**Number System**

**Introduction**

A **number system** is a way of representing numbers using a set of symbols and rules.  
In computer science, number systems are crucial because computers represent and process data using **binary digits (0 and 1)**.  
Understanding various number systems helps in programming, digital design, and data representation.

**Types of Number Systems**

| **Number System** | **Base** | **Digits Used** | **Example** | **Usage** |
| --- | --- | --- | --- | --- |
| **Binary** | 2 | 0, 1 | 1011₂ | Internal data representation in computers |
| **Octal** | 8 | 0–7 | 157₈ | Compact representation of binary numbers |
| **Decimal** | 10 | 0–9 | 245₁₀ | Standard human number system |
| **Hexadecimal** | 16 | 0–9, A–F | 9A₁₆ | Used in memory addressing, color codes, etc. |

**Binary Number System**

* **Base:** 2
* **Digits:** 0 and 1
* **Each digit is called a bit.**
* Example:  
  (1011)2=(8+0+2+1)=1110(1011)\_2 = (8 + 0 + 2 + 1) = 11\_{10}(1011)2​=(8+0+2+1)=1110​

**Use in Computers:**  
All digital systems operate in binary because transistors have two states: **ON (1)** and **OFF (0)**.

**Octal Number System**

* **Base:** 8
* **Digits:** 0–7
* Example:  
  (157)8=(1×82)+(5×81)+(7×80)=11110(157)\_8 = (1×8²) + (5×8¹) + (7×8⁰) = 111\_{10}(157)8​=(1×82)+(5×81)+(7×80)=11110​

**Relation to Binary:**  
Every **octal digit = 3 binary bits**.  
Example:  
(157)8=(001 101 111)2=(1111111)2(157)\_8 = (001\ 101\ 111)\_2 = (1111111)\_2(157)8​=(001 101 111)2​=(1111111)2​

**Decimal Number System**

* **Base:** 10
* **Digits:** 0–9
* Example:  
  (245)10=(2×102)+(4×101)+(5×100)(245)\_10 = (2×10²) + (4×10¹) + (5×10⁰)(245)1​0=(2×102)+(4×101)+(5×100)

**Note:** Humans naturally use the decimal system; it’s the default for arithmetic operations.

**Hexadecimal Number System**

* **Base:** 16
* **Digits:** 0–9, A–F (A=10, B=11, …, F=15)
* Example:  
  (9A)16=(9×161)+(10×160)=15410(9A)\_16 = (9×16¹) + (10×16⁰) = 154\_{10}(9A)1​6=(9×161)+(10×160)=15410​

**Relation to Binary:**  
Every **hex digit = 4 binary bits**.  
Example:  
(9A)16=(1001 1010)2(9A)\_16 = (1001\ 1010)\_2(9A)1​6=(1001 1010)2​

**Number System Conversions**

**A. Binary ↔ Decimal**

* **Binary to Decimal:**  
  Multiply each bit by 2ⁿ (where n is bit position).  
  Example: (1010)2=1×23+0×22+1×21+0×20=1010(1010)\_2 = 1×2³ + 0×2² + 1×2¹ + 0×2⁰ = 10\_{10}(1010)2​=1×23+0×22+1×21+0×20=1010​
* **Decimal to Binary:**  
  Divide by 2 repeatedly and record remainders.  
  Example: (10)10=(1010)2(10)\_{10} = (1010)\_2(10)10​=(1010)2​

**B. Binary ↔ Octal**

* Group binary digits in **3 bits** from the right.  
  Example: (110101)2=(65)8(110101)\_2 = (65)\_8(110101)2​=(65)8​

**C. Binary ↔ Hexadecimal**

* Group binary digits in **4 bits** from the right.  
  Example: (10101111)2=(AF)16(10101111)\_2 = (AF)\_{16}(10101111)2​=(AF)16​

**D. Decimal ↔ Octal / Hexadecimal**

* Use **repeated division** by 8 or 16 respectively.