Topic: Conversion of Numbers from One Radix to Another

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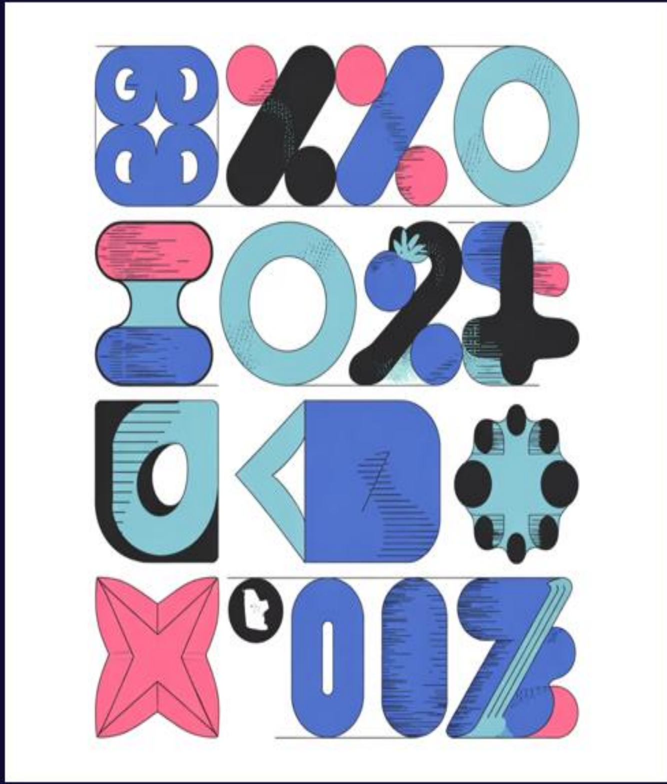
Slide 2 — Introduction

Number systems represent data in computers. Converting between systems is essential for digital design, assembly language, memory addressing, and debugging.

- Binary (base 2)
- Octal (base 8)
- Decimal (base 10)
- Hexadecimal (base 16)



Number System Overview

Quick reference: each system has a base and a set of allowed digits. Use positional weights to convert between systems.

1

Binary (base 2)

Digits: 0–1 • Example: 11011_2

2

Octal (base 8)

Digits: 0–7 • Example: 125_8

3

Decimal (base 10)

Digits: 0–9 • Example: 347_{10}

4

Hex (base 16)

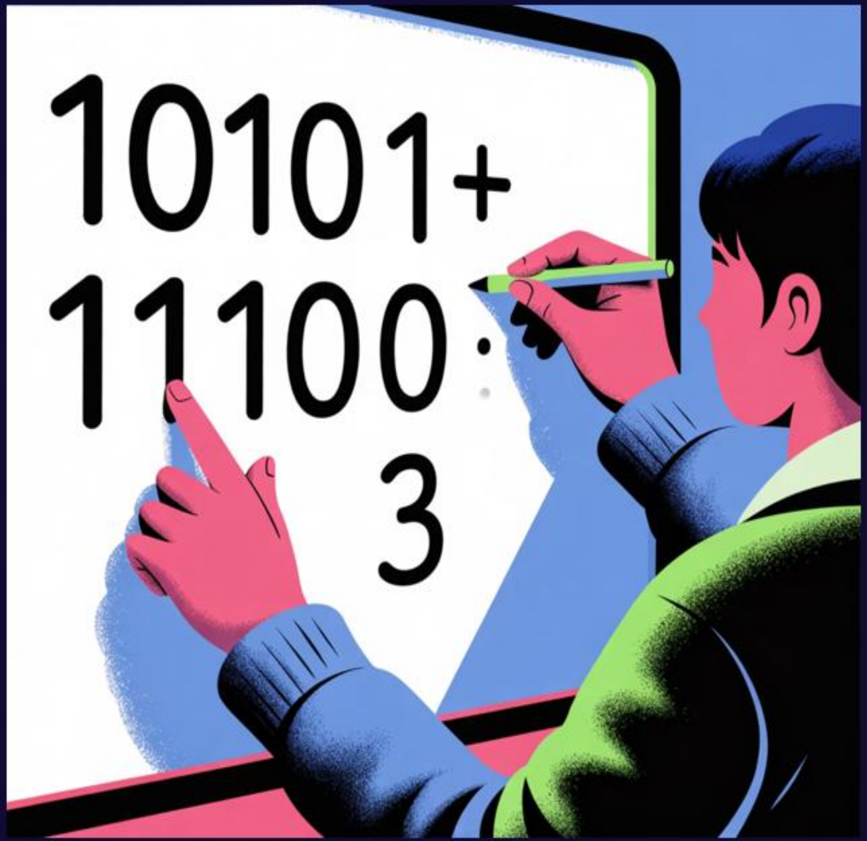
Digits: 0–9, A–F • Example: $2F_{16}$

Binary Conversions — Keyur D.

Binary → Decimal (Method)

Multiply each bit by 2^n (n = position from right, starting at 0) then sum.

Example: $(1101)_2 = 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = 8 + 4 + 0 + 1 = \mathbf{13_{10}}$



Binary → Octal & Hex

Binary → Octal

Group bits in sets of 3 from the right (pad left with 0). Convert each group to its octal digit.

Binary → Hexadecimal

Group bits in sets of 4 from the right (pad left with 0). Convert each group to hex digit (0–9, A–F).

Example: $(101101)_2$ ⟶ group as 101 101 ⟶ 5 5 ⟶ $(55)_8$ ⟶ group as 0010 1101 ⟶ 2 D ⟶ $(2D)_{16}$

🖥️ Number System Conversion Examples (GTU)

Example 2.4.26 – (GTU: Summer-16, 1 Mark)

Convert **$(1011011101101110)_2$** to **Hexadecimal**

👉 Group 4 bits: 1011 | 0111 | 0110 | 1110

👉 Convert: 1011 = B, 0111 = 7, 0110 = 6, 1110 = E

✅ **$(1011011101101110)_2 = (B76E)_{16}$**

Example 2.4.27 – (GTU: Winter-21, 4 Marks)

Convert **$(225.225)_{10}$** to **Octal & Hexadecimal**

Integer Part (225_{10}):

- Divide by 8 → 341_8
- Divide by 16 → $E1_{16}$

Fractional Part (0.225_{10}):

For Octal: 0.225×8=1.8 →1; 0.8×8=6.4→6; 0.4×8=3.2→3; 0.2×8=1.6→1 → **$.1631_8$**

For Hex: 0.225×16=3.6→3; 0.6×16=9.6→9; 0.6×16=9.6→9 → **$.399_{16}$**

✅ **$(225.225)_{10} = (341.1631)_8 = (E1.399)_{16}$**

Octal Conversions — Shivam M.

Octal → Binary

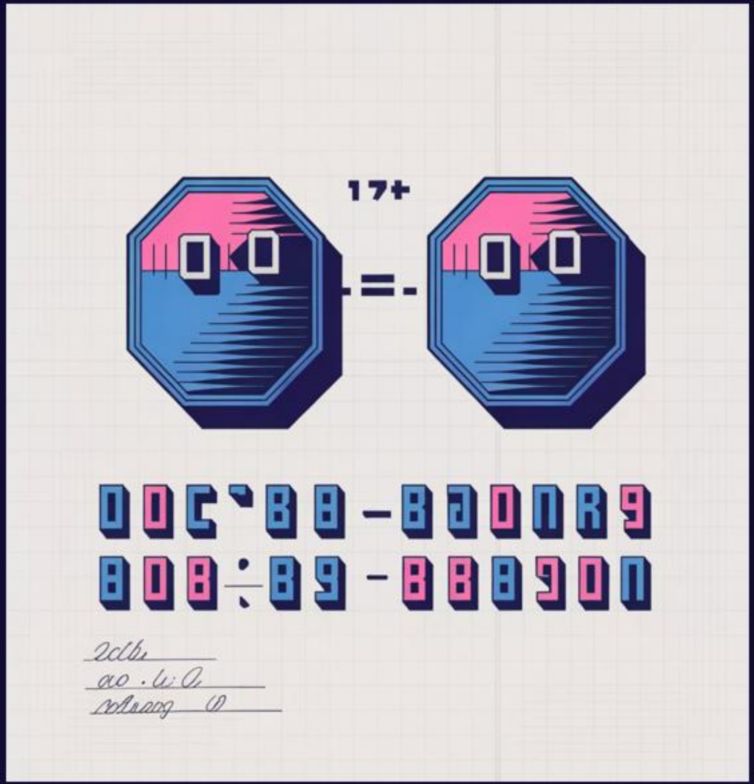
Each octal digit maps to exactly 3 binary bits. Pad to preserve groups.

Example: $(157)_8$ → digits 1 5 7 → binary groups 001 101 111 → $(001101111)_2$

Octal → Decimal & Hex

Octal → Decimal: multiply digits by 8^n and sum.Octal → Hex: convert octal → binary → hex (group binary into 4s).

Example: $(157)_8 = 1\times8^2 + 5\times8^1 + 7\times8^0 = 64 + 40 + 7 = 111_{10}$ → $(6F)_{16}$



Octal to Decimal & Hexadecimal

Octal → Decimal

To convert an octal number to its decimal equivalent, multiply each octal digit by 8 raised to the power of its position (n), starting from n=0 for the rightmost digit, and then sum the results.

Example: $(157)_8$

$$1\times 8^2 + 5\times 8^1 + 7\times 8^0 = 1\times 64 + 5\times 8 + 7\times 1 = 64 + 40 + 7 = 111_{10}$$

Octal → Hexadecimal

The simplest method is to first convert the octal number to binary, and then convert the resulting binary number to hexadecimal. Group binary digits in sets of four from the right.

Example: $(157)_8$

- Octal to Binary: $1 \to 001$ $5 \to 101$ $7 \to 111$ So, $(157)_8 = (001101111)_2$
- Binary to Hexadecimal: Group $(001101111)_2$ in 4s from right (padding left): 0001 (1) 1011 (B) 1111 (F) Therefore, $(157)_8 = (111)_{10} = (1BF)_{16}$

💻 Number System Conversion Examples (GTU)

Example 2.4.24 – (GTU: Winter–17, 4 Marks)

Convert the following numbers:

i) $(52)_{10} = (?)_2$

ii) $(436)_8 = (?)_{16}$

iii) $(507)_{16} = (?)_{10}$

iv) $(11011.101)_2 = (?)_{10}$

i) Decimal to Binary: $(52)_{10}$

- $52 \div 2 = 26$ R 0
- $26 \div 2 = 13$ R 0
- $13 \div 2 = 6$ R 1
- $6 \div 2 = 3$ R 0
- $3 \div 2 = 1$ R 1
- $1 \div 2 = 0$ R 1

Reading remainders from bottom up:

✅ $(52)_{10} = (110100)_2$

ii) Octal to Hexadecimal: $(436)_8$

- Convert each octal digit to 3-bit binary:
  - 4 → 100
  - 3 → 011
  - 6 → 110
- Combine binary: 100011110
- Group binary into 4-bit sections (from right, padding left): 0001 | 0001 | 1110
- Convert each 4-bit group to hexadecimal:
  - 0001 → 1
  - 0001 → 1
  - 1110 → E

✅ $(436)_8 = (11E)_{16}$

iii) Hexadecimal to Decimal: $(507)_{16}$

- Expand by powers of 16:
- $5 \times 16^2 + 0 \times 16^1 + 7 \times 16^0$
- $5 \times 256 + 0 \times 16 + 7 \times 1$
- $1280 + 0 + 7$

✅ $(507)_{16} = (1287)_{10}$

iv) Binary to Decimal: $(11011.101)_2$

- Integer part: 11011_2
- $1\times2^4 + 1\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0$
- $16 + 8 + 0 + 2 + 1 = 27$
- Fractional part: $.101_2$
- $1\times2^{-1} + 0\times2^{-2} + 1\times2^{-3}$
- $0.5 + 0 + 0.125 = 0.625$

✅ $(11011.101)_2 = (27.625)_{10}$

💻 Number System Conversion Examples (GTU)

Example 2.4.27 – (GTU: Winter-21, 4 Marks)
Convert **$(225.225)_{10}$** to **Octal & Hexadecimal**

Integer Part Conversion: $(225)_{10}$

To Octal:

- `225 ÷ 8 = 28 R 1`
- `28 ÷ 8 = 3 R 4`
- `3 ÷ 8 = 0 R 3`
- Reading remainders from bottom-up: `341`

To Hexadecimal:

- `225 ÷ 16 = 14 R 1`
- `14 ÷ 16 = 0 R 14 (E)`
- Reading remainders from bottom-up: `E1`

Fractional Part Conversion: $(0.225)_{10}$

To Octal:

- `0.225 x 8 = 1.8` (Integer part: 1)
- `0.8 x 8 = 6.4` (Integer part: 6)
- `0.4 x 8 = 3.2` (Integer part: 3)
- `0.2 x 8 = 1.6` (Integer part: 1)
- Reading integer parts from top-down: `.1631`

To Hexadecimal:

- `0.225 x 16 = 3.6` (Integer part: 3)
- `0.6 x 16 = 9.6` (Integer part: 9)
- `0.6 x 16 = 9.6` (Integer part: 9)
- Reading integer parts from top-down: `.399`

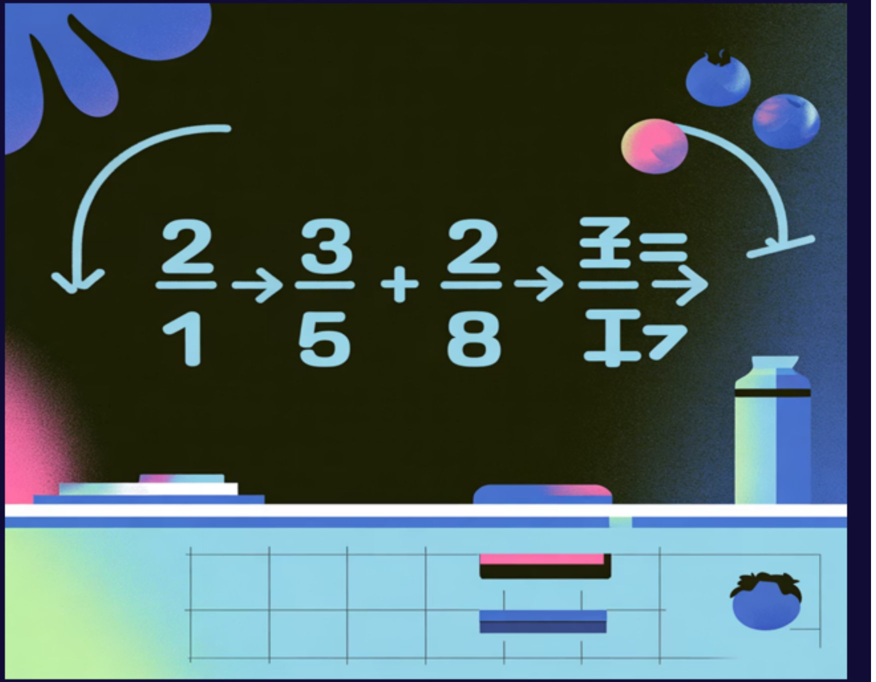
Decimal Conversions — Hardik S.

Decimal → Binary (Division Method)

Repeatedly divide by 2, record remainders, then read remainders bottom→top to get binary.

Example: 45 ÷2 → remainders: 1,0,1,1,0,1 → reversed → **101101_2**

- Decimal → Octal: divide by 8, collect remainders.
- Decimal → Hex: divide by 16, collect remainders (use A–F for 10–15).



Decimal to Octal & Hexadecimal

Building on the division method, converting decimal numbers to other bases is a systematic process of repeated division and remainder collection.

Decimal → Octal

Repeatedly **divide the decimal number by 8**. Collect the remainders in reverse order to form the octal equivalent.

Decimal → Hexadecimal

Repeatedly **divide the decimal number by 16**. Collect the remainders, using A-F for values 10-15, in reverse order for the hex equivalent.

> **Example:** $(255)_{10} = (377)_8 = (FF)_{16}$

💻 Number System Conversion Examples (GTU)

Example 2.4.27 – (GTU: Winter-21, 4 Marks)
Convert $(225.225)_{10}$ to Octal & Hexadecimal

Let's break down the conversion of the decimal number $(225.225)_{10}$ into its octal and hexadecimal equivalents by separating the integer and fractional parts.

Integer Part: $(225)_{10}$

To Octal (divide by 8, collect remainders bottom-up):

```
225 ÷ 8 = 28 R 1
 28 ÷ 8 =  3 R 4
  3 ÷ 8 =  0 R 3
=> (341)₈
```

To Hexadecimal (divide by 16, collect remainders bottom-up):

```
225 ÷ 16 = 14 R 1  (14 is E in Hex)
 14 ÷ 16 =  0 R 14 (14 is E in Hex)
=> (E1)₁₆
```

Fractional Part: $(0.225)_{10}$

To Octal (multiply by 8, collect integer parts top-down):

```
0.225 × 8 = 1.8  (Integer: 1)
0.8   × 8 = 6.4  (Integer: 6)
0.4   × 8 = 3.2  (Integer: 3)
0.2   × 8 = 1.6  (Integer: 1)
=> (.1631...)₈
```

To Hexadecimal (multiply by 16, collect integer parts top-down):

```
0.225 × 16 = 3.6  (Integer: 3)
0.6   × 16 = 9.6  (Integer: 9)
0.6   × 16 = 9.6  (Integer: 9)
=> (.399...)₁₆
```

Hexadecimal Conversions — Shyam B.

Hexadecimal → Binary

Converting hexadecimal to binary is a direct process: each hexadecimal digit corresponds to exactly four binary bits. This method simplifies conversions and is commonly used in computer science.

To convert, identify the 4-bit binary equivalent for each hexadecimal digit, then combine them in the same order.

Example: $(2F)_{16}$

Hex: 2 FBinary: 0010 1111Result: $(00101111)_2$

Hexadecimal to Decimal & Octal

Mastering these conversions allows for seamless data manipulation across different number systems.

Hexadecimal → Decimal

To convert a hexadecimal number to its decimal equivalent, multiply each hexadecimal digit by 16 raised to the power of its position (n), starting from n=0 for the rightmost digit, and then sum the results. Remember that A-F represent values 10-15.

Example: $(2F)_{16}$

$$2 \times 16^1 + F \times 16^0 = 2 \times 16 + 15 \times 1 = 32 + 15 = 47_{10}$$

Hexadecimal → Octal

The most common approach is a two-step process: first convert the hexadecimal number to binary, and then convert the resulting binary number to octal by grouping bits in sets of three from the right.

Example: $(2F)_{16}$

- Hex to Binary: Each hex digit maps to 4 binary bits. `2 → 0010` `F → 1111` So, $(2F)_{16} = (00101111)_2$
- Binary to Octal: Group the binary bits in sets of 3 from the right (pad left with 0s if needed). `001 011 111` `001 → 1` `011 → 3` `111 → 7` Therefore, $(2F)_{16} = (137)_8$

Hexadecimal Conversion Table

This table provides a quick reference for hexadecimal values and their equivalents in decimal, binary, and octal. It's particularly useful for understanding the mapping of single hexadecimal digits greater than 9.

A	10	1010	12
B	11	1011	13
C	12	1100	14
D	13	1101	15
E	14	1110	16
F	15	1111	17

Number System Conversion Examples (GTU)

Let's practice adding hexadecimal numbers, a common operation in computer science and digital electronics, by hand.

Example 2.9.3 – Adding Multiple Hexadecimal Numbers

Add **$(892)_{16}$, $(58F)_{16}$, $(17B)_{16}$,** and **$(48E)_{16}$**

```
  Carry:  1 2 2
(indicates carries in
hexadecimal
arithmetic)
             8 9 2
(892)16
             5 8 F
(58F)16   (F = 15)
             1 7 B
(17B)16   (B = 11)
          +  4 8 E
(48E)16   (E = 14)
          ---------
           1 4 2 7
```

✅ **$(892)_{16} + (58F)_{16} + (17B)_{16} + (48E)_{16} = (1427)_{16}$**

Example 2.9.4 – (GTU: Summer–16, Winter–19, 1 Mark)

Add **$(6E)_{16}$** and **$(C5)_{16}$**

```
  Carry:  1 1
(indicates carries in
hexadecimal
arithmetic)
              6 E
(6E)16   (E = 14)
           +  C 5
(C5)16   (C = 12)
           ---------
            1 3 3
```

✅ **$(6E)_{16} + (C5)_{16} = (133)_{16}$**

Thank You!

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