Number Systems

What is a number system?

It is a system of representing numbers using numbers or other symbols in a consistent manner.

Types of number system

- Binary number system (base 2)
- Octal number system (base 8)
- Decimal number system(base 10)
- Hexadecimal number system(base 16)

In this class, we will discuss the binary, decimal and hexadecimal number systems

Decimal Number System

The decimal number system uses ten digits: 0,1,2,3,4,5,6,7,8 and 9 with the base number as 10. The decimal number system is the system that we generally use to represent numbers in real life.

Examples of decimal numbers

- 723
- 21
- 4570

Binary Number System

The binary number system uses only two digits: 0 and 1.

Digits 0 and 1 are called bits

The numbers in this system have a base of 2

Examples of binary numbers:

- $(1010)_2$
- $(1111)_2$
- $(0000)_2$

Hexadecimal Number System

In the hexadecimal number system, there are sixteen digits/alphabets: 0,1,2,3,4,5,6,7,8, 9 and A,B,C,D, E, F with the base number of 16. The numbers A-F of the hexadecimal system correspond to the decimal numbers 10-15.

Examples of Hexadecimals:

- $(F73_{16}$
- $5F_{16}$
- $4B3A_{16}$

Number System Conversions

We can be able to convert a number from one system to another, for example a binary number to hexadecimal

Converting Decimals to Binaries

How to convert decimal to binary?

Conversion steps:

1. Divide the number by 2.
2. Get the integer quotient for the next iteration.
3. Get the remainder for the binary digit.
4. Repeat the steps until the quotient is equal to 0.

Example 1

Convert 12_{10} into a binary number

Division by 2	Quotient	Remainder
12 / 2	6	0
6 / 2	3	0
3 / 2	1	1
1/2	0	1

So $12_{10} = 1100_2$

Example 1

Convert 13_{10} into a binary number

Division by 2	Quotient	Remainder
13 / 2	6	1
6 / 2	3	0
3 / 2	1	1
1/2	0	1

So $13_{10} = 1101_2$

Example 1

Convert 10 (base 10) into a binary number

Division by 2	Quotient	Remainder
10 / 2	5	0
5 / 2	2	1
2 / 2	1	0
1/2	0	1

So 10 (base 10) = 1010 (base 2)

Activity

Convert the following numbers into binary numbers

1. 32_{10}
2. 500_{10}
3. 200_{10}
4. 69_{10}

Converting Binaries to Decimals

How to convert binary to decimal

For binary number with n digits:

dn-1 ... d3 d2 d1 d0

The decimal number is equal to the sum of binary digits (dn) times their power of 2 (2n):

decimal = d0×20 + d1×21 + d2×22 + ...

Example 1

Convert $(1101)_2$ base to a decimal number?

Binary number	1	1	0	1
Power of 2	2^3	2^2	2^1	2^0

$(1101)_2 = 1 * 2^3 + 1 * 2^2 + 0 * 2^1 + 1 * 2^0$

$= 1 * 8 + 1 * 4 + 0 * 2 + 1 * 1$

$= 8 + 4 + 0 + 1$

$= 13_{10}$

Converting Binaries to HexaDecimals

How to convert binary to hex?

Convert every 4 binary digits (start from bit 0) to 1 hex digit, with this table:

Binary	Hex
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C

Example 1

Convert binary 1101100_2 to hex:

Convert every 4 binary bits (from bit0) to hex digit:

$110\boldsymbol{1100}_2 = 0110\ \boldsymbol{1100} = 6\ \boldsymbol{C} = 6C_{16}$

Example 1

Convert binary 10001110_2 to hex:

Convert every 4 binary bits (from bit0) to hex digit:

$1000\boldsymbol{1110}_2 = 1000\ \boldsymbol{1110} = 8\ \boldsymbol{E} = 6E_{16}$

Converting HexaDecimals to Binaries

For hex number with n digits:

$d_{n-1} \ldots d_3\ d_2\ d_1\ d_0$

Multiply each digit of the hex number with its corresponding power of 16 and sum:

$\text{decimal} = d_{n-1} \times 16^{n-1} + \ldots + d_3 \times 16^3 + d_2 \times 16^2 + d_1 \times 16^1 + d_0 \times 16^0$

Example

Convert $2B_{16}$ to base 10

$$3B_{16} = 3\times16^1+11\times16^0 = 48+11 = 59_{10}$$