Number System

Number systems are systems in mathematics that are used to express numbers in various forms and are understood by computers.

Number system is a method of representing numbers on the number line with the help of a set of Symbols and rules. These symbols range from 0–9 and are termed as digits. Let's learn about the number system in detail, including its types, and conversion.

Types of Number Systems

Based on the base value and the number of allowed digits, number systems are of many types. The four common types of Number System are:

1. **Decimal Number System**

Number system with base value 10 is termed as Decimal number system. This is also known as base10 number system which has 10 symbols, these are: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. For example, 28_{10}, 45_{10}, 23_{10}, etc.

2. **Binary Number system**

Number System with base value 2 is termed as Binary number system. It uses 2 digits i.e. 0 and 1 for the creation of numbers. The numbers formed using these two digits are termed as Binary Numbers. For example, 1110001, 11010, 11010101, etc.

3. **Octal number system**

Number system with base 8 is termed as octal number system and it uses eight symbols (or digits) namely 0, 1, 2, 3, 4, 5, 6, and 7. For example, 22_8, 13_8, 17_8, etc. are octal numbers.

4. **Hexadecimal number system**

Number System with base value 16 is termed as Hexadecimal Number System. It uses 16 digits for the creation of its numbers. Digits from 0–9 are taken like the

digits in the decimal number system but the digits from 10–15 are represented as A–F i.e. 10 is represented as A, 11 as B, 12 as C, 13 as D, 14 as E, and 15 as F. Hexadecimal Numbers are useful for handling memory address locations.

- **Conversion from Decimal to Other Number Systems**

Decimal Numbers are represented with digits 0–9 and with base 10. Conversion of a number system means conversion from one base to another. Following is the conversion of the Decimal Number System to other Number Systems:

Decimal to Binary Conversion

Decimal numbers are represented in base 10, but the binary numbers are of base 2. Hence, to convert a decimal number to binary number, the base of that number is to be changed. Follow the steps given below:

- **Step 1:** Divide the Decimal Number with the base of the number system to be converted to. Here the conversion is to binary, hence the divisor will be 2.

- **Step 2:** The remainder obtained from the division will become the least significant digit of the new number.

- **Step 3:** The quotient obtained from the division will become the next dividend and will be divided by base i.e. 2.

- **Step 4:** The remainder obtained will become the second least significant digit i.e. it will be added in the left of the previously obtained digit.

Now, the steps 3 and 4 are repeated until the quotient obtained becomes 0, and the remainders obtained after each iteration are added to the left of the existing digits.

After all the iterations are over, the last obtained remainder will be termed as the Most Significant digit.

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Decimal to Octal Conversion

Decimal to Binary Conversion

$$(243)_{10} \longrightarrow (?)_2$$

```
2 | 243    1
2 | 121    1
2 | 60     0
2 | 30     0
2 | 15     1
2 | 7      1
2 | 3      1
    | 1
```

$$\longrightarrow (11110011)_2$$

Octal Numbers are represented in base 8. Hence, to convert a decimal number to octal number, the base of that number is to be changed. Follow the steps given below:

- **Step 1:** Divide the Decimal Number with the base of the number system to be converted to. Here the conversion is to octal, hence the divisor will be 8.

- **Step 2:** The remainder obtained from the division will become the least significant digit of the new number.

- **Step 3:** The quotient obtained from the division will become the next dividend and will be divided by base i.e. 8.

- **Step 4:** The remainder obtained will become the second least significant digit i.e. it will be added in the left of the previously obtained digit.

Now, the steps 3 and 4 are repeated until the quotient obtained becomes 0, and the remainders obtained after each iteration are added to the left of the existing digits.

Decimal to Hexadecimal Conversion

Hexadecimal Numbers are represented in base 16. Hence, to convert a decimal number to hexadecimal number, the base of that number is to be changed. Follow the steps given below:

- Step 1: Divide the Decimal Number with the base of the number system to be converted to. Here the conversion is to Hex hence the divisor will be 16.

- Step 2: The remainder obtained from the division will become the least significant digit of the new number.

- Step 3: The quotient obtained from the division will become the next dividend and will be divided by base i.e. 16.

- Step 4: The remainder obtained will become the second least significant digit i.e. it will be added in the left of the previously obtained digit.

Now, the steps 3 and 4 are repeated until the quotient obtained becomes 0, and the remainders obtained after each iteration are added to the left of the existing digits.

Decimal to Hexadecimal Conversion

$(243)_{10} \longrightarrow (?)_{16}$

$(153)_{16} \longrightarrow (F3)_{16}$

- **Conversion from Binary to Other Number Systems**

Binary Numbers are represented with digits 0 and 1 and with base 2. Conversion of a number system means conversion from one base to another. Following is the conversion of the Binary Number System to other Number Systems:

Binary to Decimal Conversion

Binary numbers are represented in base 2 but the decimal numbers are of base 10. Hence, to convert the binary number into a decimal number, the base of that number is to be changed. Follow the steps given below:

- **Step 1:** Multiply each digit of the Binary number with the place value of that digit, starting from right to left i.e. from LSB to MSB.

- **Step 2:** Add the result of this multiplication and the decimal number will be formed.

Example: To convert $(11101011)_2$ into a decimal number

Binary to Decimal Conversion

$$(11101011)_2 \longrightarrow (?)_{10}$$

$$1 \times 2^7 + 1 \times 2^6 + 1 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$$
$$128 + 64 + 32 + 0 + 8 + 0 + 2 + 1$$
$$(235)_{10}$$

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Binary to Octal Conversion

Binary numbers are represented in base 2 but the octal numbers are of base 8. Hence, to convert the binary number into octal number, the base of that number is to be changed. Follow the steps given below:

● **Step 1:** Divide the binary number into groups of three digits starting from right to left i.e. from LSB to MSB.

● **Step 2:** Convert these groups into equivalent octal digits.

Binary to Octal Conversion

$$(11101011)_2 \longrightarrow (?)_8$$

011 101 011

↓   ↓   ↓ $\longrightarrow (353)_8$

3   5   3

**Example:** To convert $(11101011)_2$ into an octal number.

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Binary to Hexadecimal Conversion

Binary numbers are represented in base 2 but the Hexadecimal numbers are of base 10. Hence, to convert the binary number into Hex number, the base of that number is to be changed. Follow the steps given below:

- **Step 1:** Divide the binary number into groups of four digits starting from right to left i.e. from LSB to MSB.

- **Step 2:** Convert these groups into equivalent hex digits.

Example: To convert $(1110101101101)_2$ into a hex number
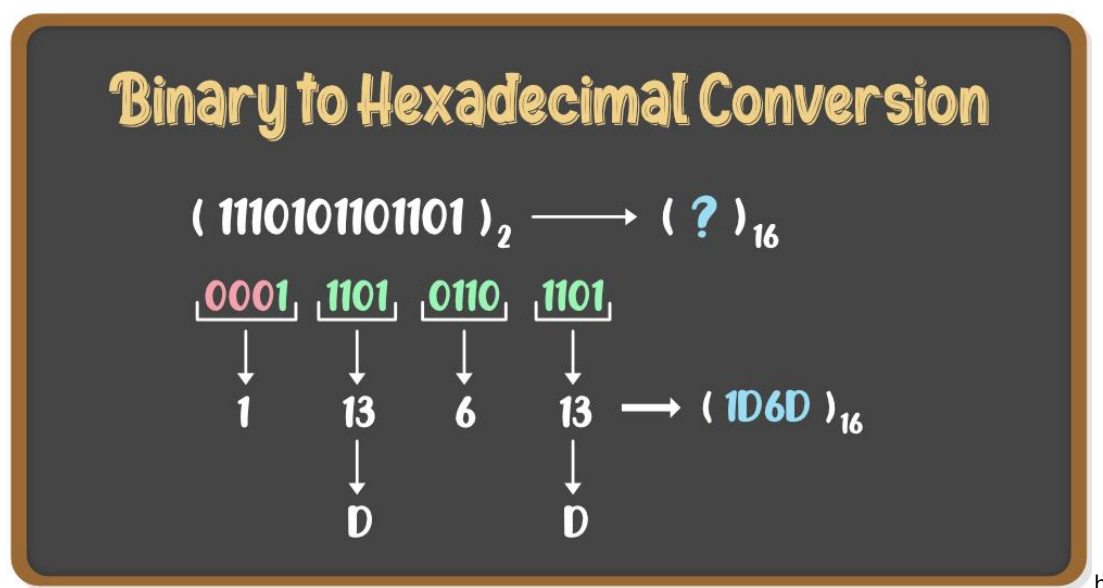
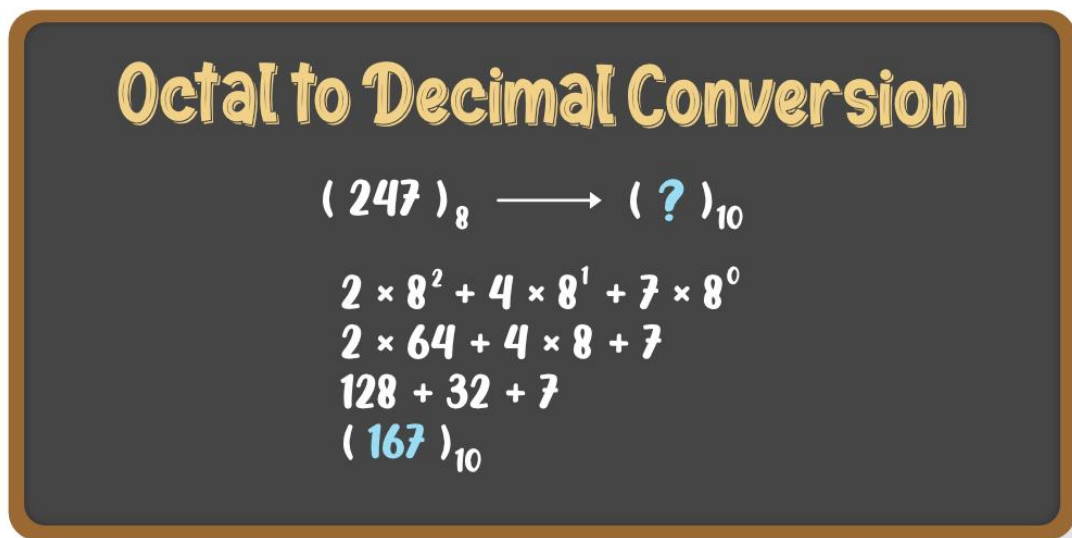- **Conversion from Octal to Other Number Systems**

Octal Numbers are represented with digits 0-7 and with base 8. Conversion of a number system means conversion from one base to another. Following are the conversions of the Octal Number System to other Number Systems:

Octal to Decimal Conversion:

Octal numbers are represented in base 8, but the decimal numbers are of base 10. Hence, to convert an octal number to a decimal number, the base of that number is to be changed. Follow the steps given below:

Step 1: Multiply each digit of the Octal number with the place value of that digit, starting from right to left i.e. from LSB to MSB.

Step 2: Add the result of this multiplication and the decimal number will be formed.

Octal to Decimal Conversion

$$(247)_8 \longrightarrow (\,?\,)_{10}$$

$$2 \times 8^2 + 4 \times 8^1 + 7 \times 8^0$$
$$2 \times 64 + 4 \times 8 + 7$$
$$128 + 32 + 7$$
$$(167)_{10}$$

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Octal to Binary Conversion:

Octal numbers are represented in base 8, but the binary numbers are of base 2. Hence, to convert an octal number to a binary number, the base of that number is to be changed. Follow the steps given below:

- **Step 1:** Write each digit of the octal number separately.

- **Step 2:** Convert each digit into an equivalent group of three binary digits.

- **Step 3:** Combine these groups to form the whole binary number.

Example: $(247)_8$ is to be converted to binary

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Octal to Hexadecimal Conversion:

Octal numbers are represented in base 8, but the hexadecimal numbers are of base 16. Hence, to convert an octal number to a hex number, the base of that number is to be changed. Follow the steps given below:

- **Step 1:** We need to convert the Octal number to Binary first. For that, follow the steps given in the above conversion.

- **Step 2:** Now to convert the binary number to Hex number, divide the binary digits into groups of four digits starting from right to left i.e. from LSB to MSB.

- **Step 3:** Add zeros prior to MSB to make it a proper group of four digits(if required)

- **Step 4:** Now convert these groups into their relevant decimal values.

- **Step 5:** For values from 10-15, convert it into Hex symbols i.e from A-F

Example: $(5456)_8$ is to be converted to hex
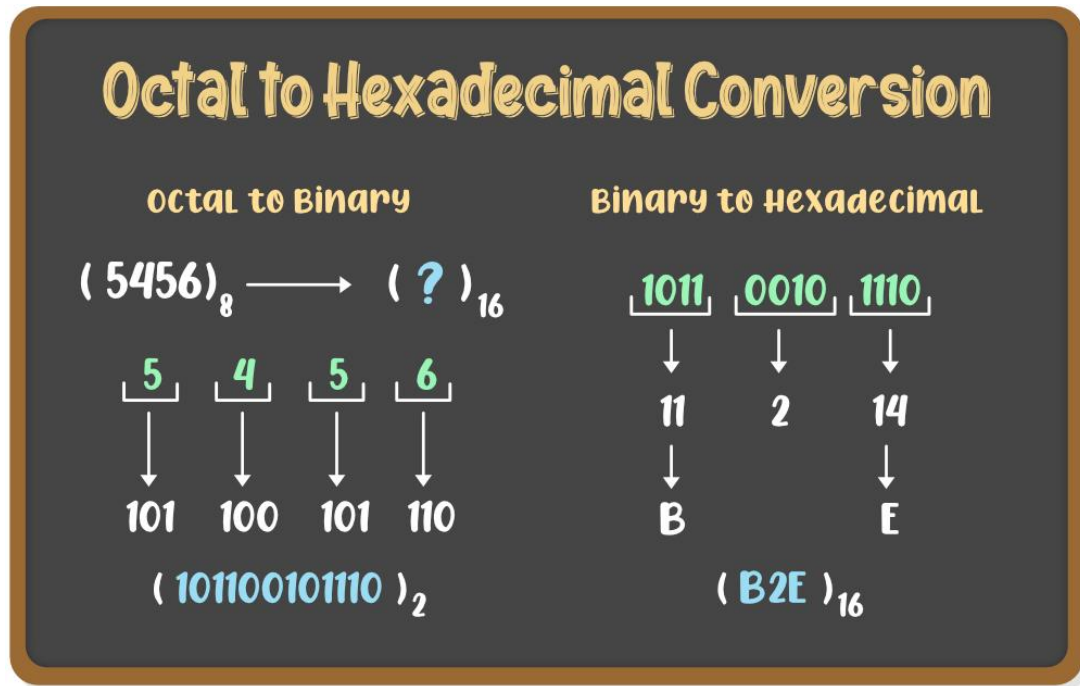
- **Conversion from Hexadecimal to Other Number Systems**

Hex Numbers are represented with digits 0–9 and with letters A–F and with base 16. Conversion of a number system means conversion from one base to another. Following are the conversions of the Hexadecimal Number System to other Number Systems:

Hexadecimal to Decimal Conversion:

Hexadecimal numbers are represented in base 16 but the decimal numbers are of base 10. Hence, to convert a hexadecimal number to a decimal number, the base of that number is to be changed. Follow the steps given below:

- **Step 1:** Write the decimal values of the symbols used in the Hex number i.e. from A–F

- **Step 2:** Multiply each digit of the Hex number with its place value. starting from right to left i.e. LSB to MSB.

- **Step 3:** Add the result of multiplications and the final sum will be the decimal number.
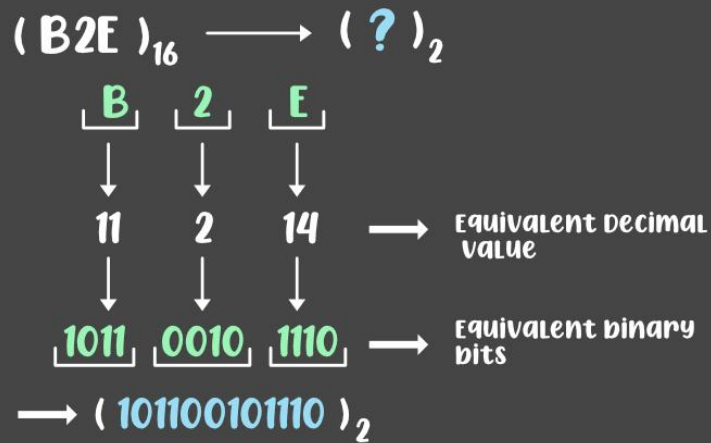

Example: To convert (8EB4)16 into a decimal value

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Hexadecimal to Binary Conversion

Hex numbers are represented in base 16, but the binary numbers are of base 2. Hence, to convert a hexadecimal number to a binary number, the base of that number is to be changed. Follow the steps given below:

- **Step 1:** Convert the Hex symbols into its equivalent decimal values.

- **Step 2:** Write each digit of the Hexadecimal number separately.

- **Step 3:** Convert each digit into an equivalent group of four binary digits.

- **Step 4:** Combine these groups to form the whole binary number.

Example: $(B2E)_{16}$ is to be converted to binary

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Hexadecimal to Octal Conversion:

Hexadecimal numbers are represented in base 16, but the octal numbers are of base 8. Hence, to convert a hex number to an octal number, the base of that number is to be changed. Follow the steps given below:
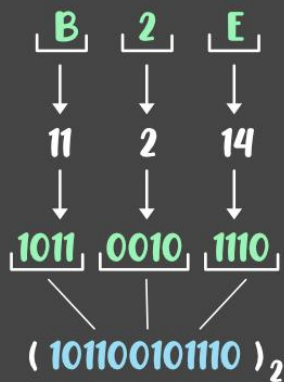
● **Step 1:** We need to convert the Hexadecimal number to Binary first. For that, follow the steps given in the above conversion.

● **Step 2:** Now to convert the binary number to Octal number, divide the binary digits into groups of three digits starting from right to left i.e. from LSB to MSB.

● **Step 3:** Add zeros prior to MSB to make it a proper group of three digits(if required)

● **Step 4:** Now convert these groups into their relevant decimal values.

Example: $(B2E)_{16}$ is to be converted to hex
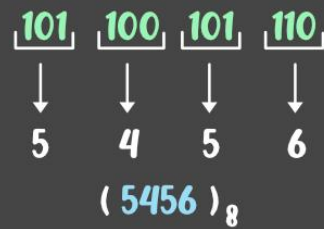
Hexadecimal to Octal Conversion

Hexadecimal to Binary

$(B2E)_{16} \longrightarrow (?)_8$

B	2	E
↓	↓	↓
11	2	14
↓	↓	↓
1011	0010	1110

$(101100101110)_2$

Binary to Octal

$(101100101110)_2$

101	100	101	110
↓	↓	↓	↓
5	4	5	6

$(5456)_8$

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