



# Numbering Systems

Computer Science Department

Comp 131

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# Outline

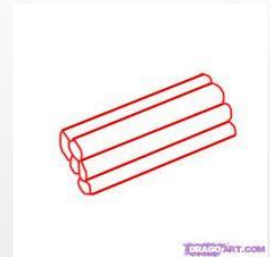
- History.
- Decimal System.
- Binary System.
- Octal System.
- Hexadecimal System.
- Converting from one System to another system & back.
- Binary Addition
- Signed Numbers
- Summary

# History

- ❖ Long ago, humans used sticks to count.



- ❖ Later learned how to draw pictures of sticks in the ground and eventually on paper.



- ❖ Using symbols to represent the numbers instead of sticks.

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# Decimal System

- ❖ Most People Use decimal representation to count.
- ❖ In decimal there are **10** digits  
0,1,2,3,4,5,6,7,8,9
- ❖ The base is **10**
- ❖ We can Represent any value for these digits  
Ex: 754 , 123 , 889 , 345

# Decimal System

Ex: 754

$$7 \cdot 10^2 + 5 \cdot 10^1 + 4 \cdot 10^0 = 700 + 50 + 4 = 754$$

base

Digit  
position

123 ???

# Binary System

- ❖ Computer is not smart as a human .
  - ❖ Easy to make an electronic machine with two states: on and off , or 1 and 0.
  - ❖ In Binary there are **2** digits  
0,1
- The base is **2**

# Binary System

- ❖ Each digit in binary number called **BIT**.

1 0 1 0 , 4 digits , **How many bits ?**

**answer : 4 bits**

- ❖ 4 bits form a **NIBBLE**.

- ❖ 8 bits form a byte.

- ❖ 1 0 1 0 0 0 1 1 , **How many Bits, Nibbles and Bytes?**

**Answer :8 bits ,2 Nibbles and 1 byte**

# Binary System

❖ Two bytes form a **WORD** and two words form a **DOUBLE WORD (rarely used)** .

**EX:**

**0000 1111 1010 1010 : 16 bits , WORD**



# Octal System

❖ Uses 8 digits

0,1,2,3,4,5,6,7

❖ The base is **8**

❖ **EX**  $(123)_8$  ,  $(156)_8$

# Hexadecimal System

❖ Uses 16 digits

0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F

❖ The base is **16**

❖ **EX: 123h , 456h 0E120h**

❖ **Suppose we need to develop new system with base 5,7 or 3?**

**Base 5 : 0,1,2,3,4**

**Base 7 : 0,1,2,3,4,5,6**

**Base 3: 0,1,2**



# Binary to Decimal

❖ 10110b

$$1*2^4+0*2^3+1*2^2+1*2^1+0*2^0=$$

$$16+0+4+2= (22)_{10}$$

**1010b =?? , 0010b = ?? , 101b=??**

**Answer: 1010b=(10)<sub>10</sub>**

**0010b=(2)<sub>10</sub>**

**101b=(5)<sub>10</sub>**

# Decimal to Binary

$$(22)_{10} = ( )_2$$

Input

Result

Remainder

22/2

11

0

11/2

5

1

5/2

2

1

2/2

1

0

1/2

0

1



$$(22)_{10} = (10110)_2$$

# Decimal to Binary

$$(13)_{10} = (1101)_2$$

$$(220)_{10} = (11011100)_2$$

$$(21)_{10} = ( \quad )_2 \text{ H.W}$$

$$(15)_{10} = ( \quad )_2 \text{ H.W}$$

# Binary to Octal

$$100101010b = ( )_8$$

$$100 \ 101 \ 010 = (452)_8$$

$$111000111b = ( )_8$$

$$111 \ 000 \ 111 = (707)_8$$

# Binary to Octal

$$\ast 100101011b = ( 453 )_8$$

$$\ast 101101011b = ( \quad )_8 \quad \text{H.W}$$

$$\ast 100101001b = ( \quad )_8 \quad \text{H.W}$$



# Binary to Hexadecimal

$$10010101b = ( \quad )_h$$

$$1001 \ 0101 \ = (95h)$$

$$11100011b = ( E3h ) \ H.W$$

# Decimal to Hexadecimal

Let's convert the value  $(39)_{10}$  to  
Hexadecimal

Input	Result	Remainder
39/16	2	7
2/16	0	2



$$(39)_{10} = (27h)$$

# H.W

Covert the following numbers to **decimal**

a.  $(72)_8 = (58)_{10}$

b.  $(72)_{16} = (114)_{10}$

c.  $(DE1)_{16} = (3553)_{10}$

# *Extra Exercises*

*Using pen and paper , solve the following questions :*

a.  $(AB)_{16} = ( \quad )_2$

b.  $(23)_4 = ( \quad )_8$

c.  $(35)_7 = ( \quad )_8$

d.  $(72E)_{16} = ( \quad )_8$

# Binary Addition

$$\begin{array}{r} 0 \\ + 0 \\ \hline \end{array}$$

0

$$\begin{array}{r} 0 \\ + 1 \\ \hline \end{array}$$

1

$$\begin{array}{r} 1 \\ + 0 \\ \hline \end{array}$$

1

$$\begin{array}{r} 1 \\ + 1 \\ \hline \end{array}$$

10

$$\begin{array}{r} 1 \\ + 1 \\ + 1 \\ \hline \end{array}$$

11

# Binary Addition

$$01111 + 00110 =$$

$$\begin{array}{r} \phantom{+} 0 \phantom{0} 1 \phantom{0} 1 \phantom{1} 1 \phantom{1} \\ + 0 \phantom{0} 0 \phantom{1} 1 \phantom{1} 0 \phantom{1} \\ \hline 1 \phantom{0} 0 \phantom{1} 0 \phantom{1} \end{array}$$

# Binary Addition

$$11010011 + 01010110 =$$

$$\begin{array}{r} \phantom{+} \phantom{0} 1 \phantom{0} 1 \phantom{0} 1 \phantom{0} 1 \\ \phantom{+} 1 \phantom{0} 1 \phantom{0} 1 \phantom{0} 0 \phantom{0} 1 \phantom{0} 1 \\ + 0 \phantom{0} 1 \phantom{0} 1 \phantom{0} 0 \phantom{0} 1 \phantom{0} 1 \phantom{0} 0 \\ \hline 1 \phantom{0} 0 \phantom{0} 1 \phantom{0} 1 \phantom{0} 0 \phantom{0} 0 \phantom{0} 1 \end{array} \quad \begin{array}{l} \rightarrow (211)_{10} \\ \rightarrow (86)_{10} \\ = (297)_{10} \end{array}$$

# Binary Addition

**H.W**

**Solve Question 7 ,lab 1 ,page 9**



# Signed Numbers

**Our study of binary arithmetic, we have only considered positive numbers .**

**What about negative numbers?**

# Signed Numbers

## ➤ Signed Magnitude

add an extra digit to the front of our binary number to indicate whether the number is positive or negative.

this digit called sign bit.

0 for positive

1 for negative

# Signed Numbers

Example:

$$(5)_{10} = (101)_2$$

Positive 5 is 0 1 0 1

Negative 5 is 1 1 0 1

**The Problem : We need to specify how many bits in our numbers so we can be certain which bit is representing the sign !!!**



# Signed Numbers

1 1 0 1 is 13 or -5

## ➤ One's Complement

Representing a signed number with 1's

Complement is done by changing all the bits that are 1 to 0 and all bits that are 0 to 1.

# Signed Numbers

- ❑ Represent -5 in 1's complement by using 4-bit arithmetic?

0101 → 1010

- ❑ Represent -1 in 1's complement ?

0001 → 1110

# Signed Numbers

## ➤ Two's Complement

2's comp = 1's comp + 1

□ Represent -5 in 2's complement by using 4-bit arithmetic?

(101)<sub>1's</sub> → 1010

2's + 1

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1 0 1 1 = (-5)

# H.W

Lab 1 . P8,9

Q.1,2,3,4,8,10

# Summary

Decimal System.

Binary System.

Octal System.

Hexadecimal System.

Converting from one System to another system & back.

Binary Addition

Signed Numbers

**Thanks to Mr. Abdallah Karakra**

