Decimal	Octal	Hexadecimal	Binary
0	0	0	0
1	1	:	01
2	2	9	10
3	3	A	11
4	4	B	100
5	5	C	101
6	6	D	:
7	7	E	:
8	10	F	
9	11	10	
10	12	:	
:	:	19	
	17	1A	
	20	:	
19	:	1F	
20	:	20	
:	:	:	
29	27	2F	

* Decimal to Binary

(i) Here, the decimal number is repeatedly divided by 2 till the quoitent becomes '0' and remainder after each division is used to indicate the coeffcient of binary number to be formed.
The binary numbers are written from bottom to top.

(ii) Last remainder is called MSB and first remainder is LSB.

(iii) If any fractional numbers are there then multiply the number repeatedly by 2 till the fractional part becomes zero.

$(41.8125)_{10} = (\quad)_2$

Read

$$\begin{array}{r|l}
2 & 41 \\
2 & 20 - 1 \\
2 & 10 - 0 \\
2 & 5 - 0 \\
2 & 2 - 1 \\
 & 1 - 0
\end{array}$$

1 (Least signifigant bit)

0 (Most signifigant bit) MSB

101001

Ans. 101001.1101

$0.8125 \times 2 = 1.6250$ 1 (MSB).

$0.6250 \times 2 = 1.2500$ 1

$0.2500 \times 2 = 0.5000$ 0

$0.5000 \times 2 = 1.0000$ 1 (LSB)

Binary to Decimal

→ Any binary number can be converted into its equivalent decimal number using weight assigned to each bit position.

Q. Convert $(101001.1101)_2 = (\quad)_{D/10}$

$2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$; $2^{-1}\ 2^{-2}\ 2^{-3}\ 2^{-4}$

$101001 = 1\times2^5 + 1\times2^3 + 1\times1 \,.\, 1\times2^{-1} + 1\times2^{-2} + 1\times2^{-4}$

$= 32 + 8 + 1$

$= 41 \,.\, \frac{1}{2} + \frac{1}{4} + \frac{1}{16}$

$= 41.(0.5 + 0.25 + \cancel{0.0625})$ 1/16

$= 41.8125$

* Decimal to Octal :-

In octal system base is 8,

① First divide the ~~octal~~ number repeatedly by 8, till the ~~quotient~~ quotient becomes '0' and record its remainder.

$(153)_{10} = (\quad)_8$

$$\begin{array}{r|l} 8 & 153 \\ 8 & 19 - 1 \text{ (LSB)} \\ 8 & 2 - 3 \\ & 0 - 2 \text{ (MSB)} \end{array}$$

(231)

$(153.26)_{10} = (231.2050)_8$

$0.26 \times 8 = 2.08$ ②
$0.08 \times 8 = 0.64$ ⓪
$0.64 \times 8 = 5.12$ ⑤
$0.12 \times 8 = 0.96$ ⓪

* Octal to Decimal

$(231.2050)_8 = (\quad)_{10}$

$= (2 \times 8^2 + 3 \times 8^1 + 1 \times 8^0 . 2 \times 8^{-1} + 0 + 5 \times 8^{-3} + 0)$
$= \underline{(153.26)}$.

* Decimal to Hexadecimal

$(489)_{10} = (\quad)_{16}$

$16 \,|\, 489$
$16 \,|\, 30 - 9$ (LSB)
$16 \,|\, 1 - E$
$0 \rightarrow 1$ (MSB)

$(1E9)_{16}$

* Hexadecimal to Decimal

$(1E9)_{16} = (\quad)_{10}$

$= (1 \times 16^2 + E \times 16^1 + 9 \times 16^0)$
$= (256 + 224 + 9) = \underline{489}$

* Octal Number to binary

$(237)_8 = (\quad)_2$

For converting octal to binary express each octal digits into its 3 bit binary notation.

$(2\ 3\ 7)_8 = (\quad)_2$

$(010 \quad 011 \quad 111)_2$

237 . 6 7
110 111

* Binary to Octal

$0(01101101101)_2 = (1555)_8$

$0.101011100 = (\quad)_8$

* Hexadecimal to binary

$(123A)_{16} = (\quad)_2$

0001 0010 0011 1010

* Binary to Hexadecimal

Addition in Number System

Binary

```
   1
 1 0 1 1 0 1
 1 0 0 0 0 1
(1 0 0 1 1 1 0)
```

0 + 0 = 0
0 + 1 = 1
1 + 0 = 1
1 + 1 = 1 0
carry

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

1

Q.

```
 1 1 1 1 1
 1 0 1 1 1 0 1 1
 1 0 1 0 1 0 1 1
1 0 1 1 0 0 1 1 0
```

1 0 1 1 0 0 1 1 0

2^5 2^4 2^3 2^2 2^1 2^0

1 0 1 1 0 1

1 0 0 1 1 1 0

32
8
4
1
45
+ 35
80

64
8
4
2
78

→ Octal addition

$(235)_8 + (164)_8 = (\quad)_8$

2	3	5
1	6	4
4	2	1

Direct

010	011	101
001	110	100
100 010		001

→ 4 2 1

through binary.

→ Hexadecimal addition

$(123A)_{16} + (EA45)_{16} = (\quad)_{16}$

1	2	3	A
E	A	4	5
F	C	7	F

0
1
2
3
4
5
6
7
8
9
A — 10
B — 11
C — 12
D — 13
E — 14
F — 15

Q. $(1567)_8 + (AECD)_{16} = (\quad)_{16}$

$(1567)_8 = (\quad)_{16}$

001 101 110 111

3 7 7

		3	7	7
+	A	E	C	D
	B	2	4	4

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Signed magnitude representation

(+5) (-5)

(0, 101) (1, 101)

$-20 = (1, \underbrace{10100}_{20})$

sign

1's complement.

$(-101101)_2$

1's → 010010
2's → 1's + 1
= 010011

$$\begin{array}{r} 010010 \\ 1 \\ \hline 010011 \end{array}$$

100100

$$\begin{array}{rr} \text{1's} \Rightarrow & 011011 \\ + & 1 \\ \hline & 011100 \end{array}$$

Q. Represent -9 in 8 bit signed magnitude representation, 1's complement, 2's complement

$2^3\ 2^2\ 2^1\ 2^0$
1 0 0 1

$-9 = (\ \ )_2$
$= (1, 0001001)_2$
$-9(1's) =$ 1, 1110110
$-9(2's) =$ 1, 10111

Binary Substraction :-

$(1000)_2$
 1 1

$0 - 0 = 0$
$1 - 1 = 0$
$1 - 0 = 1$
$0 - 1 = 1$

Substraction

The subtraction of unsigned number m-n in base r can be done as follows :

M → minued bit
N → Subtrarand bit.

(i) Both no. i.e. minued & substrand must have same number of digits, if it is not, add 0 to the left side of the number, add the minued 'm' to the RS complement of Subtrahand 'N'.

(ii) If m>n,

Q. 10's complement subtract (72532 - 3250)

M - N

M + (-N)

M → 72532

N → 03250

$$\begin{array}{r} 72532 \\ -\ \ 3250 \\ \hline 69282 \end{array}$$

10's of N →

$$\begin{array}{r} 9\ 9\ 9\ 10 \\ 0\ 3\ 2\ 5\ 0 \\ \hline 9\ 6\ 7\ 5\ 0 \end{array}$$

M + 10's of N

$$\begin{array}{r} 72532 \\ +\ 96750 \\ \hline 69282 \end{array}$$

Q. 3250 - 72532

M = 03250

N = 72532

10's of N = $\begin{array}{r} 9\ 9\ 9\ 9\ 10 \\ 72532 \\ \hline 2 \end{array}$

Q. 9's complement Subtract (72532 - 3250)

M = 72532 M + (-N)

N = 3250

$$\begin{array}{r} 72532 \\ -\ \ 3250 \\ \hline 69282 \end{array}$$

9's of N

$$\begin{array}{r} 9\ 9\ 9\ 9\ 9 \\ -\ 0\ 3\ 2\ 5\ 0 \\ \hline 9\ 6\ 7\ 4\ 9 \end{array}$$

M + 9's of N

$$\begin{array}{r} 7\ 2\ 5\ 3\ 2 \\ 9\ 6\ 7\ 4\ 9 \\ \hline 1\ 6\ 9\ 2\ 8\ 1 \end{array}$$

Q. (7188 - 3049) using complement method.

M - 7188

N - 3049

M > N

$$\begin{array}{r} 7188 \\ -3049 \\ \hline 4139 \end{array}$$

10's complement of N,

$$\begin{array}{cccc} 9 & 9 & 9 & 10 \\ 3 & 0 & 4 & 9 \\ \hline 6 & 9 & 5 & 1 \end{array}$$

M + 10's complement.

$$\begin{array}{ccccc} & 7 & 1 & 8 & 8 \\ & 6 & 9 & 5 & 1 \\ \hline 1 & 4 & 1 & 3 & 9 \end{array}$$

remove ← 1

Q. (2997 - 7992)

M = 2997

N = 7992

M < N.

10's complement of N, →

$$\begin{array}{cccc} 9 & 9 & 9 & 10 \\ 7 & 9 & 9 & 2 \\ \hline 2 & 0 & 0 & 8 \end{array}$$

M + 10's complement,

$$\begin{array}{cccc} 2 & 9 & 9 & 7 \\ 2 & 0 & 0 & 8 \\ \hline 5 & 0 & 0 & 5 \end{array}$$

10's complement

$$\begin{array}{ccccc} & 9 & 9 & 9 & 10 \\ & 5 & 0 & 0 & 5 \\ \hline - & 4 & 9 & 9 & 5 \end{array}$$

Q. $(11011 - 11001)_2$

M - 11011

N - 11001

2's complement - 00110
+ 1
00111

M + 2's compliment

1111
11011
00111
remove ← 1 00010

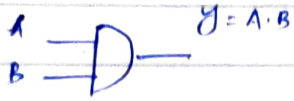
Q. 1011 - 110000.

$16 + 8 + 2 + 1 = 27$

$16 + 8 + 1 = 25$

LOGIC GATES

AND

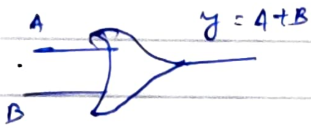


A	B	y
0	0	0
0	1	0
1	0	0
1	1	1

NOT

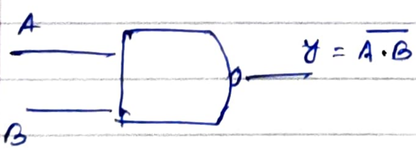
A	$\bar{A}$
0	1
1	0

OR



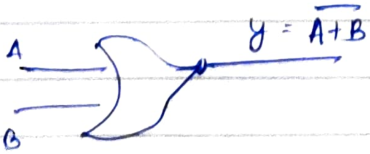
A	B	y
0	0	0
0	1	1
1	0	1
1	1	1

NAND



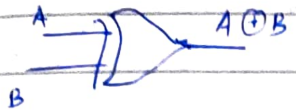
A	B	y
0	0	1
0	1	1
1	0	1
1	1	0

NOR



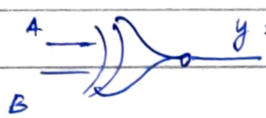
A	B	y
0	0	1
0	1	0
1	0	0
1	1	0

Ex-OR



A	B	$y = \bar{A}B + A\bar{B}$
0	0	0
0	1	1
1	0	1
1	1	0

Ex-NOR



$y = \overline{A \oplus B} = A \odot B$

A	B	$y = AB + \bar{A}\bar{B}$
0	0	1
0	1	0
1	0	0
1	1	1

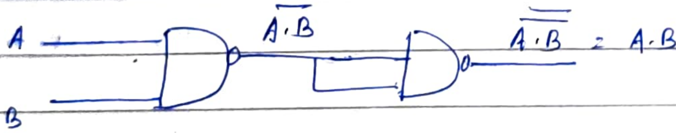
Basic gates

AND, OR, NOT, EX-OR, EX-NOR

Universal gates

NAND, NOR

Q. Design AND gate using NAND & NOR



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Boolean Algebra is used for sol^n of Boolean expression. These are set of rules or an algebraic structure defined on set of elements together with two binary operator (+) & (.). These set of rules formulated by English Mathematician George Boole which outcome will be true or false.

① Complementation Law :-

$X \cdot \bar{X} = 0$

$X + \bar{X} = 1$

② Commutative law :

$X + Y = Y + X$

$X \cdot Y = Y \cdot X$

③ AND law :-

$X \cdot 0 = 0$

$X \cdot 1 = X$

$X \cdot X = X$

$X \cdot \bar{X} = 0$

④ OR Law

$X + 0 = X$

$X + 1 = 1$

$X + X = X$

$X + \bar{X} = 1$

⑥ Distributive Law

$X \cdot (Y + Z) = X \cdot Y + X \cdot Z$

$X + (Y \cdot Z) = (X + Y)(X + Z)$

$X + \bar{X} \cdot Y = X + Y$

⑤ Associative Law :-

$X + (Y + Z) = (X + Y) + Z$

$X (Y \cdot Z) = (X \cdot Y) \cdot Z$

⑦ Absorption Law :-

$x + x \cdot y = x$

$x (x + y) = x$

(8) **Consensus law / Term law :-**

$$x.y + \bar{x} z + yz = xy + \bar{x} z.$$

$$(x+y)(\bar{x}+z)(y+z) = (x+y)(\bar{x}+z).$$

(9) **Transposition law**

$$xy + \bar{x} z = (x+z)(\bar{x}+y)$$

$$(\bar{x}+y)(\bar{x}+z) = xz + \bar{x}y$$

(10) **De Morgan's Theorem :-**

$$\overline{x+y} = \bar{x}.\bar{y}$$

$$\overline{x.y} = \bar{x}+\bar{y}$$

11) **Vality Theorem :-**

Q. (a) $x[y + z.(\overline{\bar{x}.y + x.z})]$

$$= x[y + z.(\overline{\bar{x}.y}.\overline{x.z})]$$

$$= x[y + z.\{(\bar{\bar{x}}+\bar{y}).(\bar{x}+\bar{z})\}]$$

$$= x[y + z.(\bar{x}+(\bar{y}.\bar{z}))]$$

$$= x[y + z.(\bar{x}+(\overline{y+z})]$$

$$= x[y + z.\bar{x} + z.(\bar{y}.\bar{z})]$$

$$= x[y + z.\bar{x} + \cancel{z\bar{y}\bar{z}}^{0}$$

$$= xy + \cancel{x\bar{x}z}^{0}$$