NUMBER SYSTEM

NUMBER SYSTEM

Number systems are the technique to represent numbers in the computer system architecture, every value that you are saving or getting into/from computer memory has a defined number system.

Computer architecture supports following number systems.

- **Binary number system**
- **Octal number system**
- **Decimal number system**

Hexadecimal (hex) number system

- **BINARY NUMBER SYSTEM**

A Binary number system has only two digits that are **0 and 1**. Every number (value) represents with 0 and 1 in this number system. The base of binary number system is 2, because it has only two digits.

OCTAL NUMBER SYSTEM

Octal number system has only eight (8) digits from **0 to 7**. Every number (value) represents with 0,1,2,3,4,5,6 and 7 in this number system. The base of octal number system is 8, because it has only 8 digits.

DECIMAL NUMBER SYSTEM

Decimal number system has only ten (10) digits from **0 to 9**. Every number (value) represents with 0,1,2,3,4,5,6, 7,8 and 9 in this number system. The base of decimal number system is 10, because it has only 10 digits.

HEXADECIMAL NUMBER SYSTEM

A Hexadecimal number system has sixteen (16) alphanumeric values from **0 to 9** and **A to F**. Every number (value) represents with 0,1,2,3,4,5,6, 7,8,9,A,B,C,D,E and F in this number system. The base of hexadecimal number system is 16, because it has 16 alphanumeric values. Here A is 10, B is 11, C is 12, D is 14, E is 15 and F is 16.

Number system	Base(Radix)	Used digits	Example
Binary	2	0,1	$(11110000)_2$
Octal	8	0,1,2,3,4,5,6,7	$(360)_8$
Decimal	10	0,1,2,3,4,5,6,7,8,9	$(240)_{10}$
Hexadecimal	16	0,1,2,3,4,5,6,7,8,9, A,B,C,D,E,F	$(F0)_{16}$

1. DECIMAL TO BINARY

To convert Number system from **Decimal Number System** to **Any Other Base** is quite easy; you have to follow just two steps:

A) Divide the Number (Decimal Number) by the base of target base system (in which you want to convert the number: Binary (2), octal (8) and Hexadecimal (16)).
B) Write the remainder from step 1 as a Least Signification Bit (LSB) to Step last as a Most Significant Bit (MSB).

Decimal to Binary Conversion	Result

Decimal Number is : **$(12345)_{10}$**

2	12345	1	**LSB**
2	6172	0	
2	3086	0	
2	1543	1	
2	771	1	
2	385	1	
2	192	0	
2	96	0	
2	48	0	
2	24	0	
2	12	0	
2	6	0	
2	3	1	
	1	1	**MSB**

Binary Number is **$(11000000111001)_2$**

DECIMAL TO OCTAL

Decimal to Octal Conversion	Result
Decimal Number is : **$(12345)_{10}$** 8 | 12345 | 1 LSB 8 | 1543 | 7 8 | 192 | 0 8 | 24 | 0 3 | 3 MSB	Octal Number is **$(30071)_8$**

Decimal to Hexadecimal Conversion	Result
Example 1 Decimal Number is : **$(12345)_{10}$** 16 | 12345 | 9 **LSB** 16 | 771 | 3 16 | 48 | 0 8 | 3 | 3 **MSB**	Hexadecimal Number is **$(3039)_{16}$**

Example 2

Decimal Number is : **$(725)_{10}$**

16	725	5	5	LSB
16	45	13	D	
	2	2	2	MSB

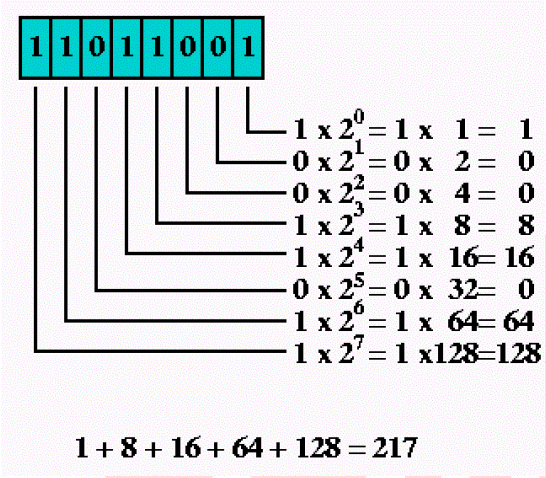
Hexadecimal Number is **$(2D5)_{16}$**

Convert
10, 11, 12, 13, 14, 15
to its equivalent...
A, B, C, D, E, F

BINARY TO OTHER

A) Multiply the digit with 2(with place value exponent). Eventually add all the multiplication becomes the Decimal number.

1. BINARY TO DECIMAL



1. BINARY TO OCTAL

An easy way to convert from binary to octal is to group binary digits into sets of three, starting with the least significant (rightmost) digits.

Binary: 11100101 =	11 100 101	
	011 100 101	Pad the most significant digits with zeros if necessary to complete a group of three.

Then, look up each group in a table:

Binary:	000	001	010	011	100	101	110	111
Octal:	0	1	2	3	4	5	6	7

Binary =	011 100 101	
Octal =	3 4 5	= 345 oct

1. BINARY TO HEXADECIMAL

An equally easy way to convert from binary to hexadecimal is to group binary digits into sets of four, starting with the least significant (rightmost) digits.

Binary: 11100101 = 1110 0101

Then, look up each group in a table:

Binary:	0000	0001	0010	0011	0100	0101	0110	0111
Hexadecimal:	0	1	2	3	4	5	6	7

Binary:	1000	1001	1010	1011	1100	1101	1110	1111
Hexadecimal:	8	9	A	B	C	D	E	F

Binary =	1110	0101	
Hexadecimal =	E	5	= E5 hex

1. OCTAL TO BINARY

Converting from octal to binary is as easy as converting from binary to octal. Simply

look up each octal digit to obtain the equivalent group of three binary digits.

Octal:	0	1	2	3	4	5	6	7
Binary:	000	001	010	011	100	101	110	111

Octal =	3	4	5	
Binary =	011	100	101	= 011100101 binary

1. OCTAL TO DECIMAL

The conversion can also be performed in the conventional mathematical way, by showing each digit place as an increasing power of 8.

345 octal = $(3 * 8^2) + (4 * 8^1) + (5 * 8^0) = (3 * 64) + (4 * 8) + (5 * 1) = 229$

Octal Digits	Operation	Decimal Result	Operation	Decimal Result
345	+3	3	× 8	24
45	+4	28	× 8	224
5	+5	229	done.	

1. HEXADECIMAL TO BINARY

Converting from hexadecimal to binary is as easy as converting from binary to hexadecimal. Simply look up each hexadecimal digit to obtain the equivalent group of four binary digits.

Hexadecimal:	0	1	2	3	4	5	6	7
Binary:	0000	0001	0010	0011	0100	0101	0110	0111
Hexadecimal:	8	9	A	B	C	D	E	F
Binary:	1000	1001	1010	1011	1100	1101	1110	1111

Hexadecimal =	A	2	D	E	
Binary =	1010	0010	1101	1110	= 1010001011011110 binary

Binary Addition

It is a key for binary subtraction, multiplication, division. There are four rules of binary addition.

Case	A + B	Sum	Carry
1	0 + 0	0	0
2	0 + 1	1	0
3	1 + 0	1	0
4	1 + 1	0	1

In fourth case, a binary addition is creating a sum of (1 + 1 = 10) i.e. 0 is written in the given column and a carry of 1 over to the next column.

Example – Addition

0011010 + 001100 = 00100110

```
  1 1          carry
  0 0 1 1 0 1 0  = 26₁₀
+ 0 0 0 1 1 0 0  = 12₁₀
-----------------
  0 1 0 0 1 1 0  = 38₁₀
```

Rules of Binary Multiplication

- 0 x 0 = 0
- 0 x 1 = 0
- 1 x 0 = 0
- 1 x 1 = 1, and no carry or borrow bits

For example,

00101001 × 00000110 = 11110110

	0	0	1	0	1	0	0	1	= $41_{(base\ 10)}$
×	0	0	0	0	0	1	1	0	= $6_{(base\ 10)}$
	0	0	0	0	0	0	0	0	
	0	0	1	0	1	0	0	1	
0	0	1	0	1	0	0	1		
0	0	1	1	1	1	0	1	1	0 = $246_{(base\ 10)}$

Binary Division

Binary division is the repeated process of subtraction, just as in decimal division.

101010 / 000110 = 000111

```
          1 1 1      = 7₁₀
      ┌──────────
000110 ) 1 0 1 0 1 0  = 42₁₀
       - 1 1 0        = 6₁₀
       ─────
         1 0 0 1
       - 1 1 0
       ─────────
           1 1 0
         - 1 1 0
         ───────
               0
```