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Unit-3 Data Representation

How to represent data in computer memory?

Data in the form of :-

1. Numeric → 0 to 9 digits
2. Alphabets → A to Z and a to z
3. Alphanumeric → Combination of alphabets + numerics
4. Special Character → +, -, %, /, *, ?

IMPORTANT TERMS

Bit → Basic Information stored in computer memory is called bit (Binary Digit)

Byte → collection of 8-bits

Nibble → collection of 4-bits

Word Size → size of the register
Eg: $\underbrace{16 \text{ bits / word}}_{\text{register size}}$

Number System → A way to represent numbers into a computer system to store and process.

Every no. system has minimum value = 0 & maximum value = Base - 1

GOOD WRITE

Number System

Non-Positional No. System

↓

Eg: Roman Numerals

Positional No. System

↓

Eg: Decimal No. System

$(256)_{10}$

↓

$2 \times 10^2 + 5 \times 10^1 + 6 \times 10^0$

$200 + 50 + 6 = (256)_{10}$

$\boxed{6 \times 10^{0}}$ → Position

The digit itself   Base

Binary No. System

→ Binary to Decimal conversion

$(10101)_2 \rightarrow 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$

$= 16 + 4 + 1 = (21)_{10}$

Octal No. System

→ ~~Octal to Decimal Conversion~~

$(125)_8 \rightarrow$ Octal

$(852)_8 \rightarrow$ Not Octal becoz it contains 8 as its element whereas maximum value can be 7 only.

Positional Number System

Decimal	Binary	Octal	HexaDecimal
Base = 10	Base = 2	Base = 8	Base = 16
Total no.s → 0-9	Total No → 0 & 1	Total No → 0 to 7	No. used are 0 to 9
Min = 0	Min = 0	Min = 0	A, B, C, D, E, F
Max = 9	Max = 1	Max = 7	↓ 10, 11, 12, 13, 14, 15

Q. Convert hexadecimal to decimal.

1. $(25)_{16}$

$$= 2 \times 16^1 + 5 \times 16^0 = 37$$

Ans $(37)_{10}$

2. $(1B6)_{16}$

$$= 1 \times 16^2 + B \times 16^1 + 6 \times 16^0$$
$$= 256 + 11 \times 16 + 6 \times 1$$
$$= 256 + 176 + 6 = 438$$

Ans. $(438)_{10}$

Binary = Base 2 = 2^1 → n-bit
Octal = Base 8 = 2^3
Hexadecimal = Base 16 = 2^4

$$\underbrace{10^4 \quad 10^3 \quad 10^2 \quad 10^1 \quad 10^0}_{\text{integer part}} \;.\; \underbrace{10^{-1} \quad 10^{-2} \quad 10^{-3}}_{\text{Fraction part}}$$

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Conversion

It plays an Important role in data representation as we use decimal number system externally, but internally we use binary number ~~system~~ equivalent (i.e. in terms of 0 & 1)

TYPE 1 Conversion from Decimal to Binary, Octal and Hexadecimal Number System

OR

Conversion from Decimal to Another Number System

Case 1 To convert Decimal integer into Binary, Octal and Hexadecimal

Example 1 Convert decimal 25 to Binary, Octal & HD

a) $(25)_{10} = (?)_2$

To Base	Number	Remainder
2	25	1
2	12	0
2	6	0
2	3	1
2	1	1
	0	

Ans. $(11001)_2$

b) $(25)_{10} = (?)_8$

8	25	1
8	3	3
	0	

Ans. $(31)_8$

c) $(25)_{10} = (?)_{16}$

To Base	Number	Remainder
16	25	9
16	1	1
	0	

Ans. $(19)_{16}$

Q. $(16)_{10} = (?)_2$

2	16	0
2	8	0
2	4	0
2	2	0
2	1	1
	0	

Ans. $(10000)_2$

Q $(94)_{10} = (?)_{16}$

16	94	14=E
16	5	5
	0	

Ans. $(5E)_{16}$

Steps to follow

Step 1 → Divide the decimal Integer to
(a) Binary – then divide by 2
(b) Octal – then divide by 8
(c) Hexadecimal – then divide by 16

Step 2 → Record the remainder in the table

Step 3 → Repeat step 1 with the quotient and then perform step 2 until the quotient becomes 0 or less than the base to be converted.

Step 4 → Write the result on the order starting from the last remainder to the first

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one i.e. from bottom to top.

Case 2 Converting decimal fraction into Binary, Octal and Hexadecimal

Q. $(0.625)_{10} = (?)_2$
$(0.625)_{10} = (?)_8$
$(0.625)_{10} = (?)_{16}$

a) $(.625)_{10} = (?)_2$

Fractional Number	Base		Integer Part (Result)
0.625	× 2	= 1.250	1
0.250	× 2	= 0.500	0
0.500	× 2	= 1.000	1

Ans. $(.101)_2$

b) $(.625)_{10} = (?)_8$ $0.625 \times 8 = 5.000$ 5

Ans = $(.5)_8$

c) $(.625)_{10} = (?)_{16}$ $0.625 \times 16 = 10.000$ 10=A

Ans: $(.A)_{16}$

Q. $(25.625)_{10} = (?)_2$

Case 1 → $(25)_{10} \rightarrow (11001)_2$

Case 2 → $(0.625)_{10} \rightarrow (.101)_2$

Ans. $(11001.101)_2$

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TYPE 2 Conversion of any base (Binary, Octal, H.D., base 4, base 6, etc.) into Decimal Number System

Eg:- ① $(1011)_2 = (?)_{10}$

② $(1011.11)_2 = (?)_{10}$

③ $(123)_8 = (?)_{10}$

④ $(123.35)_8 = (?)_{10}$

⑤ $(1A5.6B)_{16} = (?)_{10}$

⑥ $(121)_4 = (?)_{10}$

⑦ $(512)_6 = (?)_{10}$

Ans ①

$$\begin{matrix} 1 & 0 & 1 & 1 \\ 2^3 & 2^2 & 2^1 & 2^0 \end{matrix}$$

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

$= 8 + 0 + 2 + 1 = 11$

Ans. $(1011)_2 = (11)_{10}$

② $(1011.11)_2$

$$\begin{matrix} 1 & 0 & 1 & 1 & . & 1 & 1 \\ 2^3 & 2^2 & 2^1 & 2^0 & & 2^{-1} & 2^{-2} \end{matrix}$$

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

$= 8 + 0 + 2 + 1 + 0.5 + 0.25$

$= (11.75)_{10}$

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(3) $(123)_8$

$$\begin{array}{ccc} 1 & 2 & 3 \\ 8^2 & 8^1 & 8^0 \end{array}$$

$= 8^2 \times 1 + 8^1 \times 2 + 8^0 \times 3$
$= 64 + 16 + 3$
$= (83)_{10}$

(4) $(123.35)_8$

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

$= 8^2 \times 1 + 8^1 \times 2 + 8^0 \times 3 + 8^{-1} \times 3 + 8^{-2} \times 5$
$= 64 + 16 + 3 + \frac{3}{8} + \frac{5}{64}$

$= 83 + 0.375 + 0.078$
$= (83.453)_{10}$

(5) $(1A5.6B)_{16}$

$$\begin{array}{cccccc} 1 & A & 5 & . & 6 & B \\ 16^2 & 16^1 & 16^0 & & 16^{-1} & 16^{-2} \end{array}$$

$= 16^2 \times 1 + 10 \times 16 + 5 \times 16^0 + 16^{-1} \times 6 + 16^{-2} \times 11$
$= 256 + 160 + 5 + 0.375 + 0.042$
$= (421.417)_{10}$

(6) $(121)_4$

$$\begin{array}{ccc} 1 & 2 & 1 \\ 4^2 & 4^1 & 4^0 \end{array}$$

$= 4^2 \times 1 + 4^1 \times 2 + 4^0 \times 1$
$= 16 + 8 + 1$
$= (25)_{10}$

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⑦ $(512)_6$

$$\begin{matrix} 5 & 1 & 2 \\ 6^2 & 6^1 & 6^0 \end{matrix}$$

$= 5 \times 6^2 + 1 \times 6^1 + 2 \times 6^0$
$= 180 + 6 + 2$
$= (188)_{10}$

$36 \times 5 = 180$

TYPE 3 Binary to Octal and vica-versa

Eg :- 1. $(101)_2 = (?)_8$
Right to Left

$(101)_2 = 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$
$= 4 + 0 + 1$
$= (5)_8$ ↳ Ans.

Table

0	0	0	→ 0
0	0	1	→ 1
0	1	0	→ 2
0	1	1	→ 3
1	0	0	→ 4
1	0	1	→ 5
1	1	0	→ 6
1	1	1	→ 7

2. $(10111101)_2 = (?)_8$

$$\underbrace{010}_{2}\ \underbrace{111}_{7}\ \underbrace{101}_{5}$$

Ans. $(275)_8$

* each octal equivalent can be converted into 3 bits

GOOD WRITE

3. $(5)_8 = (?)_2$

2	5	1
2	2	0
2	1	1
	0	

Ans. $(101)_2$

4. $(275)_8 = (?)_2$

2 → 010, 7 → 111, 5 → 101

~~2~~	~~275~~	~~1~~	1
~~2~~	~~137~~	~~1~~	0
~~2~~	~~68~~	~~0~~	1
~~2~~	~~34~~	~~0~~	1
~~2~~	~~17~~	~~1~~	1
~~2~~	~~8~~	~~0~~	1
~~2~~	~~4~~	~~0~~	0
~~2~~	~~2~~	~~0~~	1
~~2~~	~~1~~	~~1~~	0
	~~0~~		

Ans. $(010\ 111\ 101)_2$

5. $(523)_8 = (?)_2$

5 → 101, 2 → 010, 3 → 011

Ans. $(101\ 010\ 011)_2$

Type 4 Binary to H.D and vice-versa

$16 = 2^4$ → 4 bits are needed for making a group.

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Table

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

Eg:- ① $(1011110101)_2 = (?)_{16}$

→ Right to left
→ Make a group of 4 bits
→ Write equivalent HD no.

$\underbrace{0010}_{2}\ \underbrace{1111}_{F}\ \underbrace{0101}_{5}$

Ans. $(2F5)_{16}$

② $(2F5)_{16} = (?)_2$.

2 → 0010
F → 1111
5 → 0101

Ans. $(001011110101)_2$

③ $(0101111\,0.\,11)_2 = (?)_{16}$

$\underbrace{0101}_{5}\ \underbrace{1110}_{E}\ .\ \underbrace{1100}_{C}$

GOOD WRITE

Scanned by CamScanner

Ans: $(5E.C)_{16}$

Binary Arithmatic.

when arithmatic operations (eg: Addition, Subtraction, Multiplication & Division) applied to binary numbers, then it is called Binary Arithmatic.

- Computer actually doing Binary arithmatic operations
- Two most important operations are :-
  1) Binary Addition &
  11) Binary Subtraction

Rules for Binary addition of 2 digits

a	b	sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

→ Truth Table

Eg:

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

$1 + 1 = 2$ → 10 in binary form

1 0
↓ carry ↓ sum

★ carry is always added to the left side

Rules for Binary addition of 3 digits

Decimal	a	b	c	Sum	Carry
0	0	0	0	0	0
1	0	0	1	1	0
2	0	1	0	1	0
3	0	1	1	0	1
4	1	0	0	1	0
5	1	0	1	0	1
6	1	1	0	0	1
7	1	1	1	1	1

→ Truth table

Carry ← 1 1

Eg:
```
  1 1
  1 1 0 0
  0 1 1 0
---------
1 0 0 1 0
```

Eg:
```
1 1          Verify
  1 0   →    2
    1   →    1
    1   →    1
-----        ---
1 0 0   →    4
```
→ decimal form

Examples

a)
```
  1        0        0       1
                            1
+ 0      + 0      + 1     + 1
---      ---      ---     ----
  1        0        1      1 0
```

b)
```
 1
  1 0 → 2            1 1 → 3
+ 1 1 → +3         + 0 0 → +0
-----   ---        -----   ---
1 0 1 → 5            1 1 → 3
```

c)
```
 1 1
  1 1 → 3
+ 1 1 → +3
-----   ---
1 1 0 → 6
```

Q. Perform Binary addition for the following:-

a)
```
   1
   1100  → 12
 + 1010  → 10
  10110  → 22
```

b)
```
   1111
   1001  → 9
 + 1111  → 15
  11000  → 24
```

c)
```
  111
   0110  → 6
 + 1110  → 14
  10100  → 20
```

d)
```
   1 1 1
   111100  → 60
 + 011011  → 27
  1010111  → 87
```

Binary Subtraction

Rules for Binary subtraction of 2 digits

a	b	Difference	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

→ Truth Table

Eg :-
```
   11  → 3
 - 10  → 2
   01  → 1
```

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Rules for subtraction of 3 digits

Decimal	a	b	c	Difference	Borrow
0	0	0	0	0	0
1	0	0	1	1	1
2	0	1	0	1	1
3	0	1	1	0	1
4	1	0	0	1	0
5	1	0	1	0	0
6	1	1	0	0	0
7	1	1	1	1	1

→ Truth Table

Eg:-

```
   1   → first we subtract 1 from 1.
 - 1     Ans = 0
 - 1     Then again we have to subtract 1 from 0
 ----    Now, we'll borrow.
  11     0 becomes 10 i.e 2 in decimal
         Hence 2-1 = 1 OR 10-1 = 1
```

Ques Perform Binary subtraction for following numbers:-

a)
```
  1111 → 15
- 1001 → 9
  ----
  0110 → 6
```

c)
```
  0110 → 6
- 0010 → -2
  ----
  0100 → 4
```

b)
```
  1 ~~1~~⁰ 00 → 12
- 1010 → -10
  ----
  0010 → 2
```

d)
```
  111000 → 56
- 011010 → -26
  ------
   11110 → 30
```

Binary Subtraction using Additive Method (also called complementary Method)

Q. What is complement of a number?

→ $a-b = a+(-b)$

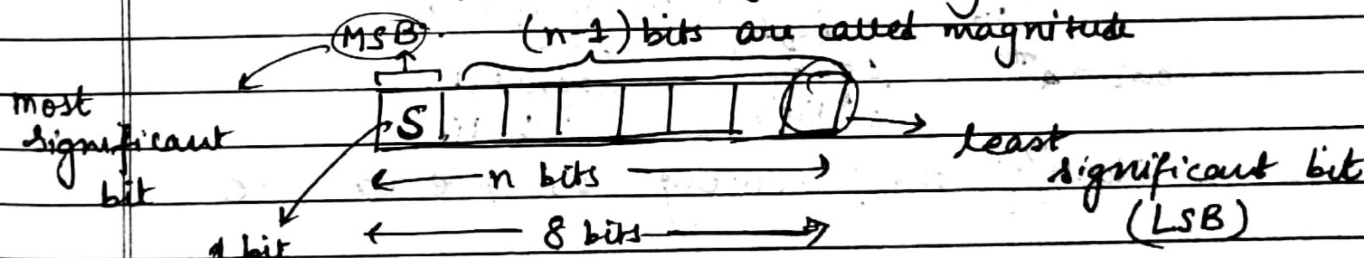
+12, +15, +0 } → unsigned integers

−12, −15, −0, +12, +15, +0 } signed integer

+12.50, +15.20, +0.0 } → unsigned real / floating no.

−12.50, −15.20, −0.0 } signed real no.s

8 bits representation of a binary number



Binary No = Sign Bit + Magnitude

Represent $(+12)_{10}$ and $(-12)_{10}$ into 8 bits register

→ $(+12)_{10}$

0	0	0	0	1	1	0	0

Sign bit (1 bit) magnitude (7 bits)

NOTE
if S = 0 +ve no.
S = 1 −ve no.

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→ But the negative binary number can be represented by using the following method :-

1. Signed Magnitude Method
2. 1's Complement
3. 2's complement.

I. Signed Magnitude Method

The M.S.B is used for signed bit (1-bit) and ~~are~~ occupied with value 1, the rest of the bits (n-1) are represented for the actual number (magnitude)

$(-12)_{10}$ → | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |

becoz -ve no. — Sign bit (1-bit) — magnitude (7 bits)

Q. Identify the following as +ve or -ve

1. 10010001 → -ve becoz sign bit is 1.
2. 00011110 → +ve becoz sign bit is 0.

II. 1's Complement

Q. Represent $(-12)_{10}$ into 1's complement

$(+12)_{10}$ = | 00001100 |

1's complement | 11110011 |

↳ change 1 into 0 and vica-versa

GOOD WRITE

III 2's Complement

1. Find 1's complement of the number
2. Add 1 at L.S.B (least significant bit)

Q. Find $(-12)_{10}$ into 2's complement from using 8 bits.

$(+12)_{10}$ → 0 0 0 0 1 1 0 0

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

+1

2's complement 1 1 1 1 0 1 0 0

Ques $0-4 = 0+(-4)$ -0 → 1 000 0000

Eg:- +0   0 0 0 0 0 0 0 0

↓

1's complement → 1 1 1 1 1 1 1 1

+1

↓

2's Complement 1 0 0 0 0 0 0 0 0

↓

neglect becoz 8 bit representation.

NOTE :- $a-b$

$a+(-b)$

(-b) should be represented in 3 forms -
(I) Signed magnitude
(II) 1's complement
(III) 2's complement.

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4 + (-0)

Q. 4-0 using signed magnitude

$(+4)_{10} \Rightarrow (00000100)_2$

+0 → $\boxed{00000000}$

-0 → $\boxed{10000000}$

4 → $\boxed{00000100}$
+ -0 → $\boxed{10000000}$

$\boxed{10000100}$

-4

The answer is not accurate as it should come +4.

Q4 4-0 using 1's complement

+4 → $\boxed{00000100}$

~~+0 → 00000000~~
~~1st complement of +0 → 11111111~~

+0 → $\boxed{00000000}$

1's complement (-0) → $\boxed{11111111}$

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```
        1 1 1 1 1
 +4    00000100
+ -0   11111111

     1 00000011   => This ans. is 3
```

↳ neglect becoz 8 bit

It is not precise and accurate.

Ques 4-0 using 2's complement

```
+4 →              00000100
+0 →              00000000
                  1111111
1's complement →  11111111
                        +1
2's complement → 1 00000000
```

↳ neglect

```
+4  →   00000100
+ -0 →  00000000

        00000100  → This ans. is 4
```

It gives accurate ans.

Hence, this method is used.

Complement Method

r's complement | (r-1)'s complement

where r = Base of No. System

$r=2$ Binary have 2's and 1's complement
$r=10$ Decimal have 10's and 9's complement
$r=8$ Octal have 8's and 7's complement
$r=16$ Hexadecimal have 16's and 15's complement
$r=4$ Base 4 have 4's and 3's complement

For (r-1)'s complement system,
Complement of a no. $(C) = B^n - 1 - N$

where B = base
n = total no. of digits
N = the actual no.

Q. To find out complements of binary no. $(101)_2$

Ans. $C = 2^3 - 1 - (101)_2$
$= 7 - (101)_2 = (111)_2 - (101)_2$

$$\begin{array}{r} 111 \\ -\,101 \\ \hline 010 \end{array}$$

$C = 010$ i.e 2 Ans.

Q. Find the complement of $(37)_{10}$

Ans $C = B^n - 1 - N$

$= 10^2 - 1 - (37)_{10}$

~~100 - 1~~

$= 99 - 37 = \underline{\underline{62}}$ Ans.

Q. Find the complement of $(6)_8$

Ans $C = B^n - 1 - N$

$C = 8^1 - 1 - (6)_8$

$C = 7 - 6 = \underline{\underline{1}}$ Ans.

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Rules for subtraction using (r-1)'s complement Method

Step 1 Find the complement of a number you want to subtract (subtrahend)

Step 2 Add this to the no. (minuend)

Step 3 1) if there is carry of 1, add it to the result.

2) if there is no carry i.e. carry = 0,

a) recomplement the result
b) Put a -ve symbol to obtain the final result

Eg:- a - b = Result

a ↓ minuend
b ↘ subtrahend

$\Rightarrow a + (-b)$

Q1. Subtract $(56)_{10}$ from $(92)_{10}$ using complementary method. [Decimal system]

Ans

92 - 56 → we'll find the complement of 56

step 1 $C = 10^2 - 1 - 56$
$= 99 - 56 = (43)_{10}$

GOOD WRITE

Step 2 92 + 43

$$\begin{array}{r} 92 \\ +\ 43 \\ \hline 1\ 35 \\ +1 \\ \hline 36 \\ \hline \end{array}$$

carry is added to the LSB

Step 3 $(36)_{10}$

Q2. Subtract $(35)_{10}$ from $(18)_{10}$

Ans

18 − 35

Step I $C = 10^2 - 1 - 35$
$C = 99 - 35 = (64)_{10}$

Step 2 18 + 64

$$\begin{array}{r} 18 \\ +\ 64 \\ \hline 82 \\ \hline \end{array}$$

i.e no carry generated.

Step 3 (ii) a)

$C = 10^2 - 1 - 82$
$= 99 - 82$
$= 17$

b) Putting −ve sign to the result.

Result = $(-17)_{10}$

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Q. Subtract a) $(6)_8$ from $(3)_8$ } octal system.
b) $(16)_8$ from $(30)_8$

Ans a) 1. $3-6$

$C = 8^1 - 1 - 6 = 1$

2. $3+1 = 4$

i.e no carry.

3. a) complement of 4

$C = 8^1 - 1 - 4 = 3$

b) Put -ve sign

Ans = -3

b)

$30 - 16$

1. $C = 8^2 - 1 - 16 = 64 - 17 = 47$

2.
$$\begin{array}{r} 30 \\ +\ 47 \\ \hline 77 \end{array}$$

i.e no carry

3. a) complement of 77

$C = 8^2 - 1 - 77 = 64 - 78 = -14$

3 b) Put -ve sign i.e $-(-14) = (14)_8$

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Q. Subtract $(011)_2$ from $(101)_2$

Ans. 101 − 011

Step 1 Complement of $(011)_2$ = $(100)_2$

→ C can be directly found by converting 0 to 1 and vica versa

Step 2
$$\begin{array}{r} 101 \\ +\,100 \\ \hline 1\,001 \\ +1 \end{array}$$

Step 3 010 → Ans.

~~Step 4~~ Verify :- 101 − 011 = 010
5 − 3 = 2

Q. Subtract $(101)_2$ from $(011)_2$

Ans. $(011)_2 - (101)_2$

1. Complement of $(101)_2$ = $(010)_2$

2.
$$\begin{array}{r} 011 \\ +\,010 \\ \hline 101 \end{array}$$

i.e. no carry

3 a) Compleent of ~~(101)~~ $(101)_2$ = $(010)_2$

b) Ans. $(-010)_2$

GOOD WRITE

Verify :- 011 - 101 = -010

3 - 5 = -2

Q.

a) $(1011100)_2 - (0111000)_2$

b) $(010010)_2 - (100011)_2$

a) $(1011100)_2 - (0111000)_2$

1. complement of 0111000 is : $(1000111)_2$

2.
```
   1 1 1
   1011100
 + 1000111
 ---------
 1 0100011
 +       1
 ---------
```
3. 0100100

Ans. $(0100100)_2$

verify : 1011100 - 0111000 = 0100100

92 - 56 = 36

b) $(010010)_2 - (100011)_2$

1. Complement of 100011 is : $(011100)_2$

2.
```
   1
   010010
 + 011100
 --------
   101110
```
i.e no carry

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3a. Complement of 101110 is : $(010001)_2$

3b) Put -ve sign : $(-010001)_2$ Ans.

verify: 010010 - 100011 = -010001
18 - 35 = -17

Computer Codes / Character Coding Schemes

Computer codes are used to represent data in memory or internal representation of data.

Data means,
numeric data → 0 to 9 = 10 values
Character = Uppercase & lowercase alphabets. (26+26) = 52 values/ alphabets.
Alphanumerical = Number + Alphabets + Special Characters

⇒ Computer codes using binary coding scheme because computer only understands binary digits i.e 0 & 1.

Computer codes are :-

- BCD (Binary Coded Decimal)
- EBCDIC (Extended Binary Coded Decimal Interchange Code)
- ASCII (American Standard Code for Information Interchange)
- Grey Code
- 8421 CODE (WRITE)

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BCD or 8421 Code

→ It uses 4-bits/ 6-bits to represent a symbol.

→ For 4-bits, total combinations are $2^4 = 16$ symbols.

→ For 6-bits, total combinations are $2^6 = 64$ symbols

→ Basically used to represent decimal values i.e 0 to 9

→ This is one of the early computer coding scheme.

→ Also called weighted code

Table → Representation of BCD using 4 bits

Decimal	Equivalent BCD using 4-bits
0	0 0 0 0
1	0 0 0 1
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

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Eg :- $(25)_{10} = (0010\ 0101)_{BCD}$

$(10)_{10} = (00010000)_{BCD}$

$(625)_{10} = (0110\ 0010\ 0101)_{BCD}$

BCD using 6-bits

Refer Ch-5 (PK Sinha) → computer code

Decimal	BCD code 6-bits ZONE (2 bits)	BCD (4 bits)
0	00	0000
1	00	0001
2	00	0010
3	00	0011
4	00	0100
5	00	0101
6	00	0110
7	00	0111
8	00	1000
9	00	1001
A-I	11	0001
	11	0010
	"	⋮
	11	1001
J-R	10	0001
	⋮	⋮
	10	1001
S-Z	01	0001
	"	⋮
	01	1001

GOOD WRITE

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Q. Represent 'HELLO' in BCD Code.

Ans

H	E	L	L	O
111000	110101	100011	100011	100110

For Octal conversion

$2^3 = 8$ ~~bits~~

So we will make pairs of 3.

H	E	L	L	O
$\underbrace{111}\underbrace{000}$	$\underbrace{110}\underbrace{101}$	$\underbrace{100}\underbrace{011}$	100011	100110
↓ ↓	↓ ↓			
7 0	6 5			
$(70)_8$	$(65)_8$			

EBCDIC

→ Extended Binary Coded Decimal Interchange Code

→ Uses 8-bits to represent a character | symbol in the data.

→ 2^8 combination i.e $2^8 = 256$ characters | symbols which include decimal digit (0-9), lower case (a-z), uppercase (A to Z), special characters, some non-printable characters, etc.

→ Mostly used in mainframe computers.

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EBCDIC code

ZONE (4 bits)	Digit (4 bits)

← 8 bits →

→ Fig 4.3 Pg 41 (P.K. Sinha)

Eg:-

EBCDIC	character	Hexadecimal Equivalent
1100 0001	A	C1
1100 0010	B	C2

Gray code (Not in P.K. Sinha)

→ It is non-weighted code.
→ Not suitable for arithmatic operation but used in analog to digital conversion.

A. Conversion from Binary no. to gray code

$(\text{Given})_2 = (\ ?\ )_{\text{Gray code}}$

Step1 → The first bit (MSB) of the gray code is same as the first bit of the binary number.

Step2 → The second bit (next to MSB) of the gray code is equal to the EX-OR (exclusive OR) of second and first bit of the binary number.

Step 3 The third bit of the gray code is the EX-OR of the second and third bit of the binary code and so on.

A	B	$A+B = AB' + BA'$ (EX-OR)
0	0	$0 \cdot 1 + 0 \cdot 1 =$ 0
0	1	1
1	0	1
1	1	0

Eg:- $(0100)_2 = (\ ?\ )$ Gray code

Binary	Gray Code
0100	0 1 1 0

∴ **Ans.** (0110) Gray Code

Q. Convert $(1001)_2 = (\ ?\ )$ Gray code

Binary	Gray Code
1001	1 1 0 1

Ans. (1101) Gray code

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Binary	Gray Code
0 0 0 0	0 0 0 0
0 0 0 1	0 0 0 1
0 0 1 0	0 0 1 1
0 0 1 1	0 0 1 0
0 1 0 0	0 1 1 0
0 1 0 1	0 1 1 1
0 1 1 0	0 1 0 1
0 1 1 1	0 1 0 0
1 0 0 0	1 1 0 0
1 0 0 1	1 1 0 1
1 0 1 0	1 1 1 1
1 0 1 1	1 1 1 0
1 1 0 0	1 0 1 0
1 1 0 1	1 0 1 1
1 1 1 0	1 0 0 1
1 1 1 1	1 0 0 0

B. Conversion from Gray code to Binary

$(\text{Given})_{\text{Gray code}} = (\,?\,)_2$

Step 1 The first binary bit (MSB) is same as the first bit (MSB) of the gray code.

Step 2 a) If the second bit of the gray code is 0, then the second bit of the binary ~~to~~ will be same as that of first ~~Gray~~ binary bit.

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Step 2 b) If the second bit of the gray code is 1, then the second binary bit will be the inverse / complement of the first ~~gray~~ binary code.

Step 3 → Step 2 is repeated for each succeeding bit.

Eg: ① $(0010)_{\text{Gray code}} = (?)_2$

$(0010)_{\text{Gray Code}} = (\underline{0}\ \underline{0}\ \underline{1}\ \underline{1})_2$

② $(1010)_{\text{Gray Code}} = (?)_2$

Ans. $(\underline{1}\ \underline{1}\ \underline{1}\ \underline{1})_2$

③ $(1001)_{\text{Gray Code}} = (?)_2$

$(1001)_{\text{Gray code}} = (\underline{1}\ \underline{1}\ \underline{0}\ \underline{1})_2$

COMPUTER CODES

① ASCII character coding Scheme

→ American Standard Code for Information Interchange
→ Popular and widely used in all types of computer systems.

→ Used for data communication networks.

→ It is of 2 types.

2 types

ASCII - 7	ASCII - 8
b_6 b_5 (3 bits) b_4 b_3 b_2 b_1 b_0	b_7 b_6 b_5 b_4 (4 bits) b_3 b_2 b_1 b_0 (4 bits)
[ZONE | 4 bit Digit]	[ZONE | Digit]
← 7 bits →	← 8 bits →
Possible combinations = 2^7 = 128 characters	Possible combinations = 2^8 = 256 characters

0	000	0000	0	0000	0000
⋮	⋮		⋮	⋮	
127	111	1111	255	1111	1111

ASCII characters → Pg 44 Fig 4.6 PK Sinha

② UNICODE

→ Universal character coding
→ Used for multiple languages like Hindi, Chineese, Japanese, etc
→ Main advantage is that it is compatible with ASCII-8 code

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→ It uses 32-bits to represent the data.
→ First 256 characters are taken for ASCII-8 code
→ Total possible combinations $= 2^{32}$

Represent A in unicode

0 .... 0 0 0 1 0 0 0 0 0 1

31 ------------------------- 0

$A = (65)_{10}$
↳ convert in binary

0 1 0 0 0 0 0 1

3 - Encoding formats for Unicode

1. UTF-8
(Unicode Transformation Format-8)
2. UTF-16
(Unicode Transformation Format-16)
3. UTF-32
(Unicode Transformation Format-32)

UTF-8

1B	1B	1B	1B

← 32 bits →

Minimum → 1 Byte
Max → 4 Bytes

→ ~~Also called Byte-formatted~~

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UTF-16

1 word	1 word

← 32 bits →

16 bits = 1 word

⇒ Also called word formatted

UTF-32

1D

← 32 bits →

32 bits = 1 double

⇒ Also called Double-word formatted

Q. Do the following binary arithmatic addition and subtraction of binary real numbers.

(a) 110100.101 + 10011.10

```
   11010 0. 101
 + 100 11. 100
 -------------
 1001000.001
```

(b) 10100.101 − 10011.10

```
   10100.101
 − 10011.100
 -----------
   00001.001
```

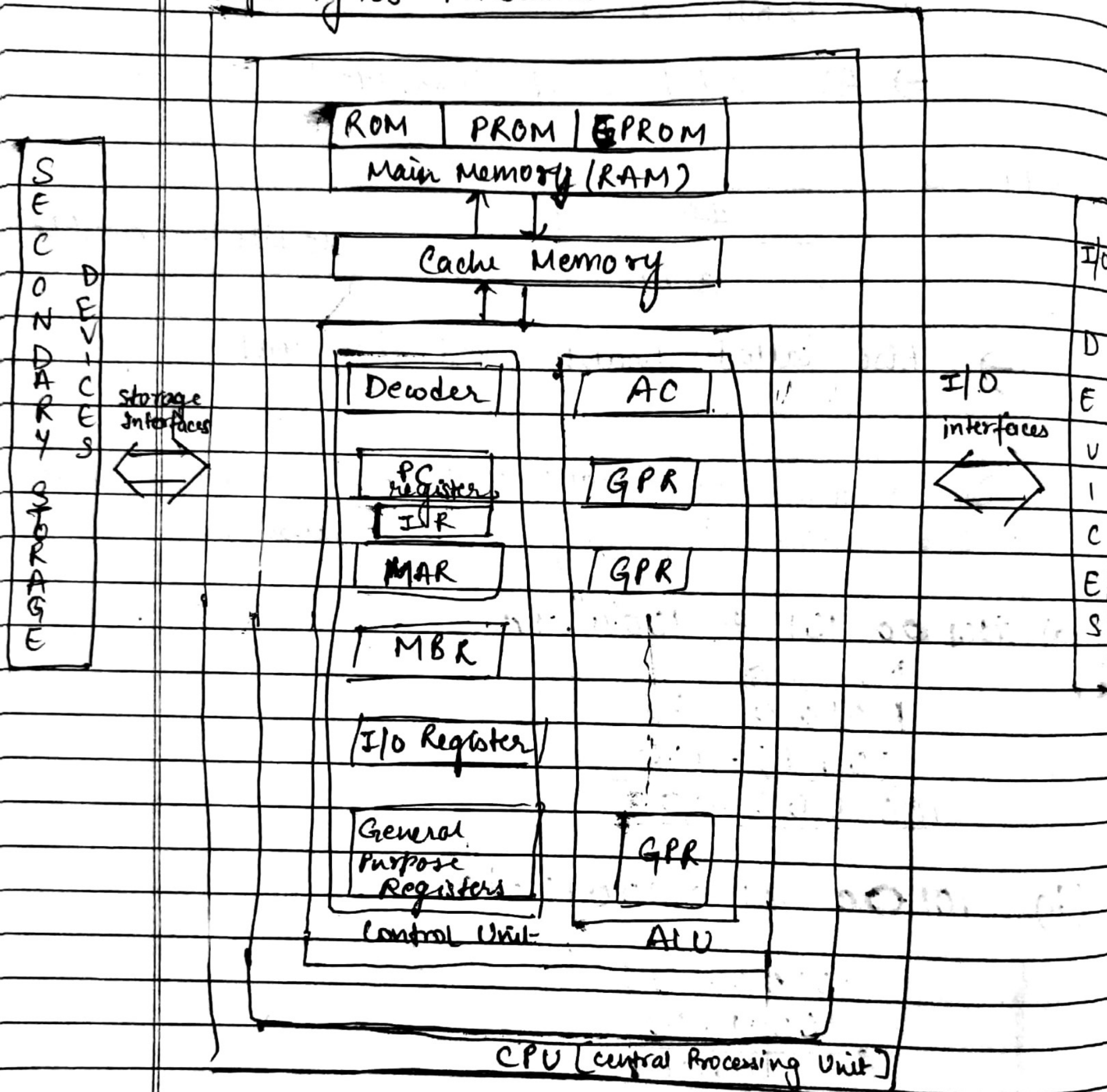
(c) 11100.110 + 1110.10

(d) 11100.110 − 1110.10

GOOD WRITE

PROCESS AND MEMORY ARCHITECTURE OF A COMP. SYSTEM

Refer Pg 105 PK Sinha



where PC → Program control Register
IR → Instruction Register
MAR → Memory Address Register
MBR → Memory buffer register

I/O Register → Input / Output Register
AC → Accumulator Register
GPR → General Purpose Register

Computer Memory

↳ storage unit of the computer system

→ A memory unit is a collection of storage cells together with associated circuits need to transfer data / information / program in and out of storage.

→ Basic storage element is called "Bit"
BINARY DIGIT = BIT

clock cycle on / enable → $\boxed{1}$ Flip-Flop
or
clock cycle off / disable → $\boxed{0}$

1 Flip-flop takes 1 bit
So to represent symbols and words, we use registers.

Register → 

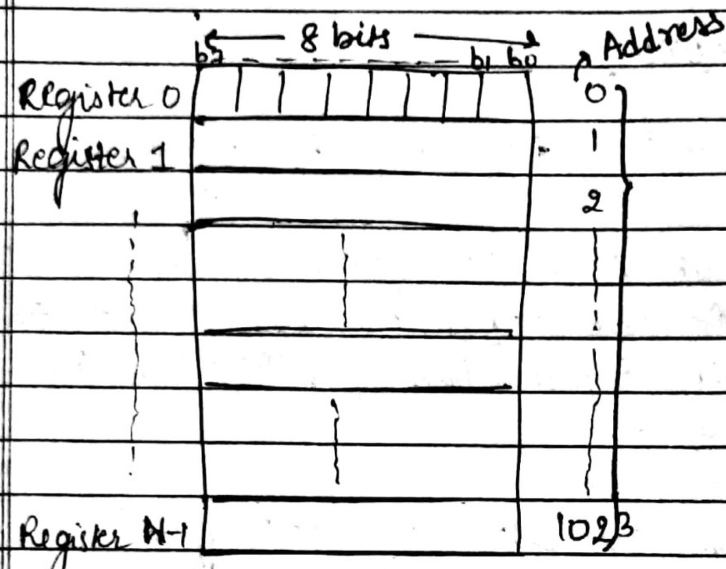
8 bits register
or
word

1 Byte = 8 bits

Two ways of accessing memory.
→ Read from
→ Write into

Main Memory Organisation

↳ Identifies the structure that determines how data is accessed.

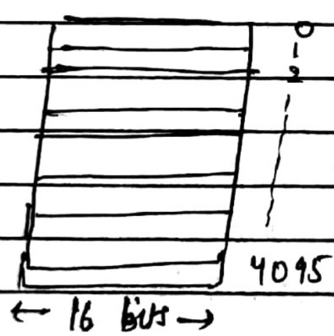


Main Memory

Suppose 1024 registers

Total size = 1024 × 8
= 8192 bits

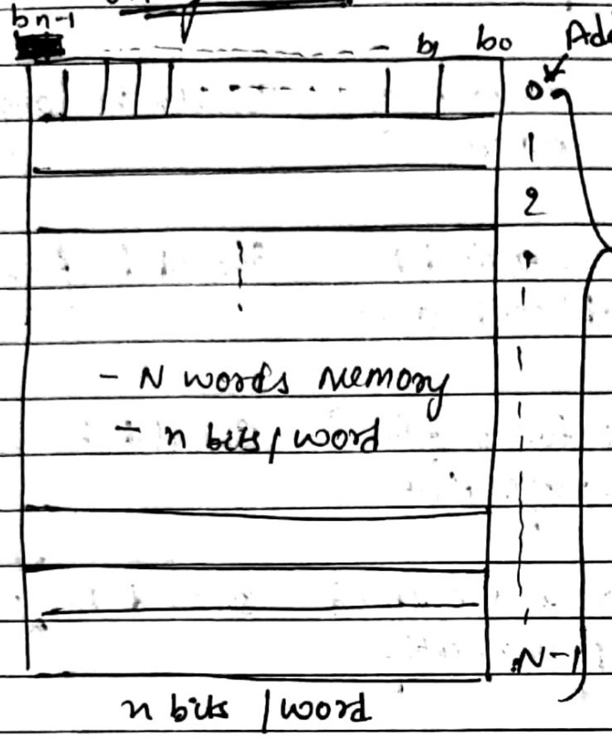
Eg:-



Total size = 4096 × 16
= ___ bits

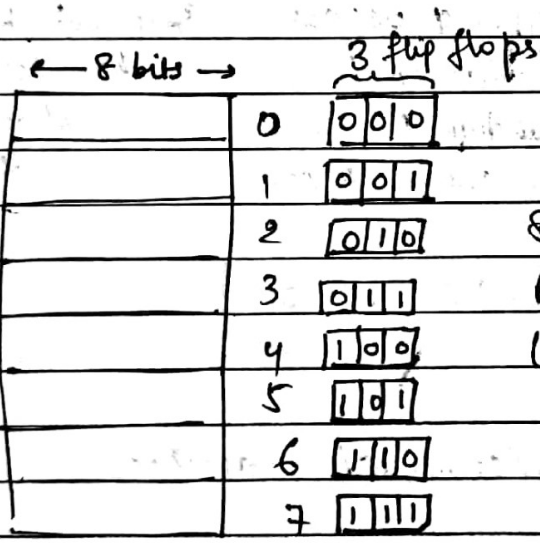
NOTE: 1 B = 8 bits
1 KB = 1024 B = 2^{10} B
1 MB = 1024 × 1024 B = 2^{20} B
1 GB = 1024 × 1024 × 1024 B = 2^{30} B
1 TB = 2^{40} B

In general



Total N words
where $N = 2^k$
K = address bits

Eg:



$8 = 2^{3} \rightarrow K$

first address → 0

last address → 7

Storage Evaluation criteria

→ Any storage unit can be evaluated using the following criteria:

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Criteria	Purpose	Desirable
1. Storage Capacity	Total amount of data	Should be large
2. Access time	Time required to read / write data	Should be fast
3. Cost per ~~unit~~ bit storage	Cost for a given storage unit	Should be lower
4. Volatility	Data is not stored permanently	Should be non volatile.
5. Access Mechanism	2 types of access mechanism: 1) Random Access 2) Sequential Access	~~Should be~~ Random access should be desirable.

Primary Memory (Main Memory)

Characterstics

- made up of semiconductor devices
- very expensive
- volatile in nature
- Speed is very fast
- computer system can't run without primary memory.

Q. Computer system cannot run without primary memory. Why?

Ans

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V.V. Imp.

Primary Memory

- RAM (Random Access Memory)
  - SRAM (Static RAM)
    - → It is used as cache memory due to the fast speed.
    - → Access speed = ~~20~~ 2 to 10 nsec
  - DRAM (Dynamic RAM)
    - → Main Memory
    - → Access speed = 50 - 100 nsec
- ROM (Read Only Memory)
  - Manufactured ROM
    - a) MROM
  - User programmed ROM
    - PROM
    - EPROM
      - UVEPROM (Ultra violet EPROM)
      - EEPROM (Electrical EPROM)

Q. Difference b/w SRAM and DRAM?
Q. Difference b/w PROM and EPROM?
Q. Difference b/w primary and secondary memory?

* BIOS Program stored in ROM (Bootable Program)
↳ Basic Input Output System

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Memory Hierarchy

Access Time: high → low
cost: high → low
capacity: low → high

$\boxed{\text{Registers}}$

$\boxed{\text{Cache Memory}}$

$\boxed{\text{Primary / Main Memory}}$

} Semi-conductor memory or Primary Storage

$\boxed{\text{Magnetic Disk / Optical Disk}}$

$\boxed{\text{Magnetic Tape}}$

} secondary Storage

REVISION FIT

→ Do the following

(1) Write BCD equivalent of the following decimals:-
a) $(125)_{10}$
b) $(256)_{10}$
c) $(45)_{10}$

(2) Convert $(111011100)_{Gray\ code}$ to $(\quad)_2$

(3) Add 10111 + 11000 + 111

(4) 1100 − 1010

(5) Represent $(-20)_{10}$ as signed magnitude, 1's complement and 2's complement form.

(6) $(94.76)_{10} = (\quad)_2, (\quad)_8, (\quad)_{16}$

(7) Five basic functions of computer system.

(8) Five characteristics of computer system

(9) $(234.334)_{10} = (\quad)_2, (\quad)_8, (\quad)_{16}$

Answers.

Ans 7
1. Inputting
2. Storing
3. Processing
4. Controlling
5. Outputting

Ans 2 $(11101100)_{\text{Gray Code}}$ = ~~(10011010)~~$_2$

= $(10110111)_2$

Ans 1

① $(185)_{10}$

= $(0001\ 0010\ 0101)_{BCD}$

② $(256)_{10}$

= $(0010\ 0101\ 0110)_{BCD}$

③ $(45)_{10}$

= $(0100\ 0101)_{BCD}$

0	0	0	0	→	0
0	0	0	1	→	1
0	0	1	0	→	2
0	0	1	1	→	3
0	1	0	0	→	4
0	1	0	1	→	5
0	1	1	0	→	6
0	1	1	1	→	7
1	0	0	0	→	8
1	0	0	1	→	9

Ans 3

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

Ans 4

```
  1100 → 12
- 1010 → 10
  ----
  0010 → 2
```

Now subtract using complement method.

complement of 1010 → 0101

Now add 0101 + 1100 = 0010

```
   1
  0101
+ 1100
 -----
 (1)0001
  ↳  +1
  ----
  0010
```

Ans 5 . $(-20)_{10}$

Signed Magnitude.

1	0	0	1	0	1	0	0

signed bit

1's complement.

Step 1 : Convert $(+20)_{10}$ two binary form.

$(+20)_{10} \rightarrow \boxed{00010100}$

1's complement $\boxed{111\ 01011}$

2's Complement

$(+20)_{10} \rightarrow \boxed{00010100}$

1's complement $\rightarrow \boxed{11101011}$

$+1$

Add 1 to LSB $\rightarrow \boxed{11101100}$

Ans 6 $(94.76)_{10}$

To Binary.

2	94	0
2	47	1
2	23	1
2	11	1
2	5	1
2	2	0
2	1	1
	0	

		Integer
0.76×2	$= 1.52$	1
0.52×2	$= 1.04$	1
0.04×2	$= 0.08$	0
0.08×2	$= 0.16$	0
0.16×2	$= 0.32$	0
0.32×2	$= 0.64$	0
0.64×2	$= 1.28$	1

Ans. $(1011110.1100001)_2$

To Octal.

6	$0.76 \times 8 = 6.08$
0	$0.08 \times 8 = 0.64$
5	$0.64 \times 8 = 5.12$
0	$0.12 \times 8 = 0.96$
7	$0.96 \times 8 = 7.68$
5	$0.68 \times 8 = 5.44$

8	94	6
8	11	3
8	1	1
	0	

Ans. $(136.605075)_8$

To hexadecimal.

12 = C	$0.76 \times 16 = 12.16$
2	$0.16 \times 16 = 2.56$
8	$0.56 \times 16 = 8.96$
15 = F	$0.96 \times 16 = 15.36$
5	$0.36 \times 16 = 5.76$
12 = C	$0.76 \times 16 = 12.16$

16	94	14 = E
16	5	5
	0	

Ans. $(5E.C28F5C)_{16}$

Ans 8 ① Speed
② Accuracy
③ Versatile
④ NO IQ
⑤ Diligence

Ans 9 $(234.334)_{10}$

To Binary.

0	$0.334 \times 2 = 0.668$
1	$0.668 \times 2 = 1.336$
0	$0.336 \times 2 = 0.672$
1	$0.672 \times 2 = 1.344$
0	$0.344 \times 2 = 0.688$
1	$0.688 \times 2 = 1.376$

2	234	0
2	117	1
2	58	0
2	29	1
2	14	0
2	7	1
2	3	1
2	1	1
	0	

Ans. $(11101010.010101)_2$

To Octal.

8	234	2
8	29	5
8	3	3
	0	

2	$0.334 \times 8 = 2.672$
5	$0.672 \times 8 = 5.376$
3	$0.376 \times 8 = 3.008$
0	$0.008 \times 8 = 0.064$
0	$0.064 \times 8 = 0.512$

Ans. $(352.25300)_8$

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To hexadecimal

16	234
16	14
	0

10 = A
14 = E

5 $0.334 \times 16 = 5.344$
5 $0.344 \times 16 = 5.504$
8 $0.504 \times 16 = 8.064$
1 $0.064 \times 16 = 1.024$
0 $0.024 \times 16 = 0.384$

Ans. $(EA.55810)_{16}$

GOOD WRITE