



NUMBER SYSTEM

CONVERSION

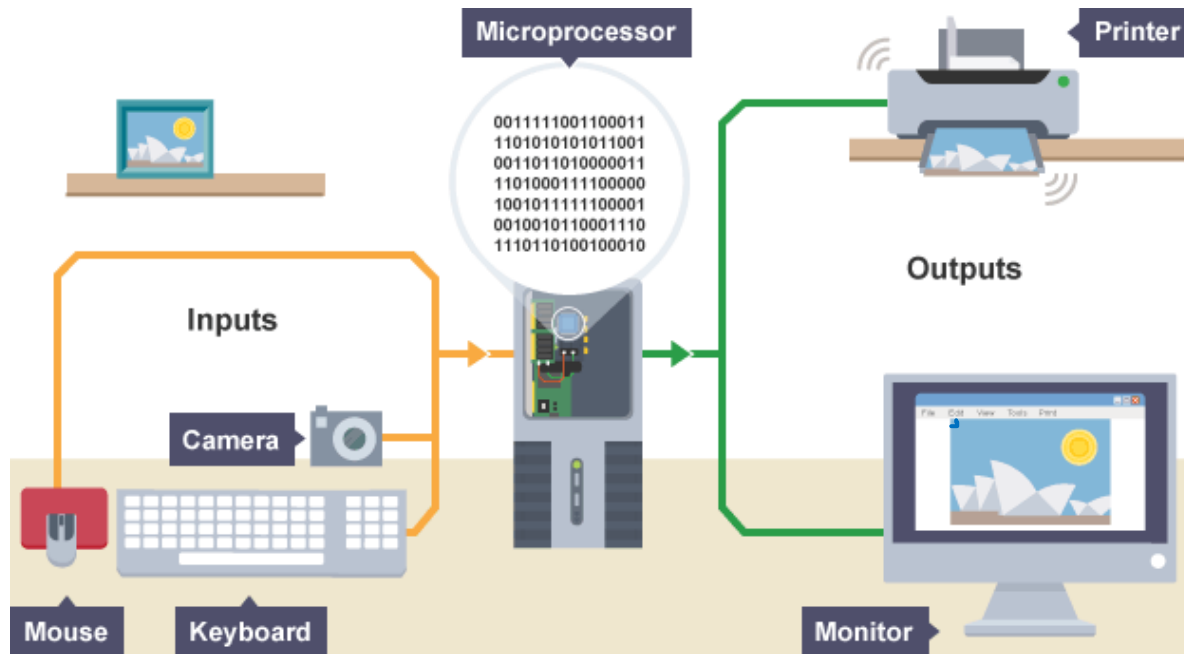


Senior Capstone Courses

Defined as a system of writing to express numbers.

It is the mathematical notation for representing numbers of a given set by using digits or other symbols in a consistent manner.





**Why is binary
system used
in computer?**

APPLICATION



NUMBER SYSTEM

1001_2 11110_2

BASE 2 (0, 1)

BINARY

45_8 74_8 4_8
BASE 8 (0-7)

OCTAL

45_{10} 2_{10}

0 1 2 3 4 5 6 7 8 9

BASE 10 (0-9)

DECIMAL

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

BASE 16 (0-9, A-F)

HEXADECIMAL

$$6 + 10 = 16$$



PRACTICE

~~64~~₈ ✓

~~111~~₂ ✓

~~2~~₂ → 1, 0

~~100~~₁₀ ✓

~~995~~₈ (0-7)

~~100~~₂ ✓

~~12D~~₁₆ ✓

~~101~~₁₆ ✓



CONVERSION

BINARY



DECIMAL

101_2

=

5_{10}

$2^2 \ 2^1 \ 2^0$

$4 + 1 = 5$

2^n



POWER of 2's

$$2 \times 2 =$$

△ → 2^2

2^0	1	2^5	32
2^1	2	2^6	64
2^2	4	2^7	128
2^3	8	2^8	256
2^4	16	2^9	512



EXAMPLE

2^0	1	2^5	32
2^1	2	2^6	64
2^2	4	2^7	128
2^3	8	2^8	256
2^4	16	2^9	512

110₂

2^2 2^1 2^0

$$4 + 2 + 0 = 6$$

$$= 6_{10}$$



EXAMPLE

2^0	1	2^5	32
2^1	2	2^6	64
2^2	4	2^7	128
2^3	8	2^8	256
2^4	16	2^9	512

$$\begin{array}{cccc} 1 & 1 & 0 & 1 \\ 2^3 & 2^2 & 2^1 & 2^0 \end{array} \quad = \quad 13_{10}$$
$$8 + 4 + 0 + 1 = 13$$



EXAMPLE

2^0	1	2^5	32
2^1	2	2^6	64
2^2	4	2^7	128
2^3	8	2^8	256
2^4	16	2^9	512

$$\begin{array}{ccccccccc} 1 & 0 & 1 & 0 & 1 & & & & \\ 2^4 & 2^3 & 2^2 & 2^1 & 2^0 & & & & \\ 16 & + & 0 & + & 4 & + & 0 & + & 1 & = & 21 \end{array}$$

$10101_2 = 21_{10}$



EXAMPLE

2^0	1	2^5	32
2^1	2	2^6	64
2^2	4	2^7	128
2^3	8	2^8	256
2^4	16	2^9	512

$$111010_2 = 32_{10} + 16_{10} + 8_{10} + 0 + 2_{10} + 0 = 58_{10}$$

Handwritten calculation showing the conversion of the binary number 111010 to decimal. The binary digits are aligned with their corresponding powers of 2 (32, 16, 8, 4, 2, 1) and the values are summed: 32 + 16 + 8 + 0 + 2 + 0 = 58.



PRACTICE

$$11011_2 = 27_{10}$$

16 8 4 2 1

$16 + 8 + 2 + 1$

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

~~8~~ 4 2 1

$(8 \times 1) + (4 \times 1) + (2 \times 0) + (1 \times 0)$

$8 + 4 + 0 + 0$

12_{10}



CONVERSION

BINARY



OCTAL

(0-7)

101₂

$2^2 \quad 2^1 \quad 2^0$

4 + 0 + 1

5

8

4 2 1



EXAMPLE

$$\begin{array}{c} 110_2 \\ \begin{array}{ccc} 4 & 2 & 1 \end{array} \\ 4 + 2 + 0 = 6 \end{array} = 6_{10}$$



EXAMPLE

$$\begin{array}{ccc|ccc} 0 & 0 & & 1 & 1 & 0 & 1 \\ 4 & 2 & 1 & 4 & 2 & 1 & \\ 0+0+1 & & & 4+0+1 & & & \\ 1 & & & 5 & & & \end{array} = 15_8$$



EXAMPLE

$$\begin{array}{ccccccc} & 4 & 2 & 1 & & 4 & 2 & 1 \\ & \text{ } & \text{ } & \text{ } & | & \text{ } & \text{ } & \text{ } \\ 0 & 1 & 0 & 1 & 0 & 1 & 1 & 2 \\ & 2+0 & & & | & 4+0 & +1 & \\ & 2 & & & & 5 & & \end{array}$$

$$= 25_8$$



EXAMPLE

111010₂

4 2 1 | 4 2 1

7 2

= 72₈



PRACTICE

$$\begin{array}{c} 11011_2 \\ \begin{array}{c} 3 \quad | \quad 3 \end{array} \end{array} = 33_8$$

$$\begin{array}{c} 11000_2 \\ \begin{array}{c} 1 \quad | \quad 4 \end{array} \end{array} = 14_8$$



CONVERSION

BINARY



HEXADECIMAL

101_2

$4 + 0 + 1$
5

5×16

$\boxed{8} \boxed{4} \boxed{2} \boxed{1} = 15 = F$



EXAMPLE

$$\begin{array}{lll} A = 10 & C = 12 & E = 14 \\ B = 11 & \underline{D = 13} & F = 15 \end{array}$$

$$\begin{array}{l} 11110_2 \\ \hline 1 \quad 8 \quad 4 \quad 2 \quad 1 \\ 1 \quad 8 + 4 + 2 + 0 = 14 = E_{16} \end{array}$$

$$= 1E_{16}$$



EXAMPLE

$$\begin{array}{cccc|cccc} 1 & 1 & 0 & 1 & 1 & 0 & 1 & 2 \\ 4 & 2 & 1 & & 8 & 4 & 2 & 1 \\ 4 + 2 + 0 & & & & 8 + 4 + 0 + 1 & & & \\ 6 & & & & 13 = D & & & \end{array} = 6D_{16}$$



EXAMPLE

$$110101_2 = 35_{10}$$

The binary number 110101₂ is shown in purple. A blue vertical line is drawn between the first two digits (11) and the remaining digits (0101). A blue '3' is written below the first two digits, and a blue '5' is written below the remaining digits. To the right of the binary number, an equals sign is followed by the decimal number 35, with a blue '10' as a subscript.



EXAMPLE

111010₂



PRACTICE

$$\begin{array}{ccccccc} 1 & 1 & 0 & 0 & 0 & 1 & 1 \\ 4 & 3 & 2 & 1 & & & \\ \hline & & & & 3 & & \end{array} \quad = \quad 63_{16}$$

$$\begin{array}{ccccccc} 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 6 & & & & & & \\ \hline & & & & 0 & & \end{array} \quad = \quad 60_{16}$$



CONVERSION

DECIMAL



BINARY

25_{10}

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



11001 $_2$



CONVERSION

DECIMAL



BINARY

25₁₀

11011 2

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



EXAMPLE

79₁₀

1001111₂

2	79	= 1
2	39	= 1
2	19	= 1
2	9	= 1
2	4	= 0
2	2	= 0
2	1	= 1



EXAMPLE

255₁₀

→ 11111111₂

$$\begin{array}{r} 2 \overline{) 255} = 1 \\ 2 \overline{) 127} = 1 \\ 2 \overline{) 63} = 1 \\ 2 \overline{) 31} = 1 \\ 2 \overline{) 15} = 1 \\ 2 \overline{) 7} = 1 \\ 2 \overline{) 3} = 1 \\ 2 \overline{) 1} = 1 \end{array}$$



EXAMPLE

42₁₀

101010₂

2	42	= 0
2	21	= 1
2	10	= 0
2	5	= 1
2	2	= 0
2	1	= 1

↑



EXAMPLE

166₁₀ =

10110110₂

010100110₂

2	166	= 0
2	83	= 1
2	41	= 1
2	20	= 0
2	10	= 0
2	5	= 1
2	2	= 0
2	1	= 1



CONVERSION

DECIMAL

25₁₀



OCTAL

$$\begin{array}{l} 8 \overline{) 25} = 3 \uparrow \\ 8 \overline{) 3} = 3 \end{array}$$

31

8



CONVERSION



25₁₀

11001₂

31₈

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

	1	1
4	2	1

0	0	1
4	2	1



EXAMPLE

79₁₀

117₈

$$\begin{array}{l} 8 \overline{) 79} = 7 \\ 8 \overline{) 9} = 1 \\ 8 \overline{) 1} = 1 \end{array}$$



EXAMPLE

255₁₀

→ 377₈

$$\begin{array}{r} 8 \overline{) 255} = 7 \\ 8 \overline{) 31} = 7 \\ 8 \overline{) 3} = 3 \end{array} \uparrow$$



EXAMPLE

$$\begin{array}{l} 8 \overline{) 42} = 2 \\ 8 \overline{) 5} = 5 \end{array}$$

$$42_{10} \rightarrow 152_8$$



EXAMPLE

166₁₀

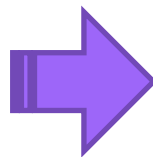
→ 246₈

$$\begin{array}{r|l} 8 & 166 \\ \hline 8 & 20 \\ \hline 8 & 2 \end{array} \begin{array}{l} = 6 \\ = 4 \\ = 2 \end{array} \uparrow$$



CONVERSION

DECIMAL



HEXADECIMAL

25₁₀

$$\begin{array}{r} 16 \overline{) 25} = 9 \uparrow \\ 16 \overline{) 1} = 1 \uparrow \end{array} \quad \begin{array}{r} 19 \\ 16 \end{array}$$



CONVERSION



25₁₀

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

2

			1
8	4	2	1

19 16

1	0	0	1
8	4	2	1



EXAMPLE

$$A=10$$

$$B=11$$

$$C=12$$

$$D=13$$

$$E=14$$

$$F=15$$

79₁₀

$$\begin{array}{r|l} 16 & 79 = 15 = F \\ 16 & 4 = 4 \end{array} \uparrow \begin{array}{r} 79 \\ -64 \\ \hline 15 \end{array}$$

$$= 4F_{16}$$



EXAMPLE

$$\begin{array}{r} 16 \overline{) 255} = 15 = F \\ 16 \overline{) 15} = 15 = F \end{array} \quad \begin{array}{r} 255 \\ - 240 \\ \hline 15 \end{array}$$

$$255_{10} = FF_{16}$$



EXAMPLE

$$\begin{array}{r|l} 16 & 42 = 10 = A \\ 16 & 2 = 2 \end{array} \quad \uparrow$$

$$42_{10} = 2A_{16}$$



EXAMPLE

$$\begin{array}{r} 16 \overline{) 166} = 6 \\ 16 \overline{) 10} = 10 = A \end{array}$$

$$166_{10} = A6$$



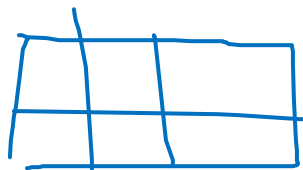
CONVERSION

OCTAL



BINARY

25₈



010101₂

2

0	1	0
4	2	1

151

1	0	1
4	2	1



EXAMPLE

~~0157~~

$$\begin{array}{r} 166_8 \\ \begin{array}{r} 421 \quad 421 \quad 421 \\ 001 \quad 110 \quad 110 \end{array} \\ \hline \end{array} \rightarrow$$

$$= \begin{array}{r} \cancel{1110} \\ 110110 \end{array}_2$$



EXAMPLE

1054₈ → 1000101100₂

421 421 421 421
1 000 101 100
—————→





EXAMPLE

77₈
4 2 1 4 2 1
1 1 1 1 1 1

$$= \frac{111111_2}{2}$$



CONVERSION

OCTAL



DECIMAL

25₈

$$\begin{array}{r} 8^1 \quad 8^0 \\ 2 \times 8^1 + 5 \times 8^0 = \\ 2 \times 8 + 5 \times 1 \\ 16 + 5 \\ = 21 \end{array}$$

21₁₀



EXAMPLE

166₈

$$= 118_{10}$$

$$1 \times 8^2 + 6 \times 8^1 + 6 \times 8^0$$

$$1 \times 64 + 6 \times 8 + 6 \times 1$$

$$64 + 48 + 6$$

$$= 118_{10}$$



EXAMPLE

1054₈

$$= 556_{10}$$

$$1 \times 8^3 + 0 \times 8^2 + 5 \times 8^1 + 4 \times 8^0$$

$$1 \times 512 + 0 + 5 \times 8 + 4 \times 1$$

$$512 + 0 + 40 + 4$$

$$= 556_{10}$$



EXAMPLE

$$64_8 = 52_{10}$$



EXAMPLE

77₈



CONVERSION

OCTAL

25₈

Handwritten conversion of 25₈ to decimal:

4	2	1
---	---	---

4	2	1
---	---	---

0	0	0	1
---	---	---	---

0	1	6	1
---	---	---	---

8 4 2 1 8 4 2 1 2

1 5 = 15₁₀

0-9, A-F
6 + 10 ≠ 16

HEXADECIMAL

15₁₆

Handwritten conversion of 15₁₆ to decimal:

8	4	2	1
---	---	---	---

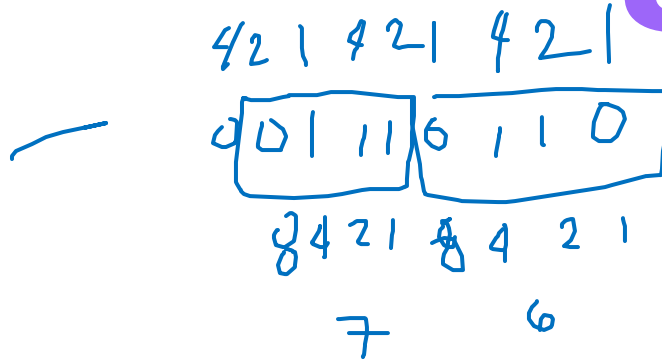
2⁴ 2² 2¹ 2⁰ = 15



EXAMPLE

166₈

= 76₁₆



EXAMPLE

invalid outd #

649~~8~~

= ~~349~~₁₄

4	2	1
---	---	---

4	2	1
---	---	---

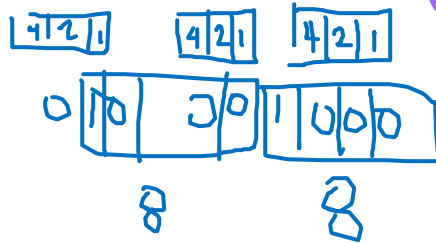
4	2	1
---	---	---



EXAMPLE

210₈

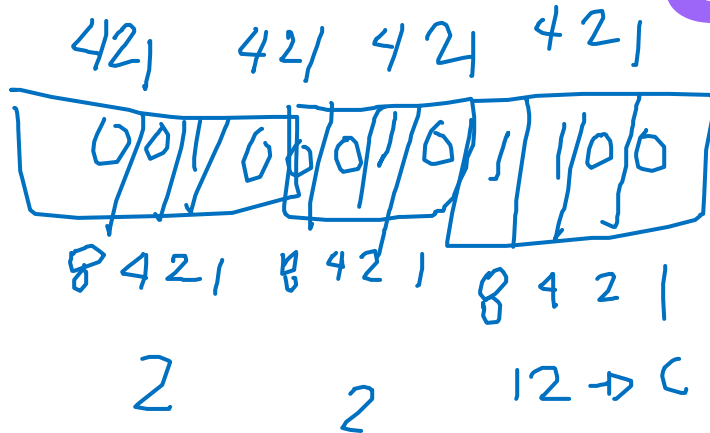
= 38₁₆



EXAMPLE

1054₈

$$= 22C_{16}$$



CONVERSION

HEXADECIMAL



BINARY

39₁₆

2 ³	2 ²	2 ¹	2 ⁰	2 ³	2 ²	2 ¹	2 ⁰
8	4	2	1	8	4	2	1

0 0 1 1 1 0 0 1



0 0 1 1 0 0 1₂



EXAMPLE

168₁₆

8421 8421 8421
0001 0110 1000₂



EXAMPLE

210₁₆



EXAMPLE

40E₁₆

8421 8421 8421

0100 0000 0110

2



EXAMPLE

AF₁₆



CONVERSION

HEXADECIMAL



OCTAL

39₁₆

8



EXAMPLE

168₁₆



EXAMPLE

210₁₆



EXAMPLE

40E₁₆



EXAMPLE

AF₁₆



CONVERSION

HEXADECIMAL



DECIMAL

39₁₆

10



EXAMPLE

168₁₆



EXAMPLE

210₁₆



EXAMPLE

40E₁₆



EXAMPLE

AF₁₆



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