Digital logic Design

UNIT - I

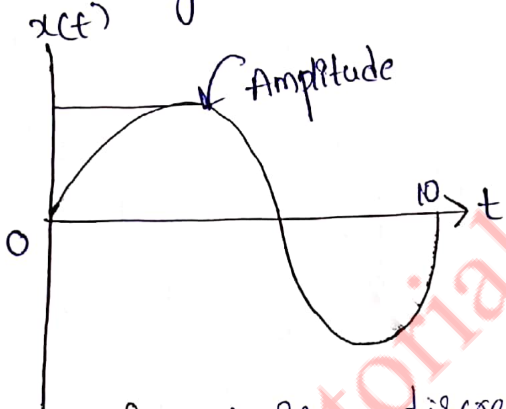
Digital system and binary numbers

Introduction:- In a real time basic signal is analog signal analog signal is converted into digital signal

Analog signal:-

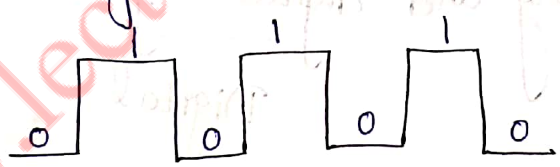
* It is a continous time signal with respect to the amplitude

Ex:- Sinusoidal signal



Digital signal:- It is a discreate time signal. It's binary digits.

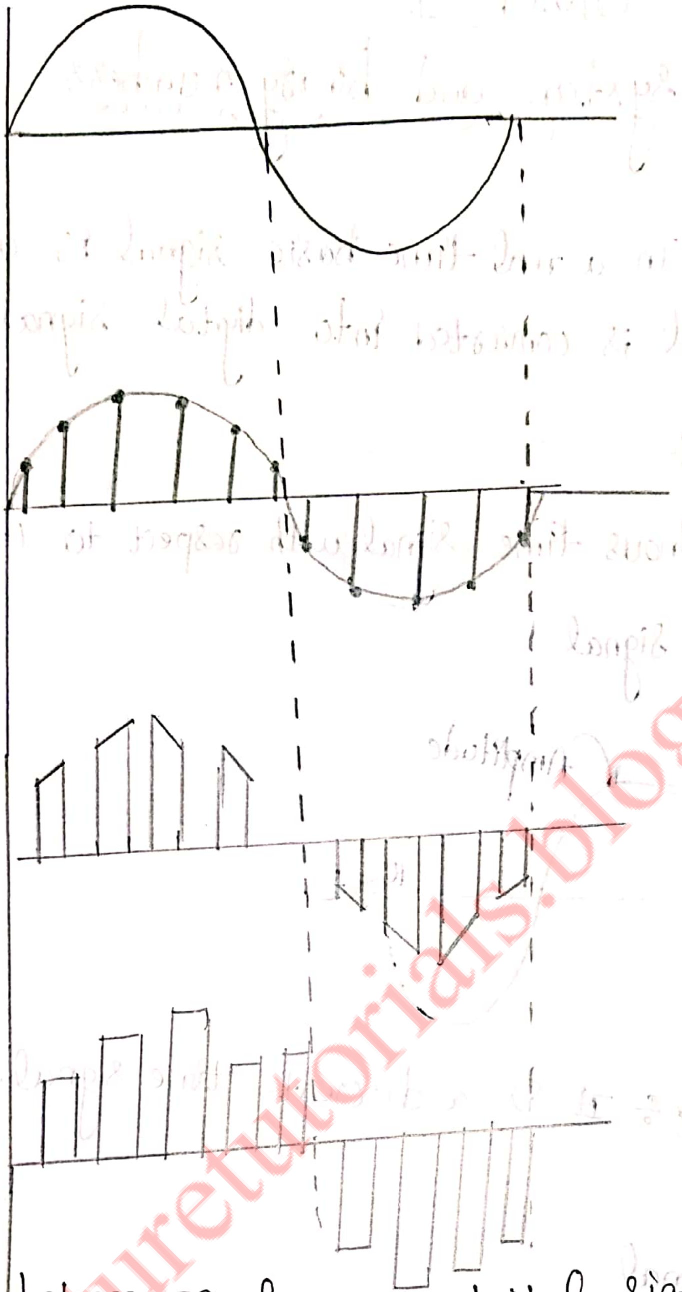
Ex:- pulse signal



Convert analog to digital signal:-

Basically analog to digital signal is converstion in a three steps.

1. sampleing
2. quatisation
3. coder



* Difference between analog and digital signal

Analog	Digital
* low accuracy	* more accuracy
* procesur is slow	* procesure is large
* size is large	* size is small
* Expensive (or) highcost	* lowcost
* It is not upgraded	* It is easily upgard device
* more noise occur	* low noise occur

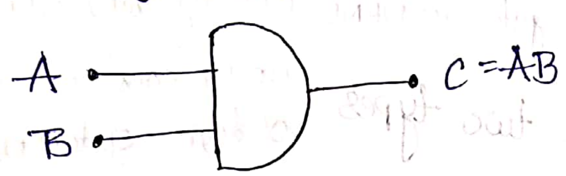
logic gates:

Basically logic gates are three types. They are

1) AND gate
2) OR gate
3) NOT gate

AND gate:

The AND gate symbol is given below.

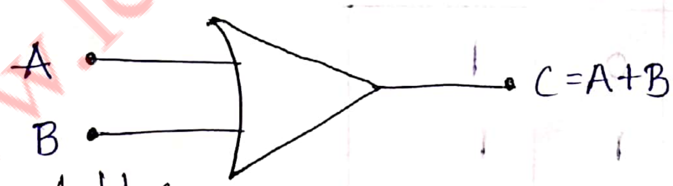


truth table:

A	B	C=AB
0	0	0
0	1	0
1	0	0
1	1	1

OR gate:

The OR gata symbol is given below

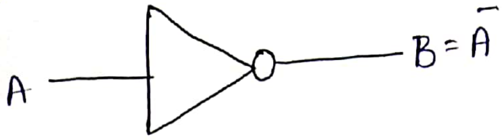


Truth table:

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

NOT gate:

NOT gate symbol is given below



truth table:

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

Universal gates: universal gates are NAND, NOR By using NAND and NOR we can construct any type of logic gate. NAND and NOR easily constructed Transistor Circuits.

The universal gates are two types

1. NAND
2. NOR

1. NAND gate:

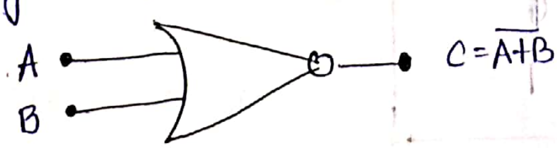
The NAND gate symbol is given below

Truth table:

A	B	$C=\overline{AB}$
0	0	1
0	1	1
1	0	1
1	1	0

NOR gate:

NOR gate symbol is given below



truth table:

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

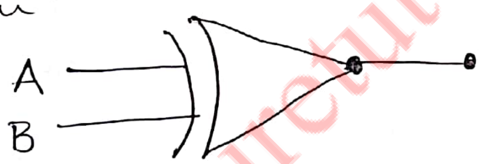
Design: Designd means to reduce the logic gates to (or) generate logic gates (or) different components is connected to the sequentional manner (or) sequence manner

Exclusive gates:

X-OR gate:

X-OR gate symbol is given below

Symbol:



$C = \bar{A}B + A\bar{B}$

$C = A \oplus B$

$\bar{A}B + A\bar{B}$

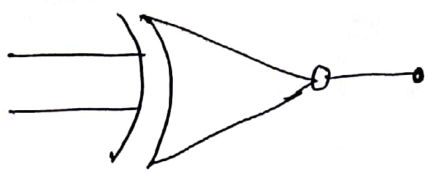
Truth table:

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

X-NOR gate:

X-NOR gate symbol is given below

Symbol:



$C = AB + \bar{A}\bar{B}$

$C = A \odot B$

truth table:

A	B	C=A⊙B
0	0	1
0	1	0
1	0	0
1	1	1

Feature scope of digital logic design:

The digital logic design mainly use is a real time

→ Tele communication

→ Internet of thing (IOT)

→ Cloud computing

→ body area networking

→ Information technology

→ microweb point

→ satlight & optical fibre technology

→ Instrumentation

→ Remote searching

→ Signal processing

→ Image processing

UNIT-I

Digital System and Binary Numbers

Digital system or number system:-

→ The basic ~~digital~~ decimal number system with its 10 digits. they are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.

→ In digital communication operate with binary numbers. which is use only the digits 0s and 1s

→ The number systems are basically fourtypes they are:

i) Binary number system (2)

ii) octal number system (8)

iii) decimal number system (10)

iv) Hexadecimal number system (16)

(i) Binary number System (2):-

→ The binary number system are used in digits 0s and 1s

→ The binary Position Values as a power of '2' is represented by

.....	2^3	2^2	2^1	2^0	.	2^{-1}	2^{-2}	2^{-3}	......

MSB – Most significance Bit

LSB – Least Significance Bit

Ex:- Represent binary number 1101.101 in power of '2'. find its decimal Equalent?

2^3	2^2	2^1	2^0	.	2^{-1}	2^{-2}	2^{-3}
1	1	0	1	.	1	0	1

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

$$N = 8+4+0+1+\frac{1}{2}+0+1/8 \qquad \left[\because a^0 = 1,\ 2^0 = 1\right]$$

$$N = (13.625)_{10}$$

Ex:-2 $(1001101.10111)_2$

2^6	2^5	2^4	2^3	2^2	2^1	2^0	.	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}
1	0	0	1	1	0	1	.	1	0	1	1	1

$$N = 1\times2^6 + 0\times2^5 + 0\times2^4 + 1\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0 + 1\times2^{-1} + 0\times2^{-2} + 1\times2^{-3} + 1\times2^{-4}\times1\times2^{-5}$$

$$N = 64+8+4+2+0.5+0.125+0.0625+0.03125$$

$$N = (78.71875)_{10}$$

* The octal number system uses first Eight values are decimal number system. they are 0,1,2,3,4,5,6,7. It's base is '8', octal position Value as a power of '8' represented is given by

...	8^3	8^2	8^1	8^0	.	8^{-1}	8^{-2}	8^{-3}

MSB LSB

*Represent octal number 567 in power of 8 and find its decimal Equalent.

$[8^0 = 1]$

8^2	8^1	8^0
5	6	7

$N = 5\times8^2 + 6\times8^1 + 7\times8^0$

$= 5\times64 + 6\times8 + 7\times1$

$N = (375)_{10}$

* $(4271.635)_8$

8^3	8^2	8^1	8^0		8^{-1}	8^{-2}	8^{-3}
4	2	7	1	.	6	3	5

$N = 1\times8^0 + 7\times8^1 + 2\times8^2 + 4\times8^3 + 6\times8^{-1} + 3\times8^{-2} + 5\times8^{-3}$

$= 1 + 56 + 128 + 2048 + 6.125 + 0.1875 + 0.00976$

$= (2239.80)_{10}$

* $(64562.1057)_8$

8^4	8^3	8^2	8^1	8^0		8^{-1}	8^{-2}	8^{-3}	8^{-4}
6	4	5	6	2	.	1	0	5	7

$N = 6\times8^4 + 4\times8^3 + 5\times8^2 + 6\times8^1 + 2\times8^0 + 1\times8^{-1} + 0\times8^{-2} + 5\times8^{-3} + 7\times8^{-4}$

$= 24576 + 2048 + 320 + 48 + 2 + 0.125 +$ [illegible] $+ 0.00968 +$
0.0017089

$N = (26994.13639)_{10}$

Decimal number system:

→ In Decimal number system we can Express any decimal number in units, tens, Hundreds and thuasands.......

→ In Decimal number system the numbers are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

→ The Decimal Position Values as a power of 10 is represented by

....	10^2	10^1	10^0	.	10^{-1}	10^{-2}	10^{-3}	.....

MSB LSB

Ex: 6587.6

10^3	10^2	10^1	10^0		10^{-1}
6	5	8	7	.	6

$$N = 6\times10^3 + 5\times10^2 + 8\times10^1 + 7\times10^0 + 6\times10^{-1}$$

$$= 6000 + 500 + 80 + 7 + 0.6$$

$$= 6587.6$$

Hexa Decimal number system:

→ The Hexa Decimal number system as a base of 16.

it having 16 digits they are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F (A=10, B=11, C=12, D=13, E=14, F=15)

→ The Hexa decimal position Values as a power of 16 is represented by

....	16^3	16^2	16^1	16^0	.	16^{-1}	16^{-2}	16^{-3}	....

MSB (left) — LSB (right)

Ex:- Represents Hexadecimal number 3FD in power of 16 and find Decimal Equilent.

16^2	16^1	16^0
3	F	D

$$N = 3\times16^2 + F\times16^1 + D\times16^0$$

$$= 3\times256 + 15\times16 + 13\times1$$

$$= (1021)_{10}$$

Ex:- FDE42A.1DB9

16^5	16^4	16^3	16^2	16^1	16^0	.	16^{-1}	16^{-2}	16^{-3}	16^{-4}
F	D	E	4	2	A	.	1	D	B	9

$$N = 15\times16^5 + 13\times16^4 + 14\times16^3 + 4\times16^2 + 2\times16^1 + 10\times16^0 + 1\times16^{-1} + 13\times16^{-2} + 11\times16^{-3} + 9\times16^{-4}$$

$$= 16639018 + 851968 + 57344 + 1024 + 32 + 10 + 0.0625 + 0.0507 + 0.0026 + 0.00013732$$

$$= (17549396.12)_{10}$$

Relation b/w binary, decimal, Hex decimal in below tables.

Decimal	Binary 8421	Hexa Decimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3

Decimal	Binary 8421	HexaDecimal
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

Counting in Radix (Base) r:-

Radix (Base) r	Character in set
r = 2	0, 1
r = 8	0, 1, 2, 3, 4, 5, 6, 7
r = 10	0, 1, 2, 3, 4, 5, 6, 7, 8, 9
r = 16	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, F

Ex:- To find Decimal values of 0 to 9 by using radix 5

Decimal	radix	
0	00	$0\times5^1+0\times5^0 = 0$
1	01	$0\times5^1+1\times5^0 = 1$
2	02	$0\times5^1+2\times5^0 = 2$
3	03	$0\times5^1+3\times5^0 = 3$
4	04	$0\times5^1+4\times5^0 = 4$
5	10	$1\times5^1+0\times5^0 = 5$
6	11	$1\times5^1+1\times5^0 = 6$
7	12	$1\times5^1+2\times5^0 = 7$
8	13	$1\times5^1+3\times5^0 = 8$
9	14	$1\times5^1+4\times5^0 = 9$

* find the decimal Equalent of 231.23 base 4.

4^2	4^1	4^0		4^{-1}	4^{-2}
2	3	1	.	2	3

$$N = 2\times16+3\times4+1\times4+2\times4^{-1}+3\times4^{-2}$$

$$= 32+12+4+0.5+0.1875$$

$$= (48.6875)_{10}$$

Number base Conversion:-

→ The decimal, binary, octal and hexadecimal table is given below

Decimal	Binary 8421	octal	Hexa
0	0000	0	0
1	0001	1	1
2	0010	2	2

Decimal	Binary 8421	Octal	Hexadecimal
3	0011	3	3
4	0100	4	4
5	0101	5	5
6	0110	6	6
7	0111	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

Conversions:

→ Basically binary, octal, Hexdecimal conversions or 6 types

1. Binary to octal
2. octal to Binary
3. Binary to Hexa
4. Hexa to Binary
5. octal to Hexa
6. Hexa to octal

1. Binary to Octal:

→ The binary numbers are 0 and 1. The octal numbers are 0 to 7 the ~~oc~~ octal number table is given below

Decimal	Binary - 421
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

Ex: $(110101010 \cdot 101010)_2$ to convert octal

Sol:

$$\begin{matrix} 110 & 101 & 010 & \cdot & 101 & 010 \\ \downarrow & \downarrow & \downarrow & & \downarrow & \downarrow \\ 6 & 5 & 2 & & 5 & 2 \end{matrix}$$

$\therefore (652 \cdot 52)_8$

Ex: $(100101010 \cdot 0101)_2$

$$\begin{matrix} 100 & 101 & 010 & \cdot & 101 \\ \downarrow & \downarrow & \downarrow & & \downarrow \\ 4 & 5 & 2 & & 5 \end{matrix}$$

010 010 101 · 010 100

$(452 \cdot 5)_8$

Ex:

(ii) Octal to Binary Conversion:

Ex: $(643.27)_8$

6	4	3	.	2	7
↓	↓	↓		↓	↓
110	100	011		010	111

∴ $(110100011.010111)_2$

(iii) Binary to Hexa conversion:

Ex: $(1101100010011011)_2$

1101	1000	1001	1011
↓	↓	↓	↓
D	8	9	B

$(D89B)_{16}$

∴ $(D89B)_H$

(iv) Hexa to Binary conversion:

Ex: Convert $(3FD)_H$

3	F	D
↓	↓	↓
0011	1111	1101

$(0011\ 1111\ 1101)_2$

Ex: $(F9B0.1D8)_H$

F	9	B (11)	0	.	1	D (13)	8
↓	↓	↓	↓		↓	↓	↓
1111	1001	1011	0000		0001	1101	1000

$(1111\ 1001\ 1011\ 0000\ 0001\ 1101\ 1000)_2$

Ex÷ convert $(5A89\cdot B4)_H$ to binary

5	A	8	9	.	B	4
↓	↓	↓	↓		↓	↓
0101	1010	1000	1001		1011	0100

$(0101\ 1010\ 1000\ 1001\ 1011\ 0100)_2$

v) Octal to Hexadecimal÷

→ The easyest way to convert octal number to Hexadecimal number in two steps.

i) convert octal number to binary form

ii) convert binary form to Hexa decimal

Ex÷ convert $(615)_8$ to its Hexa decimal equivalent.

$(615)_8$

(i) octal – binary

6 1 5

$(110\ 001\ 101)_2$

(ii) Binary – Hexa (110001101)

0001 1000 1101

1 8 D

∴ $(18D)_H$

Ex÷ $(7523\cdot 426)_8$

(i) octal – binary

7	5	2	3	.	4	2	6
↓	↓	↓	↓		↓	↓	↓
111	101	010	011		100	010	110

111101010011100010110

ii) Binary – Hexa

0001	1110	1010	0111	0001	0110
↓	↓	↓	↓	↓	↓
1	E	A	7	1	6

∴ $(1EA716)_H$

vi) Hexa to octal conversion:-

→ The Hexa decimal to octal conversion two steps is there

i) Convert Hexa to binary

ii) Convert binary - octal

Ex:- Convert $(25B)_H$ to its octal equalent

$(25B)_H$

(i) Hexa to binary

2 → 0010

5 → 0101

B → 1011

(ii) binary - octal

0010 0101 1011

001 → 1

001 → 1

011 → 3

011 → 3

$\therefore (1133)_8$

Ex:- ② $(9DF6.C83)_H$

(i) Hexa to binary

9 → 1001

D → 1101

F → 1111

6 → 0110

.

C → 1100

8 → 1000

3 → 0011

(ii) binary - octal

10011101111101101100 1000

010 011 011 111 011 011 001 000

010 → 2

011 → 3

011 → 3

111 → 7

011 → 3

011 → 3

001 → 1

000 → 0

$\therefore (23373310)_8$

* Convert any Radix to Decimal ÷

In genral the number can be represented as

$$N = A_{n-1} r^{n-1} + A_{n-2} r^{n-2} + \dots + A_1 r^1 + A_0 r^0 + A_{-1} r^{-1} + A_{-2} r^{-2} + \dots + C_m r^{-m}$$

where N = number in decimal

A = digit

r = radix (or) base of a number system

n = The number of digits in the integer portion of number

m = The no. of digits in the fractional portion of number

① $(1101.1)_2$ to convert Decimal

② $(475.25)_8$ to convert Decimal

③ $(9B2.1A)_H$ to convert Decimal

④ $(3102.12)_4$ to Decimal

⑤ $(614.15)_7$ to Decimal

① $(1101.1)_2$

2^3	2^2	2^1	2^0		2^{-1}
1	1	0	1	.	1

$N = 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 + 1 \times 1/2$

$= (13.5)_{10}$

② $(475.25)_8$

8^2	8^1	8^0		8^{-1}	8^{-2}
4	7	5	.	2	5

$$N = 4\times 8^2 + 7\times 8^1 + 5\times 8^0 + 2\times 8^{-1} + 5\times 8^{-2}$$

$$= (317.328)_8$$

(3) $(9B2.1A)_H$

16^2	16^1	16^0		16^{-1}	16^{-2}
9	B	2	.	1	A

$$N = 9\times 16^2 + B\times 16^1 + 2\times 16^0 + 1\times 16^{-1} + A\times 16^{-2}$$

$$= (2482.101563)_{10}$$

(4) $(3102.12)_4$

4^3	4^2	4^1	4^0		4^{-1}	4^{-2}
3	1	0	2	.	1	2

$$N = 3\times 4^3 + 1\times 4^2 + 2\times 1 + 1\times 1/4 + 2\times 1/16$$

$$= (210.375)_{10}$$

(5) $(614.15)_7$

7^2	7^1	7^0		7^{-1}	7^{-2}
6	1	4	.	1	5

$$N = 6\times 7^2 + 1\times 7^1 + 4\times 7^0 + 1\times 1/7 + 5\times 1/49$$

$$N = (301.244)_{10}$$

Conversion of Decimal numbers to radix numbers

→ Basically the conversions of radix numbers are two type

1. Succesive division for Integer part Convertion
2. Succesive multiplication for fractional part convertion

1. Succesive division for Integer part Convertion:

→ In this method we repeatedly divided the Integer part of the decimal number by "r". until ~~Coeff.~~ qotient is '0'.

→ The reminder of each division becomes the numarical in the new radix.

→ The reminders are taken in the reverse order to a new radix number.

→ This means that first remainder is the least significant bit in the new and the last significant is the most significant bit in the new radix number.

Ex: Convert decimal number 37 to in binary Equalent

$(37)_{10}$ ↑ LSB

2	37	
2	18	− 1
2	9	− 0
2	4	− 1
2	2	− 0
	1	− 0

MSB

$\because (10010\cancel{0}1)_2$

$\therefore (37)_{10} = (10010\cancel{0}1)_2$

Verification:

2^5	2^4	2^3	2^2		2^1	2^0
1	0	0	1	$\cancel{0}$	0	1

$= 1\times2^5 + 1\times2^2 + 1\times2^0$

$= 32 + 4 + 1\times1$

$= 37$

HW

1) (625) to Binary
2) (739) to "
3) (523) to Octal
4) (649) "

Ex÷ convert decimal to octal

(214)

8	214	
8	26	− 6
	3	− 2

∴ $(326)_8$

Ex÷ Convert decimal number (3509) to Hexa decimal Equalent

16	3509	
16	219	− 5
16	13	− 11

∴ (13 11 5)

∴ $(DB5)_{16}$

Ex÷ convert decimal to Hexa (4559)

Ex ÷ Convert decimal to Hexa (5320)

(i) (4559)

16	4559	
16	284	− 15
16	17	− 12
16	1	− 1

∴ $(15\ 12\ 1\ 1)_{16}$

∴ $(4559) = (FC11)_H$

(ii) (5320)

16	5320	
16	332	−8
16	20	−12
16	1	−4

∴ (5320) = (8 12 4 1)

∴ $(8C41)_H$

2. Successive multiplication for fractional part conversion

→ convert 0.8125 to Binary

fractional	Radix	Result		Recorded carry
0.8125	x 2	= 1.625	= 0.625	with carry 1
0.625	x 2	= 1.25	= 0.25	with carry 1
0.25	x 2	= 0.5	= 0.5	with carry 0
0.5	x 2	= 1.0	= 0.0	with carry 1

MSB ↓ LSB

$\therefore (0.8125)_{10} = (0.1101)_2$

→ convert 0.95 to Decimal number to its binary Equalent

fractional	Radix	Result		Recorded carry
0.95	x 2	= 1.9	= 0.9	with carry 1
0.9	x 2	= 1.8	= 0.8	with carry 1
0.8	x 2	= 1.6	= 0.6	" 1
0.6	x 2	= 1.2	= 0.2	" 0
0.2	x 2	= 0.4	= 0.8	" 0
0.4	x 2	= 0.8	= 0.8	" 0
0.8	x 2	= 1.6	= 0.6	" 1

$(0.95)_{10} = (0.1110001)_2$.

1) 625 to Binary

2 | 625
2 | 312 − 1
2 | 156 − 0
2 | 78 − 0
2 | 39 − 0
2 | 19 − 1

2 | 9 − 1
2 | 4 − 1
2 | 2 − 0
2 | 1 − 0

$\therefore$ ~~$(1000111000)_2$~~ $(1001110001)_2$

Verification:

~~2^8~~	~~2^7~~	~~2^6~~	~~2^5~~	~~2^4~~	~~2^3~~	~~2~~	~~2^1~~	~~2^0~~	2^0
~~1~~	~~0~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	0	1

$N = 1\times 2^8 + 1\times 2^4 + 1\times 2^3 + 1\times 2^2$

(2) 739

LSB

$$\begin{array}{r|l}
2 & 739 \\
2 & 369 - 1 \\
2 & 184 - 1 \\
2 & 92 - 0 \\
2 & 46 - 0 \\
2 & 23 - 0 \\
2 & 11 - 1 \\
2 & 5 - 1 \\
2 & 2 - 1 \\
2 & 1 - 0
\end{array}$$

MSB

$\therefore (1011100011)_2$

(3) 523

$$\begin{array}{r|l}
8 & 523 \\
8 & 65 - 3 \\
8 & 8 - 1 \\
8 & 1 - 0
\end{array}$$

$\therefore (1013)_8$

(4) 649

$$\begin{array}{r|l}
8 & 649 \\
8 & 81 - 1 \\
8 & 10 - 1 \\
 & 1 - 2
\end{array}$$

$(1211)_8$

Ex:- Convert 0.640625 decimal number to its octal Equivalent

Fraction	Radix	Result	Recorded with carry
0.640625	× 8	= 5.125 = 0.125	with carry 5
0.125	× 8	= 1.0 = 0.0	with carry 1

MSB

LSB

$\therefore (0.640625)_{10} = (0.51)_8$

i) (0.925284) (ii) (0.752386)

Fraction	Radix	Result	Recorded with carry
0.925284	× 8	7.402272 = 0.402272	With carry 7
0.402272	× 8	= 3.218176 = 0.218176	with carry 3
0.2	× 8	= 0.2 1.6 = 0.6	with carry 1
0.6	× 8	4.8 0.8	with carry 4
0.8	× 8	6.4 0.4	with carry 6

$\therefore (0.925284)_{10} = (0.73146)_8$

ii) (0.752386)

Fraction	Radix	Result	Recording with carry
0.752386	× 8	6.019088 = 0.01	with carry 6
0.01	× 8	= 0.08	with carry 0
0.08	× 8	= 0.08 0.64	with carry 0
0.12	× 8	5.12 = 0.12	with carry 5
0.96	× 8	0.96	with carry 0
0.68	× 8	1.68 0.68	with carry 1

* Convert 0.1289062 Decimal to Hexa Decimal

Wrong

fraction	Radix	Result	Recorded with carry
0.1289062	× 16	2.0624992 = 0.0624992	with carry 2
0.0624992	× 16	0.999872 = 0.999872	with carry 9
0.999872	× 16	15.997952 = 0.997952	with carry 15
0.997952	× 16	15	

fraction	Radix	Result	Recorded with carry
0.1289062	× 16	2.0624992 = 0.0625	with carry 2
0.0625	× 16	= 1.0 0.0	with carry 1

MSB ↓ LSB

$\therefore (0.1289062) = (0.21)_{16}$

(iii) (0.15638) iv) (0.29725) Hexa

$0.15638 \times 16 = 2.50208$

0.50

0.8

* Convert decimal number 35.45 to octal number

i) $(35.45)_{10}$

(i) Integer Part

$8 \underline{|35}$
4 — 3

$\therefore (35)_{10} = (43)_8$

ii) fractional Part

fraction	Radix	Result	Recorded with carry
0.45	x 8	= 3.6 = 0.6	Carry 3
0.6	x 8	= 4.8 = 0.8	Carry 4
0.8	x 8	= 6.4 = 0.4	Carry 6
0.4	x 8	= 3.2 = 0.2	Carry 3
0.2	x 8	= 1.6 = 0.6	Carry 1
0.6	x 8	= 4.8 = 0.8	Carry 4

$\therefore (0.45)_{10} = (0.346314)_8$

finally

$\therefore (35.45)_{10} = (43.346314)_8$

*(i) Convert $(22.64)_{10}$ to Hexa decimal

(ii) Convert $(24.6)_{10}$ to Binary

22.64

$16 \underline{|22}$
1 — 6

(i) $(22.64)_{10}$

(i) Integer part ÷ 22

22.64

$16 \underline{|22}$
$16 \underline{|16}$ — 6
1 — 0

$2 \underline{|24}$
$2 \underline{|12}$ — 0
$2 \underline{|6}$ — 0
$2 \underline{|3}$ — 1 — 0
1

(10100

$\therefore (22)_{10} = (106)_{16}$

(ii) fractional Part : 0.64

Fraction	Radix	Result	Recorded with carry
0.64	× 16	= 10.24 = 0.24	with carry 10 (MSB)
0.24	× 16	= 3.84 = 0.84	with carry 3
0.84	× 16	= 13.44 0.44	with carry 13
0.44	× 16	= 7.04 0.04	with carry 7
0.04	× 16	= 0.64 = 0.64	with carry 0
0.64	× 16	= 10.24 = 0.24	with carry 10 (LSB)

$\therefore (0.64)_{10} = (0.103137010)_H$

finally

$\therefore (22.64)_{10} = (16.103137010)_H$

(iii) $(24.6)_{10}$

(i) Integration part : 24

```
2 | 24
2 | 12 — 0
2 |  6 — 0
2 |  3 — 0
  |  1 — 1
```

$\therefore (24)_{10} = (11000)_2$

fraction	Radix	Result	Recorded with carry
0.6	× 2	= 1.2 = 0.2	with carry 1
0.2	× 2	= 0.4 = 0.4	with carry 0
0.4	× 2	= 0.8	with carry 0
0.8	× 2	1.6 = 0.6	with carry 1
0.6	× 2	1.2 = 0.2	with carry 1

$(0.6)_{10} = (10011)_2$

$\therefore (24.6)_{10} = (11000.10011)_2$

(iv) (0.29725) to Hexa

fraction	Radix	Result	Recorded with carry
0.29725	× 16	4.756 = 0.756	with carry 4
0.756	× 16	12.096 = 0.096	with carry 12
0.096	× 16	15.36 = 0.36	with carry 15
0.36	× 16	5.76 = 0.76	with carry 5
0.76	× 16	12.16 = 0.16	with carry 12
0.16	× 16	2.56 = 0.56	with carry 2
0.56	× 16	8.96 = 0.96	with carry 8

0.96	× 16	15.36 = 0.36	with carry 15
0.36	× 16	5.76 = 0.76	with carry 5

$\therefore (0.29725) = (4\,12\,15\,5\,12\,8\,8\,15\,5\,5)_{16}$

(iii) (0.15638)

fraction	Radix	Result	Recorded with carry
0.15638	× 16	2.50208 = 0.502	with carry 2
0.502	× 16	8.032 = 0.032	with carry 8
0.032	× 16	0.512 = 0.512	with carry 0
0.512	× 16	8.192 = 0.192	with carry 8
0.192	× 16	3.072 = 0.072	with carry 3
0.072	× 16	1.152 = 0.152	with carry 1
0.152	× 16	2.432 = 0.432	with carry 2
0.432	× 16	6.912 = 0.912	with carry 6
0.912	× 16	14.592 0.592	with carry 14
0.592	× 16	9.472 0.9472	with carry 9
0.9472	× 16	15.1552 0.1552	with carry 15

$\therefore (0.15638)_{10} = (2\,8\,0\,8\,3\,12\,6\,14\,9\,15)_H$

$= (28083C6E9F)_H$

Complement of numbers:

(i) 1's complement representation:

→ The 1's complement of a binary number is the number that results when we change all 1's is 0's and all 0's to 1's

Ex: find 1's complement of $(1101)_2$

$(1101)_2$

$= 0010$

Ex: find 1's complement of $(10111010111)_2$

$(10111010111)_2$

01000101000

(ii) 2's complement representation:

→ The 2's complement is the binary number that results when we add 1 to the 1's complement. It can be represented as

[2's complement = 1's complement + 1]

Addition operation:

truth table

A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

→ The 2's complement form is used to represent a (-ve) numbers

Ex:- find 2's complement of $(1001)_2$

$(1001)_2$

$= 0110$ — 1st complement

$= 0110$

$+1$ → adding +1

0111

Ex:- $(1010100110)_2$

0101011001 → 1st complement

0101011001

1 +1 → adding +1

0101011010

$\therefore (1010100110)_2 = (0101011010)$

1's Complement Subtraction:-

→ For subtraction of two numbers we have two cases

(i) subtraction of smaller number from larger number

L - S

(ii) subtraction of larger number from smaller number

S - L

(i) Smaller number from larger number:-

Steps:-

1. Determine the 1's complement of the smaller number.
2. Add the 1's complement of the larger number.

3. Remove the carry and adding to the Result This is called End around the carry

Ex:- Subtract ~~1010~~ $(101011)_2$ from $(111001)_2$ using the 1's Complement method

$(101011)_2$ from $(111001)_2$

(1) first u-find big number are large number

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

= 43

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

= 57

L - S

```
  1 1 1 0 0 1
  0 1 0 1 0 0  →  1st complement of 101011
  -----------
① 0 0 1 1 0 1
           +1
  -----------
  0 0 1 1 1 0
```

End around Carry

$$\begin{array}{r} 57 \\ 43 \\ \hline 14 \end{array}$$

∴ (001110)

Ex:- $(1101011)_2$ from $(111001)_2$

$(1101011)_2$ from (0111001)

2^6	2^5	2^4	2^3	2^2	2^1	2^0
1	1	0	1	0	1	1

107

2^6	2^5	2^4	2^3	2^2	2^1	2^0
0	1	1	1	0	0	1

57

L - S

```
  1 1 0 1 0 1 1
  1 0 0 0 1 1 0  →  1st complement of 0111001
  -------------
① 0 1 1 0 0 0 1
```

0 1 1 0 0 0 1

1 1

0 1 1 0 0 1 0

107
57
50

∴ (0110010)

= 50 //

(ii) Subtraction of large number from smaller number:

Steps: S − L

1. Determine the 1's complement of the larger number
2. Add the 1's complement of the smaller number
3. Answer is in 1's complement from to set the answer in true form take the 1's complement and assign (−ve) sign to the answer.

Ex: subtract (111001)₂ from (101011)₂ using the 1's complement method

57 43
(111001)₂ from (101011)₂

1 0 1 0 1 1
0 0 0 1 1 0 ← 1's complement

1 1 0 0 0 1

0 0 1 1 1 0 → 1's complem

100111

−14

Ex: $(1111101)_2$ from $(1101011)_2$

$2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$ — $2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$

1 1 1 1 1 0 1 — 1 1 0 1 0 1 1

125 — 107

(a) S - L

```
  1 1 0 1 0 1 1
  0 0 0 0 0 1 0  → 1's complement of (1111101)
            1
 ---------------
  1 1 0 1 1 0 1
 ---------------
- 0 0 1 0 0 1 0  → 1's complement
```

-18 //

(b) L - S

```
                  1 1 1 1 1 0 1
                  0 0 0 0 0 1 0  ← 1's
                  1 1 1 1 1 1
End around      ---------------
carry         (1) 0 0 0 0 0 0 1
                              1
                ---------------
                  0 0 1 0 0 1 0
```

= 18 //

2's complement subtraction:

(i) subtraction of smaller number from larger number:

→ Determine the 2's complement of a small number

→ Add the 2's complement to the large number

→ Dicaurd the carry (or) remove the carry

Ex: subtract $(101011)_2$ from $(111001)_2$

43 57

(i) L − S

```
    111001
(+) 010101
   -------
  1 001110
↓
remove
```

2's complement

```
101011
010100 → 1st compl
     1
------
010101
```

(ii) S − L

```
  101011
  000111
 -------
  110010
  001101
      1
 -------
− 001110
```

2's complement

```
111001
000110 → 1's
     1
------
000111
```

(ii) subtraction of Larger number from smaller number:

→ Determine the 2's complement of the large number

→ Add the 2's complement to the smaller n

→ Answer is in the 2's complement form to ~~chee~~ get the Answer in the true from to take the 2's complement add a sign (-ve) sign to the Answer

Signed binary numbers:

→ The sign magnitude formate for 8 bit signed number is given by

128	64	32	16	8	4	2	1
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0

B_7: sign Bit; B_6 to B_0: magnitude

Ex:
1) +6 = 0000 0110
2) -14 = 1000 1110
3) +24 = 0001 1000
4) -64 = 1100 0000
5) +127 = 0111 1111
6) -128 = 1111 1111

→ The maximum (+ve) number +127 = 0111 1111

Binary Airthematic

Rules for binary addition:

A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Ex:- Add $(1010)_2$ & $(0011)_2$

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

Ex:- Add 28 and 15 binary

16 8 4 2 1

```
    1 1 1 0 0
    0 1 1 1 1
  1 1 1 1 1
-------------
  1 0 1 0 1 1
 32
```

28
15
43

Ex:- B

Binary subtraction

A	B	Difference	Barrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

Ex:- subtract $(0101)_2$ from $(1011)_2$

5 11

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

Hexa Decimal Arithmatic:-

① $9_{16} + 3_{16} = C_{16}$

② $9_{16} + 7_{16} = (16-16) = 0$ carry 1

③ $A_{16} + 8_{16} = (18-16) = 2$ carry 1

① Add $(3F8)_{16}$ and $(5B3)_{16}$ $(26-16)_{10}$

Add

	1		
	3	F	8
	5	B	3
	$(9$	A	$B)_{16}$

② Add Hexadecimal number $(4FB)_{16}$ & $(75D)_{16}$, $(A12)_{16}$, $(C39)_{16}$

1	2	
4	F	B
7	5	D
A	1	2
C	3	9
2 2	A	3

i) $35 = (35-16) = 19$ carry 1

$= (19-16) = 3$ carry 2

ii) $26 = (26-16) = 10$ carry 1

iii) $34 = (34-16) = 18$ carry 1

$(18-16) = 2$ carry 2

Subtraction with 15's Complement

→ The 15's complement of a Hexadecimal number is formed by subtracting each digit from 15

Ex:- find 15's complement of $(A9B)_{16}$

	15	15	15
(–)	A	9	B
	5	6	4

Ex:- Use the 15's complement method of subtraction to compute $(B02)_{16} - (98F)_{16}$

(–)	15	15	15
first (-ve) value tho (-)ve	9	8	F
	6	7	0

Adding

(+)	B	0	2
	6	7	0
①	1	7	2
			1
	1	7	3

$17-16=1$

Subtraction of 15's complement

→ find 15's complement of subtratend

→ Add to Hexadecimal numbers (1st number and 15's complement of 2nd number)

→ If carry is produced in the addition, add carry to the least significant bit of the sum, otherwise find 15's complement of the sum as a result with a (-ve) sign.

Ex: Use the 15's complement method of subtracted to Compute $(69B)_{16} - (C14)_{16}$

(22-16)=6 carry 1
24-16 =8 carry 1

step 1:

	15	15	15
(+)	C	1	4
	3	E	B

step 2:

	6	9	B
(+)	3	E	B
	A	8	6

step 3: (no carry)

15	15	15
- A	8	6
- 5	7	9

$\therefore (69B)_{16} - (C14)_{16} = (-579)_{16}$

Subtraction of 16's complement

→ The 15's complement of a Hexa decimal number is found by subtracting each digit from "15" and add 1.

Steps: steps for Hexadecimal subtraction using 16's complement method.

→ find 16's complement of subtratend

→ Add to Hexadecimal numbers (1st number & 16's complement of the 2nd number)

→ If carry is produced in the addition it is discarded or removed, otherwise find 16's complement of the sum as a result with a (-ve) sign

Ex:- find the 16's complement of $(A8C)_{16}$

$$\begin{array}{rrrl} 15 & 15 & 15 & \leftarrow 15\text{'s complement} \\ -\ A & 8 & C & \\ \hline 5 & 7 & 3 & \\ & & +1 & \\ \hline 5 & 7 & 4 & \end{array}$$

2. Use the 16's Complement method of subtraction to compute $(CB2)_{16} - (972)_{16}$

Step 1:-

$$\begin{array}{rrrl} 15 & 15 & 15 & \leftarrow 15\text{'s} \\ -\ 9 & 7 & 2 & \\ \hline 6 & 8 & D & \\ & & +1 & \\ \hline 6 & 8 & E & \leftarrow 16\text{'s complement} \end{array}$$

Step 2:-

$$\begin{array}{rrr} C & B & 2 \\ +\ 6 & 8 & E \\ \hline 3 & 4 & 1 \end{array}$$

(16-16) = 1 carry
(20-16) = 4 carry
(19-16) = 3 carry 1

3. Use the 16's complement method of subtraction to compute $(387)_{16} - (854)_{16}$

Step:-1

$$\begin{array}{rrrl} 15 & 15 & 15 & \\ -\ 8 & 5 & 4 & \\ \hline 7 & A & B & \\ & & +1 & \\ \hline 7 & A & C & \leftarrow 16\text{'s complement} \end{array}$$

$(19-16) = 3$ carry 1
$(22-16) = 6$ carry 1

Step 2:

$$\begin{array}{cccc} & 3 & B & 7 \\ (+) & 7 & A & C \\ \hline & B & 6 & 3 \\ \hline \end{array}$$

Step 3: If No carry

$$\begin{array}{cccc} & 15 & 15 & 15 \\ - & B & 6 & 3 \\ \hline & 4 & 9 & C \\ & & & 1 \\ \hline & -4 & 9 & D \\ \hline \end{array}$$

$\therefore (3B7)_{16} - (854)_{16} = (-49D)_{16}$

If no carry

$$\begin{array}{ccc} 15 & 15 & 15 \\ B & 6 & 3 \\ \hline 4 & 9 & C \\ \hline -4 & 9 & D \end{array}$$

Binary codes:

Codes

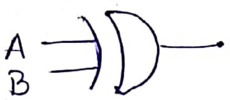
- Weighted
  - Binary
  - BCD (Binary coded Decimal)
    - 8421
    - 2421
    - 3321
    - 4221
    - 5211
    - 5311
    - 5421
    - 6311
    - 7421
    - 7421
- Non-weighted
  - Ex-3
  - Gray
  - five-bit BCD code
- Reflective
  - 2421
  - 5211
  - Ex-3
- Sequential
  - 8421
  - Ex-3
- Alpha numeric
  - ASCII
- Error Defective & correction
  1. Parity
  2. Hamming Code

Excess3 Code (Ex-3)

Decimal	Ex-3	Binary code
0	0+3=3	0011
1	4	0100
2	5	0101
3	6	0110
4	7	0111

* To find binary code and Gray code the given binary number is 1101010101

truth table of Hexa X-OR Gate



$C = A\bar{B} + \bar{A}B$

$= A \oplus B$

A	B	$C = A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

binary - gray

(i) 1101010101

↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓

1 0 1 1 1 1 1 1 1 1

$\therefore$ 1011111111

(ii) 1011101011

↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓

1110011110

gray - binary

Gray code: (1) 1101010101

1 1 0 1 0 1 0 1 0 1

↓ ⊕ ↓ ⊕ ↓ ⊕ ↓ ⊕ ↓ ⊕ ↓ ⊕ ↓ ⊕ ↓ ⊕ ↓ ⊕ ↓

1 0 0 1 1 0 0 1 1 0

$\therefore$ 1001100110

(I) BCD Addition:

Ex: BCD of 58

5	8
↓	↓
0101	1000

(i) sum Equals "9" or less with Carry is "0"

Ex: Add 3 and 6 in BCD

```
   3  —   0011
 + 6  —   0110
 ----    ------
   9      1001  → Ans
```

(ii) sum > 9 with carry is "0"

Ex: Add 6 and 8

```
   6  —   0110
 + 8  —   1000
 ----    ------
  14      1110  → 14
          0110  ← Add 6
 Carry ①
   0001   0100
   ----   ----
     1      4   → BCD
```

(iii) Sum Equals to 9 or less with Carry 1:

Ex: Add 8 + 9

```
   8  —   1000
 + 9  —   1001
 ----    ------
  17   0001 0001  ← Invalid BCD
          0110
   ----------
   0001 0111
     1     7
```

* Perform each of the following decimal addition in 8421 BCD

① 24 + 18

		8421	8421
24	—	0010	0100
18	—	0001	1000
42		0011	1100
			carry 0110 ← Add 6
		0011	0010
		0100	0010 ← valid BCD
		4	2

② 48 + 58

58	—	0101	1000
48	—	0100	1000
106		1001	0000
		1010	0000 ← Add 6
			0110
		1010	0110
		10	6
		A	

③ 175 + 326

175	—	0001	0111	0101
326	—	0011	0010	0110
501		0100	1001	1011
				0110 ← Add 6
			1001	0001
			1010	

1010 ← Add 6
1 0110
0000

0100

0101 ← Add 6
0101 0000 0001

(4) 589 + 199

589 — 0101 1000 1001
199 — 0001 1001 1001
788

0110 | 0001 | 0010

0111 0010 0010
0110 ← Add 6

1000

0010
0110 ← Add 6

1000

0111 1000 1000
7 8 8

BCD subtraction:

(i) subtraction with 9's complement

Digits	9's complement
0	9
1	8
2	7
3	6
4	5
5	4
6	3
7	2

Digits	9's com
8	1
9	0

Regular subtraction

1)
$$\begin{array}{r} 8 \\ -\,2 \\ \hline 6 \end{array}$$

(2)
$$\begin{array}{r} 9 \\ -\,5 \\ \hline 4 \end{array}$$

(3)
$$\begin{array}{r} 4 \\ -\,8 \\ \hline -4 \end{array}$$

9's complement subtraction

(i)
$$\begin{array}{r} 8 \\ 7 \\ \hline 1\;5 \\ 1 \\ \hline 6 \end{array}$$
(9's complement of 2)

(ii)
$$\begin{array}{r} 9 \\ 4 \\ \hline 1\;3 \\ 1 \\ \hline 4 \end{array}$$

(iii)
$$\begin{array}{r} 4 \\ 1 \\ \hline 5 \end{array}$$
(9's complement of result no Carry indicates that the answer is negative and completed from)

* perform Each of the following decimal subtraction in 8421 BCD using 9's complement method.

(i) 79 − 26

$$\begin{array}{r} 79 \\ -\,26 \\ \hline 53 \end{array}$$

[9 − 2 = 7
6 − 2 = 3]

0111	1001	
0111	0011	← (9's complemt of 26)
1110	1100	
	0110	← Add 6
1110	1 0010	
1		
1111		
0110		Add 6
1 0101	0010	carry
	1	
0101	0011	

10's complement

ⓐ

$$\begin{array}{r} 8 \\ -\ 2 \\ \hline 6 \end{array} \qquad \begin{array}{r} 8 \\ 8 \\ \hline \text{remove } ① \ 6 \end{array} \rightarrow (10\text{'s complement } (10-2)=8)$$

②

$$\begin{array}{r} 9 \\ -\ 5 \\ \hline 4 \end{array} \qquad \begin{array}{r} 9 \\ 5 \\ \hline \text{remove } ① \ 4 \end{array} \rightarrow (10\text{'s complement } (10-5)=5)$$

③

$$\begin{array}{r} 4 \\ -8 \\ \hline -4 \end{array} \qquad \begin{array}{r} 4 \\ 2 \\ \hline 6 \end{array} \rightarrow (10\text{'s complent of } (10-8)=2)$$

Result no carry indicate that the answer is (-ve) and in the 10's complement form (or) in completed form