



CSC103

Computer Programming for Scientists & Engineers

Lesson (1) : Numbering Systems

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System	Base	Symbols
Decimal	10	0 - 9
Binary	2	0, 1
Octal	8	0 - 7
Hexa-decimal	16	0 - 9 A - F

$$(10)_{10} = (1010)_2 = (12)_8 = (A)_{16}$$

(Note: In the original image, the binary digits 1, 0, 1, 0 are grouped under weights 8, 4, 2, 1 respectively. The octal value 12 is derived from the first two digits 10, and the hexadecimal value A is derived from the last two digits 10.)

$$010 = 2$$

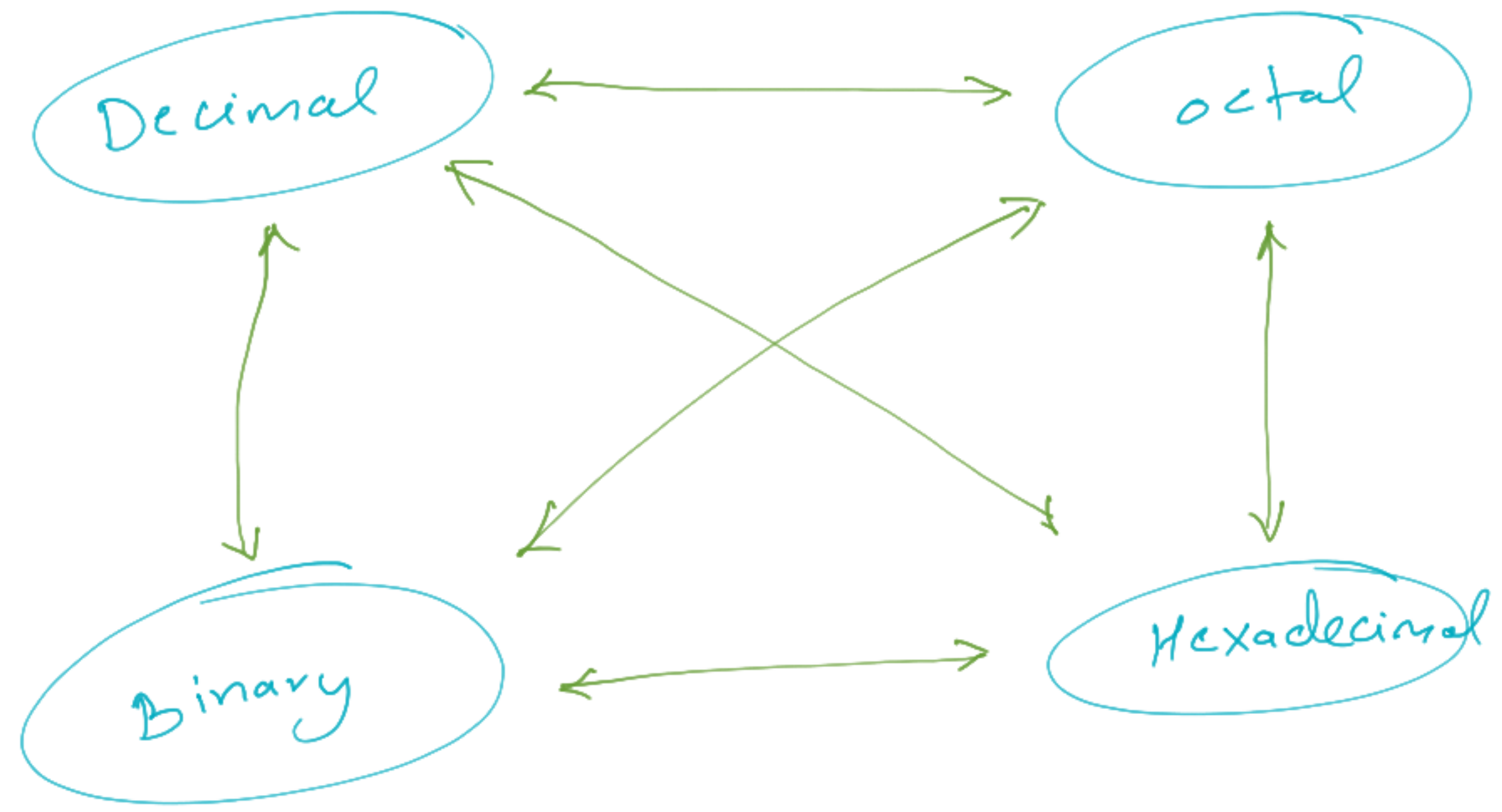
(Note: In the original image, the digits 0, 1, 0 are grouped under weights 4, 2, 1 respectively.)

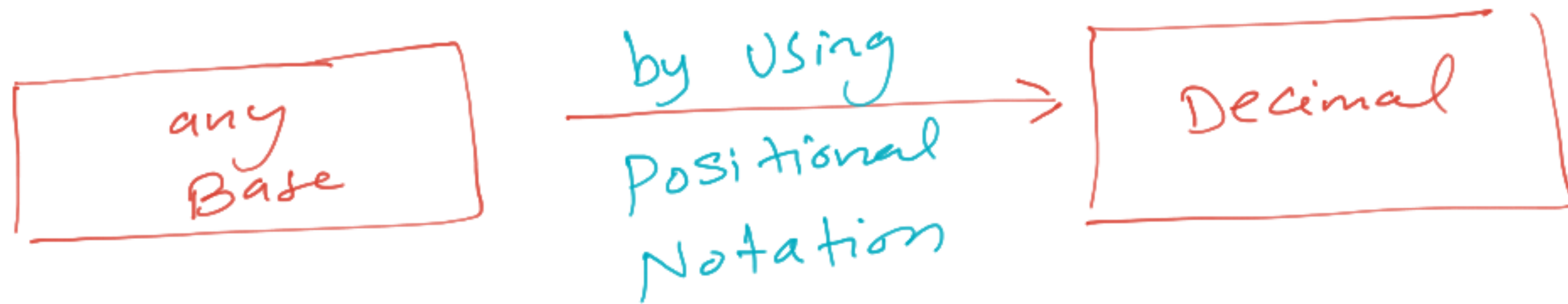
$$0010 = 2$$

1010 → A

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

Conversion Among Bases





Binary to Decimal

$$\begin{array}{cccc} 3 & 2 & 1 & 0 \\ (1 & 0 & 0 & 1) \end{array}_2$$

$$\begin{array}{cccc} 3 & 2 & 1 & 0 \\ 2 & 2 & 2 & 2 \end{array}$$

$$\longrightarrow (9)_{10}$$

$$1 \times 2^3 = 8$$

$$0 \times 2^2 = 0$$

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

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

$$\begin{array}{r} 8 \\ 0 \\ 0 \\ 1 \\ \hline 9 \end{array} +$$

$$\begin{matrix} 64 & 32 & 16 & 8 & 4 & 2 & 1 \\ (1 & 0 & 0 & 1 & 1 & 0 & 1) \end{matrix}_2 = (77)_{10}$$

- Octal to Decimal

$$\begin{matrix} 1 & 0 \\ (7 & 5) \end{matrix}_8 = (61)_{10}$$

$$\begin{matrix} 1 & 0 \\ 8 & 8 \end{matrix}$$

$$\begin{aligned} 5 \times 8^0 &= 5 \\ 7 \times 8^1 &= 56 \\ \hline &61 \end{aligned} +$$

$$\begin{matrix} & 7 & 5 \\ \swarrow & & \\ 32 & 16 & 8 & 4 & 2 & 1 \\ 1 & 1 & 1 & 1 & 0 & 1 \end{matrix} =$$

$$32 + 16 + 8 + 4 + 1 = 61$$

Ex : $(724)_8 = (468)_{10}$

Decimal

Binary

0

0000

1

0001

4 2 1

2

0010

3

0011

4

1000

5

1001

6

1100

7

1111

8 4 2 1

1000

8

$(724)_8$

128 32 16 8 4 2 1

111 010 100
256 64

$$256 + 128 + 64 + 16 + 4 = (468)_{10}$$

$$4 \times 8^0 = 4$$

$$2 \times 8^1 = 16$$

$$7 \times 8^2 = 448$$

Hexadecimal to Decimal

$$\begin{array}{c} 16^2 \quad 16^1 \quad 16^0 \\ (A \ 2)_{16} = (162)_{10} \\ \begin{array}{c} 64 \quad 16 \\ 10 \ 10 \\ 128 \quad 32 \end{array} \quad \begin{array}{c} 8 \ 4 \ 2 \ 1 \\ 0010 \end{array} \end{array}$$

$$128 + 32 + 2 = 162$$

$$\begin{array}{r} 2 \times 16^0 = 2 \\ 10 \times 16^1 = 160 + \\ \hline 162 \end{array}$$

0

8 4 2 1

9

10

A

1010

11

B

⋮

15

F

8 4 2 1

1111

3 2 1 0

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

$$12 \times 16^1 = 192$$

$$10 \times 16^3 = \underline{40960}$$

43975

32768

Convert from Decimal to any Base

Decimal

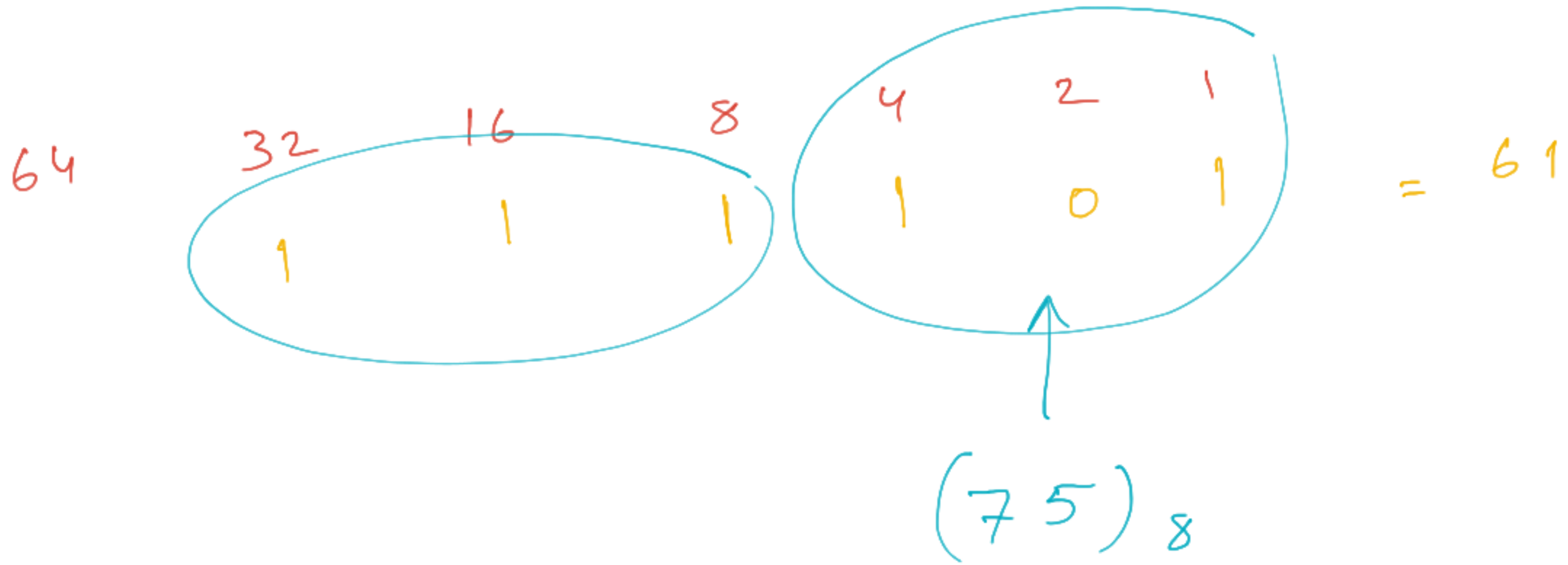
Division
method

any
Base

$(21)_{10} \longrightarrow (10101)_2$

16	8	4	2	1
1	0	1	0	1

$$(61)_{10} = (75)_8$$

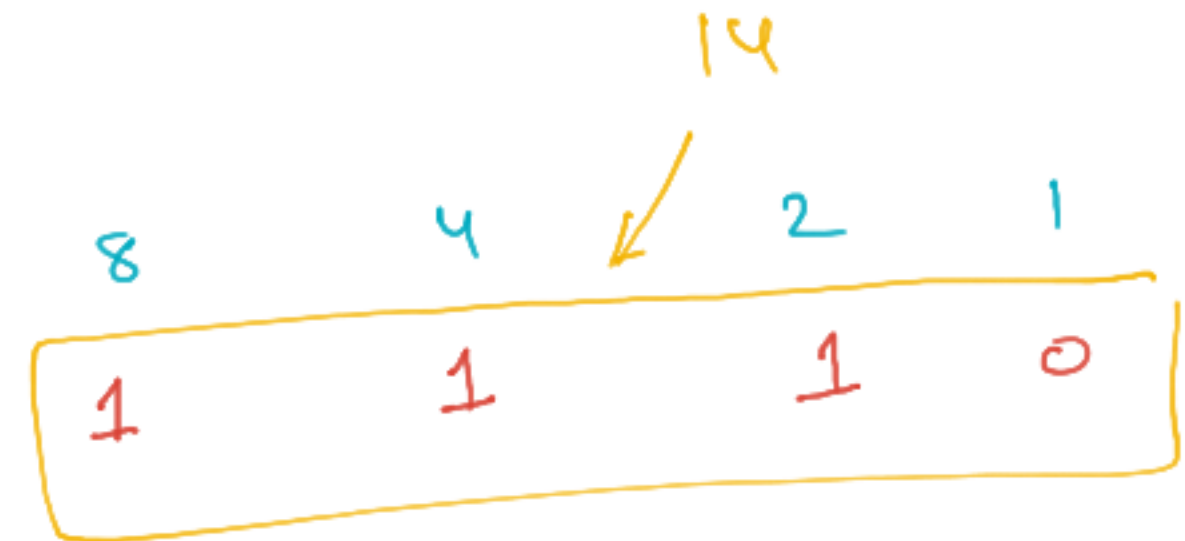


Decimal to Hexadecimal

$$(590)_{10} = (24E)_{16}$$



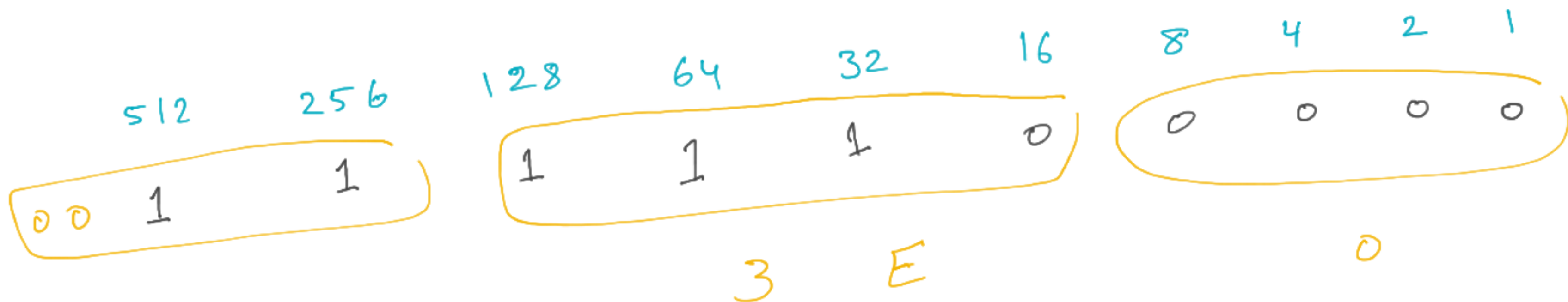
(2 4



E)

1 1 1 0	14	E
0 1 0 0	4	4
0 0 1 0	2	2

$$(992)_{10} = (3E0)_{16}$$



$$(324)_{10} = (144)_{16}$$

324		16
20		16

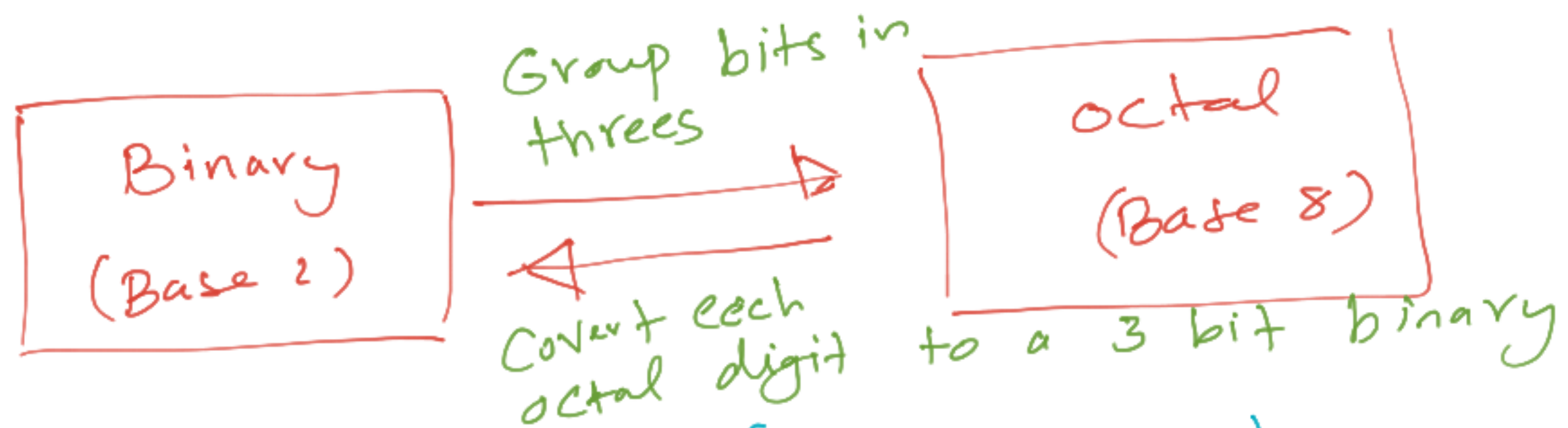
Result	Reminder
20	4
1	4
0	1

↑

256	128	64	32	16	8	4	2	1
1	0	1	0	0	0	1	0	0

1
4
4

Binary to octal & vice versa



$(735)_8$

=

$(111\ 011\ 101)_2$

$(\textcircled{111}\textcircled{011}\textcircled{101})_2$

=

$(\ 735)$

Binary to Hexadecimal & Vice Verse

Binary

Group bits in four.

Convert each hex.
digit to a 4-bit
binary

Hexadecimal

$(01001101)_2$
4 D

$= (4D)_{16}$

$(A7)_{16} = (10100111)_2$

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