INDEX

unit-1 :- Number System and codes

Decimal, Binary, Hexadecimal, octal, codes : BCD, Gray and excess-3-codes - Code Conversions - Complements (1's, 2's, 9's and 10's), Addition - substraction using complement methods.

unit-2 :- Boolean algebra and Theorems

Boolean theorems, De-morgan's Laws, digital Logic gates, multi level NAND & NOR gates, standard representation of Logic functions (SOP and POS), minimization Techniques (Karnaugh map method : 2,3 Variables).

unit-3 :- Combinational digital circuits (o/p depends on present I/p)

Adders - half & full adder, Subtractor - Half and full Subtractors, parallel binary adder, magnitude Comparator, multiplexers (4:1) and Demultiplexers (1:4), Encoder (8-line-to-3-line) and Decoder (3-line-to-8-line), IC-Logic Families : TTL Logic, CMOS Logic families (NAND & NOR gates).

unit-4 :- Sequential digital circuits (o/p depends on past & present I/p)

flip flops : S-R FF, J-K FF, T and D type FFS, master - slave FFS, Excitation tables, Registers : Serial in Serial out and parallel in and parallel out, Counters Asynchronous Mod-8, mod-10, Synchronous - 4-bit & Ring Counter

unit-5 :- Memory devices

General Memory operations, ROM, RAM (static and dynamic), PROM, EPROM, EEPROM, EAROM.

PAL & PLA (programmable logic Array)

Number Systems :-

They are 4 different types of Number systems

1) Binary Number System
2) Decimal Number System
3) octal Number system
4) Hexadecimal Number System

⇒ We can recognise Number System by radix or base

Binary Number System :-

→ It has the base 2

→ 0's and 1's are the part of this Binary Number System.

Eg:- $(10110101)_2$

Decimal Number System :-

⇒ It has the base 10

⇒ 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 are the part of decimal Number System

eg:- $(8998)_{10}$

octal Number System :-

⇒ It has the base 8

⇒ 0, 1, 2, 3, 4, 5, 6, 7 are the part of octal Number System

eg:- $(765)_8$

Hexadecimal Number System :-

⇒ It has the base 16

⇒ 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F are the part of Hexadecimal

eg :- 2AF

Number System definition :- It is a language of digital system consisting of an ordered set of symbols called digits with rules defined for addition, Multiplication and other mathematical operations.

Radix or Base :- Specifies Number of Symbols used for corresponding Number System

Number System Conversions:-

⇒ one form of a Number in base is converted into another form of Number System in equivalent base.

1) Decimal to any base Number System
2) Any base Number System to decimal Number System
3) Binary to any base Number System
4) octal to any b Hexadecimal Number System
5) Hexadecimal to octal Number System

Decimal to any base Number System:-

→ Decimal to Binary
→ Decimal to octal
→ Decimal to Hexadecimal

Binary to decimal
octal to decimal
Hexa to decimal

Binary to octal
octal to binary
Binary to Hexadecimal
Hexadecimal to Binary
octal to hexadecimal
Hexadecimal to octal

Decimal to binary :-

Steps -1

1) The given decimal integer divided by 2, leave a Remainder. (deniloki convert cheyyalo dani base tho divide cheyyal)

Step-2 :- Divide the quotient obtained from the step-1 will leave a remainder.

Step-3 :- Repeat the step-2 until the quotient is less than base 2.

Step-4 :- Collect the Remainders from bottom to top to get the equivalent binary Number.

eg:- Convert decimal Number 46 into binary

2	46	
2	23	- 0
2	11	- 1
2	5	- 1
2	2	- 1
	1	- 0

$\therefore (46)_{10} = (101110)_2$

2) Convert $(115)_{10}$ into binary

$$
\begin{array}{r|l}
2 & 115 \\
2 & 57 - 1 \\
2 & 28 - 1 \\
2 & 14 - 0 \\
2 & 7 - 0 \\
2 & 3 - 1 \\
 & 1 - 1
\end{array}
$$

$\therefore (115)_{10} = (1110011)_2$

⇒ Decimal number with fraction to binary

Step-1 :- Multiply the decimal fraction by 2 to producing product from the product integer part is either 0 or 1, this part is Separated

Step-2 :- Multiply the fractional part of the product in step-1 producing the Next partial product Separate the integer part.

Step-3 :- Repeat Step-2 until the necessary steps

Step-4 :- Collect all integers from top to bottom to get equivalent fractional binary numbers

eg-1 :- $(0.2)_{10}$

Multiply with binary

$0.2 \times 2 = 0.4 \rightarrow 0$ → 0.4 integer part → 0

$0.4 \times 2 = 0.8 \rightarrow 0$ → 0.8 lo integer part 0 teesisinal 0.8 ne untundli

$0.8 \times 2 = 1.6 \rightarrow 1$ → 1.6 lo integer part = 1 teesesthe inka 0.6 untundi

$0.6 \times 2 = 1.2 \rightarrow 1$

$(0.2)_{10} = (0.0011)_2$

eg-3 :- Convert $(25.75)_{10}$ to base 2

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

$(25)_{10} = (11001)_2$

0.75

$0.75 \times 2 \rightarrow 1.5 \rightarrow 1$

$0.5 \times 2 \rightarrow 1.0 \rightarrow 1$

$(0.75)_{10} = (0.11)_2$

Decimal to octal :-

Step-1 :- The given decimal integer divided by 8, leaves a Remainder.

Step-2 :- Divide the quotient obtained from step-1 will leave the remainder.

Step-3 :- Repeat the step-2 until the quotient is less than base-8

Step4 :- Collect the Remainders from bottom to top to get the equivalent Octal Number

Convert the decimal number 86 into octal

$$\begin{array}{r|l} 8 & 86 \\ \hline 8 & 10 - 6 \\ \hline & 1 - 2 \end{array}$$

$(86)_{10} = (126)_8$

Decimal number with fraction to octal

Step-1 :- Multiply decimal fraction by 8 to producing product from the product integer part is either 0 to 7, this part is Separated

Step-2 : Multiply the fractional part of the product in step-1 producing the Next partial product Separate the integer part.

Step-3 : Repeat the step-2, until the required data is obtained.

Step-4 :- Collect all integer from top to bottom to get equivalent fractional part of octal Numbers.

Convert $(0.45)_{10}$ to base 8

Multiply with octal

$0.45 \times 8 = 3.60 \rightarrow 3$ (Integer part separate chesam)

$0.60 \times 8 = 4.80 \rightarrow 4$ Migilina danani malli

$0.80 \times 8 = 6.40 \rightarrow 6$ 8 tho multiply

$0.40 \times 8 = 3.20 \rightarrow 3$ chestham

$0.20 \times 8 = 1.60 \rightarrow 1$

$0.60 \rightarrow$ It can be Repeated

pai nuchi kindaki Rayali fraction ayithe

$\therefore (0.45)_{10} = (0.34631)_8$

Convert $(2142.53)_{10}$ to base 8

$$\cancel{\begin{array}{r|l} 8 & 2142 \\ 8 & 267 - 6 \\ 8 & 33 - 4 \\ & 4 - 1 \end{array}} \qquad \begin{array}{r|l} 8 & 2142 \\ 8 & 267 - 6 \\ 8 & 33 - 3 \\ & 4 - 1 \end{array}$$

$(2142)_{10} = (4136)_8$

$0.53 \times 8 = 4.24 \rightarrow 4$

$0.24 \times 8 = 1.92 \rightarrow 1$

$0.92 \times 8 = 7.36 \rightarrow 7$

$0.36 \times 8 = 2.88 \rightarrow 2$

$0.88 \times 8 = 7.04 \rightarrow 7$

$\cancel{0.56 \times 8 = 4.48 \rightarrow 4}$

$0.04 \times 8 = 0.32$

$(0.53)_{10} = (0.417270)_8$

$\therefore (2142.53)_{10} = (4136.417270)_8$

Decimal to hexadecimal :-

Step-1 :- The given decimal integer divided by 16 leaves a Remainder

Step-2 :- Divide the quotient obtained from step-1 will leave the Remainder

Step-3 :- Repeat the step-2 until the quotient is less than base-16

Step-4 :- Collect the Remainders from bottom to top to get the equivalent Hexadecimal

$$\begin{array}{r|l} 16 & 214 \\ \hline & 13 - 6 \end{array}$$

A B C D E F (10 11 12 13)

D = 13

$(214)_{10} = (D6)_{16}$

i) Decimal fraction to Hexadecimal

$(0.35)_{10}$

$0.35 \times 16 = 5.60 \rightarrow 5$

$0.60 \times 16 = 9.60 \rightarrow 9$

$0.60 \times 16 = 9.60 \rightarrow 9$ (Repeat other time)
So akkada tho leave cheyyachu

$(0.35)_{10} = (0.59)_{16}$

2) Convert $(348.75)_{10}$ to Hexadecimal

$$\begin{array}{r|l} 16 & 348 \\ \hline 16 & 21 - 12 \\ \hline & 1 - 5 \end{array}$$

12 = C

$(348)_{10} = (15C)$

$0.75 \times 16 = 12.00 \rightarrow 12$

0.00

$(0.75)_{10} = (0.C)_{16}$

3) Convert $(783.46)_{10}$ to Hexadecimal

$$\begin{array}{r|l} 16 & 783 \\ \hline 16 & 48 - 15 \\ \hline & 3 - 0 \end{array}$$

$$\begin{array}{r} 78 \\ 64 \\ \hline 14 \end{array} \qquad \begin{array}{r} 3\,13 \\ 143 \\ 128 \\ \hline 15 \end{array}$$

$(783)_{10} = (30F)_{16}$

$0.46 \times 16 = 7.36 \rightarrow 7$

$0.36 \times 16 = 5.76 \rightarrow 5$

$0.76 \times 16 = 12.16 \rightarrow 12$

$0.16 \times 16 = 2.56 \rightarrow 2$

$0.56 \times 16 = 8.96 \rightarrow 8$

$0.96 \times 16 = 15.36 \rightarrow 15$

$(0.46)_{10} = (0.75C28F)_{16}$

$(783.46) = (30F.75C28F)_{16}$

Any base number System to decimal Number System

⇒ Binary to decimal

⇒ octal to decimal

⇒ Hexadecimal to decimal

Binary to decimal :-

Step-1 :- Mark the positional weights for each bit

Step-2 :- Multiply the positional weight with the bit and add the products together

Step-3 :- Sum obtained from step-2 is the equivalent decimal number

octal → digits

Binary → bit

Hexadecimal → digits

1) Convert $(1101.11)_2$

$$\begin{array}{cccccccc} 2^3 & 2^2 & 2^1 & 2^0 & & 2^{-1} & 2^{-2} \\ 1 & 1 & 0 & 1 & \cdot & 1 & 1 \end{array}$$

$8+4+1+\frac{1}{2}+\frac{1}{4}$ $\qquad \frac{1}{2}+\frac{1}{4} = \frac{2+1}{4}$

$13+\frac{3}{4} = \frac{55}{4}$ (or) $13+0.5+0.25$

$= 13.75$

$\therefore (1101.11)_2 = (13.75)_{10}$ Any base to decimal

2) Convert the following binary into decimal

(i) (10111011)

$$\begin{array}{cccccccc} 2^7 & 2^6 & 2^5 & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 \\ 1 & 0 & 1 & 1 & 1 & 0 & 1 & 1 \end{array}$$

$128+32+16+8+2+1$

$= 187$

$(10111011)_2 = (187)_{10}$

$$\begin{array}{r} 11 \\ 16 \\ 32 \\ \hline 59 \\ 128 \\ \hline 187 \end{array}$$

(ii) 0.11101

$$\begin{array}{ccccccc} & & 2^{-1} & 2^{-2} & 2^{-3} & 2^{-4} & 2^{-5} \\ 0 & \cdot & 1 & 1 & 1 & 0 & 1 \end{array}$$

$\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{32}$

$0.5+0.25+0.12+0.03$

$= 0.90$

8) 10 (.12
8
20

32) 100 (.03

$$\begin{array}{r} 0.50 \\ 0.25 \\ 0.12 \\ 0.03 \\ \hline 0.90 \end{array}$$

(iii) 111011.1011

$$\begin{array}{ccccccccccc} 2^5 & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 & & 2^{-1} & 2^{-2} & 2^{-3} & 2^{-4} \\ 1 & 1 & 1 & 0 & 1 & 1 & \cdot & 1 & 0 & 1 & 1 \end{array}$$

$32+16+8+2+1+\frac{1}{2}+\frac{1}{8}+\frac{1}{16}$

$32+16+8+2+1+0.5+0.12+0.06$

59.68

$\therefore (111011.1011)_2 = (59.68)_{10}$

16) 100 (.06

$$\begin{array}{r} 0.50 \\ 0.12 \\ 0.06 \\ \hline 68 \end{array}$$

(iv) 11010.101

$$\begin{array}{ccccccccc} 2^4 & 2^3 & 2^2 & 2^1 & 2^0 & & 2^{-1} & 2^{-2} & 2^{-3} \\ 1 & 1 & 0 & 1 & 0 & \cdot & 1 & 0 & 1 \end{array}$$

$16+8+2+\frac{1}{2}+\frac{1}{8}$

$$\begin{array}{r} 0.50 \\ 0.12 \\ \hline 62 \end{array}$$

$26+0.5+0.12$

octal to decimal

Same steps as Binary

1) Convert $(427.35)_8$ to decimal

$$\begin{array}{cccccc} 8^2 & 8^1 & 8^0 & & 8^{-1} & 8^{-2} \\ 4 & 2 & 7 & . & 3 & 5 \end{array}$$

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

$$25496 + 16 + 7 + \frac{3}{8}\times\frac{5}{64}$$

$$256\cancel{496} + 16 + 7 + 0.37 + 0.07$$

$$\underline{\underline{279.44}}$$

$$\begin{array}{r} 256 \\ 23 \\ \hline 279 \end{array} \qquad \begin{array}{r} 0.37 \\ 0.07 \\ \hline 0.44 \end{array}$$

$$\begin{array}{r} 64\times4 \\ \hline 496 \end{array}$$

$$3\times \quad \frac{5}{64} \qquad \begin{array}{r} 64\times7 \\ \hline 448 \end{array}$$

$$8)\,30\,(.37 \qquad \begin{array}{r} 64\times5 \\ \hline 320 \end{array}$$
$$\begin{array}{r} 24 \\ \hline 60 \\ 56 \end{array}$$
$$64)\,500\,(.07$$

Hexadecimal to decimal

1) Convert $(A6)_{16}$ into decimal

$$\cancel{\begin{array}{ccc} 16^2 & 16^1 & 16^0 \\ 1 & 0 & 6 \end{array}} \qquad \begin{array}{cc} 16^1 & 16^0 \\ A & 6 \end{array}$$

$$= 10\times16^1 + 6\times16^0$$
$$= 160 + 6$$
$$= \underline{166}$$

$$\therefore (A6)_{16} = (166)_{10}$$

Hexa Decimal		Binary 8 4 2 1 (2^3 2^2 2^1 2^0)
	0	0 0 0 0 — $0\times2^0+0\times2^1+0\times2^2+0\times2^3$
	1	0 0 0 1 — $1\times2^0+0\times2^1+0\times2^2+0\times2^3$
	2	0 0 1 0
	3	0 0 1 1
	4	0 1 0 0
	5	0 1 0 1
	6	0 1 1 0
	7	0 1 1 1
	8	1 0 0 0
	9	1 0 0 1
A	10	1 0 1 0
B	11	1 0 1 1
C	12	1 1 0 0
D	13	1 1 0 1
E	14	1 1 1 0
F	15	1 1 1 1

Binary to octal :-

⇒ for integer part grouping will be start from right to left and write the equivalent octal digit for each group.

⇒ for fractional part grouping is starting from left to right after the integer part and replace by one octal digit for group

⇒ If any group containing less than 3 bits the padding (add) the zero's infront of the binary bit (for integer) and padding the 0's after the bits (for fractional part) to make 3 bit group

1) Convert the binary Number $(1101101.10101)_2$ to octal

1 101 101 . 101 01

adding two zeros to form group ← $\underline{001}$ $\underline{101}$ $\underline{101}$. $\underline{101}$ $\underline{010}$

1 5 5 . 5 2

First integer part ni right to left 3 numbers(bits) oka group ga form cheyyali, tarvatha group lo 3 bits lekapothe 0's ni mundhu add cheyukovali

⇒ fraction part ni left side to right side 3 bits ga oka group ga divide cheyyali edaina group lo 3 bits lekapothe right side 0's add cheyyali.

$\therefore (1101101.10101)_2 = (155.52)_8$

Octal to binary

Octal to binary steps same as Binary to octal kani daggara equivalent octal ki equivalent binary

1) Convert $(732.45)_8$ to binary

7 → 111, 3 → 011, 2 → 010, 4 → 100, 5 → 101

$\therefore (732.45)_8 = (111\ 011\ 010 . 100101)_2$

Binary to Hexadecimal

St Binary to octal steps lo 3 bits unna daggara 4 bits Rayali

1) Convert $(110111.10101111)_2$ into Hexa decimal lo 4 bits ga ni group cheyyali

$\underline{0011}$ $\underline{0111}$. $\underline{1010}$ $\underline{1111}$

3 7 . A F

$\therefore (110111.10101111)_2 = (37.AF)$

Hexadecimal to Binary

1) $(1CEF.2B)_{16}$

1 C E F . 2 B

0001 11000 1110 1111 0010 1011

$(1CEF.2B)_{16} = (1110011101111 . 00101011)_2$

Octal to Hexa decimal :-

→ Convert given octal Number to its binary equivalent by write 3 bit group for each octal digit

→ Regroup the bits in 4 bit group.

→ Replace the each 4 bit group by one hexadecimal digit

eg :- Convert the octal Number $(7324.456)_8$ to hexa decimal

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

1110	1101	0100	·	1001	0 1110
14	13	4		9	7

E D 4 . 9 7

∴ $(7324.456)_8 = (ED4.97)_{16}$

Hexa decimal Number System to octal Number :-

→ Convert given hexa decimal Number to it's binary equivalent by write 4 bit group for each hexa decimal digit.

→ Regroup the bits in 3 bit group

→ Replace the each 3 bit group by one octal digit

eg:- Convert $(4ECE.43F)_{16}$ to base 8

4	E	C	E	·	4	3	F
↓	↓	↓	↓		↓	↓	↓
0100	1110	1100	1110		0100	0011	1111

0 100	111	011	001	110	·	010	000	111	111
4	7	3	1	6		2	0	7	7

∴ $(4ECE.43F)_{16} = (47316.2077)_8$

Binary coded decimal (BCD)

→ It is the way of expressing each of the decimal digits with a binary code.

→ They are only 10 code group in the BCD System, So it is very easy to convert b/w decimal to BCD

→ BCD means that each decimal digit 0 to 9 0 through 9 is represented by a binary code of 4 bits

Decimal digit	BCD code
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	0001 0000
11	0001 0001

~~Exa~~

eg-1 :- Convert the $(72)_{10}$ into BCD & Binary

$(72)_{10}$

decimal to BCD

7 → 0111, 2 → 0010

$(72)_{10} = (0111\ 0010)_{BCD}$

(ii)

decimal to Binary

$$
\begin{array}{r|l}
2 & 72 \\
2 & 36 - 0 \\
2 & 18 - 0 \\
2 & 9 - 0 \\
2 & 4 - 1 \\
2 & 2 - 0 \\
 & 1 - 0
\end{array}
$$

$(72)_{10} = (1001000)_2$

Excess-3 Code :-

→ Excess-3 code is a modify form of BCD code, It can be obtained from the natural BCD code by adding 3 to each decimal digit.

→ In this code no definite weights are assaigned to the 4 bit position.

→ Hence this code is called a non-weighted code

Decimal digit	BCD code	Excess-3 code	
0	0000	0011	(0+3)
1	0001	0100	(1+3)
2	0010	0101	(2+3)
3	0011	0110	(3+3)
4	0100	0111	(4+3)
5	0101	1000	(5+3)
6	0110	1001	(6+3)
7	0111	1010	(7+3)
8	1000	1011	(8+3)
9	1001	1100	(9+3)
10	0001 0000	0100 0011	
11	0001 0001	0100 0100	

Eg :- write a Excess 3 code for 72

72

7+3 → 10, 2+3 → 5 ⇒ 1010 0101

1010 ⇓ Binary Code for 10

0101 ⇓ Binary Code for 5

1) Addition

			Sum	Carry	Substraction Diff	Borrow
0	0	⇒ 0+0	= 0		0	
0	1	→ 0+1	= 1		1	1 → (neg... indica...)
1	0	⇒ 1+0	= 1		1	
1	1	⇒ 1+1	= 0	1	0	

Gray Code :-

[Binary code to Gray ki Convert chesthe MSB to LSB Chusukovali
⇒ MSB nunchi, first digit Binary ki Gray ki Same
⇒ adjacent digit ni add cheri gray code lo rayali
⇒ Sum ki Carry vasthe ignore cheyyali

LSB → Least Significant Bit

MSB → Most Significant Bit

eg:

	MSB				LSB
Binary	1	0	1	1	0
	↓	1+0	0+1	1+1 (Sum 0, Carry 1)	1+0
Gray	1	1	1	0	1
To cross check	↓	+	+	+	+
Binary	1	0	1	1	0

(Carry ni ignore chestham)

⇒ The code which exhibits only a single bit change from one number to next is known as Gray code i.e in this the code between any two successive code words (adjacent codes) there will be change in only one position. This code is also called as cyclic code or non-weighted code.

Decimal	Binary Code	Gray code
0	0 0 0 0	0 0 0 0
1	0 0 0 1	0 0 0 1
2	0 0 1 0	0 0 1 1
3	0 0 1 1	0 0 1 0
4	0 1 0 0	0 1 1 0
5	0 1 0 1	0 1 1 1
6	0 1 1 0	0 1 0 1

Binary Code to Gray Code :-

Step-1 ⇒ The MSB (Most Significant bit) in gray code is same as in the binary number

Step-2 :- Add the MSB to the bit immediately to its right (adjacent) in Binary. if Carry produced ignore it and

Step-3 :- Record the next bit of gray code

Step-4 :- Repeat the step-2 until all the bits in Binary numbers have been added. Result is equivalent gray code.

Gray code to Binary code Conversion:-

① ⇒ The MSB of Gray code is Same as binary.

② ⇒ Add the MSB in the binary to the bit immediately on its right in the gray code

③ ⇒ put the Sum in the Binary code

④ ⇒ Carry can be neglected.

⑤ ⇒ Repeat the step-2 until the all the gray code bits converted to binary

1) Convert the following binary to Gray

a) Binary code : 1 1 0 1 1 1

Same ↓   1+1   1+0   0+1   1+1

Gray code :- 1 0 1 1 0 0

b) Binary code : 1 0 0 1 1 0

Gray code : 1 1 0 1 0 1

2) Convert the Gray codes to Binary

a) Gray code : 1 0 1 0 0 1

Binary code 1 1 0 0 0 1

b) Gray code : 1 1 1 0 0 1

Binary code 1 0 1 1 1 0

Binary code : 101110

09-09-21

ichina digit ki complement Rayadame

Complements :-

Complements :-

⇒ In digital system to simplify the substraction operation and for logical manuplulation complements are used.

⇒ They are 2 types of complements, the first is refferred to r's complement and the second is r-1 complements

1's Complements :- ichina digit ki Complement Rayadame

⇒ The 1's Complement of a binary number is obtained by change all 1's to 0's and 0's to 1's.

Find the 1's complement ?

1) $(11010100)_2$

00101011

2's Complement :- 1's Complement chesi vachina answer ki +1 cheyyali

⇒ The 2's Complement is obtained by adding 1 to the 1's Complement

2's Complement = 1's Complement +1

Binary Substraction using 1's Complement method

⇒ In a 1's complement method negative number is represented in the 1's complement form and actual addition is performed to get the deserived result

for example :- A - B is performed using following steps

Step-1 :- Take the one's complement of B

Step-2 :- Result is A+ (1's complement of B)

Step-3 :- If carry is generated then the result is positive and in the true form and add carry to the result to get the final result.

Step-4 :- If the Carry is not generated then the result is negative and it is in the 1's Complement form

1's Complement lo vuntundhi kanuka result kolam malli Complement cheyyali

1) perform $(28)_{10} - (15)_{10}$ using 1's complement ?

$2 \,|\, 28$
$2 \,|\, 14 - 0$
$2 \,|\, 7 - 0$
$2 \,|\, 3 - 1$
$1 - 1$

$(28)_{10} = (11100)_2$

$2 \,|\, 15$
$2 \,|\, 7 - 1$
$2 \,|\, 3 - 1$
$1 - 1$

$(15)_{10} = (01111)_2$

$(28)_{10}$ ki 5 digits unnayi kanuka $(15)_{10}$ ki kuda 5 digits vundali so oka zero left side add chestham

$\Rightarrow (28)_{10}$ have 5 digit so we add "0" to $(15)_{10}$

1's complement of $(15)_{10} = (10000)_2$

$(28)_{10}$ + 1's complement of $(15)_{10} = (10000)_2$

Sum			Carry
0	0	=	0
0	1	=	1
1	0	=	1

```
      1 1 1 0 0
(+)   1 0 0 0 0
    -----------
Carry <- (1) 0 1 1 0 0
                  1   => Add one to 1's complement
    -----------
      0 1 1 0 1
```

Carry
$(1+1) = 0$
Carry - 1

2) $(15)_{10} - (28)_{10}$

$(15)_{10} = (01111)_2$

$= (01111)_2$

$(28)_{10} = (11100)_2$

Complement $= (11100)_2$

```
  0 1 1 1 1
  0 0 0 1 1   -> 1's complement of (28)10
  ---------
  1 0 0 1 0
```

$\Rightarrow$ Carry generate avvaledhu kanuka value -ve lo vundhi.

1's complement = 01101

result $= (-13)_{10}$

problems based on 2's Complement

1) $(28)_{10} - (15)_{10}$

$(28)_{10} = (11100)_2$

$(15)_{10} = (01111)_2$

1's complement of $(15)_{10} = (10000)_2$

1's Complement +1 = 2's com

$$\begin{array}{r} 10000 \\ 1 \\ \hline 10001 \end{array}$$

$(28)_{10}$ + 2's Complement of $(15)_{10}$

$$\begin{array}{r} 11100 \\ +\ 10001 \\ \hline \text{Carry} \leftarrow 1\ 01101 \end{array}$$

ignore cheyyali

[2's Complement lo Carry generate ayithe result +ve Carry neglect Cheyyali]

$(28)_{10} - (15)_{10} = 01101 = (13)$

=> If Carry is generate result is positive and neglect Carry it is true form and

=> If Carry is not generated the result is negative and it is in 2's Complement form

2) $(15)_{10} - (28)_{10}$

$(28)_{10} = (11100)_2$

$(15)_{10} = (01111)_2$

1's complement of $(28)_{10} = (00011)_2$

1's Complement +1 = 2's Complement

$$\begin{array}{r} 00011 \\ 1 \\ \hline \text{2's Comp} \Rightarrow 00100 \end{array}$$

$(15)_{10}$ + 2's Complement of $(28)_{10}$

$$\begin{array}{r} 01111 \\ (+)\ 00100 \\ \hline 10011 \end{array}$$

=> Carry is not generated so it is in 2's Complement (-ve) form

Carry raledhu kanuka inka Convert chesam

-ve form So convert to 1's complement and then +1

1's comp of 10011 = 01100

$$\begin{array}{r} 01100 \\ +\ 1 \\ \hline 01101 \end{array}$$

$(15)_{10} - (28)_{10} = (13)$

2's Complement lo vundhi kanuka answer ni 1's Complement raasi +1 cheyyali

3) i) 11010 − 10000

ii) 11010 − 1101

1's Complement of 10000 is 01111

```
        1 1 0 1 0
        0 1 1 1 1
carry ← ① 0 1 0 0 1
                  1
        0 1 0 1 0
```

(11010) − (10000) = (01010)

26 − 16 = 10

(ii) 1's complement of 01101 is 10010

```
        1 1 0 1 0
        1 0 0 1 0
Carry ← ① 0 1 1 0 0
                  1
        0 1 1 0 1
```

(11010) − (01101) = 01101

26 − 13 = 13

By using 2's Complement

i) 11010 − 10000

2's complement of 10000 = 1's complement + 1

= 01111

1

10000

(11010) + 2's Complement of 10000

```
               1 1 0 1 0
               1 0 0 0 0
Carry ignore ← ① 0 1 0 1 0
```

∴ (11010) − (10000) = 01010

26 − 16 = 10

2) 11010 − 1101

2's complement of 01101 = 1's complement + 1

= 10010

1

10011

(11010) + 2's Complement of 01101

```
               1 1 0 1 0
               1 0 0 1 1
Carry ignore ← ① 0 1 1 0 1
```

∴ (11010) − (1101) = 01101

26 − 13 = 13

BCD addition

Step-1 :- Add two BCD numbers using ordinary binary addition.

Step-2 :- If 4 bit sum is equal or less than 9 no correction is needed the sum is in proper BCD form.

Step-3 :- If the 4 bit sum is greater than 9, or a carry is generated from the 4 bit sum, the sum is invalid.

Step-4 :- To correct the invalid sum add 6 (0110) to the 4 bit sum, if a carry results from this addition add it to the next higher order BCD digit.

1) perform 24 + 18 using BCD addition

BCD Kanuka individual digits ki veyyali binary

```
 24
+18
----
 42

24 → 0010  0100
18 → 0001  1000
     ----------
(3) ← 0011  1100 = 12 (invalid BCD)
```

<6 So 6 add cheyyanavasaram ledhu

Greater than 9 So add 6 to 1100

```
 0011  1100
       0110  ⇒ 6 add
 ----------
 0100  0010
  ↓     ↓
  4     2
```

6 = 0110

Chesam enduku ante >9

Okavela ikkada carry vasthe malli add cheyyali

(24) + (18) = 42

2) 48 + 58 using BCD

```
48 → 0100  1000
58 → 0101  1000
     ----------
     1010  0000
```

>9 So add 6

```
  1010  0000
  0110
  ----------
① 0000  0000
        0110
  ----------
0001  0000  0110
```

carry can consider as value

48 + 58 = 1 0 6

BCD Substraction using 9's Complement method

⇒ find the 9's Complement of negative number

⇒ Add two numbers using BCD addition

⇒ If Carry is not generated result is negative and find the 9's Complement of the result and otherwise result is positive add Carry to result.

9's comp of 55
999
555
444

99 ← No of digit
58
41

9's Complement ante ichina number enni digits vunte anni 9's nunchi Subtract cheyyali

⇒

(1) 78 - 15

78
15
63

9's Complement of 15

99
15
84

78+84

78 → 0111 1000
84 → 1000 0100
1111 (>9) 1100 (>9)
0110 0110
Carry ← 1 0110 0010
ni add cheyyali → 1
BCD Subtraction 0110 0011

78 - 15 = 6 3

79 so add +6

2)

46
-22
24

9's Complement of 22

99
22
77

46+77

46 → 0100 0110
77 → 0111 0111
1011 (>9) 1101 (>9)
0110 0110
① 0010 0011
1
0010 0100

46 - 22 = 2 4

3) 54 - 28

$$\begin{array}{r} \overset{4\,14}{\cancel{5}4} \\ 28 \\ \hline 26 \end{array}$$

9's Complement of 28

$$\begin{array}{r} 99 \\ 28 \\ \hline 71 \end{array}$$

54 + 71

54 →	0101	0100
71 →	0111	0001
	1100 (>9)	0101
	0110	
Carry ni ← 1	0010	0101
		→ 1
	0010	0110

>9 So add +6

9's Complement lo Carry add Cheyyali

Carry ni add Cheyyali malli

10's complement = 9's Comp + 1

10's Complement lo Carry add Cheyyanavasaram ledhu

54 - 28 = 2 6

4) 24 - 56

9's Complement of 56

$$\begin{array}{r} 99 \\ 56 \\ \hline 43 \end{array}$$

24+43

24 →	0010	0100
43 →	0100	0011
	0110	0111
	6	7

<9 So we didn't add 6

Carry generate avvaledhu kanuka result negative ga vundhi

Carry is not generated So result is -ve So write 9's Complement of result

So vachina result ki 9's Complement anedhi answer avutundhi

$$\begin{array}{r} 99 \\ 67 \\ \hline 32 \end{array}$$

24 - 56 = -32

⇓

⟹ 10's Complement ayithe -ve ayithe vachina 9's Complement answer ki +1 Cheyyali

⟹ 10's Complement +ve ayithe Carry neglect cheyyali