NUMBER SYSTEMS – SS1

Meaning of a Number System

A **number system** is a method of representing and writing numbers using a particular set of symbols or digits. Computers use the **binary number system** to process and represent information. The four common number systems studied in computer science are:

1. **Binary** 2. **Decimal** 3. **Octal** 4. **Hexadecimal**

Types of Number Systems

Number System	Base	Digits Used
Binary	2	0, 1
Decimal	10	0 – 9
Octal	8	0 – 7
Hexadecimal	16	0 – 9 and A – F

Binary Number System

The **binary number system** has a base of **2**. It uses only two digits: **0 and 1**

Examples of binary numbers

- 101 1101 10010 111001

A binary digit is called a **bit**. For example: $\mathbf{1011_2}$ The small $_2$ indicates that the number is in base 2.

Place values in binary: Starting from the right:

$\mathbf{2^3}$	$\mathbf{2^2}$	$\mathbf{2^1}$	$\mathbf{2^0}$
8	4	2	1

Therefore: $\mathbf{1011_2}$
$= (1 \times 8) + (0 \times 4) + (1 \times 2) + (1 \times 1)$
$= 8 + 0 + 2 + 1$
$= \mathbf{11_{10}}$

Decimal Number System

The **decimal number system** has a base of **10**. It uses ten digits: **0, 1, 2, 3, 4, 5, 6, 7, 8 and 9**
It is the number system we use in our everyday calculations.

Decimal place values: For example: **4,325**

Octal Number System: The **octal number system** has a base of **8**. It uses eight digits:
0, 1, 2, 3, 4, 5, 6 and 7 The digits **8 and 9 are not used** in octal.

Examples: 17_8 25_8 103_8 745_8

Hexadecimal Number System

The **hexadecimal number system** has a base of **16**. It uses 16 symbols: **0–9 and A–F**
The letters represent values as follows:

Examples: $2A_{16}$ $3F_{16}$ $A5_{16}$ FF_{16}

Conversion Between Number Systems

Number conversion means changing a number from one number system to another **without changing its actual value**.

Binary to Decimal Conversion

To convert binary to decimal: **Step 1** :Write the powers of 2 under the binary digits.
Step 2: Multiply each binary digit by its place value. **Step 3:** Add the results.

Example: Convert $\mathbf{10110_2}$ to decimal(base 10).

Digit 1 0 1 1 0

$= 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$
$= (1 \times 16) + (0 \times 8) + (1 \times 4) + (1 \times 2) + (0 \times 1)$
$= 16 + 0 + 4 + 2 + 0 = \mathbf{22_{10}}$
Therefore: $\mathbf{10110_2 = 22_{10}}$

Decimal to Binary Conversion

To convert decimal to binary, repeatedly **divide the decimal number by 2** and record the remainders.

Example: Convert 25_{10} to binary (base 2)

Division	Quotient	Remainder
25 ÷ 2	12	1
12 ÷ 2	6	0
6 ÷ 2	3	0
3 ÷ 2	1	1
1 ÷ 2	0	1

Read the remainders **from bottom to top**: $\mathbf{11001_2}$ Therefore: $\mathbf{25_{10} = 11001_2}$

Decimal to Octal Conversion: Divide the decimal number repeatedly by **8**.

Example: Convert 83_{10} to octal.

Division	Quotient	Remainder
83 ÷ 8	10	3
10 ÷ 8	1	2
1 ÷ 8	0	1

Read from bottom to top: $\mathbf{123_8}$ Therefore: $\mathbf{83_{10} = 123_8}$

Octal to Decimal Conversion: Multiply each digit by the appropriate power of 8 and add.

Example: Convert 157_8 to decimal.

157_8

$= (1 \times 8^2) + (5 \times 8^1) + (7 \times 8^0)$

$= (1 \times 64) + (5 \times 8) + (7 \times 1)$

$= 64 + 40 + 7$

$= \mathbf{111_{10}}$ Therefore: $\mathbf{157_8 = 111_{10}}$

Decimal to Hexadecimal Conversion

Divide repeatedly by **16**. **Example: Convert 254_{10} to hexadecimal.**

Division	Quotient	Remainder
254 ÷ 16	15	14
15 ÷ 16	0	15

Remember:

- 14 = **E**
- 15 = **F**

Read from bottom to top: $\mathbf{FE_{16}}$ Therefore: $\mathbf{254_{10} = FE_{16}}$
