ISO 9001:2008
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Computer Systems: Organization and Architecture

Introduction to Computing

AY 2024-2035

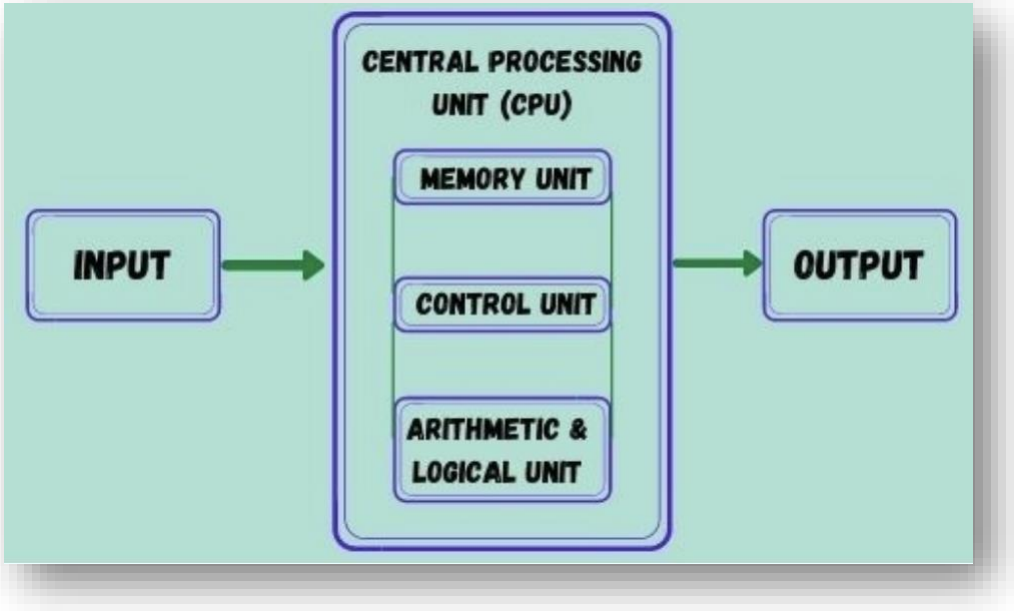
Topics

- Basic components of a computer system
- CPU, memory, and storage devices
- Input and output devices
- Number Systems

Components of a computer system

A computer device is made up of various elements which help in its effective functioning and processing. There are **five** basic components of the computer which help in making this processing of data easier and convenient:

- Input Unit
- Output Unit
- Memory Unit
- Control Unit
- Arithmetical and Logical Unit



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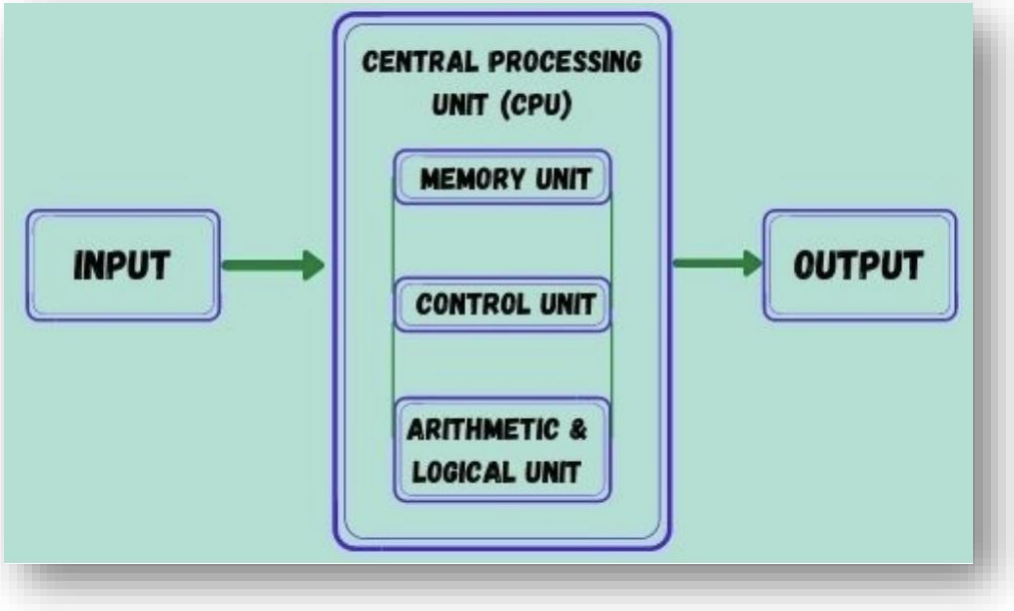
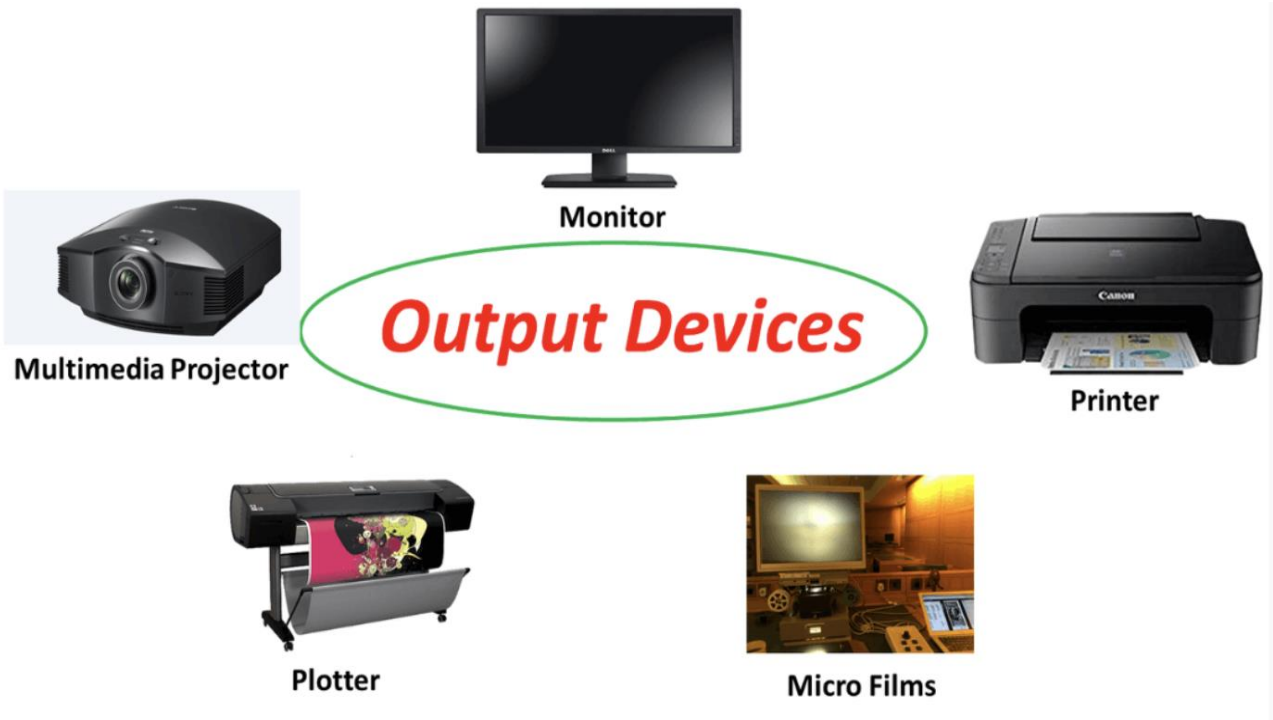


Input unit

A computer will only respond when a command is given to the device. These commands can be given using the input unit or the input devices.

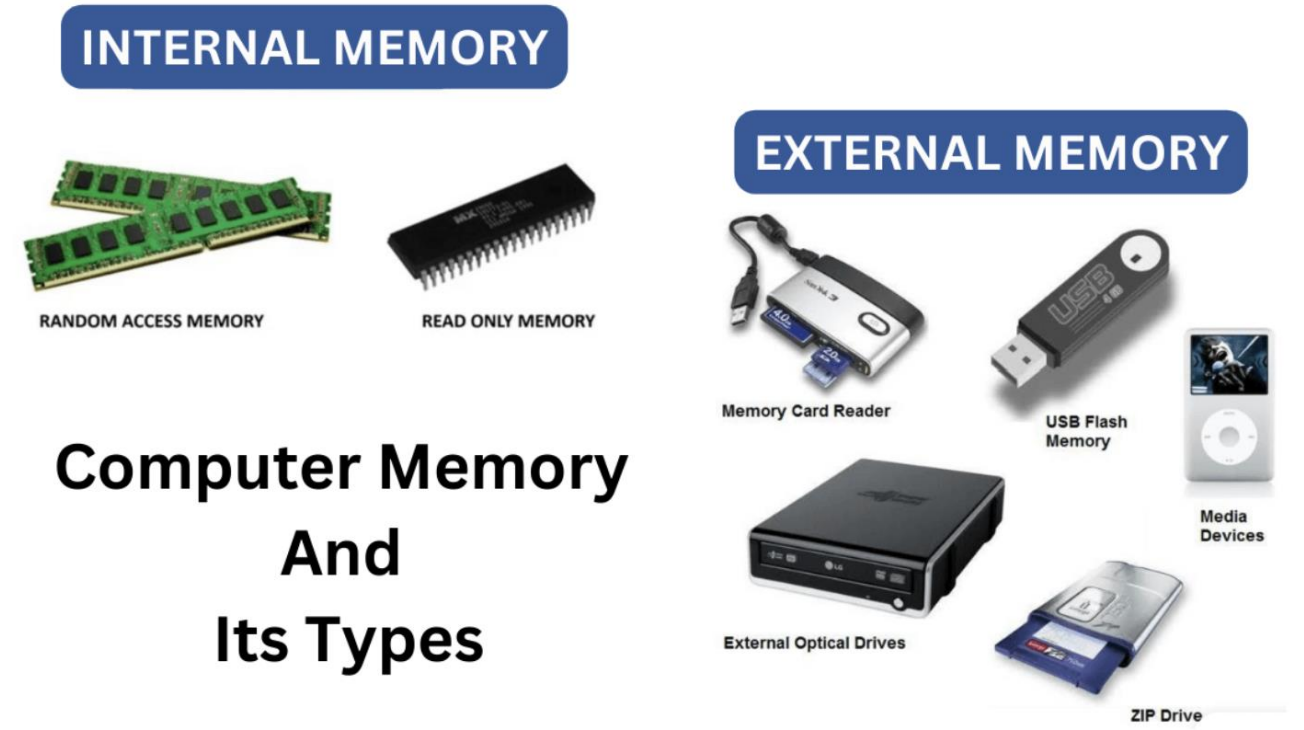
Output unit

When we command a computer to perform a task, it reverts for the action performed and gives us a result. This result is called output. There are various output devices connected to the computer.



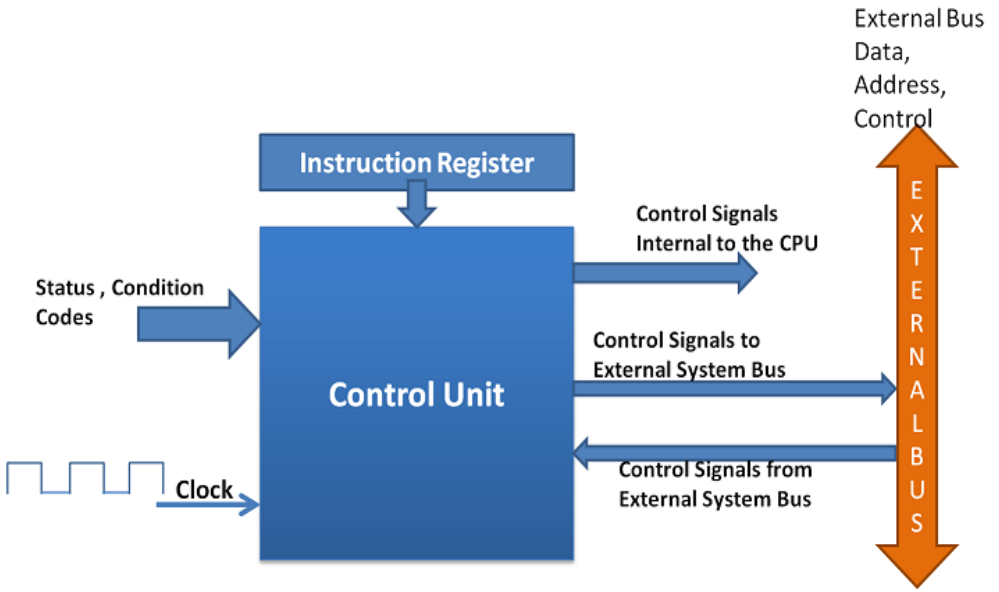
Memory unit

When we enter the data into the computer using an input device, the entered information immediately gets saved in the memory unit of the Central Processing Unit (CPU)



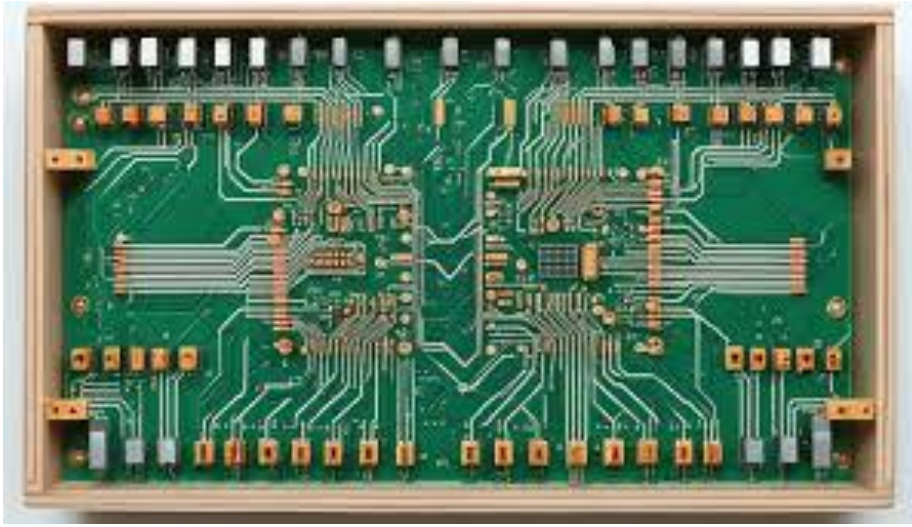
Control Unit

- This is the core unit which manages the entire functioning of the computer device. It is one of the most essential components of the computer system.
- It collects the data entered using the input unit, leads it on for processing and once that is done, receives the output and presents it to the user.
- It can be said to the center of all processing actions taking place inside a computer device.



Arithmetic and Logical unit

- All the mathematical calculations or arithmetic operations are performed in the Arithmetic and Logical Unit of the CPU.
- It can also perform actions like a comparison of data and decision-making actions.
- The ALU comprises circuits using which addition, subtraction, multiplication, division and other numerical based calculations can be performed.



Number Systems

- The number system or the numeral system is the system of naming or representing numbers.
- A number system is defined as a system of writing to express numbers. It is the mathematical notation for representing numbers of a given set by using digits or other symbols in a consistent manner.
- The value of any digit in a number can be determined by:
  - The digit
  - Its position in the number
  - The base of the number system

Number Systems

- Types:
  - Decimal number system (Base- 10)
  - Binary number system (Base- 2)
  - Octal number system (Base-8)
  - Hexadecimal number system (Base- 16)

Decimal System	Binary System	Octal System	Hexadecimal System
0	00000000	000	0
1	00000001	001	1
2	00000010	002	2
3	00000011	003	3
4	00000100	004	4
5	00000101	005	5
6	00000110	006	6
7	00000111	007	7
8	00001000	010	8
9	00001001	011	9
10	00001010	012	A
11	00001011	013	B
12	00001100	014	C
13	00001101	015	D
14	00001110	016	E
15	00001111	017	F

Decimal Number System

- In this number system, the digits 0 to 9 represents numbers.
- As it uses 10 digits to represent a number, it is also called the **base 10** number system. Each digit has a value based on its position called **place value**. The value of the position increases by 10 times as we move from right to left in the number.

For example, the value of 786 is

$= 7 \times 10^2 + 8 \times 10^1 + 6 \times 10^0$

$= 700 + 80 + 6$

Decimal Number System: Uses

- **Everyday arithmetic**: Decimal is the standard number system used for day-to-day counting, financial transactions, and any general-purpose calculation.
- **Science and engineering**: Decimal numbers are used in scientific measurements, formulas, and engineering calculations where high precision and human understanding are essential.
- **Commerce and banking**: Decimal is universally used in financial systems, accounting, and commerce, where precise monetary calculations are necessary.
- **Measurement systems**: Most systems of measurement (metric, imperial) use decimal-based units for length, weight, volume, and time.

Binary Number System

- A computer can understand only the “on” and “off” state of a switch. These two states are represented by **1** and **0**. These numbers represent various data. As two digits are used to represent numbers, it is called a binary or **base 2** number system.

  For example, $(101101)_2$ in decimal is

  $= 1 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$

  $= 1 \times 32 + 0 \times 16 + 1 \times 8 + 1 \times 4 + 0 \times 2 + 1 \times 1$

  $= 32 + 8 + 4 + 1$

  $= (45)_{10}$

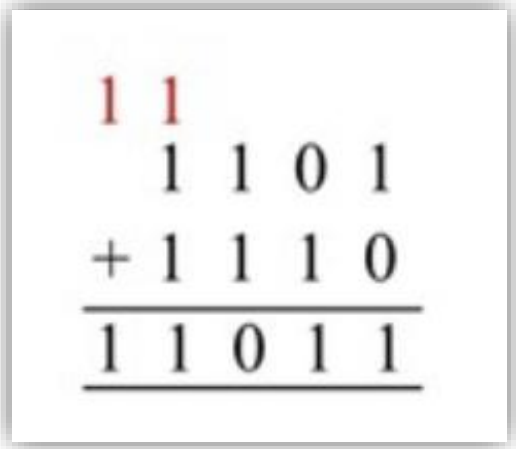
Binary Number System: Uses

- **Computing**: Computers operate on binary logic, where electrical signals represent these two states (on/off or true/false).
- **Networking**: Binary is used in IP addressing (in the conversion of addresses) and subnetting.
- **Data storage**: All forms of digital storage—files, programs, and multimedia—are stored in binary. Even complex applications like AI algorithms or cloud computing depend on binary for low-level data processing.
- **Programming**: Binary values are used for machine-level programming, including defining flags, masks, and manipulating individual bits.

Binary Arithmetic

Binary arithmetic is one of the fundamental concepts in the field of digital electronics and computer engineering and forms the foundation of the digital computing.

- Binary Addition
  - 0+0=0
  - 0+1=1
  - 1+0=1
  - 1+1=10(Sum=0&Carry=1)



Binary Arithmetic

- Binary Subtraction
  - 0–0=0
  - 1–0=1
  - 1–1=0
  - 0–1=1 (borrow 1 from the next higher bit)

$$\begin{array}{r} 1\ 1\ 0\ 1 \\ -\ 1\ 1\ 0\ 0 \\ \hline 0\ 0\ 0\ 1 \end{array}$$

$$\begin{array}{r} 1\ 1\ 1\ 1 \\ -\ \ 1\ 0\ 1 \\ \hline 1\ 0\ 1\ 0 \end{array}$$

$$\begin{array}{r} \ \ 0\ 10 \\ 1\ \cancel{1}\ \cancel{0}\ 1 \\ -1\ 0\ 1\ 1 \\ \hline 0\ 0\ 1\ 0 \end{array}$$

Binary Arithmetic

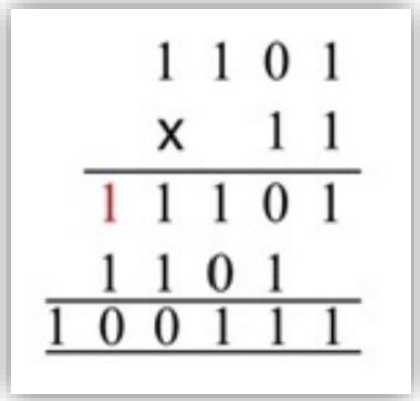
- Binary Multiplication

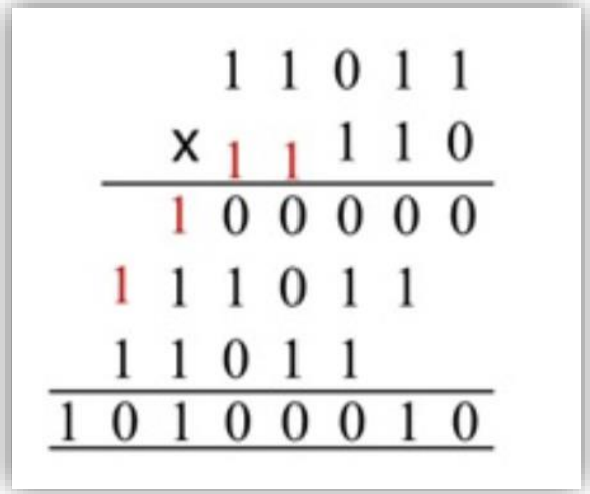
$$0 \times 0 = 0$$

$$0 \times 1 = 0$$

$$1 \times 0 = 0$$

$$1 \times 1 = 1$$





Binary Arithmetic

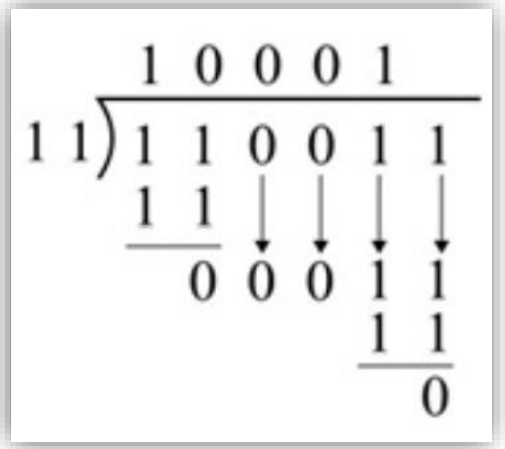
- Binary Division

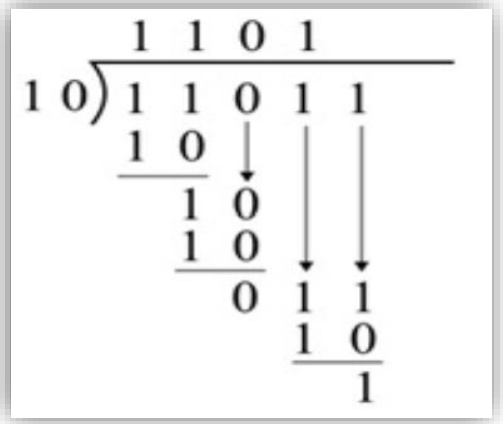
$$0 \div 0 = \text{Undefined}$$

$$0 \div 1 = 0 \text{ with Remainder} = 0$$

$$1 \div 0 = \text{Undefined}$$

$$1 \div 1 = 1 \text{ with Remainder} = 0$$





Octal Number System

- This system uses digits **0 to 7** (i.e. 8 digits) to represent a number and the numbers are as a **base of 8**.

  For example, $(24)_8$ in decimal is

  $= 2\times8^1+4\times8^0$

  $= (20)_{10}$
- Uses
  - **Early computing**: Before hexadecimal became dominant, octal was used in early computer systems (e.g., mainframes) because it was a compact way to represent binary data

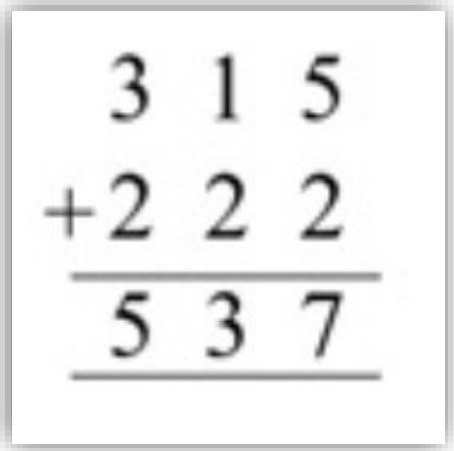
Octal Number System

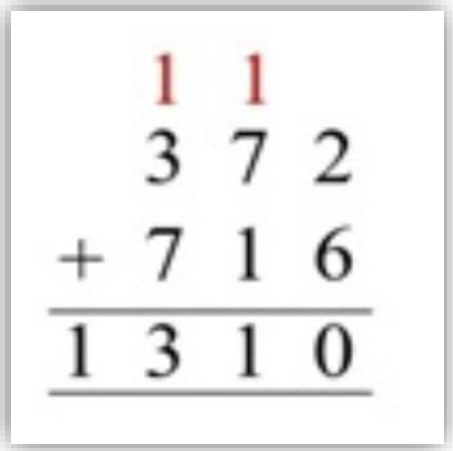
- **Permissions in Unix/Linux systems**: Octal numbers are still used in Unix and Linux systems to represent file permissions. For example, chmod 755 is a command to change file permissions, where the octal values represent different permission levels (read, write, execute).
- **Digital electronics**: In some older digital systems, octal notation is used to represent addresses and data.

Octal Arithmetic

Octal Addition

- Same as decimal addition, but, a carry is generated to pass over to the next column when the sum is equal to or greater than 8.

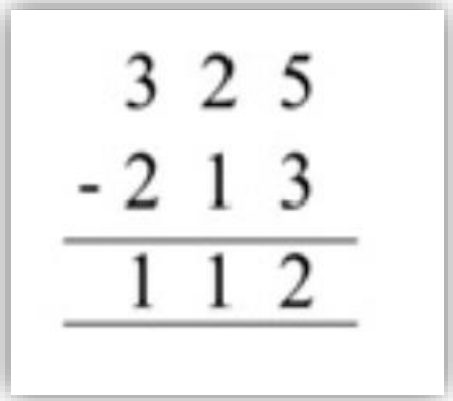


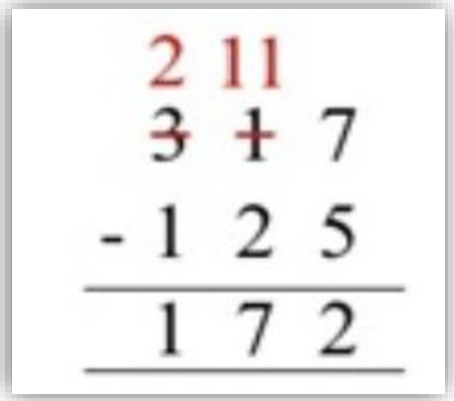


Octal Arithmetic

Octal Subtraction

- Let an octal subtraction as (x)8 - (y)8, if the digit x is smaller than the digit y, a borrow 1 from the next higher order position is taken to perform the octal subtraction.

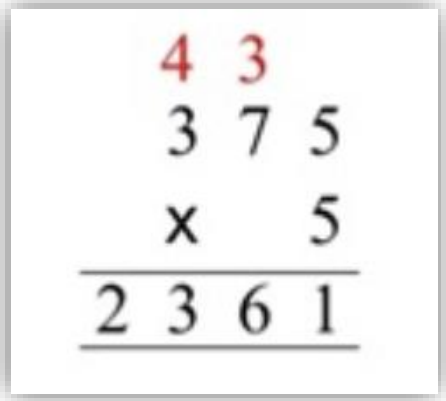


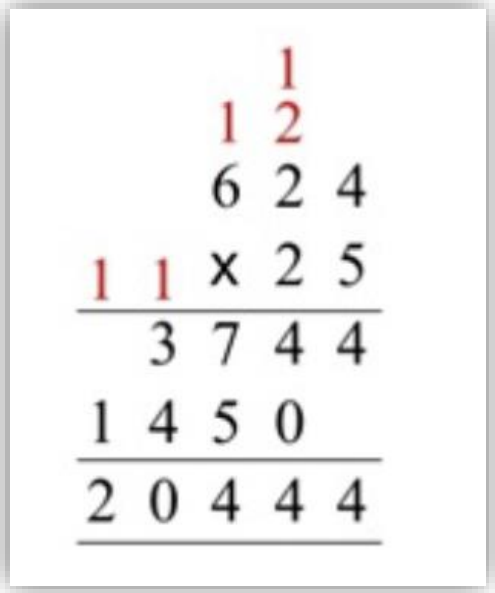


Octal Arithmetic

Octal Multiplication

- multiply each digit of one octal number by each digit of another octal number. The final result is obtained by summing up all the partial products of the multiplication.





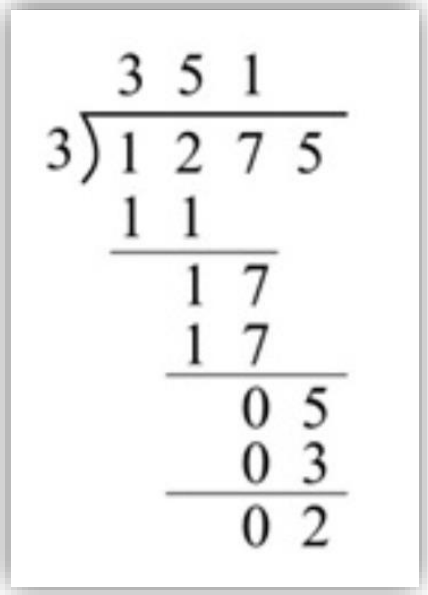
Octal Arithmetic

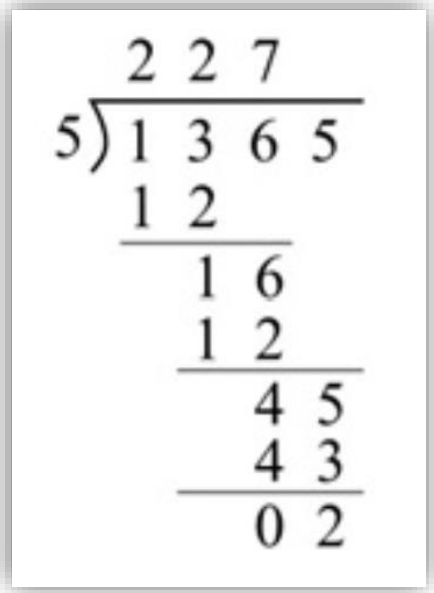
Octal Division

1 − Start by dividing the leftmost digits of the dividend by the divisor.

2 − Multiply the quotient obtained by the divisor and subtract the product from the dividend.

3 − Bring down the next octal digits of the dividend and repeat the above two steps until all the digits in the dividend are used.





Hexadecimal Number System

- In this system, **16** digits used to represent a given number. Thus it is also known as the **base 16** number system. Each digit position represents a power of 16. As the base is greater than 10, the number system is supplemented by letters. Following are the hexadecimal symbols: **0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F**
- To take A, B, C, D, E, and F as part of the number system is conventional and has no logical or deductive reason.

Hexadecimal Number System: Use

- **Memory addresses**: Hexadecimal is used to represent memory addresses in programming, debugging, and computer hardware design. It is more compact than binary and easier for humans to read.
- **Color codes in web development**: Hexadecimal values are used to represent colors in web design (e.g., #FF5733 for a shade of orange). Each pair of digits represents red, green, and blue values.
- **Assembly language and machine code**: Hexadecimal is used to represent machine code in a human-readable form, making it easier for programmers to understand and debug low-level code.

Hexadecimal Number System: Use

- **Data encryption and hash codes**: In cryptography, hash values (like MD5, SHA) are often displayed in hexadecimal format, making large binary values easier to handle and interpret.
- **Networking**: MAC addresses and IPv6 addresses in networking are often represented in hexadecimal notation for compactness and readability.