DLD CLASS : 02

TOPICS

=> Whole number binary to decimal

=> fraction number binary to decimal

=> Whole number decimal to binary

=> fraction number decimal to binary

=> Binary Arithmetic

Addition

Substraction

=> 1's and 2's compliment.

=> Signed binary numbers.

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=> BINARY TO DECIMAL

=> A binary number is a weighted number

110110① → $\boxed{2^0 = 1}$

=> The right most bit is the L.S.B in a binary whole number and has a weight of $2^0 = 1$

=> The weight increase from ~~left~~ right to left by a power of 2 for each bit

①101101

=> The left most bit is the most significant bit in a binary whole number. Its weight depend on the size of binary number.

=> fractional number can also be represented in binary by placing bits to the right of the binary point.

$2^{n-1} \ldots\ldots 2^3\ 2^2\ 2^1\ 2^0 . 2^{-1}\ 2^{-2} \ldots 2$

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Q.

convert these binary whole numbers into decimal.

1) 1101101 → Example 2.3

Sol:

$\Rightarrow 1\times2^5+0\times2^4+1\times2^3+1\times2^2+0\times2^1+1\times2^0$

$1\times2^6+$

$\Rightarrow 64+32+0+8+4+0+1$

$\Rightarrow 109$ // $\Rightarrow (109)_{10}$

2) 0 1 0 0

Sol:

$\Rightarrow 0\times2^3+1\times2^2+0\times2^1+0\times2^0$

$\Rightarrow 0+4+0+0$

$\Rightarrow 4$ // $(4)_{10}$

3) 1001

Sol:

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

$\Rightarrow 8+0+0+1$

$\Rightarrow 9$ // $(9)_{10}$

4) 10101

Sol:

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

$\Rightarrow 16+0+4+0+1$

$\Rightarrow 21$ // $(21)_{10}$

5) 1101

Sol:

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

$\Rightarrow 8+4+0+1$

$\Rightarrow 13$ // $\Rightarrow (13)_{10}$

6) 11001

Sol:

$\Rightarrow 1\times2^4+1\times2^3+0\times2^2+0\times2^1+1\times2^0$

$\Rightarrow 16+8+0+0+1$

$\Rightarrow 25$ // $= (25)_{10}$

7) 10001

Sol:

$\Rightarrow 1\times2^4+0\times2^3+0\times2^2+0\times2^1+1\times2^0$

$\Rightarrow 16+0+0+0+1$

$\Rightarrow 17$ // $\Rightarrow (17)_{10}$

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8) 1111

Sol:

$\Rightarrow \quad 1\times2^3 + 1\times2^2 + 1\times2^1 + 1\times2^0$

$\Rightarrow \quad 8+4+2+1$

$\Rightarrow \quad 15 \,// = (15)_{10}$

9) 111010

Sol:

$\Rightarrow \quad 1\times2^4 + 1\times2^3 + 0\times2^2 + 1\times2^1 + 0\times2^0$

$1\times2^5 +$

$\Rightarrow \quad 32+16+8+0+2$

$\Rightarrow \quad 58 \,// = (58)_{10}$

10) 00001

Sol:

$\Rightarrow \quad 0\times2^4 + 0\times2^3 + 0\times2^2 + 0\times2^1 + 1\times2^0$

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$= 1$ // $\Rightarrow (1)_{10}$

1) 11110

Sol:

$\Rightarrow 1\times2^4 + 1\times2^3 + 1\times2^2 + 1\times2^1 + 0\times2^0$

$\Rightarrow 16 + 8 + 4 + 2 + 0$

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

Q. convert fraction binary number into decimal.

1) $(100101.01)_2 = (\quad)_{10}$

Sol:-

$\Rightarrow (100101)_2$

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

$\Rightarrow 32+0+0+4+0+1$

$\Rightarrow 37$

$(.01)_2$

$\Rightarrow (2^{-1}\times 0) + 2^{-2}\times 1$

$\Rightarrow 0+0.25$

$= 0.25$

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=> 37 + 0.25 = $(37.25)_{10}$ //

2) 0.1011 → Example 2.4

Sol:

=> 0

=> 0×2^0

=> 0

=> .1011

=> $2^{-1} \times 1 + 2^{-2} \times 0 + 2^{-3} \times 1 + 2^{-4} \times 1$

=> 0.5 + 0 + 0.125 + 0.0625

=> 0.6875

=> $(0.6875)_{10}$ //

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⇒ DECIMAL TO BINARY

⇒ Whole number decimal to binary

└→ Repeated divison by 2 method.

⇒ fraction number decimal to binary.

└→ Repeated multiplication by '2' method.

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Q. convert these whole number decimal to binary.

1) $(49)_{10} = (\quad)_2$

Sol:

2	49 − 1 → L.S.B
2	24 − 0
2	12 − 0
2	6 − 0
2	3 − 1
	1 → M.S.B

=> $(110001)_2$ //

Q. Example 2.5

2) $(12)_{10} = (\quad)_2$

Sol:

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2	12 — 0 → L·S·B
2	6 — 0
2	3 — 1
	1 → M·S·B

$\Rightarrow (1\ 1\ 0\ 0)_2$

3) $(25)_{10} = (\qquad)_2$

Sol:

2	25 — 1 → L·S·B
2	12 — 0
2	6 — 0
2	3 — 1
	1 → M·S·B

$= (11001)_2$

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4) $(58)_{10} = (\quad)_2$

Sol:

2	58 − 0 → L·S·B
2	29 − 1
2	14 − 0
2	7 − 1
2	3 − 1
	1 → M·S·B

$\Rightarrow (111010)_2$

5) $(82)_{10} = (\quad)_2$

Sol:-

2	82 − 0 → L·S·B
2	41 − 1
2	20 − 0
2	10 − 0
2	5 − 1
2	2 − 0
	1 → M·S·B

$\Rightarrow (1010010)_2$

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6) $(125)_{10} = (\quad)_2$

Sol:-

2	125 - 1 → L·S·B
2	62 - 0
2	31 - 1
2	15 - 1
2	7 - 1
2	3 - 1
	1 → M·S·B

$\Rightarrow (1111101)_2$

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EXAMPLE : 2·6

7) $(19)_{10} = (\quad)_2$

Sol:

2	19 – 1 → L·S·B
2	9 – 1
2	4 – 0
2	2 – 0
	1 → M·S·B

$\Rightarrow (1\,0\,0\,1\,1)_2$

8) $(45)_{10} = (\quad)_2$

Sol:

2	45 – 1 → L·S·B
2	22 – 0
2	11 – 1
2	5 – 1
2	2 – 0
	1 → M·S·B

$\Rightarrow (1\,0\,1\,1\,0\,1)_2$

9) $(39)_{10} = (\quad)_2$

Sol:

2	39 – 1 → L.S.B
2	19 – 1
2	9 – 1
2	4 – 0
2	2 – 0
	1 → M.S.B

$\Rightarrow (100111)_2$

Q. convert these decimal fraction to binary.

1) $(0.625)_{10} = (\quad)_2$

Sol:-

$\Rightarrow$ $0.625 \times 2 = \underline{1}.25 \longrightarrow 1 \rightarrow$ M.S.B

$0.25 \times 2 = 0.5 \longrightarrow 0$

$0.5 \times 2 = 1.0 \longrightarrow 1 \rightarrow$ L.S.B

↳ stop when the fractional part is all zero

$\Rightarrow (0.101)_2$ //

2) $(0.3125)_{10} = (\quad)_2$

<u>Sol:</u>

$\Rightarrow$ $0.3125 \times 2 = 0.625 \longrightarrow 0 \rightarrow$ M.S.B
$0.625 \times 2 = 1.25 \longrightarrow 1$
$0.25 \times 2 = 0.5 \longrightarrow 0$
$0.5 \times 2 = 1.0 \longrightarrow 1 \rightarrow$ L.S.B

$\Rightarrow (0.0101)_2$

3) 0.188

<u>Sol:</u>

$\Rightarrow$ $0.188 \times 2 = 0.376 \longrightarrow 0 \rightarrow$ M.S.B
$0.376 \times 2 = 0.752 \longrightarrow 0$
$0.752 \times 2 = 1.504 \longrightarrow 1$
$0.504 \times 2 = 1.008 \longrightarrow 1$
$0.008 \times 2 = 0.016 \longrightarrow 0 \rightarrow$ L.S.B

↳ for five significant figure

$\Rightarrow (0.00110)_2$

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⇒ Binary Addition

Rules

	sum	carry
⇒ 1 + 0 =	1	0
⇒ 0 + 1 =	1	0
⇒ 0 + 0 =	0	0
⇒ 1 + 1 =	0	1

(For three binary numbers)

	carry	sum
⇒ 1 + 0 + 0 =	0	1
⇒ 1 + 1 + 0 =	1	0
⇒ 1 + 1 + 1 =	1	1
⇒ 1 + 0 + 1 =	10	0

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Q.

Add the following binary number

1) (0 0 1 1 1) + (1 0 1 0 1)

Sol:

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

=> 0 0 1 1 1

=> $0 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$

=> $0 + 0 + 4 + 2 + 1$

=> 9 7

=> 1 0 1 0 1

=> $1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$

=> $16 + 0 + 4 + 0 + 1$

=> 21

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$$\Rightarrow \begin{array}{r} 21 \\ +\,07 \\ \hline 3028 \\ \hline \end{array}$$

$\Rightarrow$ 1 1 1 0 0

$\Rightarrow 1\times2^4+1\times2^3+1\times2^2+0\times2^1+0\times2^0$

$\Rightarrow 16+8+4 \boxed{=28}$

Ad

i)

=>

=>

=>

=

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Scanned with CamScanner

Q.1

Add the following binary numbers:

) (00111) + (10101)

Sol:-

$$
\begin{array}{cccccc}
 & & 1 & 1 & 1 & \\
 & 0 & 0 & 1 & 1 & 1 \\
+ & 1 & 0 & 1 & 0 & 1 \\
\hline
 & 1 & 1 & 1 & 0 & 0 \\
\hline
\end{array}
\quad
\begin{array}{r}
\Rightarrow 7 \\
\Rightarrow +21 \\
\hline
\Rightarrow 28 \\
\hline
\end{array}
$$

CHECKING:

$\Rightarrow (0\ 0\ 1\ 1\ 1)_2$

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

$\Rightarrow 0 + 0 + 4 + 2 + 1$

$\Rightarrow (7)_{10}$

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$\Rightarrow (10101)_2$

$\Rightarrow 1\times2^4 + 0\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0$

$\Rightarrow 16 + 0 + 4 + 0 + 1$

$\Rightarrow (21)_{10}$

$\Rightarrow 21 + 7 = \boxed{(28)_{10}}$

$\Rightarrow (11100)_2$

$\Rightarrow 1\times2^4 + 1\times2^3 + 1\times2^2 + 0\times2^1 + 0\times2^0$

$\Rightarrow 16 + 8 + 2^{\times2} + 0 + 0$

$\Rightarrow \boxed{(28)_{10}}$

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EXAMPLE: 2.7

ii) 11 + 11

Sol:

$$
\begin{array}{rrr}
 & \overset{1}{1} & 1 \\
+ & 1 & 1 \\
\hline
1 & 1 & 0
\end{array}
\quad \Rightarrow \quad
\begin{array}{r}
3 \\
+3 \\
\hline
6
\end{array}
$$

CHECKING:

$\Rightarrow (11)_2$

$\Rightarrow 1\times2^1 + 1\times2^0$

$\Rightarrow 2+1$

$\Rightarrow 3$

$\Rightarrow 3+3 = \boxed{6}$

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$= (1\ 1\ 0)_2$

$\Rightarrow \quad 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$

$\Rightarrow \quad 4 + 2 + 0$

$\Rightarrow \quad \boxed{6}$

iii) $100 + 10$

Sol:

$$\begin{array}{r} 100 \\ +\ 10 \\ \hline 110 \\ \hline \end{array} \qquad \begin{array}{r} \Rightarrow 4 \\ \Rightarrow +62 \\ \hline 6 \\ \hline \end{array}$$

$\Rightarrow \quad (100)_2$

$\Rightarrow \quad 1 \times 2^2 + 0 \times 2^1 + 0 \times 2^0$

$\Rightarrow \quad 4 + 0 + 0$

$\Rightarrow \quad 4$

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$\Rightarrow (10)_2$

$\Rightarrow \quad 1\times2^1 + 0\times2^0$

$\Rightarrow \quad 2+0$

$\Rightarrow \quad 2 \qquad \Rightarrow \quad 4+2=\boxed{6}$

$\Rightarrow (1\,1\,0)_2$

$\Rightarrow \quad 1\times2^2 + 1\times2^1 + 0\times2^0$

$\Rightarrow \quad 4+2+0$

$\Rightarrow \quad \boxed{6}$

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iv) $111 + 11$

Sol:

$$\begin{array}{r} 111 \\ +\ 11 \\ \hline 1010 \\ \hline \end{array} \Rightarrow \begin{array}{r} 7 \\ +3 \\ \hline 10 \\ \hline \end{array}$$

⇒ **CHECKING:**

$\Rightarrow (111)_2$

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

$\Rightarrow 4 + 2 + 1$

$\Rightarrow 7$

$\Rightarrow (11)_2$

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

$\Rightarrow 2 + 1$

$\Rightarrow 3$

Scanned with CamScanner

$\Rightarrow 7 + 3 = 10$

$\Rightarrow (1010)_2$

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

$\Rightarrow 8 + 0 + 2 + 0$

$\Rightarrow \boxed{10}$

v) 110 + 100

Sol:

$$\begin{array}{rrrrl} & 1 & 1 & 0 & = 6 \\ + & 1 & 0 & 0 & = +4 \\ \hline 1 & 0 & 1 & 0 & \Rightarrow 10 \end{array}$$

$\Rightarrow$ CHECKING:

Scanned with CamScanner

v)

$\Rightarrow (110)_2$

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

$\Rightarrow 4 + 2 + 0$

$\Rightarrow 6$

$\Rightarrow (100)_2$

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

$\Rightarrow 4 + 0 + 0$

$= 4$

$= 6 + 4 = \boxed{10}$

Scanned with CamScanner

$\Rightarrow (1010)_2$

$\Rightarrow 1\times2^3 + 0\times2^2 + 1\times2^1 + 0\times2^0$

$\Rightarrow 8+0+2+0$

$\Rightarrow \boxed{10}$

vi) 1111 + 1100

Sol:

$$\begin{array}{rrcr} & 1111 & \Rightarrow & 15 \\ + & 1100 & \Rightarrow & +12 \\ \hline & 11011 & \Rightarrow & 27 \end{array}$$

$\Rightarrow$ **CHECKING:**

$\Rightarrow (1111)_2$

$\Rightarrow 1\times2^3 + 1\times2^2 + 1\times2^1 + 1\times2^0$

$\Rightarrow 8+4+2+1 \Rightarrow 15$

Scanned with CamScanner

$\Rightarrow (1100)_2$

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

$\Rightarrow 8 + 4 + 0 + 0$

$\Rightarrow 12$ $\Rightarrow 15 + 12 = \boxed{27}$

$\Rightarrow (11011)_2$

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

$\Rightarrow 16 + 8 + 0 + 2 + 1$

$\Rightarrow \boxed{27}$

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BINARY SUBSTRACTION

Rules :

=> 1 - 0 = 1

=> 0 - 0 = 0

=> 1 - 1 = 0

=> 0 - 1 = 1 (with a borrow of 1)

EXAMPE : 2·8

Q. Perform the following binary substraction.

(a) 11 - 01

Sol:-

$$\begin{array}{r} 11 \\ -\ 01 \\ \hline 10 \end{array} \quad \begin{array}{r} = 3 \\ = -1 \\ \hline = 2 \end{array}$$

CHECKING:-

$\Rightarrow (1\ 1)_2$

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

$\Rightarrow 2 + 1$

$\Rightarrow 3$

$\Rightarrow (01)_2$

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

$\Rightarrow 1$

$\Rightarrow 3 - 1 = \boxed{2}$

$\Rightarrow (10)_2$

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

$\Rightarrow \boxed{2}$

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(b) 11 - 10

Sol:

$$\begin{array}{r} 11 \\ -10 \\ \hline 01 \\ \hline \end{array} = \begin{array}{r} 3 \\ -2 \\ \hline 1 \\ \hline \end{array}$$

=> **CHECKING:-**

=> $(11)_2$

=> $1 \times 2^1 + 1 \times 2^0$

=> $2 + 1$

=> 3

=> $(10)_2$

=> $1 \times 2^1 + 0 \times 2^0$

=> 2

$= 3 - 2 = \boxed{1}$

$\Rightarrow (01)_2$

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

$\Rightarrow \boxed{1}$

Q. substract 100 from 111

Sol:

$$\begin{array}{r} 1\ 1\ 1 \\ -\ 1\ 0\ 0 \\ \hline 0\ 1\ 1 \\ \hline \end{array} \quad \begin{array}{r} = 7 \\ = -4 \\ \hline = 3 \\ \hline \end{array}$$

CHECKING:-

$\Rightarrow (111)_2$

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

$\Rightarrow 4 + 2 + 1$

$\Rightarrow 7$

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$\Rightarrow (100)_2$

$\Rightarrow 1\times2^2 + 0\times2^1 + 0\times2^0$

$\Rightarrow 4+0+0$

$\Rightarrow 4$

$\Rightarrow 7-4 = \boxed{3}$

$\Rightarrow (011)_2$

$\Rightarrow 0\times2^2 + 1\times2^1 + 1\times2^0$

$\Rightarrow 0+2+1$

$\Rightarrow \boxed{3}$

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EXAMPLE 2-9

Q. substract 011 from 101

Sol:

$$\begin{array}{r} 101 \\ -011 \\ \hline 10 \end{array} \quad \begin{array}{r} = 5 \\ = -3 \\ \hline = 2 \end{array}$$

=> **CHECKING:-**

=> $(101)_2$

=> $1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$

=> $4 + 0 + 1$

=> 5

=> $(011)_2$

=> $0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$

=> $2 + 1 = 3$

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$= 5-3 = \boxed{2}$

$\Rightarrow (10)_2$

$\Rightarrow 1\times2^1 + 0\times2^0$

$\Rightarrow 2+0$

$= \boxed{2}$

Q. substract 101 from 110

Sol:

$$\begin{array}{r} 1\cancel{1}10 \\ -\ 101 \\ \hline 001 \end{array} \quad \begin{array}{r} =6 \\ =-5 \\ \hline =1 \end{array}$$

$\Rightarrow$ **CHECKING:**

$\Rightarrow (110)_2$

$\Rightarrow 1\times2^2 + 1\times2^1 + 0\times2^0$

$\Rightarrow 4+2+0$

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$= 6$

$\Rightarrow (101)_2$

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

$\Rightarrow 4 + 0 + 1$

$\Rightarrow 5$

$6 - 5 = \boxed{1}$

$\Rightarrow (001)_2$

$\Rightarrow 1 \times 2^0$

$= \boxed{1}$

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Scanned with CamScanner

SECTION 2-4

2. perform the following binary addition.

(a) 1101 + 1010

Sol:

$$\begin{array}{r} 1101 \\ +\ 1010 \\ \hline 10111 \end{array} \quad \begin{array}{r} =13 \\ =+10 \\ \hline =23 \end{array}$$

CHECKING:-

=> $(1101)_2$

=> $1\times2^3+1\times2^2+0\times2^1+1\times2^0$

=> $8+4+0+1$

=> 13

$\Rightarrow (1010)_2$

$\Rightarrow 1\times2^3+0\times2^2+1\times2^1+0\times2^0$

$\Rightarrow 8+0+2+0$

$\Rightarrow 10$

$\Rightarrow 13+10=\boxed{23}$

$\Rightarrow (10111)_2$

$\Rightarrow 1\times2^4+0\times2^3+1\times2^2+1\times2^1+1\times2^0$

$\Rightarrow 16+4+2+1$

$\Rightarrow \boxed{23}$

(b)

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(b) 10111 + 01101

Sol:

$$
\begin{array}{r}
\scriptstyle 1\ 1\ 1\ 1 \\
1\ 0\ 1\ 1\ 1 \\
+\ 0\ 1\ 1\ 0\ 1 \\
\hline
1\ 0\ 0\ 1\ 0\ 0 \\
\hline
\end{array}
\qquad
\begin{array}{r}
= 23 \\
= +13 \\
\hline
36 \\
\hline
\end{array}
$$

CHECKING:-

=> $(10111)_2$

=> $1\times2^4 + 0\times2^3 + 1\times2^2 + 1\times2^1 + 1\times2^0$

=> $16 + 0 + 4 + 2 + 1$

=> 23

=> $(01101)_2$

=> $0\times2^4 + 1\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0$

=> $8 + 4 + 1$ => 13

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$\Rightarrow 23+13 = \boxed{36}$

$\Rightarrow (100100)_2$

$\Rightarrow 1\times2^5 + 0\times2^4 + 0\times2^3 + 1\times2^2 + 0\times2^1 + 0\times2^0$

$\Rightarrow 32 + 4$

$\Rightarrow \boxed{36}$

Q.2: perform the following binary substraction:

a) 1101 - 0100

Sol:

$$\begin{array}{r} 1101 \\ -\ 0100 \\ \hline 1001 \end{array}$$

$\Rightarrow$ CHECKING:

Scanned with CamScanner

$\Rightarrow (1101)_2$

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

$\Rightarrow 8 + 4 + 0 + 1$

$\Rightarrow 13$

$\Rightarrow (0100)_2$

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

$\Rightarrow 0 + 4 + 0 + 0$

$\Rightarrow 4$

$\Rightarrow 13 - 4 = \boxed{9}$

$\Rightarrow (1001)_2$

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

$\Rightarrow 8 + 0 + 0 + 1 \quad \boxed{= 9}$

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(b) 1001 - 0111

Sol:-

$$\begin{array}{r} 1001 \\ -\ 0111 \\ \hline 0010 \\ \hline \end{array}$$

=> CHECKING:-

=> $(1001)_2$

=> $1\times2^3 + 0\times2^2 + 0\times2^1 + 1\times2^0$

=> $8+0+0+1$

=> 9

=> $(0111)_2$

=> $0\times2^3 + 1\times2^2 + 1\times2^1 + 1\times2^0$

=> $0+4+2+1$

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= 7

= 9 - 7 = $\boxed{2}$

=> $(0010)_2$

=> $0 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$

=> $0 + 0 + 2 + 0$

=> $\boxed{2}$

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⇒ 1's And 2's Compliment Of A Binary Number:-

⇒ 1's compliment and 2's compliment of a binary number is very important because they permit the representation of negative numbers.

⇒ 1's Compliment:

⇒ 1's compliment is found by changing all 0's to 1's and 1's to 0's

⇒ 2's COMPLIMENT:-

⇒ 2's compliment is found by adding 1 to the L.S.B of the 1's compliment.

2's compliment = (1's compliment) + 1

EXAMPLE 2-12

Q. Find the 2's compliment of 10110010

10110010

↓

01001101 (1's compliment)

+1

01001110 (2's compliment)

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Q. Determine the 2's compliment of 11001011

Sol:

1 1 0 0 1 0 1 1

0 0 1 1 0 1 0 0 (1's complimen

+ 1

0 0 1 1 0 1 0 1 (2's complime

Q. Find the 2's compliment of 10111000

Sol:

1 0 1 1 1 0 0 0

0 1 0 0 0 1 1 1 (1's complimen

+ 1

0 1 0 0 1 0 0 0 (2's complime

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SECTION 2-5

Q. Determine the 1's compliment of each binary number.

(a) 00011010

Sol:-

00011010

=> 11100101 (1's compliment)

(b) 11110111

Sol:

=> 11110111

=> 00001000 (1's compliment).

(c) 10001101

Sol:

=> 10001101

=> 01110010 (1's compliment)

Q.2 Determine the 2's compliment of each binary number.

(a) 00010110

Sol:

=> 00010110

=> 11101001 (1's compliment)

$$\begin{array}{r} 11101001 \\ +1 \\ \hline 11101010 \end{array}$$ (2's compliment)

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=> Alternate method:-

=> 00010110

=> $\underbrace{11101}_{\text{1's compliment of original bits}}\underbrace{010}_{\text{These bits stay the same}}$ (2's compliment)

(b) 11111100

Sol:

=> 11111100

=> 00000011 (1's compliment)

$$\begin{array}{r} 00000011 \\ +\ 1 \\ \hline 00000100 \end{array}$$ (2's compliment)

=> Alternate method.

=> 11111100

=> $\underbrace{00000}_{\text{1's compliment of original bits}}\underbrace{100}_{\text{These bits stay the same}}$ (2's compliment)

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(C) 10010001

<u>Sol:</u>

=> 10010001

=> 01101110 (1's compliment)

$$\begin{array}{r} 01101110 \\ +1 \\ \hline 01101111 \\ \hline \end{array}$$ (2's compliment)

=> Alternatē method.

=> 10010001

=> $\underbrace{0110111}_{\text{1's compliment of original bits}}\ \underset{\text{This bit stay the same}}{\underset{\downarrow}{1}}$ (2's compliment)

SIGN

=> A sign
of bo
informatio

=> The s
the num

=> Magnit
number

=> There
sign in
represen

=> sign r

=> 1's c

=> 2's c

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SIGNED BINARY NUMBERS

=> A signed binary number consists of both sign and magnitude information

=> The sign indicates whether the number is positive or negative

=> Magnitude is the value of the number.

=> There are three forms in which sign integer whole number can be represented.

=> sign magnitude form → least used.

=> 1's compliment

=> 2's compliment. → Most important.

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SIGN BIT:-

The leftmost bit in a signed binary number is the sign bit, which tells You whether the number is positive or negative

- 0 sign bit, indicates a positive number
- 1 sign bit, indicates a negative number.

SIGN MAGNITUDE FORM:

=> When a signed binary number is represented in sign magnitude the left most bit is the sign bit and the remaining bits are the magnitude bit

$$\underset{\text{sign}}{0}\underbrace{0011001}$$

NOTE:

> In sign magnitude form, a negative number has the same magnitude bits as the corresponding positive number but the sign bit is 1 rather than zero.

1's COMPLIMENT FORM:.

- positive numbers in 1's compliment form are represented the sameway as the positive sign-magnitude numbers.

- In the 1's compliment form, negative number is the 1's compliment of the corresponding positive number.

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2's COMPLIMENT FORM:

=> positive number in the 2's compliment form is represented the same way as in the sign magnitude and 1's compliment forms.

=> negative numbers are the 2's compliment of the corresponding positive numbers

Q. Express +58 as an 8 bit.

2	58	– 0
2	29	– 1
2	14	– 0
2	7	– 1
2	3	– 1
	1	

L.S.B

1 → M.S.B

$\Rightarrow$ $\underset{\substack{\text{sign}\\\text{bit}}}{0}\ \underbrace{0\,1\,1\,1\,0\,1\,0}_{\text{Magnitude bit}}$

Q. Express $\underbrace{-58 \text{ as an } 8 \text{ bit}}_{\text{means 2's compliment}}$

2	58	– 0
2	29	– 1
2	14	– 0
2	7	– 1
2	3	– 1
	1	

$\Rightarrow$ 0 0 1 1 1 0 1 0

$\Rightarrow$

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SIGN- MAGNITUDE FORM:

$$\Rightarrow \underset{\substack{\downarrow \\ \text{sign bit}}}{1}\underbrace{0111010}_{\text{Magnitude bit}}$$

⇒ 1's COMPLIMENT

⇒ 1 1 0 0 0 1 0 1

⇒ 2's COMPLIMENT :-

$$\begin{array}{r} 11000101 \\ +\ 1 \\ \hline 11000110 \\ \hline \end{array}$$

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EXAMPLE 2-14

Express the decimal number -39 as an 8 bit number in the sign magnitude, 1's compliment and 2's compliment.

SIGN MAGNITUDE FORM:

2	39	1
2	19	1
2	9	1
2	4	0
2	2	0
	1	

(0 0 1 0 0 1 1 1)

$\Rightarrow$ $(\underbrace{1}_{\text{sign bit}}\underbrace{0100111}_{\text{Magnitude bit}})$

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1's COMPLIMENT:-

=> 1 1 0 1 1 0 0 0

2's COMPLIMENT:-

$$
\begin{array}{r}
11011000 \\
+\ 1 \\
\hline
11011001 \\
\hline
\end{array}
$$

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Q.

Express -19 as 8 bit numbers in sign-magnitude, 1's compliment and 2's compliment.

SIGN MAGNITUDE FORM:

2	19	-1
2	9	-1
2	4	-0
2	2	-0
	1	

0 0 0 1 0 0 1 1

$$\Rightarrow \underset{\substack{\downarrow \\ \text{sign} \\ \text{bit}}}{\underline{1}}\ \underbrace{0\ 0\ 1\ 0\ 0\ 1\ 1}_{\text{Magnitude bit}}$$

1's COMPLIMENT:

= 1 1 1 0 1 1 0 0

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2's COMPLIMENT:

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

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HEXA DECIMAL TO DECIMAL CONVERSION

=> There are two ways to find decimal equivalent of a hexa decimal number.

=> One way to find the decimal equivalent of a hexa decimal number is to first convert the hexadecimal number to binary and then binary to decimal

=> The second way to find the decimal equivalent of a hexadecimal number is by "sum of weight" method.

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EXAMPLE 2-26

convert the following hexadecimal numbers to decimal

(a) $1C_{16}$

Sol:-

METHOD: 01

$\Rightarrow (1C)_{16} \longrightarrow (\quad)_2$

$1 \longrightarrow 0001$

$C \rightarrow 12 \rightarrow 1100$

$\Rightarrow (00011100)_2 \longrightarrow (\quad)_{10}$

$= 0 \times 2^5 + 1 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 0 \times 2^0$

$0 \times 2^7 + 0 \times 2^6 +$

$\Rightarrow 16 + 8 + 4 \Rightarrow \boxed{28}$ //

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METHOD: 02

$\Rightarrow 1 \times 16^1 + 12 \times 16^0$

$\Rightarrow 16 + 12$

$= (28)_{10}$

(b) $A85_{16}$

<u>Sol:</u>

METHOD: 01

$(A85)_{16} \longrightarrow (\quad)_2$

$\Rightarrow A \longrightarrow 10 \longrightarrow 1010$

$\Rightarrow 8 \longrightarrow 1000$

$\Rightarrow 5 \longrightarrow 0101$

$= (101010000101)_2 \longrightarrow (\quad)_{10}$

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$\Rightarrow + 0\times2^4 + 0\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0$

$1\times2^9 + 0\times2^8 + 1\times2^7 + 0\times2^6 + 0\times2^5$

$1\times2^{11} + 0\times2^{10} +$

$\Rightarrow (2693)_{10}$

METHOD : 02

$\Rightarrow \quad 10\times16^2 + 8\times16^1 + (5\times16^0)$

$\Rightarrow \quad 2560 + 128 + 5$

$\Rightarrow \quad (2693)_{10}$

c) $(6BD)_{16}$

Sol:.

=> **METHOD: 01**

$(6BD)_{16} \longrightarrow (\quad)_2$

=> $6 \longrightarrow 0110$

=> $B \rightarrow 11 \longrightarrow 1011$

=> $D \rightarrow 13 \longrightarrow 1101$

=> $(011010111101)_2 \longrightarrow (\quad)_{10}$

=> $+ 1\times2^4 + 1\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0$

$1\times2^{10} + 1\times2^9 + 0\times2^8 + 1\times2^7 + 0\times2^6 + 1\times2^5$

$0\times2^{11} +$

=> $(1725)_{10}$

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METHOD:02

$\Rightarrow \quad 6 \times 16^2 + 11 \times 16^1 + 13 \times 16^0$

$\Rightarrow \quad 1536 + 176 + 13$

$\Rightarrow \quad (1725)_{10}$

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EXAMPLE 2-27

convert the following hexadecimal numbers to decimal.

(a) $(E5)_{16}$

Sol:

=> METHOD: 01

=> $(E5)_{16} \longrightarrow (\quad)_2$

=> $E = 14 \longrightarrow 1110$

=> $5 \longrightarrow 0101$

=> $(1110\ 0101)_2 \rightarrow (\quad)_{10}$

=> $1 \times 2^7 + 1 \times 2^6 + 1 \times 2^5 + 0 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$

=> $(229)_{10}$

=> **METHOD : 02**

=> $14 \times 16^1 + 5 \times 16^0$

=> $224 + 5$

=> $(229)_{10}$

ii) $(B2F8)_{16}$

<u>Sol:</u>

=> **METHOD : 01**

=> $(B2F8)_{16} \longrightarrow (\quad\quad)_2$

=> $B \rightarrow 11 \rightarrow 1011$

=> $2 \longrightarrow 0010$

=> $F \longrightarrow 15 \rightarrow 1111$

=> $8 \longrightarrow 1000$

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$\Rightarrow (1011001011111000)_2$

$\Rightarrow +1\times 2^5 + 1\times 2^4 + 1\times 2^3 + 0\times 2^2 + 0\times 2^1 + 0\times 2^0$
$0\times 2^{11} + 0\times 2^{10} + 1\times 2^9 + 0\times 2^8 + 1\times 2^7 + 1\times 2^6$
$1\times 2^{15} + 0\times 2^{14} + 1\times 2^{13} + 1\times 2^{12} +$

$\Rightarrow (45816)_{10}$

METHOD:02

$\Rightarrow 11\times 16^3 + 2\times 16^2 + 15\times 16^1 + 8\times 16^0$

$\Rightarrow (45816)_{10}$

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(iii) $(60A)_{16}$

Sol:-

METHOD:01

$\Rightarrow (60A)_{16} \longrightarrow (\quad)_2$

$\Rightarrow 6 \longrightarrow 0110$

$\Rightarrow 0 \longrightarrow 0000$

$\Rightarrow A \rightarrow 10 \rightarrow 1010$

$\Rightarrow (011000001010)_2 \longrightarrow (\quad)_{10}$

$\Rightarrow 0\times 2^4 + 1\times 2^3 + 0\times 2^2 + 1\times 2^1 + 0\times 2^0 + 0\times 2^8 + 0\times 2^7 + 0\times 2^6 + 0\times 2^5 + 0\times 2^{11} + 1\times 2^{10} + 1\times 2^9$

$\Rightarrow (1546)_{10}$

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METHOD : 02

$\Rightarrow \quad 6 \times 16^2 + 0 \times 16^1 + 10 \times 16^0$

$\Rightarrow \quad 1536 + 0 + 10$

$\Rightarrow \quad (1546)_{10}$

<u>Lecture question</u>

i) $(1AF)_{16} \longrightarrow (\quad)_{10}$

<u>Sol:</u>

$\Rightarrow$ METHOD : 01

$\Rightarrow \quad (1AF)_{16} \longrightarrow (\quad)_2$

$1 \longrightarrow 0001$

$A \longrightarrow 10 \longrightarrow 1010$

$F \rightarrow 15 \rightarrow 1111$

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$$(000110101111)_2 \rightarrow (\quad)_{10}$$

$$\Rightarrow (000110101111)_2$$

$$\Rightarrow + 0\times 2^4 + 1\times 2^3 + 1\times 2^2 + 1\times 2^1 + 1\times 2^0$$
$$+ 0\times 2^9 + 1\times 2^8 + 1\times 2^7 + 0\times 2^6 + 1\times 2^5$$
$$0\times 2^{11} + 0\times 2^{10}$$

$$\Rightarrow (431)_{10}$$

METHOD : 02

$$\Rightarrow 1\times 16^2 + 10\times 16^1 + 15\times 16^0$$

$$\Rightarrow (431)_{10}.$$

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DECIMAL TO HEXADECIMAL CONVERSION

⇒ Repeated division of a decimal number by 16 will produce the equivalent hexadecimal number, formed by the remainders of the division.

⇒ The first remainder produced is the (L.S.D).
↳ least significant digit

⇒ Each successive division by 16 yields a remainder that becomes a digit in the equivalent hexadecimal number.

⇒ Note that when a quotient has a fractional part, the fractional part is multiplied by the divisor to get the remainder.

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EXAMPLE 2-28

convert the decimal number 650 to hexadecimal.

i) $(650)_{10} \rightarrow (\quad)_{16}$

16	650
16	40
16	2
	0.125

↳ stop when the whole number quotient is zero

$40.625 = 0.625 \times 16 = 10$ → L.S.D

$2.5 = 0.5 \times 16 = 8$

$0.125 \times 16 = 2$

M.S.D

$= (28A)_{16}$.

ii) $(2591)_{10} \rightarrow (\quad)_{16}$

16	2591
16	161
16	10
	0.625

↳ stop when the whole number quotient is zero

L.S.D

$161.9375 = 0.9375 \times 16 = 15$

$10.0625 = 0.0625 \times 16 = 1$

$0.625 \times 16 = 10$

M.S.D

$(A1F)_{16}$.

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OCTAL TO DECIMAL

CONVERSION

=> The way to find the find the decimal equivalent of a octal number is "sum of weight" method.

Q. convert octal number 2374 into decimal.

=> $(2374)_8 \longrightarrow (\quad)_{10}$

=> $2 \times 8^3 + 3 \times 8^2 + 7 \times 8^1 + 4 \times 8^0$

=> $(1276)_{10}$

2.9

ii) $(73)_8 \rightarrow (\quad)_{10}$

Sol:

=> $7 \times 8^1 + 3 \times 8^0$

=> $56 + 3$ => $(59)_{10}$

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iii) $(125)_8 \rightarrow (\quad)_{10}$

Sol:

$\Rightarrow \quad 1 \times 8^2 + 2 \times 8^1 + 5 \times 8^0$

$\Rightarrow \quad 64 + 16 + 5$

$\Rightarrow \quad (85)_{10}$.

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DECIMAL TO OCTAL CONVERSION:-

⇒ A method of converting a decimal number to an octal number is the repeated division by 8 method, which is similar to method used in conversion of decimal to binary or to hexadecimal.

⇒ Each successive division by 8 Yields a remainder that becomes a digit in the equivalent octal number.

⇒ The first remainder generated is the least significant digit. (L.S.D).

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Q.

convert 359 decimal number to octal

8	359
8	44
8	5
	0.625

$44.875 = 0.875 \times 8 = 7$ → L.S.D

$5.5 = 0.5 \times 8 = 4$

$0.625 \times 8 = 5$ → M.S.D

↳ stop when the whole number quotient is zero

$(547)_8$.

ii) $(98)_{10} \longrightarrow (\quad)_8$

Sol:-

8	98
8	12
8	1
	0.125

$12.25 = 0.25 \times 8 = 2$ → L.S.D

$1.5 = 0.5 \times 8 = 4$

$0.125 \times 8 = 1$ → M.S.D

↳ stop when the whole number quotient is zero.

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$\Rightarrow (142)_8$

iii) $(163)_{10} \rightarrow (\quad)_8$

Sol:-

8	163	$20.375 : 0.375 \times 8 = 3$ L.S.D
8	20	$2.5 : 0.5 \times 8 = 4$
8	2	$0.25 \times 8 = 2$ M.S.D
	0.25	

$(243)_8$

Stop when the whole number quotient is zero.

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OCTAL TO BINARY

CONVERSION

=> each octal digit can be represented by a 3 bit binary number, it is very easy to convert from octal to binary.

EXAMPLE 2-31

(a) $(13)_8 \longrightarrow (\quad)_2$

Sol:-

$1 \rightarrow 001$

$3 \rightarrow 011$

$\Rightarrow (001011)_2$

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b) $(25)_8 \rightarrow (\quad)_2$

d)

Sol:-

$2 \rightarrow 010$

$5 \rightarrow 101$

$\Rightarrow (010101)_2$

c) $(140)_8 \rightarrow (\quad)_2$

Sol:-

$\Rightarrow 1 \rightarrow 001$

$\Rightarrow 4 \rightarrow 100$

$\Rightarrow 0 \rightarrow 000$

$\Rightarrow (001100000)_2$

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d) $(7526)_8 \rightarrow (\quad)_2$

Sol:

=> $7 \longrightarrow 111$

=> $5 \longrightarrow 101$

=> $2 \longrightarrow 010$

=> $6 \longrightarrow 110$

=> $(111101010110)_2$

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⇒ BINARY TO OCTAL

CONVERSION:

⇒ conversion of binary number to an octal number is the reverse of octal to binary conversion.

⇒ Start with the right most group of three bits and moving from right to left convert each three bit group to the octal equivalent.

⇒ If there are not three bits available for the left most group, add either one or two zeros to make a complete group.

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EXAMPLE 2-32

Q. convert each of the following binary number to octal.

a) 110101

Sol:

=> $\underbrace{110}_{6}\ \underbrace{101}_{75}$

=> $(675)_8$

b) 101111001

Sol:-

=> $\underbrace{101}_{5}\ \underbrace{111}_{7}\ \underbrace{001}_{1}$

=> $(571)_8$

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(c) 100110011010

Sol:-

$\Rightarrow \underbrace{100}_{4} \ \underbrace{110}_{6} \ \underbrace{011}_{3} \ \underbrace{010}_{2}$

$\Rightarrow (4632)_8$

d) 11010000100

Sol:

$\Rightarrow \underbrace{011}_{3} \ \underbrace{010}_{2} \ \underbrace{000}_{0} \ \underbrace{100}_{4}$

$\Rightarrow (3204)_8$

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e) 1010101000111110010

Sol:

$\Rightarrow \underbrace{001}_{1}\ \underbrace{010}_{2}\ \underbrace{101}_{5}\ \underbrace{000}_{0}\ \underbrace{111}_{7}\ \underbrace{110}_{6}\ \underbrace{010}_{2}$

$\Rightarrow (1250762)_8$

8421 BCD Code:

⇒ Binary coded decimal (BCD) is a way to express each of the decimal digits with a binary code.

⇒ Binary coded decimal means that each decimal digit, 0 through 9, is represented by a binary code of four bits.

Q convert each of the following decimal number to BCD.

(a) 35 (b) 98 (c) 170

(d) 2469

(a) 35

Sol:-

$3 \longrightarrow 0011$

$5 \longrightarrow 0101$

$= (00110101)_2$

(b) 98

Sol:-

$9 \longrightarrow 1001$

$8 \longrightarrow 1000$

$\Rightarrow (10011000)_2$

(c) 170

Sol:

$1 \longrightarrow 0001$

$7 \longrightarrow 0111$

$0 \longrightarrow 0000$

$\Rightarrow (000101110000)_2$

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(d) 2469

Sol:-

=> $2 \longrightarrow 0010$

=> $4 \longrightarrow 0100$

=> $6 \longrightarrow 0110$

=> $9 \longrightarrow 1001$

=> $(0010010001101001)_2$

e) 9673

Sol:-

=> $9 \longrightarrow 1001$

=> $6 \longrightarrow 0110$

=> $7 \longrightarrow 0111$

=> $3 \longrightarrow 0011$

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=> $(1001011001110011)_2$

BCD To DECIMAL :-

=> It is equally easy to determine a decimal number from a BCD number. Start at the right most bit and break the code into group of four bits. Then write the decimal digit represented by each 4-bit group.

Q. convert each of the following BCD codes to decimal.

(a) 10000110

Sol:

=> $\underbrace{1000}_{8}\ \underbrace{0110}_{6}$ => $(86)_{10}$

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(b) 001101010001

Sol:

$\Rightarrow \underbrace{0011}_{3}\ \underbrace{0101}_{5}\ \underbrace{0001}_{1}$

$\Rightarrow (351)_{10}$

(C) 1001010001110000

Sol:-

$\Rightarrow \underbrace{1001}_{9}\ \underbrace{0100}_{4}\ \underbrace{0111}_{7}\ \underbrace{0000}_{0}$

$\Rightarrow (9470)_{10}$.

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(a) 1000001000100111 0110

Sol:

$\Rightarrow \underbrace{1000}_{8}\ \underbrace{0010}_{2}\ \underbrace{0010}_{2}\ \underbrace{0111}_{7}\ \underbrace{0110}_{6}$

$\Rightarrow (82276)_{10}$.

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LOGIC GATES:-

- Logic gates are fundamental building blocks of digital system. These devices are able to make decisions, in the sense that they produce one output level when some combinations of input levels are present and a different output when other combinations are applied.

- The two levels produced by digital circuitary are referred to variously as HIGH and LOW, TRUE and FALSE, ON and OFF, and simply 0 and 1.

TYPES OF LOGIC GATES:

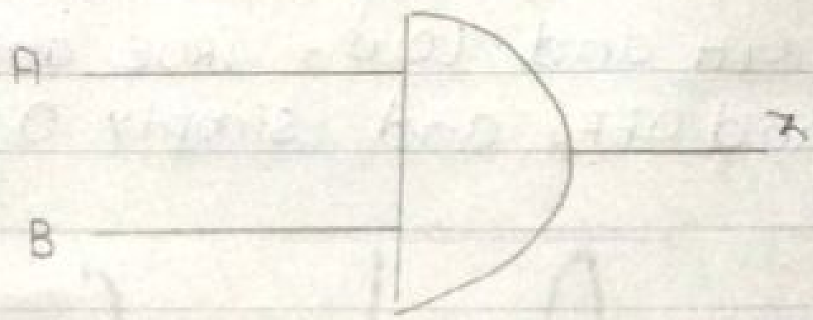
- AND Gate
- OR Gate
- NOT Gate
- NOR Gate
- NAND Gate
- XOR Gate
- XNOR Gate.

⇒ And Gate :-

An And's gate output is "1" Iff an only Iff its all inputs are "1". Otherwise the output will be '0'.

⇒ FOR TWO INPUTS

· LOGICAL DIAGRAM :-



· BOOLEAN EXPRESSION :-

$Z = A \cdot B$

· TRUTH TABLE

A	B	$Z = A \cdot B$
0	0	0
0	1	0
1	0	0
1	1	1

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FOR THREE INPUTS :-

LOGICAL DIAGRAM :-

BOOLEAN EXPRESSION :-

$Z = A \cdot B \cdot C$

TRUTH TABLE :-

A	B	C	$Z = A \cdot B \cdot C$
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

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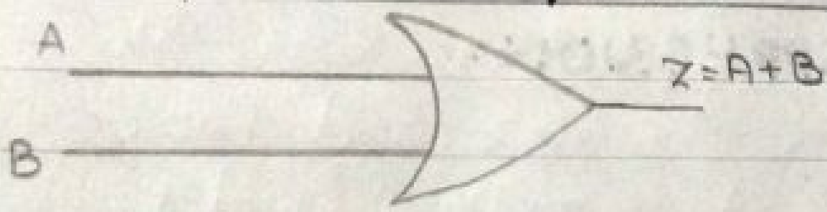
Or Gate:-

An Or's gate output is '0' iff and only iff its all inputs are '0' otherwise the output will be '1'.

FOR TWO INPUTS:-

LOGICAL DIAGRAM:-



BOOLEAN EXPRESSION:-

$Z = A + B$

TRUTH TABLE:-

A	B	Z=A+B
0	0	0
0	1	1
1	0	1
1	1	1

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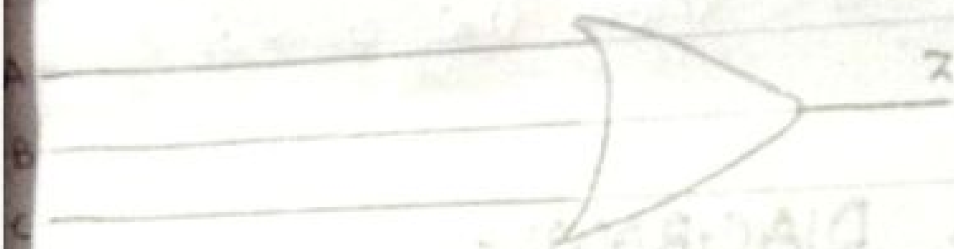
· FOR THREE INPUTS:-

LOGICAL DIAGRAM:



BOOLEAN EXPRESSION:-

$Z = A + B + C$

TRUTH TABLE:-

A	B	C	Z = A+B+C
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

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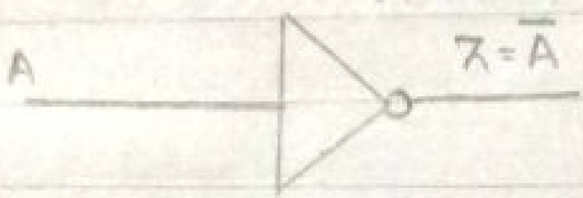
NOT GATE:-

Not gate is simply an inverter. If the input is '1' then the output will be '0'. If the input is '0' then the output will be '1'.

LOGICAL DIAGRAM:-



BOOLEAN EXPRESSION:-

$Z = \overline{A}$

TRUTH TABLE:-

A	$Z = \overline{A}$
0	1
1	0

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⇒ NOR GATE:-

A Nor's gate output is "high" If and only Iff its all inputs are 'zero' otherwise "low"

• **LOGICAL DIAGRAM:-**

• **BOOLEAN EXPRESSION:**

$Z = \overline{A+B}$

• **TRUTH TABLE:-**

A	B	A+B	$Z = \overline{A+B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

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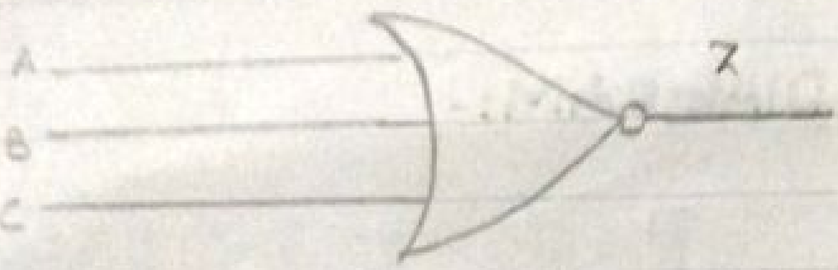
• For Three Inputs:-

• Logical Diagram:-



• Boolean Expression:-

$Z = \overline{A+B+C}$

• Truth Table:-

A	B	C	A+B+C	$Z = \overline{A+B+C}$
0	0	0	0	1
0	0	1	1	0
0	1	0	1	0
0	1	1	1	0
1	0	0	1	0
1	0	1	1	0
1	1	0	1	0
1	1	1	1	0

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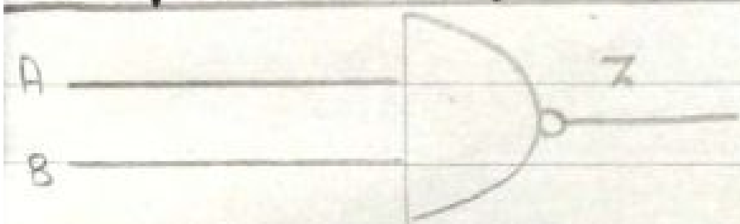
=> NAND GATE:-

A nand's gate output is '0' iff and only iff its on all inputs are '1' otherwise the output will be '1'

FOR TWO INPUTS:-

LOGICAL DIAGRAM:



BOOLEAN EXPRESSION:-

$Z = \overline{A \cdot B}$

• TRUTH TABLE:-

A	B	$A \cdot B$	$\overline{A \cdot B}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

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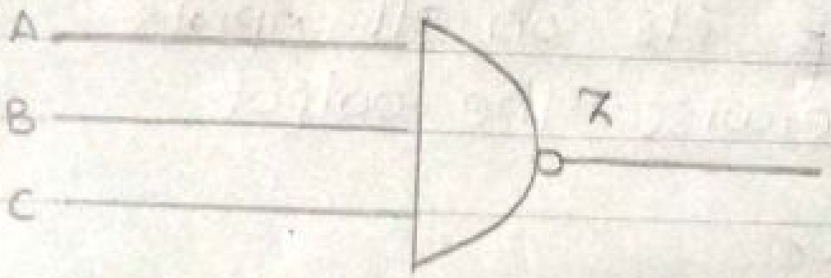
FOR THREE INPUTS

LOGICAL DIAGRAM:-



BOOLEAN EXPRESSION:-

$Z = \overline{A \cdot B \cdot C}$

TRUTH TABLE:-

A	B	C	$A \cdot B \cdot C$	$Z = \overline{ABC}$
0	0	0	0	1
0	0	1	0	1
0	1	0	0	1
0	1	1	0	1
1	0	0	0	1
1	0	1	0	1
1	1	0	0	1
1	1	1	1	0

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Ex-OR Gate:-

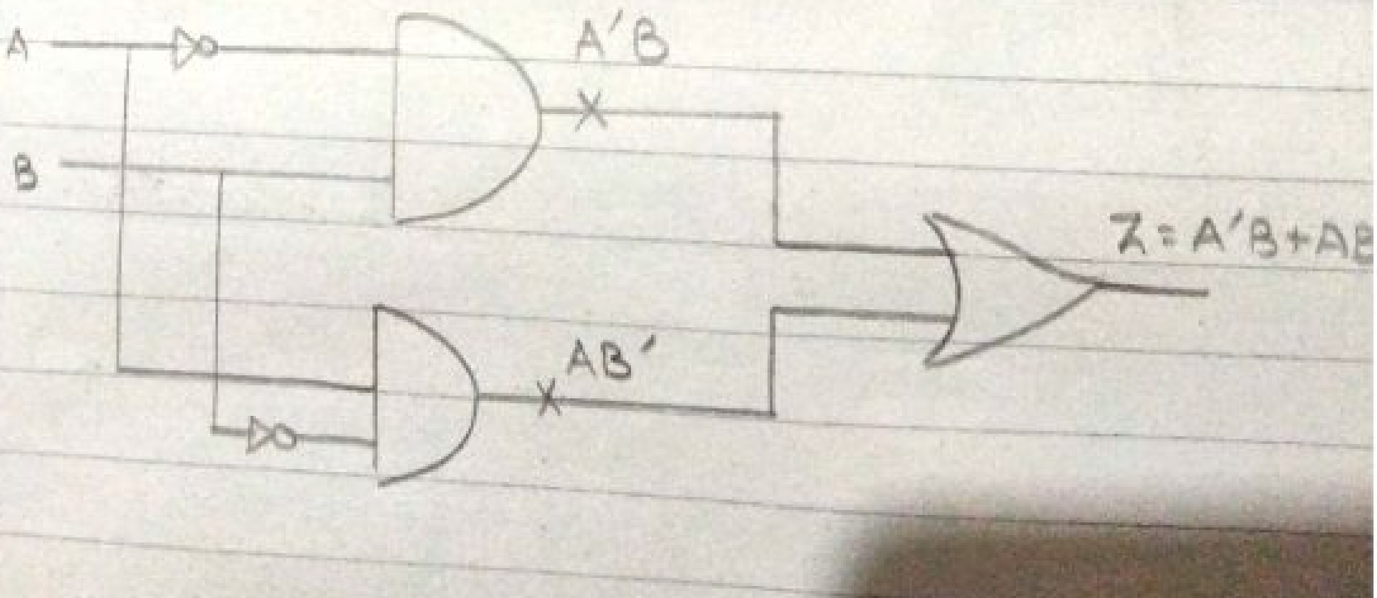
Logical Diagram:-

Boolean Expression:-

$Z = A \oplus B$

Equivalent Circuit:-

$Z = A'B + AB'$



TRUTH TABLE:

A	B	A′	B′	A′B	AB′	Z = A′B + AB′
0	0	1	1	0	0	0
0	1	1	0	1	0	1
1	0	0	1	0	1	1
1	1	0	0	0	0	0

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Ex-NOR Gate:-

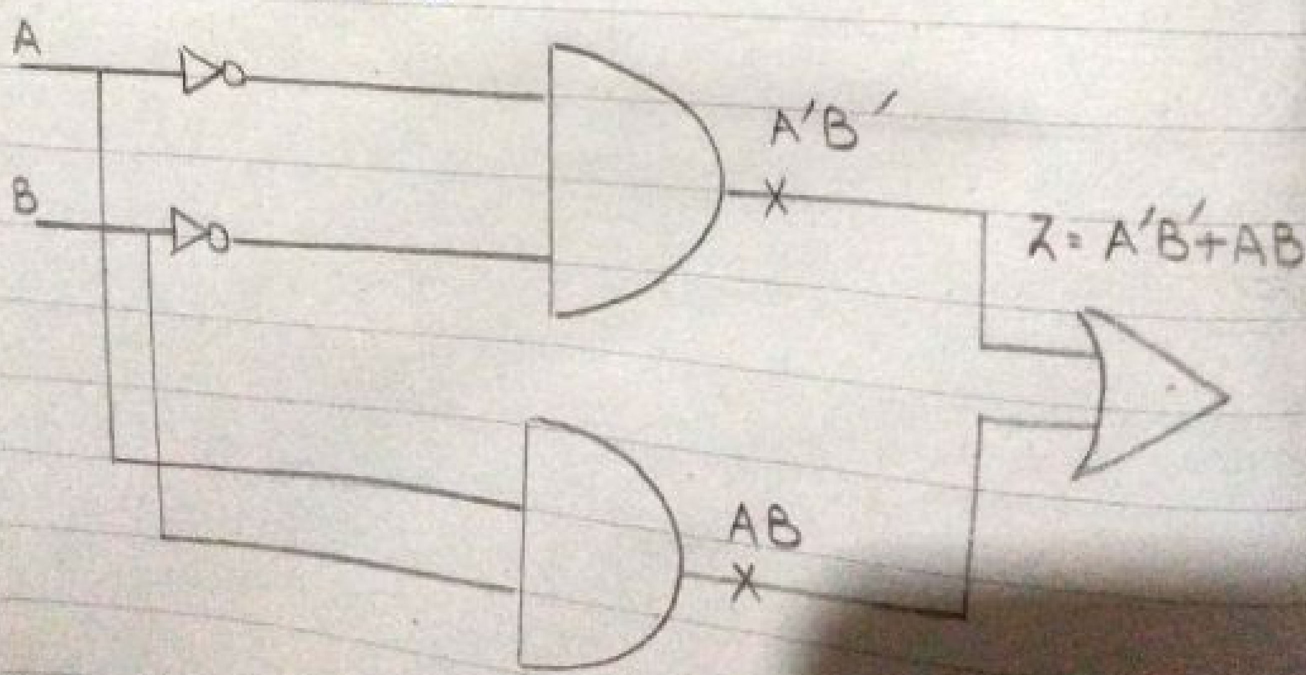
LOGICAL DIAGRAM:-

BOOLEAN EXPRESSION:-

$Z = \overline{A \oplus B}$

EQUIVALENT CIRCUIT:-

$Z = A'B' + AB$



TRUTH TABLE

A	B	A'	B'	A'B'	AB	X
0	0	1	1	1	0	1
0	1	1	0	0	0	0
1	0	0	1	0	0	0
1	1	0	0	0	1	1

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