Third Chapter Lesson-4: Conversion among Binary, Octal & Hexadecimal numbers.

At the end of this lesson-

1. You will be able to convert Octal & Hexadecimal to Binary Number system.

2. You will be able to convert Binary to Octal & Hexadecimal Number system.

3. You will be able to convert Octal to Hexadecimal Number system.

4. You will be able to convert Hexadecimal to Octal Number system.

Conversion among Non-Decimal that means Binary, Octal & Hexadecimal Number Systems:

Step-01: Convert the number from any base to base 10.

Step-02: Convert the number from base 10 to any base.

That is, in case of non-decimal numbers, any conversion can be done in two steps.
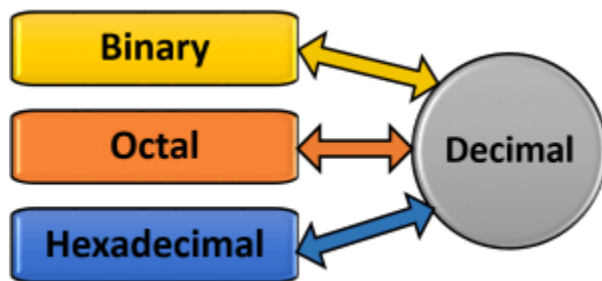
Except above rules there are following rules:

2^n (where, n=0,1,2,3,…..) formula can be used to convert directly from Octal & Hexadecimal into Binary and from Binary into Octal & Hexadecimal.

- In case of Octal, **4 2 1** (2^n ; where n=0,1,2)
- In case of Hexadecimal, **8 4 2 1** (2^n ; where n=0,1,2,3)

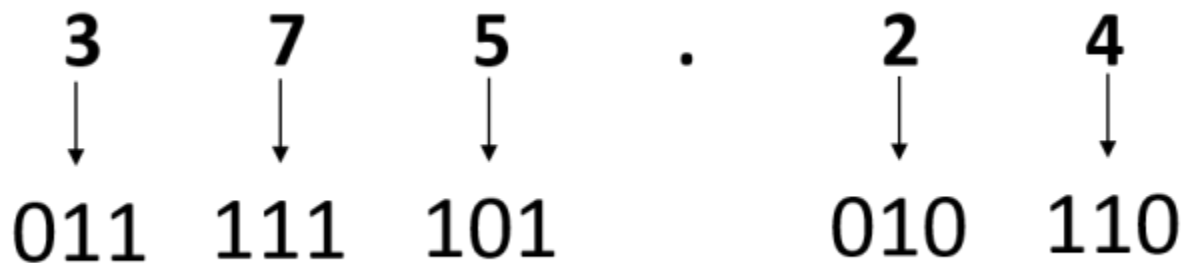Above rules have been applied in the following conversions-

Conversion of octal number into binary number:

Same rules are followed for integer and fractional part-

Step-1: Convert each octal digit into 3-bit binary number [follow **4 2 1** rules]

Step-2: Combine the binary groups of all digits.

3	7	5	.	2	4
↓	↓	↓		↓	↓
011	111	101		010	110

So, $(375.24)_8 = (011111101.010110)_2$

- **Convert $(127)_8$ into binary number system.**
- **Convert $(.7125)_8$ into binary number system.**
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Conversion of hexadecimal number into binary number:

Same rules are followed for integer and fractional part-

Step-1: Convert each hexadecimal digit into 4-bit binary number [follow **8 4 2 1** rules]

Step-2: Combine the binary groups of all digits.

Example: Convert $(35D.4F)_{16}$ into binary number system.

3	5	D	.	4	F
↓	↓	↓		↓	↓
0011	0101	1101		0100	1111

So, $(35D.4F)_{16} = (001101011101.01001111)_2$

- **Convert $(D218)_{16}$ into binary number system.**
- **Convert $(.1C39)_{16}$ into binary number system.**

Conversion of binary number into octal number:
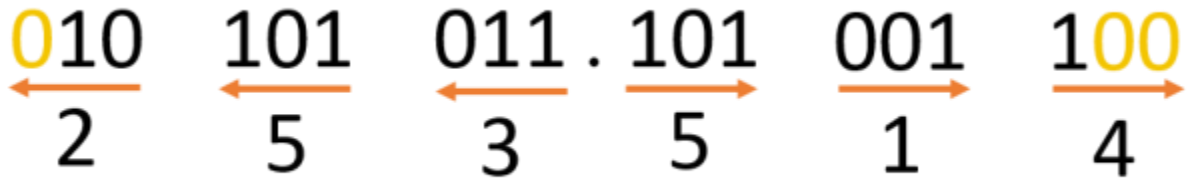
For integer and fractional number-

Step-1: In case of integer number divide the binary numbers into groups of 3-bits form right to left and In case of fractional number divide the binary numbers into groups of 3-bits form left to right.

[In case of integer number, If lack of bits to make 3-bits group, add the required number of zeros on the left and in case of fractions, If lack of bits to make 3-bits group, add the required number of zeros on the right]

Step-2: Write octal value of each group of 3-bits

Step-3: Combine the octal value

Example: Convert (10101011.1011011)₂ into octal number system.

$$010 \quad 101 \quad 011 . 101 \quad 001 \quad 100$$
$$2 \quad\quad 5 \quad\quad 3 \quad\quad 5 \quad\quad 1 \quad\quad 4$$

So, $(10101011.1011011)_2 = (253.514)_8$

- **Convert (1101001)₂ into octal number system.**
- **Convert (.1010011)₂ into octal number system.**

Conversion of binary number into hexadecimal number:

For integer and fractional number-

Step-1: In case of integer number divide the binary numbers into groups of 4-bits form right to left and In case of fractional number divide the binary numbers into groups of 4-bits form left to right.

[In case of integer number, If lack of bits to make 4-bits group, add the required number of zeros on the left and in case of fractions, If lack of bits to make 4-bits group, add the required number of zeros on the right]

Step-2: Write hexadecimal value of each group of 3-bits

Step-3: Combine the hexadecimal value

Example: Convert (0111001011.1010011)₂ into hexadecimal number system.

$$0001\ 1100\ 1011\ .\ 1010\ 0110$$
$$1 \quad C \quad B \quad \cdot \quad A \quad 6$$

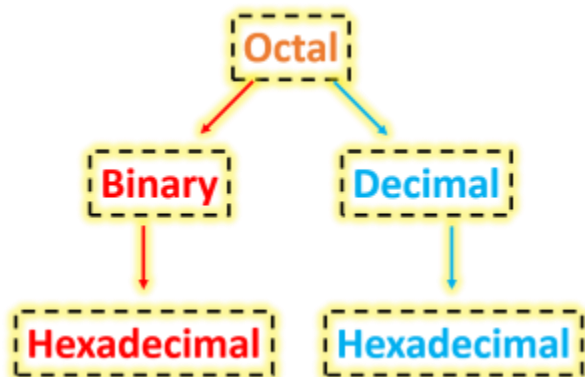So, $(0111001011.1010011)_2 = (1CB.A6)_{16}$

- **Convert (1101101)₂ into hexadecimal number system.**
- **Convert (.1010011)₂ into hexadecimal number system.**

Conversion of Octal into Hexadecimal Number:

The following two ways to convert octal to hexadecimal number-

One: First octal to decimal then decimal to hexadecimal

Two: First octal to binary then binary to hexadecimal

Example: Convert $(375.246)_8$ into Hexadecimal number.

First Conversion of Octal into Binary

3   7   5   .   2   4   6

011 111 101   010 100 110

$(375.246)_8 = (011111101.010100110)_2$

Again Conversion of Binary into Hexadecimal

0000 1111 1101 . 0101 0011 0000

0   F   D   5   3   0

$(011111101.010100110)_2 = (0FD.530)_{16}$
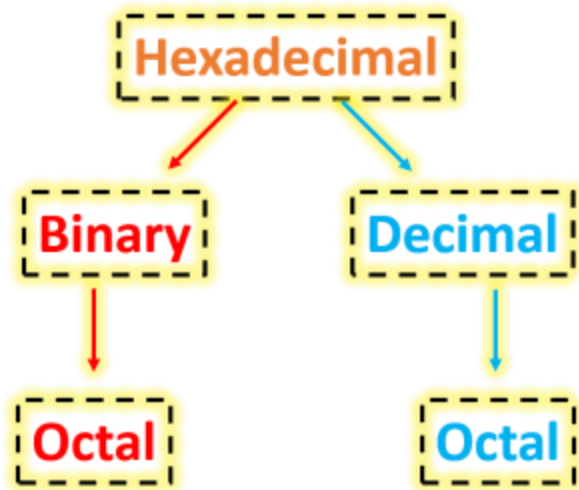
So $(375.246)_8 = (0FD.530)_{16}$

- Convert $(5273)_8$ into hexadecimal number.
- Convert $(.5137)_8$ into hexadecimal number.

Conversion of Hexadecimal into Octal Number:

The following two ways to convert hexadecimal to octal number-

One: First hexadecimal to decimal then decimal to octal

Two: First hexadecimal to binary then binary to octal

Example: Convert (08B.FCD)$_{16}$ into Octal number.

First Conversion of Hexadecimal into Binary

0	8	B	.	F	C	D
↓	↓	↓		↓	↓	↓
0000	1000	1011		1111	1100	1101

$(08B.FCD)_{16} = (000010001011.111111001101)_2$

Again Conversion of Binary into Octal

000	010	001	011	.	111	111	001	101
0	2	1	3		7	7	1	5

$(000010001011.111111001101)_2 = (213.7715)_8$

So $(08B.FCD)_{16} = (213.7715)_8$

- **Convert (5F293)$_{16}$ into octal number.**
- **Convert (.A127)$_{16}$ into octal number.**

Knowledge Based Questions:

Comprehension Based Questions:

Creative Questions:

According to the stem answer the following questions:

The professor of ICT was teaching the number system in the classroom. When asked about Imran's half-yearly and annual test scores for his ICT subject, he said he got $(37)_8$ marks in half-yearly and $(3F)_{16}$ marks in annual examination. When the other students asked Sir if they did not understand what it meant, Sir explained the details.

c) Convert Imran's marks obtained in half-yearly and annual exam into binary numbers.

d) Convert Imran's half-yearly marks into hexadecimal and annual marks into octal.

Multiple Choice Questions:

1. Which one is equivalent binary to $(127)_8$?

a) 1010101   b) 1010111   c) 1110101   d) 1011101

2. Which one is equivalent binary to 4C ?

a) 11001100   b) 01001100   c) 01001010   d) 01001101

3. Which one is equivalent hexadecimal to $(1110.0011)_2$?

a) E.3   b) E.8   c) E.C   d) C.E

4. Which one is equivalent hexadecimal to $(11011.110111)_2$?

a) 1B.37   b) 1B.DC   c) D8.DC   d) D8.37

5. Equivalent value of $(1010)_2$ –

i. $(10)_{10}$ ii. $(12)_8$ iii. $(14)_{16}$

Which one is correct?

a) i & ii   b) i & iii   c) ii & iii   d) i,ii & iii

Read the stem and answer the question No-6 and 7:

Mr. Atik said to Kamal, " How old are you?" Kamal replied $(101101)_2$

6. Which one is equivalent octal value to Kamal's age?

a) $(25)_8$ b) $(35)_8$ c) $(55)_8$ d) $(65)_8$

7. How old will Kamal be in binary after ten years?

a) $(101011)_2$ b) $(101110)_2$ c) $(101111)_2$ d) $(110111)_2$

8. Equivalent value of $(110110)_2$ –

i. $(66)_8$ ii. $(54)_{10}$ iii. $(36)_{16}$

Which one is correct?

a) i & ii   b) i & iii   c) ii & iii   d) i,ii & iii