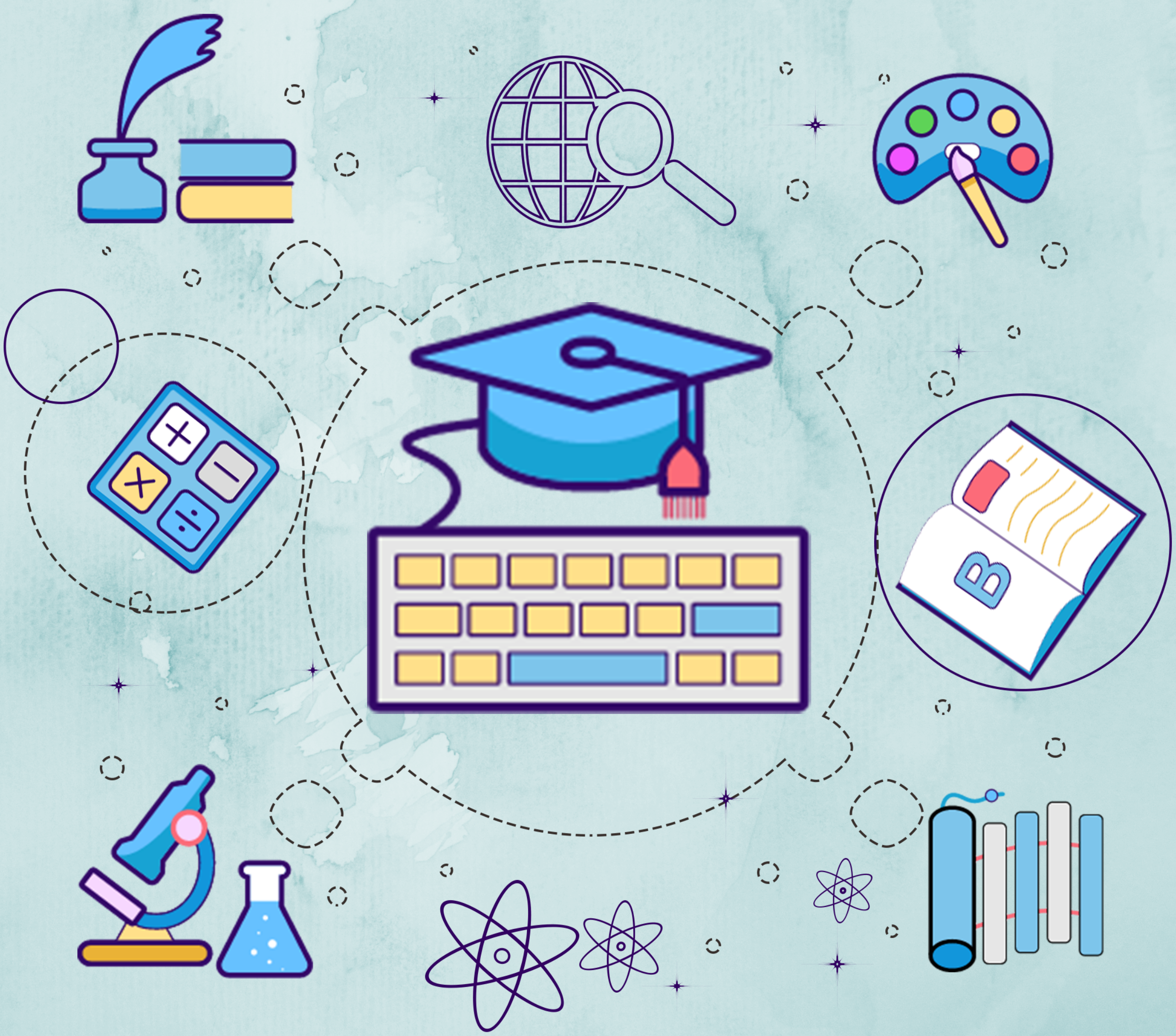

KTU STUDY MATERIALS

LOGIC SYSTEM DESIGN
CST 203

Module 1

Module - 1

Number system, operation and codes

Number system

- For counting various item
- Naming or representing numbers
- mathematical notation. symbols etc.

Number system classification

→ Binary number system
- Base 2
- 0, 1

→ Decimal number system
- Base 10
- 0, 1 9

→ octal number system
- Base 8
- 0, 1 8

→ Hexa decimal number system
- Base 16
- 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

Decimal number system

- Radix -10 number system
- 10 different digit / symbol
, 0 9

Eg: 5678.9 = 5000 + 600 + 70 + 8 + 0.9

most significant bit (MSB) ... least significant bit (LSB)

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

2. Binary number system

Radix - 2 Number system

- 2 " 0, 1
- power of 2

$2^3, 2^2, 2^1, 2^0, 2^{-1} \ldots$

3. octal number system

- Radix - 8 number system
- 0 7
- power of 8

Eg: 567 $\quad 5 \times 8^2 + 6 \times 8^1 + 7 \times 8^0$

567

4. Hexa decimal number system

- Radix - 16 Number system
- 0 . . . . 9, A . . . . F
- power of 16

Eg: 3FD

$3 \times 16^2 + F \times 16^1 + D \times 16^0$

3FD

Relationship b/w Decimal, Binary, octal & Hexadecimal numbers

Decimal	octal	Hexadecimal	Binary
0	0	0	0000
1	1	1	0001
2	2	2	0010
3	3	3	0011
4	4	4	0100
5	5	5	0101
6	6	6	0110
7	7	7	0111
8	10	8	1000
9	11	9	1001
10	12	A	1010
11	13	B	1011
12	14	C	1100
13	15	D	1101
14	16	E	1110
15	17	F	1111

Number system convertion

→ Decimal – Binary

(10) (2)

1. $(39.25)_{10} \longrightarrow (\ )_2$

real no. (÷) ↳ 39

fraction (x)

Binary base(2)

2	39	1 - reminder
2	19	1
2	9	1
2	4	0
2	2	0
	1	

Bottom to top

100111

fraction: 0.25

$= 0.25 \times 2 = 0.5$

$0.5 \times 2 = 1.0$

$0.0 \times 2 = 0.0$

Top to bottom

min 2 step

$(0.25)_{10} = (010)$

$= (100111.010)_2 \rightarrow$ Binary

* If real no. only no need of fraction

Decimal to octal

(10) (8)

1. $(39.25)_{10} \longrightarrow (\ )_8$

$$8 \,|\, \underline{39} \quad 7$$
$$\quad 4$$

47

$0.25 \times 8 = 2.00$

$0.00 \times 8 = 0.00$

20

$= (47.20)_8 \rightarrow$ octal.

Decimal to Hexadecimal

(10) (16)

10 → A
11 → B
12 → C
13 → D
14 → E
15 → F

1. (47.35)

$(47.35)_{10} \rightarrow (\ )_{16}$

$16 \,|\, 47 \quad 15 \rightarrow F$

$\quad\ \ 2$

60×
16
360
60
9.60

16
16
32

35×
16
210
35
5.60

3

~~2 15~~

2F

$0.35 \times 16 = 5.60$

$0.60 \times 16 = 9.60$

$= 59$

$\Rightarrow (2F.59)_{16}$

2 | 7 1
2 | 3 1
1

(i) Octal to Binary
(8) (2)

3 bit

$0 \rightarrow 000$

$1 \rightarrow 001$

$2 \rightarrow 010$

$3 \rightarrow 011$

$4 \rightarrow 100$

$5 \rightarrow 101$

$6 \rightarrow 110$

$7 \rightarrow 111$

Eg: $(37.45)_8 \rightarrow (\ )_2$

$= [\underbrace{011}_{3}\ \underbrace{111}_{7} . \underbrace{100}_{4}\ \underbrace{101}_{5}]_2$

=

4 → 0 4 → 1
2 → 0 2 → 1
0, 1, 0, 1 . . . .

2 | 4 0
2 | 2 0
1

4 = 0
10

(ii) Binary - octal

Eg: $(10110.11)_2 \rightarrow (\quad)_8$

group of 3

010 110 . 110

$(26.6)_8$

Q solve $(672.13)_8 \rightarrow (\quad)_2$

$= (110\ 111\ 010.001\ 011)_2$

Q $(1011 1011.100)_2 \rightarrow (\quad)_8$

0 10 111 011 . 100

~~273~~

$\therefore (273.4)_8$

(i) Hexadecimel to binary

(16) (2)

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	→ 10 (A)
1 0 1 1	→ 11 (B)
1 1 0 0	→ 12 (C)
1 1 0 1	→ 13 (D)
1 1 1 0	→ 14 [E]
1 1 1 1	→ 15 [F]

8→0, 8→1

4→0, 4→1, 4→0, 4→1

2→0, 2→1, 2→0, 2→1

0, 1, 0, 1, 0, 1, 0 . . .

1
2
3
4
5
6
7
8
9
10 (A)
11 (A)
12 (B)
13 (C)
14 (D)
15 (E)
$\boxed{15}$ (F)

Eg:

1. $(259A)_{16} \rightarrow (\ )_2$

$(\underbrace{0\,010}_{2}\ \underbrace{0101}_{5}\ \underbrace{1001}_{9}\ \underbrace{1010}_{A})$

(ii) Binary - Hexadecimal
2 16

$(11000\,1001 \cdot 11)_2 \rightarrow (\ )_{16}$

0 0011 0001001.11 00

$(189 \cdot C)$

Q $(FE02)_{16} \rightarrow (\ )_2$

1111 1110 0000 0010

Q $(11100111 0 \cdot 101)_2 \rightarrow (\ )_{16}$

0001|1100|1110.1010

1 C E . A

Octal to Hexadecimal

Hexadecimal to octal

- octal → Binary → hexadecimal
- hexadecimal → Binary → octal

Eg 1. $(653)_8 \rightarrow (\ )_{16}$

$000(1|10\ 10|1\ 011)_2 \rightarrow (\ )_{16}$

1 A B

octal to binary

$\underbrace{110}_{6}\ \underbrace{101}_{5}\ \underbrace{011}_{3} \rightarrow (\ )_{16}$

0 01|1 0 1 0|1 0 1 1

6 5 3
↓ ↓ ↓
110 101 011

- 1 A B

000'1|10 1 0|1 0 1 1
1 A 3

(2) Binary
(8) octal
16) Hexadecimal

$\left.\begin{matrix}(2)\ \text{Binary}\\(8)\ \text{octal}\\16)\ \text{Hexadecimal}\end{matrix}\right\} \rightarrow$ Decimal

10

$a_3\, a_2\, a_1\, a_0 \cdot a$

1011·11
2753·36
BCA2·F2

$$a_3 \quad a_2 \quad a_1 \quad a_0 \ldots\ a_{-1} \quad a_{-2} \ldots$$

$$(a_3 \times r^3) + (a_2 r^2) + (a_1 r^1) + (a_0 r^0)$$
$$+ (a_{-1} r^{-1}) + (a_{-2} r^{-2})$$

$r \rightarrow$ Base of system $\quad r = 2$ - Binary
$= 8$ - octal
16 - Hexadecimal

<u>Examples</u>:

<u>Binary - Decimal</u>
(2) $\qquad$ (10)

position weight

Eg: 1. $(10101 \cdot 11)_2 \rightarrow (\ )_{10}$

1	0	1	0	1	·	1	1

~~$a_3\, a_2\, a_1\, a_0$~~

$a_4 \quad a_3\, a_2\, a_1\, a_0 \quad a_{-1}\, a_{-2}$
$r^4 \quad r^3\, r^2\, r^1\, r^0 \quad r^{-1}\, r^{-2}$

Here $r = 2$

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

$$(1 \times 2^4) + (0 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0) + (1 \times 2^{-1}) + (1 \times 2^{-2})$$

$$2^{-1} = \frac{1}{2^1} = 0.5$$

$$= 16 + 0 + 4 + 1 + 0.50 + 0.25$$

$$= \cancel{20.30} = 21.75$$

$$(21.75)_{10}$$

we can check by converting

2. **Octal to Decimal**

(8)   (10)

$$(57.4)_8 \rightarrow (\quad)_{10}$$

Here $r = 8$

5	7	.	4
a_1	a_0		a_{-1}
r^1	r^0		r^{-1}

$8^0 = 1$ $8^{-1} = \frac{1}{8}$ $\frac{4}{8}$

$$(5 \times 8^1) + (7 \times 8^0) + (4 \times 8^{-1})$$

$$40 + 7 + 0.5$$

$(47.5)_{10}$

Q $(4507.44)_8 \rightarrow (\ )_{10}$

4	5	0	7	.	4	4
a_3	a_2	a_1	a_0		a_{-1}	a_{-2}
r^3	r^2	r^1	r^0		r^{-1}	r^{-2}

Here $r = 8$

$$(4\times 8^3) + (5\times 8^2) + (0\times 8^1) + (7\times 8^0) + (4\times 8^{-1}) + (4\times 8^{-2})$$

$= 2048 + 320 + 0 + 7 + 0.5 + 0.0625$

$= 2375.5625$

$2\ 4 \times \frac{1}{64}$

64×8

$16 \times 5 = 80$

$16 \times 6 = 96$

$512 \times 4 = 2048$

$64 \times 5 = 320$

$4 \times \frac{1}{8} = 0.5$

Hexadecimal to Decimal

(16) (10)

$(BAD.8)_{16} \rightarrow (\quad)_{10}$

B	A	D	.	8
a_2	a_1	a_0		a_{-1}
r^2	r^1	r^0		r^{-1}

A - 10
B - 11
C - 12
D - 13
E - 14
F - 15

$r = 16$

$$(11 \times 16^2) + (10 \times 16^1) + (13 \times 16^0) + (8 \times 16^{-1})$$

$$2816 + 160 + 13 + 0.5$$

$$= \underline{2989.5}$$

<u>part 3</u>

Decimal -> Binary
-> octal
-> Hexadecimal

$(\div \; \& \; \times)$ bottom to top
rise ve or

Binary -> octal (3 bit)
-> Hexadecimal (4 bit)

octal -> Hexadeci

Hexadecimal to octal

Practice problems:

1. $(250.55)_{10} - (\ )_{16},\ (\ )_{8}$

$(250.55)_{10} \rightarrow (\ )_{16}$

$$
\begin{array}{r|l}
16 & 250 \ (10) \rightarrow A \\
\hline
 & 15 \rightarrow F
\end{array}
$$

$0.55 \times 16 = 8.8$

$0.8 \times 16 = 12.8$

$0.0 \times 16 = 0.0$

$(FA.8C0)_{16}$

$(250.55)_{10} \rightarrow (\ )_{8}$

$$
\begin{array}{r|l}
8 & 250 \ (2) \\
\hline
8 & 31 \ \ (7) \\
\hline
 & 3
\end{array}
$$

$0.55 \times 8 = 4.4$

$0.4 \times 8 = 3.2$

$0.2 \times 8 = 1.6$

$0.6 \times 8 = 4.8$

$(372.4314)_{8}$

2. $(357)_8 - (\ )_{10}, (\ )_{16}$

$(357)_8 - (\ )_{10}$

3	5	7
a_2	a_1	a_0
r^2	r^1	r^0

Here $r = 8$.

$(3\times8^2)+(5\times8^1)+(7\times8^0)$

$= 192+40+7$

$=(239)_{10}$

$\cancel{(357)_8 \rightarrow (\ )_{16}}$

$\cancel{3}$	$\cancel{5}$	$\cancel{7}$
$\cancel{a_2}$	$\cancel{a_1}$	$\cancel{a_0}$
$\cancel{r^2}$	$\cancel{r^1}$	$\cancel{r^0}$

$\cancel{(3\times16^2)+(5\times16^1)+(7\times16^0)}$

$\cancel{768+80+7}$

$\cancel{=(855)_{16}}$

$(357)_8 \rightarrow (\ )_{16}$

$(011\ 101\ 111)_2 \rightarrow (\ )_{16}$

r^8	r^7	r^6	r^5	r^4	r^3	r^2	r^1	r^0
0	1	1	1	0	1	1	1	1
a_8	a_7	a_6	a_5	a_4	a_3	a_2	a_1	a_0

③. ~~Here r=2~~

$\cancel{(0\times 2^8)+(1\times 2^7)+(1\times 2^6)+(1\times 2^5)+(0\times 2^4)+(1\times 2^3)+(1\times 2^2)+(1\times 2^1)+(1\times 2^0)}$

$= \cancel{128+64+32+16+8+4+2+1}$

$\cancel{(255)_{16}}$

$0000|1110|1111$

$\underline{(0EF)_{16}}$

3. $(110101.1011)_2 - (\ )_8, (\ )_{16}$

$(110101.1011)_2 - (\ )_8$

110|101.|101|100

$(65.54)_8$

$(110101.1011) - (\ )_{16}$

0011|0101.|1011

$(35.B)_{16}$

4. $(463.25)_{10} - (\ )_2, (\ )_8$

$(463.25)_{10} - (\ )_2$

2	463	(1)
2	231	(1)
2	115	(1)
2	57	(1)
2	28	(0)
2	14	(0)
2	7	(1)
2	3	(1)
	1	

111001111

$0.25 \times 2 = 0.5$

$0.5 \times 2 = 1.0$ $= 010$

$0.0 \times 2 = 0.0$

$(11100111.010)_2$

$(463.25)_{10} \rightarrow (\ )_8$

$$\begin{array}{r|l} 8 & 463 \quad (7) \\ \hline 8 & 57 \quad (1) \\ \hline 8 & 7 \quad (7) \\ \hline & 0 \end{array}$$

$0.25 \times 8 = 2.0$

$0.0 \times 8 = 0.0$

$= \cancel{(00717.2000)_8}$

$(717.20)_8$

5. $(36.25)_{10} \rightarrow (\ )_8, (\ )_{16}$

$(36.25)_{10} \rightarrow (\ )_8$

$$8 \,\underline{|\, 36.\cancel{25}}\ (4)$$
$$\;\; |\, 4$$

$0.25 \times 8 = (2).0$

$0.0 \times 8 = (0).0$

$= 44$

$(44.20)_8$

$(36.25)_{10} - (\;)_{16}$

$$16 \,\underline{|\, 36}\ (4)$$
$$\;\; |\, 2$$

$0.25 \times 16 = (4).0$

$0.0 \times 16 = (0).0$

$= 24$

$= (24.40)_{16}$

6. $(455)_{10} - (\;)_2, (\;)_4, (\;)_8$

$$
\begin{array}{r|ll}
2 & 455 & (1) \\
2 & 227 & (1) \\
2 & 113 & (1) \\
2 & 56 & (0) \\
2 & 28 & (0) \\
2 & 14 & (0) \\
2 & 7 & (1) \\
2 & 3 & (1) \\
 & 1 &
\end{array}
$$

$(111000111)_2$

$(455)_{10} \rightarrow (\ )_4$

$$
\begin{array}{r|l}
4 & 455\ (3) \\
4 & 113\ (1) \\
4 & 28\ (0) \\
4 & 7\ (3) \\
 & 1
\end{array}
$$

$(13013)_4$

$(455)_{10} - (\ )_8$

$$
\begin{array}{r|l}
8 & 455\ (7) \\
8 & 56\ (0) \\
 & 7
\end{array}
$$

$(707)_8$

6. $(12.0625)_{10} - (\ )_{16}, (\ )_8$

$(12.0625)_{10} - (\ )_{16}$

$16 \underline{\lfloor 12} \ (12) \rightarrow c$

$0.625 \times 16 = 10.0$

$0.0 \times 16 = 0.0$

$= (c.100)_{16}$

$(12.0625)_{10} \rightarrow (\ )_8$

$8 \underline{\lfloor 12} \ (4)$
$\ \ \lfloor 1$

$0.625 \times 8 = \cancel{5.00}$ ... 0.5

$\cancel{0.0 \times 8} = \cancel{0.0}$

14

$0.5 \times 8 = 4.0$

$0.0 \times 8 = 0.0$

$\cancel{(14.500)_8}$ $(14.040)_8$

8\. $(37.Fc)_{16} - (\ )_2, (\ )_8, (\ )_{10}$

$(37.Fc)_{16} - (\ )_2$

$(0011\ 0111.1111\ 1100)_2$

$(37.Fc)_{16} - (\ )_8$

$000|110|111.111|111|100|000$

$(067.770)_8$

$(37.FC)_{16} \rightarrow (\ )_{10}$

			15	12
3	7	.	F	C
a_1	a_0		a_{-1}	a_{-2}
r^1	r^0		r^{-1}	r^{-2}

Here $r = 16$

e.g. $(3 \times 16^1) + (7 \times 16^0) + (15 \times 16^{-1}) + (12 \times 16^{-2})$

$48 + 7 + 0.9375 + 0.046875$

$\underline{(55.984375)_{10}}$

Addiction, Subtraction → Binary, octal, Hexa decimal

Multiplication, Division → Binary

Binary addiction

(2)

* one bit

$$\begin{array}{r} 1 + \\ 1 \\ \hline 2 \end{array}$$

↓

1 0

$2 \,|\underline{\,2\,}\; 0$

$\;\;\; 1$

↓ Two bit

$$\begin{array}{r} 1+ \\ 1 \\ \hline 1\,0 \end{array}$$

0 sum, 1 carry

	sum	carry
0 + 0	0	0
0 + 1	1	0
1 + 0	1	0
1 + 1	0	1

*

$$\begin{array}{r} 1+ \\ 1 \\ 1 \\ \hline 1\,1 \end{array}$$

carry - 1, 1 - sum

$2 \,|\underline{\,3\,}\; (1)$

$\;\;\; 1$

1 1

Eg: carry

$$\begin{array}{r} 1\ 1\ 1\ 0 \\ 1\ 0\ 1 \\ \hline 1\ 0\ 1\ 1 \end{array} + \quad \text{or} \quad \begin{array}{l} \text{— (6)} \\ \text{— (5)} \end{array} > 11 \quad = 1011$$

Eg:

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

octal addiction

(8)

Eg:

$$\begin{array}{r} (1)\ 1\ 1 \\ 1\ 7\ 7\ 6 \\ 1\ 3\ 4\ 5 \\ \hline 3\ 3\ 4\ 3 \end{array} +$$

$(6+5) = 11 = (1 \times 8) + 3$

$12 = (1 \times 8) + 4$

$11 = (1 \times 8) + 3$

Decimal (10)

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

$(7+9) \to 16$

$16 = \underset{\text{carry}}{1} \times 10 + \underset{\text{sum}}{6}$

$(14) \to 1 \times 10 + 4$

$18 \to 1 \times 10 + 8$

$17 \to 1 \times 10 + 7$

Eg:

$$\begin{array}{r} \overset{1}{7}\ \overset{1}{7}\ 7 \\ 6\ 6\ 6\ + \\ \hline 1\ 6\ 6\ 5 \end{array}$$

$13 = (1 \times 8) + 5$

$14 = (1 \times 8) + 6$

$15 = (1 \times 8) + 6$

Hexadecimal addiction (16)

Eg:

$$\begin{array}{r} \overset{1}{A}\ \overset{1}{D}\ D\ + \\ D\ A\ D \\ \hline 18\ 8\ A \end{array}$$

A - 10
B - 11
C - 12
D - 13
E - 14
F - 15

$(26) = (1 \times 16) + 10$
(A)

$24 = (1 \times 16) + 8$

$24 = (1 \times 16) + 8$

Octal

	2		2	
	7	7	7	
2	6	6	6	+
	7	7	7	
2	6	6	4	

$20 = (1\times 8)+12$ ~~x~~

$= (2\times 8)+4$

$22 = (2\times 8)+6$

~~24~~

Hexadecimal

	1	2		
	F	F	F	
	E	0	F	+
1	1	6	A	
1	F	6	7	8

A - 10
B - 11
C - 12
D - 13
E - 14
F - 15

$40 = (2\times 16) + 8$

$23 = (1\times 16) + 7$

$31 = (1\times 16) + 15$

$\downarrow$ F

Binary Multiplication

Eg:

```
    1010  x
     101
  --------
   1010
  0000
 1010
  --------
 110010
```

	sum	carry
0+0	0	0
1+0	1	0
0+1	1	0
1+1	0	1

Binary Substraction

1. General method
2. 1's complement method
3. 2's complemel method

1. General method of Substraction

(a) $0 - 0 = 0$

$1 - 1 = 0$

$1 - 0 = 1$

$0 - 1 = 1$
with borrow 1

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

Binary 8 - 0, 1

Eg:

1 - borrow

$$1.\quad \begin{array}{r} 11011 - \\ 10110 \\ \hline 00101 \end{array}$$

(5) 1's and 2's complement method

1's complement → substract each bit by 1
or
(invert the number)
[0 → 1, 1 → 0 or sub with 1]

2's complement → 1's comp + 1

Example:

1. 1000 (a) 1's complement
(b) 2's complement

(a) 0111 - 1's comp

(b)
$$\begin{array}{r} 111 \text{ - carry} \\ 0111+ \\ 1 \\ \hline 1000 \end{array} \rightarrow 2's$$

2. 1010 → 1's complement

(a) 0101

(b)
$$\begin{array}{r} 1 \text{ - carry} \\ 0101+ \\ 1 \\ \hline 0110 \end{array} \rightarrow 2's \text{ complement}$$

2. Binary Substraction using 1's complement

Steps:

1. • find the 1'st compliment of the number to be substracted

2. • perform Addiction [Add first number and 1's compliment of subtrahend)

3. • IF carry is generated, Add the carry with the result.
   • IF there is no carry, take the 1's compliment of the sum and assign negative sign

Examples.

1. B → 1's comple
2. A + B's 1's complement

1. $(1100)_2 - (0101)_2$

$0+0=0$
$0+1=1$
$1+0=1$
$1+1=0$ with carry 1

1. 1's compliment of 0101 (B)

= 1010

2.
```
   1100 +   — give A
 ① 1010     → B's 1's complement
 ─────────
 ① 0110
carry  4 bit
```

3. $\begin{array}{r} 0110 + \\ 1 \\ \hline 01101 \end{array}$

<u>trick</u>

$\Rightarrow 0111$

in decimal $\rightarrow 7$

$(1100)_2 - (0101)_2$

$12 - 5 = 7$

2. $\overset{A}{(0101)_2} - \overset{B}{(1100)_2}$

1. 0011

2. $\begin{array}{r} 0101 + \\ 0011 \\ \hline 1000 \end{array}$ No carry so

3. ↓

so 1's compliment of 1000

0111

putting negative sign $= -\underline{0111}$ (-7)

3. Binary substraction using 2's complement

Steps:

1. Find the 2's compliment of the number to be substracted

2. perform Addiction (Add first number and 2's complement of the subtrahend)

3. • If carry is generated, Discard the carry
   • If there is no carry, Take the 2's complement of the sum and assign negative sign

Example:

1. $(1001)_2 - (0100)_2$

1. 2's compliment of 0100

   1's complement = 1011

   2's " = 1011 +

   1

   1100

2.

$$\begin{array}{r} 1001 \\ (1)\ 1100\ + \\ \hline 1\ 0001 \end{array}$$

carry we can neglect carry

= 0101

2. (0110) - (1011)

1. 2's compliment of 1011

1's coml = 0100 +
1
0101

2.
0110 +
0101
~~1000~~
1011 NO carry so

3. take 2's compliment of result of 1011

1's compliment → 0100
2's compliment 0100 +
1
- 0101

Octal Substraction

1. General method
2. 7's compliment method
3. 8's compliment method

1. General method

a)

→ Decimal substraction (10)

	10	
8	5	10
9	6	4
4	8	8
4	7	6

964 - 488

$$\begin{array}{r} 9\,\cancel{6}^{5}\,\cancel{4}^{14} \\ -\;4\,8\,8 \\ \hline \end{array}$$

$10+4-8=6$

$10+5-8=7$

→ octal substraction

6	3^8	8
7	4	3
5	6	4
1	5	7

$8+3-4=7$

$8+3-6=5$

$$\begin{array}{r} \overset{5}{6}\ \overset{10}{2}\ 8 \\ -\ 2\ 6\ 5 \\ \hline 3\ 4\ 3 \end{array}$$

$8+2-6=4$

(b) 7's and 8's complement of octal number

7's compliment

Substract each and every octal digit from Number 7

eg: 7's compliment of 65 is 12

[77 - 65 = 12]

Eg: 7's compliment of 423 is 354

(777 - 423 = 354)

8's complement

7's compliment + 1

Eg: 8's compliment of 27 is 51

[77 - 27 + 1 = 51]

Eg: 8's compliment of

321 is 457 (777 - 321 + 1 = 457)

⇒ 7's - sub each bit wit 7

⇒ 8's - 7's comp + 1

eg: 6075

7's →

$$\begin{array}{r} 7\ 7\ 7\ 7 \\ -\ 6\ 0\ 7\ 5 \\ \hline 1\ 7\ 0\ 2 \end{array}$$

$\underbrace{1702}_{7's}$

8's →

$$\begin{array}{r} 1\ 7\ 0\ 2 \\ +\ 1 \\ \hline 1\ 7\ 0\ 3 \end{array}$$

Q Eg: 3056

7's →

$$\begin{array}{r} 7\ 7\ 7\ 7 \\ 3\ 0\ 5\ 6 \\ \hline 4\ 7\ 2\ 1 \end{array}$$

8's → 4722

Q eg: 605.535

$$
\begin{array}{rr}
7's \rightarrow & 777.777 \\
 & 605.535 \\
\hline
 & 172.242
\end{array}
$$

$$
\begin{array}{rl}
8's \rightarrow & \cancel{173.242} \\
 & 172.242 \\
 & +1 \quad \text{add with last bit} \\
\hline
 & 172.243
\end{array}
$$

2. Octal substraction using 7's complement

Steps:

1. Find the 7's compliment of the number to be substracted
2. perform Addiction [Add first number and 7's compliment of subtrahend)
3. • If carry is generated, Add the carry with the result
   • If carry is not there, take 7's

compliment of the sum and assign negative sign.

Eg: $(412)_8 - (263)_8$

Here octal so max 7 [0....7]

1. 263 7's compliment →

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

2.

$$\begin{array}{r} 4\ 1\ 2 \\ 5\ 1\ 4 \\ \hline 1\ 1\ 2\ 6 \end{array}$$

carry

Here 4+5 = 9 it is more than 7

so $9 = 1 \times 8 + 1$

3.

$$\begin{array}{r} 1\ 2\ 6 + \\ 1 \\ \hline 1\ 2\ 7 \end{array}$$

Eg: $(263)_8 - (412)_8$

1. 7's compliment of 412 =

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

2.

$$\begin{array}{r} 2\ 6\ 3 + \\ 3\ 6\ 5 \\ \hline 6\ 5\ 0 \end{array}$$

$8 = 1 \times 8 + 0$

$13 = 1 \times 8 + 5$

No carry

7's compliment of 650

$$\begin{array}{r} 777 \\ 650 \\ \hline 127 \end{array}$$

give -ve = -127

3. octal's substraction using 8's complement

Step:

1. Find the 8's complement of the number to be substracted
2. perform addition [Add first number and 8's complement of subtrahend]
3.
   - If carry is generated, Discard the carry
   - If there is no carry, Take the 8's complement of the sum and assign negative sign.

Eg: $(372)_8 - (144)_8$

1. 144 → 8's compliment → 7's + 1

$$\begin{array}{r} 777 \\ 144 \\ \hline 633 \end{array} \rightarrow 633 + 1 = \underline{\underline{634}}$$

2.
$$\begin{array}{r} \overset{1}{3}\,7\,2 \\ +\ 634 \\ \hline (1)\ 226 \end{array}$$

carry

$10 = 1 \times 8 + 2$

$10 = 1 \times 8 + 2$

3. Discarding carry = 226

Eg. $(144)_8 - (372)_8$

1. 8's compliment of 372 = 7's + 1

$$\begin{array}{r} = 777 \\ 372 \\ \hline 405 \end{array} + 1$$

$= 406$

2.
$$\begin{array}{r} \overset{(1)}{1}\,4\,4 \\ +\ 406 \\ \hline 552 \end{array}$$

$10 = 1 \times 8 + 2$

3. No carry

so 8's compliment → ~~4006~~ 552

$$\begin{array}{r} 777 \\ 426 \\ \hline \end{array} \qquad \begin{array}{r} 777 \\ 552 \\ \hline 225 \\ +\ \ 1 \\ \hline 226 \\ \hline \end{array}$$

give negative sign

⇒ -226 //

Q Compute 8's complement of octal number 672.23

= 7's comp+1 ⇒

$$\begin{array}{r} 777.77 \\ -\ 672.23 \\ \hline 105.54 \\ +\ \ \ \ \ \ 1 \\ \hline 105.56 \end{array}$$

Q perform the octal number of substraction (417) - (237) using 7's and 8's compliment method

(a) 7's compliment method

1. $$\begin{array}{r} 777 - \\ 237 \\ \hline 540 \end{array}$$

2. $$\begin{array}{r} 417 + \\ ① \quad 540 \\ \hline 1 \quad 157 \end{array}$$

$9 = 1 \times 8 + 1$

3. $$\begin{array}{r} 15\cancel{7} + \\ 1 \\ \hline 158 \end{array}$$

$$\begin{array}{r} 157 + \\ 1 \\ \hline 160 \end{array}$$

$1 \times 8 + 0$

(b) 8's complement method

1. $$\begin{array}{r} 777 \\ 237 \\ \hline 540 \end{array}$$

$\rightarrow$ $$\begin{array}{r} 540 + \\ 1 \\ \hline 541 \end{array}$$ $\rightarrow$ 8's compliment

$$\begin{array}{r} 417 \\ 541 \\ \hline 1 \quad 160 \end{array}$$

2. $$\begin{array}{r} 4\cancel{17} + \\ 1 \quad 54\cancel{1} \\ \hline 1 \quad 1\cancel{58} \end{array}$$

$9 = 1 \times 8 + 1$

Discard carry

$= \underline{\underline{158}}$

$\underline{\underline{160}}$

Hexadecimal Substraction

1. General method
2. 15's complement method
3. 16's complement method

1. General method

```
  16 16
 8 6 3 16
 9 7 4 B
 5 8 7 C  -
 -------
 3 E C F
```

A → 10
B → 11
C → 12
D → 13
E → 14
F → 15

16 + B - C
16 + 11 - 12
27 - 12 = 15

16 + 6 - 8
22 - 8 = 14

15's and 16's complement of Hexadecimal substraction

→ 15's complement - Substract each and every HD digit from numb F (15)

eg: A 86 →

```
 F F F -
 A 8 6
 -----
 5 7 9
```

→ 16's complement - 15's + 1

eg: E21A.F2

15's 16's

$$\begin{array}{r} FFFF.FF - \\ E21A.F2 \\ \hline 1DE5.0D \end{array}$$

$$\begin{array}{r} 1DE5.0D + \\ 1 \\ \hline 1DE5.0E \end{array}$$

1DE5.0E → 16's compliment

2. Hexadecimal substraction using 15's complement

step:

1. Find the 15's complement of the number to be substracted

2. perform Addiction (Add first number and 15's complement of subtrahend)

3. • If carry is generated, Add with the result
   • If carry is not generated, take the 15's complement of the sum and assign -ve sign

Examples:

1. $(B01)_{16} - (98F)_{16}$

1.
$$\begin{array}{r} FFF - \\ 98F \\ \hline 670 \end{array}$$

2.
$$\begin{array}{r} B01 + \\ 670 \\ \hline 1\ 171 \end{array}$$

carry

$B + 6 = 17 = 1 \times 16 + 1$

3.
$$\begin{array}{r} 171 + \\ 1 \\ \hline 172 \end{array}$$

2. $(69A)_{16} - (C13)_{16}$

1.
$$\begin{array}{r} - FFF \\ C13 \\ \hline 3EC \end{array}$$

2.
$$\begin{array}{r} 69A \\ 3EC \\ \hline A86 \end{array}$$

$A + C = 22 = 1 \times 16 + 6$

$1 + 9 + E = 24 = 1 \times 16 + 8$

No carry

3. A FFF
A86
579

-579

Hexadecimal Substraction using 16's complement

Step:

1. Find the 16's complement of the number to be substracted

2. perform Addiction (Add first number and 16's complement of subtrahend)

3. • IF carry is generated, Discard the carry
• If there is no carry, Take the 16's compliment of the sum and assign negative sign.

Example:

1. $(971)_{16} - (CB1)_{16}$

1.

$$\begin{array}{r} FFF \\ CB1 \\ \hline 34E \end{array}$$

16's comple → $\begin{array}{r} 34E + \\ 1 \\ \hline 34F \end{array}$

2.

$$\begin{array}{r} 971 + \\ 34F \\ \hline CC0 \end{array}$$

$1 + F = 16 = 1 \times 16 + 0$

3. No carry

$$\begin{array}{r} FFF \\ CC0 \\ \hline 33F \end{array}$$

$\cancel{F = 15 = 1 \times 15}$

$$\begin{array}{r} 33F + \\ 1 \\ \hline 340 \end{array}$$

$16 = 1 \times 16 + 0$

340 → 16's complement

$\cancel{\Rightarrow}$ ⇒ -340

2. $(CB1)_{16} - (971)_{16}$

1.
$$\begin{array}{r} F\;F\;F \\ 9\;7\;1 \\ \hline 6\;8\;E \end{array} \rightarrow 15's$$

$$\begin{array}{r} 6\;8\;E\;+ \\ 1 \\ \hline 6\;8\;F \end{array} \rightarrow 16's$$

2.
$$\begin{array}{r} C\;B\;1\;+ \\ 6\;8\;F \\ \hline 1\;3\;4\;0 \end{array}$$

carry

16 = 1×16+0

20 = 1×16+4

19 = 1×16+3

3. discarding carry => 340

Q1. 16's complement of hexadecimal number FA0C.2B

A - 10
B - 11
C - 12
D - 13
E - 14
F - 15

$$\begin{array}{r} F\;F\;F\;F\;.\;F\;F \\ F\;A\;0\;C\;.\;2\;B \\ \hline 0\;5\;F\;3\;.\;D\;4 \end{array} \rightarrow 15's$$

$$\begin{array}{r} 5\;F\;3\;.\;D\;4\;+ \\ 1 \\ \hline 5\;F\;3\;.\;D\;5 \end{array}$$

Q2. 15's and 16's complement of 3AC.F0

$$\begin{array}{cccccc} 7 & 7 & 7 & . & 7 & 7 \\ 3 & A & C & . & F & 0 \\ \hline 3 & C & A & . & 8 & 7 \end{array}$$

FFF.FF
3AC.F0
CS3.0F

$\cancel{16+7}=15$

3CA.87 → 15's complement

16's complement → ~~3CA.87~~ + 1 = ~~3CA.88~~ ; CS3.0F + 1 = CS3.10

Q3. (3AF) − (4AC) perform the substraction using 15's and 16's complement method

(a) 15's complement method

(3AF) − (4AC)

1.
FFF
4AC −
B53

A − 10
B − 11
C − 12
D − 13
E − 14
F − 15

2.
1 (1)
3AF +
B53
F02

18 = 1×16 + 2
16 = 1×16 + 0

3. No carry =>

$$\begin{array}{r} F\,F\,F \\ -\;7\,7\,7 \\ \hline \end{array}$$

$$\begin{array}{r} F\,0\,2 \\ \hline 0\,F\,D \end{array} \quad FD$$

$\therefore$ $\underline{\underline{-FD}}$

(b) <u>16's complement method</u>

$(3AF) - (4AC)$

1.
$$\begin{array}{r} F\,F\,F\,- \\ 4\,A\,C \\ \hline B\,5\,3 \end{array} \rightarrow 15's$$

$B54 \rightarrow 16's$

2.
$$\begin{array}{r} (1)\,(1) \\ 3\,A\,F\,+ \\ B\,5\,4 \\ \hline 1\;0\;3 \end{array}$$

carry

$19 = 1 \times 16 + 3$

$16 = 1 \times 16 + 0$

$17 = 1 \times 16 + 1$

3. => $\underline{\underline{103}}$

Q4. $(F236) - (EC2E)$ compute hexadecimal substraction using Normal method.

(F236) − (EC2E)

$$\begin{array}{r} \overset{6}{\cancel{F}}\ \overset{16}{\cancel{2}}\ \overset{2}{\cancel{3}}\ \overset{16}{6} \\ -\ E\ C\ 2\ E \\ \hline D\ 6\ 0\ 8 \end{array}$$

16 + 6 − E

22 − E =

16 + 2 − C

Binary Coded Decimal

1. Representation
2. BCD Addiction
3. BCD Substraction

In this code each digit is represented by 4 bit binary number

Decimal	Binary	BCD
0	0000	0000
1	0001	0001
2	0010	0010
3	0011	0011
4	0100	0100
5	0101	0101
6	0110	0110
7	0111	0111

8	1000	
9	1001	1001
10	1010	(1) (0) 0001 0000
11	1011	0001 0001
12	1100	0001 0010
13	1101	0001 0011
14	1110	0001 0100
15	1111	0001 0101

eg: BCD of 156

1 5 6

↓ ↓ →

0001 0101 0110

Eg: BCD of 907

1001 0000 0111

<u>BCD → Decimal</u>

Eg: 10100 → Decimal

000 $\boxed{1|0100}$ => 14

BCD Addiction

Steps:

(1) sum ≤ 9; carry 0 → Answer correct

(2) Sum ≤ 9; carry 1 → Answer incorrect or invalid BCD

(3) Sum > 9 → Add 6 (0110) to convert valid

Examples:

1. BCD 2 + BCD 6

2+6 = 2 → 0 0 1 0
6 → 0 1 1 0 +

1 0 0 0 → 8

8 is < 9 and carry 0

Here condition 1, Answer is correct

2. BCD 3 + BCD 7

3 → 0 0 1 1
7 → 0 1 1 1

1 0 1 0 → 10 → A > 9

invalid => 10010 +

Adding with 6 -> 0110

10000

=> 0001 | 0000 (10)

=> 10

3. BCD 8 + BCD 9

8 -> 1000

9 -> 1001

1 | 0001

carry

if carry 1 is invalid

so => 10001 +

0110

10111

=> 0001 | 0111 (17)

4. Imp

BCD 57 + BCD 26

	1 1		
5 →	0101	0111	+
2 →	0010	0110	→ 6
	0111	1101	(D → 13)

0111 → (7) Valid

1101 → invalid

⇒ 1101 +
0110 → 6
1 0111

⇒
1 111
0111 1101 +
0110 → (6)

1000 0011

$\downarrow$ 8 $\quad\downarrow$ 3 → (83)

⇒ 1000 0011

BCD Substraction (9's complement)

step:

1. Take 9's complement of number to be substracted

2. ADD it to the result

3. If the result is invalid BCD, add 6 (0110)

4. Shift the carry to next bit

5. if end around carry is generated add it to the result

9's complement → eg: 186 ⇒

$$\begin{array}{r} 999 \\ 186 \\ \hline 813 \end{array}$$

1. 987.6 − 678.9 BCD

1.
$$\begin{array}{r} 999.9 \\ 678.9 \\ \hline 321.0 \end{array}$$

2. 987.6

1001 1000 0111 . 0110 +
0011 0010 0001 . 0000

1001	1000	0111	· 0110	
0011	0010	0001	0000	+
1100	1010	1000 → (8)	0110 → (6)	
(12)	(10), A			
invalid	invalid	valid	valid	

1100	1010	1000	· 0110	
0110	0110			+
~~10010 10000 1000 0110~~				
10010	10000	01000	00110	

4. shifting the carry to next bit

if no carry we can simply write (0)

5.

0010	0000	1000	· 0110	NO
1	0	0	1	+
0011	0000	1000	0111	
3	0	8	7	

=> 308.7

2. ~~988~~ 98.3 − 81.2

Step:1

$$\begin{array}{r} 99.9 \\ -\ 81.2 \\ \hline 18.7 \end{array}$$

Step 2

98.3

1001	1000	.0011
0001	1000	.0111 +
0 1010	1 0000	0 1010 − (10)
(10)	(0)	

Step 3:

not valid	~~valid~~ invalid [≤9 but carry 1]	Not valid

1001	1000	0011 +
0001	1000	0111
1011 (11)	0000 (0)	1010 − (10)
not valid	valid	invalid

```
   1010  |  10000  |  1010
   0110  |   0110  |  0110  +
 -------------------------------
 (1)0000 | (1)0110 | (1)00000

   0000     0110     0000
      1        1        1  +
 -------------------------------
   0001     0111     0001
      1       87        1
```

$\Rightarrow 171$

Q1. Substract BCD number 837 using 9's and 10's complement method.

837

9's → 999 -
837

162

10's comp → 163

Q2. Substract BCD number 366 - 170 using 9's compliment method

1. 999 -
170

829

366 -
170

196

2. 366 + 829

0011	0110	~~0111~~	
1000	0010	1001	+
1011	1000	(1)0000	
~~invalid~~ (ii)	valid	valid	

3. 1011 1000 10000 +
0110
10000 01000 00000

4. 0000 1000 0000 +
0 0 1
0000 1000 0001
0 9 1

366 + 829

0011 0110 0110
1000 0010 1001 +
1011 1000 1111

invalid 11 | valid 9 | 15 invalid

1011 1000 1111
0110 0110 +

10001 01000 01001

0001 1000 0101
0 1 1 +

~~0000~~ 0001 1001 0110

1 9 6 => 196

0011 0110 0110
1000 0010 1001 +

1011 1000 10000
0110 0110 +

10001 1000 10110

1001

1 0

3. convert BCD number 1000 1110 into decimal number

|1000|1110

8 14 ⇒ <u>814</u>

Types of code

Special code

- weighted code
- non weighted code
- Reflective code
- error detection code
- Alpha numeric code

(i) <u>weighted code</u>

Each position of the number is represented a specific weight

eg: in Decimal code, if number is 567 then weight of 5 is 100

6 is 10

7 is 1

Types of weighted code

(a) 8421 code →

(b) 2421 code →

1010
2^3 2^2 2^1 0

1010
2421

(ii) Non weighted code

non weighted code are not assign with any weight to each digit position. That is each digit position within the number is not assigned a fixed value.

Type of weighted code

(a) Excess 3 code

(b) Gray code

Error detecting and correcting code

(Hamming code / parity code)

- code which allow error detection
  → error detection code
- code which allow error detection and as well as correction
  → error detecting and correcting code

Hamming code (error [illegible] code)

7 bit

4 Bit → Data

3 Bit → parity [error detection]

parity two type:

1
0

(i) odd parity : odd no of ones

(ii) even parity : even no. of ones

eg: 1000, 1110 Data bits

eg: 110

D_7	D_6	D_5	P_4	D_3	P_2	P_1
7	6	5	4	3	2	1

- parity

$P_1 = D_3 \; D_5 \; D_7$

$P_2 = D_3 \; D_6 \; D_7$

$P_4 = D_5 \; D_6 \; D_7$

parity

2^0 = parity = 1

2^1 = " = 2

2^2 = " = 4

$\boxed{2^3 = \text{"} = 8}$

No need because upto 7

ODD → 1

Even → 0

Q Eg: Data bits are 1011, find hamming code

D7	D6	D5		D3		
1	0	1	P_4	1	P_2	P_1

so $P_1 = D_3 \, D_5 \, D_7 \Rightarrow \underbrace{111}$ ↳ odd parity $= 1$

$P_2 = D_3 \, D_6 \, D_7 \Rightarrow 101 = \text{even} = 0$

$P_4 = D_5 \, D_6 \, D_7 \Rightarrow \underset{\text{even}}{101} = 0$

Hamming code : 1010101

Q Eg: 1110101 Find No. of errors in the hamming code

1	1	1	0	1	0	1
D_7	D_6	D_5	P_4	D_3	P_2	P_1

$P_1 = D_3 \, D_5 \, D_7 = \underset{\text{odd}}{\underset{(\text{even})}{111}} = 1$

$P_2 = D_3 \, D_6 \, D_7 = \underset{(\text{odd})}{111} = 1 \rightarrow \text{error}$

$P_4 = D_5 \, D_6 \, D_7 = \underset{(\text{odd})}{111} = 1 \rightarrow \text{error}$

two errors

Q1. write the hamming code of the databits 1010

D7	D6	D5		D3		
1	0	1	P4	0	P2	P1

$P_1 = D_3\ D_5\ D_7 \Rightarrow 0\ 1\ 1 = 0$ (even)

$P_2 = D_3\ D_6\ D_7 \Rightarrow 0\ 0\ 1 = 1$ (odd)

~~P3~~

$P_4 = D_5\ D_6\ D_7 \Rightarrow 1\ 0\ 1 = 0$ (even)

Hamming code: 1010010

Q2. 7 bit Hamming code will be 1110010 find the number of error

1	1	1	0	0	1	0
D7	D6	D5	P4	D3	P2	P1

$P_1 = D_3\ D_5\ D_7 = 0\ 1\ 1 = 0$ (even)

$P_2 = D_3\ D_6\ D_7 = 0\ 1\ 1 = 0$ (even) → error

$P_4 = D_5\ D_6\ D_7 = 1\ 1\ 1 = 1$ (odd) → error

two error

Excess 3 code
2421 code
ASCII code
EBCDIC code
Gray code

Reflective Code

(Self complement code)

- A code is said to be reflective when the
  - code 9 is the complement of code 0,
  - code 8 " 1,
  - code 7 " 2,
  - code 6 " 3,
  - code 5 " 4.

Type of Reflective code

(i) 2421 code
(ii) Excess 3 code

Excess 3 code

- Excess 3 code is a modification form of BCD number
- Excess 3 can be derived from natural BCD code by adding 3 to each coded number

Eg: Decimal 12 can be represented in BCD as 0001 0010
Now adding 3 to each digit we get excess 3 ~~de~~ code as 0100 0101

(BCD+3)

	BCD	Excess
0	0000	0011
1	0001	0101
2	0010	0110
3	0011	0111
4	0100	0111
5	~~0110~~ 0101	1000
6	~~0111~~ 0110	1001
7	0111	1010
8	1000	1011
9	1001	1100

	BCD	Excess [BCD
0	0000	0011 [0000+0011]
1	0001	0100
2	0010	0101
3	0011	0110
4	0100	0111
5	0101 [5+0+0]	1000
6	0110	1001
7	0111	1010
8	1000	1011
9	1001	1100

9 complement → 9
0 → 9
1 → 8

Eg: 156 → BCD & Excess

BCD = 0001 (1) 0101 (5) 0110 (6)

Excess = 0100 (4) 1000 (8) 1001 (9)

- In Excess 3 code we get 9's comple of a number by just compl each bit. Due to this excess 3 code are called self complementing code / Reflective code

9 comp → 0
8 → 1

2421 code

- The weights of this code are 2, 4, 2 & 1
- This code has all positive weights. So It is positively weighted code.
- It is an unnatural BCD code. Sum of weight of unnatural BCD code are equal to 9. [2+4+2+1=9]
- It is a self-complementing code. Self complementing code provide the 9's complement of a decimal number, just by interchanging 1's and 0's in its equivalent 2421 representation.

Decimal	8421 BCD	2421 BCD
0	0000	0000
1	0001	0001
2	0010	0010
3	0011	0011
4	0100	0100
5	0101	1011
6	0110	1100
7	0111	1101
8	1000	1110
9	1001	1111

9's complement

eg:

$\frac{24\ 21}{1100} = 6$ / $\frac{\overset{5}{24\ 21}}{1011} \rightarrow 2421\ BCD$

Gray code

- Gray code is a special case in unit distance code
- In unit distance code, bit patterns for two consecutive number differ only in one bit position

These code are also called cyclic code.

Binary		Gray	
0 →	0000	0 →	0000
1 →	0001	1 →	0001
2 →	0010	2 →	0011
3 →	0011	3 →	0010
4 →	0100	4 →	0110
5 →	0101	5 →	0111
6 →	0110	6 →	0101
7 →	0111	7 →	0100
8 →	1000	8 →	1100
9 →	1001	9 →	1101
10 →	1010	10 →	1111

1 change

Gray → Two consecutive Number differ only one position

Alpha Numeric Codes

[character code]

The code which consist of letters, digits and various special characters are called Alpha numeric code

Types:

(i) ASCII CODE
(ii) EBCDIC CODE

ASCII CODE

American standard code for information interchange is a 7 bit code

- The standard ASCII character set consist of 128 decimal number $(2^7 = 128)$

A - Z → 65 - 90
a - z → 97 - 122
Space → 32
. → 46
0 → 48

Example:

1. computer

A = 65
= 64+1 = 97+1

z = 96+26

C -> 64+3 = 67 -> Binary (7 bit)

o -> 96+15 = 111

m -> 96+13 = 109

p -> 96+16 = 112

u -> 96+21 = 117

t -> 96+20 = 116

e -> 96+5 = 101

r -> 96+18 = 114

Shotcut:

E	J	O	T	Y
5	10	15	20	25

A -> 64+1

a -> 96+1

Q How Old Are You

H -> 64+8 = 72

o -> 96+15 = 111

w -> 96+23 = 119

space -> 32

O -> 64+15 = 111

l -> 96+12 = 108

d -> 96+4 = 100

space -> 32

space -> 32

A -> 96+1 = 97

r -> 96+18 = 114

e -> 96+5 = 101

space -> 32

Y -> 64+25 = 121

o -> 96+15 = 111

u -> 96+21 = 117

EBCDIC Code

- The Extended Binary coded Decimal interchange code is a standard 8 bit code Developed by IBM

- The standard EBCDIC code character set consist of 256 decimal number ($2^8 = 256$)

- The code is rarely used. Used for IBM mainframes only