**Number Systems Introduction**

 Units **place**: 80 (which is 1)

 Eights **place**: 81 (which is 8)

 Sixty**-fours place**: 82 (which is 64)

 And so on...

**Decimal System (Base 10)**

**- Digits:** 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

**- Example:** 345 (which means 3 hundreds, 4 tens, and 5 units)

**Binary System (Base 2)**

**- Digits:** 0, 1

**- Example:** 1011 (which means 1 eight, 0 fours, 1 two, and 1 one)

**Octal System (Base 8)**

**- Digits:** 0, 1, 2, 3, 4, 5, 6, 7

**- Example:** 57 (which means 5 eights and 7 units)

**Hexadecimal System (Base 16)**

**- Digits:** 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A (10), B (11), C (12), D (13), E (14), F (15)

**- Example:** 2F (which means 2 sixteens and 15 units)

**Conversion**

**Decimal to Binary**

1. Divide the decimal number by 2.

2. Write down the remainder.

3. Repeat with the quotient until you reach 0.

4. The binary number is the remainders read from bottom to top.

**Example:** Convert 13 to binary.

* 13 ÷ 2 = 6 remainder 1
* 6 ÷ 2 = 3 remainder 0
* 3 ÷ 2 = 1 remainder 1
* 1 ÷ 2 = 0 remainder 1

So, 13 in binary is 1101.

**Binary to Decimal**

1. Write down the binary number.

2. Starting from the right (least significant bit), multiply each bit by 2 raised to the power of its position.

3. Sum the results.

**Example:** Convert 1101 to decimal.

* 1 × 23 + 1 × 22 + 0 × 21 + 1 × 20
* 8 + 4 + 0 + 1 = 13

**Example:** Convert 101.101 to decimal.

* 1 × 22 + 0 × 21 +1 × 2-0 + 1× 2-1 + 0 × 2-2 + 1 × 2-3
* 4 + 0 + 1 + ½ + 0/4 + 1/8
* 5 + 5/8 =45/8 = 5.625

**Decimal to Octal**

1. Divide the decimal number by 8.

2. Write down the remainder.

3. Repeat with the quotient until you reach 0.

4. The octal number is the remainders read from bottom to top.

**Example**: Convert 65 to octal.

* 65 ÷ 8 = 8 remainder 1
* 8 ÷ 8 = 1 remainder 0
* 1 ÷ 8 = 0 remainder 1

So, 65 in octal is 101.

**Octal to Decimal**

1. Write down the octal number.

2. Starting from the right, multiply each digit by 8 raised to the power of its position.

3. Sum the results.

**Example:** Convert 101 to decimal.

1 × 82 + 0 × 81 + 1 × 80

64 + 0 + 1 = 65

**Decimal to Hexadecimal**

1. Divide the decimal number by 16.

2. Write down the remainder.

3. Repeat with the quotient until you reach 0.

4. The hexadecimal number is the remainders read from bottom to top.

**Example:** Convert 255 to hexadecimal.

* 255 ÷ 16 = 15 remainder 15 (F)
* 15 ÷ 16 = 0 remainder 15 (F)

So, 255 in hexadecimal is FF.

**Hexadecimal to Decimal**

1. Write down the hexadecimal number.

2. Starting from the right, multiply each digit by 16 raised to the power of its position.

3. Sum the results.

**Example**: Convert 2F to decimal.

2 × 161 + F ×160

2 × 16 + 15 × 1

32 + 15 = 47

**Arithmetic Operations**

**Addition**

**Binary Addition:**

- Similar to decimal addition but base 2.

- Carry over if the sum is 2 or more.

**Example:**

0+0 =0

0+1=1

1+1=0 (carry 1)

1+1+1=0 (carry 1)

And so on……...

**Example:** 1011

+ 1101

1 + 1 = 10 (0 carry 1)

1 + 0 + 1 (carry) = 10 (0 carry 1)

0 + 1 + 1 (carry) = 10 (0 carry 1)

1 + 1 (carry) = 10 (0 carry 1)

Final result: 11000

**Subtraction**

**Binary Subtraction:**

Similar to decimal subtraction but base 2.

Borrow if needed.

Example: 1101

- 1011

1 - 1 = 0

0 - 1 = -1 (borrow 1 from next digit: becomes 10 - 1 = 1)

( ~~1~~  = 0) = borrow 1

0 - 0 = 0

1 - 1 = 0

Final result: 0010 (or simply 10)

**Multiplication**

Binary Multiplication:

Similar to decimal multiplication but base 2.

Multiply and add as in decimal.

**Example:**  101 \* 11

101 × 1 = 101

101 × 10 = 1010

Add the results: 101 + 1010 = 1111

**Summary**

**Decimal:** Base 10

**Binary:** Base 2

**Octal:** Base 8

**Hexadecimal:** Base 16

Conversions involve dividing by the base and tracking remainders, while arithmetic operations follow the same principles but within the respective base system.