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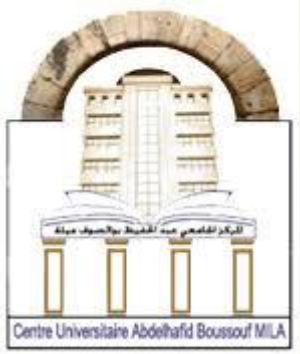

Structure of Computers and Applications
1st year ST – ENGINEERING

Part 1: Introduction to Computer Science

Course 02: Computer Coding System

Data Representation

By

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Academic year : 2024/2025

3- Computer Coding System

Itroduction

- Computer processes different nature of Information (number, text, image, sound, video, …etc.)
- This information is always represented in a binary form (sequence of two digits 0 and 1) such as: 01001011, 11000011…..etc,
- The two digits (0 and 1) are referred to as **bit** (**bi**nary digi**t**).
- **Binary States:** In electronic systems, a bit is represented by two distinct electrical states:
  - **1 (High State):** Often represented by the presence of an electrical pulse or a high voltage level.
  - **0 (Low State):** Represented by the absence of an electrical pulse or a low voltage level.
- The process that allows to move from the initial representation of information (number, text, etc.) to a binary representation is called **information coding**.

3- Computer Coding System

Itroduction

- Information coding goes through the following stages:

1. Representation of Information by a Sequence of Numbers:

Data Conversion: Initially, information (text, images, audio…) is converted into a numerical format. This is a crucial step because computers operate using numeric data.

2. Encoding Each Number in Binary Form:

Binary Conversion: Once the information is represented numerically, each number is then encoded into binary format. Binary encoding is the process of converting decimal numbers (or other numeric bases) into binary, which is the fundamental language of computers.

- A number can be represented by different symbols depending on the used **number system**

3- Computer Coding System

What is Number System?

- A **number system** is indeed a system of writing used to express numbers, involving a **set of symbols** and **rules** to represent numerical values.
- The total number of symbols that are used in a number system is called the **base** of the number system.
- In the context of computers, the different number systems are used depending on the **context** and **application**.
- There are mainly **four types** of the number system in computer:

a. **Decimal Number System (Base-10)**

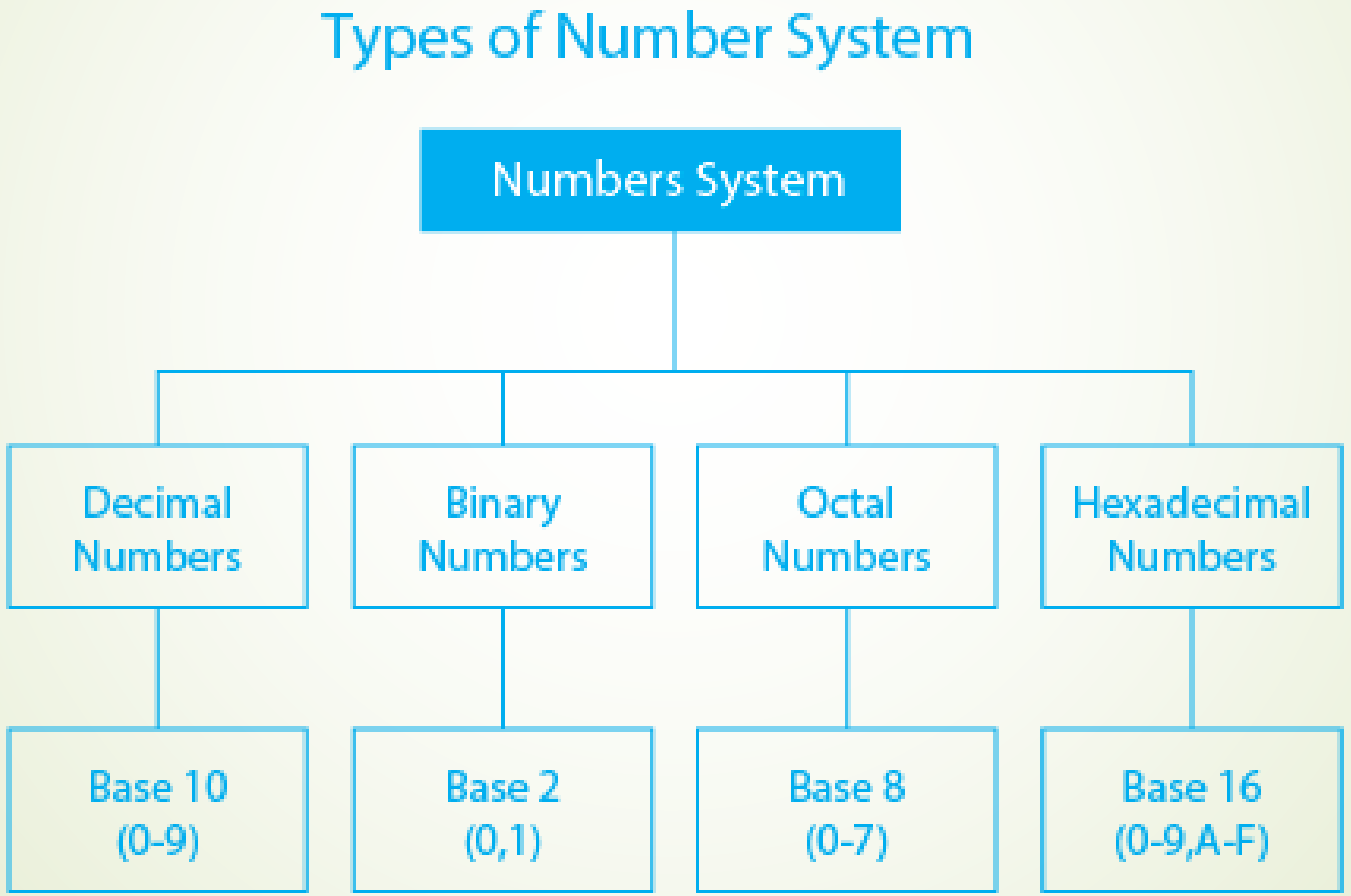
b. **Binary Number System (Base-2)**

c. **Octal Number System (Base-8)**

d. **Hexadecimal Number System (Base-16)**

3- Computer Coding System

What is Number System?



3- Computer Coding System

a. Decimal Number System:

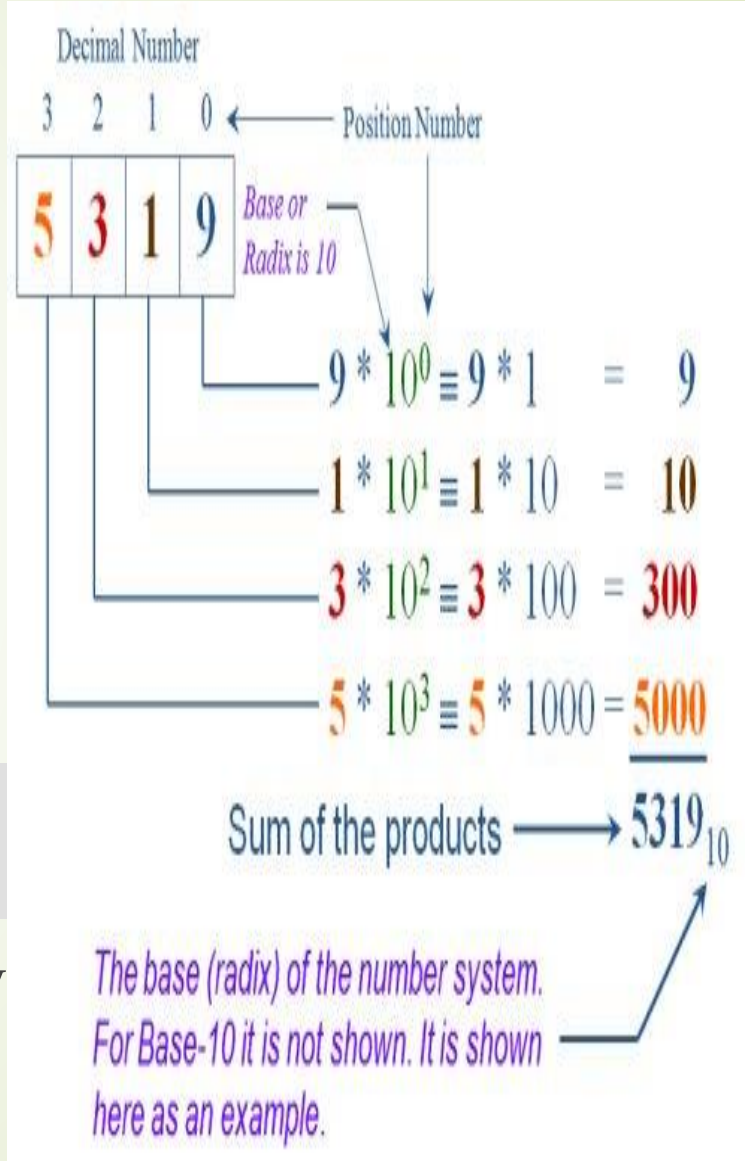
- Decimal number system has only ten (10) digits {0,1,2,3,4,5,6,7,8,9} ➡ **base 10**
- In this number system, every number (value) **represents** with unique symbols {0,1,2,3,4,5,6,7,8,9}.
- It is the weighted (**positional**) number representation,

where value of each digit is determined by its position in a number.

For example:

$$(5319)_{10} = (9 + 10 + 300 + 5000)_{10}$$
$$= (9\times10^0 + 1\times10^1 + 3\times10^2 + 5\times10^3)_{10}$$

- **Advantages:** easy readability, used by humans, and easy to manipulate.
- **Disadvantages:** wastage of space and time.



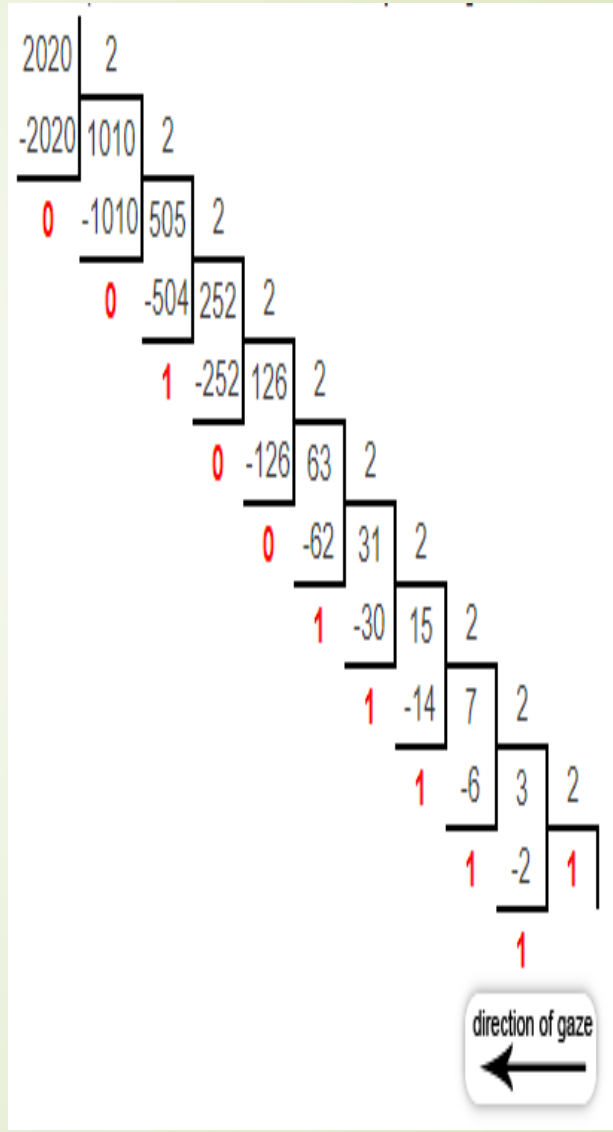
3- Computer Coding System

❑ b. Binary Number System

- Binary number system has only two symbols (**digits**) that are **0 and 1** ⟹ **base 2**.
- In this number system, every number (value) represents with {**0**,**1**}.
- Each digit in the binary number system is called a "**bit**".

For example:

$$(2020)_{10} = (2^{10}x1+2^{9}x1+2^{8}x1+2^{7}x1+2^{6}x1+2^{5}x1+2^{4}x0+2^{3}x0 +2^{2}x1+2^{1}x0+2^{0}x0)_{10} = (11111100100)_{2}$$



❑ Decimal vs Binary

Here are some equivalent values:

Decimal:	0	1	2	3	4	5	6	7	8	9	10	11	12
Binary:	0	1	10	11	100	101	110	111	1000	1001	1010	1011	1100

3- Computer Coding System

c. Octal Number System

- Octal number system has only 8 symbols (digits) **{**0,1,2,3,4,5,6,7**}** ➡ **base 8**.
- In this number system, every number (value) represents with 0,1,2,3,4,5,6,7.

For example: $123_8 = 1 \times 8^2 + 2 \times 8^1 + 3 \times 8^0 \Rightarrow 123_8 = 1 \times 64 + 2 \times 8 + 3 \times 1 = 83_{10}$

Hence 83_{10} is decimal representation of 123_8.

d. Hexadecimal Number System

- A Hexadecimal number system has sixteen (16) alphanumeric values from **0 to 9** and **A to F** ➡ **base 16**.
- In this number system, every number (value) represents with {0,…,9,A,B, C,D,E,F}.

For example: $(A7B)_{16} = A \times 16^2 + 7 \times 16^1 + B \times 16^0 \Rightarrow \quad 2560 + 112 + 11 = 2683$

Remark: (convert symbols A and B to their decimal equivalents; A = 10, B = 11)

Therefore, the decimal equivalent of $(A7B)_{16}$ is $(2683)_{10}$.

3- Computer Coding System

❑ Number System Conversion

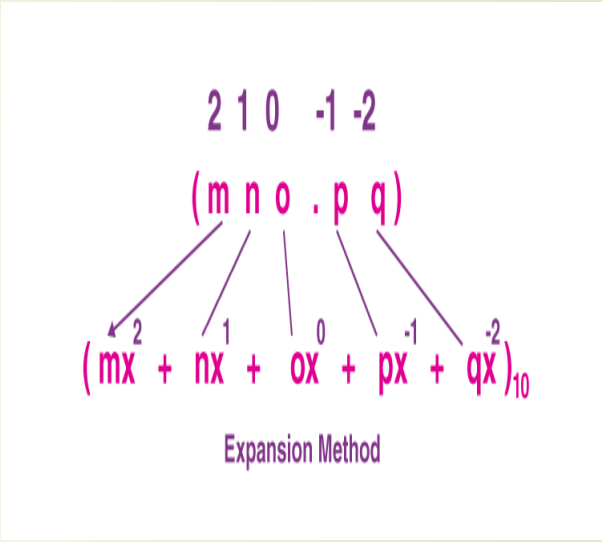
- **Conversion from base 'b' to base 10**

➢ Use polynomial representation (**expansion method**)

$$X = (a_{n..}a_2a_1a_0)_b = b^0a_0 + b^1a_{1+...}b^na_n = (\sum a_i b^i)_{10}$$

➢ If we have a number mno.pq in base x, its value in **base 10** can be represented as follows:

$$(mno.pq)_x = (mx^2 + nx^1 + ox^0 + px^{-1} + qx^{-2})_{10}$$



For example:

Convert the number $(11001)_2$ to base 10

Answer:

$$(11001)_2 = (1 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0)_{10}$$

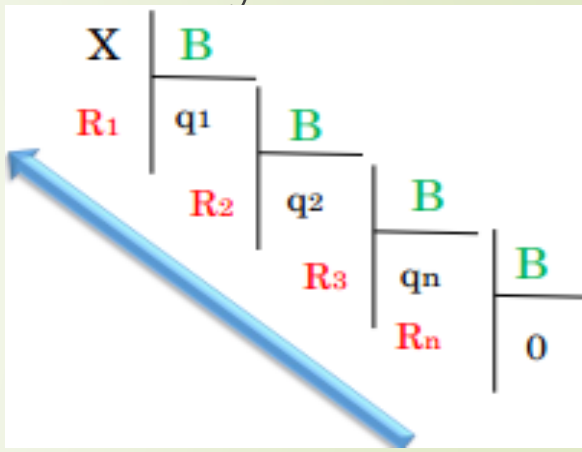
$$= (16 + 8 + 0 + 0 + 1)_{10} = (25)_{10}$$

3- Computer Coding System

Number System Conversion

- **Conversion from base 10 to another base B**

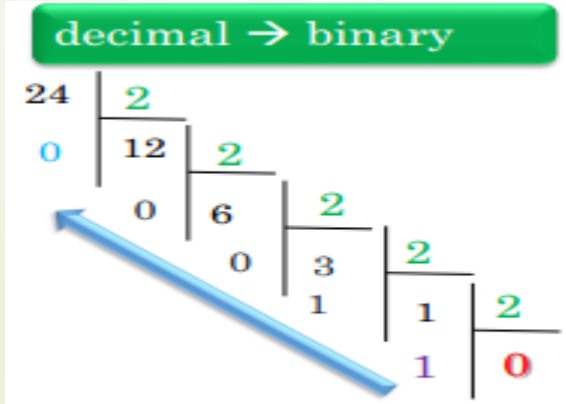
The decimal number **"X"** can be converted to a number on base **"B"** by:



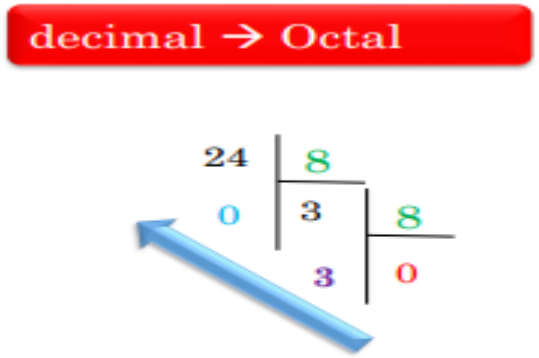
- ✓ Repeatedly dividing **inputNum** by base **B**
- ✓ Store the remainder
- ✓ Finally, reverse the obtained string to get the desired result.

Therefore, $(X)_{10}=(R_n..R_3R_2R_1)_B$

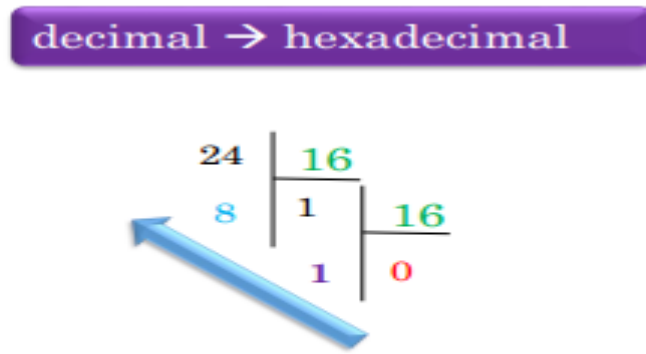
Examples:



$(24)_{10}= (11000)_2$



$(24)_{10}= (30)_8$



$(24)_{10}= (18)_{16}$

4_ Data Representation

What are three popular coding systems to represent data ?

- **ASCII**—American Standard Code for Information Interchange
- **EBCDIC**—Extended Binary Coded Decimal Interchange Code
- **Unicode**—coding scheme capable of representing all world's languages

4_ Data Representation

❑ Examples of coding system

DATA	CODING SYSTEM		
	ASCII	EBCDIC	UNICODE
1	0000001	00000001	0000000000000001
4	0000100	00000100	0000000000000100
9	0001001	00001001	0000000000001001
13	0001101	00001101	0000000000001101