Computing Fundamentals

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Number System

When we type some letters or words, the computer translates them in numbers as computers can understand only numbers.

A computer can understand the positional number system where there are only a few symbols called digits and these symbols represent different values depending on the position they occupy in the number.

The value of each digit in a number can be determined using −

- The digit
- The position of the digit in the number
- The base of the number system (where the base is defined as the total number of digits available in the number system)

Number Systems Used in Computers

Name of Radix	Radix	Set of Digits	Example
Decimal	r=10	{0,1,2,3,4,5,6,7,8,9}	255_{10}
Binary	r=2	{0,1}	11111111_2
Octal	r= 8	{0,1,2,3,4,5,6,7}	377_8
Hexadecimal	r=16	{0,1,2,3,4,5,6,7,8,9,A, B, C, D, E, F}	FF_{16}

Number Base Conversions

- Decimal to Binary
- Binary to Decimal
- Octal to Binary
- Binary to Octal
- Hexadecimal to Binary
- Binary to Hexadecimal
- Decimal to Octal
- Octal to Decimal
- Decimal to Hexadecimal
- Hexadecimal to Decimal

Decimal to Binary Conversion

- Convert 41 from decimal to binary:

2	41	
2	20	1
2	10	0
2	5	0
2	2	1
	1	0

$$(41)_{10} = (101001)_2$$

Decimal to Binary Conversion

- To convert decimal fractions to binary, repeated multiplication by 2 is used, until the fractional product is 0 (or until the desired number of binary places). The whole digits of the multiplication results produce the answer, with the first as the MSB, and the last as the LSB.
- Example: Convert 0.3125_{10} to binary

			Result Digit
$.3125 \times 2$	=	0.625	0 (MSB)
$.625 \times 2$	=	1.25	1
$.25 \times 2$	=	0.50	0
$.5 \times 2$	=	1.0	1 (LSB)

$(0.3125)_{10} = (0.0101)_2$

Binary to Decimal Conversion

- Remember, each digit represents a power of 2, therefore $(1011)_2$ is

  $$1 \cdot 2^3 + 0 \cdot 2^2 + 1 \cdot 2^1 + 1 \cdot 2^0$$

  or

  $$1 \cdot 8 + 0 \cdot 4 + 1 \cdot 2 + 1 \cdot 1 = 11$$

- What about decimal equivalent of $(101.11)_2$?

  $$1 \cdot 2^2 + 0 \cdot 2^1 + 1 \cdot 2^0 + 1 \cdot 2^{-1} + 1 \cdot 2^{-2}$$

  or

  $$1 \cdot 4 + 0 \cdot 2 + 1 \cdot 1 + 0.5 + 0.25 = 5.75$$

OCTAL TO BINARY CONVERSION

Steps

- **Step 1** − Convert each octal digit to a 3 digit binary number (the octal digits may be treated as decimal for this conversion).
- **Step 2** − Combine all the resulting binary groups (of 3 digits each) into a single binary number.

Example

Octal Number : 25_8

Calculating Binary Equivalent:

Step	Octal Number	Binary Number
Step 1	25_8	2_{10} 5_{10}
Step 2	25_8	010_2 101_2
Step 3	25_8	010101_2

Octal Number : 25_8 = Binary Number : 10101_2

Octal to Binary Conversion

- Base 8 – uses 0, 1, 2, 3, 4, 5, 6, 7 as digits
- For octal to binary convert each octal digit into its 3 bit binary equivalent. For example:

$$(\underbrace{7}_{111}\ \underbrace{5}_{101}\ \underbrace{6}_{110}\ \underbrace{2}_{010})_8 = (\mathbf{111101110010})_2$$

BINARY TO OCTAL CONVERSION

Steps

- **Step 1** - Divide the binary digits into groups of three (starting from the right).
- **Step 2** - Convert each group of three binary digits to one octal digit.

Example

Binary Number : 10101_2

Calculating Octal Equivalent:

Step	Binary Number	Octal Number
Step 1	10101_2	010 101
Step 2	10101_2	2_8 5_8
Step 3	10101_2	25_8

Binary Number : 10101_2 = Octal Number : 25_8

Binary to Octal Conversion

For binary to octal group each 3-bit starting from least significant bits and convert into one octal digit. For example:

$$(\underbrace{100}_{4}\underbrace{101}_{5}\underbrace{011}_{3})_2 = \mathbf{(453)_8}$$

Hexadecimal to Binary Conversion

- Base 16
- Uses 0, 1, 2, 3, 4,5, 6, 7, 8, 9, A, B, C, D, E, F as digits.
- Hexadecimal is indicated by *0x* prefix in computer literature.
- For example 0x2ac in binary will be:

0x2AC

0010 1010 1100

$$\boxed{0x2AC = (001010101100)_2}$$

HEXADECIMAL TO BINARY

steps

- **Step 1** - Convert each hexadecimal digit to a 4 digit binary number (the hexadecimal digits may be treated as decimal for this conversion).
- **Step 2** - Combine all the resulting binary groups (of 4 digits each) into a single binary number.

Example

Hexadecimal Number : $0x15_{16}$

Calculating Binary Equivalent:

Step	Hexadecimal Number	Binary Number
Step 1	15_{16}	1_{10} 5_{10}
Step 2	15_{16}	0001_2 0101_2
Step 3	15_{16}	00010101_2

Hexadecimal Number : 15_{16} = Binary Number : 10101_2

BINARY TO HEXADECIMAL

Steps

- **Step 1** - Divide the binary digits into groups of four (starting from the right).
- **Step 2** - Convert each group of four binary digits to one hexadecimal symbol.

Example

Binary Number : 10101_2

Calculating hexadecimal Equivalent:

Step	Binary Number	Hexadecimal Number
Step 1	10101_2	0001 0101
Step 2	10101_2	1_{10} 5_{10}
Step 3	10101_2	15_{16}

Binary Number : 10101_2 = Hexadecimal Number : $0x15_{16}$

Binary to Hexadecimal Conversion

- Just make the group of 4 bits from left to right.
- For example $(101001101111011)_2$ in Hex will be:

$$\begin{array}{cccc} 0101 & 0011 & 0111 & 1011 \\ \downarrow & \downarrow & \downarrow & \downarrow \\ 5 & 3 & 7 & B \end{array}$$

- So, $(0101\ 0011\ 0111\ 1011)_2 = 0x537B$

Octal to Decimal Conversion

- The rule is same as we follow in Binary to Decimal conversion.
- But obviously the base is 8
- Example: what is the decimal equivalent of $(725)_8$

$$
\begin{aligned}
(725)_8 &= 7x8^2 + 2*8^1 + 5*8^0 \\
&= (448)_{10} + (16)_{10} + (5)_{10} \\
&= \mathbf{(469)_{10}}
\end{aligned}
$$