ACT111L, BCS111L, BIT111L
Intro to Computing

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COMPUTING NUMBER SYSTEMS

a) Number System Conversion

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

b) Number System Operations

Introduction

- The goal of this module is to discuss the different number systems namely binary, decimal, octal and hexadecimal. To familiarize the Conversion of Number System and to determine the steps on how to convert Number System to different bases.

LEARNING OBJECTIVES

At the end of this module, the students are expected to:

- Enumerate the different types of number systems
- Apply the rules of conversion with the different number systems
- Demonstrate Binary conversion to different number systems

NUMBER SYSTEM

- NUMBER SYSTEM is a set of numbers, together with one or more operations, such as addition or multiplication.

Examples:

- Natural numbers
- integers
- rational numbers
- algebraic numbers
- real numbers
- complex numbers

Natural Numbers

Zero and any number obtained by repeatedly adding one to it.

Examples: 100, 0, 45645, 32

Negative Numbers

A value less than 0, with a – sign

Examples: -24, -1, -45645, -32

Integers

A natural number, a negative number, zero

Examples: 249, 0, - 45645, - 32

Rational Numbers

An integer or the quotient of two integers

Examples: -249, -1, 0, 3/7, -2/5

Natural Numbers

642 is 600 + 40 + 2 in **BASE 10**

The **base** of a number determines the number of digits and the value of digit positions

Positional Notation

Continuing with our example…

642 in base 10 *positional notation* is:

$6 \times 10^2 = 6 \times 100 = 600$

$+ 4 \times 10^1 = 4 \times 10 = 40$

$+ 2 \times 10^0 = 2 \times 1 = 2$ $= 642$ in base 10

This number is in base 10

The power indicates the position of the number

Positional Notation

R is the base of the number

As a formula:

$$d_n * R^{n-1} + d_{n-1} * R^{n-2} + \ldots + d_2 * R + d_1$$

n is the number of digits in the number

d is the digit in the i^{th} position in the number

642 is $6_3 * 10^2 + 4_2 * 10 + 2_1$

DECIMAL SYSTEM

- 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
- The number system that we use in our day-to-day life
- Decimal number system has base 10 as it uses 10 digits from 0 to 9.
- In decimal number system, the successive positions to the left of the decimal point represent units, tens, hundreds, thousands, and so on.

DECIMAL SYSTEM

- Each position represents a specific power of the base (10).

- For example,
  the decimal number 1234 consists of the digits
  4 in the unit's position,
  3 in the tens position,
  2 in the hundreds position
  1 in the thousands position.
  Its value can be written as 1234

Example: 1,234 or 1234_{10}

$(\mathbf{1} \times 10^3) + (\mathbf{2} \times 10^2) + (\mathbf{3} \times 10^1) + (\mathbf{4} \times 10^0)$

$(1 \times 1000) + (2 \times 100) + (3 \times 10) + (4 \times 1)$

$1000 + 200 + 30 + 4$

1234

$= 1,234$

Another example : 5729_{10}

$(5 \times 10^3) + (7 \times 10^2) + (2 \times 10^1) + (9 \times 10^0)$

$(5 \times 1000) + (7 \times 100) + (2 \times 10) + (9 \times 1)$

$5000 + 700 + 20 + 9$

5729

$= 5{,}729$

Another example : $84,642_{10}$

$(8 \times 10^4)+(4 \times 10^3)+ (6 \times 10^2)+ (4 \times 10^1)+ (2 \times 10^0)$

$(8 \times 10,000)+(4 \times 1000)+ (6 \times 100)+ (4 \times 10)+ (2 \times 1)$

$80,000+4,000 + 600 + 40 + 2$

84642

$= 84,642$

BIT & BYTE

- Computer uses the binary system.

- A binary digit is called a **BIT**.

- There are two possible states in a bit, usually expressed as **0** and **1**.

- A series of eight (8) bits strung together makes a **BYTE**.
- 8 BITS = 1 BYTE

BIT & BYTE

- Also called as base 2 number system.

- Each position in a binary number represents a 0 power of the base (2).

- Each position in a binary number represents a 0 power of the base (2). Example 2^0

- Last position in a binary number represents a x power of the base (2). Example 2^x where x represents the last position - 1.

Example : 1101_2

$$=(1 \times 2^3) + (1 \times 2^2)+(0 \times 2^1)+(1 \times 2^0)$$

$$=8 + 4 + 0 + 1$$

$$=13$$

Example : 10101_2

$= (1 \times 2^4)+(0 \times 2^3) + (1 \times 2^2)+(0 \times 2^1)+(1 \times 2^0)$

$= (1 \times 16)+(0 \times 8)+(1 \times 4)+(0 \times 2)+(1 \times 1)$

$=16 + 0 + 4 + 0 + 1$

$=21$

Example : 10001_2

$= (1 \times 2^4)+(0 \times 2^3) + (0 \times 2^2)+(0 \times 2^1)+(1 \times 2^0)$

$=16 + 0 + 0 + 0 + 1$

$=17$

OCTAL SYSTEM

- Uses eight digits: 0,1,2,3,4,5,6,7
- Also called as base 8 number system
- Each position in an octal number represents a 0 power of the base (8)
- Last position in an octal number represents a x power of the base (8).

Example : 1076_8

$=(1 \times 8^3) + (0 \times 8^2)+(7 \times 8^1)+(6 \times 8^0)$

$=512 \ \ +0+ 56 \ \ + 6$

$=574_{10}$

Example : 5310_8

$$=(5 \times 8^3) + (3 \times 8^2)+(1 \times 8^1)+(0 \times 8^0)$$

$$=2560 + 192+ \mathbf{8} + \mathbf{0}$$

$$=2760_{10}$$

Example : 10076_8

$=(1 \times 8^4) + (0 \times 8^3) + (0 \times 8^2)+(7 \times 8^1)+(6 \times 8^0)$

$=4096 + 0+ 0+ 56 + 6$

$=4158_{10}$

HEXADECIMAL SYSTEM

- 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
  Note: A = 10, B = 11, C = 12, D = 13, E = 14, F = 15
- Also called as base 16 number system
- Each position in a hexadecimal number represents a 0 power of the base (16).
- Last position in a hexadecimal number represents a x power of the base (16).

Example: $1AF2_{16}$

$= (1 \times 16^3) + (10 \times 16^2) + (15 \times 16^1) + (2 \times 16^0)$

$= 4096 + 2560 + 240 + 2$

$=6898$

Example: 1BAE

$$= (1 \times 16^3) + (\mathbf{11} \times 16^2) + (\mathbf{10} \times 16^1) + (\mathbf{14} \times 16^0)$$

$$= 4096 + 2816 + 160 + 14$$

$$= \mathbf{7086}$$

Example: 2BAD

$= (2 \times 16^3) + (11 \times 16^2) + (10 \times 16^1) + (13 \times 16^0)$

$= 8192 + 2816 + 160 + 13$

$= 11{,}181_{10}$

CONVERSION OF NUMBER SYSTEM

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

CONVERSION OF NUMBER SYSTEM

BINARY	DECIMAL
0	0
1	1
10	2
11	3
100	4
101	5
110	6
111	7
1000	8
1001	9
1010	10

BINARY	OCTAL
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

BINARY	Hexadecimal
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

Decimal to Binary

$74_{10} = 1001010_2$

$74 / 2 = 37$ remainder 0

$37 / 2 = 18$ 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

Decimal to Binary

$29_{10} = \_\_\_\_\_\_\_\__{2}$

$29 / 2 = 14$	r. 1
$14 / 2 = 7$	r. 0
$7 / 2 = 3$	r. 1
$3 / 2 = 1$	r. 1
$1 / 2 = 0$	r. 1

Decimal to Binary

$112_{10} = 1110000_{2}$

$112/2 = 56$ r.0
$56/2 = 28$ r.0
$28/2 = 14$ r.0
$14/2 = 7$ r.0
$7/2 = 3$ r.1
$3/2 = 1$ r.1
$1/2 = 0$ r.1

Decimal to OCTAL

$74_{10} = 112_8$

$74 / 8 = 9$ r. 2

$9 / 8 = 1$ r. 1

$1 / 8 = 0$ r. 1

Decimal to OCTAL

$29_{10} = 35_{8}$

$29 / 8 = 3$ r. 5

$3 / 8 = 0$ r. 3

Decimal to OCTAL

$112_{10} = 160_8$

$112 / 8 = 14 \quad r.\ 0$

$14 / 8 = 1 \quad r.\ 6$

$1 / 8 = 0 \quad r.\ 1$

Decimal to HEXADECIMAL

$74_{10} = 4A_{16}$

$74 / 16 = 4 \quad r.\ 10 \sim A$

$4 / 16 = 0 \quad r.\ 4$

Decimal to HEXADECIMAL

185711_{10} = $2D56F_{16}$

185711 / 16 = 11 606	r. 15 ~ F
11 606/ 16 = 725	r. 6
725 / 16 = 45	r. 5
45 / 16 = 2	r. 13 ~ D
2 / 16 = 0	r. 2

BINARY to DECIMAL

$1001010_2 = 74_{10}$

$1 \times 2^6 = 64$

$0 \times 2^5 = 0$

$0 \times 2^4 = 0$

$1 \times 2^3 = 8$

$0 \times 2^2 = 0$

$1 \times 2^1 = 2$

$0 \times 2^0 = 0$

BINARY to DECIMAL

$1111111_2 = 127_{10}$

$1x\ 2^6 = 64$

$1x\ 2^5 = 32$

$1x\ 2^4 = 16$

$1x\ 2^3 = 8$

$1x\ 2^2 = 4$

$1x\ 2^1 = 2$

$1x\ 2^0 = 1$

OCTAL to DECIMAL

$112_8 = 74_{10}$

$1 \times 8^2 = 1 * 64 = 64$

$1 \times 8^1 = 1 * 8 = 8$

$2 \times 8^0 = 2 * 1 = 2$

$64+8+2 = 74$

OCTAL to DECIMAL

$3746_8 = 2022_{10}$

$3 \times 8^3 = 3 * 512 = 1536$
$7 \times 8^2 = 7 * 64 = 448$
$4 \times 8^1 = 4 * 8 = 32$
$6 \times 8^0 = 6 * 1 = 6$

HEXADECIMAL to DECIMAL

$A2C_{16} = 2604_{10}$

$10 \times 16^2 = 10 * 256 = 2560$

$2 \times 16^1 = 2 * 16 = 32$

$12 \times 16^0 = 12 * 1 = 12$

HEXADECIMAL to DECIMAL

$ACED_{16}$ = 44269_{10}

$10 \times 16^3 = 10 * 4096 = 40960$

$12 \times 16^2 = 12 * 256 = 3072$

$14 \times 16^1 = 14 * 16 = 224$

$13 \times 16^0 = 13 * 1 = 13$