

Number Systems

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L-1 Number Systems

Decimal	Binary	Octal	Hexadecimal
0	0	0	0
1	1	1	1
2	10	2	2
3	11	3	3
4	100	4	4
5	101	5	5
6	110	6	6
7	111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F
16	10000	20	10

$$\begin{array}{r}
 F \\
 + 1 \\
 \hline
 10 \quad (16)
 \end{array}
 \quad
 \begin{array}{r}
 7 \\
 + 1 \\
 \hline
 10 \quad (8)
 \end{array}
 \quad
 \begin{array}{r}
 9 \\
 + 1 \\
 \hline
 10 \quad (10)
 \end{array}$$

⇒ How binary made -

$$\begin{array}{r}
 0 \\
 + 1 \\
 \hline
 1 \rightarrow 1
 \end{array}$$

$$\begin{array}{r}
 + 1 \\
 \hline
 10 \rightarrow 2
 \end{array}$$

$$\begin{array}{r}
 + 1 \\
 \hline
 11 \rightarrow 3
 \end{array}$$

$$\begin{array}{r} 11 \\ + 1 \\ \hline 100 \rightarrow 4 \\ + 1 \\ \hline \end{array}$$

$$\begin{array}{r} 101 \rightarrow 5 \\ + 1 \\ \hline \end{array}$$

$$\begin{array}{r} 110 \rightarrow 6 \\ + 1 \\ \hline \end{array}$$

$$\begin{array}{r} 111 \rightarrow 7 \\ + 1 \\ \hline \end{array}$$

$$\begin{array}{r} 1000 \rightarrow 8 \\ + 1 \\ \hline \end{array}$$

$$\begin{array}{r} 1001 \rightarrow 9 \\ + 1 \\ \hline \end{array}$$

$$\begin{array}{r} 1010 \rightarrow 10 \\ + 1 \\ \hline \end{array}$$

$$\begin{array}{r} 1011 \rightarrow 11 \\ + 1 \\ \hline \end{array}$$

$$\begin{array}{r} 1100 \rightarrow 12 \\ + 1 \\ \hline \end{array}$$

$$\begin{array}{r} 1101 \rightarrow 13 \\ + 1 \\ \hline \end{array}$$

$$\begin{array}{r} 1110 \rightarrow 14 \\ + 1 \\ \hline \end{array}$$

$$\begin{array}{r} 1111 \rightarrow 15 \\ + 1 \\ \hline \end{array}$$

$$\begin{array}{r} 10000 \rightarrow 16 \\ + 1 \\ \hline \end{array}$$

$$\begin{array}{r} 10000 \\ + 1 \\ \hline \end{array}$$

$$\begin{array}{r} 10001 \rightarrow 17 \\ + 1 \\ \hline \end{array}$$

$$\begin{array}{r} 10010 \rightarrow 18 \\ + 1 \\ \hline \end{array}$$

$$\begin{array}{r} 10011 \rightarrow 19 \\ + 1 \\ \hline \end{array}$$

$$101000 \rightarrow 20$$

\leftarrow DNS

$$\Rightarrow 259_{(10)}$$

$$\hookrightarrow 200 + 50 + 9$$

$$2 \times 10^2 + 5 \times 10^1 + 9 \times 10^0$$

\nwarrow Powers of 10

$$\Rightarrow 10100_{(2)} \leftarrow BNS$$

$$\begin{array}{r} 1 \ 0 \quad 1 \ 0 \ 0 \\ 2^4 \ 2^3 \ 2^2 \ 2^1 \ 2^0 \end{array}$$

\leftarrow in powers of 2

$$\Rightarrow 2^4 \times 1 + 2^3 \times 0 + 2^2 \times 1 + 2^1 \times 0 + 2^0 \times 0$$

$$\Rightarrow 16 + 0 + 4 + 0 + 0$$

$$\Rightarrow 20 \leftarrow \text{Value in real}$$

\rightarrow 1 ends

L-2 Decimal to binary, octal and hexadecimal

$$\underline{\underline{\text{Ex}}}(1) 30_{(10)}$$

\hookrightarrow To binary \rightarrow

$$2 \overline{)30} \rightarrow 0$$

$$2 \overline{)15} \rightarrow 1$$

$$7 \rightarrow 1$$

$$3 \rightarrow 1$$

$$1 \rightarrow 1$$

$$0 \rightarrow 1$$

Remainder

(Read from
bottom to above)

$$\Rightarrow 11110_{(2)} = 30_{(10)}$$

(containing 30₍₁₀₎)
to Octal

$$\begin{array}{r} 8 \mid 30 \\ 8 \mid 3 \rightarrow 6 \\ 10 \rightarrow 3 \uparrow \end{array}$$

$$30_{(10)} = 36_{(8)}$$

To hexadecimel

$$\begin{array}{r} 16 \mid 30 \\ 16 \mid 1 \rightarrow 14 \\ 10 \rightarrow 1 \end{array} \rightarrow \text{will be written as E}$$

$$\Rightarrow 30_{(10)} = 1E_{(16)}$$

(ii)

$$19_{(10)}$$

To binary

$$\begin{array}{r} 2 \mid 19 \\ 2 \mid 9 \rightarrow 1 \\ 2 \mid 4 \rightarrow 1 \uparrow \\ 2 \mid 2 \rightarrow 0 \\ 2 \mid 1 \rightarrow 0 \\ 0 \rightarrow 1 \end{array}$$

$$19_{(10)} = 10011_{(2)}$$

To octal

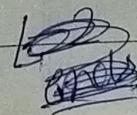
$$\begin{array}{r} 8 \mid 19 \\ 8 \mid 2 \rightarrow 3 \uparrow \\ 0 \rightarrow 2 \end{array}$$

$$19_{(10)} = 23_{(8)}$$

To hexadecimel

$$\begin{array}{r} 16 \mid 19 \\ 16 \mid 1 \rightarrow 3 \uparrow \\ 10 \rightarrow 1 \end{array}$$

$$19_{(10)} = 13_{(16)}$$



(ii) $43_{(10)}$ (to binary)

SOL

$$\begin{array}{r} 2 \sqrt{43} \\ 2 \quad | 21 \rightarrow 1 \\ 2 \quad | 10 \rightarrow 1 \\ 2 \quad | 5 \rightarrow 0 \\ 2 \quad | 2 \rightarrow 1 \\ 1 \rightarrow 0 \\ 0 \rightarrow 1 \end{array}$$

$$\Rightarrow 101011_{(2)} = 43_{(10)}$$

To octal

$$\begin{array}{r} 8 \sqrt{43} \\ 8 \quad | 5 \rightarrow 3 \\ 0 \rightarrow 5 \end{array}$$

$$\Rightarrow 43_{(10)} = 53_{(8)}$$

To hexadecimal

$$\begin{array}{r} 16 \sqrt{43} \\ 16 \quad | 2 \\ 0 \quad 2 \end{array}$$

will be written
as B

$$\Rightarrow 43_{(10)} = 2B_{(16)}$$

L-2 ends

L-3
Binary, octal and Hexadecimal to decimal
Binary to decimal

Ex: (i) 11110_2

Sol

$$\begin{array}{r} 1 \ 1 \ 1 \ 1 \ 0 \\ 2^4 \ 2^3 \ 2^2 \ 2^1 \ 2^0 \end{array}$$

$$\Rightarrow 1 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$$
$$\Rightarrow 16 + 8 + 4 + 2$$
$$\Rightarrow 30_{(10)}$$

(ii) 101011_2

Sol

$$\begin{array}{r} 1 \ 0 \ 1 \ 0 \ 1 \ 1 \\ 2^5 \ 2^4 \ 2^3 \ 2^2 \ 2^1 \ 2^0 \end{array}$$

$$\Rightarrow 2^5 \times 1 + 2^4 \times 0 + 2^3 \times 1 + 2^2 \times 0 + 2^1 \times 1 + 2^0 \times 1$$
$$\Rightarrow 32 + 0 + 8 + 0 + 2 + 1$$
$$\Rightarrow 43$$

(iii) 101101_2 (Quickly)

Sol

$$\begin{array}{r} 1 \ 0 \ 1 \ 1 \ 0 \ 1 \\ 32 \ 16 \ 8 \ 4 \ 2 \ 1 \end{array}$$

$$\Rightarrow 32 + 8 + 4 + 1 \Rightarrow 45_{(10)}$$

(iv) 1000111

Sol

$$\begin{array}{r} 1 \ 0 \ 0 \ 0 \ 1 \ 1 \ 1 \\ 64 \ 32 \ 16 \ 8 \ 4 \ 2 \ 1 \end{array}$$

$$\Rightarrow 64 + 4 + 2 + 1 \Rightarrow 71_{(10)}$$

⇒ Octal to decimal

i) $36_{(8)}$

Sol

$$\begin{array}{r} 3 \quad 6 \\ 8^1 \quad 8^0 \end{array}$$

$$\Rightarrow 8 \times 3 + 6 \times 1$$

$$\Rightarrow 24 + 6 = 30_{(10)}$$

ii) $53_{(8)}$

Sol

$$\begin{array}{r} 5 \quad 3 \\ 8^1 \quad 8^0 \end{array}$$

$$\Rightarrow 8 \times 5 + 3 \times 1$$

$$\Rightarrow 43_{(10)}$$

⇒ Hexadecimal to decimal

iii) $1E_{(16)}$

Sol

$$\begin{array}{r} 1 \quad E \\ 16^1 \quad 16^0 \end{array}$$

$$\Rightarrow 16 \times 1 + 1 \times E$$

$$\Rightarrow 16 + 14$$

$$\Rightarrow 30_{(10)}$$

iv) $2B_{(16)}$

Sol

$$\begin{array}{r} 2 \quad B \\ 16 \quad 1 \end{array}$$

$$\Rightarrow 32 + B \Rightarrow 32 + 11 = 43_{(10)}$$

L-3 ends

L-4

Octal and Hexadecimal to Binary conversion

? Octal to binary
125₍₈₎

Sol

1 2 5
001 010 101 (Make 3 digits)

⇒ 1010101₍₂₎

(ii)

274₍₈₎

2 7 4
00 111 100

⇒ 1011100₍₂₎

(iii)

~~Now binary~~ 563₍₈₎

9 6 5 6 3
01 110 011

⇒ 101110011₍₂₎

→ Now converse

(i)

1010101₍₂₎ to octal

Sol

1010101
1 5 2 5 ⇒ 125₍₈₎

(ii)

1011100₍₂₎ to octal

Sol

1011100
2 5 7 4 ⇒ 274₍₈₎

vii) $101010011(2)$

Sol
$$\begin{array}{r} 101010 \quad 011 \\ \hline 55 \quad \swarrow 2 \quad \swarrow 3 \end{array} \rightarrow 523(8)$$

⇒ Hexadecimal to binary

i) $2A(16)$
Sol
$$\begin{array}{r} 2 \quad A \\ 0010 \quad 1010 \end{array}$$

⇒ $101010(2)$

ii) $7C4(16)$
Sol
$$\begin{array}{r} 7 \quad C \quad 4 \\ 0111 \quad 1100 \quad 0100 \end{array}$$

⇒ $1111000100(2)$

→ Converse

v) $101010(2) \rightarrow$ Hexadecimal
Sol
$$\begin{array}{r} 0010 \quad 1010 \\ \hline 52 \quad \swarrow A \end{array}$$

⇒ $2A(16)$

vii) $10011001010(2) \rightarrow$ Hexadecimal
Sol

$$\begin{array}{r} 0100 \quad 1100 \quad 1010 \\ \hline 4 \quad C \quad \swarrow A \end{array} \Rightarrow 4CA(16)$$

L-4 ends

L-5 Octal to Hexadecimal Conversion

(i) $276_{(8)}$

$$\begin{array}{r}
 2 \ 7 \ 6 \\
 10 \ 111 \ 110 \rightarrow \text{binary} \\
 \hline
 10111110 \\
 \hline
 B \quad E
 \end{array}$$

$\Rightarrow BE_{(16)}$

\rightarrow Hexa to octal

(ii) $1C8_{(16)}$

$$\begin{array}{r}
 1 \ C \ 8 \\
 1 \ 1100 \ 1000
 \end{array}$$

$$\begin{array}{r}
 111 \ 001 \ 000 \\
 \hline
 7 \ 1 \quad 0
 \end{array}$$

$\Rightarrow 710_{(8)}$

L-5 ends