

Computing Fundamentals

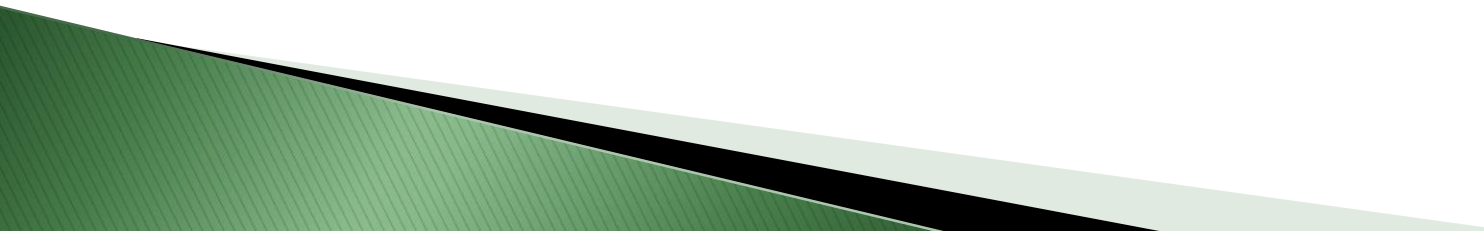
Engr. Mahawish Fatima

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.

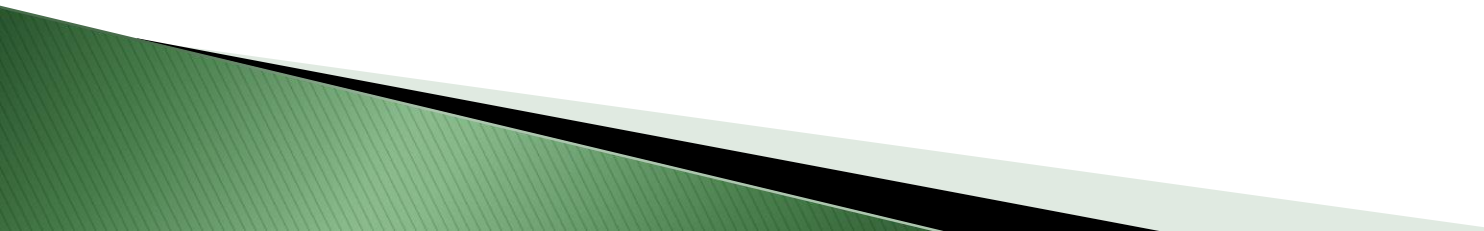
The value of each digit in a number can be determined using –

- ▶ 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)
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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	$r=2$	$\{0,1\}$	1111111_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
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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:

$$\begin{array}{cccc} (7 & 5 & 6 & 2)_8 \\ \underbrace{} & \underbrace{} & \underbrace{} & \underbrace{} \\ 111 & 101 & 110 & 010 \end{array} = (111101110010)_2$$

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

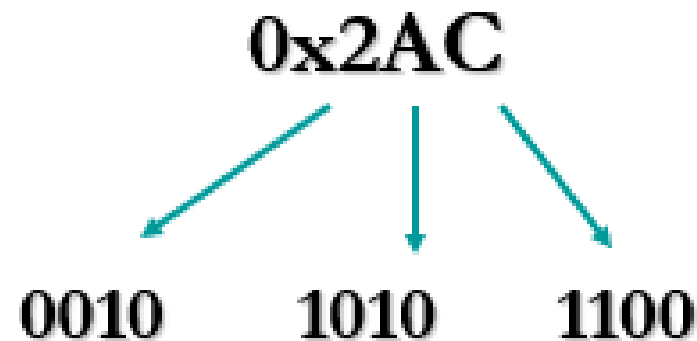
Binary to Octal Conversion

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

$$\begin{array}{ccccccc} 1 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 1 \\ \underbrace{\hspace{1cm}} & \underbrace{\hspace{1cm}} & \underbrace{\hspace{1cm}} & & & & & & \\ 4 & 5 & 3 & & & & & & \end{array} (100101011)_2 = (453)_8$$

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:



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

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:

0101 0011 0111 1011



5 3 7 B

- 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 $(725)_8$

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