Number system and codes

Number system Definiation →
A number system defines a set of values used to represent a quantity.

Ratix or base :- The number of values that a digit can have is equal to the base of the system. It is called base or Ratix.

For Ex :-
binary system → base or radix 2
octal system → base or ratix 8
decimal system → base or ratix 10
Hexadecimal system → base or ratix 16

weight :- Each place represents a different multiple of base or ratix. These Multiples are also called as weighted values or weight.

For Ex :-

$(349.25)_{10}$

3 4 9 . 2 5

$3 \times 10^2 = 300$ $4 \times 10^1 = 40$ $9 \times 10^0 = 9$ $2 \times 10^{-1} = 2/10$ $5 \times 10^{-2} = 5/100$.

base is binary i.e 2 then.

Ratix point

$\times B^3$ $\times B^2$ $\times B^1$ $\times B^0$. $\times B^{-1}$ $\times B^{-2}$ $\times B^{-3}$

* Various Numbering system :-

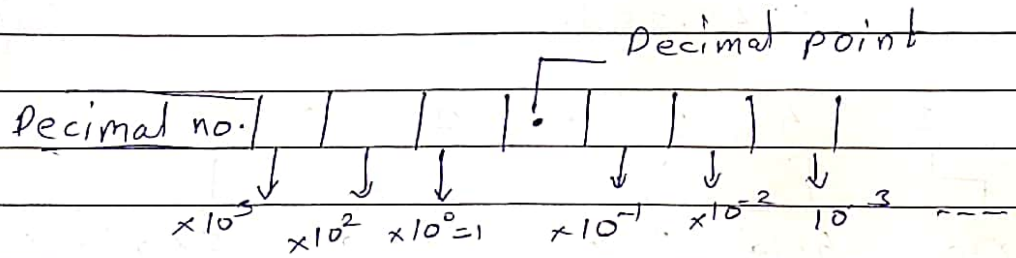
Number system	base
1) Binary	2
2) octal	8
3) Decimal	10
4) Duodecimal	12
5) Hexadecimal.	16

1) Decimal Number system :-

The number system we have been taught to use since school is called decimal number system.

characteristics of decimal system :-

1) It uses base of 10.
2) The largest value of digit is 9
3) Each place represent a different multiple of 10.



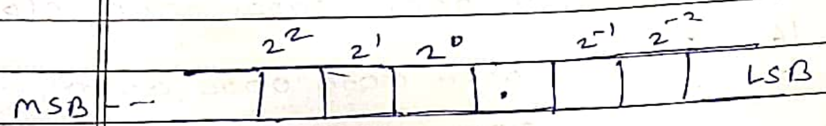
* most significant Digit (MSD) :-

The leftmost digit having the highest weight is called as the most significant of a number.

* **least significant Digit (LSD):-**
The rightmost digit having the lowest weight is called as the least significant digit of a number.

MSB | Number | LSB.

2) **Binary number system:-**
A number with radix 2 is called as binary number system.
A binary number system uses only two digit 0 and 1.



The binary digits (0 and 1) are also called as **bits**.

Binary Number	Decimal number
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9

1010	10
1011	11
1100	12
1101	13
1110	14
1111	15

* Binary Number Formats :-

Name	size (bits)	Example
Bit	1	1 or 0
Nibble	4	0101
Byte	8	0000 0101
word	16	0000 0000 0000 0101
Double word	32	0000 0000 0000 0000 0000 0000 0000 0101

Disadvantages of binary system :-
The binary number system has an important drawback. It requires a very long string of 1's and 0's to represent a decimal number.

$$(128)_{10} = (10000000)_2$$

3) octal Number system :-
A number system with radix 8 is called as the octal number system.

Base → 8

Number of system in digit → 0, 1, 2, 3, 4, 5, 6, 7.

octal number :-

0	10	20	30	40
1	11	21	31	41
2	12	22	32	42
3	13	23	33	43
4	14	24	34	44
5	15	25	35	45
6	16	26	36	46
7	17	27	37	47

MSB | | | | . | | | LSB

$\times 8^2$ $\times 8^1$ $\times 8^0$. $\times 8^{-1}$ $\times 8^{-2}$

4) **Hexadecimal number system:-**

A number system with a radix 16 is called hexadecimal number.

Number used → 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F.

Hexadecimal number:-

0	A
1	B
2	C
3	D
4	E
5	F
6	~~10~~
7	
8	~~11~~
9	~~12~~

MSB | | | | . | | | | LSB

$\times 16^2$ $\times 16^1$ $\times 16^0$. $\times 16^{-1}$ $\times 16^{-2}$ $\times 16^{-3}$

* Conversion of Number system:-

1) Conversion from other number system to decimal number system :-

1) Convert binary to decimal number system:-

step 1 → Note down the given number

step 2 → Write down the weights corresponding to different positions.

step 3 → Multiply each digit in the given no. with the corresponding weight to obtain product numbers.

step 4 → Add all the product numbers to get the decimal equivalent.

For Example :-

1) convert the binary number 1011.01_2 into its decimal equivalent.

$$\begin{array}{cccccc} 1 & 0 & 1 & 1 . & 0 & 1 \\ \uparrow & \uparrow & \uparrow & \uparrow & \uparrow & \uparrow \\ 1\times2^3 & 0\times2^2 & 1\times2^1 & 1\times2^0 & 0\times2^{-1} & 1\times2^{-2} \end{array}$$

$1\times2^3 = 8$ $\quad$ $0\times2^{-1} = 0$

$0\times2^2 = 0$ $\quad$ $1\times2^{-2} = \frac{1}{4} = 0.25$

$1\times2^1 = 2$

$1\times2^0 = 1$

$0+0.25 = 0.25$

$8+0+2+1 = 11$

$11 + 0.25 = (11.25)_{10}$

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ANS :- $\boxed{(1011.01)_2 = (11.25)_{10}}$

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Exersice

Q.1 convert following binary number to decimal number.

1) $(101.11)_2$ 2) $(110.1)_2$ 3) $(1111.111)_2$

4) $(0101.111)_2$ 5) $(101010.11)_2$

2) conversion from octal number to decimal number

For Example :-

Q) convert the octal number $(365.24)_8$ into its equivalent decimal number.

3 6 5 . 2 4

$3\times 8^2 + 6\times 8^1 + 5\times 8^0 + 2\times 8^{-1} + 4\times 8^{-2}$

$192 + 48 + 5 + 0.25 + 0.0625$

$(245.3125)_{10}$

ANs. $\rightarrow$ $(365.24)_8 = (245.3125)_{10}$

Q.1) convert the octal number to equivalent decimal number.

1) $(25.4)_8$ 2) $(314.02)_8$ 3) $(10)_8$

4) $(104)_8$ 5) $(25.25)_8$

3) convert from hex number to decimal no.

Q.1) convert the hex number $(4C8.2)_{16}$ into its equivalent decimal number.

given no. 4 C 8 . 2

4 C 8 . 2

$4\times16^2 + C\times16^1 + 8\times16^0 + 2\times16^{-1}$

$1024 + 192 + 8 + 0.125$

1224.

** conversion from Decimal to other system:-

step-1 → Divide the integer part of given decimal number by the base and note down the remainder

step-2 → continue the divide the quotient by the base(r) until there is nothing left, noting the remainders from each step.

step 3 → list the remainder value in reverse order from the bottom to top to find the equivalent.

1) convert decimal to equivalent binary number:-

Q. convert $(105)_{10}$ to the equivalent binary number

Given no. remindar.

2	105	
2	52	1
2	26	0
2	13	0
2	6	1
2	3	0
2	1	1
	0	1

MSB LSB

(1101001)

ANS :- $\boxed{(105)_{10} = (1101001)_2}$

For Fractional part

Q. convert decimal no. ~~105.42~~ $(105.42)_{10}$ to binary no.

1) (105) → (0.42)

2	105	
2	52	1
2	26	0
2	13	0
2	6	1
2	3	0
2	1	1
	0	1

$0.42 \times 2 = 0.84 \rightarrow 0$

$0.84 \times 2 = 1.68 \rightarrow 1$

$0.68 \times 2 = 1.36 \rightarrow 1$

$0.36 \times 2 = 0.72 \rightarrow 0$

$0.72 \times 2 = 1.44 \rightarrow 1$

MSB (0 1 1 0 1) LSB

$(105.42)_{10} = (1101001.01101)_2$

2) convert decimal no. to octal no.

Q) convert decimal no. $(204.6234)_{10}$ to octal no.

8	204	
8	25	4
8	3	1
	0	3

$(204)_{10} = (314)_8$

$0.6234 \times 8 = 4.9872$

$0.9872 \times 8 = 7.8976$

$0.8976 \times 8 = 7.1808$

$0.1808 \times 8 = 1.4464$

$0.4464 \times 8 = 3.5712$

(0.47713)

$\boxed{\text{Ans} \rightarrow (205.6234)_{10} = (314.47713)_8}$

3) convert decimal to hex:-

Q. Convert $(2003.31)_{10}$ into equivalent hex number:-

→ 1)

16	2003	
16	125	3
16	7	13
		7

$0.31 \times 16 = 4.96 \rightarrow 4$

$0.96 \times 16 = 15.36 \rightarrow F$

$0.36 \times 16 = 5.76 \rightarrow 5$

$0.76 \times 16 = 12.16 \rightarrow 12 \rightarrow C$

$0.16 \times 16 = 2.56 \rightarrow 2 \rightarrow 2$

$(2003.31)_{10} = (7D3.4F5C2)_{16}$

Q. convert ~~other~~ decimal no. system to other no. system

1) $(57)_{10} = (\;)_2$ 2) $(146.25)_{10} = (\;)_8$

3) $(268.75)_{10} = (\;)_2$ 4) $(123.12)_{10} = (\;)_2$

5) $(246.12)_{10} = (\;)_{16}$

* Conversion from binary to other systems:-

1) convert binary to octal:-

step-1 → Divide the binary bits into groups of 3 starting from the LSB.

step 2 → convert each group into its equivalent decimal. As the number of bits in each group is restricted to 3. the decimal number will be same as octal number.

Ex:-

Q convert the binary number $(11010010)_2$ into its equivalent octal number.

1) given no. is | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |

2) make group of 3 — group 3, group 2, group 1

3) convert into octal → 3 2 2

$(11010010)_2 = (322)_8$

Q. convert binary no. to octal no.

1) $(101101)_2 = (\quad)_8$

2) $(100011)_2 = (\quad)_8$

3) $(01011111)_2 = (\quad)_8$

4) $(1010111)_2 = (\quad)_8$

2) convert binary to Hex number system:-

step-1 → Divide the binary number into 4-bit sections from the LSB to the MSB.

step 2 → convert each 4-bit binary number to its hex equivalent.

For Ex:-

Q. convert binary number 1010111110110010 into the hex number?

→ split given no. into group of 4 bits = 1010 1111 1011 0010

A F B 2

Ans :- $\boxed{(AFB2)_{16}}$

Q. convert binary number to hex number?

1) $(101111)_2 = (\quad)_{16}$ 2) $(1011111)_2 = (\quad)_{16}$

3) $(1111111111)_2 = (\quad)_{16}$ 4) $(10000011111)_2 = (\quad)_{16}$

* conversion from other system to binary system:-

1) conversion from decimal to binary. already discussed.

2) octal to binary conversion :-

Q. convert the octal number $(364)_8$ into equivalent binary number.

→ given octal number → 3 6 4
convert each digit to binary → 011 110 100

$(364)_8 = (011110100)_2$

Q. convert the octal number to binary number
1) $(362)_8 = (\ )_2$ 2) $(364.25)_8 = (\ )_2$

3) convert ~~to~~ Hex number to binary :-
step-1 → convert each hex digit to its 4 bit binary equivalent.
step 2 → combine 4-bit sections by removing the spaces.

Q. convert hex number AFB2 into equivalent binary number.

→ given no. → A F B 2
convert to binary 1010 1111 1011 0010

Ans → $(AFB2)_{16} = (1010111110110010)_2$

Q. convert hex no. to binary no.
1) 20ABH = $(\ )_2$ 2) $(2005)_{16} = (\ )_2$

* Conversion from other system to octal:-

1) Decimal to octal:
2) Binary to octal
Alredy discuss.

3) Conversion from Hex to octal:-
step 1 → Represent each hex digit by 4-bit binary number.
step 2 → combine these 4-bit binary sections by removing the spaces.
step 3 → Now group these binary bits into group of 3 bits, starting from the LSB side
step 4 → Then convert each of this 3-bit group into an octal digit.

Q.1 convert hex no. to octal no.
1) $(4CA)_{16}$

step-1 convert to binary.
4 C A
0100 1100 1010

step 2 → combine 4 bit spacing by removing space

$(4CA)_{16} = (010011001010)_2$

step 3 → Group these binary bit to group of 3

$\underbrace{010}_{2}\ \underbrace{011}_{3}\ \underbrace{001}_{1}\ \underbrace{010}_{2}$

ANS :- $\boxed{(4CA)_{16} = (2312)_8}$

* fraction hex to octal conversion :-

step 1 → convert the given fractional hex number into its equivalent Binary number.

step 2 → Group the binary bits into groups of 3 bits

step 3 → Convert group of 3 bits into an octal digit.

Q. convert $(0.12E)_{16}$ into equivalent octal number.

→ step 1 → convert each hex digit into 4-bit binary word.

given hex number 0 . 1 2 E

binary number . 0001 0010 1110

step 2, 3 → group the binary into groups of 3 bits and convert each group into an octal number.

.000	100	101	110	group of 3 bits
0	4	5	6	octal digit

$\boxed{(0.12E)_{16} = (0.0456)_8}$

* Conversions Related to Hexadecimal system:-

Other system to Hex:-

1) Decimal to Hex   2) Binary to Hex
3) Octal to Hex

We have already discussed.

* Hex to other system:-

1) Hex to decimal   2) Hex to binary
3) Hex to octal

We have already discussed.

Examples:-

1) convert $(6AC)_{16} = (\ )_{10} = (\ )_2$

→ Hex Number → $(6AC)_{16}$

6 A C

$6 \times 16^2 + 10 \times 16^1 + 12 \times 16^0$

$1536 + 160 + 12 = 1708$

$(6AC)_{16} = (1708)_{10}$

Convert hex to binary

$(6AC)_{16} = (\ \ )_2$

6	A	C
0110	1010	1100

$(6AC)_{16} = (011010101100)_2$

Q. Convert the following ?

1) $(11001)_2 = (\ \ )_{10}$ 2) $(10101)_2 = (\ \ )_8$

3) $(37)_8 = (\ \ )_2$ 4) $(5AC) = (\ \ )_2$

4) $(366.54)_8 = (\ \ )_{10}$ 5) $(2015.32)_{10} = (\ \ )_{16}$

6) $(25.45)_D = (\ \ )_B$ 7) $(11011010)_B = (\ \ )_H$

8) $(498.25)_{16} = (\ \ )_{10}$ 9) $(10110101)_2 = (\ \ )_{16}$

10) $(B689D)_{16} = (\ \ )_8$

* Binary Addition :-

	A		B	Addition (sum)	carry
case 1	0	+	0	0	0
case 2	0	+	1	1	0
case 3	1	+	0	1	0
case 4	1	+	1	0	1

In case 4 1+1 is sum is 0 and carry 1.

For Example :-

1) $A = (10111)_2$ $B = (11001)_2$

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

Ans $\rightarrow (110000)_2$

2) $(1011)_2 + (1100)_2 = (\ )_2$

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

ANS $= (10111)_2$

3) $(12)_{10} + (8)_{10}$

$(12)_{10} = (1100)_2$

$(8)_{10} = (1000)_2$

$$\begin{array}{r} 1100 \\ +\ 1000 \\ \hline 10100 \end{array}$$

ANs = $(10100)_2$

$= (20)_{10}$

2) $(15)_{10} + (10)_{10}$

$(15)_{10} = (1111)_2$

$(10)_{10} = (1010)_2$

$$\begin{array}{r} 1111 \\ +\ 1010 \\ \hline 11001 \end{array}$$

ANs = $(11001)_2$

$= (25)_{10}$

Q. For Example :-

1) perform the following binary arithmatic operations

1) $(10101)_2 + (10110)_2$ 2) $(101011)_2 + (110011)_2$

3) $(10101 + 10110)_2$

* Binary subtraction :-

case 1 A B

2 0 – 0

3 1 – 0

4 1

binary subtraction :-

case	A		B	subtraction	Borrow
1	0	−	0	0	0
2	0	−	1	1	0
3	1	−	0	0	0
4	1	−	1	1	1

Ex :- $A = (11011)_2$
$B = (10110)_2$

$$\begin{array}{r} 1\ 1\ 0\ 1\ 1 \\ -\ 1\ 0\ 1\ 1\ 0 \\ \hline 0\ 0\ 1\ 0\ 1 \end{array}$$

ANS → $(00101)_2$

2) $(11101.1101)_2 - (101.011)_2 = (?)_2$

$$\begin{array}{r} 1\ 1\ 1\ 0\ 1\ .\ 1\ 1\ 0\ 1 \\ -\ 1\ 0\ 1\ .\ 0\ 1\ 1\ 0 \\ \hline 1\ 1\ 0\ 0\ 0\ .\ 0\ 1\ 1\ 1 \end{array}$$

ANS :- $(11000.0111)_2$

* 1's complement of a binary Number:-

1's complement → of a number is found by inverting all the bits in that number. that is called taking complement.

Ex:- obtain the 1's complement of the following numbers. 1) $(1010)_2$ 2) $(11010101)_2$

given number → 1) $(1010)_2$ 2) $(11010101)_2$
1's complement → $(0101)_2$ → $(00101010)_2$

1) 1 0 1 0
↓ ↓ ↓ ↓
0 1 0 1

2) 1 1 0 1 0 1 0 1
↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓
0 0 1 0 1 0 1 0

* 2's complement :-

Definiation → The 2's complement of a binary number is obtained by adding 1 to the LSB of 1's complement of that number.

2's complement = 1's complement +1

Ex:- obtain the 2's complement of $(10110010)_2$

→ given number → 1 0 1 1 0 0 1 0
1's complement → 0 1 0 0 1 1 0 1
Add 1 to 1's complement → + 1

0 1 0 0 1 1 1 0

ANs → $(01001110)_2$

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* Binary subtraction using 1's and 2's complement:-

1) The direct binary subtraction becomes complicated as the number size increases.

2) Therefor we can represent the subtraction of A-B in the form of attition as A+(-B).

subtraction using 1's complement :-

1) convert number to be subtracted $(B)_2$ to its 1's complement.

2) Add $(A)_2$ and 1's complement of (B_2) using the rules of binary attition.

3) If final carry is 1, then add it to the result of attition obtained in step 2 to get the final result of $(A)_2 - (B)_2$

Note :- If the final carry is 1 then the substraction is positive and in its true form.

4) If the final carry produced in step 2 is 0 then the result obtained in step 2 is negati and in the 1's complement form.
so convert it into the true form by complementing all the bits.

Ex:- Perform $(9)_{10} - (4)_{10}$ using 1's complement method

→ 1) convert $(4)_{10}$ into 1's complement.

$$(4)_{10} = (0100)_2$$

1's complement $(0100)_2 = (1011)_2$

2) Add $(9)_{10}$ and 1's complement of $(4)_{10}$

$$
\begin{array}{lcl}
(9)_{10} & \rightarrow & 1\,0\,0\,1 \\
\text{1's complement}(4)_{10} & \rightarrow & 1\,0\,1\,1 \\
\hline
 & & \boxed{1}\,0\,1\,0\,0
\end{array}
$$

Final carry is generated.

3) Add the final carry to the result obtained in step 2.

~~$(9)_{10}$~~

$$
\begin{array}{r}
0\,1\,0\,0 \\
+\quad\quad 1 \\
\hline
0\,1\,0\,1
\end{array}
\rightarrow \text{Ans is positive and in the true form.}
$$

Ans $= (0101)_2 = (5)_{10}$

$(9)_{10} - (4)_{10} = (5)_{10}$.

2) subtract $(9)_{10}$ from $(4)_{10}$ using 1's complement.

→ given $A = (4)_{10} = (0100)_2$ $B = (9)_{10} = (1001)_2$

1) obtain 1's complement of $(9)_{10} \rightarrow (0110)_2$

2) Add $(4)_{10}$ and 1's complement of $(9)_{10}$

$(4)_{10} = 0\ 1\ 0\ 0$

1's of $(9)_{10} = 0\ 1\ 1\ 0$

$$\begin{array}{r} 0100 \\ 0110 \\ \hline 1010 \end{array}$$

No carry to the final ~~bit~~ ans is negative.
so convert 1's of Ans.

$1\ 0\ 1\ 0$
$\downarrow\ \downarrow\ \downarrow\ \downarrow$
$0\ 1\ 0\ 1 \longrightarrow$ Ans.

$(0101)_2 = (5)_{10}$

so Ans is $(-)$ because no carry form.

~~$(9)_{10}$~~ $(4)_{10} - (9)_{10} = (-5)_{10}$

Q. subtract using 1's complement method
1) $(11011)_2 - (1010)_2$
2) $(10111)_2 - (11000)_2$

* Binary subtraction using 2's complement Method :-

1) Add $(A)_2$ to the 2's complement of $(B)_2$
2) If the carry is generated then the result is positive and in it's true form.
3) If the carry is not produced then the result is negative and in it's 2's complement form.

Note → carry is always discarded.

Ex :- Perform the following subtraction using 2's complement method $(54)_{10} - (33)_{10}$

→ 1) obtain the 2's complement of $(33)_{10}$

Decimal	binary	2's complement
$(33)_{10}$	100001	011111

2) Add 2's complement of $(33)_{10}$ and $(54)_{10}$

$(54)_{10}$ → 1 1 0 1 1 0

2's complement of $(33)_{10}$ → + 0 1 1 1 1 1

$\boxed{1}$ 0 1 0 1 0 1 → Answer

↳ carry discard.

carry 1 indicate that result is positive and in true form - $(010101)_2 = (21)_{10}$

$(54)_{10} - (33)_{10} = (21)_{10}$

Q: Perform binary subtraction using 2's complement

1) $(1010)_2 - (101)_2$

2) $(45)_{10} - (65)_2$

2) $(48)_{10} - (68)_2$

1) convert both number to binary.

$(48)_{10} = 110000$ $\quad$ $(68)_{10} = 1000100$

2) obtain 2's complement of $(68)_{10}$

Decimal	binary	2's complement
$(68)_{10}$	$(1000100)_2$	0111100

3) Add $(48)_{10}$ to 2's complement of $(68)_{10}$

$(48)_{10} \rightarrow$ 0 1 1 0 0 0 0

2's of $(68)_{10} \rightarrow$ 0 1 1 1 1 0 0

$\boxed{0}$ 1 1 0 1 1 0 0

Carry is 0 indicates that the result is -ve and In its 2's complement form.

4) convert answer to its true form.

Answer 1 1 0 1 1 0 0

\- 1

1 1 0 1 0 1 1

$\underbrace{1101011}_{\text{Invert all bit}}$

0 0 1 0 1 0 0

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Thus the Ans $\rightarrow (0010100)_2 = \boxed{(-20)_{10}}$

Q. convert no to 2's complement
1) $(1100)_2$ 2) $(0010)_2$ 3) $(11010111)_2$

Q. perform following operation by using 2's complement method
1) $(53)_{10} - (67)_{10}$
2) $(53)_{10} - (97)_{10}$
3) $(59)_{10} - (62)_{10}$
4) $(01000)_2 - (01001)_2$
5) $(01100)_2 - (00011)_2$
6) $(10110)_2 - (10001)_2$

* Binary Multiplication :-

A		B	Ans
0	×	0	0
0	×	1	0
1	×	0	0
1	×	1	1

Ex:- Multiply $(9)_{10}$ by $(8)_{10}$

$A = (9)_{10} = (1001)_2$

$B = (8)_{10} = (1000)_2$

$$
\begin{array}{r}
1001 \\
\times\ 1000 \\
\hline
0000 \\
0000\times \\
+\ 0000\times\times \\
1001\times\times\times \\
\hline
1001000
\end{array}
$$

$\boxed{Ans = (1001000)_2}$

$(9 \times 8)_{10} = (72)_{10}$

Ex :- Perform multiplication of $(15)_{10}$ and $(8)_{10}$.

* Binary Division :-

Ex :- Perform the following binary division :

1) $110 \div 10$

~~001~~

~~10) 110~~
~~10~~
~~010~~
~~00~~
~~10~~
~~10~~
~~00~~

$$\begin{array}{r} 011 \\ 10\,\overline{)\,110} \\ -\,00 \\ \hline 110 \\ -\,10 \\ \hline 010 \\ -\,10 \\ \hline 00 \end{array}$$

$(110)_2 = (6)_{10}$

$(10)_2 = (2)_{10}$

$\boxed{(011)_2 = (3)_{10}}$

Ans $= (011)_2 = (3)_{10}$.

2) $(25)_{10} \div (5)_{10}$

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

$(5)_{10} = (101)_2$

$$\begin{array}{r} 101 \\ 101\,\overline{)\,11001} \\ -\,101 \\ \hline 00101 \\ -\,101 \\ \hline 000 \end{array}$$

Ans $= (101)_2 = (5)_{10}$.

$(25)_{10} \div (5)_{10} = (5)_{10}$.

Ex:- Perform the division.

1) $(111110.1)_2 \div (101)_2$
2) $(11001)_2 \div (101)_2$
3) $(1101101)_2 \div (1001)_2$

Q) Perform multiplication.

1) 111.01×110
2) 101101×110

* BCD Arithmetic:-

BCD Addition:-

case 1 → sum is equal to or less then 9 and carry is 0

case 2 → sum is greater than 9 and carry is 0

case 3 → sum is less than or equal to 9 but carry is 1.

1) case 1 → sum equal to or less than 9 with carry = 0

The addition of $(2)_{10}$ and $(6)_{10}$ in BCD is shown.

Decimal		BCD
2	→	0010
+ 6	→	0110
		$\boxed{0}$ 1000

sum is valid BCD number.

Final carry is 0.

$$\boxed{(2)_{10} + (6)_{10} = (8)_{10}}$$

2) Case 2 → sum is greater than 9 but carry = 0

In this case the sum of the two BCD number is greater than 9 that means it is invalid BCD number. But the final carry is 0.

so we have to correct the sum by adding decimal 6 or BCD 0110 it.

After doing this we get the correct BCD sum.

example → $(7)_{10} + (6)_{10}$

→ Decimal BCD

$$\begin{array}{r} 7 \\ +\ 6 \\ \hline 13 \end{array} \qquad \begin{array}{r} 0111 \\ 0110 \\ \hline 1101 \end{array} \rightarrow (13)_{10} \text{ but it is invalid BCD number.}$$

so, correct is by adding 6.

$$\begin{array}{r} 1101 \\ +\ 0110 \\ \hline 1\ 0011 \end{array}$$

$$\underbrace{0001}_{1} \quad \underbrace{0011}_{3}$$

so it is valid BCD → $(00010011) \rightarrow (13)_{10}$.

3) case - 3

sum less than or equal to 9 but carry = 1.

Here the sum of two BCD numbers is less than or equal to 9 i.e it is ~~as~~ a valid BCD number. and final carry = 1

A nonzero carry indicates that the answer is wrong and needs correction.

Add $(6)_{10}$ or $(0110)_{BCD}$ to the sum ~~of carry~~ to correct the answer.

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Decimal		BCD
9	$\rightarrow$	1001
+ 8	$\rightarrow$	1000

$\boxed{1}\underbrace{0001}$ — valid BCD number.

final carry

$(0001\ 0001)_{BCD}$ but carry is 1
so correct it.

$$
\begin{array}{r}
0001\ 0001 \\
+\ 0000\ 0110 \\
\hline
\underbrace{0001}_{1}\ \underbrace{0111}_{7}
\end{array}
$$

$(17)_{10} \rightarrow (0001\ 0111)_{BCD}$.

$(9)_{10} + (8)_{10} = (17)_{10}$.

* Summary $\rightarrow$

Add two BCD no. A & B

sum ≤ 9, carry = 0	sum ≤ 9, carry = 1	sum > 9, carry = 0
Answer is correct. No correction required	Add 6 to sum to get correct answer.	Add to 6 to sum to get correct answer

example :-

1) Add $(57)_{10}$ and $(26)_{10}$ in BCD.

→ Decimal   BCD

$$
\begin{array}{rrr}
 & 57 & 0101\ 0111 \\
+ & 26 & 0010\ 0110 \\
\hline
 & & \boxed{0}\ \underbrace{0111}_{\text{valid BCD}}\ \underbrace{1101}_{\text{invalid BCD}}
\end{array}
$$

final carry = 0   carry = 0.

we have to add 6.

$$
\begin{array}{rr}
 & 0111\ 1101 \\
+ & 0000\ 0110 \\
\hline
 & \underbrace{1000}_{8}\ \underbrace{0011}_{3}
\end{array}
$$

→ final result.

$(57)_{10} + (26)_{10} = (83)_{10}$.

Home work :-

1) Add BCD arithmatic

1) $(637)_{10} + (463)_{10}$
2) $(63)_{10} + (19)_{10}$
3) $(264)_{10} + (668)_{10}$
4) $(454)_{10} + (379)_{10}$
5) $(630)_{10} + (468)_{10}$.
6) $(245)_{10} + (186)_{10}$

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1) $(637)_{10} + (463)_{10}$

Decimal	BCD		
637	0110	0011	0111
+ 463	+ 0100	0110	0011
1100	1010	1001	1010
	invalid BCD	valid BCD	invalid BCD.

Add $(0110)_2$ to invalid BCD.

$$
\begin{array}{rccc}
 & 1010 & 1001 & 1010 \\
+ & 0110 & 0000 & 0110 \\
\hline
\boxed{1}\ 0000 & & \underbrace{1010}_{\text{invalid BCD.}} & 0000
\end{array}
$$

$$
\begin{array}{rcccc}
 & 0001 & 0000 & 1010 & 0000 \\
+ & 0000 & 0000 & 0110 & 0000 \\
\hline
 & 0001 & 0001 & 0000 & 0000 \\
 & \downarrow & \downarrow & & \\
 & 1 & 1 & 0 & 0
\end{array}
$$

$(637)_{10} + (463)_{10} = (1100)_{10} = (0001000100000000)_{BCD}$

Scanned with CamScanner

* Gray to binary conversion :-

conversion to using modulo addition $\oplus$

$0 \oplus 0 = 0$

$0 \oplus 1 = 1$

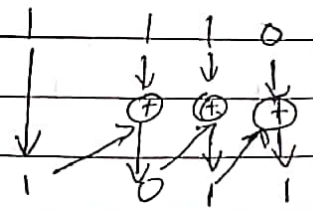
$1 \oplus 0 = 1$

$1 \oplus 1 = 0$

1) For example :-
convert 1110 gray to binary.

$B_3 (MSB) = G_3 (MSB)$
$B_1 = B_2 \oplus G_1$
$B_2 = B_3 \oplus G_2$
$B_0 = B_1 \oplus G_0$.

Gray code

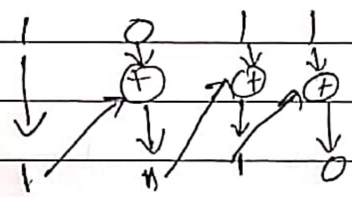


$(1110)_{gray} = (1011)_2$.

2) Binary to Gray conversion.

For example :-
convert binary 1011 to gray.

binary



$G_3 = B_3$
$G_2 = B_3 \oplus B_2$
$G_1 = B_2 \oplus B_1$
$G_0 = B_1 \oplus B_0$.

$(1011)_2 = (1110)_{gray}$.