Practical class № 1-2

Subject: «Number systems. Transfer numbers from one number system to another. Arithmetic in the number systems.»

Purpose: To acquire the skills of operations in different number systems.

There are many methods or techniques which can be used to convert numbers from one base to another. We'll demonstrate here the following

- Decimal to Other Base System
- Other Base System to Decimal
- Other Base System to Non-Decimal
- Shortcut method - Binary to Octal
- Shortcut method - Octal to Binary
- Shortcut method - Binary to Hexadecimal
- Shortcut method - Hexadecimal to Binary

Decimal to Other Base System

Steps

- Step 1 - Divide the decimal number to be converted by the value of the new base.
- Step 2 - Get the remainder from Step 1 as the rightmost digit (least significant digit) of new base number.
- Step 3 - Divide the quotient of the previous divide by the new base.
- Step 4 - Record the remainder from Step 3 as the next digit (to the left) of the new base number.

Repeat Steps 3 and 4, getting remainders from right to left, until the quotient becomes zero in Step 3.

The last remainder thus obtained will be the most significant digit (MSD) of the new base number.

Example

Decimal Number: 29_{10}

Calculating Binary Equivalent:

Step	Operation	Result	Remainder
Step 1	29 / 2	14	1
Step 2	14 / 2	7	0
Step 3	7 / 2	3	1
Step 4	3 / 2	1	1
Step 5	1 / 2	0	1

As mentioned in Steps 2 and 4, the remainders have to be arranged in the reverse order so that the first remainder becomes the least significant digit (LSD) and the last remainder becomes the most significant digit (MSD).

Decimal Number: 29_{10} = Binary Number: 11101_2.

Other base system to Decimal System

Steps

- Step 1 - Determine the column (positional) value of each digit (this depends on the position of the digit and the base of the number system).
- Step 2 - Multiply the obtained column values (in Step 1) by the digits in the corresponding columns.
- Step 3 - Sum the products calculated in Step 2. The total is the equivalent value in decimal.

Example

Binary Number: 11101_2

Calculating Decimal Equivalent:

Step	Binary Number	Decimal Number
Step 1	111012	((1 x 24) + (1 x 23) + (1 x 22) + (0 x 21) + (1 x 20))10
Step 2	111012	(16 + 8 + 4 + 0 + 1)10
Step 3	111012	29_{10}

Binary Number: 111012 = Decimal Number: 29_{10}

Other Base System to Non-Decimal System

Steps

- Step 1 - Convert the original number to a decimal number (base 10).
- Step 2 - Convert the decimal number so obtained to the new base number.

Example

Octal Number: 25_8 Calculating

Binary Equivalent:

Step 1: Convert to Decimal

Step	Octal Number	Decimal Number
Step 1	25_8	((2 x 81) + (5 x 80))10

Step 2	25_8	(16 + 5)10
Step 3	25_8	2110

Octal Number: 25_8 = Decimal Number: 21_{10}

Step 2: Convert Decimal to Binary

Step	Operation	Result	Remainder
Step 1	21 / 2	10	1
Step 2	10 / 2	5	0
Step 3	5 / 2	2	1
Step 4	2 / 2	1	0
Step 5	1 / 2	0	1

Decimal Number: 21_{10} = Binary Number: 10101_2

Octal Number: 25_8 = Binary Number: 10101_2

Shortcut method - Binary to Octal

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	101012	010 101
Step 2	101012	28 58
Step 3	101012	258

Binary Number: 10101_2 = Octal Number: 25_8

Shortcut method - Octal to Binary

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	210 510
Step 2	25_8	0102 1012
Step 3	25_8	0101012

Octal Number: 25_8 = Binary Number: 10101_2

Shortcut method - 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	110 5_{10}
Step 3	101012	15_{16}

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

Shortcut method - 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: 15_{16}

Calculating Binary Equivalent:

Step	Hexadecimal Number	Binary Number
Step 1	15_{16}	110 510
Step 2	15_{16}	0001_2 0101_2
Step 3	15_{16}	00010101_2

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

Десятичная система	*Двоичная система*	*Шестнадцатеричная система*
0	0	0
1	1	1
2	10	2
3	11	3
4	100	4
5	101	5
6	110	6
7	111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F
16	10000	10

Tasks.

1. This figure in the decimal system to translate into binary, octal and hexadecimal numbers.
2. Set this a number on the decimal system.
3. Add the numbers.

Variant 1

1. а) 860_{10}; б) 785_{10}; в) 149_{10}; г) 953_{10}; д) 228_{10}.
2. а) 1001010_2; б) 1100111_2; в) 110101101_2; г) 111111100_2; д) 775_8; е) 294_{16}.
3. а) $1101100000_2 + 10110110_2$; б) $101110111_2 + 1000100001_2$; в)$1001000111_2+100001101_2$;

Variant2

1. а) 250_{10}; б) 757_{10}; в) 711_{10}; г) 914_{10}; д) 261_{10}.
2. а) 1111000_2; б) 1111000000_2; в) 111101100_2; г) 100111100_2; д) 1233_8; е)$2B3_{16}$.
3. а) $1010101_2+10000101_2$; б) $1111011101_2+101101000_2$; в) $100100111_2+100111010_2$;

Variant 3

1. а) 759_{10}; б) 265_{10}; в) 79_{10}; г) 360_{10}; д) 240_{10}.
2. а) 1001101_2; б) 10001000_2; в) 100111001_2; г) 1111010000_2; д) 1461_8; е) $9D_{16}$.
3. а) $100101011_2+111010011_2$; б) $1001101110_2+1101100111_2$; в) $1010000100_2+11011110_2$

Variant4

1. а) 216_{10}; б) 336_{10}; в) 741_{10}; г) 712_{10}; д) 184_{10}.
2. а) 1100000110_2; б) 1100010_2; в) 1011010_2; г) 1010100010_2; д) 1537_8; е) $2D9_{16}$.
3. а) $101111111_2+1101110011_2$; б) $10111110_2+100011100_2$; в) $1101100011_2+1100011_2$

Variant 5

1. а) 530_{10}; б) 265_{10}; в) 597_{10}; г) 300_{10}; д) 75_{10}.
2. а) 101000111_2; б) 110001001_2; в) 1001101010_2; г) 1011110100_2; д) 1317_8; е)$2F4_{16}$.
3. а) $1100011010_2+11101100_2$; б) $10111010_2+1010110100_2$; в)$1000110111_2+1110001111_2$