a hexadecimal system, it is necessary to count to 15. To represent the numbers 10 – 15, the letters A – F are used respectively. To distinguish the different number systems, prefixes or subscripts are often used.

Number system	prefix	example	Subscript	example
decimal	0d	0d1023	10	1023_{10}
binary	0b	0b1101	2	1101_2
hexadecimal	0x	0x12F	16	$12F_{16}$

The following table compares all three systems counting from 0 to 15.

Decimal	**Binary**	**Hexadecimal**
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
12	1101	D
14	1110	E
15	1111	F