Number Systems :-

→ A set of value used to represent quantity.

→

Name	Base (or) Radix	
Binary	2	(0, 1)
Octal	8	(0, 1, 2, 3, 4, 5, 6, 7).
Decimal	10	(0, 1, 2, - - - , 9)
Duodecimal	12	(0, 1, 2, 3 . . . , 9, A, B)
Hexadecimal	16.	(0, 1, - - - , 9, A, B, C, D, E, F).
	4.	(0 to 3) (0, 1, 2, 3)

Weighted and Unweighted codes :-

$7392 = 7000 + 300 + 90 + 2$ — coefficients.

$= 7 \times 10^3 + 3 \times 10^2 + 9 \times 10^1 + 2 \times 10^0$ — weight.

Number System & codes

weighted
Ex: decimal
binary
octal
BCD etc.

unweighted.
Ex: gray code
excess-3 etc.

Binary Number System :-

→ 0 to (r−1).
r — base
0 to (2−1) → 0 to 1 = 0, 1. (Binary digit
→ Binary digit is also called 'bit'.

→ Ex: 1 0 1 0 1 (2^4 2^3 2^2 2^1 2^0 — weights)

$= 1\times2^4 + 0\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0$
$= 16 + 4 + 1 = 21$

Ex: 10101.11

$1\times2^4 + 0\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0 + 1\times2^{-1} + 1\times2^{-2}$
$\Rightarrow 16 + 4 + 1 + 0.5 + 0.25 = 21.75$

MSB and LSB :-

MSB – Most significant bit
LSB – Least significant bit

1 0 1 0 1 = 21 (MSB, LSB)
1 0 1 0 0 = 20.) difference 1
0 0 1 0 0 = 5) difference 16

So left side is MSB, because by changing left side diff. is more.

→ Bit is smallest unit of data.

→ 1 Nibble = 4 bits — used in BCD and Hexadecimal.

1 byte = 8 bits.

1 word = 16 bits = 2 bytes

1 double word = 32 bits = 4 bytes.

Decimal to binary Conversion:-

Q: $(13)_{10} \longrightarrow (\ )_2$ — 20/03/20

method-1:-

$13 = 8 + 4 + 1$ — $2^0 = 1$

$= 2^3 + 2^2 + 2^0$ — $2^1 = 2$, $2^2 = 4$, $2^3 = 8$

1	1	0	1
b_3	b_2	b_1	b_0
↑	↑	↑	↑
2^3	2^2	2^1	2^0

method-2:-

dividend, remainder, divisor

$$
\begin{array}{r|l}
2 & 13 \\ \hline
2 & 6 \;-\; 1 \\ \hline
2 & 3 \;-\; 0 \\ \hline
 & 1 \;-\; 1
\end{array}
$$

$(1101)_2$

Q: $(25.625)_{10} \longrightarrow (\ \ )_2$

$$
\begin{array}{r|l}
2 & 25 \\ \hline
2 & 12 - 1 \\ \hline
2 & 6 - 0 \\ \hline
2 & 3 - 0 \\ \hline
 & 1 - 1
\end{array}
$$

$(11001)_2$

$0.625 \times 2 = 1.25$

$0.25 \times 2 = 0.5 \quad 0$

$0.5 \times 2 = 1.00$

$0.00 \times 2 = 0.00$

$(.1010)_2$

Ans is $(11001.101)_2$.

Decimal to Octal Conversion :-

Q) $(112)_{10} \rightarrow (\ )_8$

$8 \,|\, 112$
$8 \,|\, 14 - 0$
$\quad 1 - 6$

$(160)_2$

Q) $(25.625)_{10} \rightarrow (\ )_8$

$8 \,|\, 25$
$8 \,|\, 3 - 1$
$\quad 0 - 3$

$(31)_8$

$0.625 \times 8 = 5.000$
$.000 \times 8 = .000$

$(.5)_2$

$(31.5)_2$ is Ans.

Decimal to Hexadecimal Conversion :-

Q! $(254)_{10} \rightarrow (\ )_{16}$

$16 \,|\, 254$
$16 \,|\, 15 - 14$
$\quad 0 - 15$

$(15\ 14)_{16}$
$= (F\ E)_{16}$

Q $(25.625)_{10} \rightarrow (\ )_{16}$

$16 \,|\, 25$
$16 \,|\, 1 - 9$
$\quad 0 - 1$

$(19)_{16}$

$.625 \times 16 = 10.000 = A$
$.000 \times 16 = .000$

$(19.A)_{16}$

Q $(27.4)_{10} \rightarrow (\ )_4$

$4 \,|\, 27$
$4 \,|\, 6 - 3$
$\quad 1 - 2$

$(123)_4$

$.4 \times 4 = 1.6$
$.6 \times 4 = 2.4$
$.4 \times 4 = 1.6$
$.6 \times 4 = 2.4$

$(.1212)$

A $(123.1212)_4$.

Binary to decimal Conversion :-

Ex: $(10101 \cdot 11)_2 \longrightarrow (\ )_{10}$.

$1\times2^4 + 0\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0 + 1\times2^{-1} + 1\times2^{-2}$

$= 21 + 0.75 = (21.75)_{10}$

Octal to decimal Conversion :-

$O_3 \quad O_2 \quad O_1 \quad O_0 \cdot O_{-1} \quad O_{-2}$

Integer part — fractional part.

octal point.

Ex: $(57 \cdot 4)_8 \longrightarrow (?)_{10}$.

$= 5\times8^1 + 7\times8^0 + 4\times8^{-1} = 40 + 7 + 0.05 = 47.5$

Ex: $(4507 \cdot 44)_8 \longrightarrow (\ )_{10}$.

$= 4\times8^3 + 5\times8^2 + 0\times8^1 + 7\times8^0 + 4\times8^{-1} + 4\times8^{-2}$

$= 2048 + 320 + 0 + 7 + 0.5 + 0.062 = (2375.5625)_{10}$

Hexadecimal to Decimal Conversion :-

Ex: $(BAD)_{16} \longrightarrow (\ )_{10}$

B – 11
A – 10
D – 13

$11\times16^2 + 10\times16^1 + 13\times16^0$

$= 2816 + 160 + 13 = (2989)_{10}$.

Ex: $(57 \cdot 4)_{16} \longrightarrow (\ )_{10}$.

$5\times16^1 + 7\times16^0 + 4\times16^{-1}$

$= 80 + 7 + 0.25 = (87.25)_{10}$

Octal to binary & binary to Octal Conversion :-

→ 0 – 000
1 – 001
2 – 010
3 – 011
4 – 100
5 – 101
6 – 110
7 – 111

eg $(3745)_8 \longrightarrow (\ )_2$?

011 111 100 101

$(011111100101)_2$ Ans!

eg
→ $(10110.11)_2 \longrightarrow (\ )_8$?

010 110 · 110

2 6 · 6

grouping

$\longrightarrow (26.6)_8$ Ans!

eg $(1001.1)_2$

001 001 · 100
1 1 · 4.

$(11.4)_8$.

Hexidecimal to binary & binary to Hexadecimal :-

eg: $(25\,9\,A)_{16} \longrightarrow (\ )_2$.

0010 0101 1001 1010.

eg $(CAFE.30)_{16} \longrightarrow (\ )_2$.

1100 1010 1111 1110 . 0011 0000.

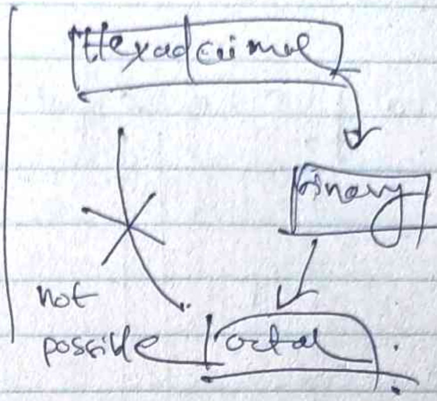
eg $(1000\ 1001.11)_2 \longrightarrow (\ )_{16}$.

grouping

$(8\ 9\ .\ C)_{16}$ Ans!

Hexadecimal to Octal and octal to Hexadecimal Conversion :-

eg $(CAD)_{16} \rightarrow (\ )_8$.



A: CAD → binary

$(1100\ 1010\ 1101)_2$

↓ octal

$(6255)_8$ A.

eg $(625)_8 \rightarrow 16$.

A: octal → binary

625 → 110 010 101.

$(110\ 010\ 101)_2$

↓

$(195)_{16}$.

Binary addition :-

	sum	carry
0 + 0	0	0.
0 + 1	1	0
1 + 0	1	0.
1 + 1	0	1

eg

```
  (1)(0) (0)
    1  1  0
 +  1  0  1
 ----------
 1  0  1  1
```

Binary multiplication :-

```
   1 0 1 0
     1 0 1
 ---------
   1 0 1 0
 0 0 0 0
1 0 1 0
 ---------
1 1 0 0 1 0
```

Binary Substraction :-

	sub	borrow
0 − 0	0	0.
0 − 1	1	1
1 − 0	1	0.
1 − 1	0	0.

eg:

```
    (−1)
 1   1  0  1  1
−1   0  1  1  0
--------------
 0   0  1  0  1
```

eg

```
(−1)(−1)(−1)
 1   1   1   0
     1   1   1
--------------
 0   1   1   1
```

Binary division :-

```
110 ) 101010 ( 000111
      0
      ------
      10
      0
      ------
      101
      000
      ------
      1010
    - 110
      ------
      01001
    - 110
      ------
      00110
      110
      ------
        0
```

Octal Addition :-

ex)

```
  0 0
  2 4 3
  2 1 2
  -----
  4 5 5
```

if the sum within 7 then no carry.

ex)

```
1 1   1
  5   6   7
  2   4   3
  ---------
1 0   3   2
```

$7 + 3 = 10$

and $10 > 7$

$10 = 1 \times 8 + 2$

carry sum

$11 > 7$

$11 = 1 \times 8 + 3$.

Carry sum

$8 > 7$

$8 = 1 \times 8 + 0$.

Carry. sum

Octal Substraction:-

Case 1

$$\begin{array}{r} 7\ 4\ 3 \\ 5\ 6\ 4 \\ \hline 1\ 5\ 7 \end{array}$$

borrow = 8

$8+3=11$

$11-4=7$

in place of 4 there is 3 now.

$3<6$.

borrow ~~there~~ is 8

$8+3=11$

$11-6=5$

in place of 7 there is 6

$6-5=1$

Case 2

$$\begin{array}{r} \overset{5}{\cancel{6}}\ \overset{9}{\cancel{2}}\ \overset{12}{\cancel{4}} \\ 2\ 6\ 5 \\ \hline 3\ 3\ 7 \end{array}$$

Octal Multiplication:-

Case 1

$$\begin{array}{r} 7\ 2 \\ 1\ 2 \\ \hline 1\ \overset{1}{\cancel{7}}\ 6\ 4 \\ 7\ 2\ \ \\ \hline 1\ 1\ 0\ 4 \end{array}$$

Ans

$2\times2=4$

$7\times2=14>8$

$14=1\times8+6$

carry sum

$6+2=8$

$\Rightarrow 8=1\times8+0$.

~~1+1+1~~ $2+7=9$

$9=8\times1+1$

Case 2

$$\begin{array}{r} 1\ \ 1 \\ 1\ 2\ 2 \\ 3\ 5\ 7 \\ 2\ 3 \\ \hline 1\ 3\ 1\ 5 \\ 7\ 3\ 6\ \ \\ \hline 1\ 0\ 6\ 7\ 5 \end{array}$$

Ans

$7\times3=21 \Rightarrow 21=2\times8+5$

$15+2=17 \Rightarrow 2\times8+1$

$11=8\times1+3$.

1's and 2's Complement :-

$(r-1)'$ comp $= r^4 - N - 1$
$= (r^4 - 1) - N$.

if $r = 10$, then $r^4 - 1 = 9999$
if $r = 8$, then $r^4 - 1 = 7777$
if $r = 16$, then $r^4 - 1 = ffff$
if $r = 2$, then $r^4 - 1 = 1111$

Q). Obtain 1's of $(1010)_2$.

A Substract from 1111

$$\begin{array}{r} 1111 \\ 1010 \\ \hline 0101 \end{array}$$ A!

we see 1's complement is just inverse.

Q) obtain 2's comp of $(10111010)_2$.

A find 1's Complement and add 1.

$$\begin{array}{rr} \text{1's comp} = & 01000101 \\ & 1 \\ \hline & 01000110 \end{array}$$ A

Shortcut for 2's Complement :-

Step-1 : write given number.
step-2 : Starting from LSB, copy all the 0's till the first 1.
step-3 : Copy the first 1.
Step 4 : Complement all the remaining bits.

Q (a) 10111000.

01001000. A!

Q) $(101100)_2$.

101100.

$(010100)_2$ A!