Unit I –Part 03
(Number Systems)

Lecture Slide

AS2023

Objectives

By the end of this session, students will be able to:

- Explain the need for number system
- Define base or radix
- Identify different number systems
- Explain all number systems
- Convert from one to another number system

Number System

- Represents numbers in a easier way
- Broad representation of numbers:
  - Decimal number system
  - Binary Number system
  - Octal Number System
  - Hexadecimal Number system
- Each number system uses different radix or base
- **Radix or base-** The number of unique digits, including the digit zero, used to represent numbers

Decimal Number System

- Base-10 number system
- Has 10 digits from 0-9
- It is also a positional value system
- Example: 734, 971 and 207 and the value of 7 in all three numbers are different

  In 734, value of 7 is 7 hundreds or 700 or 7×100 or 7×10^2
  In 971, value of 7 is 7 tens or 70 or 7×10 or 7×10^1
  In 207, value of 7 is 7 units or 7 or 7×1 or 7×10^0

- The weightage of each position can be represented as:

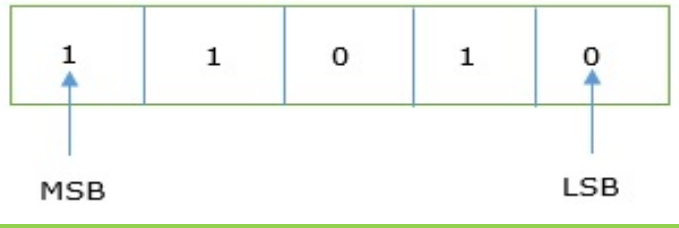
10^5	10^4	10^3	10^2	10^1	10^0

Binary Number System

- Base-2 Number system
- Two digits 0 and 1
- Each binary digit is also called a bit
- It is also positional value system but each values is represented in the power 2
- The weightage of each position can be represented as

2^5	2^4	2^3	2^2	2^1	2^0

- In binary number system:



Octal Number System

- Base-8 Number system
- Digits from 0 - 7
- It is also positional value system but each values is represented in the power 8
- The weightage of each position can be represented as:

8^5	8^4	8^3	8^2	8^1	8^0

Hexadecimal NS

- Base-16 Number System
- Digits from 0-9 and A-F where A =10 and F= 15
- It is also positional value system but each values is represented in the power 16
- The weightage of each position can be represented as

16^5	16^4	16^3	16^2	16^1	16^0

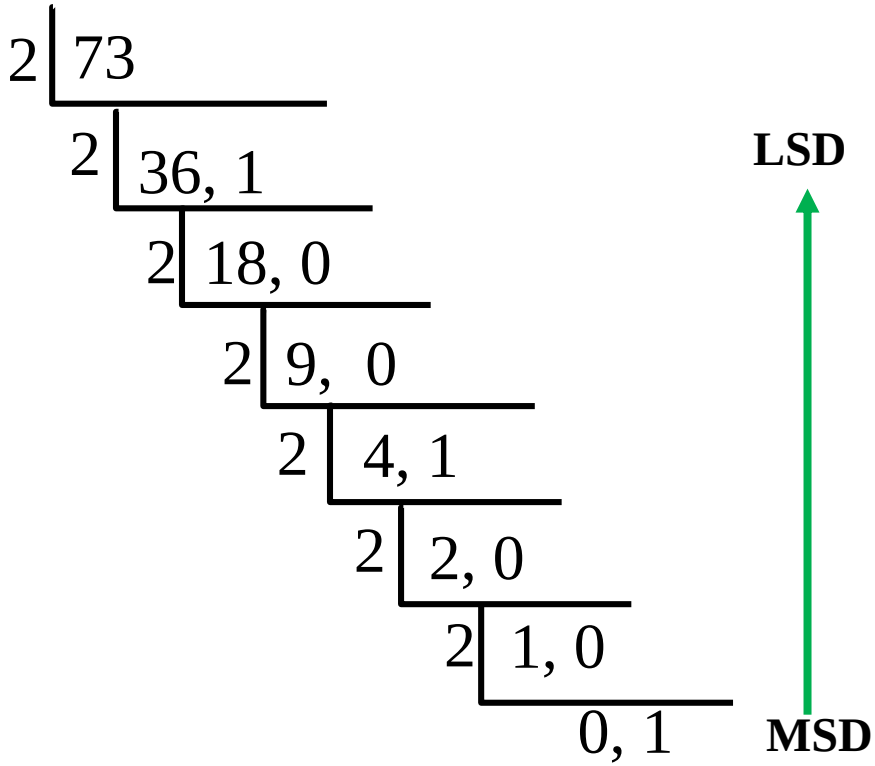
Relationship

Important for Number conversion!!!

HEXADECIMAL	DECIMAL	OCTAL	BINARY
0	0	0	0000
1	1	1	0001
2	2	2	0010
3	3	3	0011
4	4	4	0100
5	5	5	0101
6	6	6	0110
7	7	7	0111
8	8	10	1000
9	9	11	1001
A	10	12	1010
B	11	13	1011
C	12	14	1100
D	13	15	1101
E	14	16	1110
F	15	17	1111

Decimal to Binary Conversion

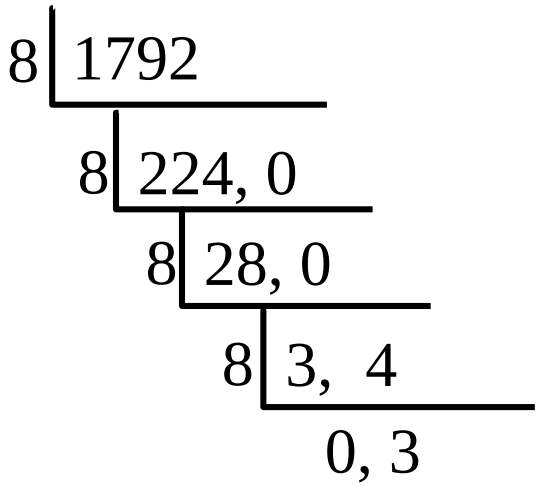
- Use **Repeated_Division-by-2** method
- Convert $(73)_{10}$ to base-2 number

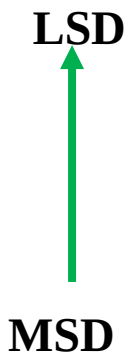


Therefore,
$(73)_{10} = (1001001)_2$

Decimal to Octal Conversion

- Use **Repeated_Division-by-8** method
- Convert $\mathbf{(1792)_{10}}$ to base-8 number

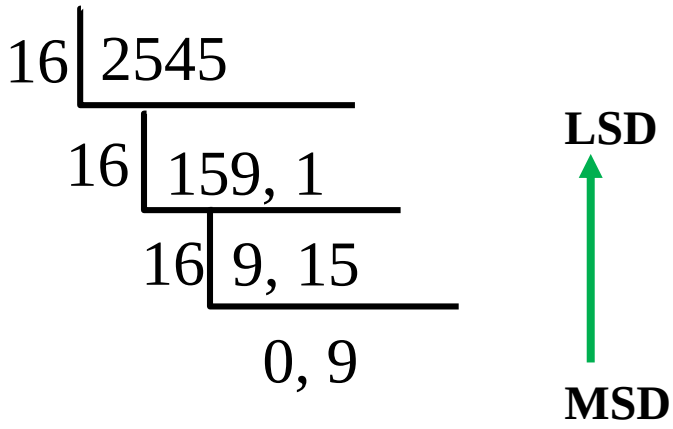




Therefore,
$(1792)_{10} = (3400)_8$

Decimal to Hexadecimal Conversion

- Use **Repeated_Division-by-16** method
- Convert $(2545)_{10}$ to base-16 number



Therefore,
$(2545)_{10} = (9F1)_{16}$

- Convert $(9836)_{10}$ to base-16 number

CLASS ACTIVITY

THINK-PAIR-SHARE

- ✓ Select your pair/peer
- ✓ Solve the given questions (10 Minutes)
- ✓ Exchange your work with the peer/pair and evaluate

Questions

- Convert $(456)_{10}$ to base-8 number system
- Convert $(9836)_{10}$ to base-16 number system

Binary to Decimal

- Using positions
  - Step 1: Write down the binary number.
  - Step 2: Starting with the least significant digit (LSB - the rightmost one), multiply the digit by the value of the position. Continue doing this until you reach the most significant digit (MSB - the leftmost one).
  - Step 3: Add the results and you will get the decimal equivalent of the given binary number.

Binary to Decimal

- Convert $(1110010)_2$ to base-10 number

Solutions:

Binary Number : 1110010

= (1 * 2^6) + (1 * 2^5) + (1 * 2^4) + (0 * 2^3) + (0 * 2^2) + (1 * 2^1)+ (0 * 2^0)

= (1 * 64) + (1 * 32) + (1 * 16) + (0 * 8) + (0 * 4) + (1 * 2) + (0 * 1)

= 64 + 32 + 16 + 0 + 0 + 2 + 0

= 114

Therefore $(1110010)_2 = (114)_{10}$

Binary to Octal System

- Two methods
  - Convert given binary to decimal and then convert decimal to octal
  - Grouping
- Grouping:
  - Take binary number
  - Divide the binary digits into groups of **three** (starting from right) for integer part and start from left for fraction part.
  - Convert each group of three binary digits to one octal digit.

Binary to Octal System

- Convert $(1010111100)_2$ to base-8 number

Solutions:

Binary Number : 1010111100

Grouping: 1 010 111 100

From the table, we get 1274

Therefore, $(1010111100)_2 = (1274)_8$

3-bit Binary Number	Octal Number
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

Binary to Hexadecimal

- Two methods
  - Convert given binary to decimal and then convert decimal to hexadecimal
  - Grouping
- Grouping:
  - Take binary number
  - Divide the binary digits into groups of **Four** (starting from right) for integer part and start from left for fraction part.
  - Convert each group of four binary digits to one hexadecimal digit.

Binary to Hexadecimal

- Convert $(1010101101001)_2$ to base-16 number

Solutions:

Binary Number : 1010101101001

Grouping: 1 0101 0110 1001

From the table, we get 1569

Therefore, $(1010111100)_2 = (1569)_{16}$

Dec	Hex	Oct	Bin
0	0	000	0000
1	1	001	0001
2	2	002	0010
3	3	003	0011
4	4	004	0100
5	5	005	0101
6	6	006	0110
7	7	007	0111
8	8	010	1000
9	9	011	1001
10	A	012	1010
11	B	013	1011
12	C	014	1100
13	D	015	1101
14	E	016	1110
15	F	017	1111

Octal to Decimal

- The following steps are adopted:
  - step 1: Separate the digits of the given octal number, if it contains more than 1 digit.
  - step 2: Multiply each digit of octal number with its increasing power of 8 from right to left (LSB to MSB)
  - step 3: Adding all the individual results provides the equivalent decimal number.

Octal to Decimal

- Convert $(143)_8$ to base-10 number

Solutions:

Octal Number : 143

$= (1*8^2) + (4*8^1) + (3*8^0)$

$= (1*64) + (4*8) + (3*1)$

$= 64 + 32 + 3$

$=99$

Therefore, $(143)_8 = (99)_{10}$

Octal to Binary

- Two options:
  - **Option 1:** Convert to decimal and then convert decimal to binary
  - **Option 2:**
    - Take Octal number as input
    - Convert each digit of octal into binary.
    - That will be output as binary number.

Octal to binary

- Convert $(540)_8$ to base-2 number

Solutions:

Octal Number : 540

From the table, we get

(101 100 000)

Therefore, $(540)_8 = (101100000)_2$

3-bit Binary Number	Octal Number
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

Octal to Hexadecimal

- Steps for conversion:
  - Take octal Numbers
  - Convert octal numbers to binary
  - Form the group of 4 binary bits to get hexadecimal equivalent

Octal to Hexadecimal

- Convert $(752)_8$ to base-16 number

Solutions:

Octal Number : 752

From the table, we get

$(111\ 101\ 010)_2$

Form a group of 4 bits:

$(1\quad 1110\quad 1010)_2$

$= 1EA$

Therefore, $(752)_8 = (1EA)_{16}$

3-bit Binary Number	Octal Number
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

CLASS ACTIVITY

Group Activity

- ✓ Divide into 12 groups
- ✓ Solve the given questions (5-7 Minutes)
- ✓ A member from a group will present the solution

Questions

- Convert $(1010)_2$ to base-10 number system (Group 1 & 2)
- Convert $(10010110)_2$ to base-8 number system (Group 3 & 4)
- Convert $(1101010)_2$ to base-16 number system (Group 5 & 6)
- Convert $(765)_8$ to base-10 number system (Group 7 & 8)
- Convert $(352)_8$ to base-2 number system (Group 9 & 10)
- Convert $(4745)_8$ to base-16 number system (Group 11 & 12)