Lab5

Number Systems

What are Number Systems?

Number systems are the technique to represent numbers in the computer system architecture, every value that you are saving or getting into/from computer memory has a defined number system.

Computer architecture supports following number systems.

- **Binary number system**
- **Octal number system**
- **Decimal number system**
- **Hexadecimal (hex) number system**

Basic Definitions

- **Binary System:**

A Binary number system has only two digits that are 0 and 1. Every number is represented with 0 and 1 in this number system. The base of binary number system is 2, because it has only two digits.

- **Octal System:**

Octal number system has only eight (8) digits from 0 to 7. Every number is represented with 0,1,2,3,4,5,6 and 7 in this number system. The base of octal number system is 8, because it has only 8 digits.

- **Decimal System:**

Decimal number system has only ten (10) digits from 0 to 9. Every number is represented with 0,1,2,3,4,5,6, 7,8 and 9 in this number system. The base of decimal number system is 10, because it has only 10 digits.

- **Hexadecimal System:**

A Hexadecimal number system has sixteen (16) alphanumeric values from 0 to 9 and A to F. Every number is represented with 0,1,2,3,4,5,6, 7,8,9,A,B,C,D,E and F in this number system. The base of hexadecimal number system is 16, because it has 16 alphanumeric values. Here A is 10, B is 11, C is 12, D is 13, E is 14 and F is 15.

Binary to Decimal Conversion

Expand Using Positional Notation

$$\begin{aligned}100101_B &= (1*2^5)+(0*2^4)+(0*2^3)+(1*2^2)+(0*2^1)+(1*2^0)\\ &= 32 + 0 + 0 + 4 + 0 + 1\\ &= 37\end{aligned}$$

Answer: 37

Decimal to Binary Conversion

Repeatedly divide by 2, consider remainder

```
37 / 2 = 18 R 1
18 / 2 =  9 R 0
 9 / 2 =  4 R 1
 4 / 2 =  2 R 0
 2 / 2 =  1 R 0
 1 / 2 =  0 R 1
```

Answer: 100101_B (Start writing from the bottom)

Hexadecimal to Decimal Conversion

Expand Using Positional Notation

$$
\begin{aligned}
25_H &= (2*16^1) + (5*16^0) \\
&= 32 + 5 \\
&= 37
\end{aligned}
$$

Answer: 37

Decimal to Hexadecimal Conversion

Repeatedly divide by 16, consider remainder

```
37 / 16 = 2 R 5
 2 / 16 = 0 R 2
```

Answer: 25_H (Start writing from the bottom)

Binary to Hexadecimal Conversion

Use Positional Notation

Every 1 hexadecimal digit corresponds to 4 binary digits

Digit count in binary number not a multiple of 4 => pad with zeros on left

$$1010\,0001\,0011\,1101_B$$

$$A \quad 1 \quad 3 \quad D_H$$

Answer: $A13D_H$

Hexadecimal to Binary Conversion

Use Positional Notation

Every 1 hexadecimal digit corresponds to 4 binary digits

Discard leading zeros from binary number if appropriate

$$\text{A} \quad 1 \quad 3 \quad \text{D}_H$$

$$1010000100111101_B$$

Answer: $1010\ 0001\ 0011\ 1101_B$

Octal to Decimal Conversion

Expand using positional notation

$$
\begin{aligned}
37_o &= (3*8^1) + (7*8^0) \\
&= 24 + 7 \\
&= 31
\end{aligned}
$$

Answer: 31

Decimal to Octal Conversion

Repeatedly divide by 8, consider remainder

```
31 / 8 = 3 R 7
 3 / 8 = 0 R 3
```

Answer: 37_O (Start writing from the bottom)

Binary to Octal Conversion

Use Positional Notation

Every 1 octal digit corresponds to 3 binary digits

Digit count in binary number not a multiple of 3 => pad with zeros on left

001010000100111101_B

$1 \quad 2 \quad 0 \quad 4 \quad 7 \quad 5_O$

Answer: 120475_O

Octal to Binary Conversion

Use Positional Notation

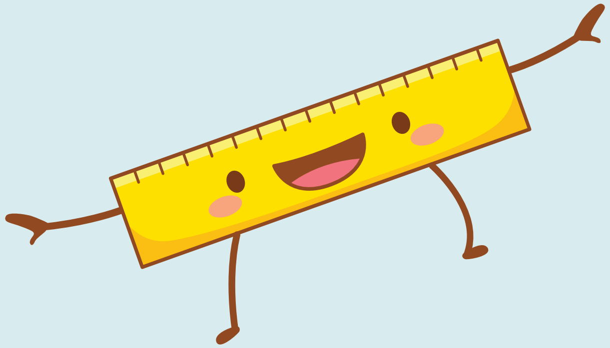
Every 1 octal digit corresponds to 3 binary digits

Discard leading zeros from binary number if appropriate

$$1\quad 2\quad 0\quad 4\quad 7\quad 5_O$$

$$001010000100111101_B$$

Answer: 001 010 000 100 111 101_B



General Conversion Rules

$$
\begin{aligned}
37_O &= (3*8^1) + (7*8^0) \\
&= 24 + 7 \\
&= 31
\end{aligned}
$$

- For any base to decimal conversion, multiply the powers of that base with each digit in question.

$$
\begin{aligned}
37 / 16 &= 2 \text{ R } 5 \\
2 / 16 &= 0 \text{ R } 2
\end{aligned}
$$

- For decimal to any base conversion, divide the number in question with the base repeatedly.

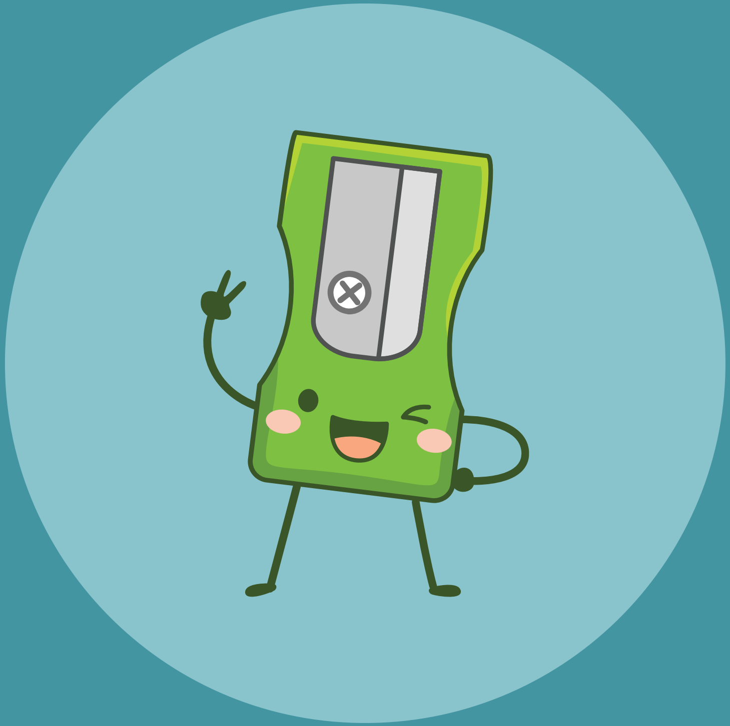
$$
\begin{aligned}
100101_B &= (1*2^5)+(0*2^4)+(0*2^3)+(1*2^2)+(0*2^1)+(1*2^0) \\
&= 32 + 0 + 0 + 4 + 0 + 1 \\
&= 37
\end{aligned}
$$

- For octal/hexadecimal to binary, or binary to base conversions, use positional notation.

- 1 octal digit = 3 binary digits, so make groups of 3

  1 hexadecimal digit = 4 binary digits, so make groups of 4

  For decimal, no grouping required, just add all the numbers



Questions?