NUMBER SYSTEM

What is Number System ?

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. It provides a unique representation of every number and represents the arithmetic and algebraic structure of the figures. It also allows us to operate arithmetic operations like addition, subtraction and division.

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

Types of Number System

There are various types of number system in mathematics. The four most common number system types are:

1. Decimal number system (Base- 10)
2. Binary number system (Base- 2)
3. Octal number system (Base-8)
4. Hexadecimal number system (Base- 16)

Decimal Number System (Base 10 Number System)

Decimal number system has base 10 because it uses ten digits from 0 to 9. In the decimal number system, the positions

successive to the left of the decimal point represent units, tens, hundreds, thousands and so on. This system is expressed in decimal numbers.

Every position shows a particular power of the base (10). For example, the decimal number 1457 consists of the digit 7 in the units position, 5 in the tens place, 4 in the hundreds position, and 1 in the thousands place whose value can be written as

$$(1\times10^3)+(4\times10^2)+(5\times10^1)+(7\times10^0)$$

$$(1\times1000)+(4\times100)+(5\times10)+(7\times1)$$

$$1000+400+50+7$$

$$1457$$

Binary Number System (Base 2 Number System)

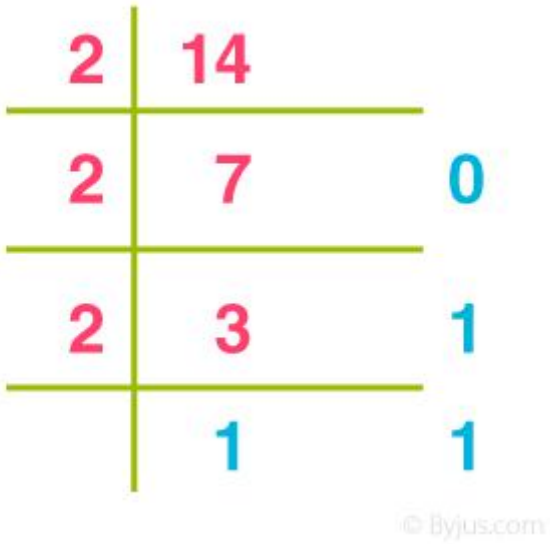
The base 2 number system is also known as the Binary number system wherein, only two binary digits exist, i.e., 0 and 1. Specifically, the usual base-2 is a radix of 2. The figures described under this system are known as binary numbers which are the combination of 0 and 1. For example, 110101 is a binary number.

We can convert any system into binary and vice versa.

Example

Write $(14)_{10}$ as a binary number.

Solution:



Base 2 Number System Example

$\therefore (14)_{10} = 1110_2$

Octal Number System (Base 8 Number System)

In the octal number system, the base is 8 and it uses numbers from 0 to 7 to represent numbers. Octal numbers are commonly used in computer applications. Converting an octal number to decimal is the same as decimal conversion and is explained below using an example.

Example: Convert 215_8 into decimal.

Solution:

$215_8 = 2 \times 8^2 + 1 \times 8^1 + 5 \times 8^0$

$= 2 \times 64 + 1 \times 8 + 5 \times 1$

$= 128 + 8 + 5$

$= 141_{10}$

Hexadecimal Number System (Base 16 Number System)

In the hexadecimal system, numbers are written or represented with base 16. In the hex system, the numbers are first represented just like in decimal system, i.e. from 0 to 9. Then, the numbers are represented using the alphabets from A to F. The below-given table shows the representation of numbers in the hexadecimal number system.

Hexadecimal	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E
Decimal	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Conversion of Number Systems

Conversion between numbers systems is quite an easy task. Any number from any number system can be converted to other number systems with the help of certain methods that will be discussed below:

1. Conversion from Decimal Number System 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 are the conversion of the Decimal Number System to other Number Systems:

A. 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.

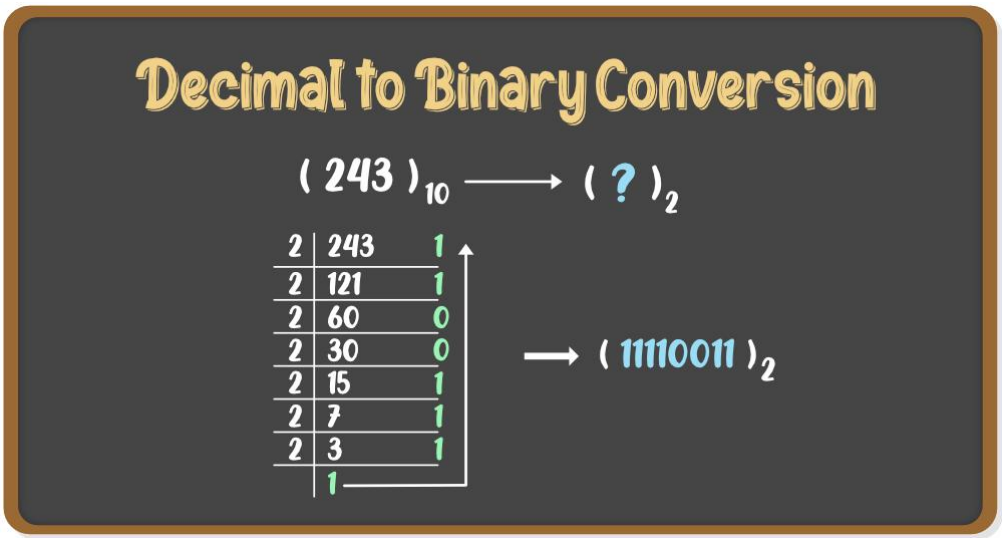
Step 2: The remainder obtained from the division will become the least significant digit of the new number.

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.



B. Decimal to Octal Conversion:

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:

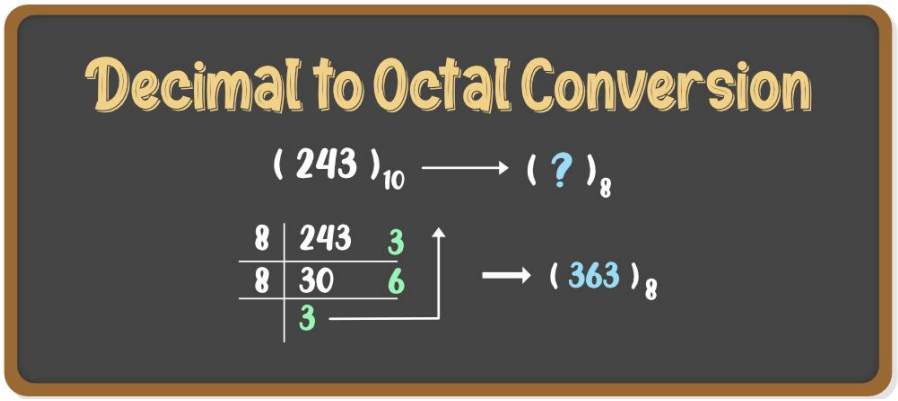
Step 1: Divide the Decimal Number with the base of the number system to be converted to. Here the conversion is to octal, hence the divisor will be 8.

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.



C. 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:

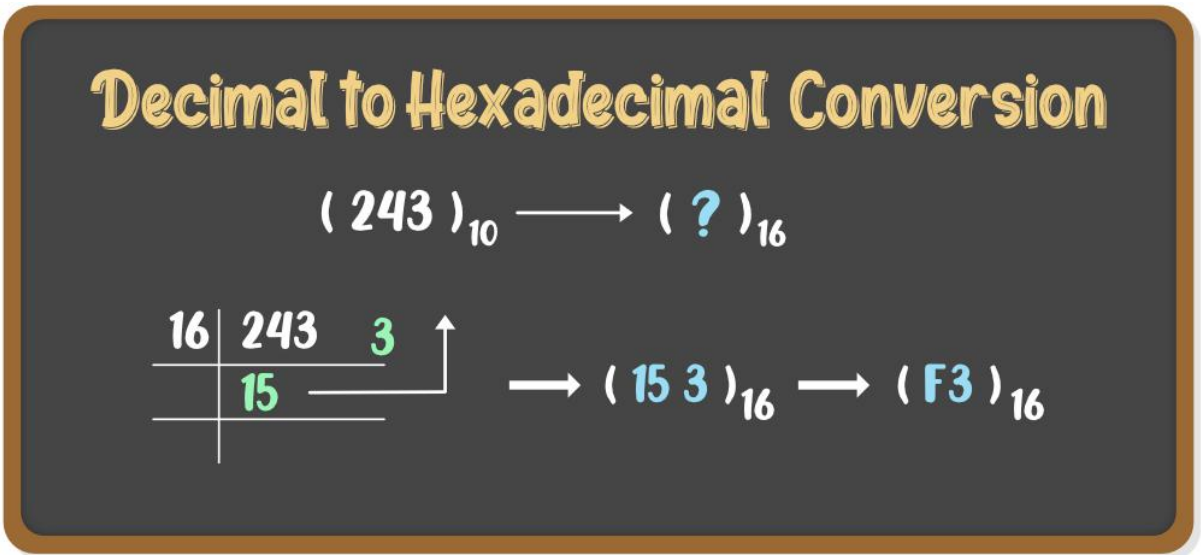
Step 1: Divide the Decimal Number with the base of the number system to be converted to. Here the conversion is to Hex hence the divisor will be 16.

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.



2. Conversion from Binary Number System 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 are the conversion of the Binary Number System to other Number Systems:

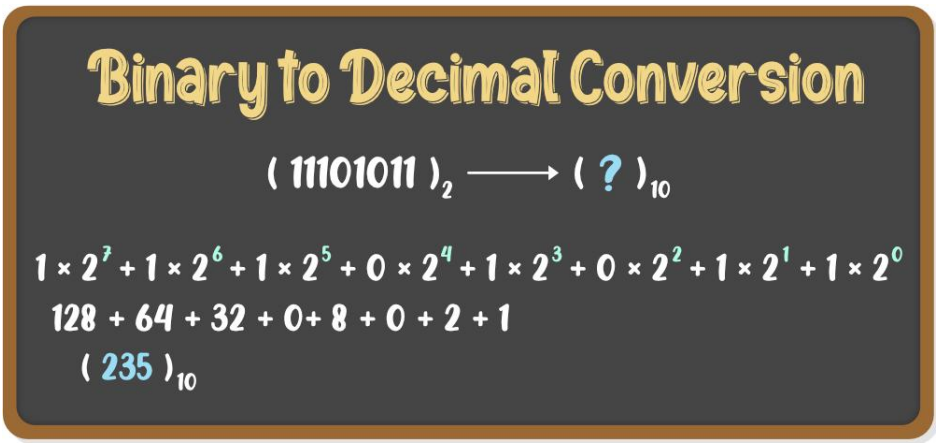
A. Binary to Decimal Conversion:

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



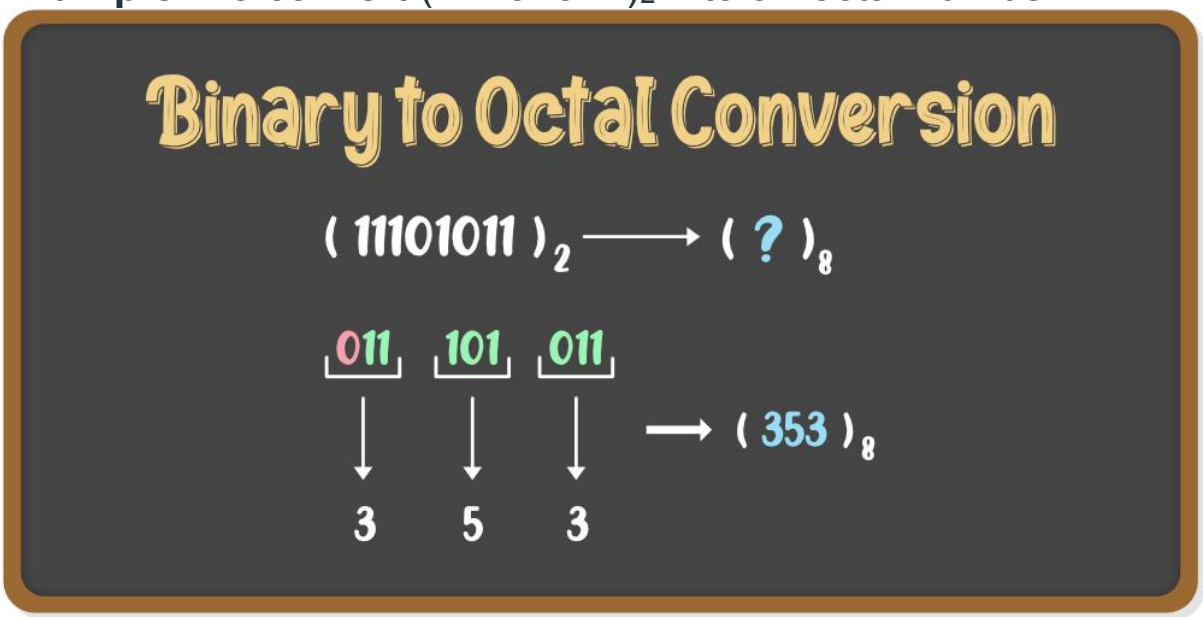
B. Binary to Octal Conversion:

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.

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



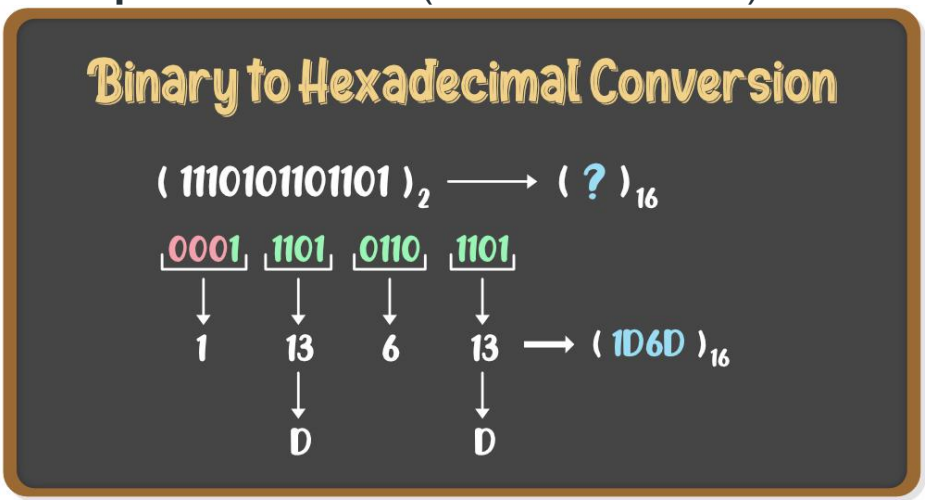
C. Binary to Hexadecimal Conversion:

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



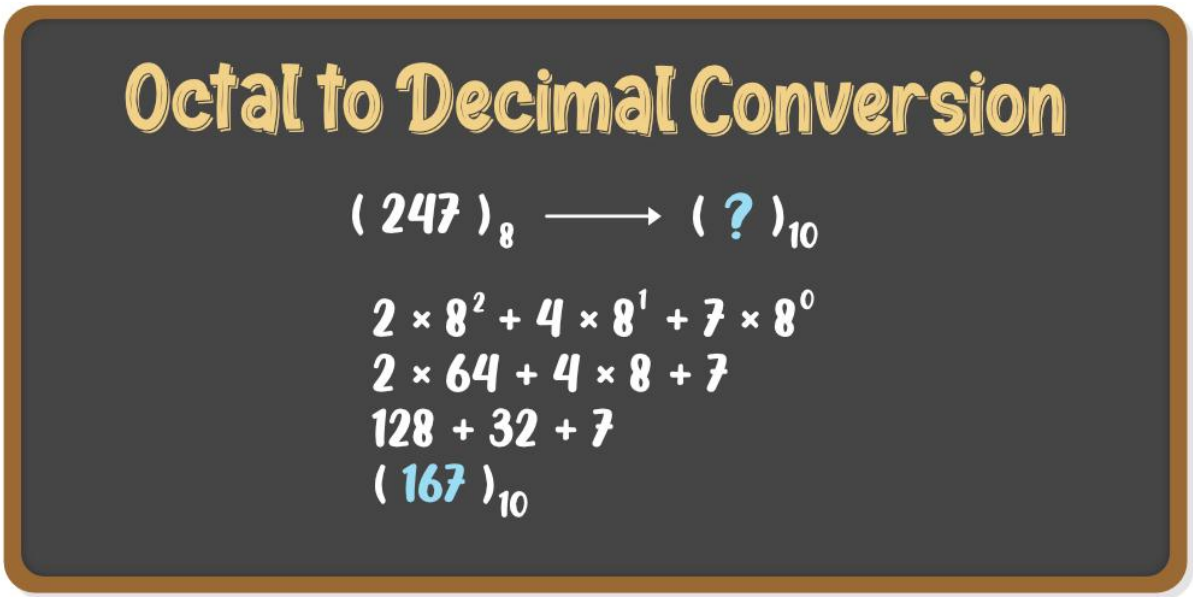
3. Conversion from Octal Number System to Other Number Systems

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:

A. 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.

Example:

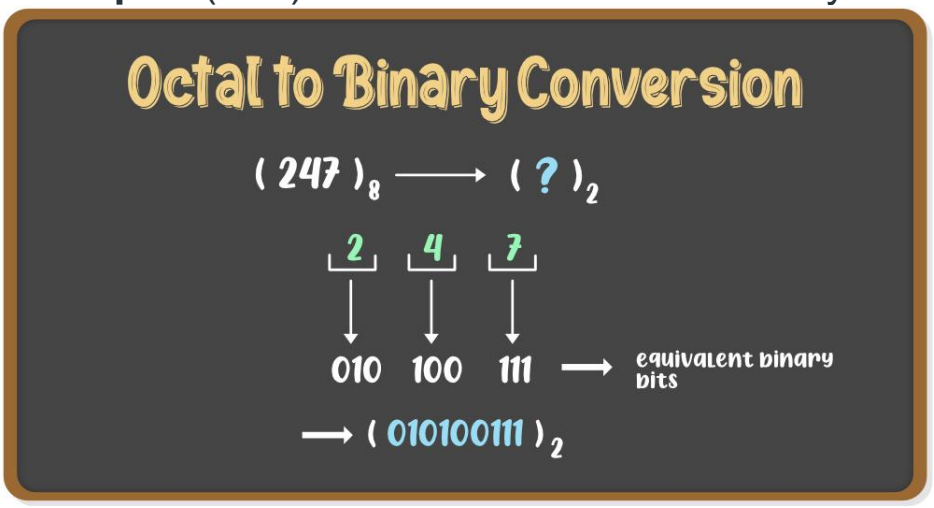


B. Octal to Binary Conversion:

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



C. 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

4. Conversion from Hexadecimal Number System 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:

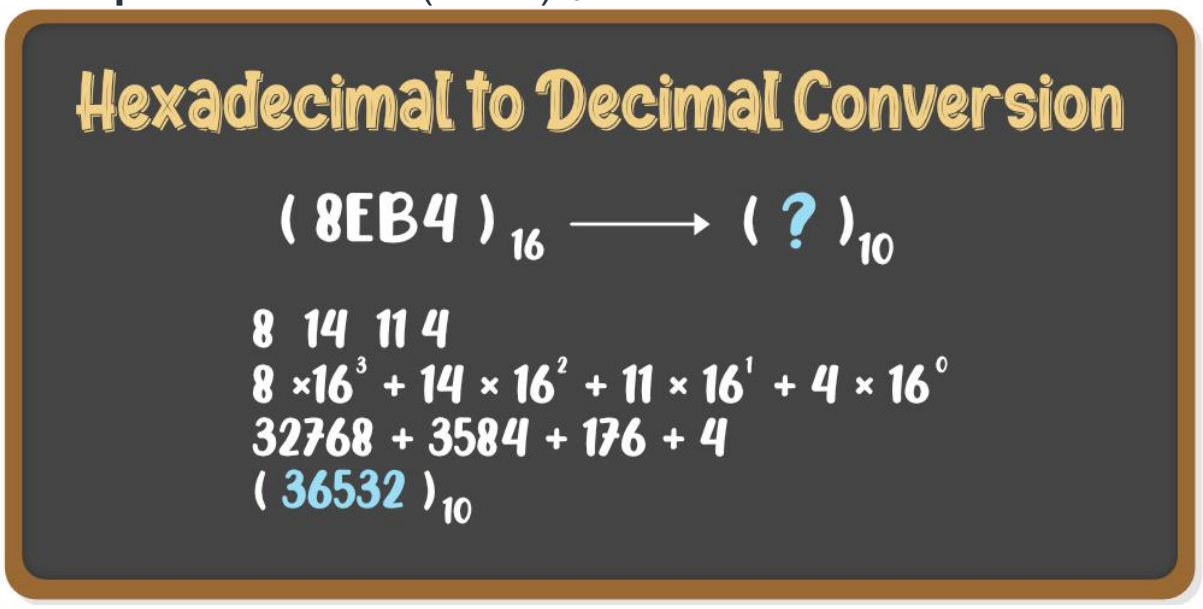
A. Hexadecimal to Decimal Conversion:
Hexadecimal numbers are represented in base 16 but the decimal numbers are of base 10. Hence, to convert a hexadecimal number to a decimal number, the base of that number is to be changed. Follow the steps given below:

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



B. 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

C. 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:

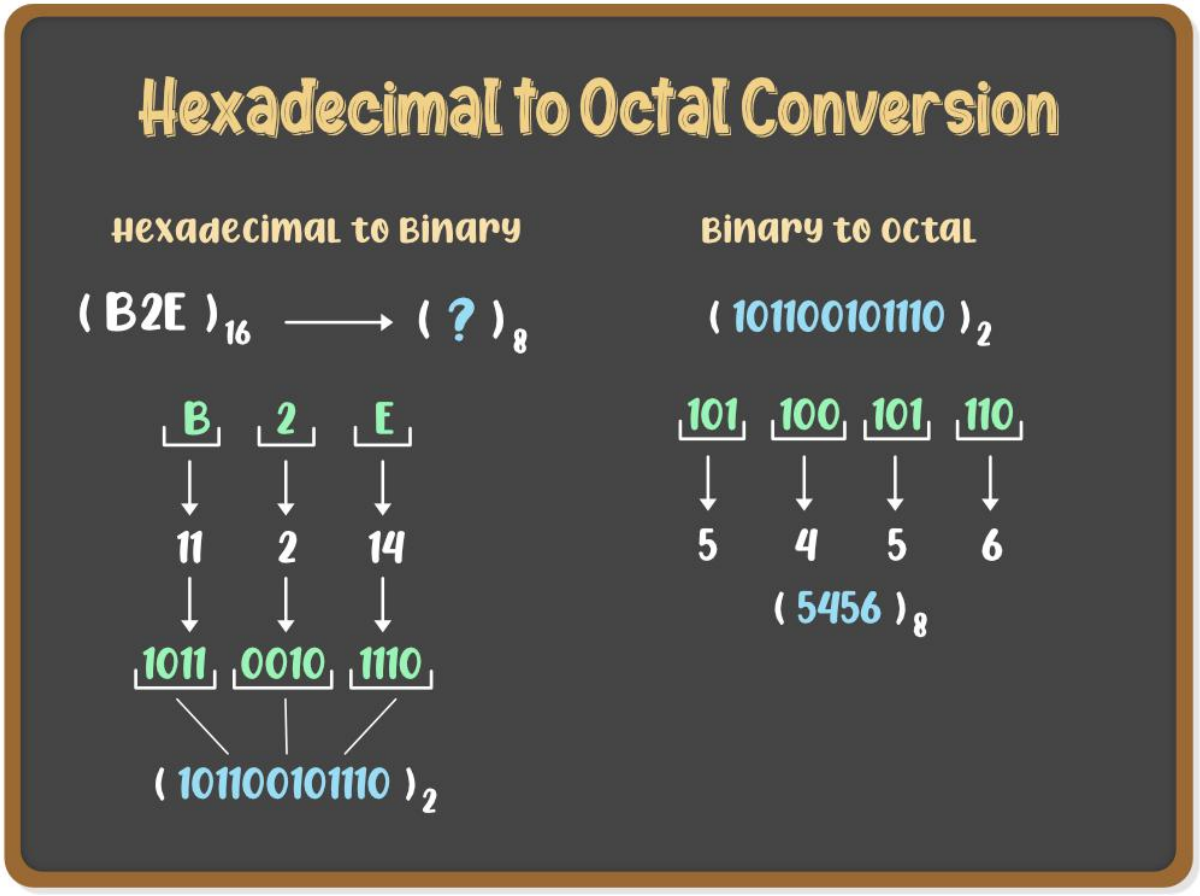
Step 1: We need to convert the Hexadecimal number to Binary first. For that, follow the steps given in the above conversion.

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



MCQs

1.The base of hexadecimal number system is

a)6 b)8 c)16 d)10

Answer: c

2.Numbers of digits in a binary are

a) 10 b) 2 c) 4 d)6

Answer: b

3.Name the number system that uses alphabets as well as numerals

a)Binary b)Octal number system c)decimal system d)hexadecimal system

Answer: d

4. Convert the hexadecimal number $(1E2)_{16}$ to decimal

a) 480 b) 482 c) 483 d)484

Answer: b

5. $(170)_{10}$ is equivalent to?

a) (FD)16 b) (AA)16 c) (AF)16 d)(DF)16

Answer: b

6. Convert binary to octal: $(110110001010)_2$

a) (5512)8 b) (6612)8 c) (4532)8 d)(6745)8

Answer: b

7. The value of radix in binary number system is:

a) 2 b) 8 c) 16 d)3

Answer: a

8. Convert the binary equivalent 10101 to its decimal equivalent.

a) 12 b) 22 c) 21 d)31

Answer: c

9. Convert the following binary number to decimal. 01011_2

a) 11 b) 35 c) 15 d)10

Answer: a

10. Convert the following decimal number to 8-bit binary.187

a) 10111011_2 b) 11011101_2 c) 10111101_2 d) 10111100_2

Answer: a