Computer Science Number Systems

Number systems are a fundamental concept in computer science, providing the foundation for how computers process, store, and communicate data. Different number systems are used for various purposes in computing and understanding them is crucial for tasks ranging from low-level programming to algorithm design. Here's an overview of the most used number systems in computer science:

We will cover Number 1, 2, 3, 4, and 6.

1. **Binary Number System (Base-2)**
   - **Digits**: 0, 1
   - **Description**: The binary number system is the most basic and essential number system in computing. It is a base-2 system, meaning it uses only two digits: 0 and 1. Each binary digit is called a "bit." Binary is the language of computers, as digital circuits in hardware use two states (on and off) to represent data. All operations in a computer, whether arithmetic, logical, or storage-related, ultimately boil down to binary.
   - **Example**: The decimal number 5 is represented in binary as `101`.

2. **Decimal Number System (Base-10)**
   - **Digits**: 0-9
   - **Description**: The decimal number system is the most familiar to humans, as it is the standard system for denoting

integer and non-integer numbers. It is a base-10 system, using ten digits (0 through 9). While computers work in binary, decimal is used by programmers and users to interact with the system since it's easier to understand.
  - **Example**: The decimal number 5 remains `5` in the decimal system.

3. **Octal Number System (Base-8)**
  - **Digits**: 0-7
  - **Description**: The octal number system is a base-8 system, using digits from 0 to 7. Octal is often used as a shorthand for binary in computing because it is more compact and easier to read, with each octal digit representing three binary digits (bits). Historically, it was used more often when computers had word lengths that were multiples of three bits.
  - **Example**: The binary number `101` can be grouped into `000 101`, which in octal is `05`.

4. **Hexadecimal Number System (Base-16)**
  - **Digits**: 0-9, A-F
  - **Description**: The hexadecimal (hex) number system is a base-16 system, using digits 0 through 9 and the letters A through F to represent values ten through fifteen. Hexadecimal is widely used in computing because it is a more compact representation of binary numbers, with each hex digit representing four binary digits. It is often used in memory addresses, color codes in web design, and other areas where binary would be too cumbersome.
  - **Example**: The binary number `10110101` can be grouped into `1011 0101`, which in hexadecimal is `B5`.

~~5. **BCD (Binary-Coded Decimal)**~~ (We do NOT explore this in this class)
~~ - **Digits**: Each decimal digit is represented by its binary equivalent.~~
~~ - **Description**: BCD is a class of binary encodings where each digit of a decimal number is represented by its own binary sequence. This is useful for applications like digital clocks and calculators where numerical data must be displayed in a form easily interpretable by humans. It differs from converting a full decimal number into binary and is often used in low-level hardware where decimal precision is crucial.~~
~~ - **Example**: The decimal number 93 in BCD is represented as `1001 0011` (9 and 3 in binary).~~

6. **Signed Number Representations**
  - **Sign-Magnitude**: Uses the leftmost bit to represent the sign (0 for positive, 1 for negative) and the remaining bits for the magnitude of the number.
  - **Two's Complement**: The most common method for representing signed integers in computers. It allows for easy arithmetic operations and only one representation for zero.
  - **One's Complement**: Similar to two's complement but has two representations for zero (positive zero and negative zero). Inverting all bits of a number gives its one's complement.

~~7. **Floating-Point Numbers**~~ (We do NOT explore this in this class)
~~ - **Description**: Floating-point numbers are used to represent real numbers that cannot be accurately represented~~

as integers. They are written in the form of a base (binary or decimal) multiplied by an exponent. IEEE 754 is the most common standard for floating-point computation.
  - **Example**: In binary, the decimal number 13.75 might be represented as `1101.11`, or in normalized scientific notation, as `1.10111 × 2^3`.

Importance in Computer Science:
Number systems are an essential part of computer science, providing the basis for how computers perform calculations, store data, and communicate information. Different number systems are used for various types of data storage and processing in computers. Understanding how data is represented in binary, octal, and hexadecimal is essential for working with low-level programming, memory management, and data manipulation.